

Tochtermann, Klaus (Ed.); Maurer, Hermann (Ed.)

Proceedings — Published Version

Proceedings of I-KNOW '10: 10th international conference on knowledge management and knowledge technologies

Suggested Citation: Tochtermann, Klaus (Ed.); Maurer, Hermann (Ed.) (2010) : Proceedings of I-KNOW '10: 10th international conference on knowledge management and knowledge technologies, Verlag der Technischen Universität Graz, Graz

This Version is available at:

<https://hdl.handle.net/10419/44446>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Journal

J.UCS

of

<http://www.jucs.org>

Proceedings of I-KNOW 2010

10th International Conference on Knowledge Management and Knowledge Technologies

Graz, Austria, September 1 – 3, 2010

Computer

Science

Editors I-KNOW

Klaus Tochtermann • Graz, Austria and Kiel / Hamburg, Germany

Hermann Maurer • Graz, Austria

Editors-in-Chief of J.UCS

Hermann Maurer (Managing Editor) • Graz, Austria

Narayanan Kulathuramaiyer • Sarawak, Malaysia

Klaus Tochtermann • Graz, Austria and Kiel / Hamburg, Germany

J.UCS

Journal of Universal Computer Science

Editors-in-Chief

Hermann Maurer (Managing Editor)

Graz University of Technology, Graz, Austria

Narayanan Kulathuramaiyer

Universiti Malaysia Sarawak (UNIMAS), Malaysia

Klaus Tochtermann

Graz University of Technology, Graz, Austria

ZBW – Leibniz Information Centre for Economics, Kiel / Hamburg, Germany



J.UCS - a publication of Verlag der Technischen Universität Graz, Austria,
Universiti Malaysia Sarawak, Malaysia, and Know-Center, Austria

I-KNOW 2010

International Conference on Knowledge Management and Knowledge Technologies

Preface I-KNOW 2010	1
K. Tochtermann, H. Maurer	
Emerging Trends in Search User Interfaces	6
M. A. Hearst	
Bring in 'da Developers, Bring in 'da Apps – Developing Search and Discovery Solutions Using Scientific Content APIs	7
R. Sidi	
European ICT Research and Development Supporting the Expansion of Semantic Technologies and Shared Knowledge Management	8
M. Nagy-Rothengass	
Coolfarming – Turn Your Great Idea into the Next Big Thing	9
P. A. Gloor	

I-KNOW 2010

I-KNOW 2010	10
K. Tochtermann, H. Maurer	
<i>Enterprise 2.0 and the Social Web</i>	
A Corporate Tagging Framework as Integration Service for Knowledge Workers	11
W. C. Kammergruber, K. Ehms	
A Knowledge Management Scheme For Enterprise 2.0	19
P. Geißler, D. Lin, S. Ehrlich, E. Schoop	
Enterprise Microblogging at Siemens, Building Technologies Division: A Descriptive Case Study	29
J. Müller, A. Stocker	
<i>Knowledge Technologies and the Semantic Web</i>	
RDF Data Analysis with Activation Patterns	41
P. Teufl, G. Lackner	
A Semantic Matchmaking System For Job Recruitment	50
V. Gatteschi, F. Lamberti, A. Sanna, C. Demartini	
Ontology Evaluation Algorithms for Extended Error Taxonomy and their Application on Well-Known Ontologies	60
N. I. Qazi, M. A. Qadir	
A Semantic Approach for Classification of Web Ontologies	69
M. Fahad, N. Moalla, A. Bouras, M. A. Qadir, M. Farukh	
Automatic Ontology Merging by Hierarchical Clustering and Inference Mechanisms	81
N. Maiz, M. Fahad, O. Boussaid, F. Bentayeb	
A Semantic Spatial Hypertext Wiki	94
C. Solis, N. Ali	
<i>Knowledge Management and Web 2.0</i>	
Engineering 2.0: Leveraging a Bottom-up and Lightweight Knowledge Sharing Approach in Cross-functional Product Development Teams	105
M. Bertoni, K. Chirumalla	
Online Dispute Resolution for the Next Web Decade: The Ontomedia Approach	117
M. Poblet, P. Casanovas, J.-M. López-Cobo	

Using Codebeamer to Manage Knowledge in an IT Consulting and System Integration Company	126
K. Neumeier, S. Retzer	
<i>Knowledge Sharing</i>	
Challenges and Solutions for Knowledge Sharing in Inter-Organizational Teams: First Experimental Results on the Positive Impact of Visualization	137
A. Comi, M. J. Eppler	
Utilising Pattern Repositories for Capturing and Sharing PLE Practices in Networked Communities	150
F. Mödritscher, Z. Petrushyna, E. L.-C. Law	
Clarity in Knowledge Communication	162
N. Bischof, M. J. Eppler	
<i>Knowledge Visualization</i>	
Visualizing and Navigating Large Multimodal Semantic Webs	175
W. O. Kow, D. Lukose	
Automatic Detection and Visualisation of Overlap for Tracking of Information Flow	186
L. Lehmann, A. Mittelbach, J. Cummings, C. Rensing, R. Steinmetz	
Ontological Framework Driven GUI Development	198
S. K. Shahzad, M. Granitzer	
<i>Knowledge Management - Models and Usage</i>	
Mobile Governance: Empowering Citizens to Enhance Democratic Processes	207
M. Poblet	
Value Creation by Knowledge Management – A Case Study at a Logistics Service Provider	218
E.-M. Kern, J. Boppert	
Timeline-based Analysis of Collaborative Knowledge practices within a Virtual Environment	231
J. Paralic, C. Richter, F. Babic, M. Racek	
A Constructivist Approach to the Organization of Performance Knowledge in Collaborative Networks	243
F. D. R. Strauhs, A. L. Soares, E. J. Wiersema, R. Ferreira, J. N. Silva	
<i>Knowledge Services</i>	
Knowledge Services in Support of Converging Knowledge, Innovation, and Practice	255
M. V. Pohjola, P. Pohjola, S. Paavola, J. T. Tuomisto	

knowCube for Exploring Decision Spaces: Sandwiches, Foams, and Drugs	267
H. L. Trinkaus	
Towards Lightweight Semantic Metadata Annotation and Management for Enterprise Services	279
P. Un, J. Vogel	
A User-Centred Approach to Define Interactive and Dynamic Video Annotations via Event Trees	290
P. Schultes, F. Lehner, H. Kosch	
<i>Knowledge Work</i>	
Does Knowledge Worker Productivity Really Matter?	301
R. Erne	
Industrialisation of the Knowledge Work: Business and Knowledge Alignment	309
R. Woitsch, V. Hrgovcic, D. Karagiannis	
Representing an Approach to Measuring Knowledge Workers Productivity based upon their Efficiency and Effectiveness: a Fuzzy DEA Method	317
A. Abdoli, J. Shahrabi, J. Heidary	
Optimisation of Knowledge Work in the Public Sector by Means of Digital Metaphors	333
H. F. Witschel, T. Leidig, V. Kaufmann, M. Ostertag, U. Brecht, O. Grebner	
<i>Knowledge Discovery</i>	
Clustering Technique for Collaborative Filtering and the Application to Venue Recommendation	343
M. C. Pham, Y. Cao, R. Klamma	
Towards Intention-Aware Systems	355
B. Schmidt, T. Stoitsev, M. Mühlhäuser	
Improving Navigability of Hierarchically-Structured Encyclopedias through Effective Tag Cloud Construction	363
C. Trattner, D. Helic, M. Strohmaier	
On the Need for Open-Source Ground Truths for Medical Information Retrieval Systems	371
M. Kreuzthaler, M. Bloice, K.-M. Simonic, A. Holzinger	
Multimedia Documentation Lab	382
G. Backfried, D. Aniola, K. Mak, H. C. Pilles, G. Quirchmayr, W. Winiwarter, P. M. Roth	
<i>Knowledge Management and Learning</i>	
Early Experiences with Responsive Open Learning Environments	391
M. Wolpers, M. Friedrich, R. Shen, C. Ullrich, R. Klamma, D. Renzel	

Utilizing Semantic Web Tools and Technologies for Competency Management	403
V. Janev, S. Vranes	
Facilitating Collaborative Knowledge Management and Self-directed Learning in Higher Education with the Help of Social Software. Concept and Implementation of CollabUni – a Social Information and Communication Infrastructure	415
J. Griesbaum, S.-J. Kepp	
<i>Short Papers</i>	
Microblogging Adoption Stages in Project Teams	427
M. Böhringer, L. Gerlach	
DL based Subsumption Analysis for Relational Semantic Cache Query Processing and Management	433
T. Ali, M. A. Qadir	
OntoBox: An Abstract Interface and Its Implementation	439
A. Malykh, A. Mantsivoda	
Semantic Structuring of Conference Contributions Using the Hofmethode	445
O. Michel, D. Läge	
Social Computing: A Future Approach of Product Lifecycle Management	451
A. Denger, M. Maletz, D. Helic	
Expert Recommender Systems: Establishing Communities of Practice Based on Social Bookmarking Systems	458
T. Heck, I. Peters	
Semantic Methods to Capture Awareness in Business Organizations	465
M. Blattner, E. Sultanow	
Ontology-based Experience Management for System Engineering Projects	472
O. Chourabi, Y. Pollet, M. B. Ahmed	
Conveying Strategy Knowledge Using Visualization vs. Text: Empirical Evidence from Asia and Europe	483
S. Bresciani, M. J. Eppler, M. Tan, K. Chang	

I-KNOW 2010

10th International Conference on Knowledge Management and Knowledge Technologies

Preface

The I-KNOW 2010, organized by Know-Center and Graz University of Technology, is the 10th conference of a very successful conference series on knowledge management and knowledge technologies. It attracts almost 500 international participants from science and industry every year. Since its inception in 2001, the International Conference on Knowledge Management and Knowledge Technologies (I-KNOW) has been developed to one of the most influencing application-oriented conferences on IT-based Knowledge Management.

For the fourth time I-KNOW is held concurrently with I-SEMANTICS – International Conference on Semantic Systems, organized by the Semantic Web Company. The aim of combining I-KNOW and I-SEMANTICS is to bring together the various communities and to close the gap between convergent research areas.

I-KNOW 2010 is dedicated to the latest scientific trends, developments, and challenges in the area of knowledge management and knowledge technologies. While I-SEMANTICS has its emphasis on new technology trends in semantic technologies, I-KNOW intensively focuses on the application of the latest technologies.

Like in the past, I-KNOW 2010 offers its participants a platform for high quality contributions reviewed by an international program committee. This year, 39 full papers and 15 short papers have been selected for publication in the conference proceedings of I-KNOW. This corresponds to an acceptance rate of about 34% for full papers. The program of I-KNOW 2010 covers scientific presentations, panel discussions, keynote talks, a poster session and an international matchmaking event. The authors of full papers give presentations in thematically clustered sessions. Presentations focus on current trends and latest developments in knowledge management and knowledge technologies. They address amongst others relevant aspects of knowledge management and knowledge technologies in the following fields of research:

- Knowledge Management Theories, Models and Concepts
- Knowledge Discovery and Knowledge Visualization
- Knowledge Services
- Social Media and Knowledge Sharing
- Enterprise 2.0 and the Social Web: Case Studies and Evaluations

Knowledge Management has become an organizational imperative for all types of corporate and governmental organizations. A key objective is to apply knowledge which resides within an organization to achieve the organization's goals most efficiently and cost-effectively. To implement knowledge management in organizations, different aspects from different disciplines have to be taken into account.

Knowledge Discovery aims at supporting search, visualization and analysis of complex knowledge spaces like the Web, corporate intranets, media repositories etc. and thus providing knowledge in a format appropriate for human information processing. Crucial points concern the identification of meaningful relationships between information entities, efficient user feedback, and scalable algorithms, as well as methods for increasing information and algorithmic quality.

Knowledge Services aim at supporting knowledge work, individual workplace learning, community learning, and organizational learning – as well as the transitions between them. This support is today typically provided via (composite) software services (e.g. web-services or SOA) which analyze the relationships between users, content, and semantic structures. Specific focus is given on usage data analysis and user feedback utilization. Beyond application within organizations such services can provide support for Science 2.0, knowledge maturing, etc.

In contrast to traditional media, **Social Media** refers to a range of new media concepts that tap into social networks as a way of propagating and aggregating information. While recent research suggests that social networks play an important role in the spread and sharing of knowledge, little is known about how network structures specifically influence knowledge processing and sharing activities on the web.

Web 2.0 has emerged as the new dynamic user-centered Web equipped with social features – it has empowered its users to become the main creators of content. Driven by this fundamental change innovative enterprises strive to adopt applications and technologies from the Social Web to facilitate inter- and intraorganizational knowledge transfer. To fully exploit the huge potential of the Social Web for Knowledge Management, managers need to master the emerging field of tension between the fundamental principles from the Social Web, e.g. the self-organization of its users vs. the prevailing hierarchical structures in enterprises.

Many thanks go to all authors who submitted their papers and of course to our international program committee for their careful reviews. The abstracts of the contributions which have been selected by the program committee are published in the printed conference proceedings. Revised and extended versions of all full papers of I-KNOW 2010 will appear in a series of special issues of J.UCS – Journal of Universal Computer Science and will be indexed by DBLP and ISI Web of Knowledge. J.UCS supports the open access initiative for scientific literature and thus ensures the knowledge transfer and dissemination towards the community.

Again we managed to attract internationally outstanding researchers and managers from science and industry to give a keynote at I-KNOW 2010. We are grateful that Marti A. Hearst (Professor in the School of Information at UC Berkeley, USA), Peter A. Gloor (Research Scientist at the Center for Collective Intelligence at MIT's Sloan School of Management, USA), Márta Nagy-Rothengass (Head of Unit European Commission DG Information Society and Media – Unit Technologies for Information Management, Luxembourg), and Rafael Sidi (Vice President, Product Management for ScienceDirect, Elsevier) will present their points of view in the fields of Knowledge Technologies, Collaboration Services, Information Management, Semantic Technologies and Knowledge Discovery.

A further highlight of this year's conference program is an international matchmaking event. Due to the great success in the last three years the organizers –

the Styrian Economy Funding Agency (SFG) in cooperation with the Internationalisation Centre Styria (ICS) and the Enterprise Europe Network (EEN) – decided to continue this success story. Prior to the conference, interested organizations have the opportunity to generate their profile containing information about their competences, services, products, needs, etc. Organizations with complementary profiles will then be invited to meet each other during a 25-minute business speed-dating. This program element fosters the conference strategy to serve as a platform for networking between science and industry.

Finally, we would like to thank our media partners (PWM – Plattform Wissensmanagement, Computerwelt, Monitor, eCommerce Magazin, xingKM Knowledge Management, DOK Magazin, internet World Business, InnoVisions, Community of Knowledge) as well as our sponsors (ZBW – Leibniz Information Centre for Economics, Fraunhofer Austria, Graz Wirtschaft). Special thanks go to Dana Kaiser for preparing the I-KNOW 2010 conference proceedings in time and in highest quality. Finally, we would also like to thank the core group at Know-Center and the Knowledge Management Institute at Graz University of Technology who are responsible for the entire successful organization of the event. This group includes in alphabetical order Anke Beckmann, Anita Griesser, Patrick Hoefler, Alexander Stocker, and Claudia Thurner-Scheuerer. Thank you for your continuous high motivation in organizing I-KNOW!

We are convinced that I-KNOW 2010 will be a terrific event. We hope the conference time in Graz will trigger many new ideas for your own research, and that you'll find new opportunities for sustainable partnerships with other organizations.

Sincerely yours,

Klaus Tochtermann and Hermann Maurer
Conference Chairs I-KNOW 2010

Graz, August 2010

Program Committee I-KNOW 2010

- Andrea Back, University of St. Gallen, Switzerland
- Jean-Yves Blaise, Centre national de la recherche scientifique, France
- Remo Burkhard, ETH Zurich, Switzerland
- Richard Chbeir, Bourgogne University, France
- Giuseppe Conti, Fondazione Graphitech, Italy
- Ulrike Cress, Knowledge Media Research Institute Tübingen, Germany
- Raffaele De Amicis, Fondazione Graphitech, Italy
- Andreas Dengel, DFKI, Germany
- Mario Döller, University of Passau, Germany
- Erik Duval, University of Leuven, Belgium
- Martin Eppler, University of St. Gallen, Switzerland
- Joaquim Filipe, School of Technology of Setubal, Portugal
- Shlomo Geva, Queensland University of Technology, Australia
- Tom Heath, Talis, UK
- Barbara Kieslinger, Centre for Social Innovation (ZSI), Austria
- Ralf Klamma, RWTH Aachen, Germany
- Jörn Kohlhammer, Fraunhofer IGD, Germany
- Michael Koch, Universität der Bundeswehr München, Germany
- Rob Koper, Open University of the Netherlands, Netherlands
- Harald Kosch, University of Passau, Germany
- Narayanan Kulathuramaiyer, Universiti Malaysia Sarawak (UNIMAS), Malaysia
- Franz Lehner, University of Passau, Germany
- Sheng-Tun Li, National Cheng-Kung University, Taiwan
- Dickson Lukose, MIMOS, Malaysia
- Mathias Lux, Alpe Adria University Klagenfurt, Austria
- Ronald Maier, University of Innsbruck, Austria
- Kathrine Mailet, Institut Telecom SudParis, France
- Ambjörn Naeve, Royal Institute of Technology, Sweden
- Wolfgang Nejdil, L3S, Germany
- Tomas Pitner, Masaryk University of Brno, Czech Republic
- Martin Potthast, Bauhaus University Weimar, Germany
- Wolfgang Prinz, RWTH Aachen and Fraunhofer FIT, Germany
- Uwe Riss, SAP Research, Germany
- Marc Rittberger, DIPF – German Institute for International Educational Research, Germany
- Paolo Rosso, Universidad Politécnica de Valencia, Spain
- Ramon Sabater, University of Murcia, Spain
- Kurt Schneider, University of Hannover, Germany
- Luciano Serafini, Fondazione Bruno Kessler (FBK-IRST), Italy
- Marc Spaniol, Max Planck Institute for Computer Science, Germany
- Benno Stein, Bauhaus University Weimar, Germany
- Rudi Studer, University of Karlsruhe, Germany
- Jim Thomas, Pacific Northwest Laboratory, USA
- Robert Tolksdorf, Free University of Berlin, Germany

- Ivan Tomek, Acadia University, Canada
- Andrew Trotman, University of Otago, New Zealand
- Sofia Tsekeridou, Athens IT Excellence Center, Greece
- Eric Tsui, Hong Kong Polytechnic University, China
- Bodo Urban, Fraunhofer IGD, Germany
- Martin Wolpers, Fraunhofer FIT, Germany
- Volker Zimmermann, imc AG, Germany

Additional Reviewers for I-KNOW 2010

- | | |
|---------------------------|-----------------------------|
| - Benjamin Adrian | - Barbara Kump |
| - Maik Anderka | - Björn Link |
| - Ingo Barkow | - Daniele Magliocchetti |
| - Ingo Bleeß | - Christina Matschke |
| - Peter Böhm | - Anees ul Mehdi |
| - Simone Braun | - Johannes Moskaliuk |
| - Marco Calderan | - Danish Nadeem |
| - Carola Carstens | - Katja Niemann |
| - James Davey | - Maren Scheffel |
| - Hannes Ebner | - Christoph Schindler |
| - Ludger van Elst | - Hans-Christian Schmitz |
| - Kerstin Fink | - Eva Schwaemmlein |
| - Tim Gollub | - Bruno Simoes |
| - Gunnar Aastrand Grimnes | - Michael Sintek |
| - Stefanie Hain | - Alexander Stocker |
| - Heiko Haller | - Philip Sorg |
| - Jörn Hees | - Claudia Thurner-Scheuerer |
| - Christoph Held | - Angela Vorndran |
| - Denis Helic | - Denny Vrandečić |
| - Julia Hoxha | - Andreas Wagner |
| - Joachim Kimmerle | - Thomas Walter |
| - Uwe Kirschenmann | - Katrin Wodzicki |
| - Marian Kogler | - Roman Zollet |
| - Milos Kravcik | |

Emerging Trends in Search User Interfaces

Keynote Speaker

Marti A. Hearst

(UC Berkeley, USA)

hearst@ischool.berkeley.edu)

Search is an integral part of peoples' online lives; people turn to search engines for help with a wide range of needs and desires. Web search is a familiar tool today, but it is surprisingly difficult to design a new search interface that is successful and widely accepted. In this talk, Prof. Hearst will discuss new ideas and trends that she thinks will impact search in future.

About Marti A. Hearst

Prof. Marti Hearst is a professor in the School of Information at the University of California, Berkeley. She received BA, MS, and PhD degrees in Computer Science from UC Berkeley and was a Member of the Research Staff at Xerox PARC from 1994 to 1997.

A primary focus of Prof. Hearst's research is user interfaces for search. She just completed the first book on the topic of Search User Interfaces and she has invented or participated in several well-known search interface projects including the Flamenco project that investigated and the promoted the use of faceted metadata for collection navigation. Professor Hearst's other research areas include computational linguistics, information visualization, and analysis of social media.

Prof. Hearst has received an NSF CAREER award, an IBM Faculty Award, a Google Research Award, an Okawa Foundation Fellowship, two Excellence in Teaching Awards, and has been principle investigator for more than \$3M in research grants.

Bring in 'da Developers, Bring in 'da Apps – Developing Search and Discovery Solutions Using Scientific Content APIs

Keynote Speaker

Rafael Sidi

(Elsevier, USA)

r.sidi@elsevier.com)

During a multi-year study of more than 3,000 scientific researchers and developers, we at Elsevier uncovered key trends that are shaping the lean research globally – workflow efficiencies, funding pressures, government policies, and global competition. We also looked at key trends defining the future of web – openness & interoperability, personalization, collaboration, and trusted views. As a global publisher of scientific literature, we wanted to know what categories of search and discovery applications were needed and how we could make it easy to connect researchers – at their moment of need – with the most targeted applications or the right development partner – the developers! We collected impressive insights into the categories of applications- recommenders, filtering tools, personalized search, clustering tools, visualization apps, and information extractors. We would like to present to the conference community our thoughts about how developers could use scientific content APIs to develop highly targeted research and discovery applications, collaborate with the scientific community and create partnerships that leverage efficient market channels.

About Rafael Sidi

Rafael Sidi is Vice President, Product Management for ScienceDirect, Elsevier's main online journal and book platform. He also leads the new search and discovery solutions and applications initiatives for Elsevier's Academic and Government Products Group. Rafael has been with Elsevier since 2001 and has been leading product development efforts for Engineering Information and then for the Engineering & Technology division. He has been instrumental in developing and creating new online productivity enhancing products for the corporate and academic markets including Engineering Village, Referex and illumin8. Engineering Village won the SIIA 2006 Codie Award for Best Content Aggregation Service. illumin8 is the first technology intelligence research tool for R&D knowledge workers, which uses natural language processing technology with Elsevier's premium scientific content and web content.

Prior to joining Elsevier, Rafael was Director of e-commerce operations for Bolt Media Inc. a portal for teenagers. Rafael has a Bsc in Electrical Engineering from Bosphorus University, Istanbul and MA from Brandeis University.

European ICT Research and Development Supporting the Expansion of Semantic Technologies and Shared Knowledge Management

Keynote Speaker

Márta Nagy-Rothengass

(European Commission DG INFSO/E2, Luxembourg
marta.nagy-rothengass@ec.europa.eu)

The European Commission has had significant funding and supporting activities to develop and deploy semantic technologies and to improve content and knowledge management methods and tools, demonstrated in different sectors of society and in business environment. In this talk I will briefly introduce the related working fields of the Directorate General Information Society and Media and present the main policy paths driven by the Digital Agenda for Europe. Further I will give an overview on recently finished and ongoing EC co-funded research and development activities based on FP6 and FP7 projects dealing with intelligent management of extremely large data and content creation. In the second part of my talk I will focus on the upcoming research activities and calls supporting more Intelligent Information Management including the real time dimension and on the launch of the ICT SME initiative on Digital Content. I will describe the main research challenges in this field focusing on large and constantly growing data management, will highlight the expected impact and target outcome of the addressed research. Last but not least I will inform about the upcoming ICT 2010 conference, the Proposers' Day (to be held in May 2011 in Budapest) and further information and networking occasions.

About Márta Nagy-Rothengass

Márta Nagy-Rothengass is Head of Unit "Technologies for Information Management" in the Information Society and Media Directorate-General of the European Commission. Her Unit manages and co-funds research and development projects on innovative ICT technologies dealing with creation of intelligent digital objects and knowledge management, supporting knowledge exchange and "semantic web". Recently she and her Unit have taken the necessary steps to deal with more effective and efficient management of extremely large scale data. Earlier Márta was engaged in the private sector across Europe and voluntarily contributed to building up of social associations. Márta graduated and received a Doctor's degree in Economics at the University of Economics Budapest, Hungary and has an MBA from Danube University, Krems, Austria.

Coolfarming – Turn Your Great Idea into the Next Big Thing

Keynote Speaker

Peter A. Gloor

(MIT's Sloan School of Management, USA
pgloor@mit.edu)

Collaborative Innovation Networks, or COINs, are cyberteams of self-motivated people with a collective vision, enabled by technology to collaborate in innovating by sharing ideas, information, and work. Although COINs have been around for hundreds of years, they are especially relevant today because the concept has reached its tipping point thanks to the Internet. COINs are powered by swarm creativity, wherein people work together in a structure that enables a fluid creation and exchange of ideas. ‘Coolhunting’ – discovering, analyzing, and measuring trends and trendsetters – and ‘Coolfarming’ – developing these trends through COINs – puts these concepts to productive use. Patterns of collaborative innovation always follow the same path, from creator to COIN to collaborative learning network to collaborative interest network. The talk also introduces Condor, a tool for dynamic semantic social network analysis. Condor applies a novel set of social network analysis based algorithms for mining the Web, blogs, and online forums to identify trends and find the people launching these new trends. The talk is based on Peter Gloor's latest book “Coolfarming” coming out in June 2010 at AMACOM.

About Peter A. Gloor

Peter A. Gloor is a Research Scientist at the Center for Collective Intelligence at MIT's Sloan School of Management where he leads a project exploring Collaborative Innovation Networks. He also teaches at the University of Cologne and Aalto University, Helsinki and is Chief Creative Officer of startup galaxyadvisors. Earlier, Peter was a Partner and European e-Business Practice leader with Deloitte Consulting, a Partner with PricewaterhouseCoopers and Section Leader for Software Engineering at UBS.

His new book “Coolfarming: Turn Your Great Idea into the Next Big Thing” comes out in June 2010 at AMACOM. Peter also blogs about Swarm Creativity.

I-KNOW 2010

International Conference on Knowledge Management and Knowledge Technologies

Conference Chairs

Klaus Tochtermann

Graz University of Technology,
ZBW – Leibniz Information Centre for Economics

Hermann Maurer

Graz University of Technology

Program Chairs

Stefanie Lindstaedt

Know-Center,
Graz University of Technology

Michael Granitzer

Know-Center,
Graz University of Technology

Horst Bischof

Graz University of Technology

Werner Haas

Joanneum Research

Dietrich Albert

University of Graz

A Corporate Tagging Framework as Integration Service for Knowledge Workers

Walter Christian Kammergruber

(Institut für Informatik Technische Universität München
Boltzmannstr. 3, 85748 Garching, Germany
walter.kammergruber@gmail.com)

Karsten Ehms

(Siemens AG, Corporate Technology
Otto-Hahn-Ring 6, 81739 München, Germany
karsten.ehms@siemens.com)

Abstract: Digitally supported knowledge work, using tags for content organization, creates inherent challenges. In this paper we show the design of a corporate tagging framework facing these challenges. We describe the implementation of a thesaurus approach as a lightweight alternative to a more sophisticated ontology design. An RDF based architecture with a Web 2.0 style editor enables average users to enrich social tagging data with semantic relations.

Key Words: tagging, orchestration, semantic, thesaurus

Category: H.5.4 D.2.10 H.3.5

1 Introduction

How do you keep your snippets, bits and pieces of information together? Today's knowledge work [Hube, 2005] is characterized by a multitude of larger information systems, smaller ICT tools and underlying file formats. Most creative — so called weakly structured — workflows stretch across systems and tools. Therefore tool supported knowledge work is often more kind of a hassle rather than an efficient flow [Csikszentmihalyi, 2002] of activities. With the advent of Web 2.0 tools in organizations (discussed as Enterprise 2.0 [McAfee, 2006]) at least granular hyperlinks and the capability to embed those into content, supports minimal integration allowing to switch from one application to another. In rare cases, the hyperlink can be complemented by dynamic linked information, e.g. through RSS or ATOM feeds. Still, cross application integration is far from being efficient. We refer to these problems as (personal) *orchestration challenge* [Ehms, 2010]. The term orchestration alludes to the requirement of composing and possibly configuring the tools needed for a certain task.

While this turns aforementioned workflows into “switch flows” between applications, challenges related to the organization of knowledge are not addressed by the mechanisms described so far. Typical Web 2.0 applications and more and

more (client sided) desktop tools inspired by the web provide *tagging* as the smallest common denominator for content organization. Tagging itself has some inherent shortcomings ([Kammergruber et al., 2010]) compared to more sophisticated “ontological” in vitro approaches. We call this the *semantic challenge* of social tagging. These drawbacks are multiplied by the orchestration challenge. Tags have to be re-entered and user assistance, such as auto completion, cannot benefit from tags stored in other systems. The same holds true for search, navigation and tag gardening [Weller and Peters, 2008] scenarios. The linkage between the semantic shortcomings of tagging and the orchestration challenge provides the rationale to tackle both in one approach delineated in section 3.

Main issues related to the orchestration challenge are: (i) *A growing number of tools* and systems being used in professional and private contexts, (ii) *a variety of technical storage formats*, partly proprietary, (iii) *different user interfaces* and underlying metaphors for interaction and finally, (iv) *heterogeneous ways of organizing information*, at least partly *not* linked to the semantic context of one application, but merely as a result of missing cross application metadata support.

Main shortcomings related to the semantic challenge are: Result sets to simple queries are incomplete because *synonyms* are not represented adequately. Ambiguous terms (*homonyms/ polysemy*) used as filters might deliver a huge amount of not relevant items. *Acronyms*, in general used as synonyms in a given context, help making domain related communication and information management more efficient. On the other hand there is an increased likelihood of polysemic clashes between terms. The latter is a problem when doing research in an open domain, again, leading to irrelevant query/filter results. Hierarchical or pseudo-hierarchical navigation, i.e. successive filtering or expansion, can only be provided if additional structural information (*hyponyms* or *hypernyms*) is present. These shortcomings can be described as a lack of explicit semantic relations between tags leading to bad precision or recall [Manning et al., 2008].

Of course it is not realistic, claiming to “solve” these mostly well known problems with yet another “magical” system. However we propose, that our tagging framework is an innovative approach, embedded into a “real world” corporate environment from the very beginning. Resolution of the sketched problems is at least possible for taggable systems, i.e. web based applications with permalinks and simple export mechanisms such as RSS or ATOM.

2 Related Work

What we call the *semantic challenge* is a problem addressed by a long list and history of scientific work. Especially in the area of research around artificial intelligence and in other fields such as information retrieval [Panyr, 1986] this

category of problems has received quite some attention. In our context we consider the concrete semantic challenge as the lack of structure between tags.

Braun et al. [Braun et al., 2007] describe an ontology maturing process, based on social tagging data, by which ontologies are created. In Soboleo [Zacharias and Braun, 2007] they provide a web based editing interface¹ for modelling concepts using SKOS². Schmidt et al. [Schmidt et al., 2009] integrate this approach in a wider context related to personal and organizational learning.

A completely different approach is followed by projects such as MOAT [Passant and Laublet, 2008] or Faviki³. In these web applications the concepts of existing ontologies or similar structures are either mapped to tags or the concepts are directly used for tagging resources.

Weller et al. [Weller and Peters, 2008] follow with “tag gardening” a method for reorganizing folksonomies. Activities thereby include editing, re-engineering, manipulating and organizing tags. Social tagging data should become more productive and effective after the tag gardening procedure.

The *orchestration problem* is a central issue dealt with by personal information management tools such as Nepomuk [Groza et al., 2007] or Haystack [Karger and Jones, 2006], [Bernstein et al., 2007]. Nepomuk and Haystack are tools for data unification in personal information management. Their major target is interlinking pieces of information and thus making these pieces easier to retrieve when needed.

Having pieces of information scattered over different applications, is also discussed under the term “Unified PIM Support” [Jones and Bruce, 2005]. Lehel [Lehel, 2007] refers to users trying to solve those kind of problems as “information inventory control strategies”.

3 Tagging Framework

In the following sections we first give a brief overview of the main characteristics of the architecture for the tagging framework. The last section focuses on the tag thesaurus editor being an essential part of the tagging framework.

3.1 General Technical Architecture

Figure 1 depicts a schema of the architecture. The tagging framework acts as mediator between different taggable applications (3). This addresses the orchestration challenge. The framework receives or fetches folksonomy data depending on the possibilities and implementation of the respective application to integrate.

¹ <http://tool.soboleo.com/editor/editor.jsp>

² <http://www.w3.org/2004/02/skos/>

³ <http://www.faviki.com/>

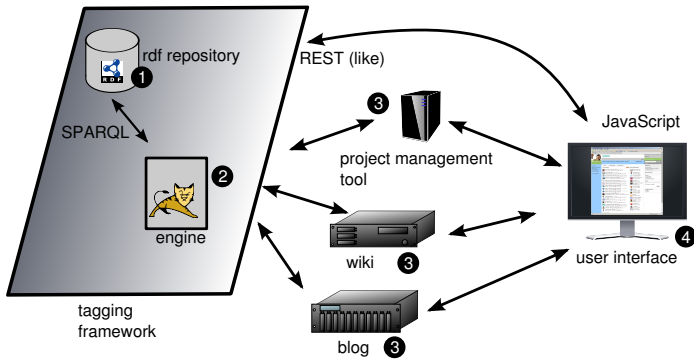


Figure 1: System Architecture.

The tagging framework consists of an RDF repository (1) and a servlet engine (2) acting as a container for the application logic. The internals of the tagging framework are transparent to the outside, i.e. the tagging framework can be accessed through a simple REST API [Fielding, 2000]. JSON⁴ is used as default data serialization format. JSON can be, additionally to classical RPC mechanisms, natively processed with client side JavaScript (direct communication between (1) and (4)).

One major difficulty in the design of the architecture is the aggregation and especially the synchronisation of tagging data. We distinguish between two mechanism: “push” and “pull”. Push means that a taggable application calls an API function from the tagging framework to inform the tagging framework that a change (create/ update/ delete) in its tagging data happened. “Pull” stands for a periodic fetch mechanism. The tagging framework triggers an update on it’s tagging data for a certain taggable application.

3.2 Tag Thesaurus as Core Component

As described in section 1, folksonomies lack explicit formal structures. Therefore our goal is to extend a folksonomy with relations and to develop a thesaurus based on tags in an evolutionary manner. Figure 2 gives an overview of alternative vocabulary approaches (derived from [Weller, 2007]). The vocabulary types are ordered from left to right in increasing order depending on the potential depth of expressible semantic relations. Folksonomies are little more expressive than free keyword indexing since there is a social component included as well. For more details about the referred vocabulary approaches see [Gaus, 2005], [Peters, 2009], [Panyr, 2006].

⁴ <http://www.json.org>

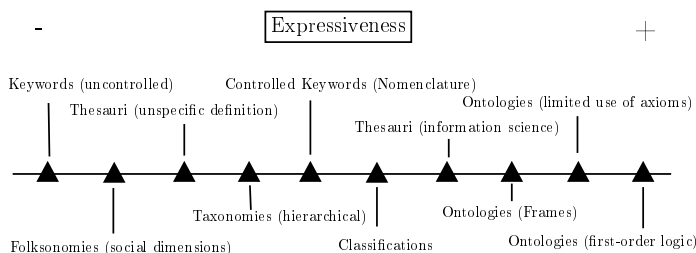


Figure 2: Expressiveness of vocabulary approaches (derived from [Weller, 2007]).

A thesaurus is a controlled vocabulary of terms that can be used as keywords. There are several variants of thesauri depending on the area they are used in. From a modeling perspective in general one can distinguish between two types of thesauri: “concept-oriented” and “term-oriented” ones. Concept-oriented means that entities in the thesaurus stand for an abstract meaning. Relations between concepts are expressed by links between concepts. Term-oriented means that term literals are interlinked directly.

There are several fields where thesauri find their application such as information science, biology or medicine. Sometimes these thesauri are a preliminary stage to an ontology and also referred to as one. The most widely used ones are linguistic thesauri since one is included in most popular word processors such as Microsoft Word or Open Office.

Recent work has proposed using social tagging data as a basis for an ontology [Braun et al., 2007]. We consider making a modest shift towards a term-oriented thesaurus being a more pragmatic solution. Since having too much complexity in the target model will most likely discourage an average user from participation. Furthermore we do not believe that a more complex model, such as a formal ontology, would provide enough additional benefit in navigation and filtering scenarios to justify the additional effort in modelling.

Out of the numerous possible thesaurus relations (see [Gaus, 2005] or thesaurus standard ISO 2788) we have selected four, which we believe are the most useful ones: *Synonym*, *Narrower*, *Broader* and *Related term*. Hence they are intuitively understandable by an average user and yet contain valuable semantic relations that can be exploited by our framework. In addition, we use a fifth relation (*Ignore*) by which a user can explicitly exclude any relation between two tags. These come in handy to overrule automatically proposed terms during query expansion and similar scenarios. Potential relations marked as *ignore* are excluded from further processing.

Figure 3 shows the user interface for the thesaurus editor. A user can define

You are here: > Home > Thesaurus Editor

[1] filter:

productivity
pilot
participationage
pkm
podcast
processes
ptech
Personal and Distributed Knowledge Management
personal
pictures
platform
pm
portal
presentation
projalexandria
problems
productivitykillers
project management
psychology
ptools

Current Tag: **knowledgemanagement** [2]

Relations: [3]

Synonym: km, wissensmanagement

Related: blogging, enterprise2.0, knowledgework, weblogs

Broader: <-----

Narrower: ----->

Ignore: ----->

Suggestions: [4]

Spelling Variant: contentmanagement, project management

Related Terms: km, wissensmanagement, web2.0, enterprise2.0, expertnetworks, infoman, knowledgework, benchmarking, blogcases, call, complexity, distributed, history, inform, knowledge, ktypes, kybernetik, presentation

Other Relations: Knowledge value, Personal knowledge management, Project blog, Collective intelligence

Figure 3: Drag and Drop thesaurus editor.

the semantic relations described above via drag and drop. One starts with selecting a tag from the folksonomy by applying a simple filter mechanism [1] (in this example the tag "knowledgemanagement" [2] is selected) which brings up already existing relations and related terms [3]. The bottom area of the screen [4] displays possibly related tags determined by different algorithms (string distance, tag co-occurrence, querying and mapping structured sources). The layout of the boxes suggests proximity between the results of certain algorithms and our thesaurus relations. The relations expressed by one user as well as user groups are stored in the RDF graph by a set of statements. The tag relation model specifies a multinary relation between a user having stated that two tags are associated by a certain *type* of relation (for details see [Kammergruber et al., 2010]).

4 Conclusion and Future Work

An instance of the tagging framework is currently under evaluation. We have tested a prototype in combination with several existing knowledge management services, such as global intranet applications (wikisphere [Lindner, 2008], blogosphere [Ehms, 2008]) and a project management tool.

Functional modules benefiting from the tag thesaurus and the tagging framework are amongst other: Tag autocompletion when searching for existing or cre-

ating new items, suggesting related tags, query refinement and expansion and tag clouds exhibiting relations between tags.

Having real world data allows us to assess the usefulness of the functionalities described. Our current experience with the framework in action has led to plausible results. We are planning quantitative empirical analysis for instance validating relations between tags defined by users against corresponding Normalized Google Distances [Cilibrasi and Vitanyi, 2005]. Planned functional extensions include recommendations based on tagging data and/or social network analysis. First results have been published in [Kammergruber et al., 2009]

Acknowledgment

Parts of this paper are based on results of research within the framework of the Theseus project⁵, more precisely the Use Case Alexandria. The project was funded by the German Federal Ministry of Economy and Technology under the promotional reference “01MQ07012”.

References

- [Bernstein et al., 2007] Bernstein, M., Kleek, M. V., Karger, D., and mc schraefel (2007). Information scraps: How and why information eludes our personal information management tools. *Transactions on Information Systems*.
- [Braun et al., 2007] Braun, S., Schmidt, A., Walter, A., Nagypal, G., and Zacharias, V. (2007). Ontology maturing: a collaborative web 2.0 approach to ontology engineering. In Noy, N., Alani, H., Stumme, G., Mika, P., Sure, Y., and Vrandečić, D., editors, *Proceedings of the Workshop on Social and Collaborative Construction of Structured Knowledge (CKC 2007) at the 16th International World Wide Web Conference (WWW2007) Banff, Canada, May 8, 2007*, volume 273 of *CEUR Workshop Proceedings*.
- [Cilibrasi and Vitanyi, 2005] Cilibrasi, R. and Vitanyi, P. M. B. (2005). Automatic meaning discovery using google.
- [Csikszentmihalyi, 2002] Csikszentmihalyi, M. (2002). *Flow: Das Geheimnis des Glücks*. Klett-Cotta.
- [Ehms, 2008] Ehms, K. (2008). *Globale Mitarbeiter-Weblogs bei der Siemens AG.*, pages 199–209. Oldenbourg, München.
- [Ehms, 2010] Ehms, K. (2010). *Persönliche Weblogs in Organisationen – Spielzeug oder Werkzeug für ein zeitgemäßes Wissensmanagement?* PhD thesis, Universität Augsburg.
- [Fielding, 2000] Fielding, R. T. (2000). *Architectural Styles and the Design of Network-based Software Architectures*. PhD thesis, University of California, Irvine.
- [Gaus, 2005] Gaus, W. (2005). *Dokumentations- und Ordnungslehre: Theorie und Praxis des Information Retrieval*. Springer, Berlin, 5., überarb. a. edition.
- [Groza et al., 2007] Groza, T., Handschuh, S., Moeller, K., Grimnes, G., Saueremann, L., Minack, E., Mesnage, C., Jazayeri, M., Reif, G., and Gudjonsdottir, R. (2007). The nepomuk project - on the way to the social semantic desktop. In Pellegrini, T. and Schaffert, S., editors, *Proceedings of I-Semantics' 07*, pages pp. 201–211. JUCS.

⁵ <http://www.theseus-programm.de/home/default.aspx>

- [Hube, 2005] Hube, G. (2005). *Beitrag zur Beschreibung und Analyse von Wissensarbeit*. PhD thesis, Universität Stuttgart.
- [Jones and Bruce, 2005] Jones, W. and Bruce, H. (2005). A report on the nsf-sponsored workshop on personal information management. Technical report, The Information School, University of Washington, Seattle, WA.
- [Kammergruber et al., 2010] Kammergruber, W. C., Brocco, M., Groh, G., and Langen, M. (2010). Collaborative Lightweight Ontologies in Open Innovation-Networks. In Hafkesbrink, J. and und Johann Schlichter, H. U. H., editors, *Competence Management for Open Innovation — Tools and IT-support to unlock the innovation potential beyond company boundaries*, pages –, Mühlheim an der Ruhr. to appear.
- [Kammergruber et al., 2009] Kammergruber, W. C., Viermetz, M., and Ziegler, C.-N. (2009). Discovering communities of interest in a tagged on-line environment. In *CASoN2009: Proceedings of the 1st International Conference on Computational Aspects of Social Networks*.
- [Karger and Jones, 2006] Karger, D. R. and Jones, W. (2006). Data unification in personal information management. *Commun. ACM*, 49(1):77–82.
- [Lehel, 2007] Lehel, V. (2007). *User-Centered Social Software — A Model and Characteristics of a Software Family for Social Information Management*. PhD thesis, Technische Universität München.
- [Lindner, 2008] Lindner, B. (2008). Der Einsatz von Wikis in der Siemens AG. I-KNOW.
- [Manning et al., 2008] Manning, C. D., Raghavan, P., and Schuetze, H. (2008). *Introduction to Information Retrieval*. Cambridge University Press.
- [McAfee, 2006] McAfee, A. P. (2006). "Enterprise 2.0: The Dawn of Emergent Collaboration" . reprint 47306. *MIT Sloan Management Review*, 47(3):21–28.
- [Panyr, 1986] Panyr, J. (1986). *Automatische Klassifikation und Information Retrieval*. Niemeyer Max Verlag GmbH.
- [Panyr, 2006] Panyr, J. (2006). Thesauri, Semantische Netze, Frames, Topic Maps, Taxonomien, Ontologien – begriffliche Verwirrung oder konzeptionelle Vielfalt? *Information und Sprache. Festschrift für Harald H. Zimmermann*, pages 139–151.
- [Passant and Laublet, 2008] Passant, A. and Laublet, P. (2008). Meaning of a tag: A collaborative approach to bridge the gap between tagging and linked data. In *Proceedings of the WWW 2008 Workshop Linked Data on the Web (LDOW2008), Beijing, China*.
- [Peters, 2009] Peters, I. (2009). *Folksonomies. Indexing and Retrieval in Web 2.0 (Knowledge & Information: Studies in Information Science)*. De Gruyter, 1 edition.
- [Schmidt et al., 2009] Schmidt, A., Hinkelmann, K., Ley, T., Lindstaedt, S., Maier, R., and Riss, U. (2009). Conceptual foundations for a service-oriented knowledge and learning architecture: Supporting content, process and ontology maturing. In *Networked Knowledge - Networked Media*, volume 221 of *Studies in Computational Intelligence*, pages 79–94. Springer Berlin / Heidelberg.
- [Weller, 2007] Weller, K. (2007). Folksonomies and Ontologies. Two New Players in Indexing and Knowledge Representation. In Jezzard, H., editor, *Applying Web 2.0. Innovation, Impact and Implementation*, pages 108–115.
- [Weller and Peters, 2008] Weller, K. and Peters, I. (2008). Seeding, weeding, fertilizing. different tag gardening activities for folksonomy maintenance and enrichment. In Auer, S., Schaffert, S., and Pellegrini, T., editors, *Proceedings of I-Semantics'08, International Conference on Semantic Systems. Graz, Austria, September 3-5*, pages 10–117.
- [Zacharias and Braun, 2007] Zacharias, V. and Braun, S. (2007). Soboleo - social bookmarking and lightweight ontology engineering. In *Workshop on Social and Collaborative Construction of Structured Knowledge (CKC), 16th International World Wide Web Conference (WWW 2007)*.

A Knowledge Management Scheme For Enterprise 2.0

Peter Geißler

(expeet|consulting, Dresden, Germany
peter.geissler@expeet.de)

Dada Lin

(Technische Universität Dresden, Dresden, Germany
dada-lin@gmx.de)

Stefan Ehrlich

(T-Systems, Multimedia Solutions, Dresden, Germany
Stefan.Ehrlich@t-systems.com)

Eric Schoop

(Technische Universität Dresden, Dresden, Germany
eric.schoop@tu-dresden.de)

Abstract: This paper looks at the convergence of knowledge management and Enterprise 2.0 and describes the possibilities for an overarching exchange and transfer of knowledge in Enterprise 2.0. This will be underlined by the presentation of the concrete example of T-Systems Multimedia Solutions GmbH (MMS), which describes the establishment of a new portfolio element using a community approach "IG eHealth". This is typified by the decentralised development of common ideas, collaboration and the assistance available to performing responsibilities as provided by Enterprise 2.0 tools. Regarding the collaboration of knowledge workers as the basis, a regulatory framework will be developed for knowledge management to serve as a template for the systemisation and definition of specific Enterprise 2.0 activities. The paper will conclude by stating enabling factors and supporting Enterprise 2.0 activities, which will facilitate the establishment of a expert knowledge management system for the optimisation of knowledge transfer.

Keywords: knowledge management, Enterprise 2.0, regulatory framework, social software, expert knowledge, enabling factors

Categories: M.1, M.2, M.4

1 A practical example

The economy today is characterised by the internationalisation of competition, increasing dynamism of innovation and market uncertainty. The coordination of the value creation chain in hierarchical organisational structures based on the Taylor paradigm is no longer able to match these developments. Instead there is a growing frequency of a clear dissolution of the traditional department and corporate boundaries. Hierarchical organisational structures are being increasingly replaced by organisational networks [Picot, 03].

As a medium-sized company providing internet-based solutions, T-Systems Multimedia Solutions GmbH is operating in an environment prone to rapidly changing market conditions. The health care sector for example is benefiting from increasing support from applications based on the infrastructure of the Internet. T-Systems MMS is seeking to become an important provider of integrated IT solutions for the health care industry by 2011. To this end the "Interest Group eHealth" was formed to prepare the bases for the establishment of the new eHealth division. The specific ambit of IG eHealth is:

- to establish the **exchange of experiences** in order to consolidate the ongoing activities in relation to eHealth as an issue and to exchange available information as well as
- to coordinate the **co-operation** arrangements within which the operational activities are agreed, the portfolio definition is prepared and cross-sector core skills are bundled.

There is an important role to be played in this by the "TeamWeb", a collaboration platform which is providing technical assistance to IG eHealth. Based on Atlassian Confluence¹ this intranet platform will be deployed for the joint preparation, organisation and publication of content as well as for the exchange of practical knowledge. The content can be discussed by means of the comment function as well as continually improved and made more complete through ongoing revision. In this way visibility is given to the participation of all the members of the interest groups and the experts. Employees append key words to various contents thereby achieving a categorisation of the content into subjects. These will improve access to relevant content and are integrated into the company-wide search systems. To avoid receiving an "information overload" there is the option to use the subscription to an information push by which the user will receive selected information about changes via email or RSS feed.

It is the technological support of the *collaboration* and *participation* that has created an environment conducive to creativity and knowledge transfer, within which the creation and editing of content, the interlinking of authors and collective tagging and commenting enables the actual content (information) to be edited and for expert knowledge to be exchanged.

2 Derivation of initial situation and research issue

Taking T-Systems MMS as our example, it will become clear how the targeted handling of expert knowledge is a task that has taken a central position within organisational practice. For some 20 years now the issue of knowledge has been attracting ever greater attention within organisational theory and practice. Alongside the intensified focus on more skill and resource-orientated organisational theories, knowledge is being reassessed as the basis of all organisational functional processes. Due to the ever decreasing half-lives of specific specialist and methodical knowledge [Probst, 97], more than ever any organisation must be able to depart from traditional

¹ cp. www.atlassian.com/software/confluence

perspectives, be willing to learn and to respond in new ways as well as to question rules and self-evident "truths".

These phenomena characterise the landscape of today's knowledge society [Heidenreich, 02], which is discernable through a shifting from *routine-based to knowledge-intensive working processes*. Knowledge-intensive processes are identifiable not least by way of their high complexity and the requirement for experts. Given these features inherent to knowledge-intensive processes, it can be deduced that it is imperative to manage collaboration better in a more knowledge-orientated manner.

Routine processes	Knowledge-intensive processes
Low complexity	High complexity
Frequent repetition	Little repetition
Contextual knowledge on hand	Little contextual knowledge on hand
Low novelty value	High novelty value
Little expert knowledge from experts required	Expert knowledge from experts required
Requisite knowledge is eminently codifiable	Requisite knowledge is difficult or nearly impossible to codify

*Table 1: Comparison of routine and knowledge-intensive processes
[cf. Hartlieb, 00, p 136]*

Alongside the shift towards knowledge-intensive processes, today's knowledge society also features the emergence of new information and communication technologies. As a result of the success of Web 2.0 within the private use, the term *Enterprise 2.0* has evolved for the use of social software within businesses [Koch, 08]. From the perspective of business informatics, social software can be understood as an "application systems that, on the basis of new developments relating to internet technologies and which utilise networking effects and economies of scale, directly and indirectly enable inter-personal interaction (coexistence, communication, coordination, cooperation) on a wide basis and which map and underpin the relationships of their users in the World Wide Web" [Koch, 07]. One feature of social software is that it makes contributions and interactions permanently and universally visible [McAfee, 08]. Project, knowledge and innovation management in particular are important application areas for social software. The enhancement of the support available to group work within enterprises is also the guiding principle of the research in Computer-Supported-Collaborative-Work established in the 1980s and which has intensified its focus on research into social software in recent years.

But the focus of the Enterprise 2.0 concept is not merely on the technology (social software) aspect. Taking a lead from the Web 2.0 trend on the Internet, "Enterprise 2.0" is taken to mean the conscious dismantling of hierarchies and the decentralising of responsibilities. The people in the individual teams organise and manage themselves while the administration acts more in the role of a chairman while also assuming responsibility for the management of networks. Enterprise 2.0 therefore takes on the role of an organisational paradigm, which encompasses the dimensions of

people, organisation and technology [Bullinger, 98] of a company and which therefore may be deemed to be integral.

Numerous authors designate the improvement of knowledge management as a significant reason for the introduction of technological and organisational aspects of the Enterprise 2.0 concept [Back, 08; Schönefeld, 09]. From a technological perspective social software can help to underpin and map knowledge-intensive working processes, while organisational and cultural changes strengthen the willingness to share knowledge. The task presented to knowledge management lies in the targeted introduction and harmonisation of these measures. In the general discussion of the Enterprise 2.0 concept the authors noticed a lack of knowledge-oriented systematisation for Enterprise 2.0 activities. In order to close this research gap 'IDEA' was developed as a knowledge-focused management model, which acts as a *regulatory framework for knowledge management* in relation to Enterprise 2.0. This regulatory framework targets to serve as a basis for planing, deployment and review of Enterprise 2.0 activities and for the derivation of concrete enabling factors.

3 Development of a regulatory framework for knowledge management in Enterprise 2.0

The objective of business informatics is the development of models and methods for the organisation of socio-technical information systems. Researchers from TU Dresden² developed in collaboration with industry the *IDEA regulatory framework* for the analysis and organisation of knowledge management in Enterprise 2.0, with the framework being evaluated taking T-Systems MMS as an example. The guiding philosophy within this is the idea of participation, which Gruber et al. [Gruber, 04] regard as the central challenge for modern knowledge management and as the solution for the exchange of complex knowledge (e.g. expert knowledge). This regulatory framework consequently provides for a person-centric approach and the self-directed participation of employees [Koch, 08, p. 52].

A variety of knowledge management models can be found in the literature. Because of its simplicity and usefulness, the pragmatic knowledge management concept of Probst et al. is widely found in practice. However a rigorously one-dimensional objective-orientated definition of knowledge is not suitable for the treatment of complex knowledge, but this is what marks out many knowledge management models [Kumbruck, 03]. The SECI model [Nonaka, 97] appears apt for the transfer of expert knowledge, because it avoids perceiving knowledge as a timeless, placeless, objective, observer-neutral and stabile entity, but instead regards knowledge as the result of a social construction process. The practical usefulness of the SECI model is the subject of increased criticism, because the transformation notions of the tacit and explicit types of knowledge appear are questionable at best or even impossible [Schreyögg, 03, p 19].

The IDEA regulatory framework as developed is aligned towards working processes, which may have four characteristic moments (lat. momentum: movement,

² Faculty of Business Management and Economics, Chair of Business Informatics, esp. Information Management.

basis, influence): interaction, documentation, evolution and adoption. In this context these IDEA moments are not to be understood as sequentially performed part processes (e.g. as in the SECI model).

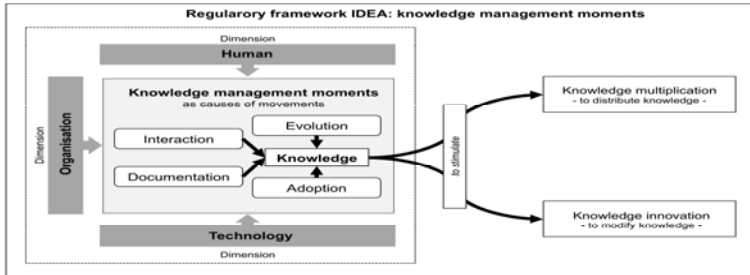


Figure 1: The IDEA knowledge management moments

3.1 Interaction

The interaction moment describes the degree of reciprocal referencing found in communicative processes. One thing of interest in this respect is the degree to which communicated messages are tailored to the specific context (situation) of the recipient. The range here extends from undirected communications (such as an entry in an anonymous database) right across to deliberate, regular communications within the terms of an intensive collaboration (e.g. work using interactive whiteboards and wiki systems). Interaction in this context enables contingency problems to be surmounted. Through a gradual approximation within the dialogue, it is possible to establish a link to the specific prior knowledge of the counterparty. Interactivity furthermore concerns motivational aspects of the knowledge process. Intensive interactions lead to the formation of a social relationship within the terms of which delight/fun will be experienced in relation to the interaction (enjoyment-based intrinsic motivation) and the feeling of reciprocal commitment arises (obligation-based intrinsic motivation) [Lindenberg, 01].

3.2 Documentation

The documentation moment encompasses the mapping and recording of results and sequences of working processes for subsequent processing. This can occur in an active or passive manner: *passive documentation* denotes the recording of working processes without additional knowledge work (e.g. video recording a meeting), whereas *active documentation* sees the (post) processing of the content (e.g. preparation of project documentation). Within this the act of formalisation and coding of the individual required for active documentation promote a better cognizance of knowledge. Cognitive content that previously had little structure has to be reflective upon and systemised in order for it to be documented. It should be noted that documentation only produces data that must first be perceived and correctly interpreted before actual knowledge can be constructed (cf. adoption).

3.3 Evolution

The evolution moment describes the extent to which the further development of existing content is permitted, encouraged and implemented organisationally. It is through exchange, interpretation and application that qualitative further development of knowledge can be performed within working processes. But the question of whether these changes are actually imported into the organisational knowledge base [Argyris, 99, p 28] largely depends on the ability to learn and willingness to change that exists within the organisation. Conceptually approximate to evolution is the Kaizen philosophy or the employee suggestion system. Within the evolution moment it must be determined what content is invariant for the organisation and what should be expressly developed further.

3.4 Adoption

The adoption moment relates to the individual-based (re-)construction of knowledge from data. The neglect of this moment in purely technologically-aligned approaches to knowledge management has led, inter alia, to the development of "dead knowledge databases" [Schütt, 03]. In such cases knowledge may well have been documented in the form of documentation, but is only infrequently called up or used due to the failure to take account of human cognition processes. For this reason the moment of adoption is of central importance for the optimisation of knowledge processes. The first step in adoption is the perception of relevant information. Only that information actually perceived by the individual will also be taken into consideration in relation to the (re-)construction of knowledge. It is particularly important that, in times of increasing abundance of data and information as a result of electronic processing and storage technologies, efficient methods of information selection are developed. The interpretation of the perceived information must subsequently be examined. Depending on the observer information is perceived and comprehended differently from an autopoietic perspective. Following the perception and interpretation the information incorporated into the mental structure of the individual can start to have an influence on his or her behaviour. It is only through the application and re-contextualisation that interlinking and solidification of the learner can take place.

This systemisation aligned to the structure of the SECI conversions forms a regulatory framework for the interventions of knowledge management. An analysis of the knowledge-intensive working processes that takes account of the four IDEA moments can aid in:

- identifying possible knowledge problems,
- identifying potential optimization in order to initiate measures in the areas of technology, organisation and people and
- providing an inter-linked/integrated view of Enterprise 2.0 activities for knowledge transfer.

4 The transfer of knowledge in Enterprise 2.0

As outlined in the initial example, knowledge work concerns the effect of various "moments" and is underpinned by Enterprise 2.0 activities. As an enabler the factor *motivation* of knowledge workers *impacts all* of the knowledge management moments. Social software concerns all *four* determinants of human behaviour [cf. von Rosenstiel, 03, p. 1ff.] and can be deployed in a targeted fashion, in order, for example, to increase the motivation for the documentation of working processes and results in Enterprise 2.0.

<i>1. Situative enablement</i>
The presence of (open) social software platforms creates the technical framework conditions for documenting content and to make it broadly available (e.g. an open Wiki or employee blog). Aside from this there must also be sufficient time for the preparation, documentation and exchange during the normal working day.
<i>2. Social permissions and duties</i>
An official introduction of social software technologies can be interpreted by employees as an organisational "authorisation" 'or "invitation" to publish content autonomously. But they could be obstructed by hidden social restrictions, for example if a shifting of information sovereignty is prevented due to micro-political interests. Alongside the mere fact of installing social software it is therefore also necessary to establish a consciousness that bridges hierarchical structures to the effect that the use and interaction with the social software platform is expressly desired.
<i>3. Individual desire</i>
This describes everything that appears important and worthwhile to an individual (e.g. value orientations, motivation). Since documentation and communication with social software takes place in an open (virtual) space, other social software users function as an "Auditorium" who communicate recognition, praise or criticism via their own contributions or comments. The social embedding of documentation processes therefore gives rise to "social feedback" [Hippner, 06, p 7], which has a decisive influence on motivation.
<i>4. Personal ability</i>
It is an essential pre-condition that the individual possesses a certain personal knowledge advantage or lead (e.g. expert knowledge, experience) which is worthwhile to exchange or document. Furthermore the technical abilities in being able to handle the social software platform are also important. Social software should therefore be made user-friendly (software usability) through a focus on the fundamentally important communication and text processing functions.

Table 2: Four determinants of human behaviour underpinned by Enterprise 2.0

Knowledge and explicit information are extremely context-based, which makes them barely comprehensible to outsiders. It is therefore crucial that there be an understanding of which factors motivate knowledge workers to ensure conscientious documentation or intensive communication using social software. The behaviour of an individual is determined both by him or herself and his or her environment.

Based on literature review [inter alia Koch, 07; McAfee, 08; Back, 08; Schönefeld, 09] general factors will now be posited which enable specific knowledge management moments to be reinforced and balanced. Further social software

applications are defined by the IDEA regulatory framework to serve as concrete support functions in Enterprise 2.0 (cf. Figure 2).

Regulatory framework for knowledge management in Enterprise 2.0				
Knowledge management moments				
	Interaction	Documentation	Evolution	Adoption
<i>Content</i>	Expand communication processes	Enable recording and mapping	Develop organisational knowledge base further	Encourage knowledge construction of the individual
<i>Result</i>	Exchange, development of a common context, increase of social capital	Data, documents, artefacts	Ideas, improvements	Perception, understanding, ability, have experiences
<i>Examples</i>	email communications, text/audio/video chats, telephone calls,	Meeting minutes, project documentation, chat history	Doubt, discussion, brainstorming, BarCamps, unconferences	Listening, reading, understanding, exercising, internalisation, applying
<i>Enabling factors in Enterprise 2.0</i>	Motivation of knowledge workers			
	Empowerment	Web-based knowledge work	Perpetual beta-knowledge culture	Navigation concepts
	Identity and reputation management	Flexible wiki application modes	Creative working processes	Integrated awareness
	relationship and cooperation management		Collective objectivisation	Contextualisation
<i>Social Software</i>	The inter-linking of the authorship enables interactive behaviour and widens the contact partner network.	Filing of knowledge work products in company wikis and blogs enables the speedy provision of knowledge, ideas, experiences, insights, comments and facts for a large audience through a number of authors.	Key wording assists in accessing content speedily and make usage behaviour explicit.	Search tools available throughout the company and which overarch individual applications enable searching and retrieval of existing knowledge. System-based prompts assist in making other similar but unknown knowledge content to be perceived.
	<ul style="list-style-type: none"> Audio/video chat Social networking services Instant Messenger Micro blogs Blogs Wikis (e.g. author announcements, campaigns, comments etc.) 	<ul style="list-style-type: none"> Wikis Blogs Micro blogs (e.g. continuous project documentation as project history within project phases) 	<ul style="list-style-type: none"> Wikis Whiteboard Tagging 	<ul style="list-style-type: none"> Push notification (RSS) Enterprise search tools Micro blogs Tagging

Figure 2: IDEA regulatory framework for knowledge management in Enterprise 2.0

5 Summary and outlook

This paper shows the convergence of knowledge management and Enterprise 2.0 to describe the necessity of collaboration management in a more knowledge-orientated manner and to avoid considering the issues of knowledge management and Enterprise 2.0 independently from one another. One aspect of the focus here is on the person-centric approach while the other is on the self-directed participation of employees. Both approaches are amalgamated under the concept of participation, which is understood as a pre-requisite for the exchange of complex knowledge, such as expert knowledge.

The IDEA regulatory framework was developed to identify and balance out various knowledge management moments (interaction, documentation, evolution, adoption) across the working processes of the knowledge worker. The IDEA additionally provides a list of recommendations for knowledge management interventions. An analysis of the knowledge-intensive working processes that takes account of the four IDEA moments can aid in the identification of the causes of possible knowledge problems, to detect potential optimization in order to initiate measures in the areas of technology, organisation and people. Furthermore the regulatory framework can provide assistance to employees in understanding aspects of knowledge management and social software as being interlinked, so as to deliberately push for the exchange of knowledge even as early as during the creation process of the actual content itself.

The regulatory framework is currently being used as the basis for a survey within MMS designed to evaluate the characteristics and intensity of specific knowledge moments. The object of the empirical study is to derive measures for Enterprise 2.0 and to achieve a balance between specific knowledge moments, i.e. between documentation and interaction and between evolution and adoption.

References

- [Argyris, 99] Argyris, C., Schön, D. A.: Die lernende Organisation Grundlagen, Methode, Praxis. Klett-Cotta, Stuttgart, 1999.
- [Back, 08] Back, A., Gronau, N., Tochtermann, K.: Web 2.0 in der Unternehmenspraxis: Grundlagen, Fallstudien und Trends zum Einsatz von Social Software. Oldenbourg, München, 2008.
- [Bullinger, 98] Bullinger, H. J., Warschat, J., Prieto, J., Wörner, K.: Wissensmanagement - Anspruch und Wirklichkeit: Ergebnisse einer Unternehmensstudie in Deutschland. *Information Management & Consulting*, 13, S. 7-23.
- [Gruber, 04] Gruber, H., Harteis, C., Rehl, M.: Wissensmanagement und Expertise. Universität Regensburg, Institut für Pädagogik, Lehrstuhl Prof. Dr. Hans Gruber, Regensburg, 2004.
- [Hartlieb, 00] Hartlieb, E.: Zur Rolle der Wissenslogistik im betrieblichen Wissensmanagement. Dissertation, TU Graz, Graz, 2000.
- [Heidenreich, 02] Heidenreich, M.: Merkmale der Wissensgesellschaft. In (BUND-LÄNDER-KOMMISSION): Lernen in der Wissensgesellschaft. Studienverlag, Innsbruck u.a., 2002.

- [Hippner, 06] Hippner, H.: Bedeutung, Anwendungen und Einsatzpotenziale von Social Software. *HMD – Praxis der Wirtschaftsinformatik*, 252, 6-16.
- [Koch, 08] Koch, M.: Lehren aus der Vergangenheit: Computer-Supported Collaborative Work & Co. In (BUHSE, W. & STAMER, S. H.): *Die Kunst Loszulassen – Enterprise 2.0*. Rhombos Verlag, Berlin, 2008.
- [Koch, 07] Koch, M., Richter, A.: *Enterprise 2.0: Planung, Einführung und erfolgreicher Einsatz von Social Software in Unternehmen*. Oldenbourg, München, 2007.
- [Kumbruck, 03] Kumbruck, C.: Die Tiefendimension des Wissensmanagements: Implizites Wissen und Intuition. *Wirtschaftspsychologie*, 3, S. 50-57.
- [Lindenberg, 01] Lindenberg, S.: Intrinsic Motivation in a New Light. *Kylos*, 54, 317-342.
- [McAfee, 08] McAfee, A. P.: Eine Definition von Enterprise 2.0. In (BUHSE, W. & STAMER, S. H.): *Enterprise 2.0: Die Kunst, loszulassen*. Rhombos Verlag, Berlin, 2008.
- [Nonaka, 97] Nonaka, I., Takeuchi, H.: *Die Organisation des Wissens : wie japanische Unternehmen eine brachliegende Ressource nutzbar machen*. Campus-Verl., Frankfurt/Main u.a., 1997.
- [Picot, 03] Picot, A., Reichwald, W., Rolf, T.: *Die grenzenlose Unternehmung. Information, Organisation und Management*. Gabler, Wiesbaden, 2003.
- [Probst, 97] Probst, G. J. B., Raub, S., Romhardt, K.: *Wissen managen: wie Unternehmen ihre wertvollste Ressource optimal nutzen*. Frankfurter Allgemeine, Zeitung für Deutschland, Gabler, Frankfurt am Main, Wiesbaden, 1997.
- [Schütt, 03] Schütt, P.: Die dritte Generation des Wissensmanagements. *KM-Journal*, 1, 1-7.
- [Schönefeld, 09] Schönefeld, F.: *Praxisleitfaden Enterprise 2.0: Wettbewerbsfähig durch neue Formen der Zusammenarbeit, Kundenbindung und Innovation ; Basiswissen zum erfolgreichen Einsatz von Web 2.0-Technologien*. Hanser, München, 2009.
- [Schreyögg, 03] Schreyögg, G., Geiger, D.: *Kann die Wissensspirale Grundlage des Wissensmanagements sein*. Berlin, 2003.
- [von Rosenstiel, 03] Von Rosenstiel, L.: *Führung durch Motivation. In (KASPER, H. H.): Strategien realisieren – Organisationen mobilisieren*. Linde, Wien, 2003.

Enterprise Microblogging at Siemens, Building Technologies Division: A Descriptive Case Study

Johannes Müller

(Siemens Switzerland Ltd., Building Technologies Division, Zug, Switzerland
j-mueller@siemens.com)

Alexander Stocker

(Know-Center & Joanneum Research, Graz, Austria
astocker@know-center.at)

Abstract: Siemens is well known for ambitious efforts in knowledge management, providing a series of innovative tools and applications within the intranet. *References@BT* is such a web-based application aimed to support globally sharing knowledge, experiences and best-practices within the Building Technologies Division. As a reaction to the demand of employees, a new microblogging service, tightly integrated into *References@BT*, was implemented in March 2009. In this paper, we comprehensively describe motivation, experiences and advantages for the organization in providing an internal microblogging application. Because of the tight integration, we also outline general facts of the knowledge management application.

Keywords: Microblogging, Enterprise Microblogging, Knowledge Management, Knowledge Transfer, Web 2.0, Enterprise 2.0, Social Media

Categories: M.0, M.6

1 Introduction

Web 2.0 [O'Reilly, 2005] has evolved as the new dynamic user-focused web being equipped with social features by default. It has empowered people to become the main creators of web content by providing a wide range of easily applicable social technology: A plethora of popular Web 2.0 platforms like Wikipedia, YouTube, Facebook, MySpace, Twitter, Flickr, Delicious, etc. was built upon such technology and the principle of user-generated content.

Besides the well-known and 'ordinary' weblogs, which are used to express a human voice on the Web [Rosenbloom, 2004], microblogging has become increasingly fascinating especially since early 2008 and was mainly driven by the huge success of the most popular microblogging service *Twitter* (twitter.com). In the context of blogging, the word 'micro' is dedicated to the limited size of such blog posts. *Twitter* for instance allows broadcasted messages to be no longer than 140 characters.

Microblogging enabled a new form of lightweight communication where users share and broadcast very small chunks of information about themselves, their activities, their thoughts, or anything else being interesting for them. Compared to traditional weblogs, *Twitter* offers a slightly different functionality. *Twitter* messages may be public or private (using the 'DM' command), can be republished by anybody (with the 'RT' command), directed to one or more persons (using the '@' symbol), and dedicated to one or more topics (by providing 'hash-tags', the '#' symbol).

Being a relatively new phenomenon, little academic research has been conducted on microblogging in general yet. [Naaman et al, 2010] have explored the characteristics of social activity and patterns of communication by performing an analysis of the content in messages on *Twitter*. They found out that a majority of users is self-focused while a much smaller set of users is driven by sharing information. [Java et al, 2007] studied the topological and geographical properties of *Twitter*'s social network. They have identified different types of user intentions and studied the microblogging community structure to learn how and why people use such services. Recently, microblogging has also been investigated on its possible contribution for the educational/scientific domain facilitating mobile learning [Ebner and Schiefner, 2008], improving technology-enhanced learning [Costa et al, 2008], and supporting social networking in scientific conferences [Ebner and Reinhardt, 2009].

The past has shown that Web 2.0 applications and technologies will find their way into enterprises sooner or later. It is worth to mention that microblogging is capable to offer various benefits for individual knowledge workers and their organization when being deployed in the enterprise [Ehrlich and Shami, 2010]. With regard to the Technology Acceptance Model presented by [Davis, 1989], the 'built in' simplicity of use will indeed have a positive effect on the users' acceptance for these new applications. The limited size of microblog postings would keep the individual information overload on a minimum level and might encourage increased participation compared to other applications. Although we feel that there is still a lack on empirical studies about the concrete adoption of microblogging in the enterprise, some research covering the organizational context has already been published. [Günther et al, 2009] have investigated new constructs including privacy concerns, communication benefits, perceptions regarding signal-to-noise-ratio, as well as codification effort for technology acceptance of microblogging systems in the workplace. [Böhringer and Richter, 2009] have provided insights from an early adopter, implementing an own microblogging system under organizational settings and belong to the first researchers to actively discuss the upcoming topic 'enterprise microblogging'. The case investigated by [Riemer and Richter, 2010] revealed that microblogging in a corporate context can be very different to what is known from Twitter. By applying genre analysis to blog-posts, they found out that the communication is much targeted, providing awareness information for colleagues and coordinating team matters [Riemer et al, 2010].

Encouraged by the huge potential for transfer, sharing and acquisition of personal knowledge and experiences, Siemens Building Technologies Division had decided to implement a microblogging service, tightly integrated in its already existing knowledge management application *References@BT*. This paper explores conceptualization, implementation and utilization of this new service especially discussing the seamless integration of microblogging into the existing knowledge management infrastructure. Thereby microblogging is compared with already existing web-based services within the corporate intranet craving the attention of the knowledge workers.

Our paper is structured as follows: In chapter 2, we discuss the selected research method (i.e. case study research). Chapter 3 covers the Siemens tradition of actively facilitating knowledge management and argues the implementation of the knowledge management infrastructure within the Siemens Building Technologies Division. Chapter 4 outlines the knowledge management application of the Building Technologies Division and discusses the integration of the microblogging service. A detailed

description of the microblogging service can be found in chapter 5. Chapter 6 provides quantitative data on system usage and qualitative data on the system success. Finally, we conclude our paper with chapter 7.

2 Research Design

Our paper is dedicated to research in Enterprise 2.0, exploring the new phenomenon ‘enterprise microblogging’. We investigate a currently established microblogging service within one division of a multinational enterprise tightly integrated in its vital knowledge management infrastructure. Our research scope can be defined as follows: We describe the need for a new service within the organization, elaborate on how enterprise microblogging was selected and launched, and show how it has evolved. Thereby we also discuss the role of the responsible manager and explain how this new service has been perceived and accepted among the employees.

We chose case study research as our preferred research strategy, investigating a single case of enterprise microblogging, providing a comprehensive and descriptive single-case study. According to [Yin, 1984], “a case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident”. As we intend to study foremost the surrounding conditions of the phenomenon, we expect to generate very valuable findings when using case study research. We thoroughly studied different sources, including an investigation of artefacts (References@BT application, microblogging service), a survey of several users and a study of quantitative usage data.

A noteworthy limitation of our findings results from our selected research strategy, as single-case studies provide only limited utility for generalization [Yin, 1984].

3 A Brief History of Knowledge Management at Siemens

Siemens divides its operations in three sectors: Industry, Energy and Healthcare, with 409,000 employees located all around the globe (as of September 2009). Developed products range from simple electronic controls to fully automated factories; from the invention of the dynamo to the world's most efficient gas turbines; and from the first views inside the body to full-body 3D scans. The three sectors generate an annual turn-over of €35.0 bn., €25.8 bn., and €11.9 bn. in 2009, respectively. The cross-sector businesses count for €4.7 bn. of its revenues [Siemens, 2009].

The company values are responsibility, excellence and innovation. To deliver these values, Siemens spends heavily on R&D: €3.9 bn. in fiscal year 2009. Effective September 2009, Siemens had 31,800 R&D employees, 176 R&D locations in over 30 countries, and more than 56,000 active patents.

Siemens is one of the pioneers in exploiting knowledge management (KM) systems. Since the early 1990s, it has responded to deregulation and technology development with a bold way of culture shift towards the development of IT-based (and since 1999 web-based) KM systems [Müller et al, 2004]. In the last 15 years, KM in Siemens has experienced various stages of development, from transferring content (explicit knowledge) to transferring capability (tacit knowledge), as well as acting as

social networking mechanism. This process does not only include the deployment and the provision of KM applications. It also needs the creation of a new way of collaboration – away from the paradigm "knowledge is power" towards a culture of trust and support across geographical, organizational, and hierarchical borders.

The Building Technologies (BT) division is the entity for the former Siemens Building Technologies (SBT) group since January 1st, 2008. SBT was founded on October 1st, 1998 as a result of integrating the former *Elektrowatt* group's industrial sector units into the building technologies activities of *Siemens*. Thus, the competencies of the former companies *Cerberus*, *Landis & Staefa* and *Siemens* were consolidated into one organization. Today, the BT division is headquartered in Zug, Switzerland, and consists of five business units: Building Automation (BAU), Control Products and Systems (CPS), Fire Safety and Security Products (FS), Low Voltage Distribution (LV), and Security Solutions (SES). In September 2009, BT's workforce counted more than 36.000 employees located in many countries around the globe.

Each business unit operates in a highly competitive market environment and sells products, systems, customized solutions and services by a decentralized organization. Because the BT division has been significantly challenged on price by its competitors, several strategic initiatives have been defined and implemented to reach the Siemens business targets. Concerning the growth of sales and profitability, one of the focus areas was to enable the global sales force to learn from successfully implemented projects and solutions. To facilitate this knowledge transfer, the SES management decided to develop a web-based intranet application, which contains solution concepts in order to replicate or re-use them.

4 References@BT – an Overview

Since 2005, References@BT is available as web-based knowledge management platform. As explained above, it was initially planned and developed only for being used within SES, i.e. on business unit level, only. Due to requirements and positive feedbacks coming from other business units, the application's target group was extended from a single business unit towards the whole division within the first year of operation. At a glance, References@BT ...

- is a web platform for the global exchange of business-related knowledge, experiences and best-practices,
- is a social networking tool, which networks colleagues and animates them to communicate to each other,
- is intended for company-internal use and thus only available within the Siemens intranet,
- considers its users as global community (currently approx. 6,800 members located in 72 countries) supporting each other.

Since the early beginning, References@BT was not planned and designed for capturing the complete 'company knowledge' and thus becoming an 'omniscient' tool [Müller, 2007a]. Moreover References@BT aims to network colleagues across geographical, hierarchical, and organizational borders and animates them to communicate to each other [Müller, 2007b]. Bringing the two parties – one is urgently needing and

the other is being able to provide the same piece of knowledge – promptly together is one of the main purposes of References@BT. Therefore it is not essential to provide fully documented contributions released by a central editorial team. Even if the contributions are not coordinated and harmonized and might lack a perfect grammatical style, it is sometimes more important to provide 80% of a certain information immediately than to have 100% of the information several days or weeks later.

References@BT supports all project phases according to the project management process at Siemens BT, i.e. finding reference projects, replicable solutions, similar solutions, experts and services opportunities. It received multifaceted input from project managers, i.e. success stories, information on ongoing projects, finalized projects and services business. In combination with MS SharePoint, References@BT is being integrated in the development process for solution packages allowing international teams easily work together across continents and time zones [Müller et al, 2009].

Besides several features for subscription and social networking (e.g. following each other, providing personal information), References@BT allows its users to publish own contributions and make them quickly and globally available for all colleagues. The usability of Reference@BT is simple and intuitive being a result of many users' requirements by consequent implementation of received user feedbacks.

In References@BT, three different content types allow a user-friendly contribution of knowledge and experiences adapted to the current situation and to the kind and amount of information:

- **Knowledge References** (available since March 2005) are structured information objects containing several data fields of different types. Knowledge references are used for covering customer projects, solution/service concepts, business excellence cases, or 'Lessons Learned'. A set of metadata, which are independent of each other (e.g. discipline, vertical market, country, year of completion, etc.), allow multi-dimensional search queries, e.g.: a list of all "customer projects with access control, executed in financial institutions in Austria and completed in 2006 or later". All possible search queries can be subscribed via e-mail or RSS feeds. Furthermore, any reader can post a so-called 'feedback' to a knowledge reference, which will be immediately displayed below the contribution. A feedback consists of an attribute (the type of feedback), a textual comment and an optional rating displayed with 0 to 5 stars. The respective average rating is displayed at the top of each knowledge reference and within any search result list.
- **Forum Postings** (available since March 2006) are contributions, which are grouped in a topic-oriented way within discussion forums or blackboards. References@BT offers several of such forums for defined technological or functional topics. It is possible to subscribe postings contributed to certain forums via e-mail or RSS feed. Within the special 'Urgent Requests' forum, all users have the opportunity to ask any kind of business-related question. Any new community member has a notification alert automatically set to this special discussion forum.
- **Microblog Postings** (available since March 2009) are short and person-oriented contributions, which are displayed in chronologically reverse order. This content type was especially implemented to stimulate the participation

of the community, as these postings are small in size and thus capable to limit the information overload when discussing project-oriented topics. A detailed description of this content type is given in the following chapter 5.

Ideally, the users of References@BT should be motivated intrinsically. This happens by receiving immediate benefit out of the contribution, by an easy and fun-providing usability, by certain social networking features, etc. To quickly increase the amount of contributions, rewards are given out to a competition within a limited observation period (e.g. four months). During this period, users can collect points, so-called ‘Ref-Coins’, for adding certain contributions, such as responding to urgent requests, responding to discussion groups, writing blog postings, and publishing new knowledge references. The top 10-15 users with the highest ‘RefCoins’ balance are rewarded. The award includes material prizes as well as non-financial measures such as certificates and nominations in company-internal media.

Currently the users participate in References@BT on a purely voluntary basis. To strengthen the knowledge sharing culture, active participation in KM systems and communities could be an integral part of working processes, business target agreements and/or HR-based staff incentive systems in the future.

5 A Detailed Description of the References@BT Microblog

Prior to the implementation of the References@BT Microblog, the following phenomenon was observed: Since end of 2008, several hundred Siemens employees joined a community on *Yammer* (yammer.com), which provides corporate microblogs in the internet and allows closed user groups according to the members’ e-mail domains. This effort showed that there was and still is a strong need for having a microblogging solution for the staff. To avoid publishing and discussing internal content on an externally hosted site, the development of an own microblogging application within the company’s firewall was treated – not only from the perspective of IT security – with high priority.

The References@BT Microblog differs from other well-known microblogging services in various aspects:

- In contrast to *Twitter*, but similar to *Yammer*, microblog postings in References@BT aren’t restricted to 140 characters.
- As it is in *Yammer*, References@BT allows direct replies to any microblog posting and to display the resulting hierarchical structure of nested replies as a so-called ‘topic’, see following figure 1.
- Every initial microblog posting must be mandatorily provided with one or several tags, which (according to a so-called ‘folksonomy’) aren’t predefined and can be arbitrarily chosen. This applies as an option for replies. Since the References@BT Microblog is not limited to any pre-defined conversation topics, these tags allow filtering the whole microblog for similar content by simply clicking on any tag.
- Mentioning other colleagues is possible, but due to a different data format a summarized view of all those mentions (as in *Twitter*) is not supported.

The screenshot displays the Siemens intranet interface for the 'References@BT' microblogging section. The page is titled 'References@BT Microblog Topic' and shows a thread of posts from four authors: Johannes Müller, Andreas Bichel, Ramesh Ramamurthy, and Hans Kessler. Each post includes a profile picture, name, location, and timestamp. The posts discuss a webinar about social computing on SharePoint 2010. The interface includes a search bar, navigation links, and a sidebar with 'Your Alert Settings' and 'Your Microblog Network' sections.

Figure 1: A topic within the References@BT Microblog

By selective ‘following’ of certain colleagues and/or selecting certain tags only, the postings can be easily classified and filtered according to relevant and interesting content by any user. Any selection can be subscribed by e-mail or RSS feed ensuring that only relevant information reaches interested readers.

At the beginning, there have been some fears about negative or useless postings and about intentional abuse, due to the fact that every user (i.e. every Siemens employee with intranet access) is able to write and publish own content. Since anonymous contributions are not possible in References@BT and all contributions clearly show the full name and location of the author, there wasn’t any intentional abuse since References@BT came into being.

Though the microblogging service was tightly integrated into the knowledge management application, a series of actions were taken to raise the awareness amongst the employees. We briefly describe them in the following:

- Soon after implementation of the new microblog section, all registered community members in References@BT have been informed about this new feature and were asked to write own microblog postings. As additional measures

for promoting the microblog, it was offered to place textual comments during a user survey (which resulted in about 150 postings) and to write and share individual Season's Greetings shortly before Christmas (which resulted in about 80 postings).

- Certain postings filtered according to defined tags are dynamically displayed on usual intranet pages, e.g. the latest blog postings related to fire safety are shown on the intranet homepage of the FS business unit. This significantly helps to spread the idea of providing user-generated content and to motivate the intranet users to write own postings spontaneously.
- References@BT allows the import of postings owning a certain hashtag from several microblogging providers (*Twitter*, *Yammer*, *Socialcast*). This has also helped to significantly increase the content quantity without the need of double posting for the contributors.
- One of the success factors is the tight identification of some participants, an identity management feature well known from social networking services [Koch and Richter, 2008]. Displaying the author's image adds a very personal touch to each posting.
- Like in *Twitter* and *Yammer*, References@BT allows to 'follow' other community members, too. Microblog postings of all those colleagues, whom anybody is following, are summarized and sent as e-mail to the follower once a day. A special RSS feed, which contains these postings, is provided as well.

The majority of the References@BT Microblog postings are related to the BT business and to the necessary information around. Many postings contain useful hints, interesting news or web pages, information around fairs or conferences, etc. There are several postings discussing issues around knowledge management and Web 2.0 within Siemens. Postings with pure private content are only rarely posted.

6 System Usage and System Success

Besides providing information on References@BT from the perspective of the manager responsible for operation and development of this application, we provide further sources of evidence on system usage (quantitative data) and system success (qualitative data).

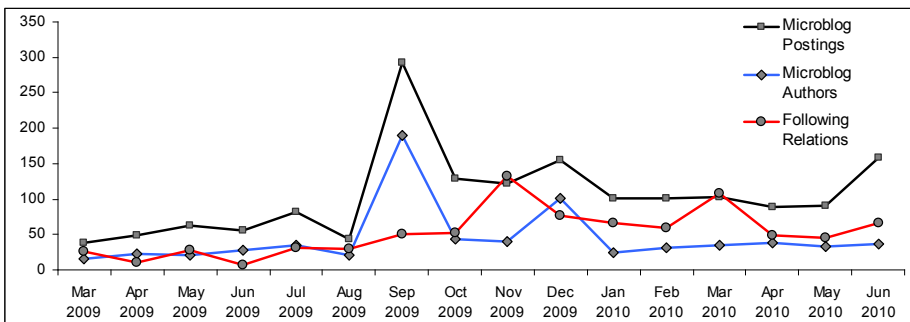


Figure 2: Usage statistics of the References@BT Microblog

Figure 2 presents user statistics, providing insights into the usage of the References@BT microblogging service. The number of new postings has two peaks in September and December 2009. This is a result from the introduction measures described in the previous chapter 5. The fact that the number of new postings remains at a significantly higher level after the first measure in September 2009 can be interpreted as a success.

To learn more qualitative success factors, we surveyed eight frequent users of the References@BT Microblog on success-relevant aspects derived from the Technology Acceptance Model [Davis, 1989] and the Information System Success Model [Delone and McLean, 1992]. The usage of these two popular models enabled us to quickly identify the core aspects for our research: perceived usefulness, ease of use, individual benefits and organizational benefits.

In the following, we present results on employee's perceived usefulness, perceived ease of use, and perceived individual and organizational benefits, asking four questions:

- What are the three main reasons why you use the new microblogging tool in daily business? (*perceived usefulness*)
- What do you particular like when using the tool, what may be improved? (*perceived ease of use*)
- What are your three main benefits gained from using this tool for your work? (*perceived individual benefits*)
- What do you think is the main benefit for an organization when owning such a microblogging tool? (*perceived organizational benefits*)

Perceived usefulness dealt with the easy way of sharing information (5 statements), the additional channel of promoting events (2 statements), new means of networking with others (2 statements), a suitable tool to improve writing skills (2 statements), a possibility to follow experts (1 statement), a way of identifying current trends (1 statement), and the new awareness of latest happenings (1 statement). The following three statements present perceived usefulness:

- "The microblogging tool helps to understand or be aware of the latest happenings in terms of product releases, features, market enhancements, etc. in the BT division. For an employee working in the Industry Sector, it is very much necessary to network with other fellow employees working in other sectors, too. It is also important for them to understand the ongoing changes, projects delivered, business challenges, etc. in other sectors. This will help to benefit in terms of knowledge, understand some of the best practices used in BT, and to network with others."
- "For a technical communicator/technical writer, it is very important to keep in contact with other groups/sectors working in the documentation business and to very well know about the standards/quality procedures used in other sectors. This would help leverage and improve their documentation standards, document quality, document processes, etc. by keeping in line with what is happening across other teams globally. Blog postings on this tool help to bring teams working in a global environment closer together."
- "Blogging, of course helps in terms of improvement towards writing skills. It helps me to keep my writing skills up-to-date. Taking a topic and sharing

views/comments about them definitely leads to gathering collective information. This information collected can further be re-used in the form of best practice or methodology that can be implemented in their respective teams.”

Perceived ease of use dealt with technological aspects which employees like, including grouping of blogs with certain tags, the possibility of adding HTML links to blog posts, the possibility of importing blog posts from externally hosted microblogging services, the possibility of forwarding blog topics or profile pages easing networking in general. However, employees also mentioned possible technical improvements as the following statement outlines:

- “We need to look at Web 2.0 aspects and try to improve this tool to be inclined towards Web 2.0 standards. Since the number of blog entries is increasing, it is good to group all the blogs to their respective blog group name.”

Perceived individual benefits dealt with the assistance of getting the right contacts (5 statements), the assistance of getting the right information (2 statements) and expert knowledge (2 statements), enlarging the personal network (1 statement), learning from followers (1 statement), and gaining an edge on information (1 statement). The following three statements present interesting insights into perceived individual benefits:

- “One of the major benefits was with respect to information regarding BACnet. As our platform was using this protocol, the microblogging tool helped me in getting the right contacts working on this protocol and to receive more information about this protocol that helped me with my documentation work.”
- “I found materials (documents, links) and people I would not have come across as easily through web search or other means of communication.”
- “From the work point of view, this tool has helped me to get information regarding the documentation standards, processes, quality procedures, editing standards used by other teams globally.”

Perceived organizational benefits dealt with the better flow of information caused by the microblogging service (4 statements), the enabling of worldwide networking (4 statements), the caused drive on knowledge management practices and learning (1 statement), reducing overall workload (1 statement), and the diffusion of rich experiences which lead to more innovative thinking and better products (1 statement). The following two statements present interesting insights into perceived organizational benefits:

- “Finding other people in the organization that might have the skills or knowledge you require for a particular problem is often very hard. Microblogging provides the ability to find and exchange knowledge with other people in the organization and thus enables very quickly best-practice sharing and avoids ‘reinventing the wheel’. It also reduces the workload compared to e-mail communication, since I as a user can search the activities that seem worthwhile engaging in instead of sifting through stuff pushed at me, which requires time to scan and judge regarding its usefulness.”

- “This tool will help the organization to drive knowledge management practices, key learning activities and enable networking with teams worldwide. The rich amount of experience possessed by each of the employees should be driven towards innovative thinking. Knowledge sharing activities within the organization help each other and also help the organization to benefit, e.g. while developing new products and solutions. There needs to be a central repository to track such knowledge activities, research activities, and innovations happening within the organization. This tool will help to share these activities leading towards an effective information management approach.”

7 Conclusions and Future Work

Our case study revealed that the new References@BT Microblog was well accepted from the user community right from the beginning. Providing the possibility to publish own content both easily and – what’s sometimes very important in daily business – quickly is an important success factor. For an organization, a frequently used microblog offers the benefit of faster knowledge exchange and better networking of the employees. Furthermore, internal Web 2.0 applications avoid the shift towards external platforms hosted by internet providers.

As more people, so-called ‘digital natives’, who are familiar with Social Media, will move into companies, the challenge “how to generally motivate the staff to participate in Web 2.0” will step-by-step move towards “how to provide Web 2.0 tools, which support our business processes in an optimal way”.

Future research will cover the perspective of microblog deniers. We intend to learn from them about perceived obstacles for using the microblog. Gathering their knowledge and motivation will enable us to continuously improve References@BT.

References

[Böhringer und Richter, 2009] Böhringer, M.; Richter, A.: Adopting Social Software to the Intranet: A Case Study on Enterprise Microblogging. Proceedings of ‘Mensch und Computer’ 2009 (Berlin, Germany, 2009).

[Costa et al, 2008] Costa, C.; Beham, G.; Reinhard, W.; Sillaoits, M.: Microblogging in technology enhanced learning: A use-case inspection of PPE summer school 2008. Proceedings of SIRTEL ‘08, 2nd Workshop on Social Information Retrieval for Technology Enhanced Learning (Maastricht, Netherlands, 2008).

[Davis, 1989] Davis, F. D.: Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340, 1989.

[DeLone and McLean, 1992] DeLone, W.H.; McLean, E.R.: Information Systems Success: The Quest for the Dependent Variable, in: *Information Systems Research* (3:1), pp 60-95, 1992.

[Ebner and Reinhardt, 2009] Ebner, M.; Reinhardt, W.: Social networking in scientific conferences - Twitter as tool for strengthen a scientific community. Proceedings of EC-TEL, Berlin, 2009.

- [Ebner and Schiefner, 2008] Ebner, M.; Schiefner, M.: Microblogging – more than fun? Proceedings of IADIS Mobile Learning Conference, Portugal, 2008.
- [Ehrlich and Shami, 2010] Ehrlich, K.; Shami, N.S.: Microblogging Inside and Outside the Workplace. Association for the Advancement of Artificial Intelligence, 2010.
- [Günther et al, 2009] Günther, O.; Krasnova, H.; Riehle, D.; Schöndienst, V.: Modeling Microblogging Adoption in the Enterprise. Proceedings of 15th Americas Conference of Information Systems (AMCIS), 2009.
- [Java et al, 2007] Java, A.; Song, X.D.; Finin, T.; Tseng, B.: Why We Twitter: Understanding Microblogging Usage and Communities. Proceedings of the Joint 9th WebKDD and 1st SNA-KDD Workshop (San Jose, United States, 2007), pp. 56-65.
- [Koch and Richter, 2008] Koch, M.; Richter, A.: Functions of Social Networking Services. Proceedings of COOP 2008, 8th International Conference on the Design of Cooperative Systems (Carr-la-Rouet, France, 2008).
- [Müller et al, 2004] Müller, J.; Baumann, F.; Manuth, A.; Meinert, R.: Learn and Change Faster by Leveraging and Capitalizing Knowledge in Siemens: The 'Com ShareNet' Case Study. Proceedings of the 'Thailand International Conference on Knowledge Management 2004: KM for Innovation and Change' (Bangkok, Thailand, 2004), pp. 41-49.
- [Müller, 2007a] Müller, J.: Global Exchange of Knowledge and Best-Practices in Siemens Building Technologies with 'References@SBT'. Proceedings of the 2007 International Conference on Knowledge Management (Vienna, Austria 2007), World Scientific, pp. 55-64.
- [Müller, 2007b] Müller, J.: References@SBT – Globaler Wissensaustausch durch 'Social Networking' bei Siemens Building Technologies. Proceedings of KnowTech 2007, 'Mehr Wissen - mehr Erfolg' (Frankfurt am Main, Germany, 2007), pp. 349-357.
- [Müller et al, 2009] Müller, J.; Bietenholz, Y.; Griga, M.; Martin Gallardo, J.; Niessen, T.; Stiphout, P.: Solution Development 2.0 – Provision and Roll-out of Solution Packages with Social Networking. Proceedings of the 5th Conference on Professional Knowledge Management (Solothurn, Switzerland, 2009), pp. 87-96.
- [Naaman et al, 2010] Naaman, M.; Boase, J.; Lai, C.-H.: Is it really about me? Message Content in Social Awareness Streams. Proceedings of CSCW 2010.
- [O'Reilly, 2005] O'Reilly, T.: What is Web 2.0. Design Patterns and Business Models of the Next Generation of Software, 2005. <http://oreilly.com/web2/archive/what-is-web-20.html>
- [Riemer et al, 2010] Riemer, K.; Richter, A.; Seltsikas, P.: Enterprise Microblogging: Procrastination or productive use. Proceedings of AMCIS 2010, 16th Americas Conference on Information Systems (Lima, Peru, 2010).
- [Riemer and Richter, 2010] Riemer, K.; Richter, A.: Tweet Inside: Microblogging in a Corporate Context. Proceedings of 23rd Bled eConference (Bled, Slovenia, 2010).
- [Rosenbloom, 2004] Rosenbloom, A.: The Blogosphere. Communications of the ACM, 17.12, 2004.
- [Siemens, 2009] Siemens Annual Report, 2009.
- [Yin, 1984] Yin, R.: Case study research: design and methods. Sage Publications, 1984.

RDF Data Analysis with Activation Patterns

Peter Teuffl

(IAIK, Graz University of Technology, Graz, Austria
peter.teuffl@iaik.tugraz.at)

Günther Lackner

(studio78.at, Graz, Austria
guenther.lackner@studio78.at)

Abstract: RDF data can be analyzed with various query languages such as SPARQL or SeRQL. Due to their nature these query languages do not support fuzzy queries. In this paper we present a new method that transforms the information presented by subject-relation-object relations within RDF data into *Activation Patterns*. These patterns represent a common model that is the basis for a number of sophisticated analysis methods such as semantic relation analysis, semantic search queries, unsupervised clustering, supervised learning or anomaly detection. In this paper, we explain the *Activation Patterns* concept and apply it to an RDF representation of the well known *CIA World Factbook*.

Key Words: machine learning, knowledge mining, semantic similarity, activation patterns, RDF, fuzzy queries

Categories: M.7

1 Introduction and Related Work

In the semantic web knowledge is presented by the Resource Description Format (RDF), which stores subject-predicate-object triplets (e.g. in XML format). An example for such a triplet would be the fact that Austria (subject) has the Euro (object) as currency (predicate). An RDF data source¹ can therefore describe arbitrary aspects of arbitrary resources and is an example for a semantic network. Since subjects, predicates and objects are identified via unique URIs², various RDF sources can easily be merged. In order to extract information from RDF data, various query languages such as SPARQL [W3C(2008)] or SeRQL [Broekstra and Kampman(2004)] have been developed. In SeRQL the query *"SELECT countries FROM (countries) border (Germany)"* selects all *countries* (subject) that *border* (predicate) *Germany* (object)³. Such query languages allow the retrieval of arbitrary information stored within the RDF data source. However, they do not allow us to find answers for questions like

¹ e.g. simple XML files, databases etc.

² Objects can either be values (e.g. Strings or real values) or refer to other subjects identified by URIs.

³ The employed XML namespaces are not shown in the query.

"How is the literacy rate typically related to the unemployment rate? Retrieve all countries according to their similarity to Austria; Find the typical features for countries that export bananas and retrieve all countries that have similar features but do not export bananas themselves; Group countries according to feature values related to gross domestic product and imported commodities." All of these queries are fuzzy in their nature and query languages such as SPARQL or SeRQL cannot directly be used to find the answers.

Therefore, we present the concept of *Activation Patterns*. The basic idea is to represent knowledge and its relations within a semantic network (RDF data sources are semantic networks). *Activation Patterns* are then generated by activating nodes (subjects) and spreading this activation over the network (through predicates). The *Activation Pattern* is a vector representation of the node activation values within the semantic network. These patterns allow the application of a wide range of fuzzy analysis methods to arbitrary RDF data sources.

The paper gives an introduction on the concept of *Activation Patterns* and shows the possibilities by applying the technique to an RDF representation of the *CIA World Factbook*⁴.

As our work is part of the broad field of semantic searching, a detailed description of related work would go far beyond the scope and space limitation of this article. The general idea of using patterns to search semantic networks is fairly old and has among others been formulated by [Minker(1977)] 30 years ago. In the following years various approaches have been developed and described i.e. by [Crestani(1997)] and [Califf and Mooney(1998)]. Statistical and graph based methods have mainly been in the focus of past research work. The current movement back towards AI based techniques, where our work is aligned with, promises further improvements in performance and reliability as these techniques significantly evolved in the recent years [Halpin(2004)]. Interested readers are requested to refer to general literacy and the following references: [Lamberti et al.(2009)], [Kim et al.(2008)], and [Ding et al.(2005)].

2 Activation Patterns

The following explanation is based on features and relations taken from the *CIA World Factbook*, which will be analyzed in the last section. Assuming we want to learn more about countries (subjects), we need to generate patterns for each country instance. The transformation of these instances into *Activation Patterns* is based on five process layers depicted in Figure 1. After extracting and pre-processing the country features, we apply the four layers L1-L4

⁴ <https://www.cia.gov/library/publications/the-world-factbook/>

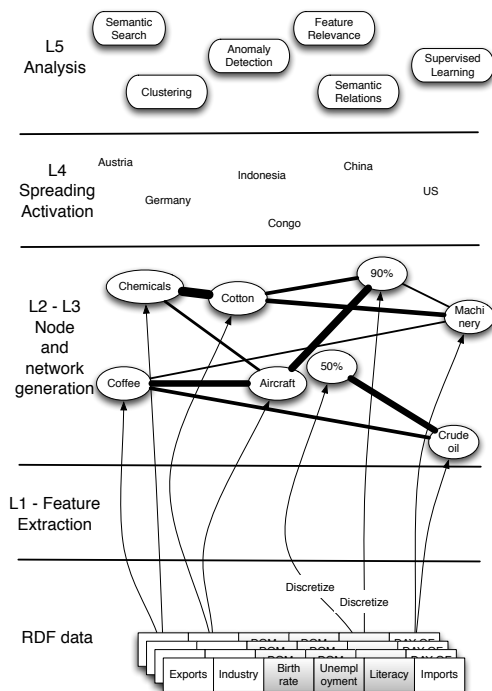


Figure 1: Layers for Activation Pattern generation

to the raw feature data in order to generate the *Activation Patterns*⁵. The techniques within these layers are based on various concepts related to machine learning and artificial intelligence: semantic networks for modeling relations within data [Quillian(1968)], [Fellbaum(1998)], [Tsatsaronis et al.(2007)], spreading activation algorithms (SA) [Crestani(1997)] for extracting knowledge from semantic networks, and supervised/unsupervised learning algorithms to analyze data extracted from the semantic network [Martinetz and Schulten(1991)], [Qin and Suganthan(2004)]. The basic idea is to create a semantic network that stores the feature values and the relations between these feature values (L2-L3). The *Activation Patterns* are then generated by applying spreading activation algorithms (L4) to the semantic network. Such a pattern is the vector representation of all the activation values of the semantic network nodes. The *Activation*

⁵ Since RDF data is already a semantic network, we would not need L1-L3 (or only parts of them) for the pattern generation. However, since our framework is not completely adapted to RDF data yet, we still need these layers for the generation process.

Pattern concept allows us to apply various analysis techniques in L5.

Semantic relations: The analysis of the nodes and the links within the semantic network allows us to gain knowledge about the relations within the given data. For example, by specifying a certain *literacy* value we are able to find how strong the other features such as *unemployment rate* or *gross domestic product* are related.

Semantic search: Such search queries utilize the links (relations) within the semantic network to find concepts related to the search query. For example, by specifying an *export commodity* (e.g. *crude oil*) we are able to retrieve similar countries even if they do not export this *commodity* but are otherwise related.

Unsupervised clustering: By grouping (clustering) semantically related patterns, countries with similar features are assigned to the same category. An example would be the creation of categories that group countries according to similar *export partners*. The number of clusters (or model complexity) influences the grade of detail covered by each category.

Supervised learning: If class labels are available, supervised learning algorithms can directly be applied for the training and classification of *Activation Patterns*.

Feature relevance: The relevance of a node representing a feature value within the network can be determined by the number of connections from this node. Nodes with a high number of connections carry less information than those with fewer connections.

Anomaly detection: By analyzing the activation energies of given instances, anomalies can be detected. In the area of network security this plays an important role for the detection of unknown attacks.

We have also applied the *Activation Patterns* concept to other domains such as event correlation for IDS systems, [Teufl et al.(2010)], e-Participation [Teufl et al.(2009)] and malware analysis.

3 CIA World Factbook RDF analysis

In order to show the benefits of the *Activation Patterns* concept we have analyzed an RDF representation⁶ of the *CIA World Factbook*⁷. Since the features used to describe the countries are well known, this RDF dataset is a perfect choice for demonstrating and evaluating the *Activation Pattern* concept. In this section we extract features for each country by utilizing the SESAME framework⁸ and the SeRQL query language. We then generate *Activation Patterns* for all countries

⁶ http://simile.mit.edu/wiki/Dataset:_CIA_Factbook

⁷ <https://www.cia.gov/library/publications/the-world-factbook/>

⁸ <http://www.openrdf.org/>

and use the patterns for the application of three different analysis methods: semantic relations, semantic search queries and unsupervised clustering⁹.

3.1 Relations between Objects

Table 1 shows examples for extracting information about semantic relations. For each feature we take all nodes and norm their activation values with the maximum value. Therefore the strongest value is always 1.0.

Relation 1 - *"How do the typical values for unemployment rate, literacy and gross domestic product sectors compare between Africa and Europe?"* By activating the node for *Africa*, we are able to extract the feature values that are typical for countries on this continent. The results for *Africa* are shown in column 1 and 2. Countries within *Africa* typically have a high *unemployment rate*, a rather low *literacy* rate and a large part of the work force is within the *agriculture sector*. The most common exports are *coffee* and *cotton*. Columns 3 and 4 show the results for European countries, which are – as expected – rather different.

Relation 2 - *"How do the same values compare for countries that export crude oil vs. countries that export machinery, equipment and chemicals?"* Here we can see that countries of the second category are typically better developed than countries of the first category (e.g. unemployment rate, literacy, services).

3.2 Semantic Aware Search Queries

By comparing *Activation Patterns* with a distance-measure (e.g. cosine similarity) we are able to find patterns that activate similar regions on the semantic network and are therefore related. This enables us to select an existing pattern (e.g. for *Austria*) and search for related countries. Furthermore, we can execute semantic search queries that only select some of the features. In this case we create an *Activation Pattern* for the given features and values and compare this generated pattern with the existing patterns.

In **Query 1** we execute a query that corresponds to *"List all countries according to their similarity with Austria"*: Therefore the *Activation Pattern* for Austria is taken and compared to the patterns of all other countries by utilizing the cosine similarity as distance measure: best matching: Germany, Sweden, Switzerland, Netherlands, worst matching: Sudan, Gaza Strip, West Bank.

In **Query 2** (see Table 2) we want to *"Find the typical features for countries that export crude oil and retrieve all countries that have similar features but do not export crude oil themselves"*: Therefore, we activate the *crude oil* node, generate the *Activation Pattern* and search for similar country patterns. The

⁹ Currently, we use Matlab for all processing steps. However, a more sophisticated Java library is under development.

Relation 1	<i>mapReference: Africa</i>		<i>mapReference: Europe</i>	
unemploy. (%)	24.45 (1.0)	52.87 (0.4)	04.02 (1.0)	12.93 (0.7)
literacyTotal	41.75 (1.0)	59.85 (0.9)	95.92 (1.0)	80.06 (1.0)
grossAgriculture	40.41 (1.0)	14.80 (0.8)	03.68 (1.0)	14.80 (0.2)
grossServices	37.45 (1.0)	48.77 (0.8)	70.37 (1.0)	60.15 (0.8)
grossIndustry	21.24 (1.0)	30.39 (0.7)	30.39 (1.0)	21.24 (0.4)
exports	coffee (1.0)	cotton (0.8)	chemicals (1.0)	machinery and equipment (0.7)
Relation 2	<i>exports: crude oil</i>		<i>exports: machinery, equipment exports: chemicals</i>	
unemploy. (%)	24.45 (1.0)	04.02 (0.2)	04.02 (1.0)	12.93 (0.9)
literacyTotal	80.06 (1.0)	95.92 (1.0)	95.92 (1.0)	80.06 (0.1)
grossAgriculture	03.68 (1.0)	14.80 (0.6)	03.68 (1.0)	14.80 (0.3)
grossServices	48.77 (1.0)	37.45 (0.7)	70.37 (1.0)	60.15 (0.8)
grossIndustry	41.40 (1.0)	53.26 (1.0)	30.39 (1.0)	41.40 (0.3)
exports	crude oil (1.0)	coffee (0.1)	machinery and equipment (1.0)	chemicals (1.0)

Table 1: Relations for given features and values. Only a fraction of available features is shown in the table. For each feature the two strongest values are taken. Due to the employed max-norm the strongest value is always equal to 1.0.

results for the 11 best matching countries are not shown, since they are *crude oil* exporters. They could have been retrieved with simple keyword matching (= *crude oil*). More interesting are the results that contain countries that do not export *crude oil* but are still related to the countries which do (results 12 to 16). Although they do not share the value *crude oil*¹⁰ they have similar industries, export goods and other features. Result 202 (at the end of the list) shows a country that is not typical at all for a *crude oil* exporter – *Germany*.

3.3 Unsupervised Clustering

By applying unsupervised clustering algorithms to the *Activation Patterns* of the country instances, we are able to find groups of similar countries. Depending on the focus of the unsupervised analysis we can filter the *Activation Patterns* according to certain features. In the example given in Table 3 only the features

¹⁰ Kuwait lists *oil and refined products* as export commodity. This commodity is not equal to *crude oil*, since they are represented with different nodes within the network. Still, Kuwait is retrieved due to other semantic similarities.

Query 2	Query for exports:crude oil	
Result	Country	exports
12	Equatorial Guinea	timber, cocoa, petroleum
13	Congo	lumber, cocoa, petroleum
14	Kuwait	fertilizers, oil and refined products
15	Cameroon	lumber, cotton, petroleum products
16	Qatar	petroleum products, fertilizers, steel
202	Germany	chemicals, textiles, foodstuffs

Table 2: Semantic search queries

for the distribution of the gross domestic product are taken (percentage: industry, agriculture, services). For clustering we apply the Robust Growing Neural Gas (RGNG) algorithm [Qin and Suganthan(2004)] to the *Activation Patterns*. By utilizing a simple model complexity we get the three clusters shown in the table. Cluster 1 represents countries with a very small agricultural sector (typically rich countries). In contrast Cluster 3 represents those countries with a rather large agricultural part and small services part (typically poor countries). Cluster 2 is somewhere in the middle between Cluster 1 and 3. The table also shows the typical export commodities for the countries within the clusters, which correspond to the gross domestic product sectors.

4 Conclusions and Future Work

In this paper we demonstrate the benefits of utilizing *Activation Patterns* for the analysis of RDF data. Currently, the RDF data needs to be transformed into another semantic network in order to be compatible with our framework. However, for the future we want to avoid this step, since the RDF data already corresponds to a semantic network and therefore could be directly used for the *Activation Patterns* process. Furthermore, we are currently in the process of creating a *Google Web Toolkit*¹¹ based visualization interface that allows the application of the discussed analysis methods and the visualization of the results.

¹¹ <http://code.google.com/webtoolkit/>

Cluster 1	Feature values
exports	machinery and equipment, chemicals manufactured goods, metals food products
mapReference	Europe (1.0) , North America (0.3), Oceania (0.1)
grossAgriculture	3.68 (1.0)
grossServices	70.37 (1.0), 60.15 (0.5)
grossIndustry	30.39 (1.0)
Cluster 2	Feature values
exports	sugar, coffee, textiles, electricity, chemicals shrimp, lobster, gold, timber
mapReference	Central America and the Caribbean (1.0) Middle East (0.3), South America (0.1)
grossAgriculture	14.80 (1.0)
grossServices	60.15 (1.0), 48.77 (0.7)
grossIndustry	30.39 (1.0)
Cluster 3	Feature values
exports	cotton, coffee, cocoa, timber, diamonds fish, aluminum, gold, livestock
mapReference	Africa (1.0), Southeast Asia (0.3) Asia (0.1)
grossAgriculture	40.41 (1.0)
grossServices	37.45 (1.0)
grossIndustry	21.24 (1.0), 30.39 (0.1)

Table 3: Relations for given features and values

References

- [Broekstra and Kampman(2004)] Broekstra, J., Kampman, A.: “Serql: An rdf query and transformation language”; (2004).
- [Califf and Mooney(1998)] Califf, M. E., Mooney, R. J.: “Relational learning of pattern-match rules for information extraction”; 328–334; 1998.
- [Crestani(1997)] Crestani, F.: “Application of spreading activation techniques in information retrieval”; (1997).
- [Ding et al.(2005)] Ding, L., Finin, T., Joshi, A., Peng, Y., Pan, R., Reddivari, P.: “Search on the semantic web”; Computer; 38 (2005), 62–69.
- [Fellbaum(1998)] Fellbaum, C.: “Wordnet: An electronic lexical database (language, speech, and communication)”; Hardcover (1998).
- [Halpin(2004)] Halpin, H.: “The semantic web: The origins of artificial intelligence redux”; (2004).
- [Kim et al.(2008)] Kim, J.-M., Kwon, S.-H., Park, Y.-T.: “Enhanced search method for ontology classification”; IEEE International Workshop on Semantic Computing and Applications; IEEE Computer Society, 2008.

- [Lamberti et al.(2009)] Lamberti, F., Sanna, A., Demarti, C.: “A relation-based page rank algorithm for semantic web search engines”; *IEEE Transactions on Knowledge and Data Engineering*; 21 (2009), 1, 123–136.
- [Martinetz and Schulten(1991)] Martinetz, T., Schulten, K.: “A ”neural gas” network learns topologies”; T. Kohonen, K. Mäkisara, O. Simula, J. Kangas, eds., *Artificial Neural Networks*; 397–402; Elsevier, Amsterdam, 1991.
- [Minker(1977)] Minker, J.: “Control structure of a pattern-directed search system”; *SIGART Bull.*; (1977), 63, 7–14.
- [Qin and Suganthan(2004)] Qin, A. K., Suganthan, P. N.: “Robust growing neural gas algorithm with application in cluster analysis”; *Neural Netw.*; 17 (2004), 8-9, 1135–1148.
- [Quillian(1968)] Quillian, M. R.: “Semantic memory”; (1968).
- [Teufl et al.(2010)] Teufl, P., Payer, U., Fellner, R.: “Event correlation on the basis of activation patterns”; (2010), 0 – 0.
- [Teufl et al.(2009)] Teufl, P., Payer, U., Parycek, P.: “Automated analysis of e-participation data by utilizing associative networks, spreading activation and unsupervised learning”; (2009), 139–150.
- [Tsatsaronis et al.(2007)] Tsatsaronis, G., Vazirgiannis, M., Androutopoulos, I.: “Word sense disambiguation with spreading activation networks generated from thesauri”; (2007).
- [W3C(2008)] W3C: “SPARQL query language for RDF”; (2008).

A Semantic Matchmaking System For Job Recruitment

Valentina Gatteschi, Fabrizio Lamberti, Andrea Sanna and Claudio Demartini
(Politecnico di Torino, Dip. di Automatica e Informatica, Torino, Italy
valentina.gatteschi, fabrizio.lamberti, andrea.sanna, claudio.demartini
@polito.it)

Abstract: Students and workers mobility in the European scenario represents today a big challenge. During the last years, several initiatives have been carried out to deal with the above picture, being the European Qualification Framework (EQF), a common architecture for describing qualifications, one of the most significant. In parallel, several research activities were established with the aim of exploiting semantic technologies for qualification comparison in the context of human resources acquisition. In this paper, the EQF specifications are applied in a practical scenario to develop a ranking algorithm allowing for qualification comparison on the basis of knowledge, skill and competence concepts, potentially aimed at supporting European employers during the recruitment phases.

Key Words: Semantic Web, Ontologies, Matchmaking

Category: H.4.2, I.2.4

1 Introduction

Nowadays, students mobility across Europe represents a big challenge. In the last years a lot of work has been done for guaranteeing transparency, comparability, transferability and recognition of qualifications and associated learning outcomes (i.e. knowledge, skills and competences) between different countries, in order to overcome the gaps among training systems and with the final aim to develop “a knowledge-based Europe” capable of ensuring a “European labor market open to all”, as it is expected from the Bruges-Copenhagen process.

Viable strategies for achieving the above goals should rely on the exploitation of common rules for the description of qualifications acquired after a training path, or during everyday work. For this reason, on April 23, 2008, the European Parliament and the Council of the European Union defined the eight levels of the novel European Qualification Framework (EQF) instrument [EQF 2008], and identified precisely the semantics, among others, of qualification, learning outcome, knowledge, skill and competence concepts, thus opening the way for the creation of a shared understanding in the life-long learning domain.

However, the definition of a common reference framework is only the beginning of a more complex process: in fact, although the EQF enables to describe qualifications according to a unified format, in order to fully guarantee mobility, other tools have to be developed, e.g. to support students and workers who want to continue their training or working career abroad, or companies who are looking

for workers with specific abilities. It is clearly visible that, in order to be able to work at the European level, the above tools should describe learning outcomes acquired by a given subject according to a standard and syntax-independent formalism. Indeed, ontology-based techniques could play a key role in this step.

Several works presenting interesting applications of semantic technologies to the learning domain already exist in the literature; one of the first examples is represented by the CUBER-project [Pöyry and Puustjärvi 2002], where a system to support learners in looking for European higher education courses that match their needs was developed. The work presented in [Nemirovskij et al. 1999] goes beyond the above solution: in particular, the authors showed a way to implement a semantic search strategy based on the analysis of the relations between concepts belonging to user queries and concepts used in learning documents, and developed a collection of Web services for searching and comparing study programmes. In [Colucci et al. 2007], the authors presented a strategy exploiting Description Logics (DL) [Baader et al. 2002] for annotating curricula based on a given ontology, so as to avoid ambiguities in the description; they also proposed an ontology-based search engine built upon the above description.

While the authors of the above works pointed out the importance of ontological descriptions for overcoming multi-cultural barriers and developed some interesting reasoning rules, the authors of [Pernici et al. 2006] took a step forward in the analysis of qualification semantics, by describing learning outcomes as a combination of knowledge, action verbs and context concepts. In particular, according to [Pernici et al. 2006], a knowledge can be defined as a set of knowledge objects (KO), whereas a skill can be represented as a KO “put into action”, i.e. as one or more pairs KO – Action Verb (AV). Finally, a competence can be identified by means of a triple KO – AV – CX, that describes the ability of putting into action a KO in a specific context (CX). Thanks to this EQF-aware representation, higher-level elements of the transnational framework could be regarded as expressed, from a practical point of view, as a sum of lower-level elements. Moreover, lower-level elements could be decomposed and analysed at an even lower level of details. Finally, KO, AV and CX elements could be organised into an ontology, and suitable inference rules could be created upon them.

In this paper we present an ontology-based matchmaking algorithm for comparing qualifications expressed according to the European specifications. In particular, we propose a ranking method that exploits a semantic comparison technique adapted from the *rankPotential* algorithm in [Di Noia et al. 2004] and integrates a subsumption technique taking into account the EQF formalism and the definition of knowledge, skills and competences given in [Pernici et al. 2006].

The rest of the paper is organised as follows: Section 2 provides some basics of Description Logics, whereas Section 3 illustrates the reference algorithm and discusses its applicability in the considered scenario. Section 4 presents the

modified algorithm, while Section 5 reports on experimental results. Finally, conclusions are drawn in Section 6.

2 Description Logics

Description Logics (DLs) are formalisms for representing knowledge of a given application domain in a structured and formally well-understood way. Basic elements of a DL are *concept* names (such as `movie`, `person`, etc.) that are used for describing real-world objects, and *role* names (such as `hasDirector`, `hasKnowledge`, etc.) that identify binary relations between objects. The *domain of interpretation* of concepts is represented by Δ , and roles denote relations in the subset of $\Delta \times \Delta$.

By using constructors like *disjunction* (\sqcup), *conjunction* (\sqcap) and *complement* (\neg) it is possible to combine concepts whereas, by exploiting *existential quantification* (\exists) and *universal quantification* constructors (\forall), *role restrictions* could be identified. Other constructors are \top and \perp , that identify all the objects in the domain and the empty set, respectively.

By exploiting the DL formalism, it is possible to describe complex concepts such as `Student` $\sqcap \neg$ `Female`, that denotes all the students that are not female. Other examples involving also roles are `Student` $\sqcap \exists$ `hasParent.Professor`, which identifies the students with at least one parent who is a professor, or `Person` $\sqcap \forall$ `hasChild.Male` that denotes persons who have only male children.

Another core element of DLs is the *Terminological Box* (TBox), that represents a set of axioms built by combining concepts through *inclusion* (\sqsupseteq) or *definition* (\sqsubseteq) operators. Consequently, in order to express the fact that, as a matter of example, a given actor could be either the main character or a supporting actor, the following two definitions could be exploited: `actor` \sqsubseteq `maincharacter` \sqcup `supportingactor` and `maincharacter` \sqsubseteq \neg `supportingactor`. It is worth remarking that, since a TBox expresses a set of relations between concepts, it could be used to represent an ontology. As a result, some inference rules could be created in order to identify implicit relations among concepts.

Some reasoning services provided by DLs are:

1. **Satisfiability:** a concept C is satisfiable with respect to a TBox \mathcal{T} if there exists an interpretation \mathcal{I} in which C is mapped into a nonempty space.
2. **Subsumption:** given a TBox \mathcal{T} and two concepts C and D , D subsumes C if it is more general than D in any model of \mathcal{T} ; the subsumption between C and D is expressed as $C \sqsubseteq_{\mathcal{T}} D$ or $\mathcal{T} \models C \sqsubseteq D$.

With the aim of favouring comparability between the proposed ranking strategy and the approach in [Di Noia et al. 2004], in this work we made reference to the CLASSIC system [Borgida et al. 1989], a data model for the description

of the general nature and structure of generic objects. According to the CLASSIC notation, each concept C can be represented through its normal form, that makes reference to a combination of three components, i.e. $D_{names} \sqcap D_{\#} \sqcap D_{all}$, where D_{names} denotes the conjunction of all the concept names belonging to the TBox, $D_{\#}$ is the conjunction of number restrictions related to roles, and D_{all} links all concepts of the form, one for each role $\forall R.D$, where D is in the normal form and hence it guarantees syntax independence.

3 Reference algorithm: context and constraints

In order to clarify the application domain of the comparison strategy presented in this paper, it could be useful to consider the example of a company that is looking for new human resources to recruit. In this scenario, the employer has clearly in mind the “qualities”, expressed as a set of knowledge, skills and competences, the future worker should have, but usually has to inspect in a short time a large amount of profiles in which the above learning outcomes are described in an heterogeneous way, without any shared lexicon.

In this context, the use of ontological descriptions for representing concepts according to a hierarchical structure could ease the work of the employer. As a matter of example, it could be interesting to focus on a company that is looking for a *programmer of dynamic Web pages*: let us assume that the human resources office receives a curriculum, built according to the EQF specifications, and containing as knowledge *ASP* and *PHP*. In this case, a semantic search engine could easily identify the applicant as a possible candidate, because *ASP* and *PHP* concepts are subsumed by the *dynamic Web pages* concept (i.e. *ASP* and *PHP* are more detailed concepts, and the knowledge of *ASP* and *PHP* implies the knowledge of *dynamic web pages*).

Even though the above scenario could hide an easy matchmaking problem, when skills and competences have to be compared in a comprehensive EQF perspective, the problem becomes definitely more complex: in fact, as previously said, these two elements can be regarded as a combination of lower-level concepts, namely KO – AV for skills, and KO – AV – CX for competences. Thus, if the source profile and the target profile differ even for only one lower-level element, they cannot be considered as equal. In order to explain this statement, it could be useful to consider a target skill *to program operating systems*, and a source skill *to use operating systems*: it can be easily seen that the two skills are different, and therefore denote different levels of ability. Moreover, like for the knowledge, also AV (and CX) elements could be organised according to an ontology; hence, in a possible scenario, a source skill *to develop Linux* could be more specific than the given target skill.

Thus, it is clear that a matchmaking algorithm designed for the EQF dimension should have to be developed by taking into account the above con-

straints. The solution proposed in this paper moves from the approach presented in [Di Noia et al. 2004] where, starting from two \mathcal{ALN} concepts C and D both satisfiable in \mathcal{T} , the *rankPotential* algorithm is designed to compute a semantic distance between the above concepts.

However, even though the *rankPotential* algorithm provides interesting results in many application scenarios [Ragone et al. 2005], it is not designed to cope with roles hierarchies and it does not allow to manage relations defined in [Pernici et al. 2006]. For this, we decided to describe AV and CX as concepts (rather than roles), linked by relations such as *hasActionVerb* and *actsOnKnowledge*. Thus, as a matter of example, the skill *to develop Linux* previously considered is no more represented as a pair role-concept *develop.Linux*, but rather as a relation *develop* \sqcap *actsOnKnowledge.Linux*.

Even though, based on the above discussion, it seems that skills and competences can be represented in a suitable way, in the above configuration the *rankPotential* algorithm shows some problems in correctly identifying relations among KO, AV and CX elements.

This could be explained again with an example: let us consider a target skill (i.e. a demand) D defined as *to compile Java and to debug C++ and C \sharp* and two source skills (or supplies), namely $S1$ and $S2$, defined as *to compile Java* and *to debug Java and to compile C++ and C \sharp* , respectively. When *rankPotential*($S1, D$) is computed, the algorithm detects the absence of *debug*, *C++* and *C \sharp* concepts. In a similar way, when *rankPotential*($S2, D$) is computed, the algorithm identifies the presence of *compile* and *debug* concepts, but it does not see the *Java*, *C++* and *C \sharp* concepts. Thus, the two supplies are assigned the same ranking ($n = 3$). Despite this result, it is evident that $S1$ should have a better ranking, as it satisfies – at least in a partial way – the requirements of D . Similarly, $S2$ should be classified as worst, since it does not match with D .

Another example showing that, in some cases, the *rankPotential* algorithm may not produce optimal results is given by the skills *to compile Java and to debug C \sharp* and *to debug C++ and C \sharp* , that will be referred to as $S3$ and $S4$. On the one hand, the distance computed by *rankPotential*($S3, D$) is $n = 1$, since the algorithm identifies the presence of *compile*, *Java*, *debug* and *C \sharp* concepts, but it does not find *C++*. On the other hand, when *rankPotential*($S4, D$) is computed, a distance $n = 2$ is obtained, as only the *debug*, *C++* and *C \sharp* concepts are found (whereas *compile* and *Java* are missed). Despite the ranking provided by the algorithm, a more detailed analysis could show that $S3$ actually lacks the pair *debug* – *C++*, whereas in $S4$ it is the pair *compile* – *Java* that is missing. This means that the two profiles should be considered as equivalent.

It is worth remarking that, even though for sake of simplicity selected examples focused only on skills, all the above considerations also apply to competences.

4 Proposed approach

The proposed *rankPotentialKSC* algorithm computes the semantic distance between two concepts C and D (expressed in normal form) and provides a rank value, that is equal to zero if a concept C is subsumed by a concept D .

Based on the discussion in Section 3, with respect to the *rankPotential* algorithm selected as a reference, when the EQF scenario has to be considered, the designed approach must take into account two main constraints:

- when a skill or competence belonging to a supply S and a demand D are compared, if they differ even only by one element, the rank value should not be a zero;
- if an AV (or a pair CX – AV) is linked (through a role R) to more than one KN element, the ranking is influenced by the number of KN elements the AV is linked to.

Hence, in order to cope with the first constraint, two integer variables d and t have been introduced: d indicates the semantic distance between two learning outcomes, whereas t counts the total number of learning outcomes with a semantic distance equal to zero (hence their composing elements are subsumed by the ones belonging to D). Thus, when $d = 0$, t is increased. This variable allows users to go into more depth during the analysis of the result provided by the algorithm in case of equality between two or more concepts (the highest ranking will be obtained by the concept showing the highest t). Moreover, in order to better characterise the rank value, it could be possible to calculate a percentage value, by dividing t by the total number of combinations.

In order to deal with the second constraint, variables a and r have been introduced: the binary variable a is used to increment the rank value when an AV (or couple CX – AV) is linked to more than one KN element, whereas the variable r is increased each time a *hasActionVerb* or *actsOnKnowledge* role is encountered, and it is exploited for the calculation of the semantic distance.

Finally, p and q variables memorise the semantic distance of the couple CX – AV and the AV element respectively. These results are exploited during the analysis of KN elements, since KN, AV and CX have not to be considered separately.

The *rankPotentialKSC* algorithm is presented below. It is worth observing that the devised methodology allows the system to attach a specific weight to any learning outcome, by adding to n the semantic distance d multiplied by the corresponding weight. In this way, ranked demands could be processed, where different requirements are assigned different levels of importance.

Algorithm *rankPotentialKSC*(C, D)

input: CLASSIC concepts C, D , in normal form, such that $C \sqcap D$ is satisfiable

output: rank $n \geq 0$ of C w.r.t. D , where 0 means $C \sqsubseteq D$ (best ranking)

begin algorithm

let $n := 0, t := 0, r := 0, d := 0, a := 0$ **in**

/ add to d the number of concept names of D which are not among the concept names of C */*

$d := d + |D_{names_+} - C_{names_+}|;$

/ if $a = 1$ add the result of previous call */*

if $a = 1$ **then**

if $|D_{names_+} - C_{names_+}| \neq 0$ **then** $d := d + r - p;$

else if $p \neq 0$ **then** $d := d + r - p + 1;$

$r := 0; q := 0;$

for each concept $\forall R.E \in D_{all}$

/ for each CX or AV, store the result of the current call */*

if $R.E = actsOnKnowledge$ **and** $a = 0$

then $a := 1; r := r + 1; p := |D_{names_+} - C_{names_+}| + q;$

else if $R.E = hasActionVerb$

then $a := 0; r := r + 1; q := |D_{names_+} - C_{names_+}|;$

else $a := 0; r := 0; n := n + d;$

if $d = 0$ **then** $t := t + 1;$

$d := 0;$

*/*for each universal role quantification in C add the result of a recursive call*/*

for each concept $\forall R.E \in D_{all}$

if there exist $\forall R.F \in C_{all}$

then $n := n + rankPotential(F, E);$

else $n := n + rankPotential(\top, E);$

return $n; \mathbf{return} t;$

end algorithm

5 Experimental results

In order to show the effectiveness of the devised solution, a sample demand D and several supplies $S1, S2, S3, S4, S5, S6$ and $S7$ could be considered (Figure 1). Results obtained by applying the *rankPotential* and *rankPotentialKSC* algorithms are reported in Table 1.

It can be easily seen that $S4$ and $S7$ are assigned the worst ranking by both algorithms, because most of their composing elements do not subsume the requirements expressed by D .

On the other hand, $S2$ and $S5$ appear to be promising supplies, as they show a low semantic distance. However, while according to the *rankPotential*

Supply	rankPotentialKSC	rankPotential	t
S1	9	6	2
S2	6	3	3
S3	10	6	2
S4	12	8	0
S5	6	4	4
S6	12	6	0
S7	12	8	0

Table 1: Experimental results on selected demand and supplies

algorithm *S2* obtains the highest ranking since it satisfies half of the requirements of *D* (a knowledge, a skill and a competence), the *rankPotentialKSC* provides the same value of *n* for both *S2* and *S5*. Only a subsequent analysis of the number of learning outcomes matched by the selected supplies (3 for *S2* and 4 for *S5*) could assign to *S5* the highest ranking, since only the competence does not fully match the requirements of *D*, whereas both skills and knowledge satisfy them.

A further case, which shows how considering a whole learning outcome instead of analysing each single element separately could provide better results, is shown by *S6*, for which the two algorithms provide a different ranking: in fact, according to the *rankPotential* algorithm, *S6* should be ranked in third position whereas, based on the *rankPotentialKSC* algorithm, it should obtain the lowest ranking, since no requirement is matched. This result is consistent with the considerations in Section 3, as it demonstrates that a KN, AV and CX should not be considered as separate elements, as each one of them influences the others.

6 Conclusion

In this paper, an adaptation of the *rankPotential* method in [Di Noia et al. 2004] is presented. The reference algorithm has been modified to take into account the EQF specifications. Core EQF elements, such as knowledge, skills and competences, have been characterized by making reference to several sub-elements, like knowledge objects, action verbs and context. The algorithm has been integrated in a Web portal designed to support matchmaking in the European dimension focusing on both the occupational and educational perspectives.

This algorithm can be effectively used in any mobility scenario, as well as in any life-long learning context relying on transparency and readability of qualifications.

DEMAND: (and (all requires (and FULLAUTHONOMY (all hasActionVerb (and CREATE (all actsOnKnowledge (and STATICWEBPAGES DINAMICWEBPAGES)))) CREATE (all actsOnKnowledge (and STATICWEBPAGES DINAMICWEBPAGES)) STATICWEBPAGES DINAMICWEBPAGES)))

SUPPLY1: (and (all requires (and SOMEAUTHONOMY (all hasActionVerb (and PROGRAM (all actsOnKnowledge PHP))) PROGRAM (all actsOnKnowledge PHP) PHP)))

SUPPLY2: (and (all requires (and FULLAUTHONOMY (all hasActionVerb (and PROGRAM (all actsOnKnowledge HTML))) PROGRAM (all actsOnKnowledge HTML) HTML)))

SUPPLY3: (and (all requires (and FULLAUTHONOMY (all hasActionVerb (and DEBUG (all actsOnKnowledge (and HTML PHP))) DEBUG (all actsOnKnowledge (and HTML PHP)) HTML PHP)))

SUPPLY4: (and (all requires (and SOMEAUTHONOMY (all hasActionVerb (and CREATE (all actsOnKnowledge WEBPAGES))) CREATE (all actsOnKnowledge WEBPAGES) WEBPAGES)))

SUPPLY5: (and (all requires (and SOMEAUTHONOMY (all hasActionVerb (and PROGRAM (all actsOnKnowledge (and HTML ASP))) PROGRAM (all actsOnKnowledge (and HTML ASP)) HTML ASP)))

SUPPLY6: (and (all requires (and FULLAUTHONOMY (all hasActionVerb (and PROGRAM (all actsOnKnowledge WEBPAGES))) PROGRAM (all actsOnKnowledge WEBPAGES) WEBPAGES)))

SUPPLY7: (and (all requires (and FULLAUTHONOMY (all hasActionVerb (and DEBUG (all actsOnKnowledge WEBPAGES))) DEBUG (all actsOnKnowledge WEBPAGES) WEBPAGES)))

Figure 1: Normal form for demand and supplies

Acknowledgements

This work was supported by the TIPTOE “Testing and Implementing EQF and ECVET Principles in Trade Organizations and Education” project funded under the Lifelong Learning Programme – Leonardo da Vinci (NL/08/LLP-LdV/TOI/123011).

References

- [Baader et al. 2002] Baader, F., Calvanese, D., Mc Guinness, D., Nardi, D. and Patel-Schneider, P. (eds.): “The Description Logic Handbook”; Cambridge University Press. 2002.
- [Borgida et al. 1989] Borgida, A., Brachman, R., McGuinness, D., Alperin Resnick, L.: “CLASSIC: a structural data model for objects”; Proc. of the 1989 ACM SIGMOD international conference on Management of data, Oregon, (June 1989), 58-67.
- [Colucci et al. 2007] Colucci, S., Di Noia, T., Di Sciascio, E., Donini, F., Ragone, A., Trizio, M.: “Semantic-based Search Engine for Professional Knowledge”; Proc. 7th Int. Conf. on Knowledge Management and Knowledge Technologies (I-KNOW 2007), (Sep 2007), 472-475.
- [Di Noia et al. 2004] Di Noia, T., Di Sciascio, E., Donini, F., Mongiello, M.: “A System for Principled Matchmaking in an Electronic Marketplace”; International Journal of Electronic Commerce, Volume 8, Issue 4, (2004), 9-37.
- [EQF 2008] The European Qualifications Framework for Lifelong Learning (EQF) http://ec.europa.eu/education/lifelong-learning-policy/doc44_en.htm.

- [Nemirovskij et al. 1999] Nemirovskij, G., Bugiel, P. and Heuel, E: “From Semantic Document Annotation to Global Search Facilities for Personalized Study Programmes”; World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, (2007) 1164-1171.
- [Pernici et al. 2006] Pernici, B. Locatelli, P. Marinoni, C.: “The eCCO System: An eCompetence Management Tool Based on Semantic Networks”; Lect. Notes Comp. Sci. 2006, Springer, Berlin.
- [Pöyry and Puustjärvi 2002] Pöyry, P. and Puustjärvi, J.: “The role of metadata in the CUBER system”; 2002 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on Enablement Through Technology, (2002) 172-178.
- [Ragone et al. 2005] Ragone, A., Coppi, S., Di Noia, T., Di Sciascio, E., Donini, F.: “Natural Language Processing for a Semantic Enabled Resource Retrieval Scenario”; 27th Intl. Conf. on Information Technology Interfaces, (2005) 395-401.

Ontology Evaluation Algorithms for Extended Error Taxonomy and their Application on Well-Known Ontologies

Najmul Ikram Qazi

(Mohammad Ali Jinnah University Islamabad Pakistan
najmalikram@yahoo.com)

Muhammad Abdul Qadir

(Mohammad Ali Jinnah University Islamabad Pakistan
aqadir@jinnah.edu.pk)

Abstract: Ontology evaluation is an integral part of the ontology development process. Errors in ontology create serious problems for the information system based on it. To our surprise, the existing systems are unable to identify most of the errors. We evaluate some well known ontologies against the published error taxonomy and describe our algorithms to evaluate ontologies. The target errors include *circulatory errors in class and property hierarchy, common class and property in disjoint decomposition, redundancy of sub class and sub property, redundancy of disjoint relation and disjoint knowledge omission*. For the implementation, ontologies are indexed using a variant of already proposed and published scheme *Ontrel*. In addition to the previous errors taxonomy, the algorithms also cover recently extended error taxonomy. We evaluate our algorithms for performance and report errors detected in well known ontologies including Gene Ontology (GO), WordNet Ontology, OntoSem Ontology.

Keywords: Ontology Evaluation, Ontological Engineering, knowledge Engineering, Knowledge Modelling, Semantic Computing, Information Systems Applications

Categories: M.1, M.2, M.3, H.3, H.4

1 Introduction

As we are moving from traditional Web to the Semantic Web, new technologies are being developed rapidly to facilitate this transition. They include XML [Bray, 00], RDF [Berners-Lee, 01] and Web Ontology Language (OWL) [Antoniou, 04]. Ontology [Antoniou, 04] models a domain of interest. It defines domain concepts, their hierarchies, relationships among them, object and data type properties and many other constructs that enable automated agents to understand and process the information according to the semantics of the domain. The systems built upon the agreed-upon and correct ontology can interoperate in a meaningful way. Therefore, correct ontologies play a key role in describing the semantics of data, which enables globally distributed machines to understand the meaning of data.

Ontology evaluation [Antoniou, 04] is an important part of the ontology development lifecycle. Ontology is evaluated against inconsistency, incompleteness and redundancy problems [Gomez-Perez, 04] before it is put into operation. Errors in

an ontology can be catastrophic for the information system built on it [Qadir, 07]. Ontology error classification is an active research area in the field of Semantic Computing. Researchers have recently identified new types of errors that can harm the information systems [Qadir, 07], [Fahad, 08b]. While developing ontology, designers may declare some thing wrong, miss some thing, or duplicate some thing. Experts need to check the ontology thoroughly to verify that each concept and its relations have been defined correctly and nothing is missing. This is a very difficult task, and without automated tools, one would always be in doubt.

Previously identified errors include circulatory errors in class hierarchy, common class in disjoint decompositions, common instances in disjoint decomposition, external instances in exhaustive decomposition, incomplete concept classification, disjoint knowledge omission between classes, exhaustive knowledge omission, redundancy of sub class relation, redundancy of instance-of relations and identical formal definition of classes/instances.

Extended errors include circulatory errors in property hierarchy, common property in disjoint decompositions, more generalised concept by subclass, domain violation by subclass, disjoint domain by subclass, disjoint knowledge omission between properties, functional and inverse-functional property omission, sufficient knowledge omission, redundancy of sub property, identical formal definition of properties and redundancy of disjoint relation.

2 Related Work

[Gomez-Perez, 04] has proposed a framework for evaluation of ontolingua ontologies on the importance of design principles. She has contributed a number of situations that can exist in design of ontologies where an error occurs. On this basis, she formed error taxonomy for assistance of ontologist. Many other researchers have contributed to that error taxonomy in later years.

[Qadir, 07] and [Fahad, 08b] revised that error taxonomy and included new errors that can be harmful to the information systems. [Fahad, 08a] present the survey on this domain, [Fahad, 08b] present extended error taxonomy for evaluation of ontologies, based on the short papers that extend the individual error classes: semantic inconsistency [Fahad, 07], incompleteness [Qadir, 07], and redundancy [Noshairwan, 07]. Racer, Pallet and Fact++ are commonly used reasoners that come as plug-ins with Protege. Since the extended errors have been discovered only recently, these systems cannot detect such errors [Fahad, 07]. There is an urgent need of algorithms to detect the extended errors.

Researchers have reported that the previously identified errors are only partially handled by existing systems. [Qadir, 07] inspect the existing system capabilities by introducing errors in ontologies. They report that even previous errors are not fully handled by these systems. [Fahad, 08c] also introduce errors in ontologies and inspect the existing systems. Results show that the dangerous circulatory errors make these systems behave abnormally and even crash.

3 Ontology Evaluation Algorithms

In the following, we describe how the algorithms are formulated and discuss the approach used to design and implement them. Algorithms' listing can be found in [Qazi, 10].

3.1 Storage and Organization of Ontology

We have to work out an appropriate scheme for the storage and retrieval of ontologies. Today's ontologies may consist of tens of thousands of concepts. For example, Gene Ontology consists of 29,534 concepts, while Wordnet ontology consists of 61,299 concepts. If an indexing scheme is totally based on RAM, it may not be appropriate for large ontologies. On the other hand, a scheme based on both RAM and persistent storage will not suffer from such limitation. Ontology evaluation algorithms have to access the concepts (and properties) of the ontology very frequently. So the scheme has to provide fast access in order to process ontologies in a reasonable time. We use a variant of OntRel ontology indexing scheme [Khalid 09] for this purpose.

3.2 Circulatory Error in Class Hierarchy

Circulatory error means some hierarchy chain makes a cycle. In a correct ontology, traversing down the hierarchy chain starting from a node **d** will take us to a leaf node, and never lead to **d** again. In an ontology with circulatory errors, such traversal will lead to **d** again and again. This is very dangerous for reasoners because they will stuck in an infinite loop.

This suggests that, to detect circulatory error, we should traverse the nodes of the ontology along the chain of hierarchy. Our algorithm starts from the root(s) node of the ontology and performs depth-first traversal. During this traversal, it maintains a (indexed) list of concepts that form the chain of hierarchy. Concepts should not be repeated in the chain. If they do repeat, it will mean circulatory error. When a new concept is inserted in the chain, it is checked whether it already exists in the chain or not. If it already existed, the circulatory error is reported.

3.3 Common Class in Disjoint Decompositions

This inconsistency error occurs when the designer declares two concepts as disjoint with each other, but later, declares a concept which is subclass of both the disjoint concepts. Our algorithm starts with the pairs of concepts which have been declared disjoint. It inspects each disjoint pair. For each concept of the pair, the algorithm performs depth-first traversal and stores the descendants of the concept in a list. It then takes intersection of the two (indexed) lists, which should be empty in normal case. If the intersection is not empty, the algorithm gives error.

3.4 Redundancy of Subclass

Redundancy of subclass occurs when a concept **c** is declared as direct child of a concept **p**, whereas, it was already indirect child of **p** through a chain of hierarchy. To detect such redundancy, the concepts having more than one parent are significant. Redundancy of sub class will occur when a concept is child of a concept directly as

well as indirectly through some intermediate concepts. This means that such concept will have multiple parents.

3.4.1 Algorithm before optimization

The algorithm uses greedy approach to detect redundancy of subclass. It starts with determining the list of nodes M having more than one parent. It takes first node a having multiple parents. It selects first parent p of a to traverse upwards. Before starting the traversal, all the parent nodes of a other than p are stored in a list L . Then a traversal is performed upwards, starting from the selected parent node p . During this traversal, each visited node is compared with the list L . Since the nodes in L are immediate parents of a , and the traversal is done through the indirect ancestors of a , therefore no match should be found.

When some concept traversed matches with one in the list, it means redundancy. The concept is immediate parent of a since it is in the list, and is indirect parent of a because it is encountered during upward traversal.

Performance Issue: Although this algorithm produces correct results, it has inherent performance problem. Figure 1 depicts a pattern of nodes which represents complexity of some ontologies like Gene Ontology. Node d has several children and each one of them will have further descendants. It has two parents, and each one has in turn two parents. When traversing upwards from a node like d , algorithm writers may not expect that the algorithm will diverge exponentially, whereas in practice, it may do so. To inspect one node below d , the algorithm visits several nodes along its chain of hierarchy. A large portion of this chain will be visited again, when it inspects some other nodes. This repetition, although difficult to avoid completely, causes serious performance problem. We overcome this performance problem by employing another approach to detect redundancy.

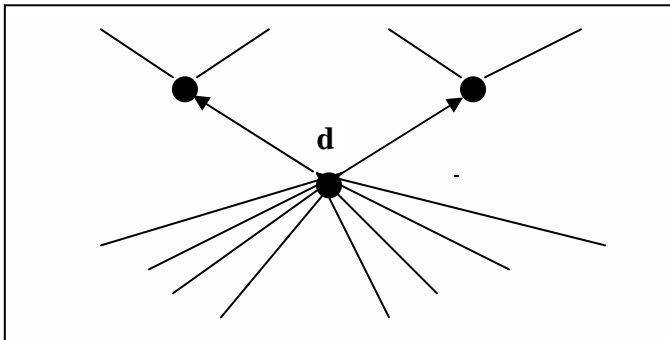


Figure 1: A pattern representing complexity of Gene Ontology

3.4.2 Optimized Algorithm

The optimized algorithm avoids the repeated processing of same nodes. To achieve this, it traverses the ontology in a top-down depth-first manner. When it visits a node, it saves it in a (indexed) list L . When it leaves a node, it deletes it from L . So at any

point, the list contains the chain of hierarchy from root to the current node. When the algorithm visits a node **b**, it also checks its immediate parents **P**. If the node has only one parent, there is no question of redundancy of sub class. If the node has more than one parent, it checks whether any of the parents, other than that in the chain of hierarchy, also exists in the chain. In an ontology free of redundancy, it should not be present in the chain.

If any of the immediate parents also exists in the chain of hierarchy, it means that this node has been declared the parent of **b** twice: once as direct parent and once as indirect parent. So the redundancy error is reported.

3.5 Redundancy of Disjoint Relation

The algorithm to detect redundancy of disjoint relation loops for every disjoint declaration in the ontology. For each pair of concepts (*d1*, *d2*) declared disjoint, it inspects whether their ancestors are also declared mutually disjoint. It takes the first concept of the disjoint pair and visits its ancestors up the hierarchy. For each ancestor visited, it checks whether there is some disjoint declaration for it. If there is a disjoint declaration, it notes the disjoint concept. Then it checks whether this disjoint concept is among the ancestors of *d2*. If so, the redundancy is reported.

3.6 Disjoint Knowledge Omission

Ontology designers may omit disjoint declaration between concepts which are actually disjoint in the domain. It is strongly recommended that if the two concepts are disjoint in the domain, they should be declared so to help in better reasoning.

The algorithm, in the start, initializes a (indexed) list of all disjoint declarations in the ontology. The algorithm has to repeat for every pair of sister concepts in the ontology. This is quite expensive due to the large number of possible combinations of sister concepts. One solution for this is to prioritize the search. Inspecting the nodes higher in the hierarchy has more chances of finding the disjoint knowledge omission cases.

If two sister concepts are not declared disjoint, the algorithm checks if there are common concepts among the children of the two concepts. It visits the nodes down the hierarchy of the first node, and prepares a (indexed) list of these nodes. It does the same for the second node, and makes the second list. It then takes intersection of the two lists. If the intersection is empty, then the algorithm considers the two concepts as the candidates for disjoint knowledge omission. It stores the two concepts in a list, along with the number of descendants. When the list is presented to human expert, the number of descendants is helpful in ranking. The candidate cases which have higher number of descendants have more chances to be endorsed by human expert as the real disjoint omission case.

3.7 Errors Detected in Well Known Ontologies

The algorithms were applied to evaluate three well known ontologies: OntoSem, WordNet and Gene Ontology (GO). We detected 3 circulatory errors and 2 redundancy of sub class errors in WordNet ontology. Figure 2 lists circulatory errors and Figure 3 lists redundancy of sub class in WordNet ontology.

1. region *is-a* location *is-a* space-region *is-a* physical-region *is-a* region
2. method *is-a* know-how *is-a* ability_power *is-a* technique *is-a* method
3. gestalt *is-a* form_shape_pattern *is-a* gestalt

Figure 2: Three circulatory errors in WordNet Ontology

Parent: geographical-object
Child: GEOGRAPHIC_POINT_GEOGRAPHICAL_POINT
Redundant Hierarchy: geographical-object**region **physical-region
 space-regionLOCATION**POINT_6
 **GEOGRAPHIC_POINT_GEOGRAPHICAL_POINT
Parent: agent-driven-role
Child: status
Redundant Hierarchy: **agent-driven-role**ROLE **social-role**status

Figure 3: Redundancy of sub class in WordNet Ontology

We found 10 redundancy of sub class errors in OntoSem (Figure 4), while Gene Ontology was found free of these errors. Disjoint knowledge omission requires verification by human expert. We have found and ranked hundreds of candidate cases of disjoint knowledge omission in each of the three ontologies, and after inspection by human experts, useful results are expected. Figure 5 shows candidate cases of disjoint knowledge omission in WordNet Ontology. The ranking mechanism helps us find real cases where disjoint declaration is omitted. For example, **AutoPilot** should be declared disjoint with **living_thing**. Initial inspection of the similar cases from Gene Ontology (Figure 6) shows that even more useful results will come out.

Parent: independent-device, **Child:** buzzer
Redundant Hierarchy: *** independent-device*** communication-device*** buzzer
Parent: non-work-activity, **Child:** dance
Redundant Hierarchy: *** non-work-activity*** hobby-activity*** artistic-activity*** dance
Parent: artifact-part, **Child:** handle
Redundant Hierarchy: *** artifact-part*** furniture-part*** handle
Parent: printed-media, **Child:** illustration
Redundant Hierarchy: *** printed-media*** picture*** illustration

Figure 4: Four out of 10 redundancy of subclass errors in OntoSem ontology

Concept1	Concept2	Children
LIFE_FORM_ORGANISM_BEING_LIVING_THING	MACHINE_1	9235
AUTOPILOT_AUTOMATIC_PILOT	LIFE_FORM_ORGANISM_BEING_LIVING_THING	9023
ARTIFACT_ARTEFACT	NATURAL_OBJECT	7409
DIVISION_8	TAXONOMIC_GROUP_TAXON	5440
PLANT_FLORA_PLANT_LIFE	PROKARYOTE_PROKARYOTE	4767
SPOROPHYTE	VASCULAR_PLANT_TRACHEOPHYTE	4380
accomplishment	FLASH_2	4107
action	communication-event	4097
activity	voicing	4094
ACT_HUMAN_ACTION_HUMAN_ACTIVITY	SHOW_2	4078
ANIMAL_ANIMATE_BEING_BEAST_BRUTE_CRI	HOST_1	3984
GENUS_2	SUBCLASS	3613

Figure 5: Candidate cases of disjoint knowledge omission in WordNet Ontology

Concept1	Label1	Concept2	Label2	Children
GO_0044236	multicellular organismal metabolism	GO_0044237	GOC:mah	29153
GO_0044091	GOC:jl	GO_0044237	GOC:mah	29122
GO_0019222	regulation of metabolism	GO_0031341	GOC:mah	28922
GO_0044238	primary metabolism	GO_0045730	Wikipedia:Respiratory_burst	14579
GO_0043112	receptor metabolism	GO_0043283	biopolymer metabolism	7936
GO_0003824	Wikipedia:Enzyme	GO_0005198	GOC:mah	7827
GO_0030155	cell adhesion receptor regulator activity	GO_0031323	regulation of cellular metabolism	7727
GO_0048583	GOC:jic	GO_0050792	GOC:tb	6400
GO_0060255	GOC:tb	GO_0060263	GOC:tb	5594
GO_0050792	GOC:tb	GO_0050793	GOC:go_curators	4748
GO_0005198	GOC:mah	GO_0005215	Reactome:1391	4722
GO_0060263	GOC:tb	GO_0080090	PMID:19211694	4296

Figure 6: Candidate cases of disjoint knowledge omission in Gene Ontology

3.8 Evaluation of Algorithms

Table 7 shows the number of errors detected and (time taken in minutes) by some of our algorithms to process three well known ontologies. To our surprise, redundancy of sub class algorithm took 420 minutes on Gene Ontology containing 29,534 concepts. This is drastically high as compared to 2.5 minutes on WordNet ontology containing 61,299 concepts. An analysis of Gene Ontology shows complex graph structure of this ontology where many concepts have multiple parents. When the algorithm scans ancestors of a node, the scan diverges in exponential manner, thus incurring high computational cost. The revised algorithm outperforms normal algorithm in Gene Ontology, but not in other ones, where normal algorithm proves more efficient.

Error	OntoSem	WordNet	Gene Ontology
Circulatory error in class hierarchy	0 (0.7)	3 (1.8)	0 (10)
Common class in disjoint decompositions and partitions	0 (0)	0 (27)	0 (3.5)
Redundancy of Subclass-of relation	10 (0.7)	2 (2.5)	0 (420)
Redundancy of Subclass (revised)	10 (15)	2 (18)	0 (23)
Disjoint Knowledge Omission (warnings)	404(7)	2582(55)	2008 (65)

Table 7: Errors detected (time taken in minutes) in 3 well known ontologies

4 Conclusions

The algorithms to evaluate ontologies against published error types are designed and implemented. The algorithms are tuned for optimum performance, and are able to process large ontologies in reasonable time. The algorithms do not require to load the entire ontology in memory, and therefore do not put limit on the size of ontology being processed. Various errors have been detected in well known ontologies: Gene Ontology, Wordnet Ontology and OntoSem Ontology. The algorithms will be useful for researchers working in Semantic Computing.

5 Future Work

The algorithms may be used to evaluate more ontologies to improve their accuracy. The errors may be verified by human experts. Algorithms may be further tested for correctness and performance.

References

- [Antoniou, 04] Antoniou, G. and Harmelen, F.V., (2004): A Semantic Web Primer. MIT Press Cambridge, ISBN 0-262-01210-3
- [Berners-Lee, 01] T. Berners-Lee, J. Hendler, and O. Lasila: The Semantic Web. Scientific American 284, May 2001, 34-43.
- [Bray, 00] T. Bray, J. Paoli, C.M. Sperberg-McQueen, E. Maler, eds: Extensible Markup Language (XML) 1.0, 2nd ed, W3C Recommendation, October 6, 2000, <http://www.w3.org/TR/REC-xml>.
- [Corcho, 05] Corcho et al., (2005): A survey on ontology tools. Technical report no. D 1.3
- [Denny, 04] Denny, M., (2004): Ontology Editor Survey Results. Technical report.
- [Fahad, 07] Fahad, M., Qadir, M.A., and Noshairwan, W., (2007): Semantic Inconsistency Errors in Ontologies. Proc. of Intl Conf. on Granular Computing, Silicon Valley, USA, IEEE.

- [Fahad, 08] Fahad, M. (2008): Ontology Evaluation, Mapping and Merging. M.S Thesis, Muhammad Ali Jinnah University Islamabad.
- [Fahad, 08a]Fahad, M., Qadir, M. A., Noshairwan, M. W., (June 2008): Ontological Errors: Consistency, Incompleteness and Redundancy. Proceedings of 10th International Conference on Enterprise Information Systems (ICEIS'08). Barcelona, Spain.
- [Fahad, 08b]Fahad, M., and Qadir, M.A., (July 2008): A Framework for Ontology Evaluation. Proceeding of 16th International Conference on Conceptual Structures (ICCS'08), Toulouse, France. Vol-354, pages 149-158.
- [Fahad, 08c]Fahad, M., Qadir, M.A., and HussainShah, S.A., (Oct 2008c): Evaluation of Ontologies and DL Reasoners. Proceeding of 5th International Conference on Intelligent Information Processing (iip'08) Oct 2008. Beijing China.
- [Gomez-Perez, 94] Gomez-Perez, A., (1994): Some ideas and examples to evaluate ontologies. Knowledge Systems Laboratory, Stanford University.
- [Gomez-Perez, 99] Gomez-Perez et al., (1999): Evaluation of Taxonomic Knowledge on Ontologies and Knowledge-Based Systems. International Workshop on Knowledge Acquisition, Modeling and Management.
- [Gomez-Perez, 04] Gomez-Perez, A., Fernández-López, M., Corcho, O., (2004): Ontological engineering: With examples from the Areas of Knowledge Management, E-Commerce and the Semantic Web. Springer, London.
- [Khalid, 09] Khalid A., Shah S.A.H., Qadir M.A., (2009): OntRel: An Ontology Indexer to Store OWL-DL Ontologies and Its Instances. International Conference of Soft Computing and Pattern Recognition Malacca, Malaysia.
- [Noshairwan, 07] Noshairwan, W., Qadir, M.A., Fahad, M. 2007: Sufficient Knowledge Omission error and Redundant Disjoint Relation in Ontology, InProc. 5th Atlantic Web Intelligence Conference June 25-27, 2007 - Fontainebleau, France.
- [Qadir, 07] Qadir M.A., Noshairwan W., (2007): Warnings for Disjoint Knowledge Omission in Ontologies. 2nd International Conference on Internet and Web Applications and Services (ICIW 07).
- [Qazi, 10] Qazi N.I., Qadir, M.A. (2010): Algorithms to Evaluate Ontologies Based on Extended Error Taxonomy. International Conference on Information and Emerging Technologies (ICIET 10).

A Semantic Approach for Classification of Web Ontologies

Muhammad Fahad¹, Nejb Moalla¹, Abdelaziz Bouras¹

(¹University of Lumière Lyon2, Bron, France
CERRAL/LIESP, IUT Lumière,
firstname.lastname@univ-lyon2.fr)

Muhammad Abdul Qadir², Muhammad Farukh¹

(²Mohammad Ali Jinnah University, Islamabad, Pakistan
aqadir@jinnah.edu.pk, mhd.farukh@gmail.com)

Abstract: Semantic web provides virtual communities that enable intelligent interaction between software agents and people due to availability of standard open ontologies. But, as the semantic web is gaining much popularity, there is a massive growth seen in the ontology development which poses new research challenges such as ontology classification, ranking, searching, retrieval, etc. This results many recent developments, like *OntoKhoj*, *Swoogle*, *OntoSearch*, that facilitate user for such tasks. These semantic web portals mainly treat ontologies as plain texts and use traditional classification algorithms of plain text for classifying ontologies in directories and assigning predefined labels rather than using semantic knowledge hidden within the ontologies. These approaches suffer with many types of classification problems and lack of accuracy, especially in the case of overlapping ontologies that share common vocabularies. In this paper, we define ontology classification problem and categorized it into many sub-problems. We present a new methodology for ontology classification that is based on ontology approach for ontology classification and retrieval. The proposed framework, *ONTCLASSIFIRE*, benefit construction, maintenance or expansion of ontologies directories on the semantic web, and helps in ontology management and retrieval for software agents and people. We conclude that the use of context specific knowledge hidden in ontologies gives more accurate results of ontology classification and retrieval.

Keywords: Ontology classification and retrieval, Semantic matching and searching, Web page Classification, Semantic web portals

Categories: H.3.2, H.3.3, H.3.7, M.3, M.7

1 Introduction

Semantic web provides virtual communities that enable knowledge extraction and usage to software agents and people for knowledge sharing [Patel, 03]. It uses the notion of ontologies for the conceptualization and elicitation of the domain knowledge, and stores knowledge in terms of concepts and properties in a machine understandable and processable manner. Due to their capacities of decidability and expressiveness, ontologies have played a fundamental role for describing semantics of data not only in the emerging semantic web but also in traditional knowledge engineering, and act as a backbone in knowledge-base and semantic-based information processing systems. Information storage, processing, retrieval, decision

making, etc., by such systems are done on the basis of ontologies. But, as the number of ontologies being developed and maintained over the web is increasing day-by-day which demands various new techniques for ontology storage, classification, ranking, search and retrieval. Same as current web, searching the relevant knowledge is one of the main problems for the emerging semantic web and knowledge management business applications, too. This requires proper classification of the web ontologies that is essential to many tasks such as development of ontologies directories on web [Dmoz, 07], focused crawling for ontology retrieval [Ehrig, 05], concept specific modular ontology analysis [Seidenberg, 06], improving quality of search [Pan, 06].

Classification is traditionally defined as a supervised learning problem in which a set of labelled data is used to train a classifier that can be used to label future examples [Mitchell, 97]. Ontology classification is a challenging problem for efficient and effective ontology management and retrieval for the semantic web and enterprise ontology based business applications. Prior to Ontology classification, much work has been done for web page classification that aims at assigning a web page to one or more predefined category labels [Chakrabarti, 02]. The current web is a heterogeneous infrastructure containing unstructured or semi-structured data of various types. This opens up other number of classification research problems like web site classification [Peng, 02; Glover, 02], blog classification [Qu, 06], image classification [Bosch, 07], semantic web page classification, etc. Semantic web page classification again opens up many research challenges for semantic web community, like ontology classification, RDF repository classification, etc. Multiple ontologies associated with a same domain/concept appear to be quite common so it is of immense importance to classify them into respective domain hierarchies. In recent years, many semantic web portals such as OntoKhoj, Swoogle, OntoSearch are developed to facilitate ontology searching, ranking and classification. But, these existing approaches exploit keywords, phrases and terms about ontologies rather than the semantic knowledge hidden within the structure of ontologies for their classification. The consequence is that the semantic of information knowledge is not understandable by machine and become a bottleneck in the process of ontology searching and retrieval on the Web. This requires new approaches for ontology classification based on structural knowledge and semantics to meet the requirements and core challenges for current landscape of ontology based research. Thus our main idea behind this work is to replace the plain text classification algorithm in the process of ontology classification with ontology specific classification algorithm. The proposed approach uses category ontology rather than bag-of-words for classification of arbitrary ontology by analysing structure of knowledge hidden in ontologies.

Rest of the paper is organized as follows. We discuss the current approaches for ontology classification, searching, and retrieval in section 2. We define the ontology classification problem and categorize it into sub problems in section 3. Following, we discuss ontology classification mechanism that fulfills the demands of ontology classification for enterprise business applications and upcoming semantic web. We elaborated the methodology of ontology classification that is exploited by our ONTOLOGY CLASSIFICATION and RETRIEVAL (*ONTCLASSIFIRE*) component in section 4. The same section presents our preliminary experiment results of ontology classification and usage of our *ONTCLASSIFIRE* in several tasks. Finally, section 5 concludes the paper and shows future directions.

2 Related Work

There are many applications that make use of ontologies for the classification of web documents, emails, text categorization and many other tasks for knowledge management and retrieval. In this regard, Grobelnik and Mladenic (2005) report a simple approach exploiting content of the document to be classified and information on the web page context which is obtained from the link structure of the Web for classification of Web documents into large topic ontology. For classification of emails, Taghva et al. (2003) propose ontology-based system that makes an ontology that later on applies rules for identification of features to be used for classification of emails. From the training set of emails, associated probabilities for features are calculated and used as a part of the feature vectors for an underlying Bayesian classifier. For ontology-based text categorization, Wu et al. (2003) describe a methodology in which the domain ontologies are automatically acquired through morphological rules and statistical methods. The role of ontologies is magical in classifying objects in various enterprise applications, and improving the quality of search, but ontology classification itself is also a problem which should be addressed in a semantic way for its own efficient management and retrieval for emerging semantic web. With the passage of time semantic web is gaining much popularity and hence there is a significant growth seen in the ontology development and reuse. This increases the demands for searching of the relevant domain ontologies over the web. Ontologies, especially those developed in Web Ontology Language (OWL), are significantly complex data structures than mere traditional web pages, as OWL builds up several levels of complexity on top of the XML of conventional web data. Moreover by defining terms on similar or the same concepts, often these ontologies overlap with each other. For example, as mentioned in one of the research studies for the development of semantic web portal, *Swoogle*, searches over 300 distinct terms that appear to stand for the only 'Person' concept [Ding, 05]. It is likely that large and complex ontologies will require a novel solution and a central index of ontologies for fulfillment of sound semantic web vision.

One of the semantic web portals that facilitates ontology searching and classification is Ontokhoj that allows engineers and software agents to retrieve trustworthy ontologies, and expedite the process of ontology engineering through extensive reuse of ontologies [Patel, 03; Supekar, 03]. It exploits and extends the strategy of ranking based on citations as used by Google PageRank, and uses semantic web crawling technique to search and retrieve ontologies. It treats ontology as plain text and uses text classification algorithms for ontology classification, which is the biggest drawback for ontology classification especially for overlapping ontologies because plain text classification algorithms only use keywords that results in poor performance and hence classifier's accuracy compromises. Another semantic web search engine is *Swoogle* that is based on metadata engine and retrieval system for the semantic web [Ding, 05]. It makes use of multiple crawlers to find semantic web documents and ontologies by meta-search. It also does not use ontology context specific search for finding ontologies. *Ontosearch2* is another ontology search engine developed to address the problem of finding ontologies appropriate for desired domains [Pan, 06]. It makes use of the semantic entailments for searching rather than only using keywords or metadata like *SWOOGLE* and *Ontokhoj*. It also provides

restricted query interface by keyword search only, and for ranking they use the citations to an ontology or links to an object within the Abox (assertional box) of ontology. It provides Tbox (terminological box) searching facility, Abox searching mechanism and other search directives by allowing these restrictions on the search query, and performs the search on the desired portion. Ontolingua is another important contribution that facilitates us a distributed collaborative environment to browse, edit, create, modify and use ontologies [Ontolingua, 10]. It requires user to first gets registered and then perform the desired piece of work.

Most of the web portals do not address the problem of ontology classification or treat ontologies (having complex structure and semantics) as plain texts. Therefore, these portals use traditional classification algorithms of plain text classification for classifying ontologies in directories assigning predefined labels. This is the main reason due to which they suffer with many types of classification problems and lack of accuracy in ontology searching and retrieval, especially in the case of overlapping ontologies. For example, classifying *EE Department* ontology in *Electrical Engineering* domain or *Electronic Engineering* or *University* domain requires ontology specific keen algorithms and in depth knowledge analysis (structure and semantics) rather than simple text classification algorithm. As the number of online ontologies is growing significantly, and multiple ontologies associated with a same domain/concept appear to be quite common so it is of immense importance to classify the ontologies into respective domain hierarchies. It helps humans and web agents to find the correct and desired ontology (or concept) on the web and supports ontology engineering processes.

In order to meet the real challenge of ontology searching and retrieval, we build ontology based approach for ontology classification that facilitates other tasks. We believe that once ontologies are classified properly, then they are searched in sound semantic manner in ontology based applications and on semantic web. For building, *ONTCLASSIFIRE*, we benefit of our existing approach for ontology matching and merging [Fahad, 07] with several modifications. Ontology based approach works better for overlapping ontologies that comes across due to the semantic heterogeneity and knowledge structure requirement during modeling the domain. Due to the use of more semantic and structural knowledge with in the ontologies, our approach of *ONTCLASSIFIRE* enhances the accuracy of ontology classification.

3 Ontology Classification Problem

Ontologies, especially that are developed in OWL, are more than texts, and contain a lot of structural and context information in terms of concepts, e.g., classes, datatype properties, object properties, parent-child relationships, description logic (DL) axioms, etc. Therefore, plain text classification algorithms that benefit the web page classification are not much useful for ontology classification and searching on the semantic web. Hence, few recent developments are seen in literature for meeting the current challenges of semantic web. However, very little work has been done specifically for ontology classification, so in this section we define specific terms of ontology classification for promoting understandability based on terminology used in web page classification. The general problem of ontology classification can be divided into more specific problems depending upon the number of classes in the

problem of interest, domain knowledge modeled in ontologies, and number of classes that can be assigned to ontology instance as shown in Figure 1. Various ontology classification sub-problems are defined as follows.

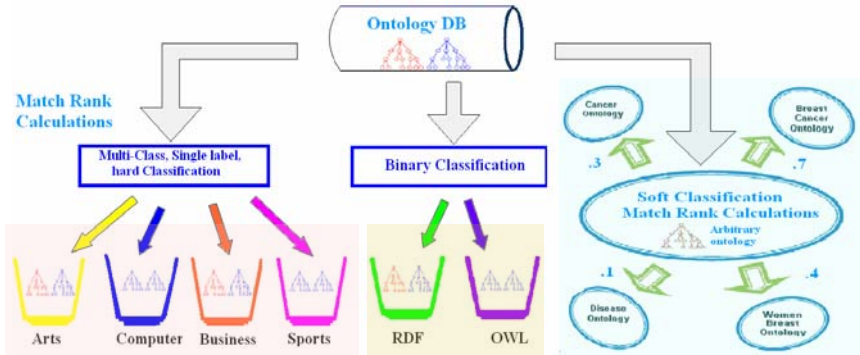


Figure 1: Examples of Ontology Classification

1. Based on the number of classes in the problem, classification can be divided into binary, ternary, or multiclass ontology classification. Binary ontology classification categorizes instance ontologies into exactly one of two classes. An example of binary ontology classification can be taken as determining the type of ontologies whether they are hierarchical ontologies (i.e. basic RDF ontologies) or expressive ontologies having DL axioms (i.e. OWL ontologies). Multiclass ontology classification associates instance ontologies with more than two classes or categories.
2. Based on the domain knowledge modeled in ontologies, classification can be divided into subject, functional and sentimental ontology classification. Subject ontology classification categorizes ontologies depending on what is the domain and topic of ontologies, e.g., art, disease, business, sports, etc. Functional ontology classification determines the role that the ontology plays, e.g., admission ontology, personal home page ontology, patient examination ontology, etc. Sentimental ontology classification determines the messages or opinion that is presented in ontologies, e.g., message between business processes or stock exchange conditions, interaction between multi-vendor semantic systems, author's attitude in blog ontology, etc.
3. Based on the type of class assignment, classification can be divided into hard or soft ontology classification. Hard ontology classification determines whether an instance can either be or not be in a particular class. In soft ontology classification, an instance can be predicted to be in some class with some likelihood and often a probability distribution across all classes.
4. Based on the organization of categories, ontology classification can be taken as flat classification scheme or hierarchical classification. In flat ontology classification, categories are considered parallel. Hierarchical ontology classification deals with the categories that are organized in a hierarchical tree-like structure, in which each category may have a number of subcategories.

5. Based on the number of classes that can be assigned to instance ontology, classification can be divided into single-label and multi-label ontology classification. Former strategy deals with assigning one and only one class label to each instance ontology, but the later deals with assigning more than one class to instance ontology.

4 ONTCLASSIFIRE – A Semantic based Ontology Classifire

This section presents our semantic based ontology classifier, *ONTCLASSIFIRE*, and discusses the semantic similarity computation for ontology classification between the domain ontology and the arbitrary ontology. It aims at classifying ontologies in one or more predefined categories for efficient ontology management and search. For each predefined category, we assume there is a representative domain ontology rather than bag of words which is used for classification purpose. *ONTCLASSIFIRE* matches domain ontology with the arbitrary ontologies and calculates the match rank. As domain Ontologies are specific to a particular domain and henceforth captures most of the common terminologies for that domain, and hence require soft classification mechanisms for their classification. To meet the needs, we adopted a soft classification approach that is very much helpful in case of overlapping ontologies where instance ontology is predicted to be in some class with some likelihood with a probability distribution across all classes. For example, assume there are only four predefined categories, it specifies $MatchRank\{thesis_ontology, 0.2\}$, $(journal_ontology, 0.3)$, $(ScientificMag_ontology, 0.38)$, $(ConferenceProceeding_ontology, 0.87)\}$ as Match Rank for multi-class soft ontology classification of an arbitrary instance ontology O_a across all domain ontologies of interest. When the match rank is found above then the threshold value, the specified predefined label is associated with the arbitrary instance ontology, however the match ranks across all ontologies is stored in the knowledge base for further assistance to application or human user.

Ontology matching would result more accurate classification of arbitrary ontologies as the context of concepts, properties and structure of knowledge is matched and analyzed. For calculation of match rank, *ONTCLASSIFIRE* exploits the existing schematic matching techniques (i.e., linguistic and synonym). We are working with OWL ontologies; however the methodology can be applied for the similarity computation and classification of other ontologies as well. The following sub-sections elaborate the methodology, show its usage, and discuss case study.

4.1 Match Rank Calculations by ONTCLASSIFIRE

The *ONTCLASSIFIRE* gets the arbitrary ontology O_a for classification. It starts the semantic similarity computation between the O_a and domain ontologies $\{O_{d1}, O_{d2}, \dots, O_{dn}\}$ of predefined categories. It employs all the syntactic, structural and semantic knowledge present in the ontologies to compute the match rank so that arbitrary ontology should be assigned with a pre-defined category label. Let two ontologies be O_d and O_a , for matching a concept c of O_d with the concept c' of O_a , it exploits many inter-ontology semantic similarity parameters to compute whether how much a concept c is similar to c' as represented by equation 1. Finally,

ONTCLASSIFIRE aggregates the concept similarities found between the ontologies, calculates the match rank, and assigns the label to the arbitrary ontology O_a .

$$Sim(c, c') = \alpha Lcc' + \beta Dcc' + \gamma Occ' + \mu Pcc' + \Theta Hcc + \Omega Acc' \quad (1)$$

Where,

Lcc' : Concept label similarity between c and c'

Dcc' : Datatype properties similarity between c and c'

Occ' : Object properties similarity between c and c'

Pcc' : Parent concepts similarity c and c'

Hcc' : Children concepts similarity c and c'

Acc' : DL Axiom similarity between c and c'

Once the similarities between the concepts of domain ontology O_d and arbitrary ontology O_a are calculated, *ONTCLASSIFIRE* then calculates the match rank between O_d and O_a by aggregating the weights of $Sim(c, c')$ as shown in equation 2.

$$MatchRank(O_d, O_a) = \sum_{i=1..n} Sim(c, c')_i \quad (2)$$

As the overlapping categories share the common vocabulary, so weights with the concepts of domain ontologies dominate the specific attributes of each category. The user can configure these weights ($\alpha, \beta, \gamma, \mu, \Theta, \Omega$) that value the parameters of semantic similarity. Moreover, the user can adjust the weight for linguistic similarity and synonym similarity accordingly. Linguistic similarity finds the string based correspondences between labels. Concepts that are equal (e.g., $c_1:Book, c_2:Book$), prefix (e.g., $c_1:ISBN, c_2:ISBN_of_Book$), suffix (e.g., $c_1:PeerReview, c_2:Review$), contains (e.g., $c_1:Publication, c_2:Pub$) are found by this type of matching. Synonym similarity based on lexical database *Word Net 2.0* helps to detect the concepts that have same meanings but are linguistically different. For example, concepts that are synonyms (e.g., $c_1:Student, c_2:Scholar$) and abbreviations (e.g., $c_1:InformationTechnology, c_2:IT$) are determined. The parameters involved in calculating match rank are elaborated as following.

Concept Label Similarity (Lcc'). Label of concept is highly significant that comprise the utmost weight in the description of concepts. Lcc' computes the correspondences between labels of concepts c and c' of ontologies O_a and O_d .

Concept Properties Similarity (Dcc' and Occ'). Attributes (or datatype properties) and relations (or object properties) between concepts in ontology represent the context and semantics of concepts. In OWL-DL ontology, these properties comprise of four things; (i) Domain concept (ii) Property name (iii) Range of property and (iv) Tags associated with that property. For example, *Book* concept has a datatype property *ISBN* of type string with Functional and Inverse-Functional tags. Here, domain concept (*Book*) represents the concept to which this property belongs. *ONTCLASSIFIRE* does not match domain concepts of datatype property as it has already computed by concept label similarity. It matches other three things, i.e., concept datatype similarity (DP) checks label of datatype property (Ld) based on linguistic and synonym strategy, Range concept type (Rd) and Tag (Td) associated.

Let nc and nc' are the number of datatype properties associated with concepts c and c' , and d be the similar datatype properties between them. Total datatype similarity (Dcc') between concept c and c' is calculated as below.

$$DP = Sim(Ld + Rd + Td)$$

$$Sim(DP_1, DP_2) = dcc' = DP$$

$$Dcc' = \sum_{i=1..n} dcc' = (d/nc + d/nc')/2$$

OWL provides four types of tags, i.e, Functional, Inverse Functional, Symmetric and Transitive. With datatype properties only first two are applicable. Likewise, similarity between object properties (Occ') is computed between concepts.

Concept Parent and Children similarity (Pcc' and Hcc'). OWL ontology starts from top concept *Thing* that captures everything. It also allows multiple inheritances, so parent similarity requires computation of correspondences between all parent concepts. Pcc' analyses whether the parents of concept c and c' are semantically similar or not, and Hcc' checks their children concept similarity. For example, let concept c and c' has d similar parent (or children) concepts, and nc and nc' be the no. of parent (or children) concepts of c and c' accordingly, Pcc' and Hcc' similarities are computed as:

$$Pcc' = \sum_{i=1..n} Pcc' = (d/nc + d/nc')/2$$

$$Hcc' = \sum_{i=1..n} hcc' = (d/nc + d/nc')/2$$

DL Axiom Similarity (Acc'). OWL classes are described through so-called class descriptions that enrich the background information of concepts and represent the constraints of real world situations. OWL ontology also supports unnamed classes that are formed by the set of restrictions on the values for particular properties of the concepts. Such class descriptions are equivalent to DL axioms, e.g., *Publication* concept can be represented as $\{Thesis \sqcap \exists \text{WrittenBy.Student}\}$ or $\{Paper \sqcap \exists \text{ReviewedBy.Committee} \sqcap \exists >8 \text{haslimit.Pages}\}$ accordingly to its context. DL axioms define the context of concept that helps a lot in finding the accurate semantic similarity between concepts. It can be formed from union, complement, intersection, and restriction operators applied on primitive concept or anonymous concept and/or by boolean combinations. DL axiom similarity checks the expression of concepts formed of (primitive or anonymous) concepts and operators between them. In case of anonymous concept, similarity constitute of correspondences between restriction type, object property and range concepts. For matching concepts, restriction analysis is highly significant as it defines the necessary conditions, or necessary and sufficient conditions for them. Necessary condition of class makes that class a subclass of the restriction class. In case of necessary and sufficient condition for the class, both the restriction class and the restricted class will be interpreted as equivalent, i.e., they always have exactly the same members. Thus, Axiomatic analysis of concepts of OWL ontologies increases the ability of classifier to make more accurate reasoning on concept for their semantic similarities and so ontology classification.

All these inter-ontology factors form the similarity computation between concepts c and c' and generate the aggregated similarity or match rank between the domain and arbitrary ontologies. But, it requires exhaustive analysis for similarity computation where each concept c of domain ontology O_d is matched with each concept c' of

arbitrary ontology O_a . Therefore, there is a tradeoff between efficiency and effectiveness of matching process that results reliable classification. Performing exhaustive computation with several factors for each concept increases the effectiveness as this enables to identify the maximum possible similarity between concepts that is helpful in overlapping domain ontologies. But applying the factors phase by phase and selecting the candidate concepts after each phase based on the weighted concepts and properties of domain ontologies reduces the exhaustive computation for each concept, which minimizes the run time complexity of ontology matching and hence for ontology classification.

4.2 Preliminary Experiment Results

In this section, we are discussing the working of *ONTCLASSFIRE* when provided with real ontologies¹. Firstly, we built the hierarchical category ontology for *Library* that contains several categories, e.g., *Book*, *Proceeding*, *Thesis*, *Journal*, etc. Secondly, each category is elaborated with the domain ontology that enriches the semantics and differentiates the categories themselves. Figure 2 shows the fragment of category ontology, and domain ontologies of two categories *Book* and *Proceeding*. These categories are overlapping and hence the domain ontologies share common vocabulary in terms of concepts (e.g., *Author*, *Publisher*, etc.), properties (*ISBN*, *Title*, *Price*, etc.) and relations (e.g., *collectionOf*, *formatType*, etc.) between them.



Figure 2: Fragments of Category (a), Book (b) and Proceeding (c) ontologies

Besides this, the differentiated concepts and properties between these categories are assigned weights in domain ontologies so that classification can be done more accurately on basis of specific differentiating aspects of each category. For example, concepts (*Academic_Papers*, *OrganizingCommittee*, *Conference*, etc.) and properties (*presentedAt*, *peerReviewedBy*, *feedback*, etc.) differentiate the category *Conference Proceeding* from *Book*, and hence provided with some weights. When the arbitrary ontology O_a comes (as represented in Figure 3), *ONTCLASSFIRE* computes the similarities between the domain ontologies and arbitrary ontology, as shown in Table 1. Finally, on basis of calculated highest match rank, arbitrary ontology is assigned a

¹ <http://www.sites.google.com/site/mhd.fahad/ontologies>

label *Proceeding*, but the match rank is preserved in the knowledge base which could be used for future perspective of query answering for ontology retrieval.

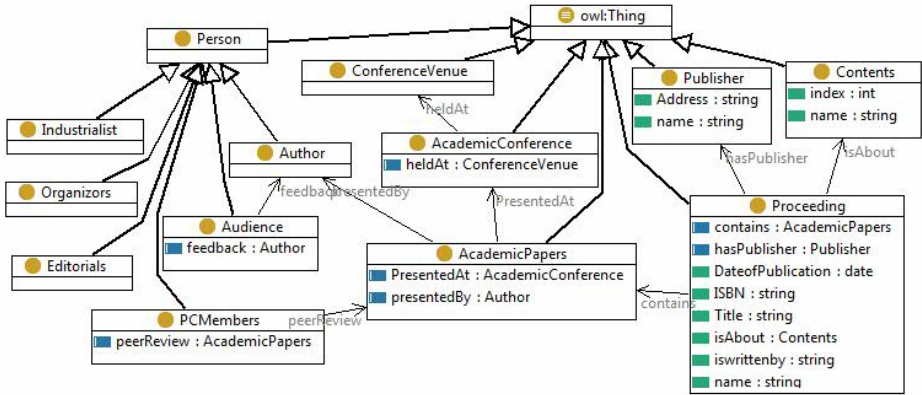


Figure 3: Arbitrary Ontology O_a for classification

Sim/Ont	O_a, O_{book}	O_a, O_{proc}	$O_a, O_{journal}$	O_a, O_{thesis}
Lcc'	0.41	0.96	0.52	0.47
Dcc'	0.46	0.87	0.53	0.60
Occ'	0.3	0.78	0.38	0.36
Pcc'	0.21	0.66	0.29	0.26
Hcc'	0.23	0.76	0.44	0.33
Acc'	0.11	0.86	0.26	0.21
Aggregated	0.286	0.815	0.403	0.374

Table 1: MatchRank between arbitrary ontology O_a and domain ontologies

4.3 Applications and Usage of Ontology Classification

In this section, we elaborate a number of such tasks which can benefit from ontology classification with *ONTCLASSIFIRE*. Classification of ontologies is essential for ontology, concept or information management and retrieval tasks on semantic web. It improves the quality of web search for specific ontologies and concepts. In addition, classification of the web ontologies is crucial tasks to promote focused crawling for ontology retrieval and concept specific modular ontology analysis. Usually search results are presented in a ranked list for assistance to users. Soft classification mechanism exploited by *ONTCLASSIFIRE* could be more useful to users in this aspect. The use of ontology matching for ontology classification provides higher accuracy of classification especially in the case of overlapping ontologies where text classification algorithms did not work well for current semantic web portals. Overlapping categories require analysis by concepts, properties, structure and semantics hidden with their combinations. Therefore ontology classification based on

ontology matching approach exploit matching of context specific knowledge that would result the classification of arbitrary ontology in appropriate category, with the probability distribution across all the categories. This work can benefit construction, maintenance or expansion of ontologies directories on the semantic web. Currently, ontology directories are maintained by human editors such as those provided by Yahoo! [Yahoo, 07] and the Dmoz Open Directory Project (ODP) [Dmoz, 07] that facilitate user to browse for ontologies within a predefined set of categories. Ontology classifier does this job automatically replacing tedious manual effort to help update and expand such directories.

5 Conclusion

Classification practice has long been adopted in digital libraries and information systems to facilitate user in clarifying his information need and to structure search results for browsing. From last decade, it has received great attention in the context of helping users to cope with the vast amount of information on the Web. For emerging semantic web, complex structure and semantics of ontologies presents additional challenges as compared to traditional text classification and web page classification. So, one of the core challenges of current semantic web research is to develop semantic web portals that assist individual knowledge engineers to search terms and ontologies, and serve tools and web-agents seeking data and knowledge in sound semantic manner. In this research paper, we discuss the state-of-the-art ontology semantic web portals, and analyze that they are not effective for meeting the demands of ontology classification for ontology based enterprise business applications and upcoming semantic web. We present *ONTCLASSIFIRE* that makes use of context specific similarity measures to fit the ontologies into a predefined directory of general categories. We replace the plain text classification algorithm in the process of ontology classification with ontology specific classification algorithm. Instead of using keyword search with bag-of-words, we use basic domain ontology for each predefined category and benefit from ontology matching research to find the correspondences between the domain ontology and arbitrary ontology for classification purpose. Finally, by calculating the weights of the correspondences found, we calculate probability whether how much both the ontologies have similarities, and hence classify the ontology in one of the predefined category. We believe that the proposed model, *ONTCLASSIFIRE*, forms a suitable basis for ontology classification for upcoming semantic web. One of the ongoing researches is to train the *ONTCLASSIFIRE* on real world ontology repository dataset such as dmoz, and present the empirical result of our semantic based technique for classification of ontologies. At the same time, we are building the retrieval mechanisms of proposed framework.

References

[Bosch, 07] Bosch, A., Zisserman, A., Munoz., X.: Image classification using random forests and ferns. In ICCV, 2007

- [Chakrabarti, 02] Chakrabarti, S., Joshi, M.M., Punera, K., Pennock, D.M.: The structure of broad topics on the web. In Proc. 11th Intl. Conference on WWW, NY, 251–262. ACM 2002
- [Ding, 05] Ding, L., Pan, R., Finin, T., Joshi, A., Peng, Y., Kolari, P.: Finding and Ranking Knowledge on the Semantic Web, In Proc. 4th International Semantic Web Conference. Springer LNCS 3729, 156–170 2005
- [Dmoz, 07] Corporation, N.C., (2007). The dmoz open Directory Project (ODP). <http://www.dmoz.com/>.
- [Ehrig, 05] Ehrig, M., and Maedche, A.: Ontology-Focused Crawling of Web Documents, In Proc. ACM symposium on Applied computing, Melbourne, Florida, 1174 – 1178 2005
- [Fahad, 07] Fahad, M., Qadir, M.A., Noshairwan, M.W., Iftakhir, N.: DKP-OM: A Semantic Based Ontology Merger. In Proc. 3rd International Conference I-Semantics 2007, Graz, Austria, 313-322 J.UCS 2007
- [Glover, 02] Glover, E.J., Tsioutsoulakis, K., Lawrence, S., Pennock, D.M., Flake, G.W.: Using web structure for classifying and describing web pages. In Proc. 11th Intl. Conference on World Wide Web, NY, 562–569 ACM 2002
- [Grobelnik, 05] Grobelnik, M., Mladenović, D.: Simple classification into large topic ontology of Web documents, Journal of Computing and Information Technology, Vol. 13(4) 2005
- [Mitchell, 97] Mitchell, T.M.: Machine Learning. New York, McGraw-Hill 1997
- [Ontolingua, 10] Ontolingua Website, <http://www.ksl.stanford.edu/software/ontolingua/>
- [Pan, 06] Pan, J.Z., Thomas, E., Sleman, D.: ONTOSEARCH2: Searching and Querying Web Ontologies. In: Proc. of WWW/Internet'06. pp. 211–218 2006
- [Patel, 03] Patel, C., Supekar, K., Lee, Y., Park, E.K.: OntoKhoj: A semanticWeb portal for ontology searching, ranking and classification. In Proc. of the 5th ACM Intl. Workshop on Web Info. and Data Management, 58–61 2003
- [Peng, 02] Peng, X., Choi, B.: Automatic web page classification in a dynamic and hierarchical way, In Proc. IEEE International Conference on Data Mining (ICDM'02), Washington, DC, 386–393. IEEE CS 2002
- [Qu, 06] Qu, H., Pietra, A.L., Poon, S.: Automated blog classification: Challenges and pitfalls, Computational Approaches to Analyzing Weblogs, AAAI Press 2006
- [Seidenberg, 06] Seidenberg, J., Rector, A.: Web ontology segmentation: Analysis, classification and use. In Proceedings of the 15th International Conference on the World Wide Web (WWW). ACM, New York, 13–22 2006
- [Supekar, 03] Supekar, K., Patel, C., Lee, Y.: Characterizing Quality of Knowledge on Semantic Web, University of Missouri -Kansas City, Technical Report, 2003
- [Taghva, 03] Taghva, K., Borsack, J., Coombs, J., Condit, A., Lumos, S., Nartker, T.: Ontology-based Classification of Email, In Proc. Intl. Conference on Information Technology: Computers and Communications, 194-200 2003
- [Wu, 03] Wu, S.H., Tsai, T.H., Hsu, W.L.: Text Categorization Using Automatically Acquired Domain Ontology, In Proc. 6th international workshop on Information retrieval with Asian languages, 138-145 Japan 2003
- [Yahoo, 07] Yahoo!, Inc. (2007). Yahoo! <http://www.yahoo.com/>.

Automatic Ontology Merging by Hierarchical Clustering and Inference Mechanisms

Nora Maiz, Muhammad Fahad, Omar Boussaid, Fadila Bentayeb

(ERIC Laboratory, University of Lyon2, Bron, France

firstname.lastname@univ-lyon2.fr)

Abstract: One of the core challenges for current landscape of ontology based research is to develop efficient ontology merging algorithms which can resolve the mismatches with no or minimum human intervention, and generate automatic global merged ontology on-the-fly to fulfil the needs of automated enterprise business applications and mediation based data warehousing. This paper presents our approach of ontology merging in context of data warehousing by mediation that aims at building analysis contexts on-the-fly. Our methodology is based on the combination of the statistical aspect represented by the hierarchical clustering technique and the inference mechanism. It generates the global ontology automatically by four steps. First, it builds classes of equivalent entities of different categories (concepts, properties, instances) by applying a hierarchical clustering algorithm. Secondly, it makes inference on detected classes to find new axioms, and solves synonymy and homonymy conflicts. This step also consists of generating sets of concept pairs from ontology hierarchies, such as the first component subsumes the second one. Third, it merges different sets together, and uses classes of synonyms and sets of concept pairs to solve semantic conflicts in the global set of concept pairs. Finally, it transforms this set to a new hierarchy, which represents the global ontology.

Keywords: Ontology Merging, Similarity Measure, Hierarchical Clustering and Inference, Data Warehouse design, Data Mining

Categories: H.3.1, H.3.2, H.3.3, H.3.7, H.5.1

1 Introduction

Decision tools are more and more used in modern companies to conduct analysis and take decisions at data that originate from distributed and heterogeneous data sources. Therefore, data integration is crucial since the analysis context, also called data cube, is built using data from different data sources in the same company or shared with other companies or on the web. There are two main strategies for data integration, i.e., data warehousing [Inmon, 92; Kimball, 98] and mediation [Goasdoue, 00; Huang, 00; Lamarre, 04]. The goal of former strategy is to build a centralized database that contains all data coming from different data sources modeled in multidimensional way promoting on-line analytical processing. This approach is characterized by its performance in terms of query response time since the data is warehoused that facilitates the decision processes. But, when data changes over time, decisional tools necessitate several updates for sound decision making. The updating processes are achieved using data warehouse refreshment strategies that cause much additional cost. To tackle this problem, we propose mediator approach to construct a virtual data warehouse to process analysis context on-the-fly.

Mediator approach consists of defining three elements; data source schemas as

local schemas, the mediator layer as a global schema and correspondence rules between local schemas. Querying data from their real sources to make decision consists of defining decisional queries. For formulating decisional queries for the mediator, we must first define a global schema that allows execution of this kind of queries. To fulfill this task, we need a powerful strategy of query transformation from the global schema language to the data sources languages. Furthermore, the obtained results from different data sources are combined to build the data cube on-the-fly. Since that we are in the analysis and decision domain, we are interested more by the pertinence of query results, so a simple search of data is not sufficient and we must proceed to a semantic research based on the semantic of terms used in the global schema or in the user query. This requires usage of ontologies as a support to data source semantic representation to ensure the knowledge sharing between different heterogeneous data sources or between different users. In this context, we propose an initial strategy for the definition of the global schema of the mediation system that aims at data searching. We use the classification technique to build the concept classes for the global ontology starting from the local ontologies that are representative of local data sources. The clustering technique based on semantic similarity is used to define clusters of concepts in the global ontology by merging local ontology classes. It takes into account the concept context that is defined as a set of roles that link this concept to other ones.

The remainder of this paper is structured as follows. Section 2 throws a light on state-of-the-art systems. Section 3 presents the methodology of our ontology merging system that exploits hierarchical clustering and inference mechanisms. Section 4 discusses the experimental validation of our approach. Finally, we draw some conclusions and show ongoing research aspects in section 5.

2 State-of-the-Art on Ontology Mapping and Merging

There are many approaches and systems for ontology alignment and mapping in research literature. IF-Map exploits instance similarity approach based on the formal concepts analysis for mapping of source ontologies by considering common reference ontology [Kalfoglou, 03]. GLUE integrates the instance matching with machine learning approach, and calculates the probabilities of concept matching by analyses of taxonomic structure for ontology integration [Doan, 04]. OBSERVER aims to work with semantic heterogeneities between distributed data repositories, and translates user queries from different ontologies using inter-ontology relationships (mappings) and retrieves desired data [Mena, 00]. QOM exploits the heuristic based dynamic programming approach for choosing only promising candidate mappings, and thus reduces the runtime complexity [Ehrig, 04]. OLA transforms ontologies to OWL-Graphs, and use Valtchev's similarity measure to compare entities belonging to the same category (Object property, datatype property, etc.) for find alignments between them [Euzenat, 04]. Besides these approaches, there are some semantic ontology matching techniques, such as CtxMatch [Bouquet, 06], S-Match [Giunchiglia, 04] and ASMOV [Jean-Marya, 09]. CtxMatch and S-Match follows the same methodology by translating concepts into the Description Logic (DL) formulas and then solves the propositional satisfiability problems with the help of available DL reasoners. Mascardi et al. make use of upper ontologies as semantic bridges for matching source

heterogeneous ontologies [Mascardi, 10].

For ontology merging, there are very few approaches contributed in the research literature. The semi-automatic interactive tools PROMPT and AnchorPROMPT [Noy, 03], and Chimaera [McGuinness, 00] exploit concept labels and to some extent the structure of source ontologies for ontology merging. These tools have no ability to find correspondences between concepts that are semantically equivalent but modeled with different names.. FCA-Merge is an algorithm for ontology merging that defines an ascending formal method of ontologies merging based on a set of natural language documents [Stumme, 01]. They use techniques for natural language treatment and concepts formal analysis to derive the concept lattice. The later is explored and transformed to ontology with the human intervention. H-Match and Merge, a dynamic ontology matching algorithm developed in the Helios framework, adopts another interesting approach by using linguistic and contextual affinity of concepts in peer-based systems [Castano, 04].

Our research on ontology merging topic has two folds. First, our semantic based ontology merger, DKP-OM, follows the hybrid approach and uses various inconsistency detection algorithms in initial mapping found in first steps [Fahad, 07]. Our hybrid strategy makes it possible to find all possible mappings, and semantic validation of mappings gives very promising final results by ignoring the incorrect correspondences which don't satisfy the test criteria. Secondly the contribution presented in this paper, automatic merging of local ontologies by clustering and inference mechanisms, for building analysis context (merged global ontology) on-the-fly in the context of data warehousing by ontology mediation approach [Maiz, 07]. The previous approaches in research literature use ontologies in XML (Extensible Markup Language), RDF (Resource Description Framework) or OWL-Lite (Ontology Web Language) format, and are not capable for automatic generation of global merged ontology. In addition, majority of them use similarity measures that cover at least the ontology structure and use a stabilization threshold to stop the alignment process, which limits the semantic propagation resulting reduction in precision. Moreover, these approaches support only two ontologies to be aligned, contrary to the reality where several ontologies need to be aligned in the same system for their share and reuse especially in case of data warehouse design. So, we need a new approach that takes into account the scalability by supporting several ontologies at the time. It is the case of our approach that fulfills these challenges as explained below.

3 Ontology Integration by Hierarchical Clustering and Inference

The main idea in our approach is to combine the power of the statistical approach represented by the hierarchical clustering algorithm with the inference mechanism offered by the semantic language OWL-DL. For generation of automatic global merged ontology, we apply the clustering algorithm on different categories of ontological entities (concepts, properties, instances) to find classes of equivalent entities belonging to different local ontologies as shown in Figure 1. For each class, we make inference to discover the new axioms representing the new relationships between entities in the same class or between different classes of the same category. After that, we make use of different classes and axioms to build the global ontology. The methodology starts by aligning the local ontologies by finding similar entities

belonging to different ones. Then, we use the result of the ontology alignment to merge local ontologies automatically. The next sections discuss various aspects of our methodology in detail.

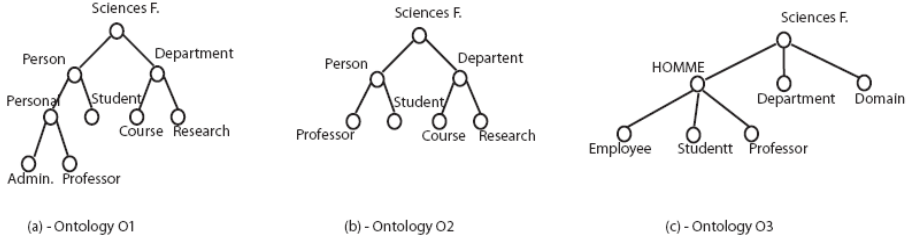


Figure 1: Examples of three local ontologies of the same domain

3.1 Ontology Alignment Strategy

3.1.1 Clustering Algorithm

Ontology. The concept Ontology can be defined with different manners according to its type and use. In our case, we define an ontology as a triplet (C, R, I) , where C is the set of concepts or OWL-classes, R is the set of relationships between concepts or OWL-properties and I is the set OWL-instances.

Concept. A concept is an attribute vector V_i defined as, $V_i = (T_i, At_1, \dots, At_k, P_1, \dots, P_j)$ where T_i is the concept term, $At_i(i=1, \dots, k)$ are attributes that describe the concept. Finally, $P_m (m=1, \dots, j)$ represent concept properties. They can be owl datatype properties or object properties. Concept term and attributes are used to compute the similarity between different concepts.

Similarity measure. Similarity measure allows managing the semantic equivalence or independence between entities. It is based on the concept terminology, properties and its neighborhood. In fact, there is a high probability of semantic equivalence of two concepts which have the same terminology, the same properties and the same relationships with other similar concepts in neighborhood. For computing the similarity between concepts, we must start by computing similarity between different pairs of attributes ($Attribute_i, Attribute_j$) where the first attribute belongs to the first concept and the second attribute to the second one. Similarity between two attributes $Attribute_i$ and $Attribute_j$ named $Sim(Attribute_i, Attribute_j)$ is a terminological similarity based on Wordnet thesaurus. Wordnet Java API returns the synonym set (Synset) of a given term, and to find similarity between two terms (attributes) At_1 and At_2 , it will be necessary to perform a breadth-first search starting from the Synset of At_1 to the Synsets of Synset of At_2 , and so on, until At_2 is found. Once the similarity between different pairs of attributes is computed, we must define a similarity threshold in the order to eliminate all pairs that are not similar and to take only into account those that have a high similarity. Then, attributes similarity measure between two concepts C_i and C_j is calculated as shown in equation 1. We define A , the set of all selected attributes of concepts.

$$Sim_A(C_i, C_j) = \sum_{(k=1, \dots, Card(A))} \prod_{ik} Sim(Attribute_{ik}, Attribute_{jm}) \quad (1)$$

Where, Attribute_{ik} (or Attribute_{jm}) is the k^{th} attribute of the concept C_i (or C_j). It can be a term, a property or a relationship between this concept and its neighbors. Π_{ik} is the k^{th} attribute weight, which is fixed by the user. Equation (2) and (3) represent the local similarity Sim_L between two concepts and the global similarity Sim_G respectively based on property similarity Sim_p and neighborhood similarity Sim_v . Figure 2 shows the Similarity GSim between two concepts with input and output.

$$\begin{aligned} \text{Sim}_L(C_i, C_j) &= \text{Sim}_T(C_i, C_j) + \text{Sim}_A(C_i, C_j) & (2) \\ \text{Sim}_G(C_i, C_j) &= \text{Sim}_L(C_i, C_j) + \text{Sim}_p(C_i, C_j) + \text{Sim}_v(C_i, C_j) & (3) \end{aligned}$$

```

Input:
  C1= V1(T1, \Pi_{11}, At11 ..., \Pi_{1i}, At1i);
  C2= V2(T2, \Pi_{21}, At21, ..., \Pi_{2j}, At2j);
  Similarity threshold S;

Output:
  Similarity GSim between Ci and Cj;
begin GSim := 0
  For each {Attribute k in V1}
    For each {Attribute m in V2}
      Simil := Sim(Attribute_{k}, Attribute_{m});
      IF {Simil > S}
        GSim := GSim+ Simil * Max (\Pi_{k}, \Pi_{m});
end.

```

Figure 2: Similarity GSim between two concepts

3.1.2 Hierarchic clustering of ontological entities

The clustering algorithm use different categories of entities (concepts, properties, etc.). We explain here only the case of concepts which is similar for other entities as well. We explain the clustering algorithm that uses the set of concepts and the similarity measure to define synonym concept classes. A synonym concept class is a set, which contains only semantically equivalent concepts. The goal of clustering algorithm is to devise the set C of all concepts belonging to all candidate ontologies, to M sets of equivalent concepts. For that, clustering algorithm implements the definition of the agglomerative hierarchical clustering mechanism that exploits the similarity measure, which we defined previously to compute the semantic similarity between different pairs of concepts.

Clustering Algorithm Application. The clustering algorithm is based on the use of a similarity matrix in the algorithm of Figure 3. The first row and the first column of the matrix contain the concepts of different ontologies. Each cell in the matrix contains a number that represents the similarity value between the two concepts of the matrix. The first step is to compute the similarity between different pairs of concepts and to load its value in the corresponding cell of the similarity matrix.

$$\text{Sim}(\text{SYN}_i, C_j) = \text{Min}(\text{Sim}(C_1, C_j), \dots, \text{Sim}(C_i, C_j)) \quad (4)$$

After that, the algorithm will search from the maximal value of similarity in the matrix and keep the pair of concepts corresponding to this value. The first class will contain the selected two concepts. The class built will be considered as an element or an individual for the algorithm. For that, it updates the matrix by re-computing the similarity value between the new class and other concepts. The similarity between a

class $SYNi$ that contains j elements ($C1, \dots, Cj$) and an other element Ck is defined in equation 4. The algorithm continues it's iterations until it obtains a representative set of classes. The similarity between elements of the same class is maximal and the similarity between different classes is minimal. The result of the algorithm is a set SYN that contains M sets $SYNi$. Each set $SYNi$ contains equivalent concepts belonging to different ontologies. The maximal cardinality of a set $SYNi$ is the cardinality of the set C of all concepts, and the minimal cardinality is one.

Algorithm 1: Concepts Hierarchic Clustering Algorithm

```

1: Input:
2:    $O_i$  ( $i=1 \dots n$ ): candidate ontologies to be merged
3:    $C = C_i$  ( $i=1 \dots k$ ) / set of concepts of candidate ontologies
4:    $M_0$ : set of singleton of  $C$ 
5:    $MatrSim[n+m+s, n+m+s]$ : Similarity matrix;
6:   Similarity threshold  $S$ ;
7: Output:
8:   Clusters  $SYNi$  of equivalent concepts
9:   Initialize the sub matrix  $M_1[n, n]$ ,  $M_2[n+1-n+m, n+1-n+m]$ 
   and  $M_3[n+m+1-n+m+s, n+m+1-n+m+s]$  of  $MatrSim$  with  $X$ .

10:  FOR ( $1 \leq i \leq n+m+s$ ) do
11:    FOR ( $1 \leq j \leq n+m+s$ ) do
12:      IF  $MatrSim[i, j] < X$  Then
13:         $MatrSim[i, j] \leftarrow GSim(C_i, C_j)$ 
14:      ENDIF
15:    ENDFOR
16:  ENDFOR
17:   $Max \leftarrow 0$ 
18:  REPEAT
19:    FOR ( $1 \leq i \leq n+m+s$ ) do
20:      FOR ( $1 \leq j \leq n+m+s$ ) do
21:        IF  $MatrSim[i, j] > Max$  Then
22:           $Max \leftarrow MatrSim[i, j]$ 
23:        ENDIF
24:      ENDFOR
25:    ENDFOR
26:    IF  $Max > seuil$  Then
27:       $M_i \leftarrow M_{i-1} \cup C_i, C_j - C_i, C_j$ 
28:       $MatrSim[i, j] \leftarrow X$ 
29:    ENDIF
30:    Update  $MatrSim$  by taking into the count the new class
31:    Make inference using the new relationship in the new class
32:  Until  $GSim(C_i, C_j) < seuil$ 

```

Figure 3: Concept Hierarchical Clustering Algorithm

Example. We consider three parts of three different heterogeneous ontologies showed in Figure 1. We start by defining C , i.e., the set of all concepts. Then after the application of the algorithm of hierarchical clustering, we obtain SYN , the set of nine $SYNi$ as follows.

$C = \{SciencesF., Person, Department, Personal, Student, Course, Research, Admin., Professor; sciencesF., person, Departement, Student, Course, Research, Professor, sciencesF., HOMME, Department, Employee, Student, Course, Research, Domain,$

Professor}

$SYN = \{\{SciencesF., SciencesF., SciencesF.\}, \{Person, Person, HOMME\}, \{Department, Department, Department\}, \{Student, Student, Student\}; \{Professor, Professor, Professor\}, \{Employee, personal\}, \{Course, Course\}, \{Admin.\}, \{Domain\}\}$

3.1.3 Inference

The mechanism of inference is used to discover the implicit relationships between different entities belonging to different classes of different categories. For example, if we have two classes *Person* and *Homme* belonging to two different ontologies, the clustering algorithm merge the two previous classes to build only one. On the other hand, if the class *Person* is an antecedent of an other class *Student*, and at the same time the class *Homme* is an antecedent of an other class *Student* which is similar to the first class *Student*, our inference mechanism detect that the property link the two classes *Person* and *Student* is similar to the property link the two classes *Homme* and *Student*. This is an example of the mechanism of inference that allows extracting all implicit relationships between different entities belonging to different ontologies. It allows to find all relations like *owl:SameAs* property, the *owl:equivalent* property and the *owl:subclassof* property, and similar other entities.

3.2 Our Ontology Merging Strategy

Figure 4 presents our ontology merging methodology comprises of four steps. In the first step, we used the hierarchical clustering algorithm in order to form a set of concept classes. Each class contains the synonym concepts belonging to different ontologies. The result of the algorithm is a set *SYN*, which is composed of *N* subset *SYNi*. Each subset contains the synonym concepts of different ontologies. The goal of this step is to find all synonym concepts in different ontologies representing the local data sources. To realize this task, we need a similarity measure for computing similarity between the two concepts by taking into account their structure and terminology.

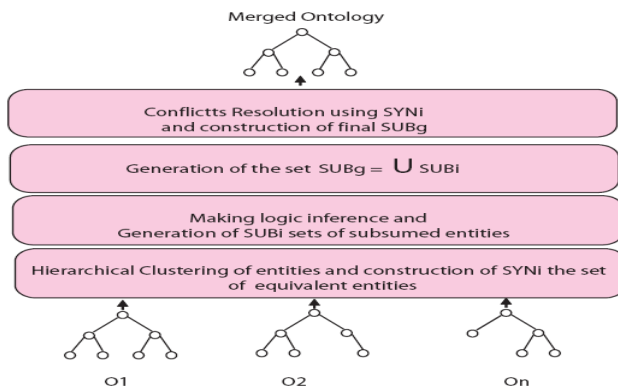


Figure 4: General schema of the ontologies merging approach

Once the concept clusters are built, we pass them to the second step that generates *SUB*, the set of pairs(*Father*, *Son*) of different ontologies. For this, we start

by generating the set of SUB_i ($i = 1, \dots, P$), where each SUB_i corresponds to an ontology O_i . After that, we merge the sets SUB_i to obtain the global set SUB . The goal of this step is to keep the hierarchy of different ontologies in order to deduce the merged ontology hierarchy. The third step consists in using classes $SY Ni$ to find the final set SUB by replacing each concept by the general concept corresponding to the $SY Ni$, which contains it. The goal of this step is to prepare the set SUB that allows semantic conflicts resolution. The result of this step is a set of pairs that can be similar or different. In the first case, we eliminate all the instances of the same pair and we keep only one. At the end of this step, we obtain a set SUB that contains all pairs of general concepts and the hierarchy of the global ontology. Finally, we use directly SUB to build the global ontology. The detail of each step based on similarity measure defined previously is as follows.

Concepts merging and general concepts definition. In this phase, we proceed to assign each class $SY Ni$, a representative concept (term), which can be one of the class element or another concept more general. Before assigning the new term to the class, we must verify that it is not yet affected to another class. In this case, we must change it for the considered class. Like this, we do not solve only the synonymy conflicts, but also homonymy conflicts. After that, we define correspondences tables to save correspondences between the new general concept and class elements. These correspondences will be used for other tasks like query rewriting.

Example. Once we built the set $SY N$, which contains subsets $SY Ni$ of synonym concepts, we replace each $SY Ni$ by the general concept assigned to the correspondent class. In our example, the set $SY N$ becomes as follows.

$SY N = \{sciencesF., Person, Department, Student, Professor, Personal, Course, Admin., Domain\}$

The general concept Cg attributes are the union of all concepts attributes belonging to the corresponding subset $SY Ni$. The link between the general concept and the class elements will be saved in the correspondences tables.

Generation of the set $SUBg$. This step consists in generating from different ontology hierarchies, the set $SUBg$ of pairs $(C_i, C_j) \in O_i$, where ($i = 1, \dots, P$) and P is the number of ontologies to be merged) where C_i is the parent and C_j is its child in the ontology hierarchy. The set $SUBg$ is used to define the global ontology hierarchy, as follows.

Generation of subsets SUB_i . The first phase consists in defining subsets SUB_i , ($i = 1, \dots, P$). Each subset SUB_i corresponds to an ontology O_i . The subsets definition is done by a simple traversal of different ontologies hierarchies and we take the node with its child. At the end of this phase, we obtain P subsets SUB_i where each one corresponds to ontology O_i . The obtained subsets contain semantic conflicts that we solve in the next step using the set $SY N$ generated in the previous step.

Example. : In our example, the three subsets SUB_1 , SUB_2 and SUB_3 that correspond to the three ontologies are as below.

$SUB_1 = \{(sciencesF., Person), (sciencesF., Department), (Person, Personal), (Person, Student), (Department, Course), (Department, Research), (Personal, Admin.), (Personal, Professor)\}$

$SUB_2 = \{(sciencesF., Person); (sciencesF., Department), (Person, professor), (Person, Student), (Department, Course), (Department, Research)\}$

$SUB_3 = \{(sciencesF., Homme); (sciencesF., Department), (sciencesF., Domain), (Homme, Personal), (Homme, Student), (Homme, Professor)\}$

SUBi merging. After the generation of the subsets SUB_i , we merge them to obtain a set SUB that contains all pairs of concepts (Parent, Child) belonging to different ontologies to be merged. SUB is so defined as below in equation 5.

$$SUBg = \bigcup_{i=1, \dots, P} SUB_i \quad (5)$$

The union operation defined in the precedent formulas is the classic union that takes only one instance of the element. But in our case, we can not compare elements coming from different subsets and to find similarity between pairs of concepts. The set SUB contains all redundant occurrences of all pairs of concepts belonging to different subsets SUB_i . For eliminating redundancies, we use the set of synonym concepts SYN defined previously to find similar or equivalent pairs.

Example. The union of the three precedent subsets SUB_i is the set $SUBg$ as below.

$SUBg = \{(SciencesF., Person), (SciencesF., Department), (Person, Personal), (Person, Student), (Department, Course), (Department, Research), (Personal, Admin.); (Personal, Professor), (sciencesF., Person), (sciencesF., Department), (Person, Professor), (Person, Student), (Department, Course), (Department, Research), (sciencesF., HOMME), (sciencesF., Department), (sciencesF., Domain), (Homme, Employee), (HOMME, Student), (HOMME, Professor)\}$

Use of SYN_i to generate $SUBg$. The generated set $SUBg$ contains redundant structures, and to eliminate them we use our knowledge store extracted from the concepts population of different ontologies. Knowledge extraction is realized by the application of the clustering algorithm defined in the first step according to the semantic equivalence. The equivalence found between concepts helps us to eliminate redundancies with two steps as follows.

1. Replace concepts in $SUBg$ by their general concept. In SUB , we traverse all pairs of concepts, one by one and for each component of the pair we find the corresponding class in SYN that contains this concept. After that, we replace the pair component by the class name. We do this for all pairs in the set SUB . We obtain so a set SUB , which contains different pairs that we can compare them each to other.

Example. : $SUBg$ in our example becomes as below.

$SUBg = \{(sciencesF., Personne), (sciencesF., Departement), (Personne, Salarie), (Personne, Etudiant), (Departement, Cours), (Departement, Recherche), (Salarie, Admin.), (Salarie, Enseignant), (sciencesF., Personne), (sciencesF., Departement), (Personne, Enseignant), (Personne, Etudiant), (Departement, Cours), (Departement, Recherche), (sciencesF., Personne), (sciencesF., Departement), (sciencesF., Domaine), (Personne, Salarie), (Personne, Etudiant), (Personne, Enseignant)\}$

2. Removing redundancies in SUB . This phase consists in traverse $SUBg$ and comparing pairs of concepts two by two. The similar pairs are removed in order to take into account only one occurrence of the pair in $SUBg$. Finally, these pairs are used to build the hierarchy of global ontology.

Example. : Finally, we obtain set $SUBg$ after removing redundant elements as follows.

$SUBg = \{(sciencesF., Personne), (sciencesF., Departement), (Personne, Salarie), (Personne, Etudiant), (Departement, Cours), (Departement, Recherche), (Salarie, Admin.), (Salarie, Enseignant), (Personne, Enseignant), (sciencesF.,Domaine)\}$

Merged ontology building. In this step, we use $SUBg$ built previously to get the global ontology hierarchy. For that, we start by traversing $SUBg$ until finding the concept, which is not the child of any one of other concepts belonging to the same set of concepts. This concept represents the tree root. The second component of the pair represents the first direct child of the selected concept (root). The selected pair will be marked. Then, we seek another pair that has the tree root as first component, the second component of this pair will represent the second child of the tree root. We repeat this search until we have more pairs that contain the concept root. After that, we take the first child of the root concept and we proceed in the same way to find their children in the set $SUBg$. We continue with all concepts in the tree until marking all pairs in $SUBg$ to get the merged ontology.

4 Experimental Validation of OMerSec

To validate our approach, we used different variations of the geographic ontology built for the project FoDoMust [Ont, 10]. These variations are showed in the Figure 5a. The basic ontology of geographic objects is composed of 39 concepts, 110 instances and 28 properties and 14 axioms. Figure 5b resumes the ontologies data set statistics.

Ont	Characteristics	NbClass. NbProp. NbInst. NbAxiom.				
1	The basic ontology					
2	The hierarchy of concepts is reduced	Min	24	17	15	12
3	The entities terms are replaced by their synonyms	Max	39	28	110	14
4	The hierarchy of concepts is reduced differently	Average	31	22	43	13

Figure 5: Variations made by us in (a), Data set statistics in (b)

Our experiments are performed using *Eclipse* platform with the free reasoner *Pellet* and the framework *Jena*. For computing similarities between concepts, we use the model similarity explained previously. It takes into account the term, attributes, relations and neighbours similarity. The last one makes it recursive. To limit the number of neighbours taken into account, we performed some tests to measure the optimal value of the diameter of neighbourhood or the path length between a concept and its neighbours that find the optimal similarity. In our case, we observed that the optimal value which gives the best similarity is the second neighbour of the concept. The experimental evaluation of our approach is conducted into two steps. First, we aligned with the help of domain experts the different ontologies manually. The mappings found in this step are considered as the alignment reference. The comparison of the alignment reference with the automatic one produce three sets, i.e., *AFound*, *AExpected* and *ACorrect*. The first one represents the entity pairs aligned with the alignment approach. The second one represents the set of entity pairs aligned

in the alignment reference and the third represents the intersection of the two previous sets that are *AFound* and *AExpected*. Using these three sets of entity pairs, we calculated the three following quality measures, i.e., *Precision*, *Recall* and *Fallout*. The *Precision* is the ratio between *ACorrect* and *AFound*, the *Recall* is defined as the ratio between *ACorrect* and *AExpected* and the *Fallout* is defined as the ratio of the difference between *AFound* and *ACorrect*. We used the candidate ontologies to measure the quality of our alignment system OMerSec, and compared our results with two other approaches that are, COMA++ and FCA-Merge. Our approach has shown the best precision results as shown in the Figure 6.

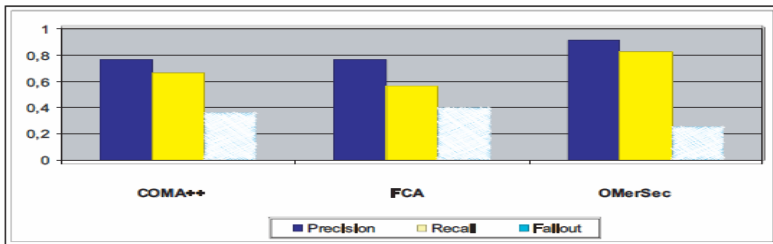


Figure 6: Comparison of our system with others

5 Conclusion and Future Directions

This paper presents the methodology of our automatic ontology merging system that deals in building analysis contexts on-the-fly for data warehouse design by defining a mediation system based on ontologies. Our approach exploits clustering algorithm and an inference mechanism offered by the language OWL. We start by clustering different entities belonging to different local ontologies and making inference on initial axioms to find others which are implicit for the user. After that, we use information in local ontologies to validate those axioms, and build global ontology from them. The proposed methodology benefits in determining and overcoming differences between local ontologies in order to allow the reuse of such ontologies, and the data annotated using these ontologies, throughout different heterogeneous semantic multi-vendor applications. One of our ongoing researches is to apply optimization strategies to enhance the performance of overall system.

References

- [Bouquet, 06] Bouquet, P., Serafini, L., Zanobini, S., Sceffer, S.: Bootstrapping semantics on the web: meaning elicitation from schemas, In Proc. 15th Intl World Wide Web Conference (WWW), 505–512 2006
- [Castano, 06] Castano, S., Ferrara, A., Montanelli, S.: Matching Ontologies in Open Networked Systems: Techniques and Applications, Journal on Data Semantics, JoDS 3870, Springer Berlin, 25–63 2006

- [Doan, 04] Doan, A., Madhavan, J., Domingos, P., Halevy, A.: *Ontology matching: A machine learning approach*, Handbook on Ontologies in Information Systems, Springer-Verlag, 397-416 2004
- [Ehrig, 04] Ehrig, M., Staab, S.: *QOM - quick ontology mapping*, In Proc. Third International Semantic Web Conference (ISWC2004), Springer, LNCS 3298, 683–696 2004
- [Euzenat, 04] Euzenat, J. and Valtchev, P.: *Similarity-based ontology alignment in owl-lite*, In Proc. 16th ECAI-04, Valencia, Spain, 333–337 2004
- [Fahad, 07] Fahad, M., Qadir, M.A., Noshairwan, M.W., Iftakhir, N.: *DKP-OM: A Semantic Based Ontology Merger*, In Proc. 3rd International Conference I-Semantics 2007, Graz, Austria, 313-322 2007
- [Giunchiglia, 04] Giunchiglia, F., Shvaiko, P., Yatskevich, M.: *S-Match: an algorithm and implementation of semantic matching*, In Proc. 1st European SemanticWeb Symposium, LNCS 3053, 61–75 2004
- [Goasdoue, 00] Goasdoue, F., Lattues, V., Rousset, M.C.: *The use of carin language and algorithms for information integration: The picisel system*, Int. J. Cooperative Inf. Syst., 9(4), 383-401 2000
- [Huang, 00] Huang, H.C., Kerridge, J.M., Chen, S.L.: *A query mediation approach to interoperability of heterogeneous databases*, In Australasian Database Conference, 41-48 2000
- [Inmon, 92] Inmon, W.H., *Building the Data Warehouse*. John Wiley & Sons, Inc., New York, USA, 1992.
- [Kalfoglou, 03] Kalfoglou, Y., Schorlemmer, M.: *If-map: an ontology mapping method based on information flow theory*, Journal of data semantics, Springer Berlin / Heidelberg, LNCS 2800, 98–127 2003
- [Kimball, 98] Kimball, R.: *The operational data warehouse*, DBMS, 11(1), 14-16 1998.
- [Klein, 01] Klein, M.: *Combining and relating ontologies: an analysis of problems and solution*, In Proc. Workshop on Ontologies and Information Sharing (IJCAI-01), Seattle, USA, 53-62 2001
- [Lamarre, 04] Lamarre, P., Cazalens, S., Lemp, S., Valduriez, P.: *A flexible mediation process for large distributed information systems*, In CoopIS/DOA/ODBASE (1), LNCS vol. 3290, Springer, 19-36 2004
- [Maiz, 07] Maiz, N., Bentayeb, F., Boussaid, O.: *Ontology based mediation system*. In Proc. 18th Information Resource Management Association International Conference (IRMA 07), Canada, May 2007
- [Mascardi, 10] Mascardi, V., Locoro, A., Rosso, P.: *Automatic Ontology Matching Via Upper Ontologies: A Systematic Evaluation*. IEEE Transaction on Knowledge and Data Engineering. Vol. 2 (5), pp. 609-623. 2010.
- [McGuinness, 00] McGuinness, D., Fikes, L., Rice, J., Wilder, S.: *An environment for merging and testing large ontologies*, In Proc. 7th Intl. Conference on Principles of Knowledge Representation and Reasoning, Breckenridge, CO, USA, 483–493 2000
- [Mena, 00] Mena, E., Illarramendi, A., Kashyap, V., Sheth, A., P.: *OBSERVER: An approach for query processing in global information systems based on interoperation across preexisting ontologies*, International Journal DAPD, 8(2), 223-271 2000

[Noy, 03] Noy, N.F., Musen, M.A.: The PROMPT suite: interactive tools for ontology merging and mapping. *IJHCS*, Elsevier, vol. 59(6), 983–1024 2003

[Ont, 10] <http://lsiit-old.u-strasbg.fr/afd/sites/fodomust/fr-accueil.php>

A Semantic Spatial Hypertext Wiki

Carlos Solis

(Lero, the Irish Software Engineering Research Centre, University of Limerick, Limerick
Ireland
carlos.solis@lero.ie)

Nour Ali

(Lero, the Irish Software Engineering Research Centre, University of Limerick, Limerick
Ireland
nour.ali@lero.ie)

Abstract: Spatial Hypertext Wiki (ShyWiki) is a wiki which represents knowledge using notes that are spatially distributed in wiki pages and have some visual characteristics such as colour, size, or font type. Spatial and visual characteristics are important in a wiki to improve human comprehension, creation and organization of knowledge. Another important capability in wikis is to allow machines to process knowledge. Wikis that formally structure knowledge for this purpose are called semantic wikis. This paper describes the semantic wiki capabilities of ShyWiki. ShyWiki can represent knowledge at different levels of formality. Users of ShyWiki can annotate the content and represent semantic relations without being experts of semantic web data description languages. The spatial hypertext features make it suitable for users to represent unstructured knowledge and implicit graphic relations among concepts. In addition, semantic web and spatial hypertext features are combined to represent structured knowledge. The semantic web features of ShyWiki improve navigation and publish the wiki knowledge as RDF resources, including the implicit relations that are analyzed using a spatial parser.

Keywords: Semantic Wiki, Spatial Hypertext, ShyWiki, Semantic Web

Categories: H.5.3, H.5.4

1 Introduction

A wiki is a web based system that allows users to collaborate and incrementally create hyperlinked web pages [Leuf, 01]. Wikis have low technical barriers, a collaborative shared information space, and are a way for providing read and write access to hypertext documents. These characteristics make wikis a popular solution for knowledge management [Wagner, 05]. Wikis permit knowledge management tasks such as capturing, searching, and sharing knowledge to be performed in an open, collaborative and distributed way.

The Semantic Web allows machines to access web textual content by enriching it with typed conceptual graph structures and standard data formats. Navigation, personalization, and search are expected to be enhanced using the semantic web [Berners-Lee, 01]. A semantic wiki uses semantic web technologies to formalize knowledge which can include content, hyperlinks, and wiki pages.

One of the most important design principles that wikis have to satisfy is that they should have low access barriers [Cunningham, 06]. Users must be able to use a

semantic wiki without previous knowledge about the use of the interface or about the semantic web [Schaffert, 08]. This is difficult to achieve in the case of semantic wikis because users have to be experts in using a web data description language and in the use of ontologies. This tradeoff between usability and semantic expressiveness has also been pointed out in [Völkel, 06]. To define machine readable knowledge, users need more formal ways to express knowledge structures. However, formality is harmful for most users [Shipman, 99]. Therefore, formality must be hidden and isolated from semantic wiki users.

In most semantic wikis, users have to explicitly interconnect wiki pages by using typed hyperlinks. However, people who are not experts in semantic wikis find it difficult to identify concepts and relations among them [Shipman, 99]. A way for encouraging users to formalize knowledge is by allowing them to create hypertext that is spatially organized instead of making them articulate explicit relations between two objects. Content that is spatially organized provides easier its navigation, better its presentation, and represents implicit relations that cannot be expressed using hyperlinks.

The Spatial Hypertext Wiki (ShyWiki) is a wiki which represents knowledge using notes, which are spatially distributed in wiki pages and have some visual characteristics such as colour, size, or font type. Spatial and visual characteristics are used to improve human comprehension, creation and organization of knowledge. In previous work, the Spatial Hypertext Model of ShyWiki has been presented in [Solis, 08]. In [Solis, 10], we presented the knowledge management capabilities of ShyWiki by supporting the knowledge conversions in the Knowledge Creation Spiral of Nonaka [Nonaka, 95].

In this paper, ShyWiki is presented as a semantic Spatial Hypertext Wiki, for supporting the collaborative and incremental formalization of knowledge. The knowledge that can be defined in ShyWiki includes unstructured, structured, and RDF machine accessible knowledge. ShyWiki's spatial hypertext features allow users to annotate the content and express implicit relations among wiki concepts. This aids users to gradually formalize knowledge. Users that are not experts in semantic wikis, can define knowledge relations implicitly by using spatial and visual characteristics. The implicit relations among notes are made explicit automatically using a spatial parser. ShyWiki's semantic web characteristics allow content to be structured, and wiki pages and hyperlinks to be typed. In addition, the wiki knowledge is published as RDF data, which allows automated agents to contribute to the wiki knowledge using web services.

This paper is structured as follows: Section 2 presents related work to semantic wikis. Section 3 presents the semantic spatial hypertext wiki, which includes an overview of ShyWiki, the representation of implicit structures and structured knowledge, and the publication of data in RDF. Finally, section 4 gives the conclusions and future work.

2 Related Work

Semantic wikis are tools that provide semantic web knowledge description languages for defining semantics to the content of wikis. Semantic wikis are an effort for allowing end users to collaboratively create semantic web information in an easy way.

According to Millard et al. [Millard, 08], the basic characteristics that make a wiki semantic are:

- **Concepts.** A wiki page represents a concept in a knowledge graph. The content of a wiki page represents the set of properties of a concept.
- **First class types.** The types of the concepts are also defined using wiki pages. Relations can be first class types, and are also represented in wiki pages.
- **Annotations.** Annotations indicate the semantics of the content. Annotations are part of the content of the wiki pages.
- **Typed hyperlinks.** A hyperlink to another wiki page is an association between concepts represented by the connected wiki pages, and it is a semantic relation that has a type.

Some semantic wikis have focused on the creation of semantic annotations. Others have focused on building ontologies, which are used to guide the structure of the wiki hypertext. In the following, examples of semantic wikis are given:

- Platypus [Tazzoli, 04] is one of the first semantic wikis. It allows users to edit a meta-data page for each wiki page, and to create annotations in RDF.
- Semantic MediaWiki [Völkel, 06] extends the popular MediaWiki with typed links, concept types and properties. In addition, it provides wiki page templates.
- Rhizome [Souzis, 05] uses a wiki mark-up language called ZML that allows users to represent semantic properties in the wiki content.
- SemperWiki [Oren, 06] is another semantic wiki that permits to annotate the wiki content using embedded RDF.
- OntoWiki [Hepp, 06] is a collaborative ontology editor and knowledge base. OntoWiki is oriented to the management and building of ontologies rather than in building hypertext content.
- IkeWiki [Schaffert, 06] is based on MediaWiki. IkeWiki has a WYSIWYG editor for updating the wiki pages content and the RDF annotations. IkeWiki allows users to create ontologies, and its annotation editor can use the ontology.
- In SweetWiki [Buffa, 06] the creation of concept types is based on social tagging and folksonomies. The creation of the wiki content is guided by the ontology. It also has a reasoner, and a WYSIWYG editor.

These wikis are able to represent unstructured and structured knowledge using typed wiki pages and hyperlinks. The initial semantic wikis used embedded RDF for the creation of semantic annotations. Embedded RDF can hardly be used by non expert users. The most recent semantic wikis are using WYSIWYG editors in order to aid users in creating annotations and categories of objects.

None of the available semantic wikis uses spatial hypertext for the definition of semantic annotations, and they lack support for expressing implicit relations among concepts. In this case, ShyWiki is an appropriate candidate for defining semantic information and expressing implicit relations among concepts using spatial hypertext.

3 The Semantic Spatial Hypertext Wiki

ShyWiki [Solis, 08] is a wiki which uses spatial hypertext for representing its content. Spatial hypertext [Marshall, 95] is based on using visual and spatial characteristics of hypertext elements for defining the relations among them. The elements of a spatial hypertext document are viewed as notes that are classified through visual clues, or spatial positions that allow users to define implicit relations. For example, related elements can be represented by sharing the same visual and spatial characteristics: colours, borders, position, proximity, geometric relations, etc.

In ShyWiki, each page is a hypermedia document that is identified by its name and is composed of a set of notes (see Figure 1). The notes can contain text, images, and hyperlinks, or a combination of them. The content of the wiki pages is spatially organized: notes may be placed in different regions of the page, or moved around. Notes can also have different sizes and colours. Composite notes can be created by dropping notes inside others.

ShyWiki provides the basic operations to create or modify wiki pages. In the edition mode, a user can perform several actions on: wiki pages such as creating new wiki pages by navigating through a link, and on notes such as creating, content editing, moving, grouping, or transcluding notes. Transcluding a note is including a note defined in another wiki page by reference. In addition, templates can be created and instantiated. A template is a wiki page which includes predefined notes. New wiki pages can be created by instantiating templates. In this way, the notes defined in a template are automatically created in the new wiki page.

The screenshot shows a web browser window titled "ShyWiki - Mozilla Firefox" with the address bar displaying "http://localhost:8080/ShyWiki/ShyWiki?page=Carlos#". The page content is titled "Person: Carlos" and includes a navigation menu with "Search", "Upload", "Log Out", "Edit", "Versions", and "Spatial Parser". The main content area is annotated with several red labels and lines pointing to specific elements:

- Wiki Page Type** and **Wiki Page Name** point to the "Person: Carlos" header.
- Personal Data Cluster** points to a yellow-bordered box containing a form with fields for "First Name" (filled with "Carlos"), "Last Name" (filled with "Solis"), "Phone" (filled with "+353 00 00 01"), and "Email" (filled with "carlos.solis@lero.ie").
- Properties Names** points to the labels "First Name" and "Last Name" within the form.
- Composite Note** points to a light blue box containing a "Club Friends Vertical List" with two entries: "Friend Fragiskos" and "Friend John".
- Typed Links from Template** points to a yellow box labeled "Best Friend" with the value "John" below it.
- Typed Links Note** points to a yellow box titled "Typed Links" containing a list: "Best Friend (Person) Nour", "Friends (Person) Fragiskos", "Friends (Person) John", and "Pet Jess".
- Link Type** and **Node Type** point to the text "(Person)" and "(Person)" respectively in the "Typed Links" list.
- Target Node** points to the text "John" in the "Friends (Person) John" entry.
- A Typed Link (Not from template)** points to a pink box containing the text "Jess is my pet".
- Map Notes** points to a diagram showing a box labeled "Carlos" connected to a box labeled "pet", which is then connected to a box labeled "Jess".

Figure 1: A ShyWiki Page

Semantic wikis give support to structured knowledge and its publishing. Structured knowledge is defined in terms of concepts, properties, and types of concepts and relations. Publishing knowledge implies using a semantic web standard [Millard, 08]. These characteristics are supported in ShyWiki. In addition to the traditional semantic wiki characteristics, ShyWiki gives support to the implicit semantic behind visual and spatial organization of concepts, which is made explicit using a spatial parser. In the following, we explain how the semantic wiki characteristics are supported in ShyWiki.

3.1 Representing Implicit Relations and the Spatial Parser

In ShyWiki, it is possible to capture implicit relations among notes in a wiki page using visual and spatial properties. Logic and cardinality relations can be expressed using visual and spatial properties [Francisco-Revilla, 05]. The following logic relations can be expressed graphically in ShyWiki: disjoint (notes not touching each other), intersection (a note partially over another), part of (a note inside another), and connection (a note touching the border of another). Users do not have to explicitly think in terms of logic relations when they are organizing the hypertext spatially. This does not represent a cognitive overhead to the users.

A group of elements which are near each other define a cluster. The elements in a cluster can also form structures as lists and stacks. ShyWiki can identify several emergent hypertext structures using a spatial parser, which is a program that recognizes implicit relations represented through spatially organized structures and makes them explicit in order to allow machines to interpret them [Marshall, 94].

ShyWiki's spatial parser is based on the spatial parser implementation described in [Igarashi, 95], which takes into account spatial attributes. ShyWiki spatial parser can recognize three spatial structures: clusters, vertical lists, and horizontal lists.

The spatial parser creates labelled graphs to identify spatial relations. A graph is created as follows: For each note-*i* the parser creates a vertex, and for each note-*x* that is near to note-*i*, it creates an edge between note-*i* and note-*x*. In addition, each edge is labelled as a vertical list, a horizontal list or a cluster type. An edge is typed as vertical or horizontal list, if the distance is less than list-distance and the notes are vertically or horizontally aligned. If the edge is neither a vertical nor a horizontal list and the distance is less than the cluster-distance, then the edge is labelled as a cluster type. Once the graphs are created, the parser analyzes if a graph has the same edge labels. If a graph contains lists and cluster types, then the implicit structure is identified as a cluster. If a graph contains only list edges of the same type, then the graph is identified as a list. If a graph contains vertical and horizontal list edges, then several vertical and horizontal lists are identified.

To work with the spatial parser, users have to enter to the spatial parser mode of ShyWiki. The spatial parser mode presents a drop down list of the identified spatial structures. If the user selects an item from the list, then the wiki page only shows notes that form part of the structure. In this way, users can observe a single implicit structure recognized by the spatial parser. Users can give a name to any recognized structure, and indicate if it will be published in the RDF wiki (see section 3.3). In this way, the implicit visual structures become explicit and are readable by machines. For example, the spatial parser recognizes in the wiki page shown in Figure 1 that *Phone*

and *Email* are *PartsOf Contact Data*, and recognizes the *Club Friends* structure as a vertical list, and *Personal Data* as a cluster.

3.2 Representing Structured Knowledge

This section presents how structured knowledge is represented in ShyWiki. ShyWiki supports the characteristics that Millard *et.al.* [Millard, 08] defined and were discussed in section 2. In the following, these are explained:

Concepts. ShyWiki can be seen as a graph knowledge structure, where the nodes are wiki pages, and the hyperlinks are associations (relations) between concepts. Therefore, a ShyWiki page is a concept. In Figure 1, the concept shown is called *Carlos* which is the name of the wiki page.

Annotations. In ShyWiki, any note in a wiki page can be optionally named. A named note is a property of the concept represented by a wiki page. A named note is also a semantic annotation of the content, and serves to describe it. In Figure 1, the concept *Carlos* has the attributes *First Name*, *Last Name*, *Contact Data*, *Phone* and *Email*.

Typed Hyperlinks. Hyperlinks represent associations between wiki pages. ShyWiki hyperlinks can be typed or not. The type of a relation can be indicated by means of a label in the wiki mark-up language by using the following notation: `[[target wiki page / label]]`.

ShyWiki provides explicit visual representation of relations. In the navigation mode, each ShyWiki page automatically presents a note called *Typed Links* (see Figure 1). This note summarizes the set of typed links defined in the wiki page. For each typed link, the label of the link, the target wiki page and its type are shown. Figure 1 has a note with the text *Jess is my pet*, where the hyperlink in the word *Jess* is labelled as *Pet* and defined in the wiki mark up language as: `[Jess/Pet]`. In addition, ShyWiki has a special kind of note called *MapNote*, which is used to explicitly draw labelled hyperlinks between two concepts (wiki pages). A wiki page can have a *MapNote* of any concept in ShyWiki. For example, in Figure 1, *Carlos* and *Jess* map notes have been added. As a result, ShyWiki draws the *Pet* label and an arrow between *Carlos* and *Jess MapNotes*.

First Class Types. In ShyWiki, concept types are supported through templates. A ShyWiki template is an abstraction that represents a set of concepts which share common properties and relations. Templates permit structured knowledge definitions to be reused. A template has a unique template name. In ShyWiki, properties and relations are defined in the following way: A property is defined by a content note with a name. If the note has some content, this content becomes the default value of the property in the instances. Relations are defined by a named note that contains a typed hyperlink. The content of the note must include a link to another template (a drop down list of templates is presented to the user, see Figure 2), and the name of the relation is the same as the name of the note. Users have the options to define relations that relate one or many elements, and to define a default spatial distribution for the elements in one to many relations as vertical or horizontal lists.

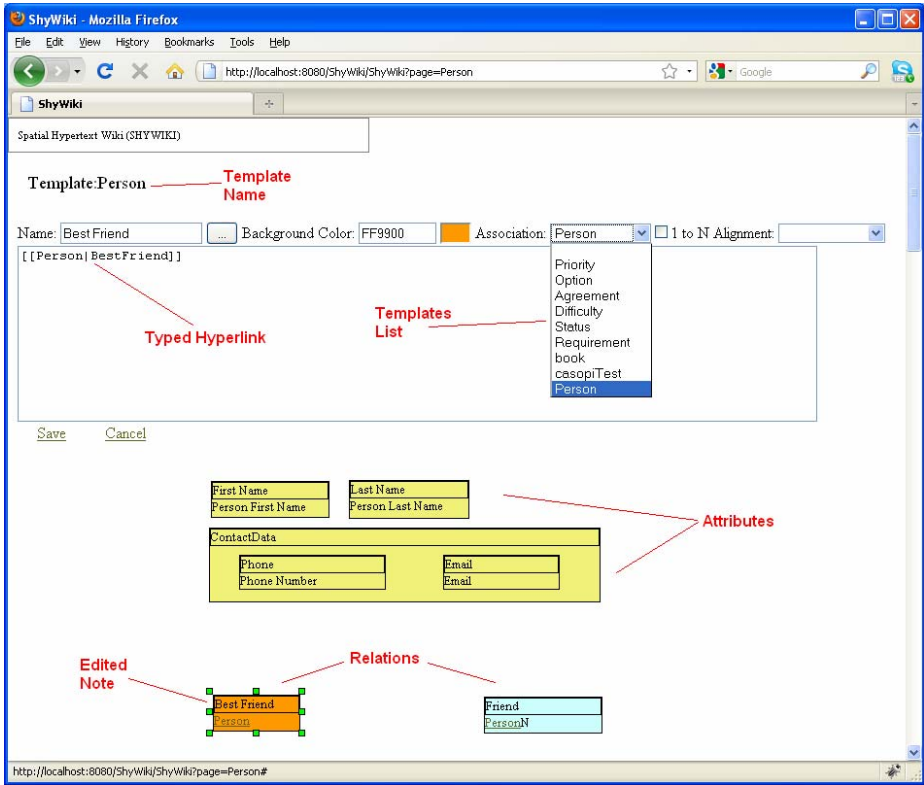


Figure 2: The Person template in edition mode

Figure 2 shows that the user has defined a template called *Person*. It is composed of 7 notes. Each note is defined by giving it a name, a colour and optionally indicating if it represents an association. When a note represents a property, then only the name and colour have to be defined. In Figure 2, the notes *First Name*, *Last Name*, *Contact Data*, *Phone* and *Email* are properties, and the notes *BestFriend*, and *Friend* are relations. Figure 2 also shows how the orange note (the note on the left bottom side) which corresponds to the *BestFriend* relation is defined. The note's name defines the name of the relation. Then, the associated element is selected from the template list which in this case is *Person*. The content of the note is then defined automatically by creating a typed hyperlink to a *Person* instance, which is labeled as *BestFriend*. The blue note (the note on the right bottom side) corresponds to the *Friend* relation. Its cardinality is 1 to N and it contains a hyperlink to a *Person*. In the template instances, the relations are defined with the help of the note editor which allows users to choose the associated instances using a drop down list, and creates the typed hyperlinks for them. In Figure 1, *Nour* is the best friend of *Carlos*, and *Fraguiskos* and *John* are friends of *Carlos*.

3.3 Machine Accessible Knowledge

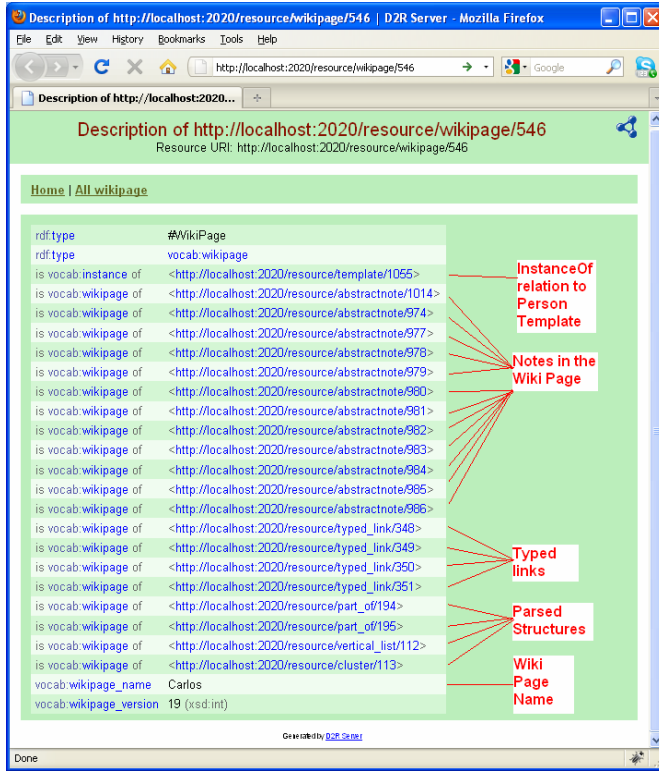


Figure 3: HTML view of the RDF resource Carlos wiki page

The publication of ShyWiki content as an RDF graph is done using D2R server [Bizer, 03]. D2R is a tool for publishing data which is stored as an RDF graph in relational databases, and also provides a SPARQL query interface. All the wiki pages and notes are published as RDF resources. The agents that need to read the semantic content of a wiki page can access the RDF projection of the page by means of the link relation included in the HTML: `<link rel = 'alternate' type = 'application/rdf+xml' href = 'http://localhost:2020/data/wikpage/546?output=rdfxml' title = 'This page in RDF'>`.

The RDF resource that describes a wiki page includes the following: the name of the wiki page, its type if it is an instance of a template, the list of notes it contains, and its typed hyperlinks. The implicit relations of “intersection”, “connect”, and “part of” are also included in the RDF. The disjoint relation can be inferred using the list of notes and the intersections. Each note, the implicit relations, typed hyperlinks, and parsed structures are described in a different RDF resource.

The content of the wiki can be read or written by agents because ShyWiki is a service oriented wiki [Solis, 08]. The ShyWiki web client interacts with the server using Asynchronous JavaScript and XML (AJAX) web services. These services can be used by other agents that are different than a web browser to interact with ShyWiki.

Figure 3 shows the HTML view of the RDF resource of the wiki page *Carlos*. It indicates the name of the wiki page (Carlos), the version (19), and a list of notes that it contains. Each note and implicit relations are described in another RDF resource. Users of ShyWiki do not have to deal with RDF definitions. The projection to a machine readable format is automatically generated when the wiki pages are saved. Users only have to manipulate and add notes to create properties, or use templates and labeled links. The RDF ShyWiki is a parallel wiki for computers. In this way, users only work with ShyWiki without worrying about the semantic notation.

4 Conclusions and Future Work

This paper has presented the characteristics of a Semantic Spatial Hypertext Wiki (ShyWiki). ShyWiki uses spatial hypertext to represent wiki pages content, which is formed of spatially organized notes. Spatial hypertext is a rich paradigm that permits ShyWiki to represent different types of knowledge. Unstructured knowledge is represented in the form of text and images contained inside notes. ShyWiki by means of spatial and visual properties can represent implicit relations among notes, which are recognized using a spatial parser, and published as RDF resources.

Similarly to other semantic wikis, ShyWiki can also represent structured knowledge. ShyWiki can have wiki page types that are used to define shared attributes and relations of a set of concepts. Any hyperlink can be typed, and ShyWiki can display graph relations by means of *MapNotes*. In addition, the attributes and typed relations of wiki pages are displayed in order to help users in their navigation. The knowledge stored in the wiki can be unstructured in the form of implicit relations, or structured. Both, can be transformed and published as RDF. This allows agents to manipulate the stored knowledge.

We are currently working on improving ShyWiki by giving better support to collaborative annotation and reducing information overload using superimposed information sets. In this way, notes can belong to different layers and users can hide or show them depending on their needs. Scalability can be also supported by providing layers because the information can be divided between them. As future work, we plan to improve the spatial parser in order to detect cardinalities, and types associated to a relation by using note types and visual characteristics. In addition, we are planning to perform a user evaluation of the semantic features.

Acknowledgements

This work was supported, in part, by Science Foundation Ireland grant 03/CE2/I303_1 to Lero - the Irish Software Engineering Research Centre (<http://www.lero.ie>).

References

[Berners-Lee, 01] Berners-Lee, T., Hendler, J., Lassila, O.: The semantic web, *Scientific American*, 5(238), 34-43, 2001.

- [Bizer, 03] Bizer, C.: D2R Map- A Database to RDF Mapping Language, In WWW (Posters), 2003.
- [Buffa, 06] Buffa, M., Gandon, F.: SweetWiki: semantic web enabled technologies in wiki, In Proceedings of the International Symposium on Wikis, 69–78, 2006.
- [Cunningham, 06] Cunningham, W.: Design principles of wiki: how can so little do so much? In: WikiSym '06: Proceedings of the 2006 international symposium on Wikis. pp. 13-14. ACM 2006.
- [Francisco-Revilla, 05] Francisco-Revilla, L., Shipman, F.M.: Parsing and interpreting ambiguous structures in spatial hypermedia, In Proceedings of the International Conference of Hypertext and hypermedia, 107-116, 2005.
- [Igarashi, 95] Igarashi, T., Matsuoka, S., and Masui, T.: Adaptive recognition of implicit structures in human-organized layouts, In Proceedings of the International Symposium. on Visual Languages, 1995.
- [Hepp, 06] Hepp, M., Bachlechner, D., Siorpaes, K.: Ontowiki: community-driven ontology engineering and ontology usage based on wikis, In Proceedings of the International Symposium on Wikis, 143-144, 2006.
- [Leuf, 01] Leuf, B., and Cunningham, W.: The Wiki Way: Quick Collaboration in the Web. Addison-Wesley Longman, Boston, USA, 2001.
- [Marshall, 94] Marshall, C.C., Shipman, F.M., and Coombs, J. H.: VIKI: spatial hypertext supporting emergent structure. In Proceedings of the 1994 ACM European Conference on Hypermedia, 13-23, 1994.
- [Marshall, 95] Marshall, C.C., Shipman, F. M.: Spatial hypertext: designing for change. Communications of the ACM, 38(8), 88-97, 1995.
- [Millard, 08] Millard, D., Bailey, C., Boulain, P., Chennupati, S., Howard, Y., Davis, H. and Wills, G.: Semantics on Demand: Can a Semantic Wiki Replace a Knowledge Base? *New Review of Hypermedia and Multimedia*, 14 (1), 95-120, 2008.
- [Nonaka, 95] Nonaka, I., Takeuchi, H.: The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press, USA, May 1995.
- [Oren, 06] Oren, E., Volkel, M., Breslin, J.G., Decker, S.: Semantic wikis for personal knowledge management, In Database and Expert Systems Applications, 509–518, 2006.
- [Schaffert, 06] Schaffert, S.: IkeWiki: A Semantic Wiki for Collaborative Knowledge Management, In Proceedings of the 15th IEEE international Workshops on Enabling Technologies: infrastructure For Collaborative Enterprises, 2006.
- [Schaffert, 08] Schaffert, S., Bry, F., Baumeister, J., and Kiesel, M.: Semantic wikis, *IEEE Software*, Vol. 25, No.4, pp. 8–11, 2008.
- [Shipman, 99] Shipman, F. M., Marshall, C.C.: Formality Considered Harmful: Experiences, Emerging Themes, and Directions on the Use of Formal Representations in Interactive Systems, *Computer Supported Cooperative Work*, (8)4, 333-352, 1999.
- [Solis, 08] Solis, C., Ali, N.: ShyWiki-A Spatial Hypertext Wiki, In Proceedings of the International Symposium on Wikis, 2008.
- [Solis, 10] Solis, C., Ali, N.: A Spatial Hypertext Wiki for Knowledge Management, In Proceedings of International Symposium on Collaborative Technologies and Systems, 225-234, 2010.

[Souzis, 05] Souzis, A. : Building a Semantic Wiki. *IEEE Intelligent Systems* 20(5), 87-91, 2005.

[Tazzoli, 04] Tazzoli, R., Castagna, P., and Campanini, S.E.: Towards a Semantic WikiWikiWeb, In Proceedings of the International Semantic Web Conference, 2004.

[Völkel, 06] Völkel, M., Krötzsch, M., Vrandečić, D., Haller, H., Studer, R.: Semantic Wikipedia. In Proceedings of the 15th International Conference on World Wide Web, 585-594, 2006.

[Wagner, 05] Wagner, C. Bolloju, N.: Supporting knowledge management in organizations with conversational technologies: Discussion forums, weblogs, and wikis, *Database Management*, 16(2), 1–8, 2005.

Engineering 2.0: Leveraging a Bottom-up and Lightweight Knowledge Sharing Approach in Cross-functional Product Development Teams

Marco Bertoni

(Luleå University of Technology, Luleå, Sweden
berber@ltu.se)

Koteshwar Chirumalla

(Luleå University of Technology, Luleå, Sweden
kotchi@ltu.se)

Abstract: The paper explores the application of Web 2.0 technologies in the engineering product development domain. Growing on data collected from a number of industrial development projects, related to several different products in various industry segments, the paper analyses the dichotomy between the prevailing hierarchical structure of CAD/PLM/PDM systems and the emerging principles of the Social Web, e.g. the self-organization of its users. It introduces the concept of Engineering 2.0, intended as a more bottom up and lightweight knowledge sharing approach supporting early stage design decisions within cross-functional product development teams. A set of scenarios related, for instance, to the application of blogs, wikis, forums and tags in the engineering domain are eventually presented, highlighting opportunities, challenges and no-go areas.

Keywords: Engineering 2.0, Product Development, Web 2.0, Functional Product Development, Cross-functional teams.

Categories: K.4.3, L.6.1, L.6.2, M.0, M.1, M.2, M.5, M.7

1 Introduction

In a “traditional” product development situation, the product specifications are grown from high-level, pre-defined archetypes (e.g. a screwdriver, a car, a washing machine) and then refined in greater detail adding additional subsystem levels until the system is reduced to base elements in a hierarchical top-down flavour. The engineering work is well supported by computer aided engineering applications such as, to mention a few, CAD (Computer Aided Design), FEM (Finite Element Method), PDM (Product Data Management), PLM (Product Lifecycle Management), and KBE (Knowledge Based Engineering). These systems are proven to provide adequate support in managing structured product information and formal communication, such as project documents, design drawings, lessons learned, best practices records and others.

More recently companies have started to extend traditional product-centred offers to incorporate more intangible assets, i.e. software and services, to secure their aftermarket and take on lifecycle responsibilities. The focus has been increasingly shifted from “selling” a product to “providing” a function (i.e. selling Functional Products [Isaksson, 09], or Product Service Systems [Baines, 07]), extending the

traditional functionalities of the hardware to satisfy increasingly sophisticated customer needs. Product Service Systems (PSS) can be considered an evolution of the leasing/pooling model, where the manufacturer maintains the ownership over the product, becoming responsible for the availability of the function through the entire life cycle, and requests the customer to pay only for the provision of agreed results.

This approach impacts the way the hardware is conceived in an early stage. Given that the ultimate design goal is even more shifted from the achievement of technical performances to the fulfilment of the customers' expectations and needs, designing a physical solution optimized towards the provision of "value" becomes the imperative for the engineering team. However, the way a certain design alternative impacts on the customer value scale can be not straightforwardly understood in an early stage, thus the capability to identify, retrieve and visualize value-related knowledge represents both a dream and an obstacle for those companies aiming to adopt the new paradigm. To further complicate the problem, "value" refers to different stakeholders and users, belonging to different organizations and groups, sitting in different locations, and who may have totally different perceptions on what value entails.

An interesting parallelism can be drawn observing how Web 2.0 technologies are revolutionizing the way information and knowledge is managed in favour of a more collective sense-making approach to knowledge exchange, enabling users to add "value" to the network by turning personal benefits public [Tang, 07]. This parallelism suggests that Web 2.0 may provide those capabilities that product developers are struggling for (i.e. grasping and understanding the value for the customer) and that are poorly supported by the traditional knowledge management solutions.

2 Purpose and objectives

In this paper, the authors make the assertion that bottom-up and lightweight technologies can have a serious potential when it comes to effectively share knowledge between actors partaking in product development in a virtual context with focus on PSS. In spite of such an opportunity, companies find difficult to adopt and successfully exploit Web 2.0 methods and tools in the organization.

The purpose of this paper is to define and discuss the Engineering 2.0 [Larsson, 08] concept, highlighting the context it originates from and the way it may enhance collaboration across dislocated and cross-functional design teams. The paper exemplifies how tools like e.g. blogs, wikis or forums can be applied in the everyday designers' work to support, for instance, the development of an aircraft engine going to be sold as functional product. Eventually, it collects application examples and lessons learned from a field study conducted in the frame of two major European projects in the manufacturing industry, highlighting the major issues and the low-hanging fruits of the 2.0 paradigm in the product development context.

A delimitation of this paper is its focus on "engineers", i.e. on the "engineering task" and on how Web 2.0 technologies can support globally dispersed engineering teams working in a business-to-business situation, where the available technology support for knowledge sharing still centers heavily on comparably "heavyweight" and top-down technologies like CAD, PDM, and PLM systems.

3 Methodology

The starting position of this research is in real industrial cases rather than in theory. The research strategy combines a case study approach [Yin, 94] and ethnographic methods [Blomberg, 93] to verify the approach close to technology and product development activities in industry. The discussion has evolved in the authors' research context, drawing on data from a number of industrial development projects related to several different products in various industry segments. In recent time, the participation in two large research projects has provided access to several international manufacturing companies and numerous people from these companies, thus the identification of the problematic situations has been noticed in the larger empirical context. The authors have conducted a number of multi-day workshops, participated in virtual meetings and made company visits to perform interviews on both a formal and informal basis.

4 Engineering 2.0: motivation

An illustration of the new “functional product” idea is apparent in the Total-Care Package [Shehab, 06] offered by Rolls-Royce plc. Rather than transferring the ownership of an engine to the airlines, the provider delivers “power-by-the-hour”, i.e. requests the customer to pay only for the use of the product, while retaining the ownership of the hardware. In this way it can maintain direct access to the asset, enabling the monitoring of the product performances in use and growing experience on how the hardware is operated through the lifecycle. This information can be used later to improve performance parameters (for example, maintenance schedules etc.), engine efficiency, asset utilization, and, eventually, to add value to the users and all the stakeholders.

Intuitively, the knowledge base from which the product specifications are drawn has to be extended to encompass all the product lifecycle phases, to know more about the ultimate customer needs, their value scale, and to tailor the hardware for a successful functional life, lowering the risk of realizing unprofitable products.

In the earliest design phases, engineers need to take crucial decisions regarding the structure of the functional offer and, consequently, on the hardware. In spite of working in a larger extent with ill-defined problems (i.e. deciding the right product-service mix), the design team has to decide over a number of question whose outcomes will impact on the business for many years to come, thus moving back and forth between “solving” a technical problem, and “predicting” lifecycle opportunities and inconveniences. The blurrier context in which product development takes place emphasizes the importance of having the right knowledge at the right time to make the right decision.

An aircraft engine is a complex product, composed by thousands of parts, with expected lifecycle of 30-40 years. Very few companies have competences, knowledge and skills to cope with the development and supply of both the hard and the soft parts of the offer in house. A way to cope with such limitations is to establish a closer collaboration with a multitude of actors across the value chain, building strategic alliances with customers, suppliers, contractors, distributors, competitors and research

centres [Isaksson, 09] and to be able to share knowledge in an open mode with them. In a Virtual Enterprise (VE) [Davidow, 92] of this kind no single company can impose its own knowledge management solution. The development of an ad-hoc collaboration platform, on the other extreme, is costly, time-consuming and difficult to configure and maintain only following a top-down logic, since nobody in the organization has knowledge in all the single aspects of the functional product.

The VE partners are requested to collaborate in an early stage and share experiences, know-how and feedback to interpret and define what customer value is (and what it would be in 5, 10 or 30 years). Each partner can have important information about, for instance, the role of consumers, retailers, customer support and maintenance [Isaksson, 09], which may allow to gain deeper insights into the basic reasoning that makes the customer link the use of performance to perceived added value. The prevailing hierarchical structure of the traditional information sharing solutions seems to contrast with the need to acquire knowledge and obtain feedbacks from a large network of independent and geographically dispersed peers. The knowledge contributors may have different roles, background, computer skills and may belong to different organization. They may find cumbersome or even impossible to interact with domain-specific applications such as CAD, PDM or PLM, leading to a situation where the vast majority of people who might have knowledge about the emerging aspects of the product cannot contribute in populating the knowledge base.

Eventually, to further complicate the picture, Bell argues from his study that 80% of the organizational knowledge is stored in people's heads, while only one fifth is formalized in Office documents e-mails, databases, XML data, etc. [Bell, 06]. This informal knowledge exchange takes place by means of emails, phone conversations, face-to-face meetings or video-conferencing, that is difficult to capture and store for later reuse. In a functional product development context this figures are likely to be higher due to the stronger focus on the intangible aspects of the product, i.e. software and services.

These factors represent a great obstacle when engineers require authentic information, expert help, or when there is a need to search and retrieve quality information. The authors believe that collaborative solutions in this context cannot be imposed top-down, but rather adapted to the capabilities, skills, understanding of all the actors involved, in a more bottom-up flavour.

5 Engineering 2.0: definition and key features

Many organizations have started to investigate the use of Web 2.0 technologies in their working environment. MacAfee summarizes the rising company interest in the use of Web 2.0 tools for generating, sharing and refining knowledge in a global setting with the term Enterprise 2.0 [McAfee, 06]. Other authors have discussed the impact of the social web in knowledge management [Richards, 09], sometime using the term Knowledge 2.0 to summarize the upcoming trend [Levy, 09].

The emerging interest towards bottom-up and lightweight applications in product development is well summarized by a recent McKinsey [Bughin, 09] survey, showing that more than 2/3 of 1700 companies interviewed worldwide have investigated or deployed Web 2.0 tools to support their product development activities.

Several initiatives are currently ongoing to integrate social features with traditional engineering tools. PTC is exploring how to leverage social interaction and collaborative features, among global design teams, complementing CAD/PDM tools with Web 2.0 applications [Shoemaker, 09]. Some other examples are Dogear social bookmarking from IBM or the Quest internal communications system from Microsoft [Patrick, 07], which includes a wiki system for effective knowledge codification and sharing. PLM systems have also been extended by incorporating Web 2.0 tools [Hóimyr, 07]. Eventually, Dell IdeaStorm [Di Gangi, 09] represents an example of how idea crowdsourcing may be exploited in an early design stage of new products.

In order to capture this emerging interest Larsson et al. [Larsson, 08] have coined the term Engineering 2.0, borrowing from the concepts of Web 2.0 [O'Reilly, 05] and Enterprise 2.0 [McAfee, 06]. This term summarizes an approach for engineering knowledge sharing that support: 1) lightweight programming models to enable loosely coupled Virtual Enterprise networks; 2) syndication rather than coordination of data, where the content flows from the bottom-up rather than from the top-down; 3) re-use and remixability in an open-source model, where knowledge can be used for other purposes than it was originally intended for.

Engineering 2.0 technologies are bottom-up and lightweight in the sense that: 1) require little time and effort to set up, use and maintain, lowering the threshold for adopting the technologies; 2) do not impose a pre-defined structure, but rather let structures evolve over time as an almost organic response to the activities, practices and interests of the knowledge workers; 3) support informal communication also in absence of physical proximity, capturing the subtle, spontaneous, and multidimensional messages that characterize personal interaction.

Engineering 2.0 technologies, with their underlying social features, may provide better conditions for knowledge sharing between virtual teams, encouraging engagement, participation, cooperation and sharing of ideas.

6 Engineering 2.0: a scenario collection

This section exemplifies the way Web 2.0 tools may be used by virtual and cross-functional design teams to capture, store, share, visualize and use lifecycle knowledge. These examples have been elaborated from the data gathered during the company field study and have been collaboratively discussed and refined with the industrial partners.

Weblogs might be used as a platform for early feedback from external stakeholders and employees, allowing them to engage in the discussion [Payne, 08] [Jim, 09] on product and service offerings. New ideas and findings on innovation projects could be presented to a larger audience as an entry in the weblog, lowering the threshold for commenting and expressing opinions or document personal experiences. Weblogs may represent the primary 2-ways communication channel to exchange knowledge between the organization and the large customer base, thus allow capturing customer usage patterns, their needs and demands.

Open authorship can leverage the way best practices or lessons learned are gathered from the different product life-cycle phases. Wikis, with their asynchronous, bottom-up and informal nature, may facilitate experience sharing among the stakeholders, building an informal memory for the Virtual Enterprise. Wikis may also

be used as a space to collaboratively grow ideas for future products, e.g. in the area of service provision, letting stakeholders propose innovations and changes directly building from the ideas of the others.

Social networking may help newcomers in exploiting the network of connections that distinguishes more experienced engineers, finding people with the right expertise inside and outside the company, i.e. “knowing who knows” [Groth, 04]. Alternatively, it may support the identification of stakeholders with similar interests across department and organizations, thus enabling the formation of cross-functional interest groups.

Virtual Enterprises are made of teams functioning simultaneously and updating key information from projects, themes, and discussions into various databases, blogs, wikis, and forums. This may eventually lead to information overload and difficulties to consolidate the updates from several sources. RSS feeds could allow design team members to subscribe their choice of content resources to get regular updates in a standardized format, pushing relevant information to the users at the right time in the right place. Organizations might create RSS pages to accumulate all updates from various databases that are specifically customized for the employees’ needs, and can help them getting an overview of the hot topics in the organizations.

The development of PSS requires long-term commitments throughout the product life cycle. It asks for easy-to-use platforms where to discuss product-related issues over a prolonged period of time. Forums could allow engineers to raise critical issues with the other partners in the network, managing heavily moderated topical conversations over a prolonged period [Mayfield, 09]. Forums can be used to scale up internal conversations and to get feedback from experts in various domains and disciplines.

Tagging practices may facilitate the discovery of relevant knowledge outside the product development boundaries. The knowledge codified by the VE stakeholders may be put into different bins at a time (per customers, competitors, projects, product types, maintenance and service offerings) making easier for others to locate and fetch information tagged in the same way from different sources. Tagging, moreover, enables the generation of user-generated taxonomies (i.e. folksonomies [Mathes, 04]) that organizations can use to consistently update their corporate taxonomies based on the popular tags from tag clouds, hit ratios and context [Ramamoorthy, 07].

Social bookmarking, as a method to store, organize and share bookmarks of web, may enable global engineering teams to search and find experts on specific topics, or people with similar interests in the projects, based on informal browsing of bookmark collections. Research engineers from various organizations can share their research with peers and allow others to rate and review to decide on usefulness of resources.

Instant messaging may improve the codification and traceability of the synchronous and informal communication that generally takes place via means of phone calls or face-to-face meetings. Short one-to-one conversations may be recorded and stored for later reuse and can be easily escalated involving multiple participants. As a side consequence, it can enhance the sense of community and accessibility, which facilitates collaborative learning environments across PSS engineering teams.

Microblogging may also act as an informal communication channel for collaborative work in multi-disciplinary teams, lower the threshold for sharing knowledge with a large audience compared to email, instant messaging and forums

[Mayfield, 09]. Microblogs might be used to spread innovative ideas, quotes, or links that may allow others to give real-time and focused feedback on technical or service matters. It might be possible to locate and follow experts in a VE setting, asking questions and getting answers, ultimately creating a learning experience and fostering professional connections.

7 Lesson learned from the field study

Although companies recognize the value of the 2.0 paradigm for leveraging creativity and information sharing in the design of new products, its uptake in industry is still limited. This section aims to summarize the major constraints and the most appealing areas for the implementation of Web 2.0 technologies, as emerged from the data gathered in the manufacturing industry.

7.1 Major barriers for Engineering 2.0 adoption

The discussion with the industrial partners has outlined a number of issues from a methodological and technological perspective that need to be addressed before a wide adoption of Web 2.0 tools could be achieved. From a technological perspective, the availability of ad-hoc mash-ups coping with the specific engineers' tasks and interests is needed. On the methodological end, the availability of robust guidelines, especially concerning security and privacy issues, is seen as a major enabler for scaling-up the approach.

The active user participation is perceived as a major constraint. Incentive policies seem to be insufficient in a situation where engineers have to "do the job" and deliver within strict deadlines. Finding ways to further reduce the effort for knowledge formalization and exchange becomes an imperative, although it may not be enough in the long term. Even the lower threshold may be seen insurmountable if people cannot see the advantage of adopting the tools compared with traditional systems. The benefit/effort ratio comes into focus to get mass participation. From this viewpoint the discussion has highlighted three main areas where benefits can be gained through a more bottom-up strategy in sharing: 1) by providing more customized knowledge at the right time, e.g., filtering the query results on the basis of their applicability and pushing information to the end users; 2) by helping engineers in finding the unexpected, locating expertise and knowledge sources in the organization and facilitating the serendipitous discovery of "unknown unknowns" [Modica, 94]; 3) by helping decision makers in recognizing relevant patterns, e.g. improving information visualization and aggregating inputs from many sources via ad-hoc mash-ups.

However, as far as the solution is populated over time, noise, spam and duplicated information increase as well, leading to a situation where the system is no longer lightweight, but cumbersome to navigate and poorly reliable. Many of the respondents in the aerospace industry have expressed major concerns about the quality of the information shared by the peers with Web 2.0 tools. Dealing with very critical product aspects, such as passenger safety, decisions have to be based on "verified" facts. A major concern about Web 2.0 is the tendency of being dominated by the loudest and most persistent voices, exposing engineers to the risk of developing critical solutions growing from personal opinions and interpretations rather than facts.

The leakage of proprietary knowledge is seen as a major threat while discussing Web 2.0 implementation in a cross-organizational setting. The possibility of letting the information flow in such an open mode exposes the company to the risk of being drained of core know-how. Strict policies are advocated as the only means to regulate these flows, although it is not straightforward to understand how these could be established in practice. The lack of clear guidelines affects negatively users' participation too. Without clear indications of what could or could not be shared, users tend to "play safe" and rely only on the traditional CAD/PDM/PLM solutions.

7.2 Key areas for leveraging a bottom-up and lightweight knowledge sharing approach

The discussion with the industrial partners has also outlined areas where the benefit/risk ratio of Engineering 2.0 is particularly high and appealing for the company. The major benefits are seen in the area of: opportunities identification, cross-functional teams composition and design rationale capturing.

When designing a product/service mix, it is increasingly important to have a clear picture of a wide variety of customer needs and to identify opportunities to improve the current offer both from a product and service perspective. The front line, the salesmen and technicians closer to the customer, may know a lot about the value of a solution for the customer. This knowledge cannot be straightforwardly represented within CAD/PDM/PLM solutions, thus Web 2.0 tools could make more explicit what is "hot" at the customer today and facilitating the product development team in aggregating, filtering and validating these heterogeneous inputs. It is not merely a matter of forwarding the customer impressions to the engineers, rather to use the capabilities of the Web 2.0 tools to attach the right context to this information and to better trace how the needs originates and evolve. Weblogs might provide a quick and lightweight way to codify the front line experiences, letting other people with similar interest to rate, comment or ask for elucidations. Alerts might be used to update the product developers about any changes in the global/local databases, while tags might allow to put this information into multiple bins and to push it to the engineers' desktop via dashboard aggregators. The most evident benefits relate to the possibility of reducing the time end effort to identify knowledge owners from the front line, to browse their inputs and to increase the awareness of the multi-functional issues regarding a given topic. Eventually the knowledge contributors may benefit from an increased awareness on people working in similar areas and, consequently, from the learning opportunity offered by their continuous feedbacks.

Web 2.0 technologies can help virtual organizations in identifying the right people to involve in new, consortium-wide, development projects. Social functionalities may support the discovery of people with the right expertise in the virtual organization, thus reducing the time needed to identify and allocate the resources for a project. Using Web 2.0 to develop "capability charts", i.e. the possibility to visualize and compare in a quick and understandable way the main domain of expertise of different people inside the organization, their availability, their network of connections, etc., is an appealing concept. The right match between people and projects will ultimately lead to better team chemistry, higher motivations and increased problem solving capabilities.

Design rationale management is another key area where the advantages of the lightweight and bottom-up paradigm are seen more clearly by the industrial partners. The rationale for decisions/solutions taken in past projects is often lost, hidden in corporate databases that are not readily accessible by the design team once the project is closed. The arguments on which early design decisions are based may remain hidden or out-of-date, especially when the rationale comes from the later lifecycle stages and relates to the way the product is correctly operated, serviced, maintained, dismissed or recycled.

The central idea is to make design rationale capture a more bottom-up activity, involving a larger stakeholders' base in the codification of the argumentations for a certain design decision. This can be pursued in several ways, acting both on the designers and on the lifecycle stakeholders' side. The latter would imply providing low-threshold means to: 1) identify the people "who should know" [Larsson, 08] in the organization; 2) formalize the design rationale carriers' know-why; 3) categorize the arguments for an easier retrieval; 4) push the information almost real time. Lightweight tools should help designers to: 1) locate the design rationale carriers; 2) identify and retrieve the "right" arguments, from multiple disciplines and functions; 3) aggregate information and display links between arguments in a visual way; 4) share the rationale in a controlled way with the other partners in the networked organization.

Wikis may be used on the top of the existing project repositories to collect and give access to the underlying rationale regarding a solution also in case the original documentation is secured. Recommendations and context-based filtering may help to make a more efficient use of the design rationale maps, by supporting users in navigating their branches and identifying the "golden nuggets". Tags may be used to cross-link map nodes in different domains and disciplines, while RSS feeds may aggregate and push real time updates to the engineers' desktop. Context-based filtering may also to control the access to the argumentation list, providing full access to a restricted group of people while excluding others.

8 Conclusions and future work

This paper has introduced and exemplified the concept of Engineering 2.0, intended as a more bottom up and lightweight knowledge sharing approach, able to complement CAD/PDM/PLM systems in the early product development stage when acting in a Virtual Enterprise and cross-functional setting.

The research work has outlined an increasing interest towards the principles of the social web in product development, together with a general lack of understanding on how such technologies could be implemented to support everyday engineering work, i.e. "socializing with a purpose". The benefits of using 2.0 technologies to cope with the engineering tasks are not evident to most of the potential users. Today's perception of the usefulness of mash-ups combining, for instance, blogs, tags and RSS feeds, is particularly low, even in Virtual Enterprise situations where the need for social functionalities might appear more evident at a first look. Moreover, engineering 2.0 can have negative consequences on the preservation of company's proprietary knowledge, e.g. pushing confidential information to unknown subscribers. Strict policies concerning dissemination of sensitive material are advocated as the only

possible solution, although the risk of spoiling the approach of its innovative potential becomes higher. Many concerns about the quality and maturity of the information exchanged have also been raised. One of the major risk is to develop a knowledge sharing solution dominated by personal opinions and interpretations rather than verified facts.

In spite of all these potential drawbacks, the opportunity of leveraging a more bottom-up and lightweight approach for knowledge sharing in the area of opportunities identification, cross-functional teams composition and design rationale capturing is widely seen. From a methodological perspective, it will be crucial in the future to investigate how the lightweight approach may increase design teams capabilities to prevent mistakes in design rather than correcting them. Engineering 2.0 should not merely support the design team in the classical “recognizing symptoms - implementing corrective actions” working mode, rather it should support designers in preventing mistakes, helping engineers in performing more effective root-cause analysis. At this purpose, an Engineering 2.0 demonstrator is under development to collect feedbacks on the use of lightweight and bottom-up techniques in a cross-functional and cross-company design situation.

The field study has also highlighted that the benefits associated to a more bottom-up and lightweight knowledge sharing approach are difficult to communicate in a product development context, mainly because methods and techniques cannot easily be related to dimensions relevant for the engineering teams. Currently under development is a categorization framework [Bertoni, 10] to benchmark Web 2.0 applications, underlining similarities and differences in a meaningful way for engineers, and to qualitatively evaluate how technology mash-ups could support the knowledge sharing activity in a cross-functional context.

Acknowledgements

The authors sincerely acknowledge the Faste Laboratory, a €4M, 10-year, VINNOVA VINN Excellence Center initiative.

References

- [Baines, 07] Baines, T.S., Lightfoot, H.W., Evans, S., et al.: State-of-the-art in Product-Service systems, *Journal of Engineering Manufacture*, Vol. 211, 2007, pp. 1543-1552.
- [Bell, 06] Bell, S.: *Lean Enterprise Systems: Using IT for Continuous Improvement*, John Wiley & Sons, Hoboken, New Jersey, USA, 2006, pp. 271.
- [Bertoni, 10] Bertoni, M.: Bottom-up knowledge sharing in PSS design. A classification framework, In *Proc. of the 11th DESIGN Conference*, Dubrovnik, May 17th-20th, 2010.
- [Blomberg, 93] Blomberg, J., Giacomini, J., et al.: *Ethnographic Field Methods and their Relation to Design*, In Schuler, D. and Namioka, A. Eds., *Participatory Design: Principles and Practices*, Hillsdale, NJ: Lawrence Erlbaum, 1993, pp.123-155.
- [Bughin, 09] Bughin, J.: *How Companies are benefiting from Web 2.0*, McKinsey Global Survey results, June 2009.

[Di Gangi , 09] Di Gangi P.M. and Wasko M.: Steal my idea! Organizational adoption of user innovations from a user innovation community: A case study of Dell IdeaStorm. *Decision Support Systems*, Vol. 48, No. 1, 2009, pp. 303-312.

[Davidow 92] Davidow, W.H. and Malone, M.S.: *The Virtual Corporation: Structuring and Revitalizing the Corporation for the 21st Century*. Harper Business.

[Groth, 04] Groth, K.: On knowing who knows – An alternative approach to knowledge Management, Ph.D. thesis, Royal Institute of Technology, Stockholm, 2004.

[Høimyr, 07] Høimyr N. and Jones P.L.: Wikis supporting PLM and Technical Documentation, *Proceedings of Product Data Technology Europe 2007*, Geneva, Switzerland, Sep. 24th-26th, 2007.

[Isaksson, 09] Isaksson, O., Larsson, T.C. et al.: Development of product-Service Systems: Challenges and Opportunities for the manufacturing firm, *Journal of Engineering Design*, Vol. 20, No .4, August 2009, pp. 329-348.

[Jim, 09] Jim, B.: *Going Social with Product Development*, Tech-Clarity, Inc., 2009.

[Larsson, 08] Larsson, A., Ericson, Å., Larsson, T., Randall, D.: Engineering 2.0: Exploring Lightweight Technologies for the Virtual Enterprise, In *Proc. of the 8th Int. Conf. on the Design of Cooperative Systems, COOP 08*, Carry-le-Rouet, France, May 20th-23rd, 2008.

[Levy, 09] Levy, M.: Web 2.0 Implications on Knowledge Management, *Journal of Knowledge Management*, Vol.13, No.1, 2009, pp.120-134.

[Mathes, 04] Mathes, A.: Folksonomies: Cooperative classification and communication through shared metadata, available at: <http://www.adammathes.com/academic/computer-mediated-communication/folksonomies.html>, 2004.

[Mayfield, 09] Mayfield, R.: *Enterprise Microblogging Whitepaper*, Socialtext, September 2009.

[McAfee, 06] McAfee, A.: Enterprise 2.0: The Dawn of Emergent Collaboration, *MIT Sloan Management Review*, Vol. 47, No. 3, 2006, pp. 21-28.

[Modica, 94] Modica, S. and Rustichini, A.: Awareness and partitional information structures. *Theory and Decision*, Vol. 37, No. 1, 1994, pp. 107-124.

[O'Reilly, 05] O'Reilly, T.: *What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software*. <http://oreilly.com/web2/archive/what-is-web-20.html>, 2005, accessed June 24th 2010.

[Patrick, 07] Patrick, K., Dotsika, F.: Knowledge Sharing: Developing from within, *The Learning Organizations Journal*, Vol. 14, No. 5, 2007, pp. 395-406.

[Payne, 08] Payne, J.: Using Wikis and blogs to improve collaborations and knowledge sharing, *Strategic HR Review*, Vol. 7, No. 3, 2008, pp. 5-12.

[Ramamoorthy, 07] Ramamoorthy, A.: *Corporate Tagging for Information Management through Work Place Democracy*, The Satyam & Microsoft Synergy, 30 October 2007.

[Richards, 09] Richards, D.: Social Software/Web 2.0 Approach to Collaborative Knowledge Engineering, *International Journal of Information Sciences*, Vol. 179, 2009, pp. 2515-2523.

[Shehab, 06] Shehab, E.M. and Roy, R.: Product service-systems: issues and challenges. In *Proc. of 4th International Conference on Manufacturing Research (ICMR 2006)*, John Moores University, Liverpool, Sept. 5th–7th, 2006.

[Shoemaker, 09] Shoemaker, T.: Social Networking and Product Development, Cadalyst, July 23rd, 2009.

[Tang, 07] Tang, J., Drews, C., Smith, M., Wu, F., Sue, A., Lau, T.: Exploring Patterns of Social Commonality Among File Directories at Work. In Proceedings of CHI'07, San Jose, CA, USA, April 28th -May 3rd, 2007.

[Yin, 94] Yin, R.K.: Case Study Research: Design and Methods, 4th Edition, Applied Social Research Methods Series, Vol. 5, Sage Publications, 2009.

Online Dispute Resolution for the Next Web Decade: The Ontomedia Approach

Marta Poblet

(ICREA, UAB Institute of Law and Technology, Barcelona, Spain
marta.poblet@uab.cat)

Pompeu Casanovas

(UAB Institute of Law and Technology, Barcelona, Spain
pompeu.casanovas@uab.cat)

José-Manuel López-Cobo

(playence, Innsbruck, Austria
ozelin.lopez@playence.com)

Abstract: More than ever, the Web is a space of social interaction. Recent trends reveal that Internet users spend more time interacting within online communities than in checking and replying to e-mail. Online communities and institutions create new spaces for interaction, but also open new avenues for the emergence of grievances, claims, and disputes. Consequently, online dispute resolution (ODR) procedures are core to these new online worlds. But can ODR mechanisms provide sufficient levels of reputation, trust, and enforceability for it to become mainstream? This contribution introduces the new approaches to ODR with an emphasis on the Ontomedia Project, which is currently developing a web-based platform to facilitate online mediation in different domains

Keywords: Semantic Web, Web-based services, Online Dispute Resolution (ODR), Relational justice

Categories: H.2, H.4

1 Introduction

Online Dispute Resolution (ODR) is an umbrella domain that covers a full range of processes (i.e. early neutral evaluation, negotiation, conciliation, mediation, and arbitration) to handle disputes online. ODR has often been equated to IT-supported or IT-enhanced Alternative Dispute Resolution (ADR) procedures and, certainly, in many ways ODR owes to traditional ADR many of its goals, principles, processes, and professional standards. Nevertheless, there is also a growing consensus in specialized literature to consider ODR more than just the delivery of ADR services through the Internet [Katsh, 01; Schultz, 02; Rule, 02; Kaufmann-Kohler, 04; Lodder, 10]. For some ten years now, more than a hundred projects, prototypes and commercial ventures altogether have shaped a distinctive domain where the technology component not only acquires a prominent role as the “fourth party” [Katsh, 01] but provides both disputants and third parties with unprecedented procedures and capacities. Yet, ODR has not moved along the track without shake: the bursting of the dot-com bubble in 2001 led to many of the then emergent ODR

providers to cease their commercial activity. By 2004, roughly 30 service providers (out of 115) were no longer operational [Conley Tyler, 04]. Since its inception in the late nineties, ODR has passed through different stages [Conley Tyler, 03, 04]:

- A “hobbyist” phase (1995-1996) where individual enthusiasts started working on ODR, often without formal backing.
- An “experimental” phase (1997-1998) where foundations and international bodies (i.e. the Hewlett Foundation and UNECE) funded academics and non-profit organisations to run pilot programs.
- An “entrepreneurial” phase where a number of for-profit organisations launched private ODR sites (1999-2001)
- An “institutional” phase (2001- onwards) piloted and adopted by a range of official bodies including courts and other dispute resolution providers.

Present ODR has become therefore a branch of dispute resolution in its own right and a mature domain with a number of consolidated services providing the default procedures for resolving disputes online [Rule, 08; Rabinovich, 08]. Especially when the judicial system is perceived too costly or inappropriate for a number of reasons (nature and/or value of the dispute, physical location of the parties, etc.) ODR has the potential to become an efficient default system. This is precisely the case for online communities such as e-Bay, whose dispute resolution services deal with roughly 40 million cases each year [Rule, 08]. Overall, recent research on ODR services has analyzed up to thirty five major service providers, most of them working on private schemes [Poblet, 10]. Even though they differ significantly on case figures, procedures, or business models, they all tend to deal with small value claims and procedural costs can be kept relatively low. However, and with some exceptions [Gabarró, 09] little is known on issues such as users’ interaction with ODR services or adoption of state-of-the-art Web 2.0 standards. And yet, the emergence of the social Web may open new avenues for a new generation of ODR services.

2 ODR 2.0

The social Web breeds an ever-growing number of social networks that share all types of contents (documents, images, videos, music, etc.), knowledge, and expertise in a number of areas. Some recent figures may give an idea of the impressive growth rate of online social communities: (i) from a time spent perspective, member communities surpassed e-mail for the first time in February 2009 [Nielsen, 09]; (ii) previously, video audiences had already surpassed e-mail audiences in November 2007 (roughly 100 million users at the end of that year) [Nielsen, 09]; (iii) in countries such as Spain, United Kingdom and Italy, Internet users spend more than 20 percent of their online time in social networking [Nielsen, 10]. Additionally, research on targeted audiences reveal interesting facts, such as “new moms” (younger, one child), being much more likely to visit social networking sites and publish or own a blog than most other online users”. For instance, new moms “are 85 percent more likely to spend time with Facebook compared to the average online consumer” [Nielsen, 09]. To Nielsen analysts, “becoming a mother is a dramatic inflection point and drives women to the Web in search of advice and a desire to connect with others in her shoes”.

To what extent are these trends relevant for ODR? In 2006, Colin Rule welcomed Web 2.0 technologies and forecasted that “ODR will be one of the biggest beneficiaries of these new technologies, because they are squarely aimed at ODR’s core functionality areas: communication, collaboration, and interactivity” [Rule, 06]. However, he also warned that “too many ODR providers rely on outdated platforms and technology because they are reluctant to make the investments in time and resources needed to bring their platforms up to Web 2.0 standards” [Hattotuwa, 08a]. Sanjana Hattotuwa went a step further anticipating unwanted consequences of ODR lagging behind the curve of Web 2.0 [Hattotuwa, 08b]:

“[T]he most obvious being that ODR itself may cease to exist. With the ubiquity of broadband wired and wireless connectivity, the ability to roll-out dispute resolution service online is possibly going to be seen as a normal service provision of ADR service providers, just like automated online tech support is now part and parcel of customer support mechanisms of many large software companies”

However, new horizons and opportunities for ODR have incredibly expanded over the last three years with the emergence of new web tools and services focusing on conflict prevention, crisis and conflict management, debate, or negotiation. Open source platforms such as Ushahidi,¹ FrontlineSMS,² or RapidSMS³ are increasingly used to aggregate crowdsourced information and data—from SMS, tweets, etc.—to facilitate logistics coordination and response in emergencies, crises, and political conflicts (i.e. post-election violence). Usually, incoming data are geolocated and can be projected onto a crisis map (i.e. by using Google Maps and/or OpenStreetMap), and then tagged with different categories.

Even though different in nature and purpose, what these platforms have all in common are featured elements of state-of-the-art Web 2.0: open source software, free access, multiplatform facilities, real-time information streams, crowdsourced information and data, exportation of datasets, etc. Some of them—i.e. SwiftRiver in combination with Ushahidi⁴—already embrace Semantic Web open standards such as FOAF, iCal, Dublin Core, as well as open publishing endpoints such as Freebase to track and verify the accuracy of reports during a crisis, add structure to crisis data and make them shareable.

How ODR and its procedures may benefit from these new applications and utilities? Section 3 below offers some preliminary answers by presenting and describing our particular contribution to the field, the Ontomedia project.

3 The Ontomedia Project

People in need of help and assistance—as the new moms example shows—tend to look for help or advise in social communities and specialized web sites. This is where the Ontomedia platform aims at contributing. From the Ontomedia standpoint, both

¹ <http://www.usahidi.com>

² <http://www.frontlinesms.com>

³ <http://www.unicefinnovation.org/mobile-and-sms.php>

⁴ <http://swift.usahidi.com/>

Web 2.0 and Web 3.0 technologies can make significant advances into the ODR field, helping professionals to gather resources relevant to the mediation, conciliation or arbitration services they are providing, and helping users to share and contribute to harness the connective intelligence about ODR that can be found on the Web.

The main objective of Ontomedia is to allow users and ODR professionals to meet in a community-driven Web portal where contents are provided by users. Nevertheless, our focus is on mediation users—disputants and third parties—rather than on content itself. Thus, we expect the mediation users to create the contents and—by their use of natural language—the semantics that reflect how present their cases, how they interact with the mediators and the other parties and, ultimately, how they experience the mediation process.

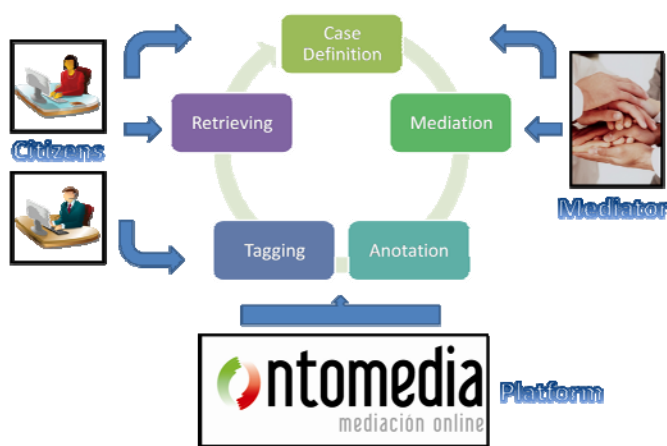


Figure 1: Ontomedia case lifecycle

The system will then map this incoming semantic content with the ontologies already stored. In this perspective, while Ontomedia will work with a Core Mediation Ontology (CMO) [Poblet, 09] and sub-domain ontologies (see Fig. 2 below for the ontology mapping conflict types in the consumer dispute domain) that model the main concepts and relationships in mediation, the Ontomedia ontologies do not aim at anticipating the needs of the users and impose formal semantic structures in advance. Rather, the aim is let the users define their needs and then elaborate semantic models that evolve as a by-product of the mediation processes.

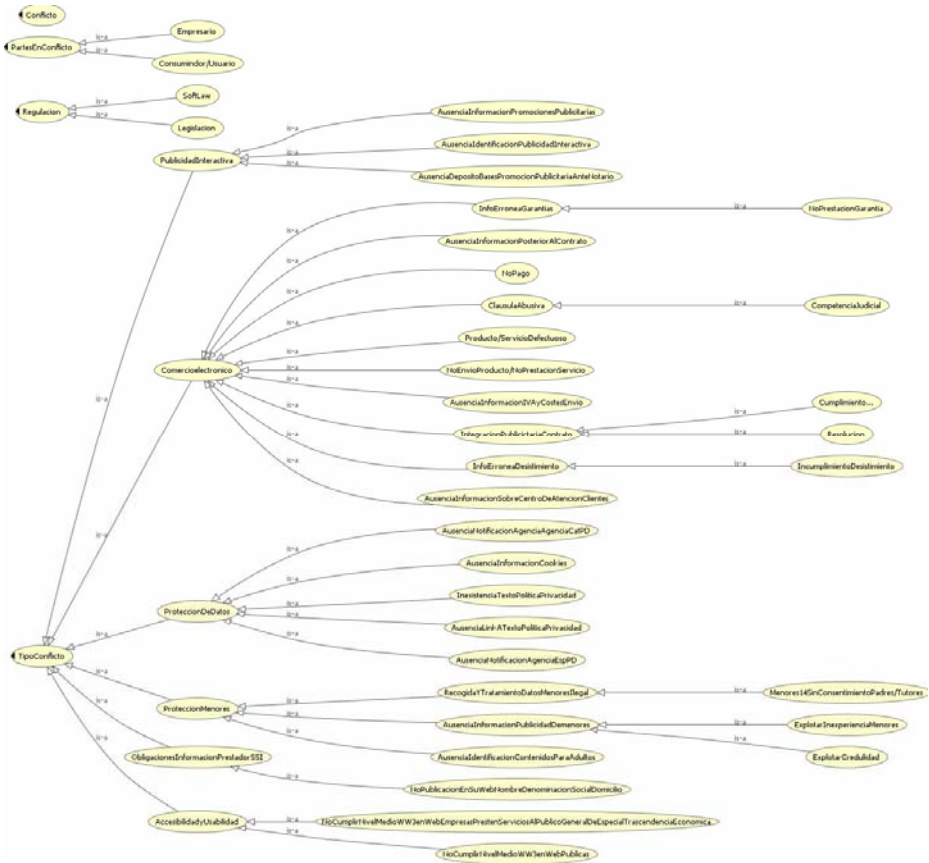


Figure 2: Ontology for mediation in the consumer domain

The Ontomedia platform will assist mediation users and professionals by providing assistance at different levels:

1. Information retrieval on previous cases. Users and mediators will be able to consult previous cases, duly anonymized to ensure privacy and compliance with current legislation. Retrieval will be enhanced by one or more ontologies.
2. Definition of a case. To control the mediation process, the Core Mediation Ontology (CMO) models the basic concepts and relationships in mediation and creates templates to guide users and mediators throughout the process.
3. Mediation. Ontomedia will have videoconferencing facilities including different tools to provide mediators with information on the mood of the users (analyzing their voice, their movements, and their reactions).
4. Annotation. The system will be able to annotate the contents of the multimedia objects, being those texts, video, audio objects. These annotations will be further used to categorized and increase the case corpus.

The annotations will be automatically realized against a set of ontologies on mediation and about the specific sub-domains.

5. Tagging. Ontomedia needs its users to enhance the contents. Every piece of information is susceptible of being tagged, thus creating mediation folksonomies that can be later used also in the information retrieval stage. Users will be able to tag, comment and suggest, creating online communities around their cases and their problems.

4 Web Oriented Architecture for an Enhanced Interaction

Mediation users and professionals alike can use any kind of devices to access the portal (computers, mobile phones), and in any format suitable to their purposes (text, speech, video, images, etc.). Users will therefore be able to participate in online mediation services as they do in a face-to-face basis, but with the advantages of distributed and even remote access.

In Ontomedia we also foresee the application of mediation services as tasks within a mediation process that will be formally described by means of both process ontologies and mediation ontologies. These services will be described, stored and made accessible through a service bus that will ensure end to end communication between consumers and providers, as well as a semantic execution engine that takes care of the execution of semantically enhanced mediation processes.

Ontologies will be used to annotate and analyze any type of content. The multimedia analysis aims at enhancing the information a mediator receives during a mediation session, capturing mood changes of the parties and any other psychological information inputs. All types of metadata will be automatically extracted and stored to be further used within the mediation process.

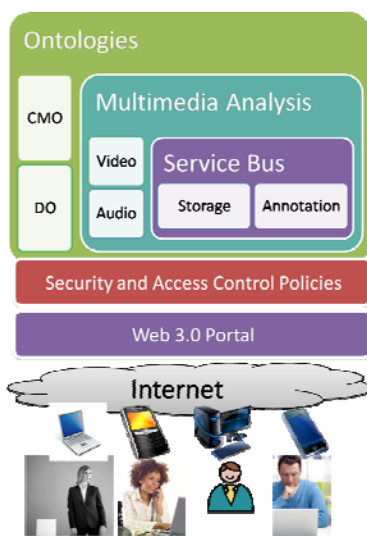


Figure 3: Ontomedia layered architecture

Ontomedia will also develop tools to invite users to exploit the advantages of sharing information and experiences with others. In this way, users will be able to tag and store content that consider useful or interesting to them, and to find similar cases. In doing so, they will be able to create social communities of people with common interests. And, related to those utilities, Ontomedia will provide a mashable suite of features that will allow users to locate similar cases to theirs. The semantic geographical location of those cases and its representation in a map is a trivial feature.

In contrast, what seems more interesting from a user perspective is the possibility to have tag clouds of concepts related to each case and a timeline of concepts against a case. The set of updated Web 3.0 features that will be enabled and accessible to users of the Ontomedia platform can be summarized here:

- Annotation of all types of contents. With this feature, a user can easily know if another case has some conceptual similarity with hers. Given a case, a useful visualization feature is the representation of those concepts more relevant in a case as a tag cloud. Just clicking in one concept or other in the tag cloud will show you a set of cases that also are related to that concept.
- Jointly with the annotation, some metadata extraction is automatically conducted, including geographical position of cases, time location and named entity recognition: (i) geo-location allows users to track similar cases, given the set of concepts related to the issues. The tag cloud will always show the concepts that are relevant to cases appearing in the map. Categorization and segmentation will be possible by means of several icons and with just a glimpse the user of the platform will have a tool for visualization and conceptual identification; (ii) with time location, users will have a timeline. Timelines can show the location of cases against time with respect a particular concept (the apparition of a case related to a concept in a particular time). With this feature, users will be able to see the evolution of the frequency of cases where a concept is concerned; (iii) where NER (Named Entity Recognition) is concerned, the platform will be able to detect where well-known entities are mentioned.

In Ontomedia, well-known entities are concepts that transcend domain ontologies like person names, organizations, dates, places, figures and some others. The power behind this feature is that in doing so, we will be able to connect well-know entities with well-know facts as those defined with the LOD (Linked Open Data) principles [Berners-Lee, 06]. Where the name of a person is mentioned, if it exists, we will retrieve her FOAF⁵ profile. Where a place is mentioned, we will extract the GeoName⁶ information available, and so on. This information can be used within Ontomedia to add formal restrictions and reason over it. Each concept, each piece of information, each resource is susceptible to have a comment from any user. Users are encouraged to participate within the platform and to build it jointly with other users.

⁵ FOAF (Friend of a Friend), <http://www.foaf-project.org/>

⁶ Geonames, <http://www.geonames.org/about.html>

5 Conclusions

Despite the conceptual vagueness of their definitions, both Web 2.0 and Web 3.0 developments and technologies offer new forms to interact with the Web that are most relevant to ODR. To be sure, some of their critical features—openness, standardization, free access, connectedness, crowdsourcing effects, etc.—make it possible to enrich ODR services in a wider perspective. The Ontomedia project attempts to learn from these innovations so as to provide an easy-to-use web platform for both mediation domain experts and end-users. A distinctive aspect of Ontomedia, nevertheless, is the application of Semantic Web technologies to enhance online mediation processes. On the one hand, Ontomedia will use basic ontologies to annotate any kind of content (either textual or multimedia) to facilitate users to participate in the process and search any useful information on related cases. On the other, a semantic execution engine will take care of the execution of the semantically enhanced mediation processes.

Acknowledgements

The research presented in this paper has been developed within the framework of two different projects: (i) ONTOMEDIA: Platform of Web Services for Online Mediation, Spanish Ministry of Industry, Tourism and Commerce (Plan AVANZA I+D, TSI-020501-2008, 2008-2010); (ii) ONTOMEDIA: Semantic Web, Ontologies and ODR: Platform of Web Services for Online Mediation (2009-2011), Spanish Ministry of Science and Innovation (CSO-2008-05536-SOCI).

References

[Berners.Lee, 06] Berners-Lee, T. Linked Data, available at <http://www.w3.org/DesignIssues/LinkedData.html>

[Conley Tyler, 03]. Conley Tyler, M. Seventy-six and Counting: An Analysis of ODR Sites. In E. Katsh and D. Choi (eds.), *Online Dispute Resolution: Technology as the “Fourth Party”*. Proceedings of the UNECE Second Forum on Online Dispute Resolution. UNECE. Center for Information Technology and Dispute Resolution, University of Massachusetts, <http://www.odr.info/unece2003/pdf/Tyler.pdf>

[Conley Tyler, 04] Conley Tyler, M. 115 and Counting: The State of ODR 2004. A M. Conley Tyler, E. Katsh, D. Choi (Eds.), *Proceedings of the Third Annual Forum on Online Dispute Resolution Melbourne, Australia, 5-6 July 2004*, <http://www.odr.info/unforum2004/ConleyTyler.htm>

[Gabarró, 09] Gabarró, S.: *Online Dispute Resolution in e-Commerce: A Study of European ODR Providers Offering Mediation in B2C*. MA Thesis, 2009, <http://idt.uab.es/publications/publications.htm>

[Hattotuwa, 08a] Hattotuwa, S.: *The Future of Online Dispute Resolution (ODR): Technologies to Keep an Eye On*, Crystal Ball Session at the 2008 Online Dispute Resolution Forum, June 22, 2008, <http://ict4peace.wordpress.com/2008/06/>

- [Hattotuwa, 08b] Hattotuwa, S.: Maps of election violence and malpractices in Eastern province elections, 10th May 2008, <http://ict4peace.wordpress.com/2008/05/10/maps-of-election-violence-and-malpractices-eastern-province-elections-sri-lanka-10th-may-2008/>
- [Katsh, 01] Katsh, E., Rifkin, J.: *Online Dispute Resolution: Resolving Conflicts in Cyberspace*. Jossey-Bass Inc., San Francisco, 2001.
- [Kaufman-Kohler, 04] Kaufman-Kohler, G., Schultz, T. *Online Dispute Resolution: Challenges for Contemporary Justice*. Kluwer Law International: The Hague, 2004.
- [Knorr, 03] Knorr, E.: The Year of Web Services, *IT magazine CIO*, December 2003: 90, http://www.cio.com/article/32050/2004_The_Year_of_Web_Services?page=1
- [Lodder, 10] Lodder, A., Zeleznikow, J. *Enhanced Dispute Resolution through the Use of Information Technology*. Cambridge: Cambridge University Press, 2010.
- [Nielsen, 09] Nielsen Online: The global online media landscape: Identifying opportunities in a challenging market, April 2009, http://nielsen-online.com/emc/0904_report/nielsen-online-global-lanscapefinal1.pdf
- [Nielsen, 10] Nielsen Online. News Release, http://www.nielsen-online.com/pr/pr_100609_es.pdf
- [Poblet, 10] Poblet, M., Noriega, P., Suquet, J., Gabarró, S. *Tecnologies per a la mediació*. In in P. Casanovas, J. Magre, E. Lauroba (eds.) *Llibre Blanc de la Mediació a Catalunya*. Barcelona: Generalitat de Catalunya, forthcoming September 2010.
- [Poblet, 09] Poblet, M., Casellas, N., Torralba, S., Casanovas, P. (Modelling Expert Knowledge in the Mediation Domain: A Mediation Core Ontology. *Proceedings of the Workshop on Legal Ontologies and Artificial Intelligence Techniques (LOAIT09)*, 2009, available at <http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-465/>
- [Rabinovich-Einy, 08] Rabinovich-Einy O. Reflecting on ODR: The Israeli Example. In M. Poblet (ed.) *Expanding the Horizons of ODR: Proceedings of the 5th International Workshop on Online Dispute Resolution (ODR Workshop'08)*, CEUR Workshop Proceedings Series, Vol. 430: 13-22, <http://ftp1.de.freebsd.org/Publications/CEUR-WS/Vol-430/>
- [Rule, 02] Rule, C. *Online Dispute Resolution For Business: B2B, ECommerce, Consumer, Employment, Insurance, and other Commercial Conflicts*. San Francisco, CA: Jossey-Bass, 2002.
- [Rule, 06] Rule, C. *ODR and Web 2.0*, <http://www.odr.info/colin/smu/odr%20and%20web%202.doc>
- [Rule, 08] Rule, C. *Making Peace on eBay: Resolving Disputes in the World's Largest Marketplace*, *ACResolution Magazine*, Fall, 2008.
- [Schultz, 02] Schultz, T. *Online Dispute Resolution: an Overview and Selected Issues*. United Nations Economic Commission for EuropeForum on Online Dispute Resolution Geneva, 6-7 June 2002. Disponible a SSRN: <http://ssrn.com/abstract=898821>.

Using Codebeamer to Manage Knowledge in an IT Consulting and System Integration Company

Kristina Neumeier, Silke Retzer

(msg systems ag, Ismaning/Munich, Germany
{firstname.lastname}@msg-systems.com)

Abstract: Technological change and high competitiveness are essential for organisations in today's fast-paced society. Information and knowledge assets thus need to be current and easily accessible. With implementing core knowledge processes such as identification and accumulation, msg systems ag - a medium-sized IT and consulting company - introduced a knowledge management system with the aim to externalise implicit knowledge. Implicit knowledge is intuitive knowledge that is generally gained through personal experience [Nonaka and Takeuchi 1995]. In this regard Probst et al.'s (2006) knowledge process concept helped identify and adapt these processes. The core knowledge processes were then implemented by the Codebeamer system, an OpenSource collaboration platform based on wiki technology. The system's development was continuously adopted and improved by using a prototype-specific approach since its productive start two years ago. This paper describes this implementation project for a knowledge management system (KMS) in an IT consulting and system integration company.

Keywords: knowledge management system, knowledge processes, knowledge goals, IT industry, OpenSource, Codebeamer

Categories: M.0, M.2, M.6, H.4

1 Introduction

Nowadays many organisations view the huge amount of knowledge and its complexity as a challenge for future development. Knowledge has become a major production factor, especially for knowledge-intensive organisations in the IT and consulting industry. In general, knowledge can be differentiated into individual and organisational knowledge [Maier et al. 2005]. Organisations are interested to make individual knowledge available to the organisation and its employees. Thus, The associated knowledge processes need to be optimized and successfully managed [Lehner 2008]. The main goal of this article is to illustrate how to implement a KMS and manage knowledge within a medium-sized enterprise with using OpenSource software (Codebeamer). The management of knowledge includes a long-term storage and accessibility of organisational and individual knowledge. The creation of awareness and motivation to manage knowledge systematically as well as the integration of KM into existing organisational processes is an essential factor for a successful implementation. Thus, for a successful knowledge management three dimensions - the individual, the organisational and the technological dimension - as suggested by [Gerhards and Trauner 2007], were considered in this project. The main

goal of this project has been to transfer implicit into explicit knowledge and make it available to the organisation and its employees.

This article is structured as follows. Firstly msg systems ag is briefly introduced as a medium-sized knowledge-intensive IT and consulting organisation. Then the project strategy, including knowledge management strategy and implementation strategy, is outlined. Next, the identification and implementation of core knowledge processes within the business unit Integration Consulting is described in alignment with Probst et al.'s (2006) knowledge process model. Then, an introduction to the OpenSource knowledge management tool Codebeamer and how it is used within msg systems ag is given. Finally, a brief conclusion and lessons learned are outlined.

2 Msg systems ag: a knowledge-intensive IT and consulting organisation

With having 25 years of experience, msg systems ag is one of the 25 largest organisations in the IT-consulting- and system integration business in Germany. Over 3000 employees develop complex systems as standard software or based on specific customer requirements. Msg systems ag focuses on the following industry sectors: insurance, financial services, health services and automotive. Competent employees and successful cooperation with customers and partners are responsible for the great development during the past 25 years. A high quality of services and products and a high reliability and customer focus are key goals. Continuous individual development is supported by management, and creative and innovative capabilities are facilitated. Direct communication and team orientation as well as goal orientation in projects are important values for msg systems ag.

This article focuses on the introduction of a KMS for the industry sector *Insurance* at msg systems ag, particularly on the business unit *Integration Consulting*. Overall, four business units are part of the insurance sector: Integration Consulting (GB I), Products & Development (GB P), Service Consulting (GB S) and Business Consulting (GB B). The business unit *Integration Consulting* focuses on the integration and consulting of in-house developments, but also on standard software such as SAP. This business unit is particularly responsible for implementation projects within German-speaking countries, but also facilitates development in international projects.

For msg systems ag, using a KMS promises more transparent and available topic-specific knowledge which is usually only inherent to individuals or groups in the organisation. The main goal of this project has been to provide a framework to identify and collect this knowledge and make it accessible across the entire organisation using a knowledge base which allows for a quick knowledge distribution. Another aim of implementing a KMS refers to potential cost reduction in regard to reduced duration for searching of knowledge. In addition, an improvement in supporting decision making for the implementation of new topics has been expected. Other goals include reducing project duration by having an efficient knowledge search functionality and additional knowledge creation. Implementing a KMS would also help reduce the loss of knowledge through fluctuation or retirement and help exchange knowledge across business units. Thus, a need to convert

individual implicit knowledge, which resides in individuals' minds into explicit knowledge that can be saved electronically was identified. For example, this knowledge could then be used for cross-unit training programs. By having a tool for knowledge transfer and acquisition, management expects quicker development cycles and time-to-market, better customer services and higher customer satisfaction.

3 Project strategy

The project strategy briefly describes the knowledge management strategy followed at msg systems ag and the implementation strategy of the new KMS.

3.1 Knowledge management strategy

In general, three knowledge management strategies can be considered: the codification strategy, the personalisation strategy and the socialisation strategy. Within the business unit *Integration Consulting*, knowledge is mainly existent in an explicit form, for example documents. This strategy is called codification. In contrast to a personalisation strategy, knowledge is not solely bound to an individual by employing a codification strategy. Information and Communication Technology (ICT) plays a key role in this strategy, whereas knowledge exchange through personal communication is more important within a personalisation KM strategy. A codification strategy allows for a long-term storage and reuse of collected knowledge by a number of people. Knowledge is mainly available in the form of documents or within databases. Content Management Systems or knowledge portals can help store this knowledge. Knowledge of individual employees needs to be explicated in order to store it in a KMS. However, it is not possible to explicate all implicit knowledge. Nevertheless, implicit knowledge such as experiences or process knowledge can be written down and collected as explicit knowledge, which is the aim of this project. However, it would be important to decide whether implicit knowledge should stay implicit or made explicit [Riempp 2004], especially in the case of additional inter-organisational knowledge exchange. Although supporting social networks for knowledge exchange in an organisation is an important aspect [Retzer, Yoong and Hooper 2010], the socialisation strategy, which includes the formation of Communities of Practice¹ or social networks, has not been employed at this stage. The first two KM strategies – codification and personalisation – have both been employed. However, the focus has been on the codified KM strategy trying to make implicit knowledge available to the organisation in the form of documents. Thus, this KM strategy has followed the technological perspective of KM. Storage and distribution of existing knowledge as well as the development of new knowledge should be facilitated by this approach. It is hoped that this strategy will help msg systems ag to foster its future competitiveness on the market.

¹ http://www.rolotec.ch/blog/archives/KM_basics.pdf

3.2 Implementation strategy

Design and implementation of the KMS followed a prototype-specific project organisation. A prototype was developed that was then continuously adapted and improved until it met the final system's requirements. This procedure allowed for a quick and flexible adaption to changes of requirements. In addition, the prototype system could be presented to the organisation at an early stage in order to identify diverse and additional requirements. A number of these implementation cycles were performed until its final adaption. This procedure resulted in a high level of quality and satisfaction as well as low maintenance costs.

4 Identification and implementation of core knowledge processes within the business unit *Integration Consulting*

This section firstly describes key knowledge processes as defined in literature [Probst et al. 2006]. These processes were then compared to existing key knowledge processes within msg systems ag. Finally revised key knowledge processes could be identified. Firstly, the six key processes as defined by Probst et al. (2006) - knowledge identification, acquisition, development, distribution, usage and storage - are described. With the help of knowledge goals and the evaluation of knowledge assets, it is possible to create a knowledge management life cycle which is illustrated in the following figure. Then, each knowledge process is briefly described.

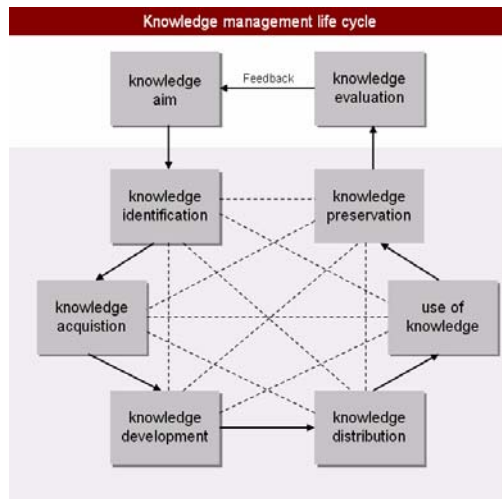


Figure 1: Knowledge management life cycle [Probst et al. 2006]

4.1 The knowledge management life cycle

4.1.1 Knowledge identification

Knowledge identification is the creation of transparency in regard to internal and external knowledge. In particular, analysis and description of knowledge within an

organisation are most important. Loss of transparency can be due to decentralisation, globalisation, lean management, organisational restructuring and fluctuation.

4.1.2. Knowledge acquisition

Knowledge acquisition is the import of external knowledge into the organisation. Examples to perform knowledge acquisition are possible with the help of the following activities: external knowledge workers (recruiting, external consultants), inter-organisational knowledge transfer (co-operations, product and knowledge links), acquisition of stakeholders' knowledge (customers, suppliers) and acquisition of knowledge assets.

4.1.3. Knowledge development

Knowledge development is closely connected to knowledge acquisition. Knowledge development describes the creation of new abilities, products, ideas and innovations. Highly productive processes are the key goal. Innovation barriers can hinder the development of knowledge. Collective knowledge development can be supported by communication, transparency, and integration.

4.1.4. Knowledge distribution

Knowledge distribution is necessary to provide individual knowledge to the entire organisation. This distribution can be performed among groups or individuals. Main tasks are to multiply knowledge, store and distribute experiences and facilitate knowledge exchange. This exchange can lead to knowledge development. Cultural barriers can hinder knowledge distribution.

4.1.5. Use of knowledge

The use of knowledge is the productive use of organisational knowledge. Knowledge management should create a context in which the use of knowledge can be facilitated. In order to overcome barriers, users' needs should be considered.

4.1.6. Knowledge preservation

Knowledge preservation refers to the organisational memory which constitutes a system of knowledge and capabilities that can be saved and reused later. Core processes for saving knowledge are selecting, saving and updating of valuable knowledge. Experts and key players can be tied to the organisation using motivational incentives [Zaunmüller 2005].

4.1.7. Evaluation of knowledge

Methods to evaluate knowledge according to previously defined knowledge goals should be available. The quality of knowledge goals is important. Knowledge could be evaluated by using a multi-dimensional cause-and-effect chain.

Probst et al.'s (2006) knowledge processes model provides a framework to successfully implement these processes. However, it does not provide a holistic implementation guideline in regard to certain organisational knowledge management

goals that are part of an organisation's overall strategic goals. In particular, this model helps analyse current processes and provides a general guideline for knowledge management. It structures the management process into logical phases, provides ideas for organisational interventions and helps identify knowledge management issues in an organisational context.

Applying this concept as a guiding framework to the implementation of a KMS in the business unit *Integration Consulting* at msg systems ag, the following core knowledge processes could be identified: knowledge accumulation, knowledge documentation, knowledge distribution and knowledge preservation. Whereas knowledge accumulation combines the processes of identification, acquisition and development, knowledge documentation refers to the use and storage of knowledge. Knowledge distribution refers to the same process as in the described model. Finally, knowledge preservation includes the long-term use and evaluation of knowledge. The following figure outlines these identified core knowledge processes at msg systems ag in relation to Probst et al.'s (2006) model. The knowledge processes at msg systems ag are shown in one line at the bottom of the figure. The efforts undertaken in the organisation in relation to these processes are outlined below Figure 2.

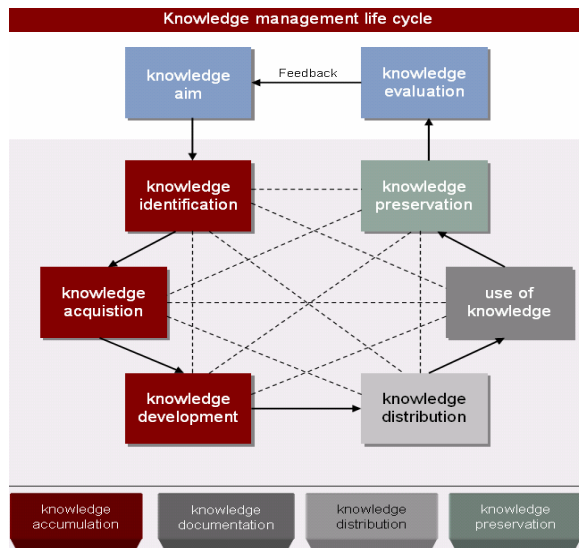


Figure 2: Core knowledge processes at msg systems ag in relation to Probst et al.'s (2006) model

4.2 Core knowledge processes at msg systems ag

4.2.1. Knowledge accumulation

This process includes the identification of completely new topics or of knowledge that is related to already existing knowledge. In this case a new document can be created for this topic and submitted to the *Proposal-Area* of the KM (see Section 5). Topic owners can be consulted for questions. Certain access to the system is necessary to submit such a document. A specific role concept, which is not described in this

article, has been created for system usage. In addition, the forum can be used to publish information around new topics.

4.2.2. Knowledge documentation

This process includes quality assurance by an integrated evaluation system and a consistent structure to save documents. The aim of this process is to provide up-to-date and quality-assured knowledge to members. Documents passing this process are moved from the *Proposal-Area* to the *Quality-assured-Area* of the KMS.

4.2.3. Knowledge distribution

This process is implemented by using push- and pull- technologies. Pull technology allows employees to access knowledge by themselves whereas push technologies provide knowledge automatically (e.g. by email notification).

4.2.4. Knowledge preservation

This process helps keep knowledge up-to-date. Continuous evaluation processes, updates and storage are necessary.

These core processes have been aligned to previously identified knowledge goals at msg systems ag such as an improved use of existing knowledge and experiences within and across business units in the organisation during the next two years. Another goal has been to facilitate an organisational culture that motivates employees to share knowledge. Resulting business goals have been a higher customer satisfaction through shorter project durations.

In regard to the implemented KMS several knowledge management goals were defined and published on the Intranet:

- Include at least twelve knowledge areas of the business unit *Integration Consulting* into the new KMS within the following six months. Recruit members, experts (topic owners) and integrate documents into the KMS. Topic owners support members.
- Submit twelve field reports, handbooks, specifications or other related documents to the topic owners who check the quality of the documents and upload them onto the KMS within one year.
- KM roles such as the topic owners who are responsible for their knowledge areas in the KMS need to keep members informed by using a quarterly newsletter.
- Members should create a field report after each project. Standardised templates will be provided for these reports within the KMS.

In summary, the implementation of the KMS introduced new organisational roles such as the knowledge manager with an overall responsibility for the KMS and the

topic owners acting as experts and reviewers of submitted documents. These topic owners have thus also been responsible for assuring the quality of explicated knowledge. With their approval only, new documents, which were submitted by knowledge workers (usual employees), could be published in the KMS. In addition, contributions to the KMS by employees have been promoted by line managers with embedding these activities in an organisational process (as part of personal goals for incentive regulations).

The following section describes the OpenSource software – Codebeamer – employed to implement these goals.

5 Codebeamer – an OpenSource solution for KM

The OpenSource collaboration solution Codebeamer² was selected as the knowledge management system at msg systems ag. Codebeamer was selected, as it was already used by msg systems ag as a collaborative platform and had the key components to implement the pre-defined knowledge processes. Codebeamer uses wiki technology, provides an area to store and structure documents and a forum for topic-specific collaboration. Codebeamer allows for the implementation of a detailed authorization and role concept as well as the creation of wiki spaces for specific topic areas. Using Codebeamer supports working from distributed locations. For external access, employees working as consultants at distributed locations can access Codebeamer via an intranet link and the use of a VPN client. For authorization the employee's Novell account, which is used for Intranet access, is needed.

Within Codebeamer's document area specific knowledge areas can be created. Currently, this document area contains four major units at msg systems ag: Reinsurance, Primary insurance, Cross and cross-unit topics. These units can again contain more specific topic areas. Finally, this structure can include subtopic areas that are part of a specific topic area. For implementing the authorization concept, it was necessary to use a definite folder structure. Three consistent folders are used for each topic area as shown in Figure 3: *Proposal-Area*, *Quality-assured-Area* and *Protected-Area*. With the help of this three-tier structure, the level of quality assured documents can be made transparent to members. A checklist serving as a template for a standardised and consistent quality assurance has been provided.

The following illustration shows the basic structure.

² Version 4.2.3.

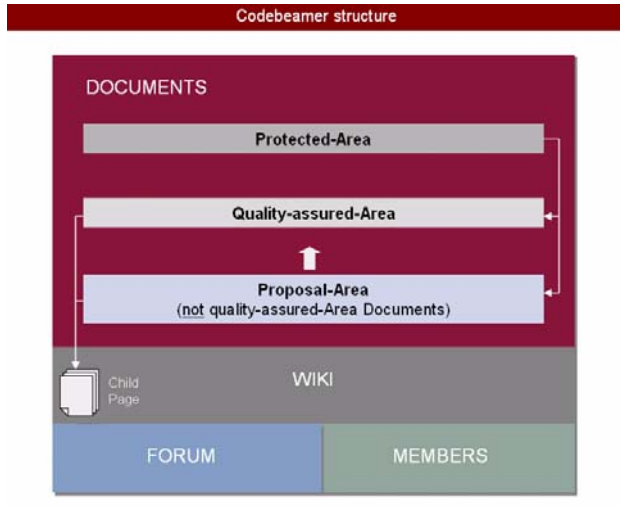


Figure 3: Codebeamer structure

Since its initial development and use, the Codebeamer system has been available to employees for about two years. At this stage, topic owners were asked for feedback on the use of the KMS. Lessons learned help to identify issues and also show successful examples. A review can provide guidelines for improvement further use.

6 Conclusion and Lessons Learned

This article described a project implementing a KMS in a large IT and system integration company in Germany. Key knowledge processes were firstly defined and then implemented by using Codebeamer - an OpenSource software solution. The four key knowledge processes identified were knowledge accumulation, knowledge documentation, knowledge distribution and knowledge preservation. These processes were guided by previously set up knowledge goals and supported by a role concept (e.g. knowledge manager, topic owners). After using Codebeamer for over two years as the main KMS within msg systems ag, some lessons learned could be drawn regarding the dimensions *people*, *organisation* and *the use of technology*.

6.1 People and organisation

Although several issues arose, some successful KM project examples developed in this timeframe. The following issues could be identified: high fluctuation of people assigned to KM roles created some inconsistency and insecurity for other KMS participants;

Motivational aspects and incentive systems should also be discussed in the near future, as there are diverse opinions about their actual existence and how they could be used effectively. In successful examples, e.g. within the business unit *Integration Consulting*, the externalisation of implicit knowledge was realised by using the

suggested processes of accumulation, documentation and distribution. Intrinsic motivation of topic owners and participants were essential aspects for this successful implementation.

6.2 Organisational embedding

The use of the KMS was integrated in organisational procedures (when setting-up personal goals in combination with appraisal interviews), but not integrated as a formal role with associated resources (time, budget) within the organisation. Thus, the creation of a formal role or at least additional resources for a facilitator (knowledge manager) and topic owners needs to be discussed with management.

6.3 Organisation and use of technology

In the past two years, the focus was primarily on the processes of accumulation, documentation and distribution, but not on preservation of knowledge. In the future, a continuous update of documents in the KMS would be necessary to ensure a long-lasting high quality of externalised knowledge. In regard to the knowledge processes set-up, employees would prefer a simpler process to accumulate and store knowledge. However, it may then be difficult to keep up a high quality standard of documents.

A future aim could include a measurement to check if goals were met and also of the actual success in regard to shorter project durations and higher customer satisfaction. In addition, a general review of the suitability of the previously set-up knowledge goals could help to further develop the use of the KMS at msg systems ag.

References

- [Gerhards and Trauner 2007] Gerhards, S. and Trauner B.: Pocket Power Wissensmanagement. München, Carl Hanser Verlag, Auflage 3 (2007)
- [Lehner 2008] Lehner, F.: Wissensmanagement: Grundlagen, Methoden und technische Unterstützung, München, Carl Hanser Verlag, Auflage 2 (2008)
- [Maier et al. 2005] Maier, R., Haedrich, T., & Peinl, R.: Enterprise knowledge infrastructures. Berlin: Springer Verlag (2005)
- [Neumeier 2008] Neumeier, K.: Aufbau und Rollout eines Wissensmanagements im Bereich SAP Insurance in einem international operierenden Software- und Beratungshaus (Bachelor thesis). Fakultät Wirtschaftsinformatik der Hochschule Furtwangen University, Germany (2008)
- [Nonaka and Takeuchi 1995] Nonaka, I. and Takeuchi, H.: The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation. New York: Oxford University Press. (1995)
- [Probst, Raub and Romhardt 2006] Probst, G., Raub S. and Romhardt, K.: Wissen managen: Wie Unternehmen ihre wertvollste Ressource optimal nutzen. Wiesbaden, GWV Fachverlage GmbH, 5. Auflage (2006)

[Retzer, Yoong and Hooper 2009] Retzer, S., Yoong, P. and Hooper, V.: Inter-Organisational Knowledge Transfer in Small-World Networks. In: Tochtermann, K. et al. (Hrsg.): Proceedings of I-KNOW'09. 9th International Conference on Knowledge Management. Verlag der Technischen Universität Graz, Graz 2009

[Riempp 2004] Riempp, G.: Integrierte Wissensmanagement-Systeme, Architektur und praktische Anwendung. Berlin, Heidelberg, Springer (2004)

[Zaunmüller 2005] Zaunmüller, H.: Anreizsysteme für das Wissensmanagement in KMU: Gestaltung von Anreizsystemen für die Wissensbereitstellung der Mitarbeiter, Gabler Verlag (2005)

Challenges and Solutions for Knowledge Sharing in Inter-Organizational Teams: First Experimental Results on the Positive Impact of Visualization

Alice Comi

(University of Lugano, Lugano, Switzerland
alice.comi@usi.ch)

Martin J. Eppler

(University of St. Gallen, St. Gallen, Switzerland
martin.eppler@unisg.ch)

Abstract: As pointed out by several scholars, inter-organizational collaboration is an important vehicle for knowledge creation. But the process of integrating knowledge across organizational boundaries entails great complexity. In this paper, we argue that visualizing knowledge in inter-organizational meetings is a conduit of knowledge sharing, and enables innovative re-combinations of organizational competences. We propose an experimental design to uncover the advantages and possible disadvantages of using visual techniques as a support for inter-organizational knowledge sharing. In particular, we compare the process and the outcome of knowledge sharing in inter-organizational teams supported with 1) software-based visualization, 2) poster-based visualization, and 3) text-based methods. The first results of our experiments suggest that software-supported teams outperform the control groups in knowledge-sharing tasks, and exhibit greater satisfaction with teamwork process and outcome. After discussing relevant implications for both researchers and practitioners, we point out limitations of our study and suggest directions for future research.

Keywords: Knowledge Sharing, Knowledge Development, Knowledge Visualization, Inter-Organizational Teams, Inter-Organizational Innovation, Experimental Research

Categories: H.4.3, H.5.3., J.4, L.2.3, M.0, M.2, M.8

1 Introduction

More than ever before, organizations continue to look for innovation opportunities beyond their organizational boundaries, therefore becoming involved in a variety of inter-organizational collaborations. A by-product of these arrangements is the formation of inter-organizational teams, set up by the partner organizations in order to make the collaboration operational. As a coordination mechanism between the partner organizations, inter-organizational teams should provide a communal medium where knowledge can be shared, integrated, and re-combined. However, team members may encounter considerable barriers to knowledge sharing, due to differences in the management styles, power bases, and cultures of the represented organizations. Failure to overcome knowledge boundaries may lead to frictions among team members, and eventually backfire on the collaborative agreement between the parent organizations [Fong, 03, Pearce, 09, Vlaar, 06].

A burgeoning stream of research [Bresciani, 09a; Ewenstein, 07; Whyte, 08] suggests that knowledge visualization plays a pivotal role in supporting knowledge intensive tasks in co-located work teams. However, none of these studies has specifically addressed the question of how visual representations can support knowledge sharing across organizational boundaries. In this paper, we propose an experimental approach to understand the advantages - and possible disadvantages - of using visual templates to facilitate knowledge communication in inter-organizational meetings. We structure the paper as follows: In the theoretical section, we take a closer look at the challenges of inter-organizational knowledge sharing, and we describe how visualization may mitigate such challenges. In the empirical part, we outline the experimental design that we have used to empirically test our hypotheses, and comment on the descriptive results of our first experiment runs. In the concluding section, we acknowledge the limitations of our study, and pinpoint avenues for future research on visual support for inter-organizational teamwork.

2 The Challenges of Knowledge Sharing in Inter-Organizational Teams

According to [van Wijk, 08], knowledge sharing refers to the process by which organizational actors - teams, units or organizations - exchange, receive, and are influenced by the knowledge of others. In their seminal study [Cook, 99] suggest that knowledge sharing at the team level is a powerful source of organizational innovation, since interpersonal interaction brings along the creative re-combination of knowledge. However, several scholars argue that knowledge sharing in inter-organizational teams is overly complex [see van Wijk, 08]. By virtue of their structural configuration, inter-organizational teams are faced with the dual challenge of overcoming both functional and organizational boundaries to knowledge sharing [Pearce, 09].

Along the functional boundary, team members are confronted with semantic barriers, namely the problems of understanding raised by the multi-disciplinary nature of inter-organizational work. Although semantic barriers are at work also in intra-organizational, cross-functional settings [Carlile, 02], they are deemed to assume a heightened relevance in inter-organizational contexts. In fact, inter-organizational teams are more likely to lack a shared language for interpreting, transferring, and integrating knowledge. [van Wijk, 08] have shown that knowledge ambiguity, defined as uncertainty about the underlying components, sources, and interrelations of knowledge, is more detrimental at the inter-, rather than intra-organizational level. In turn, this supports the notion that inter-organizational teams are endowed with fewer opportunities to eventually make sense of ambiguous knowledge.

Besides encountering semantic barriers to knowledge transfer, inter-organizational teams are confronted with pragmatic concerns related to the protection of proprietary knowledge against unintended leakages to the collaborating partners. In fact, team members may inadvertently trade away market insights that otherwise may have been an exclusive advantage of their parent company. In turn, fear of helping a competitor may induce opportunistic behaviours in knowledge sharing, and undermine the trust base of the inter-organizational team [Fong, 03]. This challenge is

not present in intra-organizational contexts, where the common organizational affiliation enables members to share knowledge without any appropriation concerns.

The organizational differences and the lack of trust may be even more prominent in the early stages of inter-organizational collaboration, when the team tasks are surrounded with ambiguity [Huiskonen, 02]. In the transition to a new relationship, team members do not know each other well and may look with suspicion at the agenda, values and beliefs of the partner organization. This may lead participants to develop different interpretations of the same phenomena, and increases the likelihood of misunderstandings in knowledge sharing [Vlaar, 06]. In the next section, we suggest that knowledge visualization may work as a conduit of knowledge sharing, and enable inter-organizational members to cope with problems of understanding.

3 Knowledge Visualization as a Conduit of Knowledge Sharing in Inter-Organizational Teams

The extant research on knowledge visualization consistently indicates that visual representations can facilitate knowledge sharing in the context of co-located team work. According to [Ewenstein, 07], visual representations are both communication devices whereby meaning is conveyed, and tangible artefacts whose manipulation affords the generation of novel insights. By virtue of their interactive property, visual representations can work as boundary objects, thus facilitating the creation of shared meaning across different practices. The interaction with visual objects enables individuals to make sense of their knowledge differences, and provides an infrastructure for translating knowledge across boundaries [Carlile, 02]. As boundary objects, visual representations should be particularly helpful in inter-organizational contexts, where the collaborating parties face multiple barriers to knowledge sharing. Along the semantic boundary, visualization may provide participants with a shared syntax for representing their knowledge, and learning about their reciprocal interdependences. Along the pragmatic boundary, visualization can contribute to address the appropriation concerns of the collaborating partners, by making explicit the border line between pooled and proprietary knowledge.

According to [Comi, 09a], visual facilitation may be particularly beneficial in the early stages of inter-organizational collaboration, where team members need to define interaction norms, and to concurrently develop mutual trust. Visualization may facilitate the decision to enter a strategic alliance, by enabling prospect partners to understand competence complementarities, and envision innovation opportunities. As put by an alliance manager interviewed by us: “Knowledge visualization is central in the early stages of a strategic alliance, serving not just planning purposes, but also mutual understanding and trust building”. While providing a means for sensemaking in collaborative settings, knowledge visualization is not without disadvantages [Bresciani, 09b]. In the transition stage to a strategic alliance, the persuasive effects of pictorial images may be particularly detrimental, inducing team members to overrate the value potential of the prospective collaboration. By engaging in the visual depiction of collaboration opportunities, team members may be cajoled by the image of a productive relationship, and develop excessive confidence in the alliance feasibility.

Although the current literature provides interesting insights on the advantages and drawbacks of visual facilitation, a systematic investigation of these phenomena in the inter-organizational contexts has thus far been absent. In addition, the current literature has largely left unaddressed the question of *whether the use of different media to convey visual representations bears an influence on knowledge sharing*. The information visualization literature suggests that software support provides a richer medium compared to printed support, but this assumption has not yet been tested empirically.

In this paper, we therefore address the question of whether, and how, the use of visual facilitation - conveyed by diverse media - bears an influence over knowledge sharing in inter-organizational teams. In doing so, we deliberately focus on the transition stage to inter-organizational collaboration, where the adoption of visual facilitation is likely to deliver the greatest effects. We hypothesize that *visual facilitation brings a positive influence on the quality of knowledge sharing* (H1), and in turn leads to *greater productivity* in inter-organizational meetings (H2). We also assume that visual-supported teams will experience *greater satisfaction* with the meeting process and outcome, compared to non-supported teams (H3). However, knowledge visualization may exert a manipulatory effect, inducing inter-organizational teams to *overrate* the value potential of the prospective collaboration (H4). We tentatively hypothesize that the above effects - positive and negative - will present greater intensity when knowledge visualization is conveyed by means of *software*, rather than *printed* support (H5). By comparing the two support conditions, we should be able to assess the added value of software-based visualization, and to appreciate the combined effect of computer interactivity and knowledge visualization.

4 Simulating Inter-Organizational Knowledge Sharing through Realistic Experiments

4.1 Experimental Design and Participants

In order to test our research hypotheses, we have developed a *between subjects* experimental design, with participants being randomly assigned to three different modalities of the independent variable. The independent variable is visual support, and the corresponding experiment conditions are i) *computer-based support*, ii) *poster-based support*, and iii) *no visual support*. As dependent variables, we have measured knowledge sharing quality, team effectiveness, team work satisfaction and attitudes towards alliance making [see 4.3 for greater details]. The 86 participants were advanced students enrolled either in an Executive Master (N=67) or a Master of Arts (N=19) in Business Administration. Data was collected in the course of three experiment runs, carried out between June and December 2009 at the Universities of Geneva and St. Gallen (Switzerland). In total, we had 8 computer-supported, 7 poster-supported, and 7 control groups - a balanced distribution allowing for comparable results across the experimental conditions. The participants were given a hidden-profile, role playing case study containing detailed information as regards their organization, but only limited information about their potential partner. The case game [Comi, 09b] is set in the construction industry, and provides asymmetric

information about two building companies considering the constitution of a strategic alliance.

After reading the case study, participants were paired up into inter-organizational teams of 3 - 4 participants, and played the role of executive managers representing the two sides of the prospective alliance. The team tasks consisted of sharing knowledge in order to identify complementary competences (task 1) and to envision opportunities for collaborative innovation (task 2). Following the tasks instructions, team members designated a facilitator of the bilateral discussion, elected from the organization hosting the meeting. The facilitator documented the bilateral discussion with the support materials received from the organizers, namely i) software files, ii) poster templates, or iii) flipcharts depending on the condition of assignment. Whereas the control groups used a blank flipchart, the experimental groups received the same visual templates, the only difference being the type of medium support. The computer supported groups worked with digital templates loaded on the let's focus visualization software, while the poster-supported groups used post-its on printed templates. The visual templates used in the experiment were the competence complementarity chain adapted from [Pietroforte, 96] and the innovation opportunity map adapted from [Muller, 02]. The first template is intended to support the identification of complementarity areas, while the second one is suited to assist the exploration of joint innovation via the systemic recombination of the partners' competences [see 4.2 for greater detail].

At the end of the joint discussion, participants received a questionnaire where they had to express their attitudes towards the prospective alliance, and to evaluate the inter-organizational knowledge sharing process (self-reported measures). Finally, the experimenters analyzed the documentation of the joint discussion against the case study solution, and accordingly evaluated team performance (objective measures). In order to reduce the risk of experimenter's bias [Jung, 71], all the participants received written instructions of the experimental tasks. The experiment lasted for about 1 hour and a half (30 min. for case study reading, 20 min. for each team task, and 10 min. for filling out the questionnaire). The groups worked in separate environments in order to avoid contaminations between groups and across experimental conditions.

4.2 Visual Templates

The rigorous selection of visual templates is of primary importance in order to ensure the internal validity of the research design, as well as the reliability of the experimental results [Bresciani, 09a]. We have identified the competence complementarity chain [Pietroforte, 96] and the innovation opportunity map [Muller, 02] by carrying out a literature review of graphical representations of inter-organizational competences. Afterwards, we have performed three experiment pre-tests (March-May 2009) to assess the suitability of the selected templates to support inter-organizational knowledge sharing. Based on the feedback received from the experiment participants, we have slightly adjusted the templates layout in order to correct minor usability problems. The visual templates used in the final experiment are displayed in [Fig. 1-2]: The left side shows the empty templates distributed to the experimental groups, while the right side displays the filled templates used to evaluate team performance. We have elaborated the filled versions in collaboration with a

consultant who had been personally involved in the strategic alliance described in the case game.

Both the visual templates are intended to represent the *collective knowledge* of the partner organizations, which is reflected in the *organizational competences* mapped onto the template canvas. The competence complementarity chain [Fig. 1] is a two-layers template where team members can display their organizations' competences along the industry value chain. By matching *core competences*, inter-organizational actors should be able to visually inspect *complementarity areas*, and to better assess the value creation potential of the strategic alliance. As visible in the filled template, team members should fill in the industry value chain (5 items) and identify 20 organizational competences, of which 3 are core competences (to be represented with arrows).

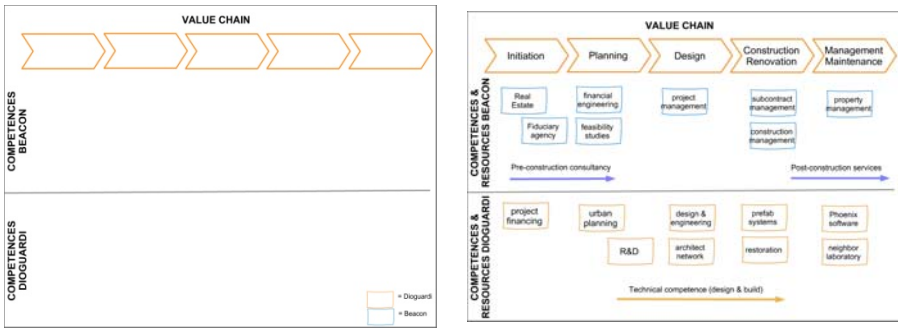


Figure 1: The Competence Complementarity Chain (for Task 1)

The innovation opportunity map [Fig. 2] is a three-layers template, displaying i) *organizational competences*, ii) *market needs and developments*, and iii) *joint innovation opportunities*. With the support of this template, team members can systematically recombine organizational competences to address market trends, and to envision corresponding opportunities for collaborative innovation. As shown in the filled template, team members should be able to generate about 7 innovation opportunities, intended to address 3 major market needs and developments.

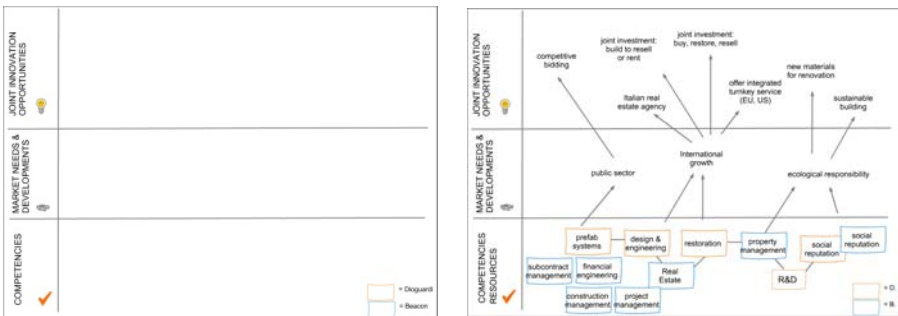


Figure 2: The Innovation Opportunity Map (for Task 2)

In summary, the first template supports the identification of organizational competences (task 1), whereas the second template facilitates the development of innovation opportunities (task 2). As mentioned above, the experimental groups are given the same visual templates, the only difference being the medium used to document team work (computer vs. poster support). The teams in the control condition do not receive any visual support, but are given the same labels reported in the empty templates as cognitive categories to structure their work. In this way, the control groups are in a fair position compared to the experimental groups, and the observed differences should be attributable to the intervention variable only. Due to space constraints, we cannot illustrate the experiment tasks with pictures of the teams' work results. However, relevant examples of team solutions produced across the three experimental conditions can be viewed online at the address: <http://www.knowledge-communication.org/visuals.html>.

4.3 Measures

Before reporting the first results of our experiments, in this section we briefly describe the operational definitions that we have used for measuring the dependent variables of our study. We have introduced self-reported measures for assessing individual perceptions of the team process, together with objective measures for evaluating team performance on the two experimental tasks. The self-reported values were collected by asking the experimental participants to fill out a questionnaire with items measured on a 7-point Likert scale. The objective values, on the other hand, were generated by the experimenters assessing the performance of each team against the official solution of the case game tasks [Comi, 09b].

4.3.1 Self-reported Measures

Team knowledge sharing quality. The quality of knowledge sharing in the inter-organizational team was measured with the interpersonal knowledge, skills and abilities scale (KSA) by [Kichul, 00], combined with two facets of the behavioral observation scale (BOS) by [Taggar, 01]. The interpersonal KSA is comprised of three sub-dimensions, i.e. conflict resolution, collaborative problem solving and communication (9 items), while the BOS facets are focus on task-at-hand and synthesis of team ideas (4 items). In our view, the selected instruments are suitable to measure knowledge-sharing quality, as they tap into the ongoing interaction among team members, with a focus on performing behaviours that precede effective teamwork.

Meeting satisfaction. The satisfaction construct was measured with a validated instrument [Briggs, 06], specifically tailored to the context of groups working with facilitation support. The selected instrument builds on a multidimensional concept of satisfaction and comprises two sub-scales, namely *satisfaction with meeting process* (SP) and *outcome* (SO), each measured with four items.

Team members' attitudes towards alliance making. For this construct, we have developed ad-hoc, single items whereby we ask respondents to estimate the value creation potential of the strategic alliance on a 7-point Likert scale.

4.3.2 Objective Measures

Team effectiveness. In order to assess this construct, we have developed a set of objective measures based on the solution of the two team tasks, reported in the teaching note of the case game [Comi, 09b]. As a measure of *team productivity*, we have counted the number of i) organizational competences, ii) market developments, and iii) innovation opportunities matching with the task solution. In parallel, we have elaborated a measure of *team precision* in solving the tasks, by dividing the number of correct items by the number of total items documented by team members. Moreover, we have evaluated the team's recognition of competence complementarities along the industry value chain (dummy coding, yes-no).

4.3.3 Control Measures

A number of factors pertaining to the characteristics of team members may influence the dependent variables of our study, therefore confounding the effect of visual support. To rule out alternative explanations, we have controlled for the following variables: 1) the cultural diversity of team members, 2) the facilitator's skilfulness, 3) the individual attitudes to teamwork, 4) the individual mastery of visualization techniques, 5) the individual experience with strategic alliances, 6) the individual knowledge of the building industry, 7) the individual mastery of the English language, and 8) the team collective effort in carrying out the experiment tasks. To measure control variables, we have developed ad-hoc single items - with the exception of teamwork attitudes (3) and team effort (8), for which we have used validated three-items scales by [Cunningham, 01] and [Campion, 93] respectively.

4.4 First Results

Thus far, we have collected data from 22 groups (N=86), distributed almost uniformly across the three experimental conditions (8 software-supported, 7 poster-supported, 7 control groups). A power analysis performed through G*Power 3 has revealed that the current sample is not sufficiently large to carry out an inferential statistical analysis. We plan to further replicate our experiment, since - assuming a moderate effect size of the independent variable - we will need about 60 cases per condition (N=180) in order to be able to detect statistically significant effects. In the meantime, we have performed a descriptive analysis of our dataset, and found initial - although statistically inconclusive - support for our hypotheses. In [Tab. 1], we report the descriptive statistics, produced by averaging the teams' self-reported and objective values in each experimental condition. We comment below on the most relevant findings, structuring our discussion according to the distinction between self-reported and objective measures.

4.4.1 Self-reported Measures: Descriptive Results

Team knowledge sharing quality. Contrary to our expectations, the highest value for *interpersonal KSAs* is found in the control condition, even though the difference with the other two conditions is only minimal. We may speculate that control groups perceived a more natural setting for knowledge sharing, since they did not have to deal with the appropriation of a support system. At times, we have observed that the

natural flow of knowledge in experimental groups was slightly inhibited by the need to learn how to use visual facilitation. On the other hand, *idea synthesis* was reportedly higher in the visual-facilitated conditions, therefore confirming the perceived helpfulness of visualization for streamlining knowledge intensive conversations. Also the reported *focus on task at hand* was higher in the software-facilitated condition, but exhibited slightly lower values among poster-supported groups. As a possible explanation, we may advance that poster-facilitated teams perceived visual templates with post-its as a bit playful, and occasionally went into off-topics discussion. There was also a tendency to focus too much on one's own post-its and listen less to the other team. If we average the three measures of team knowledge sharing quality, we observe mixed support for H1 (*visual facilitation brings a positive influence on the quality of knowledge sharing*). As visible in the row *knowledge sharing quality (avg.)* in [Tab. 1], the positive impact of visualization on team knowledge sharing is confirmed only for the computer-supported condition.

	Measures	Software (N=8)	Poster (N=7)	Control (N=7)
Self-reported*	Interpersonal KSAs	5.92	5.82	5.96
	Focus on task at hand	6.31	5.19	5.33
	Synthesis of ideas	5.70	5.63	5.52
	Knowledge sharing qual.(avg.)	5.98	5.55	5.60
	Process satisfaction	5.67	5.30	5.33
	Outcome satisfaction	5.87	5.39	5.30
	Meeting satisfaction (avg.)	5.77	5.35	5.32
	Alliance making attitudes	5.46	5.26	5.21
Objective	Competences [†]	11.3 (95%)	12.00 (83%)	8.13 (67%)
	Trends [‡]	3.86 (92%)	3.14 (64%)	1.14 (56%)
	Innovations [‡]	5.38 (92%)	3.14 (56%)	3.00 (72%)
	Complementarities [‡]	7 (88%)	6 (86%)	3 (43%)
	Team productivity**	20.54 (93%)	18.28 (68%)	12.27 (65%)

* All self-reported measures are on a 7-point Likert scale [†] Absolute count of correct items (team productivity) followed by percentage of correct items on total items (team precision) [‡] Number and corresponding percentage of teams who correctly identified competence complementarities **Sum of correct items followed by average of correct items on total items for *Competences*, *Trends*, and *Innovations* - *Complementarities* is excluded being measured as a dummy variable (yes-no).

Table 1: Descriptive Results (N=86)

Meeting Satisfaction. Satisfaction with process and outcome was higher among software-facilitated groups, while presenting comparable values across the other two conditions. The averaged values of meeting satisfaction [Fig. 1, row “Meeting satisfaction (avg.)”] provide preliminary support for H3 (*visual-supported teams will experience greater satisfaction with the meeting process and outcome*), and suggest that the effects are slightly stronger when the visual templates are conveyed by means of a software, rather than printed support (H5).

Team members' attitudes towards alliance making. The software-based support also led to a more positive assessment of the alliance potential, although the reported value is still within the range of moderate to high. Therefore, we cannot derive strong support for our hypothesis on the cajoling effect of visualization (H4) and for the stronger effects of computer-supported visualization in this respect (H5). However, it will be interesting to test if the group mean differences - albeit modest - are statistically significant.

4.4.2 Objective Measures: Descriptive Results

Team effectiveness. The visual-supported groups outperformed the control groups on all the objective measures of team effectiveness, with the software-based condition yielding the highest productivity and task precision. In general, the descriptive statistics provide preliminary support for H2 (*visual facilitation leads to greater productivity in inter-organizational meetings*) while also confirming the superior effects of computer-supported visualization compared to poster-supported visualization (H5). A minor exception regards the competence counts, on which the poster-supported groups exhibited slightly higher results compared to the software-supported condition. On the other hand, the software medium provided the greatest support for the innovation task, leading to the generation of 2.25 items more than in the poster-supported condition. The task precision was consistently superior in the software-supported condition, where team members reported the largest percentage of pertinent items (92-95%) on both the experimental tasks. In turn, the poster-facilitated groups generally outperformed the control groups in terms of task precision, except for the documentation of innovation opportunities. We believe that the most interesting finding lies in the *superiority of the software medium for fostering divergent thinking (task 2), and task precision*. This suggests that - compared to traditional visualization - the software support facilitates both the generation of creative ideas, and their refinement into a set of highly pertinent items. This advantage can be explained with reference to the higher rigidity of the software medium, which forces team members to adhere more strictly to the received instructions. This is not the case with traditional media, which allows for greater flexibility in the appropriation of visual templates. For example, we have observed poster-supported teams using post-its beyond the template frames, therefore overloading the poster with redundant items, and in turn scoring lower in task precision. In another case, using the innovation template in the horizontal - rather than vertical - sense lowered performance on the divergent task, preventing team members from seeing the high-end chaining from competences to innovations. Finally, it is remarkable that *the majority of visual-supported groups (86-88%) correctly identified competence complementarities, while more than a half of the control groups (57%) failed on this performance measure*. The identification of competence complementarities represents the foremost stage of alliance making, and the fact that non-supported groups failed in this endeavour is a non-trivial result, with relevant implications for alliance practice.

5 Conclusions and Future Work

We have reported descriptive results of our experiment, which provide preliminary support for our hypotheses about the positive impact of visual support on inter-organizational teamwork. In particular, the descriptive analysis suggests that software support generally leads to superior results on both subjective and objective performance-related measures. However, these findings are non-conclusive, and present severe limitations in terms of external validity, being only applicable to a small sample of inter-organizational teams. In addition, at a descriptive level we could not control for team-related variables with a potential to confound the effects of the independent variable [see 4.3.3]. On the other side, the random assignment of experimental subjects to the different modalities of the independent variable allows us to rule out the risk of systematic biases in our data, such as participant self-selection.

As a next step in our experimental research, we plan to collect additional data - up to about 180 cases - in order to be able to test for the statistical significance of our results. Once we will have collected sufficient data, we will conduct an inferential analysis by using analysis of variance (ANOVA) in order to test for significant differences in group means. In parallel, we will use structural equation modelling (SEM) to detect mediation effects among the endogenous variables of our research model (e.g. knowledge sharing quality may mediate team effectiveness). We are also considering the possibility of applying a multilevel analysis, which would enable us to appreciate the individual level nested within the team unit.

While limited in terms of external validity, the reported findings confirm the feasibility of our experiment design, and suggest that assessing the impact of visual support on inter-organizational teamwork is a promising field of research. If our hypotheses will be confirmed, the ensuing implications will be relevant for both practitioners and scholars in the field of knowledge management and alliance management. On the one hand, alliance professionals may consider including visual templates in their toolbox for alliance management. On the other hand, interested scholars may adopt complementary methods to further investigate the role played by knowledge visualization in inter-organizational collaboration. As the experimental method is carried out in an artificial setting, this research could be complemented by qualitative studies, such as the participant observation of inter-organizational meetings facilitated by visual techniques. Future research may also attempt to identify which visual templates - besides the ones used in our experiment - are best suited for the purposes of supporting inter-organizational knowledge sharing.

References

- [Bresciani, 09a] Bresciani, S., Eppler, M.J.: "The benefits of synchronous collaborative information visualization: Evidence from an experimental evaluation"; *IEEE Transactions on Visualization and Computer Graphics*, 15, 6 (2009), 1073-1080.
- [Bresciani, 09b] Bresciani, S., Eppler, M.J.: "The risks of visualization: A classification of disadvantages associated with graphic representations of information". In Schulz, P.J, Hartung U., Keller, S.: "Identität und Vielfalt der Kommunikations-Wissenschaft"; *UVK Verlagsgesellschaft mbH / Konstanz* (2009), 165-178.

- [Briggs, 06] Briggs, R.O., Reinig, B.A., de Vreede, G-J.: "Meeting satisfaction for technology-supported groups: An empirical validation of a goal-attainment model"; *Small Group Research*, 37, 6 (2006), 585-611.
- [Campion, 93] Campion, M.A., Medsker, G.J., Higgs, A.C.: "Relations between work group characteristics and effectiveness: Implications for Designing Effective Work Groups"; *Personnel Psychology*, 46, 4 (1993), 823-850.
- [Carlile, 02] Carlile, P.R.: "A pragmatic view of knowledge and boundaries: Boundary objects in new product development"; *Organization Science*, 13, 4 (2002), 442-455.
- [Comi, 09a] Comi, A., Eppler, M.J.: "Visualizing organizational competences: Problems, practices, perspectives"; *Proc. I-KNOW 09, Graz* (2009), 115-127.
- [Comi, 09b] Comi, A., Eppler, M.J., Pietroforte, R.: "Building innovation alliances on complementary competences: The Beacon and Dioguardi case study"; ECCH collection, (2009).
- [Cook, 99] Cook, S.D.N., Brown, J.S.: "Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing"; *Organization Science*, 10, 4 (1999), 381-400.
- [Cunningham, 01] Cunningham, B.W.: "The Impact of Reward Structure on Project Team Effectiveness"; Master thesis, Virginia Polytechnic Institute and State University, (2001).
- [Ewenstein, 07] Ewenstein, B., Whyte, J.K.: "Visual representations as 'artefacts of knowing'"; *Building Research & Information*, 35, 1 (2007), 81-89.
- [Fong, 03] Fong, P.S.W.: "Knowledge creation in multidisciplinary project teams: An empirical study of the processes and their dynamic interrelationships"; *International Journal of Project Management*, 21, 7 (2003), 479-486.
- [Huiskonen, 02] Huiskonen, J., Pirttilä, T.: "Lateral coordination in a logistics outsourcing relationship"; *International Journal of Production Economics*, 78, 2 (2002), 177-185.
- [Jung, 71] Jung, J.: "The experimenter's dilemma"; Harper and Row / New York (1971)
- [Kichul, 00] Kickul, J., Neuman, G.: "Emergent leadership behaviors: The function of personality and cognitive ability in determining teamwork performance and KSAs"; *Journal of Business and Psychology*, 15, 1 (2000), 27-51.
- [Muller, 02] Muller, A., Valikangas, L.: "Extending the boundary of corporate innovation"; *Strategy & Leadership*, 30, 3 (2002), 4-9.
- [Pearce, 09] Pearce, B., Weingart, L., Hinds, P.J., Rousseau, D.M.: "Inter-organizational groups: A new context for examining the triggers of group conflict"; Carnegie Mellon University Working Paper (2009).
- [Pietroforte, 96] Pietroforte, R.: "Building international construction alliances - successful partnering for construction firms"; E & FN Spon / London (1996)
- [Taggar, 01] Taggar, S., Brown, T.: "Problem solving team behaviors: Development and validation of BOS and hierarchical factor structure"; *Small Group Research*, 32, 6 (2001), 698-726.
- [van Wijk, 08] van Wijk, R., Jansen, J.J.P., Lyles, M.A.: "Inter- and intra-organizational knowledge transfer: A meta-analytic review and assessment of its antecedents and consequences"; *Journal of Management Studies*, 45, 4 (2008), 830-853.

[Vlaar, 06] Vlaar, P.W.L., Van den Bosch, F.A.J., Volberda, H.W.: "Coping with problems of understanding in interorganizational relationships: Using formalization as a means to make sense"; *Organization Science*, 27, 11 (2006), 1617-1638.

[Whyte, 08] Whyte, J., Ewenstein, B., Hales, M., Tidd, J.: "Visualizing knowledge in project-based work"; *Long Range Planning*, 41, 1 (2008), 74-92.

Utilising Pattern Repositories for Capturing and Sharing PLE Practices in Networked Communities

Felix Mödritscher

(Vienna University of Economics and Business, Vienna, Austria
felix.moedritscher@wu.ac.at)

Zinayida Petrushyna

(RWTH Aachen University, Aachen, Germany
petrushyna@i5.informatik.rwth-aachen.de)

Effie Lai-Chong Law

(University of Leicester, Leicester, United Kingdom
elaw@mcs.le.ac.uk)

Abstract: Personal learning environments (PLEs) comprise a new kind of learning technology which aims at putting learners into centre stage, i.e. by empowering them to design and use environments for their learning needs and purposes. Setting a PLE approach into practice, however, is not trivial at all, as the proposed end-users have varying attitudes and experiences in using ICT in general and PLE software in particular. Here, practice sharing could be an enabler for increasing the usefulness and usability of PLE solutions. In this paper we examine the relevant issues of capturing and sharing ‘good practices’ of PLE-based, collaborative activities. By good practices we refer to learning experiences provided by learners for a networked community. Moreover, we introduce the concept of a pattern repository as a back-end service for PLEs which should, in the sense of community approaches like Last.fm, support PLE users in applying learning tools for their activities. Finally, we present a preliminary prototype and argue for the advantages of such a practice sharing infrastructure with respect to community literature, experiences, and an internal evaluation study.

Keywords: Personal Learning Environments, Practice Sharing, Digital Repositories, Virtual Communities

Categories: H3.5, H3.7, J.4, L3.6, L6.1

1 Introduction

According to [Henri et al., 08], personal learning environments (PLEs) refer to a set of learning tools, services, and artefacts gathered from various contexts and to be used by the learner who designed the environment. However, user studies in the field of higher education and workplace learning [Nguyen-Ngoc & Law, 08; Kooker et al., 07] evidence that learners – and even teachers [Windschitl & Sahl, 02] – have varying attitudes towards and hand-on skills in using ICT for learning. On the one hand, they may be capable of adopting and utilising new tools for their needs easily. On the other hand, ICT may restrict them as they spend too much time on playing around, being unfocussed when using them, or even failing to achieve their goals due to frustration and distraction by trying to handle them [Windschitl & Sahl, 02]. Such negative user

experience hinders learners from proceeding with their learning as they cannot adapt their environments according to their needs and goals.

As stated by [Van Harmelen, 08], personal learning environments aim at empowering learners to design (ICT-based) environments for their learning activities and acquire competences through using the PLE and not being frustrated by ICT usage. [Eckstein et al., 01] outline the necessity of capturing and sharing successful teaching practices, i.e. through pedagogical patterns, so that instructors can set didactical strategies and translate them into practice without going through the time-consuming process of consulting didactical experts. Similar findings on pedagogical patterns are reported for CSCL processes [Persico et al., 09] and learning efficiency [Kolfshoten et al., 10]. In accordance with these experiences, practice sharing seems to be a critical requirement for personal learning environment (PLE) settings, as it can ease ICT usage and reduce frustration from working with technology.

In this paper, we build upon the idea of utilising activity patterns for capturing and sharing learning experiences with PLE technology and examine how a pattern repository can be applied to enable good practice sharing of PLE-based activities in networked communities. The term ‘good practices’ refers to the fact that we focus on experiences provided by any kind of end-user and do not restrict to best practices approved by PLE experts. The rest of the paper is structured as follows. The upcoming section describes our approach including definitions, theoretical foundations, and related work relevant for sharing PLE practices. Then, section 3 sketches the concept of a pattern repository and reviews state-of-the-art technology. Section 4 proposes an infrastructure for sharing PLE practices and describes a first prototype. This implementation is discussed with respect to an example and related work in section 5, before the paper is concluded and the next steps are indicated.

2 Capturing and sharing good practices in PLE settings

As mentioned before, personal learning environment (PLE) approaches have a strong focus on enabling learners to utilise learning tools for specific purposes in a certain context [Henri et al., 08; Van Harmelen, 08; Wild, 09]. On a very general level, learners are involved in so-called activities in which they connect to learner networks and collaborate with peers on shared artefacts [Wild, 09]. The application of PLE technology particularly focuses on the field of lifelong learning, e.g. for learning on the job, further or higher education, learning for private interests, etc., and thus can be very broad. Moreover, working with PLEs requires competences beyond the professional ones, so-called transcompetences which comprise hand-on skills for learning tools, self-regulated learning skills or social competences [Henri et al., 08; Wild et al., 09]. Based on our understanding, PLE-related competences are supposed to be latent components of lifelong learning activities, whereby we will not examine them although they could be subject to further research.

As a first step towards PLE practice sharing and regarding experiences from community approaches like Last.fm (<http://www.last.fm>) or Mendeley (<http://www.mendeley.com>), we propose **capturing the interactions of learners** with their environments, i.e. with the tools, shared artefacts, and peer actors. However, recordings of learner interactions should not be shared for two important reasons, namely trust and privacy considerations [Dwyer et al., 07]. Trust can be understood as

“the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party” [Mayer et al., 95]. Thus, it is recommended to give the learners full control over this sensitive data. Sharing these recordings should be initiated or, at least, be permitted by the learner.

In addition, privacy is defined as “the interest that individuals have in sustaining a ‘personal space’, free from interferences by other people and organizations” [Clarke, 06]. Digital recordings of learner interactions are part of this personal space and should be secured to preserve the learners’ privacy, which particularly is necessary for open systems [García-Barrios, 09]. Thus, our approach for sharing good practices starts with capturing learner interactions and continues with **distilling and abstracting them into a so-called ‘activity pattern’** if the user considers the activity to be successful and helpful for others.

[Alexander et al., 77] state that a pattern “describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice”. Similarly, activity patterns can be understood as “archetypal and reusable recordings of design decisions taken by the users or developers who created a learning environment” (adopted from [Alexander et al., 77]), i.e. a recording of an interaction sequence with (partially) removed entities.

Activity patterns can reach from a single learner interaction, e.g. the selection or visual arrangement of a tool, up to a pre-configured PLE for a specific situation (an activity) which even can involve several actors. Additionally, [Sobernig et al. 06] outline that “design activity often is a construction process that aims at building constructs and conceptual models from [learning] experience”. Fig. 1 visualises the **process of good practices in PLE settings** as a lifecycle. On the left side of the figure, users who are experts in their domain and have the required competences and skills utilise the learning tools available to achieve their goals given by lifelong learning activities like learning-on-the-job or further education.

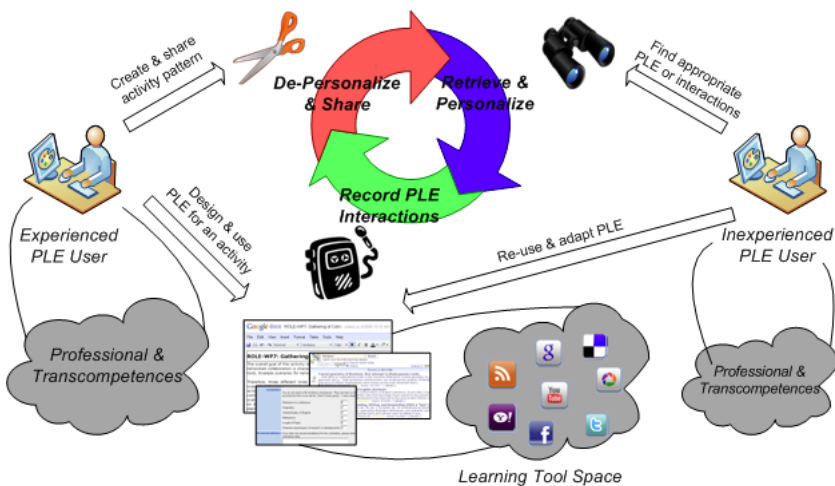


Figure 1: Good practice lifecycle in PLE settings

The first important process in the good practice lifecycle deals with recording interactions of learners with their environments (the bottom arrowed arc in the cyclic graph in Fig. 1). According to [Dillenbourg, 05], such interaction recordings contain rich information on e.g. the context of messages, knowledge sharing, sharing of construction of understanding, etc., thus being useful for other purposes like automated analysis or practice sharing. However, parts of the recordings might be sensitive or personal and, therefore, should be secured and controlled by the end-users. In the context of this paper, the process of anonymizing learner interactions is called ‘de-personalization’ which leads to digitalised learning experiences with removed or masqueraded parts, the activity patterns (the upper left arrowed arc in the cyclic graph in Fig.1). De-personalization extends the idea of anonymization in two ways. Firstly, it considers sensitive data collaboratively created by groups. Secondly, it includes the aspect that a pattern must be ‘(re-)personalizable’ for others.

Consequently, the PLEs and interactions of experienced PLE users are available to peers, either through own repositories, manual disclosure of the activity patterns, or automated approaches like recommendations mined from the patterns. Now, it should be possible that other PLE users can find and re-use these patterns in their own way (the upper right arrowed arc in the cyclic graph in Fig. 1). By re-using good practices of peers, the lifecycle starts with the recording of user interactions again, leading to new patterns which can be slightly modified or completely different from the old one.

Activity patterns are situated and context-bound, each one standing for an activity experienced by one or more learners in a specific situation. Following the dimensions for building web-based personal learning environments [Palmér et al., 09], we identified these six dimensions for characterising patterns of PLE practices:

- a) The **activity structure** comprises the underlying pedagogical model used to describe the learning activities. Due to the broad range of possible application areas and the variety of possible end-users, this model should be generic and hide the complexity of instructional design models away [Wild, 09]. In practice, activities can be flat (a simple sequence of learner interactions), hierarchically structured (with activities containing other activities), or taking into considerations interaction flows.
- b) The **interaction type** focuses on the kinds of interactions a learner has with her environment. Interactions can be pre-defined, i.e. restricted to the features of the environment and captured in the log files of the learning tools, or specified and ‘implemented’ by end-users, e.g. by selecting tools and describing their usage with tags or other metadata.
- c) The dimension ‘**tracked applications**’ deals with the types of applications which are considered for capturing learner interactions. Thereby, pattern capturing could include desktop applications, web-based tools, or both.
- d) The **privacy dimension** addresses privacy-related aspects of the interaction recordings which can be uncritical or contain private or sensitive data. How to preserve this data is addressed in the upcoming section.
- e) The **social dimension** specifies if a pattern has been derived from an activity of a single user or a group. Having a collection of many patterns, it would be even possible to analyse and evidence community behaviour in this data.
- f) The **context dimension** describes for which situations, e.g. lifelong learning activities, a pattern can be used. The context can be specified e.g. by

metadata (like the Contextualized Attention Metadata schema [Schmitz et al., 09]) or by information implicitly contained in a pattern (e.g. relations to other patterns or to activities, actors, artefacts, and tools).

Finally and in accordance with a study on **PLE-related competences** [Wild et al., 09], Fig. 1 also indicates that practice sharing does not only focus on professional competences but also on transcompetences. The development of both competence types can be triggered by patterns, which is also evidenced by other pattern-based approaches [Eckstein et al., 01; Persico et al., 09; Kolfshoten et al., 10].

3 State-of-the-art overview of pattern repositories

Motivated by developments in the field of personal learning environments, distributed learning environments can follow different architectural styles, e.g. the five models described by [MacNeill & Kraan, 10]. However, none of these models takes into consideration practice sharing strategies. In the following we explain the concept of a pattern repository and its applicability for sharing good practices in PLE settings.

3.1 Basic idea and key features

In accordance with experiences from community approaches, like Last.fm, Wakoopa, or Mendeley, a **pattern repository** is a storage place which allows publishing and retrieving patterns. In the sense of a community platform, a pattern repository should be accessible by users via web interface and also by a PLE solution through an open API, implying that a pattern repository can be plugged into any PLE. Consequently, publishing PLE experiences (i.e. patterns) could be achieved manually through a web-based user interface or through PLE facilities but also automatically by the PLE exchanging data with the pattern repository in the background.

Highly important for practice sharing, the process of **de-personalization** aims at preserving sensitive data and the learners' privacy. It can be supported by creating awareness about privacy-critical issues [García-Barrios, 09], providing facilities for manual editing interaction recordings, or by automated approaches. Automated de-personalization strategies are commonly known, e.g. in the form of anonymization and recommendation mining in social networks [Zhou et al., 08], as authentication, anonymity, and pseudonymity [Pfitzmann & Hansen, 08] or through social network analysis approaches [Das et al., 09]. User-controlled de-personalization, on the other hand, is realised in certain web applications. Amongst others, the template sharing approach by Google Docs (<http://docs.google.com>) suggests users to edit a document manually before sharing it, while Yahoo Pipes (<http://pipes.yahoo.com>) includes a form-based mechanism to masquerade user data to be shared as a pipe.

Overall, the patterns **capturing PLE practices** to be shared should include the aspects mentioned in the last section, namely (a) *a model to structure practices*, (b, c) *the types of interactions and applications used*, (d) *privacy considerations*, and (e, f) *the social form and context of an activity*.

From the perspective of pattern consumers, such a repository should allow **retrieving and re-using patterns of PLE practices**. Referring to information retrieval strategies, pattern repositories can include facilities for actively browsing and searching the patterns. Furthermore, [Resnick & Varian, 97] state that

recommendations are necessary if users have to make choices without sufficient personal experiences of alternatives, which is mostly the case for lifelong learners who try to utilise PLE technology for their very different learning contexts. Activity patterns distilled and abstracted from interaction recordings can be analysed according to a specific context which might be worth recommending to other learners.

A pattern repository could support users while working on a lifelong learning activity in two ways. On a macro level, it provides a pre-configured PLE for a particular activity in a networked community before a learner starts to act. On a micro level and while being involved in an activity, it can support learners in designing and adapting their PLEs by recommending specific tools, certain documents, or relevant peer learners. However, mining and providing recommendation should neither threaten the users' **privacy** nor decrease the **trustworthiness** of the PLE infrastructure, as evidenced with a study on trust and privacy concerns in social networks [Dwyer et al., 07].

Besides retrieving patterns (through information push or pull mechanisms), such PLE practices also have to be instantiated before they can be used. **Instantiation**, therefore, is the process of initialising and (re-)personalizing the environment which has been retrieved from or recommended through the repository. Depending on the de-personalization technique applied, this instantiation can be realised through facilities for specifying removed or masqueraded parts of the activity patterns.

3.2 Selected approaches from literature and practice

Referring to the concept of pattern repositories, related work can be found in many fields. In the following, we will highlight selected approaches in order to show how single aspects of pattern repository can be realised in practice.

First of all, **personal and mash-up pages** enable users to design web pages through inserting widgets and gadgets available. Personalisable portal sites like iGoogle (<http://www.google.com/ig>) or Netvibes (<http://www.netvibes.com>) capture the visual arrangement of online tools for each page. Others like Pageflakes (<http://www.pageflakes.com>) even support sharing of user-created widgets ('flakes') and widget mash-up pages ('pagecasts'). Pageflakes even provides recommendations of flakes and pagecasts on the basis of tags and topicality. In the scope of technology-enhanced learning, PLE-like solutions comprise the Wookie server providing widgets for the learning management system Moodle or the social networking platform Elgg, the learning services for the LifeRay portal developed in the TENcompetence project (<http://www.tencompetence.org>), or the MUPPLE prototype [Wild, 09].

Secondly and referring to **capturing of learning experiences**, there exist various technical solutions for tracking and recording user interactions. For instance, iMacros (a Firefox add-on, cf. <http://www.iopus.com/imacros/firefox/?ref=fxmoz>) enables users to record and replay interactions with their browser, thus allowing them to automate specific work flows. Another approach is Audioscrobbler, a service by the music platform Last.fm (<http://www.audioscrobbler.net>) which tracks song listening habits of users and recommends new songs and song sequences based on statistical information about other users. Furthermore, Google Wave (<http://wave.google.com>) allows recording the collaboration on a shared artefact, while the CAMera tool [Schmitz et al., 09] aims at monitoring and reporting on learning behaviour in PLE settings by using the Contextualized Attention Metadata (CAM) schema.

Thirdly, **publishing user experiences** is realised in many approaches in the Web. Amongst others, Shareaholic (<http://www.shareaholic.com>) is a plug-in for nearly all browsers, thus allowing users to publish their URLs, manage them over several social sites and structure their online activities. Last.fm provides a public API by which the Audioscrobbler application and users can submit information about their music listening habits. Similarly, Mendeley captures research activities (i.e. documents stored locally) on users' computers and submits them via a web service to an online repository. In both approaches it is possible to de-personalize the results of the activities just by moving from personal activities to community activities. Otherwise aspects of de-personalization can be identified by the template mechanisms in Google Docs or in the Learning Activity Management System (LAMS), a tool for designing, managing and delivering online collaborative activities. Thereby, de-personalization has to be done manually by experts (e.g. the teaching community at <http://e-teaching.org> or the Technology-Supported Learning Database at <http://aragorn.scca.ecu.edu.au/tsldb>), by all kind of users (e.g. the MUPPLE prototype), or automatically by a software (e.g. the APOSDLE platform to support learning at workplace, cf. <http://www.aposdle.tugraz.at>).

Fourthly, pattern repositories also relate to **information management in digital repositories**. Ideally, patterns can be managed in a structured way and enriched with metadata (like the CAM schema), as identified in approaches like the LAMS repository, APOSDLE, MUPPLE, etc. With reference to the ARIADNE repository [Najjar et al., 03], pattern repositories should store the patterns in a uniform format thus requiring the transformation of learner interaction recordings into this format.

Fifthly and with respect to **information push mechanisms**, automated analysis techniques allow providing recommendations of learning experiences for specific situations, both realised in the APOSDLE prototype (recommendations of learning events, artefacts, and experts for the current working task). Furthermore, Wakoopa (<http://wakoopa.com>) tracks which applications are used on a computer, provides tagging and annotation functionality as well as tool recommendations according to the usage patterns. The PALADIN approach [Klamma et al., 06] applies social network analysis to detect disturbances in social networks, like spammers sending irrelevant messages to a community. Thus, PALADIN can be used to analyse the user interaction recordings stored on one repository and propose the ways of a community to cure. Moreover, [Klamma et al., 09] report on AERCS, a recommender system for scientific communities based on paper writing and co-author citation activities. Such a recommender system is particularly useful for inexperienced researchers to find appropriate collaborators and relevant events to attend.

Finally, **information pull strategies** deal with aspects of supporting learners to reuse activity patterns. Amongst others, APOSDLE and LAMS allows utilising the given learning events and LAMS templates for specific topics, i.e. enabling the transfer of good practices to completely different domains. Similarly, the MUPPLE prototype [Wild, 09] supports learners in creating activities from patterns, by manually specifying the parts which have been de-personalized by the pattern creator.

4 A practice sharing infrastructure for PLE settings

Although a lot of related work can be identified for parts of the good practice lifecycle (see Fig. 1), we have not found a repository for publishing and retrieving patterns of PLE usage experiences. Therefore we propose an extended architecture for PLEs. Instead of focussing on the architectural style of personal learning environments [MacNeill & Kraan, 10], Fig. 2 shows how PLEs can be enabled for practice sharing through pattern repositories. These repositories can be plugged into the PLEs in the back-end, no matter if the learning environments are server-sided or client-sided solutions. Using the web-based API of the pattern repository, a learner can optionally authenticate at one repository, publish her experiences if willing to do so, retrieve and reuse pre-configured PLEs in the form of patterns, and receive recommendations.

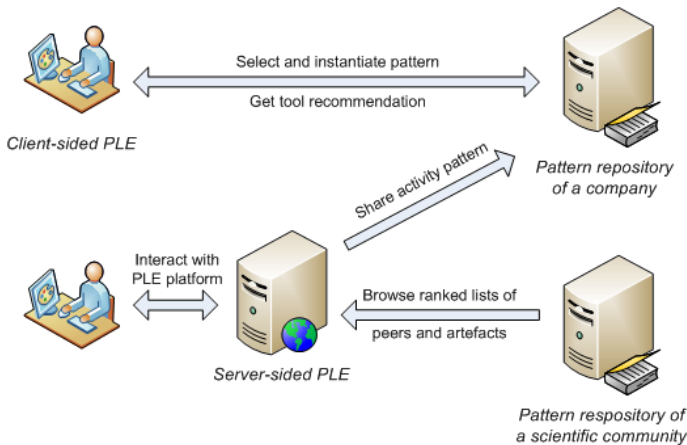


Figure 2: Proposed architecture of a PLE practice sharing infrastructure



Figure 3: Client-sided PLE prototype named Personal Activity Manager (PAcMan)

As a first proof-of-concept we have implemented the following two components: (1) PAcMan, a Firefox extension supporting learners to structure their learning context

along with activities and to manage the URLs of the tools used. (2) PLEShare, a pattern repository based on OpenACS (<http://openacs.org>) and the Wiki generator XoWiki (<http://openacs.org/xowiki>). Fig. 3 shows the user interface of the client-sided PLE solution PACMan with the navigation and management facilities being placed on the left-hand side. In the 'Activities' section, learners can create and manage their activities, the tools used, the relevant URLs, and user-given descriptions. The 'Share' section contains the pattern repositories which are currently plugged into PACMan.

These repositories can be used to share or retrieve activity patterns or to receive recommendations, both achieved over a REST-based API. In the current version, this API (integrated into the PACMan prototype) consists of the following classes and methods: (1a) *Repository.information()* returns all necessary information for accessing this repository; (1b) *Repository.statistics()* provides statistics on the patterns in the repository; (2) *User.apikey()* calculates and returns an API-key for all other operations; (3a) *Pattern.publish(apikey,content,metadata)* allows publishing one pattern; (3b) *Pattern.retrieve(apikey,query,filter)* returns the search results for querying patterns; (3c) *Pattern.recommend(apikey,mode,entity,query,filter)* provides recommendations of specific entities (patterns, peers, interactions, artefacts, tools, etc.); (3d) *Pattern.instantiate(apikey,pattern-id)* enables users to reuse a pattern.

On the technical level, the PLE client is responsible for providing the facilities for using this pattern repository API. In our client-sided PLE solution PACMan (see Fig. 3) we provide a button 'Connect' for authenticating at the repository which opens a session to the OpenACS server hosting the PLEShare component. Now users can publish their activities ('Share' button) or browse and retrieve patterns ('Search' button, not shown in Fig. 3). In the current version of PLEShare we have implemented an item-based recommender system which generates recommendations through a trivial top-n algorithm. A preliminary study (8 users to publish two to three scientific activities) showed that the number of activities (17) grew linear and the number of interactions (resources and URLs; 92 vs. 99) even quadratic, as each activity contains on average 5.41 interactions. The number of URLs grew slightly faster, as we identified that 6 interaction names occurred twice or more often, while all URLs were unique but can be grouped according to 31 top-level domains. This analysis of the data gathered as well as further usage data (e.g. number of pattern instantiations) can be used for generating recommendations based on PLE-related models (e.g. clustering interactions by activities or URLs by top-level domains).

In practice, the pattern repository can be utilised in the backend of any PLE. A typical use case in the context of an academic institution is a collaborative paper writing activity in which a learner (co-author) is working with colleagues on a shared artefact e.g. by using Google Docs. Hereby the PLE captures all relevant interactions with the tools, peers, and artifacts, creating a recording of the activity. Good practice sharing starts right after this activity has been completed by the co-author. If the co-author is convinced that this PLE experience can be useful for others she can label it with a meaningful title (e.g. 'contribute to a paper for the I-Know conference') and publish it to the pattern repository. The repository may warn her if the recording contains sensitive data, i.e. the link to the joint paper. After de-personalizing this pattern, she can successfully publish it on the selected pattern repository.

A few days later another learner is invited to join another paper writing activity. As this learner has never contributed to a conference paper before, he looks up

relevant patterns on the repository and instantiates the one mentioned above. After opening the new activity in his PLE client, he has to specify the URL of the paper to write. Furthermore, he decides to remove the suggested email application and use his own one. Finally, he inserts the search engine Google Scholar as another tool for finding relevant literature. When entering his paper contribution into the shared Wiki page, the PLE client receives two recommendations of single learner interactions from the pattern repository, namely a dictionary service and a link to the glossary of his research colleagues. The learner decides to add the glossary to his environment in order to avoid terminological inconsistencies in his paper contribution. Having finished this activity, he also shares this (adapted) experience as a new pattern.

5 Experiences from related approaches and next steps

Due to the early development stage of PAcMan/PLEShare, we have collected only few data through internal studies. Experiences from literature and practice indicate the usefulness of practice sharing through pattern repositories. For instance, [Eckstein et al., 01] built their teaching practice sharing approach upon pedagogical patterns and showed that these patterns can increase teaching efficiency generally and particularly if no didactics experts are available. On the other hand, [Shaffer et al., 09] applied Epistemic Network Analysis (ENA) to measure the evolvement of learners in digital learning environments and identified positions of different competence types in epistemic frames (competence-maps), evidencing that learners start to imitate their mentors by generating similar competence-maps over the time. Our internal study evidenced that some patterns were instantiated between one and four times for curiosity and for getting an idea how such an activity could look like.

From a more technological perspective, subsection 3.2 highlights that various aspects of the good practice lifecycle (cf. Fig. 1) are supported by systems and frameworks already. Particularly community approaches like Last.fm (including the Audioscrobbler monitoring tool) are well accepted, providing recommendations in line with the authors' expectations, and can be taken as a technical roadmap for developing a PLE practice sharing API (see <http://www.last.fm/api>). Moreover, analysis and mining approaches like PALADIN or AERCS give good insights how to infer recommendations from patterns, while other repository solutions, like LAMS or ARIADNE, lead to key features of a pattern repository for good PLE practices.

In this paper we showed how the usage of PLE technology can be enhanced for real-world scenarios by adding a practice sharing infrastructure in the back-end. Thereby, we argued for capturing and sharing good practices in PLE-based, collaborative activities through so-called pattern repositories which can be plugged into the PLEs. The patterns provided by experienced PLE users for a community can be understood as triggers for the development of professional competences and transcompetences [Wild et al., 09]. Other approaches in literature and practice indicate that practice sharing is necessary, especially under the premise of facing a broad range of possible end-users reaching from tech-savvy PLE experts to inexperienced computer users. To evidence the usefulness of our practice sharing approach, it is necessary to provide usable PLE software and to evaluate pattern repositories based on real-world data. As many PLE prototypes are under

development and in a rather immature stage, an evaluation of the PLE client PACMan and the pattern repository solution PLEShare will be the next step of our research.

Acknowledgements

The ROLE project is funded by the European Union under the ICT programme of the 7th Framework Programme (Contract number: 231396).

References

[Alexander et al., 77] Alexander, C., Ishikawa, S., Silverstein, M.: A pattern language: Towns, building, construction, Oxford University Press, Oxford, 1977.

[Clarke, 06] Clarke, R.: What's Privacy? Proc. of the Workshop at the Australian Law Reform Commission, 2006, <http://www.rogerclarke.com/DV/Privacy.html> (2010-03-30).

[Das et al., 09] Das, S., Egecioglu, Ö., El Abbadi, A.: Anonymizing Edge-Weighted Social Network Graphs, UCSB Computer Science Technical Report 2009-03, 2009.

[Dillenbourg, 05] Dillenbourg, P.: Designing Biases That Augment Socio-Cognitive Interactions, In R. Bromme, F.W. Hesse and H. Spada (Eds.): Barriers and Biases in Computer-Mediated Knowledge Communication, Springer, New York, 2005, pp. 243-264.

[Dwyer et al., 07] Dwyer, C., Hiltz, S.R., Passerini, K.: Trust and privacy concern within social networking sites: A comparison of Facebook and MySpace, Proc. of Americas Conference on Information Systems, Keystone, 2007.

[Eckstein et al., 01] Eckstein, J., Manns, M.L., Voelter, M.: Pedagogical Patterns: Capturing Best Practices in Teaching Object Technology, Software Focus 2(1), Wiley, 2001.

[García-Barrios, 09] García-Barrios, V.M.: User-centric Privacy Framework: Integrating Legal, Technological and Human Aspects into User-Adapting Systems, Proc. of the IEEE Intern. Conference on Information Privacy, Security, Risk and Trust (PASSAT), Vancouver, 2009.

[Henri et al., 08] Henri, F., Charlier, B., Limpens, F.: Understanding PLE as an Essential Component of the Learning Process. Proc. of the World Conference on Educational Multimedia, Hypermedia and Telecommunications (ED-Media), Vienna, 2008, pp. 3766-3770.

[Klamma et al., 06] Klamma, R., Spaniol, M., Denev, D.: PALADIN: A Pattern Based Approach to Knowledge Discovery in Digital Social Networks, Proc. of the International Conference on Knowledge Management (I-Know), Graz, 2006, pp. 457-464.

[Klamma et al., 09] Klamma, R., Cuong, P.M., Cao, Y.: You Never Walk Alone: Recommending Academic Events Based on Social Network Analysis, Proc. of the International Conference on Complex Science (Complex), Shanghai, 2009, pp. 657-670.

[Kolfshoten et al., 10] Kolfshoten, G., Lukosch, S., Verbraeck, A., Valentin, E., de Vreede, G.-J.: Cognitive learning efficiency through the use of design patterns in teaching, Computers and Education 54, 2010, pp. 652-660.

[Kooken et al., 07] Kooken J., Ley T., De Hoog R.: How Do People Learn at the Workplace? Investigating Four Workplace Learning Assumptions, In E. Duval, R. Klamma and M. Wolpers (Eds.): Creating New Learning Experiences on a Global Scale, Springer, 2007, pp. 158-171.

- [MacNeill & Kraan, 10] MacNeill, S., Kraan, W.: Distributed learning environments: A brief paper, JISC Centre For Educational Technology and Interoperability Standards (CETIS), 2010, http://wiki.cetis.ac.uk/images/6/6c/Distributed_Learning.pdf (2010-03-30).
- [Mayer et al., 95] Mayer, R.C., Davis, J.H., Schoorman, F.D.: An Integrative Model of Organizational Trust, *The Academy of Management Review* 20(3), 1995, pp. 709-734.
- [Najjar et al., 03] Najjar, J., Duval, E., Ternier, S., Neven, F.: Towards interoperable learning object repositories: the Ariadne experience, *Proc. of the IADIS International Conference WWW/Internet, Algarve*, 2003, pp. 219-226.
- [Nguyen-Ngoc & Law, 08] Nguyen-Ngoc, A.V., Law, E.L.: Perceived Usability of Social Software Enabling Self-Directed Learning, *Proc. of the World Conference on Educational Multimedia, Hypermedia and Telecommunications*, Toronto, 2008, pp. 1449-1458.
- [Palmér et al, 09] Palmér, M., Sire, S., Bogdanov, E., Gillet, D., Wild, F.: Mapping Web Personal Learning Environments, *Proc. of MUPPLE Workshop at the European Conference on Technology Enhanced Learning (EC-TEL)*, Nice, 2009, pp. 31-46.
- [Persico et al., 09] Persico, D., Pozzi, F., Sarti, L.: Design patterns for monitoring and evaluating CSCL processes, *Computers in Human Behavior* 25, 2009, pp. 1021-27.
- [Pfitzmann & Hansen, 08] Pfitzmann, A., Hansen, M.: Anonymity, Unlinkability, Undetectability, Unobservability, Pseudonymity, and Identity Management: a consolidated proposal for terminology. Report, 2008, http://dud.inf.tu-dresden.de/literatur/Anon_Terminology_v0.31.pdf (2010-03-30).
- [Resnick & Varian, 97] Resnick, P., Varian, H.R.: Recommender systems, *Communications of the ACM* 40(3), 1997, pp. 56-58.
- [Schmitz et al., 09] Schmitz, H.-C., Scheffel, M., Friedrich, M., Jahn, M., Niemann, K., Wolpers, M.: CAMera for PLE, *Proc. of the European Conference on Technology Enhanced Learning (EC-TEL)*, Nice, 2009, pp. 507-520.
- [Shaffer et al., 09] Shaffer, D.W., Hatfield, D., Svarovsky, G.N., Nash, P., Nulty, A., Bagley, E., Frank, K., Rupp, A.A., Mislevy, R.: Epistemic network analysis: A prototype for 21st century assessment of learning, *Intern. Journal of Learning and Media* 1(2), 2009, pp. 33-53.
- [Sobernig et al. 06] Sobernig, S., Danielewska-Tulecka, A., Wild, F., Kusiak, J.: Interoperability and Patterns in Technology-Enhanced Learning. Polish Information Processing Society (PTI), Szczyrk, 2006.
- [Van Harmelen, 08] Van Harmelen, M.: Design trajectories: four experiments in PLE implementation, *Interactive Learning Environments* 16(1), 2008, pp. 35-46.
- [Wild, 09] Wild, F. (Ed.): Mash-Up Personal Learning Environments. iCamp Deliverable D3.4, 2009, http://www.icamp.eu/wp-content/uploads/2009/01/d34_icamp_final.pdf (2010-03-30).
- [Wild et al., 09] Wild, J., Wild, F., Kalz, M., Specht, M., Hofer, M.: The MUPPLE competence continuum. *Proc. of MUPPLE Workshop at the European Conference on Technology Enhanced Learning (EC-TEL)*, Nice, 2009, pp. 80-88.
- [Windschitl & Sahl, 02] Windschitl, M., Sahl, K.: Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture, *American Educational Research Journal* 39(1), 2002, pp. 165-205.
- [Zhou et al., 08] Zhou, B., Pei, J., Luk, W.: A brief survey on anonymization techniques for privacy preserving publishing of social network data, *ACM SIGKDD Explorations Newsletter* 10(2), 2008, pp. 12-22.

Clarity in Knowledge Communication

Nicole Bischof and Martin J. Eppler

(University of St. Gallen, =mcm *institute*, St. Gallen, Switzerland
Nicole.Bischof@unisg.ch, Matrtn.Eppler@unisg.ch)

Abstract: Knowledge communication is an essential mechanism to facilitate intra- and inter-organizational knowledge transfer. In order to improve the efficiency of knowledge communication, organizations need to pay particular attention to the clarity of conveyed knowledge in order not to create confusion, misunderstandings, or misapplication of knowledge. In this contribution, we show where and how the concept of clarity matters for knowledge management in general, and for knowledge communication in particular. We review and operationalize the clarity concept so that it can become the object of a systematic management effort. Furthermore, we show ways of how clarity can be pro-actively and systematically managed. We have tested our conception of clarity in a survey on clarity in knowledge-focused presentations, and we present the results in this paper. An outlook on future research on clarity in knowledge management concludes the article.

Keywords: clarity, ambiguity, knowledge communication, knowledge transfer, PowerPoint presentations

Categories: M.0, M.3, M.4, M.8, M.9

1 Introduction and Overview

Knowledge management activities can be roughly divided into knowledge creation, sharing, retention, and application, as well as evaluation and measurement [Nonaka 2008; Nonaka and von Krogh 2009; Probst et al. 1999]. Clarity of expression plays a vital role in many of these contexts, as clarification is a necessary step in articulating new concepts (knowledge creation), in conveying one's insights to others (knowledge sharing, knowledge communication), and in appropriating knowledge to its application context (knowledge utilization) [Vera and Crossan 2003]. The process of knowledge communication can be regarded as the activity of interactively conveying and co-constructing insights, assessments, experiences, or skills through verbal and non-verbal means [Eppler 2007]. This individual face-to-face communication is therefore by its character a process, which asks for clarity [Grant 1996]. The result of knowledge communication is the successful reconstruction of an insight, experience or skill by an individual because of the communicative action of another and is the more successful the more clear it is conducted.

This article addresses the important, but under-researched issue of clarity in knowledge communication as a special case of knowledge management and answers the following questions: Why is the concept of clarity of high relevance to knowledge communication? How can clarity be pragmatically defined and used in knowledge communication? Which clarity-oriented practices and principles can be appropriated for knowledge communication and documentation? Which factors affect clarity in

knowledge sharing negatively, for example in PowerPoint presentations? We address these questions by first contextualizing clarity within the domain of knowledge management and then by outlining its different components. We review seminal contributions to the study of clarity and show how they can be used in knowledge management. We summarize these findings in a concise clarity checklist for knowledge managers. Finally, we present results from a survey on clarity in knowledge-focused presentations (where experts try to convey their insights to non-experts through PowerPoint slides). These results stem the opinion that our checklist captures some of the most relevant factors related to clarity in communication of knowledge-intensive topics.

2 The Relevance of Clarity for Knowledge Management

Clarity or the characteristic of something to be clear in appearance, thought or style, is defined, according to the Oxford dictionary, as the state of being free from doubt, *ambiguity*, or *difficulty*, to be *distinct* and *well defined*. To make something clear is equivalent to making it understood and to *reduce* what is unwanted from it. The lack of clarity in turn can make documented insights or practices difficult to understand or apply; it can interfere with knowledge transfer or make the assessment of intellectual capital tiresome and difficult. To illustrate the relevance of the notion of clarity, we have compiled a few typical knowledge management challenges that can be reduced by improving clarity (see Table 1) below.

Knowledge management problem	How clarification can reduce the problem
<i>Knowledge Creation</i>	
A new product innovation idea cannot be turned into a prototype as the engineers get lost in options instead of advancing one particular design.	A clarification process is needed to single out the key ideas and combine them to a realistic prototype. Clarity helps in distinguishing the new from the old and focus on the essential ideas.
<i>Knowledge Sharing</i>	
Best practices cannot be transferred among business units [Szulanski 2000].	Distinguish and define ambiguous elements in knowledge and clarify the origination context.
<i>Knowledge Retention</i>	
Long-term knowledge repositories are no longer understood by the subsequent generation of knowledge managers and remain unused.	Clarification of original documentation context. Systematic ambiguity reduction. Increasing clarity by updating and relating key terms.
<i>Knowledge Application</i>	
Lessons learned from a completed project are not re-used.	Adding context information to project documentation, structuring the lessons learned clearly, and reducing ambiguous terms all lead to easier to use lessons learned.

Table 1: Clarity-related knowledge management problems

This apparent need for clarity is indeed documented by prior studies on the topic: [Feinberg and Pritzker 1985] found out already some time ago that the three most important attributes that executives demand in complex communication are clarity, conciseness and logic. Also newer studies show the importance of clarity: [Bambacas

and Patrickson 2008] found in their study on human resource managers' expectations that "the skill of maintaining clarity and consistency of messages was rated as having the utmost importance. HR managers considered this skill as key in their selection of managers in new supervisory roles, key in enhancing commitment and key to any communication behaviours needing attention in the organisation" [Bambacas and Patrickson 2008]. In spite of these calls to action, clarity has received little attention in management research in general, and almost none in the knowledge management domain. Nevertheless, some seminal contributions to the study of clarity can be identified and will be summarized briefly below.

3 Literature Review: Elements of Clarity

[Suchan and Dulek's 1990] statement that „clarity is business communications' most sacrosanct topic" illustrates the importance of this topic in general. In their article on a reassessment of clarity in written business documents [Suchan and Dulek's 1990] they argue that clarity is the "most serious communication problem in business". Various aspects of clarity have been subject to research, whereas only a few scholars examine the concept of clarity as explicitly as Suchan and Dulek. While some studies focus on clarity in business communication or written texts and documents [Bennett and Olney 1986; Suchan and Dulek's 1990], others examine the issue of clarity in strategic communication [Reeves et al. 2005], in instructions [Kennedy et al. 1978] in curricula for business education [Feinberg and Pritzker 1985], or in business role allocation [Hall 2007]. The majority of research concentrates on assessments of clarity in the above contexts, but fails to provide pragmatic advice on how to *achieve* clarity, especially in such complex domains as knowledge management. Apart from the literature on managerial communication, the topic of clarity is often addressed using closely related terms such as *understanding* [Sweller and Chandler 1994], *clearness* [Carlile 2004], *distinctiveness* [Peirce 1878], *sensitivity and specificity* [Reeves et al. 2005]. One of the first definitions of clarity was given by the philosopher René Descartes, when he said "Clear means evident and distinct from other things". This definition was later further developed by the logician and pragmatist C.S. Peirce who also linked clarity to the notion of distinctiveness, but added the element of *evident action implications* to clarity [Peirce 1878]. Another forefather of clarity research is George Orwell. Though published as a critique of jargon and bad use of English in political debates, his seminal essay on the topic can be seen as a pragmatic approach to clarity. Orwell recognized thinking clearly as the necessary step toward political regeneration [Orwell 1946]. His 'clarity maxims' of reducing texts to their essence seem as timely in today's Internet era as back when they were first articulated. The domain in which we can find the most discussions of clarity regards scientific and journalistic writing [Strunk and White 2008; Williams 1990]. Unfortunately, these texts mostly consist of lengthy lists of what one should do (or not) style-wise to write clearly (i.e., avoid complex nouns in lieu of verbs, passive voice, long relative clauses, foreign terms, jargon, or unstructured texts). A notable exception to this 'list mania' approach comes from Überjournalist Joseph Pulitzer and his elegant clarity mantra: "Put it before them briefly so they will read it, clearly so they will appreciate it, picturesquely so they will remember it and, above all, accurately so they will be guided by its light." This simple formula has later been the start-

ing point to many investigations made by cognitive and educational psychologists to understand and enhance the *readability* of texts and thus enable better understanding and knowledge generation, sharing, or learning.

At the forefront of modern clarity research in this tradition is the so-called “*Hamburger Verständlichkeitskonzept*” by Langer, Schulz von Thun and Tausch [Langer 1989; Langer et al. 1974]. In their empirically based, inductive framework, the three professors propose that texts are easy to understand if attention is paid to four crucial elements of text design: *simplicity*, *structure* and order (inner and outer order), *conciseness* and brevity, and additional *stimulation* (i.e., examples, quotes, anecdotes). In contrast to [Langer et al. 1974], [Groeben 1982] incorporates different approaches of cognitive psychology and develops a context-dependent model of text understandability. He distinguishes four factors that affect comprehensibility: cognitive *structure/content* classification, semantic *redundancy*, stylistic *simplicity*, and conceptual *conflict* [Groeben 1982; Jahr 2001]. In contrast to Langer et al., the Groeben model not only takes the text and its understandability (content and style, logical structure) into account, but also the *reader’s ability* (i.e., his or her necessary foreknowledge) to understand a text [Groeben 1982; Naumann et al. 2007]. He thus conceives of clarity as a relative, context-dependent construct, an approach that we can also find in another approach: the *cognitive load theory* [Sweller and Chandler 1994], which has become increasingly influential in instructional psychology and was developed by John Sweller and his colleagues. This theory from the field of knowledge acquisition gives insights to the elements of clarity and is relevant to master clarity in complex knowledge communication [Mousavi et al. 1995]. The necessity of adapting instructions to the constraints of the learner’s cognitive system has been the main concern of this research. Cognitive load theory argues that many traditional instructional techniques do not adequately take the limitations of human cognition into account, as they unnecessarily overload the learner’s working memory. The theory refers to the beneficial effect of *removing redundant information* as the redundancy effect. It furthermore tries to integrate knowledge about the structure and functioning of the human cognitive system with principles of instructional design. Conversely, some critiques to the cognitive load theory come from Schnotz who argues that a reduction in cognitive load may sometimes impair learning rather than enhance it [Schnotz and Kürschner 2007]. Schnotz investigated the effects of animated pictures on knowledge acquisition and found that different kinds of animations have, indeed, different functions in the process of learning, while a reduction of additional information to avoid information overload is not always beneficial for the learning process [Schnotz and Rasch 2005]. Clarity in knowledge communication can thus not simply be reduced to reducing information.

In more recent academic literature on clarity in knowledge management and communication, a definition of clarity is absent, with very few exceptions. such as a definition of clarity of knowledge visualizations from Bresciani et al. as the “property of the (visual element) to be self-explanatory and easily understandable with reduced cognitive effort” [Bresciani et al. 2008]. Within the domain of knowledge management, clarity has been addressed in the literature regarding knowledge transfer and knowledge sharing [Carlile 2004; Nonaka and von Krogh 2009]. In such contexts, a lack of clarity is frequently reported as a knowledge transfer barrier [Szulanski 2000; Von Hippel 1994; Jacobson et al. 2005]. [Suchan and Dulek 1990] also link clarity to

knowledge and see clarity, or the lack thereof, as the result of an organization's *idiosyncratic knowledge* and specialized internal language. In their analysis, clarity-related problems often begin with the existing *mindset* within an organization.

Steps / Elements	Explanation	Key Questions for Knowledge Managers
<u>C</u>oncise Content	Knowledge communication should focus on the essential elements and show them in overview before going into details. The communicators should avoid lengthy sentences or needless deviations.	<ul style="list-style-type: none"> • What is the most important part? What can be left out? • How can it be said simpler? • How can it be summarized? • How can it be made accessible? How can details be found easier?
<u>L</u>ogical Structure	The structure of any knowledge communication should be logical and accessible: logical in the sense that elements build on one another in sequence; accessible in the sense that it is self-evident and intuitive.	<ul style="list-style-type: none"> • What is the overall logic of the message? • What should come first? • How can it all be organized ergonomically? • How can the parts be explicitly connected?
<u>E</u>xplicit Context	The context of knowledge needs to be made explicit with regard to the targeted audience, the reason for the communication of that knowledge, and its urgency and importance.	<ul style="list-style-type: none"> • Is it clear who should read this? • Is it clear how and when this should be used? • Is it clear why this was developed and by whom?
<u>A</u>mbiguity Low	Most knowledge communication should be free from ambiguity or multiple interpretations. Ideally, all words and sentences can only be interpreted in one way in order to avoid misunderstandings or misapplication.	<ul style="list-style-type: none"> • What could be understood the wrong way? Why? • How can it be better explained? • Which terms are not clear and should be defined?
<u>R</u>eady to use	Any communication or knowledge documentation and its format should fit the (action or problem solving) needs, preferences and foreknowledge of the audience. The knowledge must be made actionable by involving the future users (inter-)actively.	<ul style="list-style-type: none"> • When and how will people use this material? • How can we make it easier to use the insights in those situations? • What are the most directly applicable parts? How can they be highlighted? • Which interactive tools or mechanisms will help people apply the documented insights?

Table 2: Our CLEAR formula and corresponding check questions

In order to foster a *clarity mindset*, we have summarized the factors that surfaced from this literature review in a concise and easy-to-remember formula that we present in the next section and validate in the subsequent one.

4 Operationalizing Clarity for Knowledge Communication

Summarizing the different approaches and definitions reviewed above, we propose the following C-L-E-A-R formula for assuring clarity in knowledge communication. To help knowledge managers and subject matter experts consider clarity issues in their work, they can also ask themselves the corresponding diagnostic check questions in the third row for each clarity element (see table 2).

The rationale behind this formula can be summarized as follows: Conciseness is key because too much information cannot be transformed into knowledge (the information overload syndrome). A logical structure is needed to have a scaffold with which to build new knowledge. Explicit context is imperative in order to be able to re-contextualize and consequently re-apply knowledge, as one has to understand the context of origination of insights or practices. Ready-to-use is important as knowledge should be aligned towards its actual application context.

Clarification Step	Main Activities	Examples
Compressing knowledge	editing, summarizing, visualizing	Cutting out excess examples or illustrations Writing an Executive Summary or Abstract Providing a summarizing conceptual diagram
Linking elements logically through a structure to support knowledge construction	Sequencing and organizing content Linking elements explicitly Providing transitions	Providing an up-front outline Including transition sentences between sections
Eliciting the implicit (origination and application) context of knowledge	Providing background information Stating the context of origination of the message Stating the use context of the message	Stating target group Stating purpose of document or message Adding an expiration date Providing background on the author
Addressing and reducing ambiguities inherent in the captured knowledge.	Defining terms Using simple terms Editing for easier interpretability	Providing a glossary Providing synonyms Providing illustrative examples
Reformatting the knowledge for easier applicability	Providing interactive tools and checklists Providing reference sections (glossary, index, etc.) Involving the audience	Excel model instead of only word document Q&A or FAQ section Providing an alphabetical index

Table 3: Steps in the Clarification Process

We label the process of achieving these elements as *clarification*. Clarification is an iterative process whereby unessential elements are reduced and messages are compressed, a logical, accessible and consistent structure is developed, a context for the message is being made explicit, and potential occurrences of ambiguity are systemati-

cally reduced. Clarification also entails a transformation of a message into the format and style that is most useful or applicable for its intended audience. These steps do not necessarily have to be performed in this sequence, and there may be cycles or iterations among the steps.

5 Empirical Evidence: Results from a Survey

In the section above we have argued that clarity in knowledge communication can be captured in a few vital characteristics that can be systematically applied or checked. This implies that clear communication can be (to a certain degree) learned, which has been shown by several studies, e.g. with teachers and supervisors [Langer et al. 1974, 1989; Metcalf and Cruickshank 1991]. Our next ambition was to conduct a survey among academics who are familiar with knowledge-intensive complex presentations. The purpose of our survey was to validate our CLEAR formula and to check whether the five components of clarity featured in our framework actually correspond with the needs and expectations of academic software-supported presentation modes.

The survey on 'clarity in PowerPoint knowledge presentations' consisted of 41 quantitative questions and 6 qualitative questions. We have developed the questionnaire using a 5-point Likert-scale measuring either positive or negative response to different statements related to clarity in presentations, the effect of unclearness on the audience, issues to be considered when using PowerPoint and mechanisms to increase clarity. We have distributed the questionnaires manually with a short introduction regarding its purpose. The study was conducted at the University of St. Gallen and at the University of Lugano. We have asked students and academics from different degree programs and nationalities about their views on clarity in knowledge-intensive, complex PowerPoint presentation, something that they all had extensive experience in as students and course participants. Our sample consists of 14 3rd year Italian and Swiss bachelor students enrolled in a program in corporate communication, 94 master students from the University St. Gallen and Lugano, 12 PhD students with as well as 25 senior American and Canadian MBA students. Our final sample sums up to 145 completed questionnaires on this topic to validate our CLEAR framework.

The results indicate that our formula does indeed tackle the relevant clarity drivers: the most important or negative factor for (a lack of) clarity in PowerPoint presentations was considered to be 'too much text on a slide' (shows a mean of 4.3 out of 5, see table 4), which refers to our CLEAR formula step C '*concise content*'. The second highest ranked affect was 'unclear presentation structure', validating the L out of the CLEAR formula, namely *logical structure*. The third highest ranked factor for clarity (or lack thereof) concerned 'the link between speech and slides' which corresponds to our A=*ambiguity gone* dimension in the sense of better explanation and combination of the spoken word and the written text (to reduce the ambiguity in the text slide through verbal comments and thus guide the interpretation). This factor also relates to our dimension of providing 'explicit context' for information, as contextualizing the slide text is frequently the main function of orally provided slide comments. The fourth highest ranked negative factor was 'showing a slide too quickly' which means it was not ready or optimal for its intended usage (i.e. understanding its content).

Although the sample is too small to generalize, it is nevertheless a first indication of the relevance of our main clarity elements.

<i>Most negative impact on clarity in knowledge presentation?</i>	<i>N</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>Variance</i>
<i>too much text on a single slide</i>	142	2.00	5.00	4.3	0.8	0.7
<i>unclear presentation structure</i>	143	2.00	5.00	4.3	0.7	0.5
<i>missing link between presenter's speech and slide text</i>	142	1.00	5.00	4.2	0.9	0.8
<i>slide shown too quickly</i>	144	1.00	5.00	4.1	0.9	0.8
<i>long phrases instead of keywords</i>	144	1.00	5.00	4.0	1.0	1.1
<i>inconsistent presentation style</i>	143	1.00	5.00	3.9	1.0	0.9
<i>too many slides in a presentation</i>	143	1.00	5.00	3.8	1.0	1.0
<i>lack of summary / conclusion slide</i>	142	1.00	5.00	3.8	1.0	1.1
<i>missing interaction with audience</i>	144	1.00	5.00	3.8	1.1	1.3
<i>lack of agenda/overview slide</i>	145	1.00	5.00	3.5	1.0	1.1
<i>distracting animations on slide</i>	143	1.00	5.00	3.5	1.0	1.1

<i>unfitting clipart or symbols</i>	142	1.00	5.00	3.3	1.0	1.1
<i>spelling errors</i>	143	1.00	5.00	3.2	1.2	1.5
<i>some slides not explained/skipped</i>	142	1.00	5.00	3.1	1.2	1.3
<i>bullet points instead of explanations / relations among items</i>	140	1.00	5.00	2.8	1.2	1.5
<i>too little information per slide</i>	143	1.00	5.00	2.6	1.1	1.2
<i>no printed hand-outs</i>	142	1.00	5.00	2.5	1.3	1.6
<i>use of the same slide template</i>	139	1.00	5.00	2.4	1.2	1.5

Table 4: Items negatively affecting clarity in PowerPoint-based knowledge presentations (listed by overall ranked importance)

The qualitative part of our survey focused on people's general likes and dislikes regarding clarity in presentations. The following quotes illustrate very lively what students like about presentations, and again being clear is one of the student's favorites: "I like it when they are filled with essential keywords followed by oral explanation." "I like about powerpoints that they are clear, use keywords and are thus easy to understand." On the other hand students dislike PowerPoint presentations that are unclear, as stated here: "I hate it if the slides are not explained." "I hate it when presentations are too long and there is too much unexplained text on one slide."

A check question revealed that the population we surveyed generally likes PowerPoint presentations (3.85 mean out of a 5 point scale). No participant went below the mid-value of 3 in his or her assessment of PowerPoint presentations in general.

One main prerequisite for presenting our clarity framework was the opinion that clear knowledge communication can be learned and operationalized. This argument is supported by the results of our survey (see table 5). The most likely mechanism to achieve more clarity in oral presentations is considered to be 'training the presenter'. The second highest rank mechanism to improve clarity is 'rehearsing the presentation', a mechanism which hits upon the same idea namely professional training and exercise of clear and concise communication.

Most likely factor to increase clarity of a presentation?	N	Minimum	Maximum	Mean	Std. Deviation	Variance
training the presenter	144	2.00	5.00	4.3	0.7	0.5
rehearsing the presentation	137	2.00	5.00	4.0	0.8	0.7
watching great presentations	143	1.00	5.00	4.0	0.9	0.8
proof reading and style checking	144	2.00	5.00	3.9	0.8	0.7
feedback from friends	144	1.00	5.00	3.8	0.9	0.8
better presentation tools	143	1.00	5.00	3.6	0.9	0.9

Table 5: Mechanisms positively affecting clarity in PowerPoint-based knowledge presentations (listed by overall ranked importance)

6 Conclusion and Outlook: Towards a Clarity Conception for Knowledge Management

Knowledge communication is an essential ingredient of well working knowledge management efforts in organizations [Eppler 2007; Senge 1990]. Without the ability to document insights properly and communicate them clearly to others, much of the problem solving and innovation potential of knowledge remains ‘lost in translation’. The clarity concept – as reviewed and operationalized in this article – can help to make knowledge management more user-centred and consequently more effective. We believe that our study is a first step in addressing this important knowledge management issue. The results of our survey among 145 academics (bachelor, master, MBA and PhD students, and academic researchers) can be regarded as an indication of the relevance of our main clarity elements and thus indicates that our CLEAR framework is pertinent for knowledge communication and can help to operationalize clear communication of knowledge-intense topics.

In future work, we want to contextualize the clarity topic in context-rich case study material from European organizations. This material should illustrate the ge-

neric elements of clarity in knowledge-management contexts, but also reveal specific clarity factors that may vary from one knowledge management context to another. We also hope to be able to develop a clarity index, in order to semi-automatically measure and assess clarity degrees of knowledge repositories. In this way, we hope to develop a rich and yet useful conception of clarity that is tailored to the needs of the knowledge management professional and academic community.

Acknowledgements

The authors wish to acknowledge that this study has been partly financed by the Swiss National Science Foundation in the way that Nicole Bischof holds a grant for her PhD studies on “*Knowledge management in the field of natural hazards and risk management in Switzerland - An empirical analysis of knowledge communication between science and practice*”.

References

- [Bambacas and Patrickson 2008] Bambacas, M. and Patrickson, M.: “Interpersonal communication skills that enhance organisational commitment”, *Journal of Communication Management*, 12(1), (2008), 51-72.
- [Bennett and Olney 1986] Bennett, J.C. and Olney, R.J.: “Executive Priorities for Effective Communication in an Information Society”, *Journal of Business Communication*. Association for Business Communication, (1986), 13-22.
- [Bresciani et al. 2008] Bresciani, S., Blackwell, A.F. and Eppler, M.: “A Collaborative Dimensions Framework: Understanding the Mediating Role of Conceptual Visualizations in Collaborative Knowledge Work”, 41st Hawaii International Conference on System Sciences - 2008. (2008)
- [Carlile 2004] Carlile, P.R.: “Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge across Boundaries”, *Organization Science*, 15(5), (2004), 555-568.
- [Eppler 2007] Eppler, M.J.: “Knowledge Communication Problems between Experts and Decision Makers: an Overview and Classification.” *The electronic Journal of Knowledge Management*, 5(3), (2007), 291-300.
- [Feinberg, S. and Pritzker 1985] Feinberg, S. and Pritzker, I.: “An MBA Communications Course Designed by Business Executives”, *Journal of Business Communication*. Association for Business Communication, (1985), 75-83.
- [Grant 1996] Grant, R.M.: “Prospering in Dynamically-Competitive Environments: Organizational Capability as Knowledge Integration.” *Organization Science*, 7(4), (1996), 375-387.
- [Groeben 1982] Groeben, N.: “*Leserpsychologie: Textverständnis – Textverständlichkeit*“, Münster (1982)
- [Hall 2007] Hall, M.: “The effect of comprehensive performance measurement systems on role clarity, psychological empowerment and managerial performance”, *Accounting, Organizations and Society*, 33(2-3), (2007), 141-163.
- [Jacobson et al. 2005] Jacobson, N., Butterill, D. and Goering, P.: „Consulting as a Strategy for Knowledge Transfer“, *The Milbank Quarterly*, 83(2), (2005), 299-321.

- [Jahr 2001] Jahr, S.: „Adressatenspezifische Aspekte des Transfers von Wissen im wissenschaftlichen Bereich“, In: S. Wichter, Antos, G. (Editor), *Wissenstransfer zwischen Experten und Laien*. Peter Lang, Frankfurt a.M. (2001)
- [Kennedy et al. 1978] Kennedy, J.J., Cruickshank, D.R., Bush, A.J. and Myers, B.: „Additional Investigations into the Nature of Teacher Clarity“, *Journal of Educational Research*, 72(1), (1978)
- [Langer 1989] Langer, I.: „Verständlich informieren - ein Beispiel empirischer Forschung“, In: B. Fittkau (Editor), *Pädagogisch-psychologische Hilfen für Erziehung, Unterricht und Beratung*, Paderborn, (1989), 378-401.
- [Langer et al. 1974] Langer, I., Thun, F.S.v. and Tausch, R.: „Verständlichkeit in Schule, Verwaltung, Politik und Wissenschaft: mit einem Selbsttrainingsprogramm zur verständlichen Gestaltung von Lehr- und Informationstexten“, Reinhardt, München. (1974)
- [Metcalf and Cruickshank 1991] Metcalf, K.K. and Cruickshank, D.R.: “Can Teachers Be Trained to Make Clear Presentations?” *Journal of Educational Research*, 85(2), (1991), 107-116.
- [Mousavi et al. 1995] Mousavi, S.Y., Low, R. and Sweller, J.: “Reducing cognitive load by mixing auditory and visual presentation modes”, *Journal of Educational Psychology*, 87(2), (1995), 319-334.
- [Naumann et al. 2007] Naumann, J., Richter, T., Flender, J., Christmann, U. and Groeben, N.: “Signaling in expository hypertexts compensates for deficits in reading skill”, *Journal of Educational Psychology*, 99(4), (2007), 791-807.
- [Nonaka 2008] Nonaka, I.: “The Knowledge-Creating Company”, Harvard Business School Press Books: 1. (2008)
- [Nonaka and von Krogh 2009] Nonaka, I. and von Krogh, G.: “Tacit Knowledge and Knowledge Conversion: Controversy and Advancement in Organizational Knowledge Creation Theory”, *Organization Science*, (2009), 635-652.
- [Orwell 1946] Orwell, G.: “Politics and the English Language”, *Horizon*, 13(76), (1946), 252-265.
- [Peirce 1878] Peirce, C.S.: “How to Make our Ideas Clear”, *Popular Science Monthly*, (1878), 286-302.
- [Probst et al. 1999] Probst, G.J.B., Raub, S. and Romhardt, K.: “Managing Knowledge: Building Blocks for Success”, John Wiley & Sons, West Sussex, England. (1999)
- [Reeves et al. 2005] Reeves, T.C., Ford, E.W., Duncan, W.J. and Ginter, P.M.: “Communication clarity in strategic management data sources”, *Strategic Organization*, (2005), 243-278.
- [Senge 1990] Senge, P.: “The fifth discipline: the art and practice of the learning organization.” Doubleday/Currency, New York, (1990).
- [Schnotz and Kürschner 2007] Schnotz, W. and Kürschner, C.: “A Reconsideration of Cognitive Load Theory”, *Educational Psychology Review*. Springer Science & Business Media B.V., (2007), 469-508.
- [Schnotz and Rasch 2005] Schnotz, W. and Rasch, T.: “Enabling, facilitating, and inhibiting effects of animations in multimedia learning: Why reduction of cognitive load can have negative results on learning”, *Educational Technology Research and Development*, 53, 3, (2005), 47-58.

- [Strunk and White 2008] Strunk, W. and White, E.: "The Elements of Style", Penguin. (2008)
- [Suchan and Dulek 1990] Suchan, J. and Dulek, R.: "A Reassessment of Clarity in Written Managerial Communications", *Management Communication Quarterly*, 4(1), (1990), 87-99.
- [Sweller and Chandler 1994] Sweller, J. and Chandler, P.: "Why some material is difficult to learn", *Cognition and Instruction*, 12(3), (1994), 185-233.
- [Szulanski 2000] Szulanski, G.: "The Process of Knowledge Transfer: A Diachronic Analysis of Stickiness", *Organizational Behavior and Human Decision Processes*, 82(1), (2000), 9-27.
- [Von Hippel 1994] Von Hippel, E.: "'Sticky Information' and the Locus of Problem Solving: Implications for Innovation", *Management Science*, Institute for Operations Research, (1994), 429-439.
- [Vera and Crossan 2003] Vera, D. and Crossan, M.: "Organizational Learning and Knowledge Management: Toward an Integrative Framework". In: M. Easterby-Smith and M.A. Lyles (Editors), *The Blackwell Handbook of Organizational Learning and Knowledge Management*. Blackwell, (2003)
- [Williams 1990] Williams, J.M.: "Style: Toward Clarity and Grace", The University of Chicago Press. (1990)

Visualizing and Navigating Large Multimodal Semantic Webs

Weng Onn Kow and Dickson Lukose

(Artificial Intelligence Centre, MIMOS Berhad, Malaysia)

{kwonn | dickson.lukose}@mimos.my

Abstract: A graph is the most common method of visualizing a semantic web. However, when dealing with large and complex semantic webs, existing systems face challenges such as slow loading times and too much information being displayed on the screen. This paper introduces a Multimodal Semantic Browser (MMSB) that allows users to visualize and navigate through semantic webs with millions of triples. In addition, the Browser also recognizes the type of content that the user has selected and chooses the best modality and application to display that content in addition to a graph display.

Keywords: Ontology Visualization, Graph Layout, Service Oriented Architecture, Semantic Web

Categories: H.5, I.2.4

1 Introduction

Many current applications of the Resource Description Framework (RDF) [RDF] and Semantic Web technologies are as a way to represent knowledge so that computers can ‘understand’ and manipulate knowledge for intelligent reasoning. In his survey paper on the deployment of the Semantic Web technologies, Cardoso found that 69.9% of the participants used ontologies to share common understanding of the structure of information, so that models can be understood by humans and computers [Cardoso 07]. However, the trade-off of modeling knowledge this way is that the knowledge base developed becomes too complex for a human to visualize and comprehend.

A graph is a popular and elegant way of visualizing an RDF triple. By showing all triples of a concept in a specific format, we have a good method for displaying everything in the knowledge base about that concept in a single screen. Navigating from one concept to another is usually done by selecting one of the nodes linked to the main or focus concept. This new node then becomes the focus and all the triples belonging to it is displayed. According to Katifori [Katifori], displaying information this way is called the focus + context method. This method of visualization is used in, TGVizTab [TGVizTab], a popular plug-in for Protégé [Protégé], and the RKB Explorer [Glaser] developed by the University of Southampton. The main advantage of using such a visualization method is that it keeps things in a small and manageable display regardless of the size of the knowledge base.

Other ways of visualizing a knowledge base as categorized by Katifori are:

- i. Indented list
- ii. Node-link and tree
- iii. Zoomable
- iv. Space-filling
- v. 3D Information landscapes

In this paper, we tackle the problem of visualizing and navigating large semantic webs with multimodal data. In Section 2, we discuss the different challenges that are posed by large semantic webs. In Section 3, we propose some solutions to the challenges described in Section 2, and in Section 4 we describe some of the applications developed with our proposed solution. Some performance testing results are discussed in Section 5 and finally we conclude with some future enhancement ideas in Section 6.

2 Challenges in Visualizing Large Semantic Webs

One of the biggest problems of visually displaying semantic webs is the huge size of knowledge bases. Ernst and Storey [Ernst 03] in 2003 did a survey and identified 5 different categories of sizes of ontologies with the largest size being $> 100,000$ nodes.

Most visualization systems are built to handle thousands of concepts but with the emergence of the Linked Data Cloud [Berners-Lee 06], we're talking now about knowledge bases with a magnitude of millions, if not billions of triples. For example, the DBPedia [Auer 07] knowledge base has 247 million triples; while even a small domain-specific knowledge base like LinkedMDB (Linked Movie Database) [Hassanzadeh] has over 6 million triples. Such huge number of triples in a knowledge bases poses problems on multiple fronts.

First problem is to *load and store* the information to be displayed. With a small knowledge base, it is easy to just load everything into memory, but that cannot be done when the number of triples reaches hundreds of thousands. We have to develop a way to load triples dynamically so that only the things that the user is interested in are fetched. The system will retrieve more triples as the user explores the knowledge base further. This raises a new problem of latency where the user might need to wait for triples related to the concept he is exploring to be loaded and displayed after he clicks on the mouse. Imagine clicking on a web page and waiting for a minute before the screen is shown.

Second problem is to *search for information* in a knowledge base as well as a starting point to navigate. Unlike a regular database, there are no primary keys for indexing and searching.

Third problem is to *display the information*. Even with the high-resolution of computer screens today, the real estate is limited. A 1024x768 display has 786432 pixels. There aren't enough pixels to display everything in a large knowledge base! Showing just the focus node and related nodes helps, but what happens when the node has dozens or even hundreds of links? One approach is to limit the display to just the first n links where n can be selected by the user. Much like the number of results in a page in a Google search, the user can then show further links if necessary. However, there is a need for a way to sort the triples so that the most relevant ones are shown in the first 'page' to the user.

Once we have nodes and links to display, the next step is how to display it on the screen. A circle or ellipse is a typical way of displaying a concept and its triples; and for a small number of triples it is easy on the eye as well as on the brain. However, that may not be the most efficient use of screen space when the number of nodes and links surpass a limit. Also, when the user navigates to another node, does the visualization keep the previously viewed nodes? Keeping them hidden might cause the user to lose a sense of the big picture, but if the interface keeps everything, you end up with a screen filled with overlapping circles, ellipses and links.

One difference between a semantic web and a traditional database is that the meaning of the information is explicitly stored in properties and values. This allows us to make inferences regarding the information we are displaying, such as recognizing the type of knowledge as well as the best way of showing that knowledge. A concept described in the RDF format may not be the best way that a human would comprehend that piece of knowledge. A human would prefer to view a location as a point on a map instead of a pair of coordinates. They want to see the actual media such as a photo or video directly instead of the URI describing the location which they would then have to 'cut and paste' and load into the relevant viewer.

3 Our Proposed Solution

Our solution to the knowledge base loading problem described in Section 2 is a scalable Service-Oriented Architecture (SOA) based system that fetches triples in parallel as well as in multiple depths. The system as depicted in Figure 1, consists of a number of Knowledge Base Interface (KBI) web services that are deployed to fetch triples from a knowledge base through the knowledge base server. Each KBI web service is registered to a Lookup Server web service that feeds a Delegator web service with information about where the KBI web service is running. Fetch requests from users are then routed by the Delegator to any free KBI web service to fulfill that request. Fetching in parallel allows the system to scale up by adding different number of web services for fetching triples dependant on the number of users.

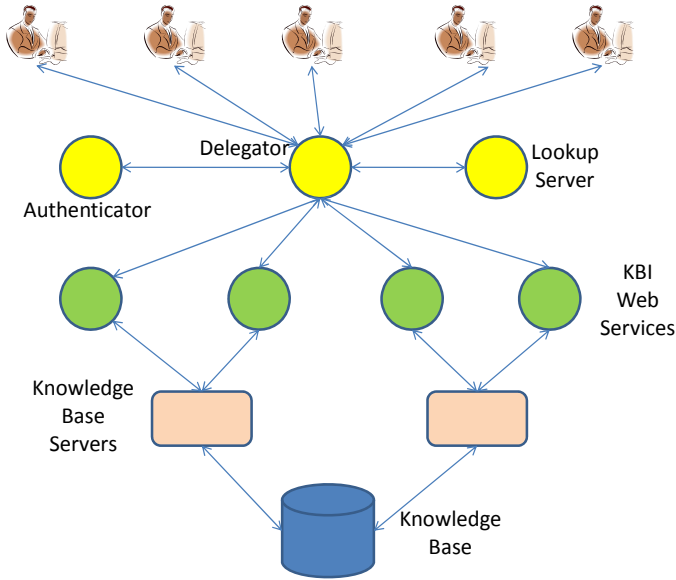


Figure 1: SOA back-end of the Multimodal Semantic Browser (MMSB)

We also implement a cache with forward fetching to further reduce the latency issue. Similar to a breadth-first search, our system fetches not just triples related to the current focus concept, but also triples related to nodes linked to the focus concept. These fetches are processed in the background while the focus concept is being displayed. This allows the system to react quickly when the user clicks on a node on the screen because all the information has already been pre-fetched. Triples are also cached on the server so that the next time a request for the same knowledge is received, the system can directly return the result without having to read again from the knowledge base server. The entire fetch process is as follows :-

- i) Fetch all triples related to the current focus concept
- ii) Display focus concept and all its triples
- iii) In the background, put all the concepts that are linked to the focus concept in a queue
- iv) Fetch the triples related to all the concepts in the queue
- v) Add the triples to the local cache, replacing older triples if necessary
- vi) Add all the concepts in the new triples into the queue
- vii) Repeat steps (iv) to (vi) to the depth specified

To solve the problem of indexing triples, we are using AllegroGraph as our knowledge base server and it has a free-text indexing capability that allows certain predicates to be indexed. This allows a quick and simple way of finding triples using plain words. For example, we can index the `rdfs:label` predicate and use that to do a

search. A list of URLs with `rdfs:label` matching the searched keyword is shown to the user, and selecting one will make the URI the focus concept.

Spring-layout [Kamada 89], where nodes repel each other like the same poles of a magnet, to separate nodes and ensure there is minimal overlap is one solution that is used to solve the overlapping problem when displaying a lot of nodes and links on the screen are algorithms that use. An example is the TouchGraph [Touchgraph] visualization technique. These algorithms produce nice layouts that adjust themselves whenever the user clicks on a node, but require extra processing time before a stable display is achieved. However, the auto-layout might not suit a user who wants the concepts to not move automatically every time he clicks on a node.

We use mathematical equations to plot nodes. Equations are fast and predictable while producing layouts that can also be pleasing aesthetically. Programmatically, easy to modify because just by tweaking the parameters in the equation, we can change the layout. Among the patterns that we have implemented include the Ellipse, Polar Rose, Epicycloid, Hypocycloid, Cosine Curve, Spiral and Archimedean Spiral. Each pattern has its strengths and weaknesses, and users can choose a pattern they prefer. Figures 2 and 3 shows the Cosine and Archimedean Spiral layout that the MMSB uses to display a concept and its triples.

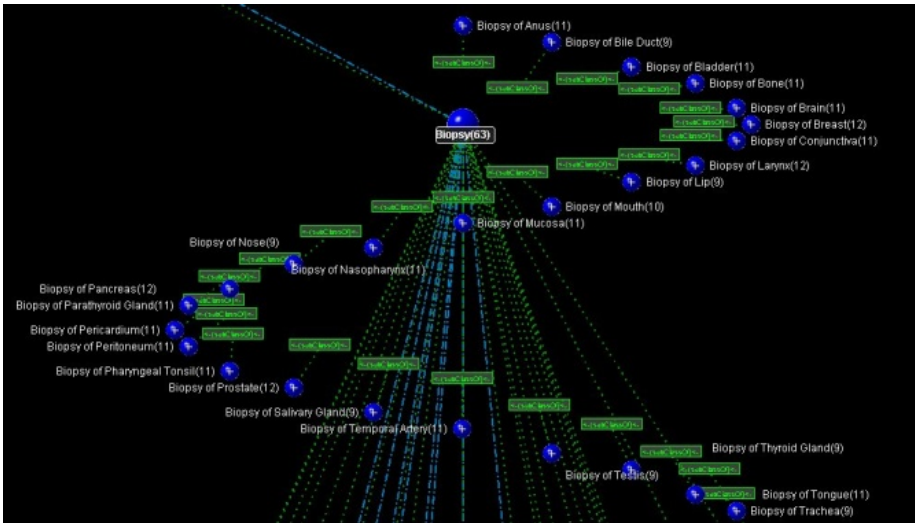


Figure 2: Cosine Layout

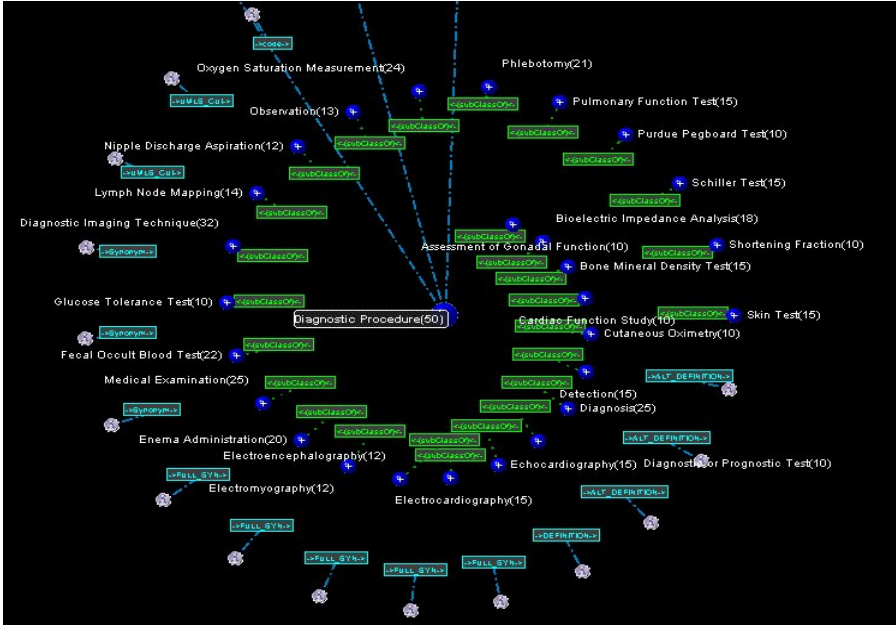


Figure 3: Archimedean Spiral Layout

As mentioned at the end of Section 2, there is information in a knowledge base that is better understood by a human being in a context other than node and links. The modality to visualize this information is identified by our browser based on the following criteria :-

1. A concept can be identified by the class it belongs to. For example, a concept that is an instance of the Image class can be viewed by an Image Viewer. In this case, the name of the Image file or URL where it is located is used to open the image. It is also possible to replace the standard icon used to display a node to the image of the concept itself.
2. A concept can be identified by its relation to other concepts. For example, a concept that is the object of the relation "homepage" is a website that is the homepage of the subject concept. The URL can then be passed to the web browser to be displayed since that is the best application to view a "homepage" object.
3. A concept can also be identified based on one or more properties (relations) that it has. For example, a concept that has a "latitude" relation as well as a "longitude" relation is a geographical location that can be shown on a map. The latitude and longitude information can now be used to draw that point on a mapping software such as Google Earth.

Once we have identified the modality of the information, we add the option to view the concept externally to a context-dependent menu that is shown when the user right-clicks on the concept in question. When the user selects that option, we retrieve the necessary knowledge (for example, latitude and longitude of a geographical

location) that will allow us to display the concept by passing it to an external application.

4 Application of the Multimodal Semantic Browser (MMSB)

The Multimodal Semantic Browser (MMSB) was developed as a generic tool that can be used to visualize and navigate any knowledge base. Our proof-of-concept initially utilized the Billion Triple Challenge (BTC) Knowledge base [BTC 08], mainly because it was one of the few really large knowledge bases available at that time.

The BTC knowledge base was developed as part of the BTC for the International Semantic Web Conference 2008. It combines 12 knowledge bases for a total of over 1 billion triples. We converted the N-Triple files that were part of the BTC dataset into the AllegroGraph format and hosted it on a blade server. Then using our SOA backend, we were able to access and display concepts from the BTC knowledge base with the MMSB.

The winner of the Billion Triple Challenge 2008 was the SemaPlover [Schenk 08], an application that allowed the user to explore the BTC knowledge base based on a geographical area of interest. They divide the knowledge base into different facets such as location, time, people and tags. Unlike the SemaPlover application, MMSB provides users more freedom to explore the BTC knowledge base while at the same time it also recognizes different types of concepts such as geographical locations, homepages and Wikipedia pages. Figure 4 shows the MMSB visualizing a concept that is a geographical location by showing it in Google Earth.

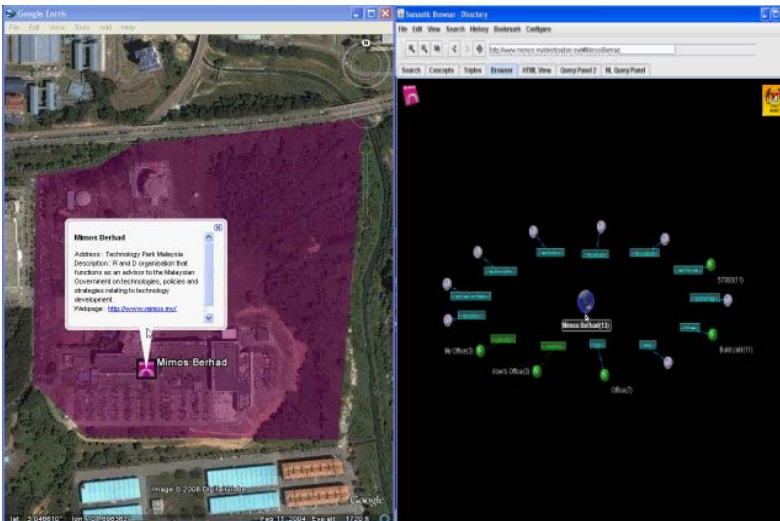


Figure 4: A geographical location concept being visualized in both the MMSB and Google Earth

5 Performance Testing

In order to test that the MMSB and its SOA back-end could handle a large number of users accessing knowledge bases concurrently, we set up the following tests using Parasoft's SOATest Tool. We indexed the BTC knowledge base and hosted it on an 8-core Blade Server. We started a single AllegroGraph Knowledge Base Server on the same server machine. We installed 5 instances of the KBI web service on a quad core machine while another quad core machine hosted the Delegator and Lookup Server web services.

There were 3 possible tasks that the user could use the MMSB that affects the SOA back-end :

- i) *Opening the knowledge base.* This opens the knowledge base for reading and returns the number of triples in the knowledge base
- ii) *Searching for a concept.* A keyword-based search that tries to match the keyword typed in by the user with any FreeText indexed predicate in the knowledge base. It returns a list of the URIs and labels of the concepts that contain the keyword.
- iii) *Fetch triples belonging to a concept.* MMSB sends a URI to the KBI and all triples where that URI is either the object or subject is returned.

Using the SOATest tool, we set up 100 virtual users running for 5 minutes at steady load. In 5 minutes, we count the total number of requests made to the SOA backend as well as the time it takes to get a response. The 3 tests are :

1. Test 1 – Open BTC Knowledge Base
2. Test 2 – Fetch triples where
<[http://dbpedia.org/resource/List of Malaysian companies](http://dbpedia.org/resource/List_of_Malaysian_companies)> is the subject or object
3. Test 3 - Randomly do one of the following - Open BTC Knowledge Base, Search for concepts with the String “Malaysia” in it, or Fetch Triples with URI <<http://dbpedia.org/resource/Malaysia>>

Table 1 shows the results of these tests.

Test	Total Runs	Loss (%)	Min Time (ms)	Max Time (ms)	Average (ms)
1	30,677	1.127	0	33603	831
2	17,493	0.000	15	79154	1637
3	21,620	0.208	62	75722	1313

Table 1: Performance Test Results

From test results (as shown in Table 1), we can see that with 100 concurrent users the average response time is within 2 seconds with just a 5 KBI and 1 AllegroGraph Server setup. From this, we can easily scale up to support more users by adding more servers and instances of the web services. As our fetching algorithm just fetches triples related to a URI, the impact of the total number of triples in the knowledge base is mitigated somewhat. We also have a threshold that we can set to limit the maximum number of triples retrieved in a single fetch. In DBPedia for example, some

URIs might have tens of thousands of links. By changing the threshold we can fetch and display just the first 100 or 200 triples, for example.

When the number of concurrent users is increased to 500, the architecture needed to support this has to be ramped up to keep the response time within 5 seconds. In our experiments, the configuration to have this performance level is one with 5 quad-core servers; with 4 servers running 16 instances of KBI each and 1 server dedicated to running 16 instances of the AllegroGraph server. The configuration is shown in Figure 5.

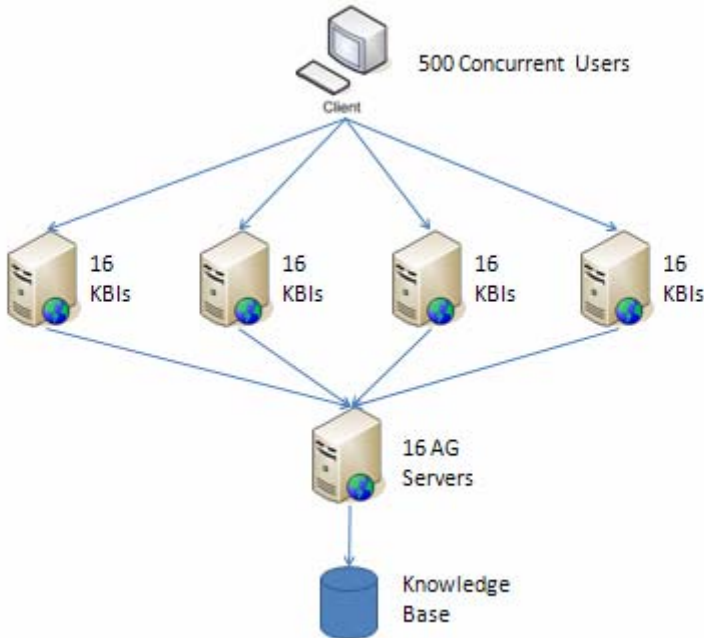


Figure 5: Configuration of SOA for handling 500 concurrent users

As the KBI web service is used not only by the MMSB but also by other components and applications, there are a total of 43 web methods in the web service. The performance testing randomly calls all of these 43 web methods, but MMSB only uses 4 of these methods. For this paper, we are only reporting the performance test results for these 4 methods as the other methods are not relevant to the MMSB. Table 2 shows the response time of these 4 methods in 5 test runs using the parameters of 500 concurrent users for 5 minutes.

Method Name	Test 1 (ms)	Test 2 (ms)	Test 3 (ms)	Test 4 (ms)	Test 5 (ms)	Average (ms)
getKBInfo()	3339	3497	3844	3850	3682	3642.4
getIndexPredicates()	5371	4156	4510	4014	4124	4435.0
processQuery()	4197	4221	5089	4253	4961	4544.2
processSPARQLQuery() ()	3273	3960	4443	4468	4830	4194.8

Table 2: Performance Test Results for 500 Concurrent Users

From the test results, each method call is completed within 5 seconds on average in the 5 tests. For example, `getIndexPredicates()` on average takes 4.435 seconds to complete although there was one test where it took over 5 seconds.

6 Future Work

Currently the pre-fetching algorithms fetch all triples related to the focus concept, then recursively fetch triples related to those concepts to which the focus concept is connected, in anticipation that the user will further click on one of these links. However, not all users will want to navigate a semantic web in such a 'linear' way. They might jump from one concept to another that is not linked at all to the first one. To get a better performance for this type of user, we need a different way to figuring out which triples to pre-fetch into memory.

The handling of multimodal information is mainly done by identifying commonly used properties in the knowledge base. Since we cannot force everyone to use the same predicates that DBpedia or Friend of a Friend (foaf) knowledge base use if we want to work with domain-specific or application-specific knowledge bases, we may have to cater to different properties. One possible improvement is to develop an interface system similar to Java where we allow listeners to be written and plugged into the browser to enable it to identify and handle any content that is not part of its default.

References

- [Alani 2003] Alani H. : TGVizTab: An ontology visualization extension for Protégé. In Proceedings of Knowledge Capture (K-Cap'03), Workshop on Visualization Information in Knowledge Engineering, Sanibel Island, Florida.
- [Auer 07] Auer S, Bizer C, Kobilarov G, Lehmann J, Cyganiak R, Zachary I : DBpedia : A Nucleus for a Web of Open Data, 6th International Semantic Web Conference 2007
- [Berners-Lee 06] Berners-Lee, T. Linked Data. 2006.
<http://www.w3.org/DesignIssues/LinkedData.html>
- [BTC 08] 2008 Billion Triples Challenge dataset : <http://www.cs.vu.nl/~pmika/swc/btc.html>

- [Cardoso 07] Cardoso J : The Semantic Vision : Where are we?, IEEE Intelligent Systems Vol 22, Issue 5, 2007
- [Ernst 03] Ernst, N. A. and Storey, M.-A. : A Preliminary Analysis of Visualization Requirements in Knowledge Engineering Tools, 2003
- [Glaser] Glaser, H. and Millard, I. C. : RKB Explorer : Application and Infrastructure
- [Hassanzadeh] Hassanzadeh O and Consens M : Linked Movie Data Base
- [Kamada 89] Kamada T and Kawai S : An algorithm for drawing general undirected graphs
- [Katifori] Katifori A., Halatsis C., Lepouras G., Vassilakis C., Giannopolou E. : Ontology Visualization Methods – A Survey
- [Protégé] Stanford University. <http://protege.stanford.edu>
- [RDF] Resource Description Framework (RDF) Model and Syntax Specification <http://www.w3.org/TR/PR-rdf-syntax/>
- [Schenk 08] Schenk S., et al. : SemaPlover – Interactive Semantic Exploration of Data and Media based on a Federated Cloud Infrastructure
- [Touchgraph] TouchGraph : <http://www.touchgraph.com>

Automatic Detection and Visualisation of Overlap for Tracking of Information Flow

Lasse Lehmann¹, Arno Mittelbach¹, James Cummings², Christoph Rensing¹ and Ralf Steinmetz¹

¹(KOM Multimedia Communications Lab
Technische Universität Darmstadt
Rundeturmstr. 10, 64283 Darmstadt, Germany
{lasse.lehmann, arno.mittelbach, christoph.rensing, ralf.steinmetz}@kom.tu-darmstadt.de)

²(Research Technologies Service
Oxford University Computing Services - University of Oxford
13 Banbury Road, Oxford, OX2 8NP, UK
James.Cummings@oucs.ox.ac.uk)

Abstract: The detection of redundant or reused passages in texts is an important basis for various tasks including tracking of information flow, plagiarism detection, origin detection, web search and information retrieval. Being able to track the evolution of a piece of information through different revisions or instances of documents can generally help to gain an impression of the document's background. In this paper we propose an efficient algorithm for detection of textual overlap between documents as well as a tool for its visualisation, created in the course of the *Holinshed Project* at the University of Oxford. The Evaluation on an annotated corpus shows that the proposed algorithm performs better than state of the art approaches.

Keywords: Information Flow, Information Tracking, Overlap Detection, Overlap Visualisation, String Matching

Categories: H.3.3, H.3.1, H.5.2

1 Introduction and Motivation

The detection of redundant or overlapping passages in texts is an important basis for various tasks including tracking of information flow [Metzler, 2005] [Kim, 2009], plagiarism detection [Clough, 2003], origin detection, web search and information retrieval [Hamid, 2009]. Being able to track the evolution of a piece of information through different revisions or instances of documents can generally help to gain an impression of the document's background. When considering information flow in historic works like e.g. *Holinshed's Chronicles* or the Bible, it is even possible to draw conclusions about historic events or changes in attitude by studying how and when information has been changed or adapted.

In this paper we present an algorithm for the detection of overlap between textual documents as well as an intuitive tool that can be used for its visualisation and annotation. Both have been created during the *Holinshed Project*. One main goal of

this project was to detect, localize, annotate and visualise the overlap between the two versions of Holinshed's famous Chronicles, which we describe in Section 2. Section 3 is dedicated to overlap detection. Herein we propose an approach for detection and localization of textual overlap and compare it to existing state of the art techniques using a corpus created in the course of the *Holinshed Project*. In Section 4 we describe the TEI Comparator, a tool that can be used for the visualisation and annotation of overlapping text, while Section 5 concludes the paper and gives an outlook on possible future work.

2 The Holinshed Project

The *Holinshed Project* at the University of Oxford has created an online parallel text edition of Holinshed's Chronicles of England, Scotland, and Ireland. This sixteenth-century work was at once the crowning achievement of Tudor historiography and the most important single source for many contemporary playwrights and poets, above all Shakespeare, Spenser, Daniel, and Drayton. Although the work is popularly known as Holinshed's Chronicles, it was necessarily a collaborative endeavour, the authors and revisers contained a range of individuals.

The work was first printed in 1577 and then a much revised and expanded second edition was printed in 1587. The difference between these two editions is significant and the revisions help us understand the changing attitudes of the day. Although the significance of the importance of Holinshed's Chronicles in helping us to understand Elizabethan literature, politics, and history is undisputed, there has not been a complete scholarly edition of them or an in-depth systematic analysis. The aim of the *Holinshed Project* is to stimulate new interest in the Chronicles, through first publishing a secondary handbook on the making, transmission, reception, appropriation, and literary and historical significance of the Chronicles as well as eventually creating a complete original-spelling annotated edition [Holinshed, 2010].

In order to undertake any systematic investigation of the two editions of Holinshed's Chronicles there are many stumbling blocks. One of the most important is simply being able to trace the changes from one edition to the other. In the absence of an existing critical edition detailing the movement, reorganisation, fragmenting, amalgamation, excising and rephrasing of all aspects of the text it was decided that it would be helpful to have a very basic set of electronic texts to commence with in order to start work on the secondary handbook. These texts would then have to be linked or aligned in some manner to allow jumping from any paragraph-level object to the corresponding one(s) in the other edition often moved quite a distance from its original location. By doing this, authors of articles for the secondary volume about Holinshed's Chronicles could compare what had happened to certain portions of the document from one edition to the other concerning the particular topic they were writing about and thus draw conclusions about changes in attitude of the authors or the political landscape of that time.

Literature published about the Holinshed Project and Holinshed's Chronicles are available at <http://www.cems.ox.ac.uk/holinshed/bibliography.shtml>. The texts themselves have been released publicly and are available at: <http://www.english.ox.ac.uk/holinshed/> and free for academic re-use. Also available is

an HTML version that has been created on the basis of above mentioned analysis, which allows for navigation between matching portions of the two editions.

3 Overlap Detection

One of the first goals of the *Holinshed Project* was to create a parallel text edition that was to form the basis for an in-depth analysis of the two editions of Holinshed's Chronicles. This meant that overlapping text sequences between the 1577 and 1587 version had to be identified and localised. As the two editions each consist of almost 20,000 paragraphs (roughly 2.5 million words in the 1577 edition and almost 4 million words in the 1587 edition) it was decided to start with an automatically created initial comparison that could then be refined by domain experts. There are several existing approaches that can be used for the detection of textual overlap in the given scenario. Section 3.2 describes these state of the art algorithms. The algorithm we have designed for this task is described in section 3.3 while Section 3.4 covers the evaluation we did on the corpus created in the course of the *Holinshed Project*.

3.1 Definitions and Preprocessing

Before the overlapping sequences in two texts can be determined, the texts usually need to be preprocessed. Typical preprocessing steps include cleaning (removal of special characters and/or punctuation), case-folding, stemming and stopword filtering. In case of the Chronicles difficulties were for example a difference in spelling between the two editions (and sometimes even within one edition) or the substitution of similar looking letters for one another (e.g. 'v' instead of 'u' or a '~' instead of 'n'). We found that a drastic cleaning step worked best, where for example all vowels were removed and special characters were replaced by their canonical counterpart (exchanged all '~' with 'n').

Usually a text is then divided into *tokens*. When the input strings represent natural language texts, a token is typically a word, as for DNA sequences usually character based tokenization is used as each character in a DNA string represents a special nucleotide.

An *n-gram*, also called *shingle*, is a sequence of n consecutive tokens extracted from the text. Transforming the title - *The description and Chronicles of England* - of one of the books within the Chronicles into 3-grams would hence result in [The description and], [description and Chronicles], [and Chronicles of], [Chronicles of England]. A *match* between two strings A and B is a string which is substring of both A and B.

A commonly used symmetric measure of similarity is the Jaccard measure [Jaccard, 1901] which is defined as the intersection of A and B divided by the union of A and B:

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|}$$

The problem herewith is that differences in length between the two strings A and B are not reflected in the measure. If, for example, a short string A is entirely included

in some longer string B then the Jaccard measure will indicate that the two strings are not very similar.

Another approach to determine if two strings overlap is to calculate their containment [Broder, 1997]. Since containment is an asymmetric measure it can be calculated in two ways, depending on the length of which string is used as divisor, thus reflecting differences in length of the two input strings: The containment of string A in string B is calculated by dividing the intersection of A and B by the length of string A and vice versa:

$$C(A,B) = \frac{|A \cap B|}{|A|}$$

3.2 Related Approaches

N-gram-overlap [Lyon, 2001] is a basic approach for detecting overlapping passages in strings. In a first step overlapping n-grams (shingles) are extracted from the strings by sliding a window of size 'n' over both strings. The shingles are stored (e.g. in lists) and the sets of n-grams of both texts compared. To determine the containment of two strings the number of matching shingles, i.e. the intersection of the two shingle sets is divided by the number of shingles in string A or B respectively. N-gram-overlap does not take into account the order of shingles in both strings. To do so, an offset has to be stored in addition to each shingle. N-gram-overlap runs in linear time.

Greedy String Tiling (GST) proposed by Wise [1993] is a heuristic that approximates the maximal tiling of two strings. A *tile* is an association of a substring of string A with an equal substring of string B. Each token of a string can only be present in one tile. A *tiling* with minimal tile length m between strings A and B is a list of unique tiles where the length of each tile is m or greater. The GST algorithm searches for matches of maximal length, marks them as tiles and then continues the search ignoring the marked tiles until no more matches with the given minimal length can be found. The heuristic prefers tiles of maximal length over an optimal tiling of two strings, e.g. a tiling with one tile of length six is preferred over a tiling with two tiles of length three and four. If, for example, the minimal tile length is 3 and a tiling was to be generated for "ACCAAT" and "ACCACAAT" then GST would choose a single tile "ACCA" rather than the two smaller tiles "ACC" and "AAT". Containment can now be calculated by dividing the overall length of all tiles in the tiling by the length of strings A or B respectively. The GST heuristic has a worst case complexity of $O(n^3)$ [Loose, 2008].

A classical problem in computer science is the identification of the **longest common subsequence (LCS)** [Maier, 1978] of two (or more) strings. A longest common subsequence is the longest sequence of common tokens of two input strings where the order of tokens has to be preserved but non matching tokens may be skipped. Usually tokens on character basis are used to determine the LCS. The LCS of two strings "ACCAAGCT" and "TACCCGCAT" thus is "ACCGCT". When the longest common subsequence is known, its length can be divided by the length of either of the strings to calculate containment measures. This approach suffers from the fact that it is extremely prone to changes in the order of the strings to compare. When

the position of one sentence changes, the resulting subsequence can be significantly different. Thus we do not expect the approach to perform well in the given use case.

3.3 ShingleCloud Approach

ShingleCloud is an extended and adapted version of the n-gram-overlap approach. It is designed for efficient detection and localisation of overlapping sequences between two strings. The intended use case of the algorithm is a needle-haystack search, where it has to be determined whether, where, and to which extent a comparatively short string A (the needle) is present within a longer string B (the haystack). However it works equally well if needle and haystack have approximately the same length.

After preprocessing the input strings, shingles are extracted from both strings and stored in lists. For performance considerations the shingles extracted from the needle should be stored in a data structure optimized for fast lookups (e.g. a hash table). The shingle size (n) is thus the first of three relevant parameters used by the algorithm. In the next step the so called ShingleCloud, in its simplest form a sequence of bits, is created. This is done by traversing the shingles of the haystack in the order they appear and adding one bit to the ShingleCloud for each traversed shingle. A one is appended, if the n-gram is also present within the needle, i.e. is contained in the corresponding list, and a zero is appended otherwise.

Based on the resulting ShingleCloud, it can be determined manually or automatically whether and where parts of the needle are present within the haystack. A simple ShingleCloud could be, for instance:

```
00000000000001110000000011110000000000
```

In this example the needle has been split up into two parts. If we assume that 3-grams were used (i.e. the shingle size is 3) then we could, for example, conclude that the first part of the needle can be found at position 15 (13 consecutive zeros represent 15 tokens if $n=3$). If we knew more about the needle, such as for example its length, we could further conclude whether it is completely enclosed in the haystack or whether it was shortened.

There are two parameters needed for the automatic evaluation of a ShingleCloud: The *minimal number of consecutive ones* (mno) needed for a sequence of ones in the ShingleCloud to count as a match and the *maximal number of zeroes* (mnz) that may exist within a match without it being interrupted. The second parameter only has an effect when a match has been detected in the first place. Usually the value of this parameter is greater than the shingle size, as a difference in one token would result in n non-matching shingles (where n is the shingle size). Hence if $mnz=n+1$ ShingleCloud would allow for two consecutive unmatched tokens without splitting up a match.

A decision regarding the detection of overlap can be found in different ways: Either by judging if a sufficiently large part of the needle is present in the haystack, i.e. if a consecutive sequence of ones of the given minimal length exists in the ShingleCloud, by means of a containment measure or by a combination of both. When the containment exceeds a given threshold the needle is assumed to be present within the haystack. This containment measure is calculated by dividing the weighted overall number of ones in the ShingleCloud by the length of needle and haystack

respectively. The weighted length of ones in the ShingleCloud is calculated as follows: If a one is preceded by a zero, the shingle size is added to the weighted length, otherwise 1 is added. Thus it is not the number of matching shingles that is used for the calculation of the containment but the number of matching tokens which can be significantly different, depending on the parameters chosen and the distribution of matches within the ShingleCloud.

The ShingleCloud concept is very flexible. In the course of the project we have extended the simple ShingleCloud as described above to include marker shingles that allow for fast lookup of the paragraph in which a match occurred. Furthermore, they allow matches inside one paragraph to be grouped together which can be used to compute containment scores not on the basis of the entire haystack but on a per paragraph level. We also experimented with wildcard shingles that match anything if encountered in a match (a sequence of “ones”). As several words or characters were illegible in the original manuscript we had hoped to improve the initial matching created by ShingleCloud. However, at least for the Chronicles the differences were not significant.

For a thorough documentation and download of ShingleCloud see [Mittelbach, 2010].

3.4 Evaluation

During the course of the *Holinshed Project* all the ~20,000 paragraphs (approximately 2.5 million words in the 1577 edition and almost 4 million words in the 1587 edition) of the 1577 and 1587 versions of Holinshed's Chronicles have been inspected manually. An initial matching was created using the ShingleCloud algorithm as described above which was then inspected and refined by a domain expert. Each paragraph in the 1577 version has been annotated regarding whether this paragraph still exists in the 1587 version and in which paragraph(s) of the 1587 version its content can be found. Thus an annotation set has been created that can serve as gold standard for the evaluation of approaches for automatic detection of overlapping textual paragraphs.

We have split the corpus into several parts using two of them for the evaluation presented here. This had to be done due to the poor runtime performance of GST, which has a worst case complexity of $O(n^3)$, while ShingleCloud and n-gram-overlap run in linear time. Holinshed's Chronicles are internally split up into several books. Part one of the evaluation corpus consists of the first four books plus the preface while part two consists of book five. The following table gives an overview of the two parts.

	Part 1	Part 2
Books	Preface, Book 1-4	Book 5
Paragraphs in 1577 version	3135	4476
Words in 1577 version	454,662	554,311
Paragraphs in 1587 version	2685	4377
Words in 1587 version	489,881	1,001,724
Number of matches in annotation	3384	4720
Theoretically possible Matches	$8,4 * 10^6$	$19,6 * 10^6$

Table 1: Characteristics of subsets used for evaluation

Since it is possible that a paragraph of the 1577 version has been split up and distributed over several paragraphs in the 1587 version there are possibly more matches in the annotation set than paragraphs in the source version. Due to the high number of possible combinations the number of possibly matching paragraphs has to be narrowed down. Thus the evaluation process is done in two steps:

1. Each algorithm selects a set of candidate pairs of paragraphs. The algorithm selects a pair when one of the containment measures is >0.02 .
2. The problem is then transformed into a categorization problem with two categories (hit and miss) using a ten fold cross validation approach based on the given annotations with the containment measures of the paragraph pairs as features. An optimal threshold is computed on the training set (using a brute force approach) which is then used as discriminant to categorize the test set. To achieve high confidence the ten fold is run 10 times.

Now quality measures like the F1 measure, precision and recall can be calculated to compare the different algorithms.

As expected, the LCS algorithm did perform significantly worse on the given corpus than ShingleCloud, n-gram-overlap, or GST; the LCS algorithm reached values for F1 lower than 0.50. Thus the results for LCS are not included in the following. Table 2 shows the F1 measures as well as precision and recall on both parts for n-gram-overlap, GST, and ShingleCloud (SC) in comparison.

Approach	F1 (σ) Pt. 1	Precision / Recall (Pt. 1)	F1 (σ) Pt. 2	Precision / Recall (Pt. 2)
GST (MTL = 7)	0,9665 (0,0005)	0,9763 / 0,9577	0,9752 (0,0004)	0,9827 / 0,9681
GST (MTL = 5)	0,9568 (0,0020)	0,9626 / 0,9518	0,9819 (0,0003)	0,9835 / 0,9815
GST (MTL = 6)	0,9669 (0,0008)	0,9742 / 0,9638	0,9794 (0,0004)	0,9827 / 0,9770
SC (n=3, mno=3, mnz=3)	0,9803 (0,0003)	0,9851 / 0,9748	0,9841 (0,0004)	0,9838 / 0,9843
SC (n=3, mno=3, mnz=0)	0,9798 (0,0002)	0,9872 / 0,9721	0,9844 (0,0003)	0,9844 / 0,9845
SC (n=5, mno=1, mnz=0)	0,9713 (0,0005)	0,9730 / 0,9694	0,9853 (0,0003)	0,9867 / 0,9843
SC (n=4, mno=3, mnz=4)	0,9751 (0,0005)	0,9826 / 0,9671	0,9854 (0,0002)	0,9884 / 0,9826
n-gram-overlap (n=5)	0,9637 (0,0008)	0,9659 / 0,9638	0,9854 (0,0001)	0,9880 / 0,9830
n-gram-overlap (n=6)	0,9721 (0,0003)	0,9806 / 0,9638	0,9820 (0,0006)	0,9860 / 0,9792
n-gram-overlap (n=4)	0,9663 (0,0004)	0,9700 / 0,9633	0,9847 (0,0002)	0,9865 / 0,9830

Table 2: Evaluation results

The results show, that all of the algorithms perform similarly well on the given corpus with slight advantages for ShingleCloud over n-gram-overlap and GST, specifically on part one. However, as for most true matches (those that were confirmed by a domain expert) the containment measures were quite high – usually above 33% – and the optimal threshold computed during the evaluation was around 5-10%, smaller differences in the containment measures between the algorithms are not reflected in the results. Figure 1 shows a visualization of the evaluation results on both parts of the Chronicles.

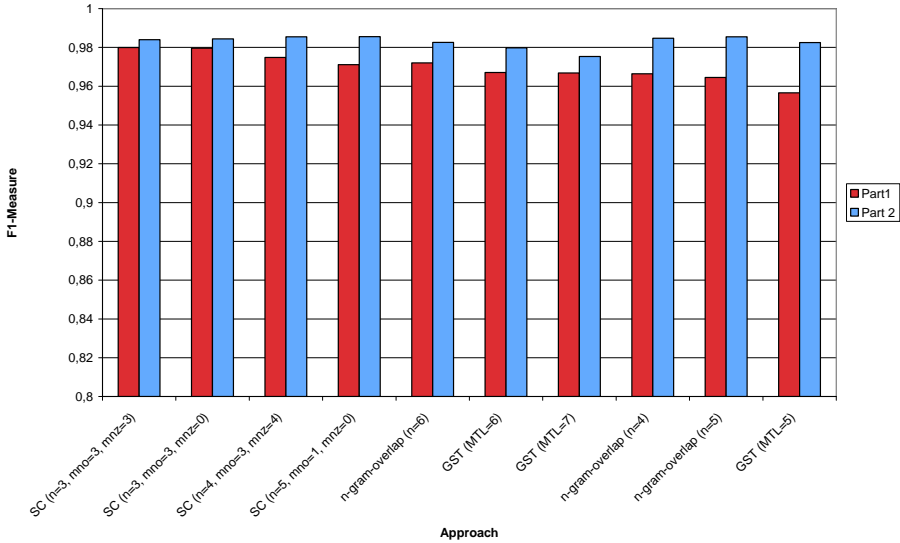


Figure 1: Evaluation Results in Comparison

Since ShingleCloud is based on n-gram-overlap it is expected that both perform almost equally well. However, ShingleCloud has several advantages, including the built-in localisation of matches, the small amount of storage it needs and its runtime efficiency in needle-haystack scenarios. As the ShingleCloud approach is very flexible (see Section 3.3) it can easily be adapted to work in different scenarios; it can be fine-tuned to a certain use-case or run with a one-fits-all configuration. The huge disadvantage of GST is its runtime complexity. While ShingleCloud when run over the entire Chronicles is done in less than three hours, GST needs days if not weeks for this task without producing better results.

4 Visualisation of Overlap - The TEI Comparator

There are some approaches that deal with the visualisation of overlap. In [Klerkx, 2006] relations resulting from the reuse of PowerPoint slides are visualised in various ways to show the form and extent of reuse within the ARIADNE repository. Visualisation methods like dotplots or Patterngrams are used in the area of plagiarism detection to determine whether there are overlapping sequences between documents or not [Clough, 2001]. Plagiarism detection tools like docoloc use a rather pragmatic method of visualisation and simply add linked annotations to the overlapping text passages. [Johnson, 1994] uses Hasse diagrams to visualise redundancies in legacy source.

The TEI Comparator is a database backed web application that was originally developed as frontend for the *Holinshed Project* and is designed for the visualisation of overlapping passages in two XML files. It was created to allow domain experts to browse through, revise and annotate the initial matching created by ShingleCloud. It

5 Conclusions and Future Work

In this paper we have proposed an algorithm and tool to support the tracking of information flow. Specifically in the context of historical documents this can help greatly to understand and interpret events and changes in attitudes and the political or religious landscape of those times. The evaluation has shown that the proposed ShingleCloud algorithm is better suited for the task of overlap detection task than state of the art approaches. Evaluations we have done on other corpora have confirmed this experience. Besides its use in the *Holinshed Project* the proposed system can be used in arbitrary scenarios where textual overlap needs to be detected and visualised in an effective and fast manner. Future work in this area might include the adaptation of the tool and algorithm for slightly different use cases like comparison of and search in DNA sequences or functional extensions to the given UI.

References

- [Broder, 1997] Broder, A. Z. (1997), On the Resemblance and Containment of Documents, in 'SEQUENCES '97: Proceedings of the Compression and Complexity of Sequences 1997', IEEE Computer Society, Washington, DC, USA, pp. 21.
- [Burrows, 2007] Burrows, S.; Tahaghoghi, S. M. M. & Zobel, J. (2007), 'Efficient plagiarism detection for large code repositories', *Softw. Pract. Exper.* 37(2), 151--175.
- [Clough, 2001] Clough, P. (2001). Measuring Text Reuse and Document Derivation. Postgraduate transfer report, Department of Computer Science, University of Sheffield, UK.
- [Clough, 2003] Clough, P. (2003), 'Old and new challenges in automatic plagiarism detection', Online: <http://ir.shef.ac.uk/cloughie/papers/pas-plagiarism.pdf>, (zuletzt abgerufen am 16.11.2009).
- [Hamid, 2009] Hamid, O. A.; Behzadi, B.; Christoph, S. & Henzinger, M. (2009), Detecting the origin of text segments efficiently, in 'WWW '09: Proceedings of the 18th international conference on World wide web', ACM, New York, NY, USA, pp. 61--70.
- [Holinshed, 2010] Holinshed's Chronicles, Online, <http://www.cems.ox.ac.uk/holinshed/>
- [Jaccard, 1901] Jaccard, P., 'Étude comparative de la distribution florale dans une portion des Alpes et des Jura', *Bulletin del la Société Vaudoise des Sciences Naturelles* 37, 547--579.
- [Johnson, 1994] Johnson, J. H. (1994), Visualizing textual redundancy in legacy source, in 'CASCON '94: Proceedings of the 1994 conference of the Centre for Advanced Studies on Collaborative research', IBM Press, , pp. 32.
- [Kim, 2009] Kim, J. W.; Candan, K. S. & Tatemura, J. (2009), Efficient Overlap and Content Reuse Detection in Blogs and Online News Articles, in '18th International World Wide Web Conference'.
- [Klerkx, 2006] Klerkx, J.; Verbert, K. & Duval, E. (2006), Visualizing Reuse: More than Meets the Eye, in 'Proceedings of the 6th International Conference on Knowledge Management (I-KNOW) 2006', pp. 489-497.
- [Loose, 2008] Loose, F.; Becker, S.; Potthast, M. & Stein, B. (2008), Retrieval-Technologien für die Plagiaterkennung in Programmen, in Joachim Baumeister & Martin Atzmüller,

ed., 'Proceedings of the Information Retrieval Workshop at LWA 2008', University of Würzburg, Germany, , pp. 5-12.

[Lyon, 2001] Lyon, C.; Malcolm, J. & Dickerson, B. (2001), Detecting Short Passages of Similar Text in Large Document Collections, in Lillian Lee & Donna Harman, ed., 'Proceedings of the 2001 Conference on Empirical Methods in Natural Language Processing', pp. 118--125.

[Maier, 1978] Maier, D. (1978), 'The Complexity of Some Problems on Subsequences and Supersequences', J. ACM 25(2), 322--336.

[Metzler, 2005] Metzler, D.; Bernstein, Y.; Croft, B. W.; Moffat, A. & Zobel, J. (2005), Similarity measures for tracking information flow, in 'CIKM '05: Proceedings of the 14th ACM international conference on Information and knowledge management', ACM, New York, NY, USA, pp. 517--524.

[Mittelbach, 2010] Mittelbach, A. & Lehmann, L. (2010), 'ShingleCloud Library for approximate string matching', Online:
<http://www.kom.tu-darmstadt.de/en/downloads/software/shinglecloud/>, Zuletzt abgerufen am 13.01.2010.

[Mittelbach, 2010b] Mittelbach, A. & Cummings, J. (2010), 'TEI-Comparator', Online:
<http://tei-comparator.sourceforge.net/>, Zuletzt abgerufen am 03.03.2010.

[TEI, 2010] TEI Consortium, eds. *TEI P5: Guidelines for Electronic Text Encoding and Interchange*. 1.6.0. Last updated on February 12th 2010.. TEI Consortium. <http://www.tei-c.org/Guidelines/P5/> (last accessed 01.06.2010).

[Wise, 1993] Wise, M. J. (1993), 'Running Karp-Rabin Matching and Greedy String Tiling', Technical report, Basser Department of Computer Science - The University of Sydney.

Ontological Framework Driven GUI Development

Syed K. Shahzad

(Graz University of Technology, Graz, Austria
shahzad@student.tugraz.at)

Michael Granitzer

(Graz University of Technology, Graz, Austria
mgranitzer@tugraz.at)

Abstract: The user experience of any software or website consists of elements from the conceptual to the concrete level. These elements of user experience assist in the design and development of user interfaces. On the other hand, Ontologies provide a framework for computable representation of user interface elements and underlying data. This paper discusses strategies of introducing ontologies at different user interface layers adapted from user experience elements. These layers range from abstract levels (e.g. User needs/Application Objectives) to concrete levels (e.g. Application User Interface) in term of data representation. The proposed ontological framework enables device independent, semi-automated GUI construction which we will demonstrate at a personal information management example.

Keywords: GUI, Personal Information Management, User Interface Ontology, HCI, Knowledge Management

Categories: H1.2, H.5.2, H5.3, I.2.4, K.6

1 Introduction

Guarino, Smith and Gruber formalized concepts using ontologies [Guarino 95] [Smith 04] [Gruber 93]. Artificial Intelligence (AI) has implemented the idea of enabling machines to compute formalized conceptual models using ontologies. Moreover, formal ontologies ensure the meaning and consistency of the presented concepts.

Recently Uschold has combined formal ontologies with the model driven software development [Uschold 08]. Uschold has suggested ontological model driven software development to improve the development of complex software systems.

Here we discuss Graphical User Interface (GUI) development using ontologies. This paper presents an approach to map formal ontologies to GUI automatically, so that the GUI preserves the properties of the underlying domain concept. Such mapping supports device independent GUI construction as well as semi automatic GUI modelling. We discuss our approach along a Personal Information Management (PIM) example. We used vCard/hCard as a standard ontological model for PIM. We used Jena and SWT for mapping vCard to GUI.

The next section discusses elements of user experience providing the layers of user's perception. In section 3, we outline the properties of formal ontology which should be presented at GUI level and conclude our work afterwards by combining User Interface Ontology (UIO) and Personal Information Management.

2 User Experience Elements

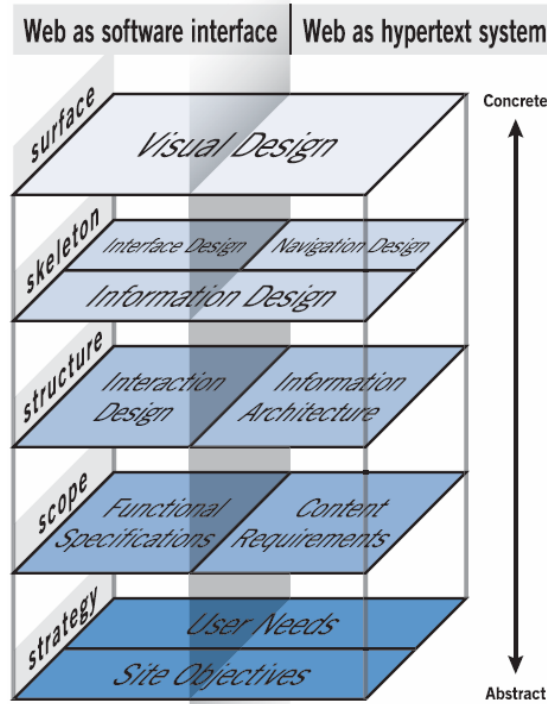


Figure 1: Adapted User Experience Elements by Garrett [Garrett 02]

Garrett [Garrett 02] introduces five elements of user experience of concepts underlying software or a website (Fig1). These application concepts summarize the goals a software system should pursue. Garrets elements collectively introduce different levels of such application concepts represented in information system.

With the reference of Garrett's model, we argue that representation and direct mapping of ontology from the base layer (i.e. strategy) to the presentation layer (i.e. surface) can help users to perceive the targeted concept. These elements can also be considered as layers of UI design and development. We adapted Garrets layered approach for the development of GUI to follow through the elements of user perception. The ontological framework provides the capability for a formal specification of the concepts. It also enables the designer and developer of the website to implement ontologically specified domain concepts. Following the user psychology also enables designer to make a user centered design.

Ontologies can be introduced to each layer as in the following fashion (Table1):

1. Garret represented the strategy as an abstract concept from the user abstractly lied down.
2. Scope talks about what exist within the boundary of the domain. In this work, it refers to the details of the concepts and sub-concept within the boundaries of major domain concept as vocabulary.

3. Domain ontology specifies the relationship of concepts and sub concept as the structure. It provides a hierarchical structure of whole and part, also associated concepts. This ontological structure makes a map of information arrangement and navigation in related concepts. This structure can be seen as a business model specified in Formal Ontology.
4. Ontologically Formalized structure can be picked by User Interface Ontology to make a skeleton for user interface generation. This skeleton provides the representation and interaction methods for UI.
5. Surface is the concrete implementation of the skeleton. It is the UI implemented through any computer graphical library.

Level of User Experience	Ontological Implementaion	Example Application using Ontlogical Framework
Surface	Graphics Look and Feel	UIO Implementation at Graphical Library SWT, OpenGL, GTK, wxWidgets, QT
Skeleton	User Interface Ontology	Customized Textbox, List box, Selection Box, Date/Time tool, Containers, Buttons
Structure	Domain Ontology	vCard, hCard
Scope	Vocabulary (for Entities and Relations) Relations also represent Functions	Name, Address, Date of Birth, Email, Phone Number, Family Name, Zip Code
Strategy		Personal Information Management

Table1: Adapted User Experience Elements by Garrett [Garrett 02]

In current example of vCard, we have dealt with visualization of vCard to the GUI. Interaction methods, update functions initiation with UI events will be discussed in future research through mapping of functional ontology to User Events.

2.1 Conceptualization through Ontological Modelling

Gruber [Gruber 93] suggested the properties of formal ontologies for conceptualization. Uschold introduced ontological modelling for model driven software development to use the properties of conceptualization. We use formal ontologies as a base structure for GUI development.

Formal ontology specifies the structure. UI Ontology will use the vocabulary of each entity concept and sub-concept, specified by formal ontology. These concepts and sub-concepts can be carried to the structured layer using ontological relations. Automatic mapping functions from formal ontology to GUI can maintain properties of conceptualization at GUI.

2.2 Personal Information Management (vCard/hCard)

Identification Properties	Name	Given
		Family
Address Properties	Street Address	
	City	
	Country	
	Zip Code	
Telephone Number	Country Code	
	Network Code	
	Phone Number	
....		

Table 2: Structure of vCard properties

Internet Mail Consortium (IMC)¹ has defined a standard for Personal Data Interchange as vCard (RFC2426). This standard has been broadly interoperably implemented (e.g. Apple's "Address Book", Microsoft Outlook). This paper discusses factors and issues in mapping of vCard to GUI. vCard provide a data structure for personal information storage and representation. We used vCard as example ontology for personal Information. Internet Mail Consortium states that vCard can be used to forward personal data in an electronic mail message. While integrating vCard support into an application, an implementor must consider a number of UI implications. Most applications provide some levels of support for interacting with other applications. It mentioned three ways to use vCard the File System, the Clipboard, and Drag/Drop techniques. It also provides two kind of grouping, first group of multiple vCard and second grouping of related properties within the same vCard. IMC White paper also argues that full potential of the vCard technology can be better utilized by an application that supports the vCard specification in each of these UI forms.

Grouping provides ontological structure (*Table2*). This structure is formed on the base of ontological relation. There are also some implicit relation exist in vCard as different groups or set of attributes.

vCard properties can be grouped and priorities according to the context and relationships. There values of grouped properties can be represented as one value but with different joining structures and delimiters.

¹ <http://www.imc.org/pdi/>

3 Ontological Framework for User Interface Development

Ontological framework includes three major sections. (i.e. vocabulary, Domain Ontology and User Interface Ontology) These sections are the layers of development procedure.

3.1 Vocabulary (Scope)

Vocabulary contains the concepts and sub-concepts exist in the domain without stating relationships. It is list of attributes of the domain ontology. vCard standard (RFC2426) provides the list of attributes being used for PIM.

3.2 Domain Ontology (Structure)

Domain ontology specifies the relationship of the attributes. It provides a structure to arrange attributes at GUI.

3.3 User Interface Ontology (Skeleton)

Uschold encourages automated code generation for UI from ontological model [Uschold 08]. But most of the research talk and present automation and translation of ontologies to GUI [Alexander, 03][Furtado 02] [Liu 05]. Paulheim provides a method to implement ontologies to UI is through plug-ins [PaulHeim 09].

We used User Interface Ontology (UIO) as the part of core development process and a base for designing UI, rather than introducing ontologies separate or parallel to the main design procedure. User Interface Ontology (UIO) describes concepts and relationship of GUI objects and interaction methodology. UIO considers the domain ontology needs to be interfaced to user. It specifies the representation of each entity in the vocabulary depending on the type of entity, relationship specified in domain ontology and role of user. UIO consider the role of user to generate GUI according to the context.

UI is two way communication “form and to the user”. The concepts discussed in UIO are presentation of a domain concept, sub-concept and the relation to the user as to the user communication; it also discusses the interaction methodology and user actions and ontological responses. Functional Ontology is part of future work and conceptual user actions to concrete event handling will also be part of future work.

4 User Interface development

This section discusses UI development methodology through UIO.

4.1 Customized User Interface Control

GUI controls can be customised and associated with the domain concepts which are going to be represented at GUI. Like textbox, list box, combo box, radio button or even a frame can be associated with a domain concept presented. IBM Semantic Layered Research Platform² has also worked on RDF-driven application development

² <http://ibm-slrp.sourceforge.net/wiki/index.php/Com.ibm.adtech.telar.ui.swt>

using JFace/SWT components. It provides examples of RDF-driven JFace widget, tooltip window and viewers. Each item within the scope level can be assigned a viewer, widget or container (like frames or tabs for representing a relationship of part and whole).

GUI control association depends upon the type of entity, the type of representation. UIO specifies the type of representation for an entity.

4.2 User Interface Generation

Customized UI controls are then joined together according to the structure provided by the OUI model.

Mapping procedure works as a part of User Interface Ontology (UIO). UIO reads the structure and vocabulary. User interface controls are associated to the entities in the vocabulary to make customised controls. Customised controls are made on the base of representation specified.

Arrangement of customised user interface controls according to the relationship specified in Domain ontology.

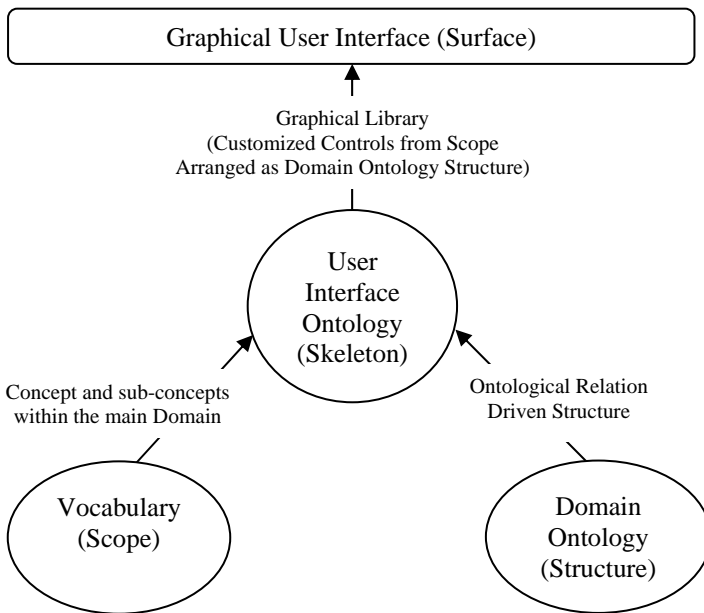


Figure 2: Ontology representation at GUI

Taking the Garrets model in consideration, the mapping process follows through the scope (vocabulary) and structure (Domain Ontology) to the skeleton (User Interface Ontology) (Fig2). Skeleton provide a base design for user interface that can be instantiated by any graphical library for any platform.

For example application of PIM, we created a dictionary for vocabulary through reading RDF.

4.3 Ontology Modelling based on Context

Doming ontologies structuring and arrangement is based on the relationships. In our example of vCard, properties groups and vCard groups are made on the criteria provided by the whole system. vCard is based on the concept of business cards. Thus the arrangement and groups of properties will be different from personal data ontology in social network. Individual properties (like name, address, date of birth etc) represent the same domain ontology. These domain ontologies are arranged on different rules in an organization than a social network.

DOLCE has discussed the calculus of individuals in an organization based on their roles in organization. The organizational structure does provide structure for grouping properties and persons.

In a network of friends, level of trust is though not dependent on the official designation or department. Social network provide a different criteria to arrange and group properties and persons. All of these structures are discussed and available in relationship, axioms, calculus in current research [Bottazi 06][Gangemi 02][Clarke 81][Gruber 93]. These structures assist us to develop UI accordingly.

5 Results

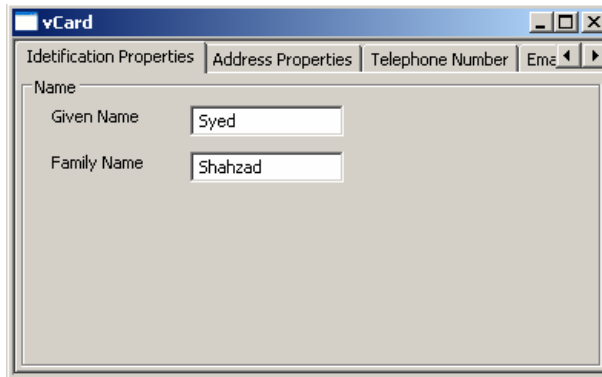


Figure 3: Example UI for a vCard

This research resulted in a very simple user interface for a vCard but it was more focused on the process and methodology of UI development. There are many alternative to represent the same concept at surface level. A group of concepts can be aggregated by a group, tab or frame. Here in this example we use to group different vCard properties by tabs. vCard can be shown in a business card view or as personal data page. Microformats also provide two views at hCard creator; first view is a web form for data entry and second is a preview of a vCard³. It is an example of UI based on modes (i.e. read mode and edit mode). Microsoft Outlook also creates same kind of UI but a little complex structure for vCard edit mode view.

³ <http://microformats.org/code/hcard/creator>

6 Conclusion

Ontological modelling and formalization used in model driven software engineering, can make concept specification and representation more consistent. It helps in ensuring proper concept delivery at user interface. A proper layered approach as layers of user perception can make the process of GUI design and development more user centred. User Interface Ontology is a junction of the domain ontology, context and look and feel. Website designs and models can also be tested at any stage through Formalized concepts, as they carry the concept throughout the development process. In our experiments, representation methods were specified as default for textual data. In general, knowledge representation depends at the knowledge domain specified. User interaction and response methods are based on the use and affordances of the knowledge domain. These interaction methods can be specified through ontological functions.

7 Future Work

Axioms constraints, validation functions can be attached in model as a part of ontology rather than at GUI. Ontological function from through Functional Ontology can be introduced and attached to user events at GUI.

Acknowledgements

This contribution is partly funded by the Know-Center and the Higher Education Commission of Pakistan. The Know-Center is funded within the Austrian COMET program -- Competence Centers for Excellent Technologies -- under the auspices of the Austrian Federal Ministry of Transport, Innovation and Technology, the Austrian Federal Ministry of Economy, Family and Youth and the State of Styria. COMET is managed by the Austrian Research Promotion Agency FFG.

References

- [Alexander, 03] Alexander K., Valeriya G.: From an ontology-oriented approach conception to user interface development. *Int. J. Information Theories & Applications*, Vol. 10, No.1, p. 87-94, 2003.
- [Bottazzi 06] Bottazzi, E., Ferrario, R.: Preliminaries to a dolce Ontology of Organizations, *Int. J. Business Process Integration and Management*, Vol. 1, Nos. 1/2/3, pp.64–74, 2006.
- [Clarke 81] Clarke B.: A Calculus of Individuals Based on 'Connection', *Notre Dame Journal of Formal Logic*, Volume 22, Number 3, July 1981
- [Furtado 02] Furtado E., Furtado J., Silva W.,Tavares D.: An Ontology-Based Method for Universal Design of User Interfaces, *Task Models and Diagrams For User Interface Design (TAMODIA 2002)*
- [Gangemi 02] Gangemi A., Guarino N., Masolo C., Oltramari A., Schneider L.: Sweetening Ontologies with DOLCE, *Proceedings of the 13th International Conference on Knowledge*

Engineering and Knowledge Management. Ontologies and the Semantic Web, p.166-181, October 01-04, 2002.

[Garrett 02] Garrett J.: The elements of user experience: user-centred design for the web, ISBN-13: 978-0735712027, October, 2002

[Gruber 93] Gruber, T.: Toward Principles for the Design of Ontologies Used for Knowledge Sharing, International Workshop on Formal Ontology, 1993, Padova, Italy, March 1993

[Liu 05] Liu B., Chen H., He W.: Deriving User Interface from Ontologies: A Model-based Approach, 17th IEEE International Conference on Tools with Artificial Intelligence (ICTAI'05), Hong Kong China

[Paulheim, 09] Paulheim H., Probst F.: A Framework for Ontologies-based User Interface Integration, The 8th International Semantic Web Conference (ISWC 2009), Northern Virginia, USA, 25-29 October 2009.

[Shahzad, 09] Shahzad, S., Granitzer, M., Tochtermann K.: Designing User Interfaces through Ontological User Model, Proceedings of the Fourth International Conference on Computer Sciences and Convergence Information Technology ICCIT 2009, Seoul, Korea, 24-26 November 2009. p 99-104.

[Smith 04] Smith, B.: Beyond concepts: ontology as reality representation. In: Proceedings of the third international conference on formal ontology in information systems (FOIS 2004). Amsterdam: IOS Press; 2004. p. 73-84.

[Uschold 08] Uschold, M.: Ontology-Driven Information Systems: Past, Present and Future, FOIS 2008, Saarbrücken, Germany, Oct 31st – Nov 2008, doi:10.3233/978-1-58603-923-3-3

Mobile Governance: Empowering Citizens to Enhance Democratic Processes

Marta Poblet

(ICREA, UAB Institute of Law and Technology, Barcelona, Spain
Marta.poblet@uab.cat)

Abstract: This paper offers an overview of the emerging domain of mobile governance as an offspring of the broader landscape of e-governance. Mobile governance initiatives have been deployed everywhere in parallel to the development of crowdsourced, open source software applications that facilitate the collection, aggregation, and dissemination of both information and data coming from different sources: citizens, organizations, public bodies, etc. Ultimately, mobile governance can be seen as a tool to promote the rule of law from a decentralized, distributed, and bottom-up perspective.

Keywords: governance, mobile technologies, mobile governance, rule of law, crowdsourcing
Categories: H.2, H.4

1 Introduction

Mobile governance is an umbrella term that covers a number of initiatives involving the use of mobile technologies (i.e. SMS, USSD, geolocation, etc.) in the domains of citizens' participation, public awareness, management of emergencies and crisis, provision of public services, information, etc. to reach wider population segments (as compared to those currently accessing the Internet). It is well known that mobile phones have become in recent years the most ubiquitous communication device world wide, with higher penetration rates than the Internet. In 2010, the number of mobile cellular subscriptions globally is expected to reach five billion [ITU, 10]. Mobile technologies provide therefore greater opportunities for social impact than any other ICT, while being more affordable and, also, less demanding in the skills and training required [Kinkade *et al.*, 08].

While deeply intertwined to e-governance, mobile governance (or m-governance *tout court*) emerges as a new domain with two-fold objectives: on the one hand, it aims at improving the provision of basic public services, specially to the less favoured populations; on the other, it bolsters the participation of citizens, grass-root organizations, NGOs, etc. in awareness campaigns, electoral processes, oversight of governments and public policy making [Hellstrom, 08]. In Hellstrom words, "mobile phones make it possible to create a bottom up participation and ultimately—what m-governance is all about—empowerment [Hellstrom, 08]. This paper presents a brief overview of this nascent domain and makes a case for considering m-governance as a crucial development of the broader domain of e-governance.

2 Governance, e-Governance, and m-Governance

For some years now, the concept of governance has been defined and measured in multiple ways by scholars, international organizations, think tanks, practitioners, etc. While some definitions emphasize the relationship between governments and citizens or markets, others highlight how institutional structures, procedures, and processes need to be implemented to deliver public services under the rule of law. Despite the variety of approaches, the notion of good governance is generally related to the principles of rule of law [Kaufmann, 08], transparency, accountability, and public participation [Sasaki, 10].

The use of the Internet and other information technologies (IT) to support governance mechanisms has led to the new paradigm of e-governance. This paradigm is broad enough to include (i) *IT supported* governance—where IT support the provision of conventional, offline public services, (ii) *IT enhanced* governance—where IT provide a complementary online channel to facilitate the relationship between government agencies and citizens, companies, organizations, etc., and (iii) *IT enabled* governance—where IT open unprecedented venues to empower citizens with improved access to government information and data (i.e. the movement of Open Data in different countries).¹ While these different uses of IT for governance usually coexist in many countries, their effective impact on making governments more transparent and accountable, or making citizens more participant should be analyzed separately. Recent case studies show that while more and more government agents publish information on their activities and budgets, they may do so “in ways that are not easily accessible or comprehensible” [Sasaki, 10]. Similarly, recent empirical research provides contradictory results on the impact of the Internet on public participation. Main debates focus on whether the Internet and other information technologies are valid sources of the skills and resources, and mobilization needed for participation—according to the “civic voluntarism” model [Verba, 95]—, and even on different conceptualizations “of the meaning and empirical referent of political participation” [Anduiza, 09]. As Hattotuwa grimly puts from his Sri Lankan experience [Hattotuwa, 08]:

Good governance in 2008 is no better and arguably in a condition far worse after the introduction of e-Governance than before it. This is not to say that e-Governance initiatives per se have contributed to the deterioration of democracy, but suggest instead to the heady telecentre idealists who reside in the stratosphere that on the ground, few citizens access telecentres to strengthen and interact with mechanisms and institutions of (local and national level) governance that are failing them daily. Some Government forms are readable and downloadable on PCs (and that too not always in Tamil), and one can see how the local government representative looks like on a webpage (for one never see him in real life) and get the numbers of telephones and faxes that are many-a-times outdated and dysfunctional.

The Sri Lanka example applies to many other countries. On the one hand, Internet penetration rates are low or very low in developing countries—18 users per 100 inhabitants—and remain modest in global terms: roughly one quarter of the world

¹ <http://www.data.gov/>

population (26.8) has access to the Internet [ITU, 10]. On the other, adding IT to governance mechanisms requires physical infrastructures and operational designs that are lacking at different levels. And even if governments are willing to provide services or public information on their activities, they may fail the attempt: transforming information reports or budgets—usually both lengthy and/or highly technical—into meaningful data that people can visualize, compare, contrast, comment, etc. is not a straightforward road to travel through.

Mobile governance, or the use of mobile technologies to enhance the provision of online services and enable new communication channels may certainly contribute to remove some barriers to the delivery of electronic services and the participation of citizens and groups in public affairs. In this regard, Kaisalam includes within the domain of mobile governance both G2C and C2G interactions (i.e. providing relevant information to citizens and complaining about services, respectively), mobile services (i.e. transactions and payments), mobile democracy (i.e. use of SMS for citizen input to political decision-making), mobile administration (i.e. a seamless environment for governmental agencies) and government management of emergency situations (i.e. in the aftermath of natural disasters) [Kailasam, 10].

While it “also rel[ies] on good back office ICT infrastructure and work processes: governance networks and databases, data quality procedures, transaction recording processes, etc.” [Kailasam, 10], mobile governance is generally considered to offer better perspectives than PC-based e-governance models. A frequently repeated argument for the extension of mobile governance relies on statistics unanimously showing how the numbers of mobile phone owners outnumber by far those of wired lines and Internet users. Potentially, then, broader population segments can be reached. A number of recent studies have indeed proved how mobile governance initiatives are currently being developed in rural areas with poor or none Internet access [Kinkade and Verclas, 08; Kaisalam, 10]. From the citizens’ perspective, mobile governance holds the promise of shaping conversations and information services to make them more “decentralized, two-way, adaptive, resilient, and pervasive” [Hattotuwa, 08]. But will the mere possession of relatively inexpensive hand-held devices make citizens more aware and vigilant towards state institutions? Will it make them more prone to public participation, in whatever form this may take? These are for sure updated research questions relevant to the well established domains of governance and political participation. To address these questions in full is out of the scope of this paper, but we will approach them by reviewing some bottom-up initiatives that have flourished from the collaboration between groups of technologists and activists, civil society organizations, and NGOs. Often referred to as “mobile activism”, these initiatives are coincident in the use of disruptive, low-cost, little-learning-curve technologies such as SMS and may provide transparent testbeds for large mobile governance programs.

3 Mobile Technology for Citizens Engagement

On March 13, 2004, forty-eight hours after the terrorist attacks of March 11 in Madrid, thousands of people concentrated before the headquarters of the Popular Party, then in office. The demonstrators wanted to know the truth on the responsibility for the attacks, the government having put the blame on the Basque terrorist

organization ETA from the immediate outset. The concentration was organized in a decentralized way by means of SMS. The use of mobiles to bolster political mobilization was replicated, among other places, in the Philippines to protest against a reform on taxes (2004), in the independence referendum in Montenegro (2006), in Burma during the Saffron Revolt (2007), in Kenya, India, or Iran after the respective electoral processes and in several countries in Africa [Ekine, 10]. Specifically, mobile activism has also a significant impact on the monitoring of the electoral processes, where it can influence the way in which the elections are organized [Schuler, 08]. According to Miard, mobile phones shape this particular form of activism by bringing into the front three important factors: mobility, personalization and multimodality [Miard, 09]:

Mobility adds a spontaneity factor to potential mobilization, because users can react instantly and emotionally to events. Personalization is given through the typically person-to-person and social type of contact. Finally, the mobile phone is multimodal because it can transmit voice, images, and sounds, making it a tool for live transmission of events to be shared on the network.

Over the last few years, new horizons and opportunities for the development of mobile governance initiatives have incredibly expanded all over the world. While the core domains of application in the area of governance are citizens' activism and public participation, monitoring of election processes, advocacy, reporting of crimes and human rights violations, new creative uses are constantly emerging out of the practical needs of citizens, organizations, and public institutions. Innovation does not lie in the design of high-tech or sophisticated technology, but in the use of an appropriate and disruptive technology such as an SMS service: appropriate in the sense that it is suited to the environment in which it is used [Schumacher, 73], which in this case is composed of citizens owning and interacting with a mobile phone, and disruptive in Christensen's sense [Christensen, 97] insofar it exploits the most basic capacities of already existing technologies to reach broader population segments which otherwise would not have had access to more costly and sophisticated mobile technologies (i.e. the mobile Internet). In this line, a number of new open source software applications and tools have simultaneously emerged and there are teams of developers around the globe cooperating in a decentralized way to improve alpha and beta versions of the software. Table 1 below summarizes the main features and functionalities of the software applications recently developed and tested in a number of world areas:

Platform Developer	Ushahidi Ushahidi	Frontline SMS Kiwanga	Rapi4SMS UNICEF, Dimagi, MVP	Swift River Ushahidi & Meedan	SlingshotSMS Development Seed	SMS Turks Ushahidi	Freedom Fone Kubatana Trust
Release year	2008	2005	2009	2009	2009	2010	2009
Status	Version 1.0	Version 1.5.5	Alpha	Alpha 0.0	Version 2.0	Not available	Version 1.5
Main purpose	Submit crisis information through text messaging using a mobile phone, email or web form	Enable mobile users to send and receive text messages with large groups of people through mobile phones, use-cases	Support the creation of personalized interdependent platforms for diverse use-cases	Determining the veracity and accuracy of news during a crisis	Provide a gateway to mobile phone text messages and the web.	Help volunteers manually parse information out of text messages	Create and conduct polls via SMS, collect opinions via telephone and make them available online
Functionalities	SMS, email & web-based data gathering + Geolocation + timeline	Create forms to be sent to a Java-enabled mobile phone through a text message. Data collection functionalities	Collect quantitative and qualitative data through a SMS. Used in Supply Chain Management, Patient Tracking and Decision Support	Database and user interface to gather and filter streams of data through both machine based algorithms and humans to understand their veracity	A minimal SMS server which connects modems to websites and applications via HTTP interface	Allow translation, categorization and geocoding of all incoming messages	Voice menu, SMS polls, leave-a-message voice menu, information callbacks
Interoperability	Mapping applications (Google, Yahoo, MSN, OSN maps), FrontlineSMS, Clickatell, IntelliSMS, Twitter, StatusNet	Integration with Ushahidi	Has developed Rapid Android, Used by CommCareHQ	First used as a complement to Ushahidi. Builds on Twitter Vote Report	Uses pygsm, sponsored by UNICEF. Integration with Managing News	Integration with Ushahidi	
Use Cases	Kenya, Lebanon, Mexico, Madagascar, Afghanistan, Gaza, Philippines, India, DR Congo, South Africa, Haiti, Chile	Worldwide (used in + 40 countries)	Ethiopia, Kenya, Nigeria, Somalia, Malawi, Uganda, Rwanda, Tanzania, Senegal, United States	India		Haiti	Zimbabwe, Tanzania

Table 1: Open source software applications for m-government

- Ushahidi—“testimony” in Swahili—is a platform that allows its users to gather distributed data via SMS, email or web and visualize it on a map or timeline.² Through Ushahidi people report real time information of events such as political disruption or natural disasters and the platform aggregates this incoming information for use in a crisis response. The website was created at the beginning of 2008 as a simple mashup, using user-generated reports and Google Maps to map reports of violence in Kenya after the post-election fallout, and it has been used in a number of election processes afterwards. But Ushahidi has really come to age with the Haiti earthquake of January 2010 with the coordination of aid and relief agencies to support rescue operations, situational awareness and near real-time online mapping of incidents related to the disaster.
- Frontline SMS was started in 2005 and it enables users to send and receive text messages with groups of people through mobile phones. It works with existing plans on all GSM phones, modems and networks.³ Frontline is mostly used in areas such as human rights monitoring, disaster relief coordination, natural resource management, and election monitoring.
- RapidSMS is a web-based platform for data collection, logistics coordination, and communication developed by the Innovations and Development team of UNICEF.⁴ With the RapidSMS web interface, multiple users are able to access the system simultaneously and to view incoming data as they arrive, export new data-sets, and send text messages to users.
- Swift River is a toolset for crowdsourced situational awareness.⁵ The first use of Swift was as a complement to Ushahidi to monitor the Indian 2009 Elections. Swift River embraces Semantic Web open standards “such as FOAF, iCal, Dublin Core, as well as open publishing endpoints such as Freebase” to add structure to crisis data and make them shareable.
- SlingshotSMS is a lightweight SMS gateway that can run on a laptop or a USB drive.⁶ SlingshotSMS sends and receives text messages on behalf of a web application. It builds on the work of pygsm, a Python library developed by UNICEF Innovation to deal with AT-compatible modems.
- SMS Turks is a very recent application developed by members of the Ushahidi community to help volunteers working with Ushahidi to manually parse information out of text messages immediately after the Haiti earthquake. The system, to be newly rewritten, allows translation, categorization and basic geocoding of all incoming messages.⁷

² <http://www.ushahidi.org>

³ <http://www.frontlinesms.com>

⁴ <http://www.unicefinnovation.org>

⁵ <http://www.swiftapp.org>

⁶ <http://www.developmentseed.org>

⁷ <http://blog.ushahidi.com/index.php/2010/02/07/sms-turks/>

- Freedom Fone allows media organisations to create and conduct polls via SMS, collect opinions via telephone and make those results available online.⁸

The vast majority of these software applications are mostly SMS-based and do not necessarily need to be connected to the Internet to operate, which is a critical asset when, as is frequently the case, networks are down or shut off for either natural or political reasons (it may happen with mobile networks as well, but in this case is easier to re-establish the services or search for technical alternatives). The applications considered so far focus primarily on information gathering and sharing and on coordinating direct political actions, but less on decision making for public policies and other political deliberations [Hellstrom, 08]. The software applications have some key defining features in common, which have already been identified in recent research on crowdsourced systems: open teams, mashability, unknowable, overlapping or conflictive requirements, continuous evolution, focus on operations, sufficient correctness, unstable resources, and emergent behaviours [Kazman and Chen, 09].

While there is no template to design a successful mobile governance project, the literature on mobile governance has already identified some key features that seem to be present in successful case studies [Kinkade and Verclas, 08]:

- Evolutionary (vs. revolutionary)
- Embedding the mobile component into an already ongoing initiative (vs. casting the mobile service as itself the development effort or otherwise asking the technology to lead the effort)
- Using the mobile technology to reduce transaction costs or increase productivity of existing practices, versus introducing entirely new behaviours via the mobile
- Requiring only basic literacy or skills from users, versus requiring additional technical knowledge or support

More specifically, a number of choices have been identified relating to: intended users (general public, population niches, professional groups, etc.), technical accessibility of the solution offered (i.e. low feature handsets vs. smart phones), self-contained solutions vs. links to other external platforms and services, and requirements from manufacturers or operators (i.e. cooperation with network operators on SIM cards or USSD channels, or with handset manufacturers). As Hellstrom also reminds, most projects have a strong local technological partner making it easier to manage, integrate and sustain the applications, so that the responsible body running the service hardly needs to know more than the end-user [Hellstrom, 08]. Successful m-governance applications, in sum, rely on a functioning, effective backend for content and support from a local technological partner facilitates the adoption of technologies [Hellstrom, 08].

⁸ <http://freedomfone.org>

4 Crowdsourcing and its Effects

One of the distinctive features of the systems being currently developed is the crowdsourcing of incoming data through SMS. The notion of “crowdsourcing” was coined by Howe to describe the outsourcing of a task to “an undefined and generally large group of people in the form of an open call” [Howe, 06].

Crowdsourcing data collection with mobile technologies enables faster feedback mechanisms for more informed decision-making in rapid response situations. However, it also brings new issues to the table: quality and accuracy of incoming data, validation, priority criteria, privacy of users reporting data, misuse, etc. Conversely, crowdsourcing can also be extended to the response or supply side, but then the main issues—especially in large disasters—become how to track such a distributed and decentralized response in order to effectively address the needs of the populations at risk and coordinate the relief or aid tasks [Meier, 10]. The initiatives considered in this paper apply different strategies to deal with the side-effects of crowdsourcing: creating persistent identities/anonymities, tagging of incoming data, developing algorithms that filter relevant information from the noise, etc. While this may not necessarily be an issue when crowdsourcing environmental data collection (i.e. an unknown number of volunteers regularly sending reports or samples on water quality or air pollution, and then verifying those data with further test and analysis), it may raise serious concerns when the data being crowdsourced report fraud-marred elections, criminal offences, or violations of human rights in the midst of conflict events.

Crowdsourcing data collection through mobile networks holds the promise to improve decision making in emergencies, crisis and conflict events, and also to foster public participation and citizens’ awareness. But it also poses important challenges, such as accuracy (of the information provided), reliability and trust (of the multiple information sources) and, last but not least, privacy. In Shilton’s words:

At the extreme, mobile phones could become the most widespread embedded surveillance tools in history. Imagine carrying a location-aware bug, complete with a camera, accelerometer, and Bluetooth stumbling, everywhere you go. Your phone could document your comings and goings, infer your activities throughout the day, and record whom you pass on the street or who engaged you in conversation. Deployed by governments or compelled by employers, 4 billion “little brothers” could be watching you [Shilton, 09].

Recent examples of political violence in Myanmar, Iran or Sri Lanka have shown not only the growing citizens’ use of social media as outlets for real time reports and data on violent incidents (i.e. the use of Twitter after the 2009 Iran election) but also the exposure to government abuses when citizens use mobile networks for the same purposes. According to Martucci, ad hoc mobile networks, which “consist of computers, often mobile, that establish on demand network connections through their wireless interfaces, enabling instantaneous networking independently of the presence or aid of any central devices” [Martucci, 09] require the design of new privacy protocols:

Thus, most of the protocols employed in wired networks are not suitable for ad hoc networks since such protocols were designed for network environments with defined borders and highly specialized devices, such as routers, servers that provide

network addresses, firewalls, and network intrusion detection systems. Moreover, such an absence of infrastructure potentially augments the risk of losing control over personal information since data is routed and forwarded through many unknown devices and users can easily be monitored. Hence, information regarding a user's communicating partners and even the contents of transmitted messages can be obtained by devices forwarding packets on the behalf of a user, if proper security measures are not implemented. Furthermore, data collection is especially not transparent in ubiquitous environments since invisible interfaces can greatly reduce the users awareness regarding when and what personal data is being collected by the ubiquitous environment [Martucci, 09].

While crowdsourcing offers a number of advantages to mobile governance initiatives and projects, their side-effects in terms of quality, accuracy, trust, and privacy also need to be addressed to avoid the consequences of technological misuse and subsequent risks for citizens.

5 Conclusions

The emerging field of mobile governance is not a substitute for e-governance. Rather, it is a complementary domain that shares the goal of providing better public services to citizens by improving access to information and data and, conversely, by opening new avenues for public participation in policy making and political debate. E-governance and m-governance share also similar concerns regarding technological choices, target populations, scalability of projects, etc. Addressing these issues and harnessing the full potential of the existing technologies available in both areas will certainly contribute to an evolutionary but sound transform of how public institutions, organizations, and citizens alike promote the rule of law on daily bases.

Acknowledgements

The research presented in this paper has been developed within the framework of two different projects: (i) ONTOMEDIA: Platform of Web Services for Online Mediation, Spanish Ministry of Industry, Tourism and Commerce (Plan AVANZA I+D, TSI-020501-2008, 2008-2010); (ii) ONTOMEDIA: Semantic Web, Ontologies and ODR: Platform of Web Services for Online Mediation (2009-2011), Spanish Ministry of Science and Innovation (CSO-2008-05536-SOCI).

References

- [Anduiza, 09] Anduiza, E., Cantijoch, M., Gallego, A. 2009. Political Participation and the Internet: A Field Essay. *Information, Communication and Society*, Vol. 12: 860-878.
- [Christensen, 97] Christensen, C. 1997. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Boston: Harvard Business School Press.
- [Ekine, 10] Ekine, S. (ed.). *SMS Uprising: Mobile Activism in Africa*. Oxford: Fahamu Books, 2010.

- [Hattotuwa, 08] Hattotuwa, S. 2008. Mobiles for Better Governance?, <http://ict4peace.files.wordpress.com/2008/06/mobiles-for-gov>
- [Hellstrom, 08] Hellstrom, J. 2008. Mobile Phones for Good Governance: Challenges and Way Forward, http://www.w3.org/2008/10/MW4D_WS/papers/hellstrom_gov.pdf
- [Howe, 06] Howe, J. The rise of crowdsourcing. *Wired* 14, 6 (June 2006); <http://www.wired.com/wired/archive/14.06/crowds.html>
- [ITU, 10] ITU, http://www.itu.int/newsroom/press_releases/2010/06.html
- [Kailasam, 10] Kailasam, R. 2010. Leveraging Mobile Technology to Extend the Reach of e-Governance, <http://www.mgovworld.org/.../m-governance-leveraging-mobile-technology-to-extend-the-reach-of-e-governance.pdf>
- [Kaufmann, 08] Kaufmann, D., Kraay, A. 2008. Governance Indicators: Where Are We, Where Should We Be Going?. *The World Bank Research Observer*: 1-30.
- [Kazman and Chen, 09] Kazman, R.; Chen, H. M. 2009. The Metropolis Model: A New Logic for Development of Crowdsourced Systems. *Communications of the ACM*, Vol. 52(7): 76-84.
- [Kinkade and Verclas, 08] Kinkade, S., Verclas, K. 2008. Wireless Technology for Social Change: Trends in Mobile Use by NGOs, http://mobileactive.org/files/MobilizingSocialChange_full.pdf
- [Kinkade *et al.*, 08] Kinkade, S., Verclas, K., Toyama, K. 2008. Reflections on MobileActive 2008 and the M4D Landscape Wireless technology for social change, http://mobileactive.org/files/DVT_M4D_choices_final.pdf
- [Martucci, 09] Martucci, L. 2009. Identity and Anonymity in Ad Hoc Networks. Ph.D. diss., Karlstad University Studies 2009 (25).
- [Meier 10] Meier, P. 2010. Using Mechanical Turk to Crowdfund Humanitarian Response. *iRevolution*, 5 February 2010, <http://irevolution.wordpress.com/2010/02/05/mechanical-turk/>
- [Miard, 09] Miard, F. 2009. Call for Power? Mobile phones as facilitators of political activism, ISA 50th Annual Convention New York, Feb. 15–18, 2009, <http://www.miard.ch/papers/phonesandpowerII.pdf>
- [Sasaki, 10] Sasaki, D. (ed.). 2010. Technology for Transparency: The Role of Technology and Citizen Media in Promoting Transparency, Accountability, and Civic Participation, <http://globalvoicesonline.org/wp-content/uploads/2010/05/Technology-For-Transparency.pdf>
- [Schuler, 08] Schuler, I. 2008. National Democratic Institute: SMS as a Tool in Election Observation. *Innovations*, Vol. 3 (2): 143-158.
- [Schumacher, 73] Schumacher, E.F. 1973. *Small is Beautiful: The Study of Economics as if People Mattered*. New York, NY: Harper & Row Publishers.
- [Shilton, 09] Shilton, K. 2009. Four Billion Little Brothers? Privacy, Mobile Phones, and Ubiquitous Data Collection, *ACM Queue*, vol. 7(7), <http://queue.acm.org/detail.cfm?id=1597790>

[Verba, 95] Verba, S.; Schlozman, K.L.; Brady, H. E. 1995. *Voice and Equality: Civic Voluntarism in American politics*. Cambridge (MA): Harvard University Press.

Value Creation by Knowledge Management – A Case Study at a Logistics Service Provider

Eva-Maria Kern

(Universität der Bundeswehr München, Germany
Chair for knowledge management and business process design
eva-maria.kern@unibw.de)

Julia Boppert

(trilogIQa, München, Germany
julia.boppert@trilogiq.de)

Abstract: Based on many analyses at enterprises over the past years we see that the economy nowadays asks for efficient and sustainable solutions in knowledge management (KM). Thus, we propose to follow the principle of value orientation also in managing knowledge regarding that there are different types of business processes with different demand for KM. To confirm this fact and to deduce adequate procedures, we conducted a case study at a logistics service provider introducing the innovative method of knowledge-based value stream mapping.

Keywords: knowledge management, case study, value creation, business processes, knowledge based value-stream mapping

Categories: A.1, M.4, M.5

1 Knowledge management in times of change

In the current economic crisis the discovery and utilization of organizational knowledge becomes more and more the critical factor of success for all companies [Hexelschneider, 09]. Knowledge management (KM) in this context is often seen as universal remedy, so that the number of KM-implementations has steadily grown over the last years.

Thereby the introduction of a holistic knowledge management is accompanied by a huge effort so that in spite of broad analytical processes and the identified knowledge gaps often not-integrated solutions are realized or tools are insufficiently maintained and updated. Due to that fact the tools and systems are often not used efficiently after a short time – the driven efforts therefore are pointless. After the time of disillusion and a slope of enlightenment (figure 1) the economy nowadays asks for efficient and sustainable solutions.

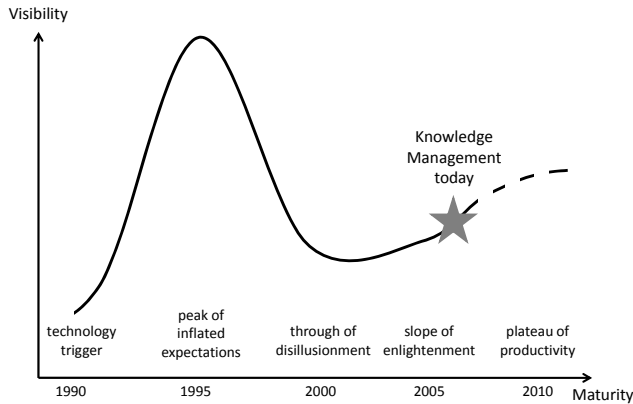


Figure 1: Gartner's hype-cycle of KM (based on [Bullinger, 09, p.701])

1.1 Orientation to value creation: a short history

In recent years value creation is getting new attention in reconsidering the organizational structures and supply networks worldwide. The origin of the orientation to value creation often is attributed to the development of Toyota's Production System (TPS) – today also known as lean production or lean management – in the post-World-War II era [Ohno, 88]. The success of the Japanese company in the following years sent a wake-up call to international enterprises in the automotive industry and showed new ways to organize and manage supply chains and production operations [Womack, 03, p.9]. Particularly the holistic analysis of process chains with elimination of waste, i.e. not value creating steps, is regarded as warranty for integrated solutions. The focus lies on the encouragement of value creating processes by realizing lean and efficient steps, and demand orientated assignment of resources.

The highest priority at this is the value as perceived by the customer. Value is defined as „a good or a service and often both at once, which meets the customer's needs at a specific time and a specific price“ [Womack, 03, p.16]. Based on that, the value stream is the set of all specific actions required for creating this value. According to this, the principle of value creation indicates, that all steps, which are not creating value directly, are waste in the first instance – the so called muda. Considering the transformation of value creation on knowledge management there is also the postulation of avoiding waste as far as possible.

This can also be an appropriate way for the introduction of knowledge management, so that only knowledge intensive processes are supported by specific knowledge management solutions. This seems to be a logical consequence regarding the fact that the consideration and analysis of human resources and the adjunctive collective knowledge started in Europe in the beginning 1980s stimulated by Japanese pioneers [Freimuth, 04, p.336], who had to deal early with employees' know-how and specific knowledge due to restricted resources [Nonaka, 95].

1.2 Aware versus unaware knowledge management

From a critical rationalism's point of view and based on experiences in reengineering projects at industrial enterprises over the past years – especially in re-planning logistics processes – we come to the following theory:

If knowledge management in a business process has to respect the principles of value creation, it can't be right to establish extensive knowledge management solutions for all business processes. Indeed, it seems to us that there are no processes in which knowledge is totally irrelevant – which is widely agreed upon in the scientific community (cf. [Amelingmeyer, 04, p.15]; [Davenport, 05, p.6]; [Remus, 02, p.73f.]; [Stewart, 98, p.50]) – but the demand for knowledge management can differ significantly. Basically, there are two alternatives in managing process knowledge [Engelhardt, 04]. On the one hand you can try to make the process itself more intelligent, on the other hand you can make the employees concerned with the process more intelligent. While the first solution seems to be an adequate way for simple processes, the second solution is suitable for the more complex processes. Thus, in many cases it can be absolutely sufficient to have an unaware knowledge management going on unscheduled and uncontrolled in the heads of the employees.

In other cases there is a strong demand for knowledge management, driven by two different objectives:

- **Knowledge saving:** The required know-how is tacit knowledge in an employee's head. Thus, the availability of knowledge in the relevant process has to be guaranteed by keeping the employee in the process or by codification and dissemination of his knowledge.
- **Knowledge preparation:** The required knowledge has to be presented by instructions, procedures, lists of jobs etc. to an employee or the process.

Based on this consideration, there are two research hypotheses to be tested:

- There are business processes which show no demand for aware KM.
- The demand for and characteristics of KM solutions depends directly on the degree of knowledge intensiveness and the kind of relevant knowledge in the process.

To verify the developed theories for correctness and suitability for daily use and to deduce adequate proceedings, we decided to conduct a case study in practice.

2 Defining a case study for value creating knowledge management

The field of sociology is associated strongly with case study research, but today also other fields are analyzing several problems with this methodology [Tellis, 97]. Yin stated a general applicability results from the set of methodological qualities of the case and detailed the procedures that would satisfy the required methodological rigor [Yin, 94]. Case study research seems to be an adequate solution in our context because it allows to authentically record and reflect a problem in the space of business environment with all relevant facts, opinions and expectancies [Wrona, 05, p.9]. It allows not only testing practicability but also integrating the human as knowledge carrier in a satisfactory way [Specht, 04, p.545f.]. A case study focuses on understanding the dynamic present and tries to constitute generality by analyzing

single cases and logical linking of data, interpretation of situations and stimulus-response-relationships [Eisenhardt, 89, p.535f.].

2.1 The procedures of case study research

The proceedings in case study research differ in small details from author to author. Subsequently we describe the proceedings following Yin [Yin, 89] but can only give a short overview of relevant steps at this point.



Figure 2: The proceedings in case study research (based on [Yin, 89])

2.1.1 Designing the case study

After verifying the applicability of case study research for the considered issue, there has to be the formulation of an explicit research theory and the definition of the general conditions. To enable an efficient conduction, it can be useful to define approximate questions and interests of investigation, as we did beforehand.

To display as much process facets as possible, we elected different business processes at a logistics service provider as the subject for our study because there we can find apparently simple as well as knowledge intensive processes with different types of knowledge within a stable organizational context.

Based on our research topics we also have to detail the meaning of knowledge intensiveness and the relevant types of knowledge in business processes.

The degree of knowledge intensiveness

We argued that a process with a high degree of knowledge intensiveness has a certain knowledge management demand whereas a process with a minor degree, often a standard process, can consciously abstain from knowledge management. Consequently, the demand for knowledge management is to increase with the degree of knowledge intensiveness. Knowledge intensive processes often show the following characteristics [Gronau, 03, p.315]:

- Variability and exceptions (ability to schedule knowledge demand)
- Diversity and incertitude of input and output
- Variety of sources and media
- Variance and dynamic development
- Many participants with different expertise in the process
- High degree of innovation
- Disposable scope for decision-making and insertion of creativity

Also Davenport [Davenport, 05, p.26-37] proposes different criteria to distinguish types of knowledge work and types of knowledge intensive processes. Even though he argues in the context of knowledge workers that “have high degrees of expertise, education, experience, and the primary purpose of their jobs involves the creation, distribution, or application of knowledge” [Davenport, 05, p.10], some of his criteria can be used to analyze the knowledge intensiveness of general business processes as well:

- Complexity of work (meaning interpretation and judgement required in the process)
- Degree of recurrence
- Business criticality

According to expert interviews, we could confirm those criteria and additionally identified

- Required experience and
- Training time

as important factors.

In order to heuristically determine the knowledge intensiveness of the processes examined we developed a scoring model with a 5-step Likert scale that integrates all of the criteria listed above.

The relevant coordinates of knowledge

To respect the specific requirements of an adequate knowledge management solution initially there has to be a structured methodology for the consideration of different kinds of knowledge. Based on former research [Boppert, 08, p.25ff.] we decided to differentiate knowledge by the following three points of view:

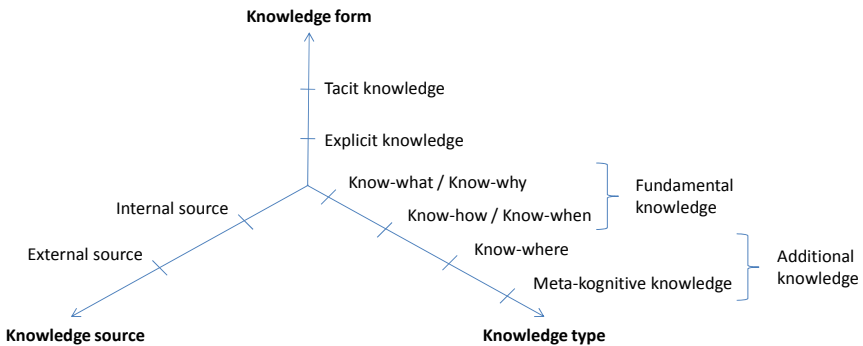


Figure 3: Coordinates of knowledge (based on [Boppert, 08])

- **Knowledge form:** We distinguish between explicit and tacit knowledge to detect appropriate and inappropriate ways for knowledge representation in the regarded context.
- **Knowledge type:** To decide on the specific design of knowledge management within processes, we have to differentiate between fundamental knowledge –

subdivided in know-what and know-why (facts and explication), and know-how and know-when (methods and processes) – and additional knowledge – subdivided into know-where (sources for further information) and the so called meta-cognitive knowledge as self-reflecting evaluative knowledge of one person about the own cognizance.

- **Knowledge source:** We define a source as internal if it is part of the process. Otherwise the knowledge has to be obtained by external sources.

Thus, knowledge needed within the processes can be represented by a set of vectors.

2.1.2 *Conducting the case study: preparing for data collection and collecting the evidence*

In the next step we have to define the data and information to be collected in order to prepare the data collection by identifying adequate methods, tools, checklists etc. to collect evidence. Regarding the avoidance of waste as intention of value creation, we decided that there has to be a pre-analysis of the relevant processes and steps initially in order to identify the value creating activities and to support especially these steps. In the end, this involves the elimination of steps to create no value and to be avoidable and the optimization of steps to create no value but to be unavoidable with current technologies or production assets. An adequate device is the so called value stream mapping [Rother, 03]. This is an approved technique in lean management used to analyze the flow of materials and information currently required to deliver a product or service to a consumer. In addition to that we collect the knowledge in the single steps in order to achieve what we title a knowledge based value-stream mapping.

For the collection of evidence we detailed our research topics by tangible questions to be answered and defined multiple instruments for collecting data:

- **Structured pre-interviews with process owners:** These initial interviews were conducted with the process owners to roughly map the processes. They covered the topics process in- and outputs, material flows, key actions, important decisions and involved persons. The results were visualized coarsely as knowledge based value-stream maps for further validation and discussion.
- **General observation:** Subsequently, the processes were observed to verify the general course of the processes and to deepen the awareness of process and knowledge streams. Afterwards, the value-stream maps were adapted if necessary.
- **Detailed observation and questioning:** By focused observing the employees' work and by questioning all activities, we detailed the process in-depths and tried to get to the bottom of coherences – in our case: why are processes realized as they are nowadays. Again, knowledge-based value maps were refined after this step.
- **Semi-structured interviews:** These detailed interviews supported finding additional information and creating meta-data for the process (training time, available media etc.). The interviews were conducted with the operating personnel as well as the process owners and some selected executives of the logistics provider and covered the following topics: process output (product) and value created, process design and process versions, process history, cycle time and process quality (criteria and current state), staffing rules and requirements, trainings (standard and/or specific), actions and decisions within the process,

knowledge sources (e.g. media, experience) and problem solving strategies, process and organizational frameworks.

After starting data collection by analyzing a pilot case, we refined our methodology for knowledge based value-stream mapping and the central questions in interviews and checklists. We finally conducted our case study by examining 14 processes in seven locations as shown in figure 4.

Process and focus		Used instruments for data collection			
		Structured interviews with process owners (# of interviewed executive managers and/or shift supervisors)	General observation (frequency)	Detailed observation and questioning (frequency)	Semi-structured interviews with operation personnel (# of interviewed shift supervisor and/or employees)
Process A	Sequencing car components	2	2	1	1
Process B	Textile distribution logistics	2	3	2	2
Process C	Shipping electronic components	1	2	1	1
Process D	Pre-assembly of car components	2	2	2	3
Process E	Storing of flexible PVC sheetings	2	2	1	2
Process F	Picking powder lacquer	1	2	1	2

Process and focus		Used instruments for data collection			
		Structured interviews with process owners (# of interviewed executive managers and/or shift supervisors)	General observation (frequency)	Detailed observation and questioning (frequency)	Semi-structured interviews with operation personnel (# of interviewed shift supervisor and/or employees)
Process G	Picking of car components	2	2	1	2
Process H	Repacking of bigger parts (automotive)	1	2	1	2
Process I	Sorting of original parts (automotive)	2	2	1	1
Process K	Sorting/storing of car components	1	2	1	2
Process L	Sorting/shipping of car components	1	2	1	2
Process M	Repacking of smaller parts (automotive)	1	2	2	3
Process N	Manufacturing logistics for automotive supplier	2	2	1	2
Process O	Retrograde parts chain	2	3	2	5

Figure 4: Reviewed processes and used instruments for data collection

One important finding was, that nearly all processes contained typical logistics activities as goods receipt (14 out of 14), buffering or storing (12 out of 14), shipping (13 out of 14) and partially one or more special process steps (pre-assembly, picking,

sequencing, sorting, packing etc.). Furthermore especially the courses of action in the typical logistics activities (goods receipt, buffering/storing, shipping) showed high similarity so that we decided to focus our analysis in the following to single process steps.

2.1.3 Analyzing the case study evidence

The third step of case study research – analyzing the evidence – comprises the transcription of the collected material and the analysis of the cases. It is important to examine each case separately as well as all the aggregated cases as a whole in order to find out the most relevant influences.

To ensure transparency and provide a holistic view, we integrated all of the data collected into knowledge based value-stream maps and compared these among themselves. To demonstrate the interconnection between process and identified knowledge as well as the impact of knowledge for the process we chose the symbol of an anchor to depict the process relevant knowledge using the coordinates of knowledge mentioned in 2.1.1.

2.1.4 Description of perception and reporting the case study

The results are described in form of a short excerpt in the following chapter based on one selected case.

3 Excerpt of an exemplary case study

Representatively for all analyzed processes, a part of a process chain at the examined logistics service provider is depicted below. In this process called “retrograde parts chain” the logistics service provider receives diverse goods from different locations all over Europe so as to return them to his customer (goods receipt). For this purpose, the parts have to be unpacked, basically checked, particularly checked based on specific guidelines and finally either sorted out or re-packed with new packing materials (special processes preparation, processing, packing). In the figure below the first three process steps are illustrated (figure 5).

In the step “goods receipt” the employee has to record the arrival of the truck, conduct a visual check concerning the loading condition and – if there is any evidence the loading condition might have led to damages to the goods – to take pictures of the truck loading. In some cases it is also required to palletize the incoming goods for further processing. If the employee has the “feeling” (tacit knowledge) that he cannot assess if the loading condition is good enough to be accepted, he has to call an expert of the quality management (QM, external source) to take this decision.

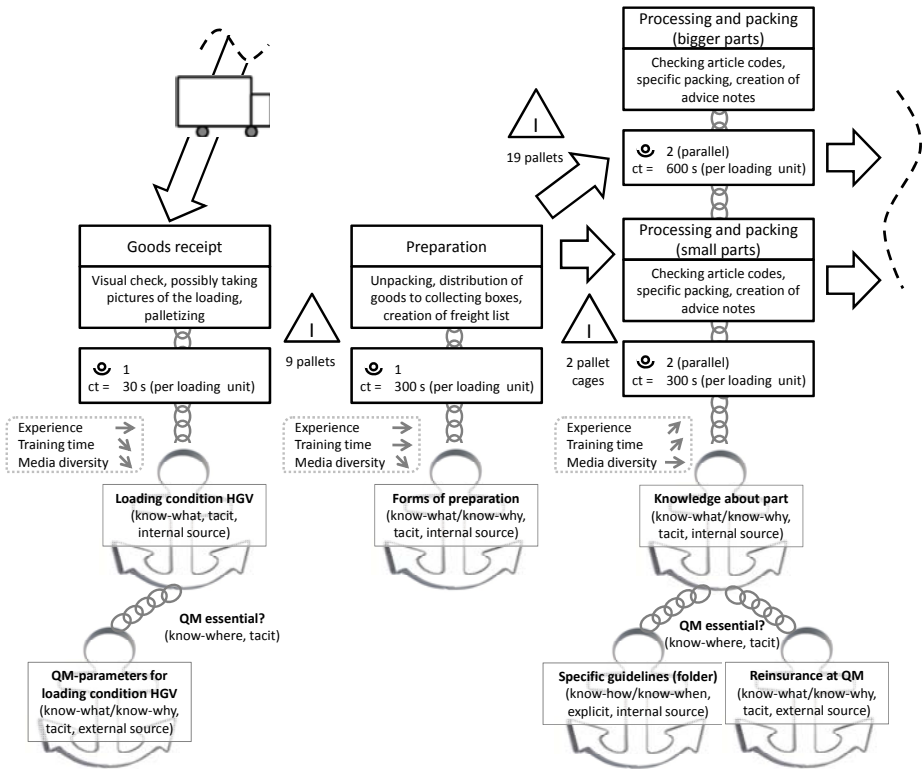


Figure 5: Three selected steps of the “retrograde parts chain” as knowledge based value-stream map

In the next step, the “preparation”, the same employee has to unpack the goods as to distribute them to different collecting boxes and to create the freight list. There he has to decide by his experience (tacit knowledge) which part has to be assigned to which form of preparation in the next step.

In the third step, the “processing and packing”, the stream splits in two parallel processes, one for small and one for bigger parts. Despite different cycle times (ct), the activities within both process alternatives are similar, starting with checking the article codes, followed by packing the goods based on specific guidelines and ending with the creation of advice notes. Due to his experience, the employee knows these guidelines for the most popular goods (tacit knowledge), for all others he has to take a look in a provided folder (explicit knowledge, internal source) or to reinsure his decision at the QM (tacit knowledge, external source).

4 Results and conclusions

For the heuristic determination of knowledge intensiveness in the regarded process steps, we used our developed scoring model with a 5-step Likert scale that integrates all the identified criteria above. For this purpose we arranged a workshop with five selected logistics experts out of the examined processes to value the knowledge intensiveness for each process step (figure 6).

In this way we identified three rating arrays and finally assigned each process step to one of these, namely

1. “mostly knowledge unintense processes” (1,0-2,3 points),
2. “moderately knowledge intense processes” (2,4-3,6 points) and
3. “strongly knowledge intense processes”(3,7-5,0 points).

The first class represents simple processes with low demand of experience and short training times (step 1 or 2 in figure 5). The second class contains processes with medium experience and moderate training times, and so represents a medium degree of knowledge intensiveness, which has to be specified in further analysis in order to deduce adequate courses of action for this class.

The third class shows more complex processes with high demand of experience, longer training times and high media diversity (step 3 in figure 5). Therefore these processes have a high degree of knowledge intensiveness. We could prove this in all examined cases (cf. figure 6) so that generalizability can be assumed.

As stated in our hypothesis, for the first class of processes we have to make the process itself more intelligent. This means the optimization by standardization of process steps and codification of knowledge e.g. by better visualization of relevant information. Furthermore external knowledge sources should be avoided because they implicate more effort and are often needless regarding the inherent simplicity. So twin knowledge anchors (as seen in step 1 in figure 5) should be eliminated – in this case e.g. by explicit (pictured) decision guidance for the acceptance of trucks. In these cases it seems absolutely sufficient to have an unaware, unscheduled and uncontrolled knowledge management in the heads of the employees. For the third class of processes – the more complex ones – we have to make the employees more intelligent. This can be done by improved or more frequent trainings, periodical exchange of experiences and also by better and easier representation of relevant and process deciding information. Here, twin knowledge anchors (as seen in step 3 in figure 5) can be an adequate way for the preparation of deeper knowledge. In these cases we need an aware knowledge management, so that we can not only enhance knowledge preparation but also guarantee knowledge saving e.g. by installing discussion between employees.

Criteria for knowledge intensiveness	Process steps							
	goods receipt	special process: preparation	special process: pre-assembly	special process: picking	special process: sequencing	special process: packing	special process: sorting	shipping
Variability and exceptions	2	3	3	3	3	4	3	3
Diversity and incertitude of input and output	1	2	5	1	2	3	2	1
Variety of sources and media	1	1	3	2	2	3	1	1
Variance and dynamic development	1	2	4	3	3	3	2	2
Many participants with different expertise in the	3	1	4	3	3	2	3	2
High degree of innovation	1	1	3	3	3	3	1	1
Disposable scope for decision-making and insertion of creativity	2	2	4	2	1	3	2	3
Complexity of work	1	2	4	3	3	3	3	2
Degree of singularity (vs. degree of recurrence)	1	2	2	2	2	3	2	1
Business criticality	2	2	5	2	4	4	2	2
Required experience	1	2	4	3	3	3	2	2
Training time	1	2	4	2	3	3	2	1
Average	1,7	2,2	4,5	2,9	3,2	3,7	2,5	2,1

5-step Likert scale	
low (l)	1
low to medium (l/m)	2
medium (m)	3
medium to high (m/h)	4
high (h)	5

Three rating arrays for knowledge intensiveness		
Array 1: mostly knowledge unintense processes	1,0 - 2,3	points
Array 2: moderately knowledge intense processes	2,4 - 3,6	points
Array 3: strongly knowledge intense processes	3,7 - 5,0	points

Figure 6: Knowledge intensiveness in the single process steps from experts view and assignment to the three rating arrays

This theoretic approach was confirmed in three ways: First, the data collected during the semi-structured interviews concerning training needs and suggestions for improvement widely were in line with our findings. Second, the selected experts and process owners as well as employees agreed on our suggestions for the single steps' knowledge management solutions being practicable and purposive. Third, preliminary findings of evaluations of the first processes adapted accordingly suggest shorter cycle times, improved decision making and higher process quality in terms of decrease in wrong decisions.

By this multiple case study we were able to collect pros and cons for our two research topics. On the one hand we could show that knowledge is a key factor – an anchor – in all processes, also in apparently simple ones. Concerning the proposition

of value creation, there has to be a sophisticated election of specific knowledge management solutions. By using value creation as framework, we could ensure knowledge management not being an end in itself, but a means for value creation. Additionally to verify our hypothesis, we could also prove that the methodology of knowledge based value-stream mapping we developed beforehand is an adequate device for structuring data collection as well as visualizing knowledge within different types of processes.

On the other hand we learned that we have to examine single process steps and not the process as a whole to get to adequate solutions.

5 Future Work

In the near future we have to refine our methodology for knowledge based value-stream mapping to enable the specific analysis for further cases of application, i.e. the identified second class of logistics processes and also strategic and administrative business processes. For this application area further case studies are planned.

In addition to that, we have to attest the benefit and sustainability of the submitted knowledge solutions by re-examining the process quality including cycle times and resource usage after a ramp-up time, i.e. approximately after four to six month. For this purpose, we have to develop instruments to quantify the costs and the exact benefit of knowledge in processes. Based on the first experiences, we are working on an adaption of the approved failure mode and effect analysis (FMEA) for this issue.

References

- [Amelingmeyer, 04] Amelingmeyer, J.: Wissensmanagement – Analyse und Gestaltung der Wissensbasis von Unternehmen, Deutscher Universitäts-Verlag, 2004.
- [Boppert, 08] Boppert, J.: Entwicklung eines wissensorientierten Konzepts zur adaptiven Logistikplanung, Lehrstuhl für Fördertechnik Materialfluss Logistik (fml) der TUM, 2008.
- [Bullinger, 09] Bullinger, H.-J., Spath, D., Warnecke H.-J., Westkämper, E.: Handbuch Unternehmensorganisation: Strategien, Planung, Umsetzung, Springer, 3d edition, 2009.
- [Davenport, 05] Davenport, T. H.: Thinking for a Living – How to Get Better Performance and Results from Knowledge Workers, Harvard Business School Press, 2005.
- [Eisenhardt, 89] Eisenhardt, K.: Building Theories from Case Study Research. In: Academy of Management Review, 1989, Vol. 14, No. 4, p.532-550.
- [Engelhardt, 04] Engelhardt, C., Hall, K., Ortner J.: Prozesswissen als Erfolgsfaktor. Effiziente Kombination von Prozessmanagement und Wissensmanagement. Deutscher Universitäts-Verlag, 2004.
- [Freimuth, 04] Freimuth, J.: Wissen, Wissenslogistik und Logistikwissen. In: Prockl, G., Bauer, A., Pflaum, A., Müller-Steinfahrt, U.: Entwicklungspfade und Meilensteine moderner Logistik: Skizzen einer Roadmap, Gabler, Wiesbaden, 2004, p.331-379.
- [Gronau, 03] Gronau, N., Palmer, U., Schulte, K., Winkler, T.: Modellierung von wissensintensiven Geschäftsprozessen mit der Beschreibungssprache K-Modeler. In: Professionelles Wissensmanagement – Erfahrungen und Visionen, Nummer 06, 2003.

- [Hexelschneider, 09] Hexelschneider, A., Schlager, R.: Wissensmanagement in der Krise – Krise im Wissensmanagement? Ein Whitepaper, 2009. <http://www.scribd.com/doc/16316124/WissensmanagementKriseWhitepaper090609>.
- [Nonaka, 95] Nonaka, I., Takeuchi, H.: Die Organisation des Wissens: Wie japanische Unternehmen eine brachliegende Ressource nutzbar machen, Campus, 1995.
- [Ohno, 88] Ohno, T.: Toyota Production System: Beyond Large-scale Production, Productivity Press; 1st edition, 1988.
- [Remus, 02] Remus, U.: Prozessorientiertes Wissensmanagement - Konzepte und Modellierung, Dissertation, Universität Regensburg, 2002.
- [Rother, 03] Rother, M., Shock, J.: Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda. The Lean Enterprise Institute, Brookline, 2003.
- [Specht, 04] Specht, G.; dos Santos, A.; Bingemer, S. (2004): Die Fallstudie im Erkenntnisprozess: Die Fallstudienmethode in den Wirtschaftswissenschaften. In: Wiedmann, K.-P.: Fundierung des Marketings - Verhaltenswissenschaftliche Erkenntnisse als Grundlage einer angewandten Marketingforschung. Wiesbaden: Deutscher Universitäts-Verlag, 2004.
- [Stewart, 98] Stewart, T. A.: Der vierte Produktionsfaktor: Wachstum und Wettbewerbsvorteile durch Wissensmanagement, Carl Hanser, 1998.
- [Tellis, 97] Tellis, W.: Introduction to Case Study - The Qualitative Report [On-line serial] 3(2), 1997, <http://www.nova.edu/ssss/QR/QR3-2/tellis1.html>.
- [Womack, 03] Womack, J., Jones, D.: Lean Thinking: Banish Waste and Create Wealth in Your Corporation, Simon & Schuster UK Ltd, 2nd edition, 2003.
- [Wrona, 05] Wrona, T.: Die Fallstudienanalyse als wissenschaftliche Forschungsmethode. Berlin: Working Paper Series, ESCP-EAP Europäische Wirtschaftshochschule, 2005.
- [Yin, 94] Yin, R.K.: Case study research: design and methods. Thousand Oaks, Sage Publications, Inc., 2nd edition, 1994.

Timeline-based Analysis of Collaborative Knowledge practices within a Virtual Environment

Ján Paralič

(Technical University of Košice, Slovakia
Jan.Paralic@tuke.sk)

Christoph Richter

(Christian-Albrechts-Universität zu Kiel, Germany
richter@paedagogik.uni-kiel.de)

František Babič

(Technical University of Košice, Slovakia
Frantisek.Babic@tuke.sk)

Michal Raček

(PÖYRY Forest Industry Oy Vantaa, Finland
Michal.Racek@poyry.com)

Abstract: Collaborative analysis and reflection on knowledge practices is a central element of the Trialogical Learning Approach as it is supposed to be a driving force in processes of practice transformation and knowledge creation. The exploitation of historical logging data holds promise to provide a great deal of information about group activities without requiring additional efforts for recording of events by the users. Building on the Trialogical Learning Approach as well as related work in the fields of Data Mining and Knowledge Discovery, Computer-Supported Collaborative Learning, and Information Visualization, this paper suggests high-level requirements for analytic tools in support of practice transformation and introduces an application called Timeline-Based Analyzer (TLBA) that was designed and developed in response to these requirements. The usability of this solution has been tested through a first iteration of several practical experiments and case studies. One of them is described in this paper and illustrates how this tool can be used to support collaborative analysis and reflection. The results of these evaluations have been used for continued improvement of the TLBA in order to provide a stable and intuitive tool.

Keywords: knowledge practices, collaborative system, timeline-based visualization, patterns

Categories: L.0.0, L.3.4, L.3.6

1 Introduction

Analyzing and reflecting on one's own and other's working or learning practices is an essential meta-activity for any kind of project work. Analysis and reflection thereby are not understood just as means to optimize or improve a given way of working, but also as an active and productive process geared towards the advancement of collaborative knowledge practices. Collective reflection thereby exceeds the exchange

of individual experiences and insights in that it aims at the development of a shared understanding and transformation of the collective knowledge practice.

To support collaborative analysis and reflection, participants need to have some kind of material evidence regarding the pursuit knowledge (working or learning) practices [Bolfiková et al., 2009]. Respective techniques include for example narrative methods of story-telling, the writing of diaries and reflection notes, but also log-file based tools that mirror collaborators' activities in terms of recorded interactions with some shared software application. The exploitation of historical logging data holds promise to provide a great deal of information about group activities without requiring additional efforts for recording of events by the users.

The goal of the proposed approach is to provide teams of students, teachers, and knowledge workers with tools and methods enabling them to reflect on their knowledge practices while being engaged in substantial project work over longer periods of time. Emphasizing the productive and open-ended nature of collective reflection our approach is focused on the development of an analytic tool that allows users to depict, and interpret the digital traces of their practices in an iterative and collaborative manner. We do not aim to identify useful indicators or patterns of successful collaboration a priori, but aim to empower students, teachers, and knowledge workers to identify meaningful indicators and patterns themselves.

We consider it important that our data analysis tool and methods can be used in connection to any virtual collaborative system that provides respective traces of users' activities. The rest of the paper is organized as follows: we first position our research with respect to relevant research areas in the rest of this section (1.1). In section 2 we outline high-level design goals for an analytic tool and introduce the Timeline-Based Analyzer (TLBA), which has been built to address these goals in section 3. Section 4 presents a case study, describing how the TLBA can be used to provide important input for collaborative project retrospectives. The paper closes with a short summary in section 5.

1.1 Related Work

Besides its foundation in the triological approach to learning [Paavola & Hakkarainen, 2009], we draw on research in the areas of Process Mining and Educational Data Mining as well as computer-supported collaborative learning (CSCL). In the following we briefly discuss related work in these fields.

Both process mining and educational data mining can be understood as extensions to classical data mining. While process mining is focused on the extraction of potentially useful information from event logs in general [Van der Aalst et al., 2009], educational data mining is concerned with the exploitation of data from educational settings, especially from web-based learning environments [Baker & Yacef, 2009].

Especially in the area of business processes several theories and approaches have been proposed, and applications have been designed and implemented to support the creation, execution and evaluation of a process model [Habala et al., 2009]. The main problem here is that the analysis of business processes is geared today mainly towards orchestration issues and/or performance improvements. Our focus is different. The core issue here is the identification, comparison and analysis of knowledge practices

projected into the learning/working process supported by an intelligent information system.

The use of process data from workplace or educational settings goes a long way with particular challenges. For example, [Perera et al., 2009] pointed out that existing data mining algorithms are often insufficient given the temporal, noisy, correlated, incomplete, and sometimes small size of the data sets available. Furthermore, it has been argued for information visualization methods in support of human judgment, which are appropriate for the users supposed to make sense of the data collected, e.g. [Baker, in press]. Against this background, this paper explores requirements for process mining and interactive visualization techniques when applied to poorly understood and loosely structured data.

The idea to visualize logged events on a timeline appears in a couple of systems, from which we selected here the most relevant ones. Semantic Spiral Timelines is an interactive visual tool aimed at the exploration and analysis of information stored in collaborative learning environments [Gomez-Aguilar et al., 2009]. It provides an interesting way of presenting the events in the form of spiral timeline that contains sequences of color-coded events. These are ordered clockwise with the oldest data at the centre of the spiral and the outermost data depicting the most recent event. The actual form of visualization can be changed with various filters as orientation of individual person, selected type of actions, selected time interval, etc. The patterns are understood here as typical histograms of frequencies of various types of events in time.

A similar approach is described in [Zaiiane and Luo, 2001] that presents a constraint-based approach for pattern discovery. This approach comprises the definition of filters to reduce the search space during the preprocessing phase, the specification of constraints during the mining phase (used methods as association rule mining, sequential pattern analysis, clustering and classification) to accelerate and control pattern discovering and the definition of constraints in the evaluation phase to ease interpretation and comprehension. The results are visualized through intuitive graphic charts and tables in order to make discovered patterns easy to interpret.

The OCAF framework [Avouris et al., 2002] shares similar motivation to our approach. It also places objects at the center of the collaborative activity. Those objects are studied as entities with their own history and evolution procedures. Synergo [Avouris et al., 2007], which builds on the OCAF framework already supports the automatic association of some kind of events, e.g. insertion, or modification event. The authors also list serious shortcomings of log analysis (especially quantitative indicators may be misleading if e.g. some events, although annotated, may be unimportant, but counted) so they recommend mainly qualitative analysis of collaborative activities.

The approach described in [Avouris et al., 2007] has been implemented in the Collaboration Analysis Tool (ColAT) for building interpretative models of activities in form of multilevel structure. ColAT provides very good support for fusion of data from multiple sources (not only logs, but also e.g. audio or video recordings). The crucial point in this kind of analysis is the multi-level annotation of events. First, so called operations level corresponds to the original events in the log file in XML format of the events, defined in [Kahrmanis et al., 2006]. Second, so called actions level, enables to group events from the first level. These manually selected groups

of events can be categorized according to a typology defined by the researcher. Similarly, third - activity level entries are created by grouping actions from the level 2, using again a different annotation schema than on the previous level.

Drawing on this work, the main aim of the approach proposed in this paper is to enable users to analyze and reflect on their collaborative work or learning practices themselves. Rather than 'outsourcing' the analysis to some external expert or algorithm, we put focus on the knowledge worker, student and teacher as analysts of their own activities. Furthermore, due to the loosely structured and emergent nature of knowledge practices we emphasize qualitative approaches taking into account the contextual knowledge of the actors involved. That means, TLBA provides historical perspective, not planning functionality for future organization of user activities, it can lead to improvement of future practices as a result of reflection. For example, in a selected virtual system (e.g. KP-Lab System or Moodle) a teacher or supervisor creates a workspace with some tasks, expected outputs, list of participants with responsibilities, etc. The course or project will be carried out by several teams each of them actualizing particular collaborative practices and creating and working with various kinds of artifacts. The whole evolution of these shared objects can be visualized and analyzed through TLBA.

2 Mirroring of knowledge practices

Collaborative analysis and reflection on knowledge practices can take quite different forms and might involve different groups of stakeholders. This fact motivated several usage scenarios that can be covered by the proposed analytic approach:

- Monitoring can be understood as the tracking and analysis of activities as they unfold in time. Monitoring activities might be carried out by a supervisor or by one or more of the persons actually enrolled in the activity at stake. The primary aim in this case is to raise awareness for and to support the analysis of critical events in the course of collaborative action.
- Project retrospectives have been suggested as an important element of project-based work. In comparison to the monitoring activities, collaborative retrospectives provide a more formal and systematic approach aimed to reflect on past activities and to derive lessons learned for future work.
- The analysis and comparison of practices across teams or projects provides the third main usage scenario. Again, this kind of analysis can be carried out by the collaborators themselves or a supervisor.

The analysis of these usage scenarios led to four main design goals for an analytic tool in support of collaborative reflection:

1. *Supporting the explorative analysis* of computer-supported knowledge practices: rather than confronting users with predefined queries and indicators, an application should enable users to make sense of the data themselves and in collaboration with others. Towards this end, users should be able to filter, aggregate, search, and annotate the data. Furthermore, they should be able to follow traces of material evidence of their activities on

different levels of abstraction, providing overview and detailed information when needed.

2. *Openness for external events*: as collaboration seldom takes place in virtual environments alone, but often comprises a complex mixture of computer-supported teamwork, face-to-face meetings and work on non-digital artifacts, users should be able to complement automatically recorded data by other sources of data, including their memories.
3. *Supporting multiple perspectives and intergroup comparison*: a tool should allow users to share and articulate different perspectives, but also allow for comparisons across groups, in order to foster cross-fertilization and exchange. Therefore it should provide mechanisms for the exchange of queries, patterns, and views as well as the possibility to annotate and comment on events.
4. *Providing meaningful and comprehensible visual metaphors, which can be easily customized to the information needs of various types of users*: to account for different backgrounds and levels of expertise a tool should offer visual formats that are meaningful and comprehensible for all stakeholder groups. In addition, user interface mechanisms for data manipulation and analysis need to be powerful but yet intuitive to be accessible even for occasional users with limited background on data analysis.

3 Timeline-Based Analyzer

Timeline-Based Analyzer (TLBA) represents a tool that displays events that were recorded by any virtual collaborative environment in chronological order based on users interaction with the objects created, see Figure 1.

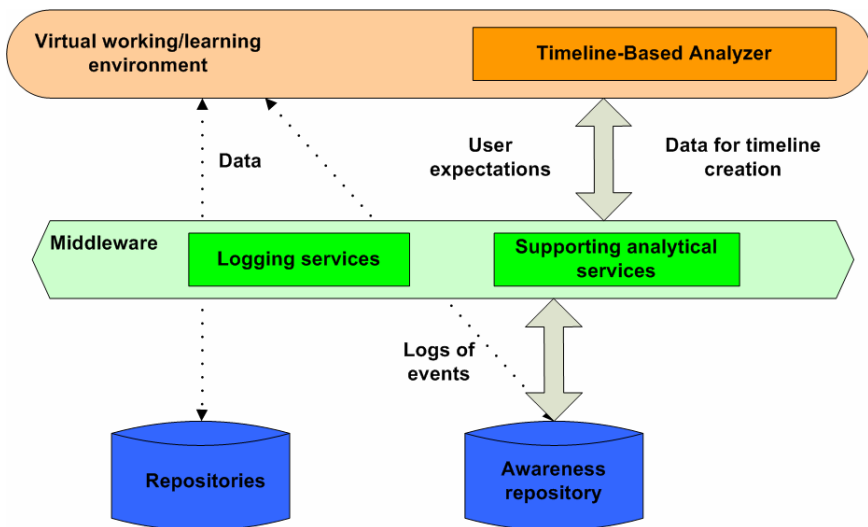


Figure 1: Architecture of TLBA integration with related supporting services.

It allows describing and storing of external events, which cannot be recorded by the collaborative environment and enables to define and search for ‘patterns’ in the logs recorded. All events are stored in an awareness repository in a predefined format of log. This generic format was designed to provide complex information for analytical purposes and can be adapted on new, specific requirements by adding new parameters or removing some of the existing ones.

3.1 Log of event

[ID, Type, Actor, Actor Type, Actor Name, Entity, Entity Type, Entity Title, Belongs to, Time, Custom properties, Custom data]

- *ID* – unique identifier of the log entry;
- *Type* – a type of performed actions, e.g. creation, modification, deletion, etc;
- *Actor* – unique identifier of actor that performed given event;
- *Actor Type* – user role that is delegated based on relevant part of the user environment;
- *Actor Name* – user name obtained from user management based on his system logging information;
- *Entity* – unique identifier of the shared object that motivates given event;
- *Entity Type* – type of shared objects, e.g. task, document, link, wiki page;
- *Entity Title* – concrete title of related shared objects
- *Belongs to* – unique identifier of relevant part of user environment where this event was performed;
- *Time* – time when the event was logged into database (represented in the following format: year-month-day HH:MM:SS);
- *Custom data and properties* – these parameters are used in situation when end-user application will store some properties or data that are typical for it.

3.2 TLBA features

The main functionalities provided by TLBA are the following:

- Sequences of performed events in chronological order are visualized via defined (one or more parallel) timeline(s). By placing events, i.e. user’s actions carried out with the virtual collaborative environment onto timelines, TLBA users get a historical overview of the activities that were performed in a collaborative space and are able to discern who performed those actions.
- Visualization of all interactions and relations between selected relevant elements based on user requirements. By linking together events involving the same object, TLBA supports objects’ path trajectories both in terms of the intensity of manipulation and its manifestation in users’ actions. All available trajectories are placed into the view so that users can explore and highlight events that are of particular interest to them. Object trajectory path, actor created objects (with their path trajectories) along with events or on-fly mouse time stamp are possible ways of focusing user’s interest in some object.

- Filtering upon type of object or type of activity is possible within the view to ease users' perception of data shown along with the ability to comment upon event or group of events, brings the opportunity to share thoughts about activities performed.
- The important functionality of this tool is possibility to define and store interesting patterns (pattern is a suitably generalised set of selected events or elements) from the timeline. These patterns are well formalized projections of interesting practices or parts of the whole evolution process.
- Basic timeline visualization consists of automatically-collected events that are performed in monitored collaborative system. In some situations, it is necessary to include elements called external events (performed outside monitored system) that are relevant to analyzed practices and this operation is performed manually by the user. This functionality is also supported by the proposed application.

Design and development of these functionalities were lead by first design goal, where openness of shown data (means to filter, highlight, comment, etc.) brings new possibilities to infer information and make sense of data collected. With regard to the second design goal, TLBA users are able to add external events to the timelines both before object creation in collaborative environment to indicate that some outside event has taken place which triggered this creation, and add external events that happened during object's lifetime. TLBA encourages users to design and share their own analytic queries by building, searching and sharing event 'patterns', by which third design goal is met.

3.3 TLBA patterns

The identified patterns usually represent sequences of events that have critical impact on the overall process, in positive or negative sense. Such kind of patterns might also represent conceptually interesting practices that emerged within a particular context – either being positive (something like good practices), or negative (bad practices).

The patterns in TLBA can be defined either from scratch, or based on any subset of events presented on the timeline in TLBA with the possibility to relax some of the attributes of selected events, stating in such a way a set of constraints. The constraints for defining a pattern (which have direct implications on searching for similar patterns in the history) can take one of the following alternative forms:

- Equality or inequality of properties of different events (e.g. different users for event 1 and event 2, equal users for event 2 and event 3 in the example above).
- Multiple occurrence of events (e.g. at least 2 comments have to be posted, for example by any user).
- Sequence of events (e.g. first event, second event, third event ...).
- Specification of a timeframe between events (e.g. there should be a comment at least 48 h after the creation of a document).

As interesting practices or activities do not have to occur frequently or regularly, typical data mining approaches (inductive learning techniques), where frequent patterns are to be discovered, appear to be of limited value. Therefore the idea of providing suitable timeline-based visualization of performed practices (with

possibility to highlight and comment particular events, but also add external events) and means for manual definition of patterns within this framework has been proposed. Efficient algorithms for searching manually defined patterns will be provided in the final release of TLBA in the autumn 2010.

4 Case study

The aim of this case study is to describe how timeline based visualizations can be used to foster collaborative reflection in student project teams and how this process might be enhanced by the use of the Timeline-Based Analyzer. This case study is based on a collaborative retrospective carried out in connection to the “Project eModeration”, a compulsory first-year course at the University of Applied Sciences Upper Austria¹. The collaborative retrospectives were facilitated by a research assistant and took place at the end of the course. The pedagogical intent of the retrospectives was to give students an opportunity to reflect on their past working practices and to derive lessons learned for future projects. The procedure described below represents previous iterations of presented case study, without usage of suitable IT analytical solution. The motivation behind it is to show the advantages of proposed application as simple analytical procedure to get retrospectives, automatic approach to obtain historical data, possibility to manual identification of interesting behavior patterns, complex visualization of realized events in selected time interval, etc.

The collaborative retrospectives lasted 60 min. on average and were divided into six steps. Following a brief introduction on the purpose and agenda for the meeting (step 1), students were asked to recollect the main activities relevant to their project and note them down on a printed timeline individually (step 2), see Figure 2.

Course meetings and short descriptions of related assignments had been added to the timeline beforehand to provide some anchoring point for the students. The students then were asked to explain the activities they had noted to the group, while the facilitator made notes on these events on large-scale print out of the same timeline (step 3). Once all activities were added and organized chronologically, the students were asked to return to their individual printouts and to mark those events they perceived as having an impact (positive or negative) on their project. Besides adding short notes on the event itself, they were also asked to rate whether the perceived impact was positive, negative or neutral (step 4). Afterwards students were asked to make visible the events they deemed critical by adding a marker to the shared timeline, whereby the position was meant to indicate both time and perceived impact. The students were then asked to inspect the shared timeline and discuss those events the students felt most relevant for the entire team. In this phase the facilitator encouraged participants to elaborate on divergent perspectives and/or to think about possible causes of these events and how they could be avoided/triggered in the future projects (step 5). In a short wrap-up phase students had time to add further comments or ask questions (step 6).

¹ <http://www.fh-ooe.at>

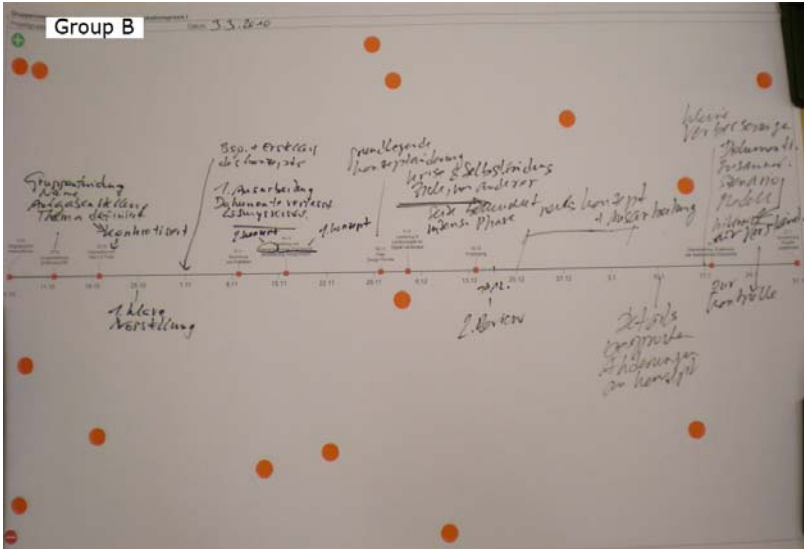


Figure 2: Paper-based timeline created during collaborative retrospective

Even though the collaborative retrospectives turned out to be quite productive and were assessed positively by the students, the case study also revealed some limitations of the current method. In particular, the paper-based format only allowed providing students with the most general events that applied to all teams, i.e. the course meetings. Consequently students had to recollect most events and their chronology from memory. In comparison tools such as the TLBA provide specific information based on the teams' actual work processes. Figure 3 provides a screenshot of the TLBA visualizing students' and teachers' activities within a collaborative working environment recorded over a period of 15 weeks.

As a consequence, less time is needed to reconstruct the work processes and more efforts can be spent on the actual analysis of critical events. In addition it was found that the mixture of individual and collaborative reflection is quite important to give room for divergent opinions and to avoid premature consensus. Sitting around a table and working on a set of printouts participants have been quite tempted to start group discussion instead of focusing on their own ideas. Working with digital media such as the TLBA might make it easier for participants to focus on their own ideas while still allowing to easily share the results with others. First tests with the TLBA revealed that the visual representation is accessible and comprehensible for students and provides meaningful input for the kind of exercise described here.



Figure 3: Screenshot of the Timeline-Based Analyzer displaying activities of a project team in a 15 weeks period for comparison with the paper-based timeline.

5 Conclusions

In summary, analytic tools in support of collaborative reflection, not only have to provide means for the faithful and comprehensible representation of data collected but also for sustained and collaborative exploration and interpretation. TLBA offers chronological overview of performed actions into the user interface, which allows seeing and exploring what kind of activities were carried out in relation to which documents or artefacts. This overview offers different analytic perspectives such as the evaluation of individual practices and their contribution to overall progress; comparison of individual practices or the whole group activities; identification of interesting sequences of actions that can be marked as 'good' or 'bad' practice for future use; visualization of shared objects evolution processes, etc.

The first prototype of TLBA was implemented at the beginning 2010 for experimental evaluation within prepared pilot courses and case studies. This evaluation was realized within EU IST project called KP-Lab². The outputs were summarized into several usability studies in order to obtain necessary information for future improvements. The actual version of TLBA is available within the KP-Lab System [Markkanen et al., 2008] [Lakkala et al., 2009] and ready for final usability evaluation with the aim to finish the whole implementation phase within stable prototype available for various research purposes.

² <http://www.kp-lab.org/>

Acknowledgements

The work presented in this paper was supported by: European Commission DG INFSO under the IST program, contract No. 27490 (50%); the Slovak Grant Agency of Ministry of Education and Academy of Science of the Slovak Republic under grant No. 1/0042/10 (10%). This work is also the result of the project implementation Development of the Center of Information and Communication Technologies for Knowledge Systems (project number: 26220120030) supported by the Research & Development Operational Program funded by the ERDF (40%).

The KP-Lab Integrated Project is sponsored under the 6th EU Framework Programme for Research and Development. The authors are solely responsible for the content of this article. It does not represent the opinion of the KP-Lab consortium or the European Community, and the European Community is not responsible for any use that might be made of data appearing therein.

References

- [Avouris et al., 2002] Avouris, N.M., Dimitracopoulou A., Komis, V., Fidas, C.: OCAF: An Object-oriented Model of Analysis of Collaborative Problem Solving, Proceedings of CSCL 2002, Colorado, January, 2002, Hillsdale: Erlbaum, pp. 92-101.
- [Avouris et al., 2007] Avouris, N., Fiotakis, G., Kahrmanis, G., Margaritis, M., Komis, V.: Beyond Logging of Fingertip Actions: Analysis of Collaborative Learning Using Multiple Sources of Data, *Journal of Interactive Learning Research* 2007, Vol. 18, No. 2, pp. 231-250.
- [Baker, in press] Baker, R.S.J.D.: Data Mining For Education, In: B. McGaw, P. Peterson, R.S.J.D. Baker (eds.), *International Encyclopedia of Education* (3rd edition), Oxford, UK.
- [Bolfíková et al., 2009] Bolfíková, Eva - Hrehová, Daniela - Chrenová, Jana: Analysis of satisfaction with a participation in organizations. In: *Serbian Journal of Management*. Vol. 4, No. 1 (2009), p. 105-115
- [Baker & Yacef, 2009] Baker, R.S.J.D., Yacef, K.: The State of Educational Data Mining in 2009: A Review and Future Visions, *Journal of Educational Data Mining*, Vol. 1, No. 1, pp. 3-17.
- [Gomez-Aguilar et al., 2009] Gomez-Aguilar, D. A., Theron, R., Garcia-Penalvo, F. J.: Semantic Spiral Timeline as a Support for E-learning, *Journal of Universal Computer Science* 2009, Vol. 15, No. 7, pp. 1526-1545.
- [Habala et al., 2009] Habala, O., Paralic, M., Bartalos, P., Rozinajova, V.: Semantically-aided Data-aware Service Workflow Composition, 35th International Conference on Current Trends in Theory and Practice of Computer Science, SOFSEM 2009, Springer, LNCS 5404, pp 317-328
- [Kahrmanis et al., 2006] Kahrmanis, G., Papasalouros, A., Avouris, N., Retalis, S.: A Model for Interoperability in Computer Supported Collaborative Learning, Proc. of the Sixth International Conference on Advanced Learning Technologies (ICALT'06), IEEE Computer Society, 2006.
- [Markkanen et al., 2008] Markkanen, H., Holi, M., Benmergui, L., Bauters, M., Richter, C.: The Knowledge Practices Environment: a Virtual Environment for Collaborative Knowledge Creation and Work around Shared Artefacts, In J.Luca & E.R. Weippl (Eds.), *Proceedings of*

ED-Media 2008, World Conference on Educational Media, Hypermedia and Telecommunications, Vienna, pp. 5035-5040, Chesapeake, VA: AACE.

[Lakkala et al., 2009] Lakkala, M., Paavola, S., Kosonen, K., Muukkonen, H., Bauters, M., Markkanen, H.: Main functionalities of the Knowledge Practices Environment (KPE) affording knowledge creation practices in education. In C. O'Malley, D. Suthers, P. Reimann, & A. Dimitracopoulou (Eds.), *Computer supported collaborative learning practices: CSCL2009 conference proceedings* (pp. 297-306). Rhodes, Creek: International Society of the Learning Sciences (ISLS)/

[Paavola & Hakkarainen, 2009] Paavola, S. Hakkarainen, K.: From Meaning Making to Joint Construction of Knowledge Practices and Artefacts – A Triological Approach to CSCL. In C. O'Malley, D. Suthers, P. Reimann, & A. Dimitracopoulou (Eds.), *Computer Supported Collaborative Learning Practices: CSCL2009 Conference Proceedings*, pp. 83-92, Rhodes, Greece: International Society of the Learning Sciences (ISLS).

[Perera, et al., 2009] Perera, D., Kay, J., Yacef, K., Koprinska, I., Zaiane, O.: Clustering and Sequential Pattern Mining of Online Collaborative Learning Data, *IEEE Transactions on Knowledge and Data Engineering*, Vol. 21, No. 6, pp. 759-772.

[Van der Aalst et al., 2009] Van der Aalst, W.M.P., van Dongen, Günther, C., Rozinat, A., Verbeek, E., Weijters, T.: ProM. The Process Mining Toolkit, In *Proceedings of the BPM 2009 Demonstration Track*, Volume 489 of CEUR-WS.org, Ulm, Germany.

[Zaïane and Luo, 2001] Zaïane, O.R., Luo, J.: Towards Evaluating Learners' Behaviour in a Web-based Distance Learning Environment, 2nd IEEE international conference on advanced learning technologies (ICALT'01), pp 357-360, Madison, WI.

A Constructivist Approach to the Organization of Performance Knowledge in Collaborative Networks

Faimara do Rocio Strauhs

(Federal University of Technology - Paraná – Paraná, Brasil
faimara@utfpr.edu.br)

António Lucas Soares

(University of Porto - Faculty of Engineering - DEI and INESC Porto, Portugal
als@fe.up.pt)

Eisse J. Wiersema

(Institute for Systems and Computer Engineering of Porto – Porto, Portugal
ewiersema@inescporto.pt)

Rui Ferreira

(Institute for Systems and Computer Engineering of Porto – Porto, Portugal
rui@pintoferreira.pt)

Jorge Neves Silva

(Institute for Systems and Computer Engineering of Porto – Porto, Portugal
jnevesilva@gmail.com)

Abstract: This paper describes a framework for the design of performance evaluation systems in collaborative networks. This framework is composed by a performance information reference model and a multi-criteria decision support method. When used in combination by the members of a collaborative network, results in specific models that result from a collective and negotiated construction.

Keywords: Performance knowledge. Collaborative networks. Constructivist approaches.

Categories: M.0, M.4

1 Introduction

Given the complexity of performance evaluation of an organisations network, it is not trivial to obtain a satisfactory information and knowledge model that is generally accepted by all the network members. This is confirmed by the scarcity of structured models of performance evaluation in literature applicable to collaborative networks. Moreover, as Wognum and Faber [Wognum, 2002] state, the method of performance measurement used for a network, and the selected performance indicators, can seldomly be used unchanged in other networks. The definition of metrics must consider a number of diverse aspects including the evaluation of objectives, the level on which the evaluation takes place, the choice of criteria, the type of network, the data sources available and more accessible, the network management model, the

power differences between members of the network, the time horizon of evaluation, times of collection of information, the frequency of data collection.

One solution to the above-mentioned problems would be to establish the performance management model in a collaborative and negotiated way between the network members. This solution would be valid for a specific network structure, composition and time horizon. In this model, in the opinion of [Ollus, 06], while recognising that criteria and indicators should be derived from individual and collective goals instead of using a standard set, this choice should be supported by a reference information model, allowing a quick setup of an initial model which would be the basis for a collective construction of a specific model to serve a given network context and situation. Thus, a methodological support to the collaboration and negotiation, centred on the establishment of a shared conceptualization of the specific performance management process, would also be of great importance.

In this paper, both the generic model of network performance information and the method to collaboratively build a shared conceptualization that will result in a network performance management model are presented.

From an epistemological perspective, the approach here presented can be considered as constructivist. There has been significant research concerning the constructivist approach, combining scientific research with practical organizational experience [Busi, 06]. Reports on the results of these studies, involving scientific research and business environments, contributed to the development of tools for knowledge explicitation, that are closer to the reality of people and their social networks.

The pmColNet approach was developed along four main activities: (i) creation of a conceptual framework for the evaluation of network performance and a metamodel for the project, (ii) creation of a model for negotiation under multicriteria decision support methods and tools, (iii) development of a prototype of a collaborative platform for network performance management, and (iv) validation of the model. An extensive review of the literature on performance evaluation and management in networks was the first step of this project. The following steps were concerned with the development of practical tools and real models, benefiting from data collected in business environments.

The following sections address performance in networks of organizations, then the construction phases of the pmColNet platform and finally the scenario-based validation of the developed models and method.

2 Performance in collaborative networking

Collaborative networks are made up of persons and organizations that unite with a common task, despite geographical, cultural, social or operational diversity, and are supported in their interaction by computational tools [Camarinha-Matos, 05].

In this type of networks, the collaborative aspect stands out. Collaboration differs from cooperation and coordination by its higher level of integration and interaction between members and organizations of the network. Cooperation includes information exchange, adjustment of activities, splitting of resources and work while aiming at specific targets. The participants of the cooperation process can work independently and the added value is the sum of the individual results [Camarinha-

Matos, 05]. Coordination requires, apart from the information exchange, the alignment and change of the activities to achieve efficient results. On the other hand, Collaboration involves mutual trust, in addition to being a process in which participants, working together, share information, resources, responsibilities and risks to achieve common goals [Camarinha-Matos, 05]. Therefore the main outcome is knowledge creation in several formats.

The benefits of effective collaboration include increased market share, gaining new customers, cost reduction, reduction of the development time and risk of failure of new products, and increase of quality, among others [Bititci, 04]. However, despite of these benefits, the expansion of these networks is still limited, as confirmed by the results obtained in the Collaborative Networks for High Performance (RCED) project, [Carneiro *et al.*, 07], and supported by the results of the pmColNet project.

Therefore, addressing the issue of performance in collaborative networks (CN) becomes crucial to its success. In particular, considering the participating organizations of the collaborative networks those are autonomous and not based on a rigid hierarchy of command, these networks are based on trust and reciprocal relations, restricted to a generally short period of time and are also subject to restrictive issues of opportunism, uncertainty and risks.

In the scope of this article, performance management (PM) is understood as a process that aims at the improvement of the organization by changing systems and processes which will positively transform organizational culture [Amaturanga, 02]. Managing performance involves a process of choosing indicators or metrics of critical success factors as well as defining criteria and areas of measurement, which can aggregate subcriteria and indicators, where performance measurement is a subprocess of PM.

Identifying the criteria to be used in network performance measurement is a distinctive factor in Performance Management. Such criteria should take a broad approach and should not be limited to financial aspects, but should have a spectrum that meets the strategic, tactical and operational levels, taking the tangible and intangible aspects into account. In this domain, PM and Knowledge Management are getting closer. Furthermore, network performance management is acknowledged as a complex issue, since it involves tangible aspects like the distributed nature of network partners and intangibles aspects such as culture, trust, participant interests and the actual type of network. Mutuality i.e., the constant interaction with real and transparent communication between partners, is a crucial factor in this process [Zhao, 02]. As such, financial criteria coexist with relational and operational criteria [Zhao, 02] [Parung. 06].

In this context, the pmColNet approach proposes that the definition of criteria and indicators to measure performance should follow the constructivist logic and should consider the vision of members, the individual performance systems (when available) and a common language created by network members, among others.

3 Collaboration in the construction of a network performance information model

Performance management within networks of organisations it is a complex subject and involves several aspects that influence the choice of metrics, such as performance objectives, evaluation level, criteria choice, network typology, data source and data access, network governance, power relations; evaluation timeframe, data gathering timing, data gathering frequency.

Due to diversity and number of influencing elements, a generic and satisfactory model is very hard to achieve, and, therefore, a situational and constructivist approach constitutes a valid option, that can be used in an specific network and its specific timeframe and constructed in a collaborative manner.

The pmColNet approach addresses the construction of shared network performance information models inspired in a constructivist perspective, which builds on the premise that knowledge creation takes place when acting in a social environment supported by interpretations of the context.

These interpretations are built as actor-environment relations in a negotiation process that continuously builds meaning. Construction of meaning is due, not only to the inter-subjective negotiation but also to the active and conscious participation of a person [Pereira, 06], generating knowledge and its products.

The proposed pmColNet approach provides the models and methods for the organization of performance information and knowledge and for the negotiation of specific models. To create the project metamodel, pmColNet uses the five-phase model of knowledge creation [Nonaka, 97]. This is a constructivist model consisting of: (i) formation of a field of interaction, (ii) development of a concept, (iii) justification of the concept, (iv) prototyping and (v) dissemination.

Roughly speaking, and from an information and knowledge management point of view, the pmColNet approach has two moments: firstly the elaboration of an individual i (the organization as member of the network) performance information model and secondly the negotiation and synthesis of a shared network N performance information model. Both moments require the adequate tools to support the individual and collective processes of domain conceptualization.

The creation of an interactive field, aggregating all network participants, is of significant importance and must be independent of the sort of technological tools available. Such a field must be put in place from the beginning of the decision-making process and supports the construction of the reference model, built from the individual perception in a relational process.

A reference performance information model ($r_PInfoModel$) was developed, aimed at being used as a structured "catalogue" of perspectives, criteria and indicators to be selected for a performance management information model, illustrated in Figure 1. From the reference model, each network member i derives its own performance information model ($i_PInfoModel$). The final network performance information model ($N_PInfoModel$), for a given time frame and network composition and structure, is a subset of the reference model and is achieved by negotiation under multi-criteria decision support. The $r_PInfoModel$ considers aspects such as network typology, stakeholders, the framework (objectives/ tasks/ periods and ranges of evaluation time), evaluation levels, perspectives, criteria, sub-criteria, and indicators.

A list of indicators is suggested, including the way of how to define them, organize them, sort them and retrieve them through the use of computational tools.

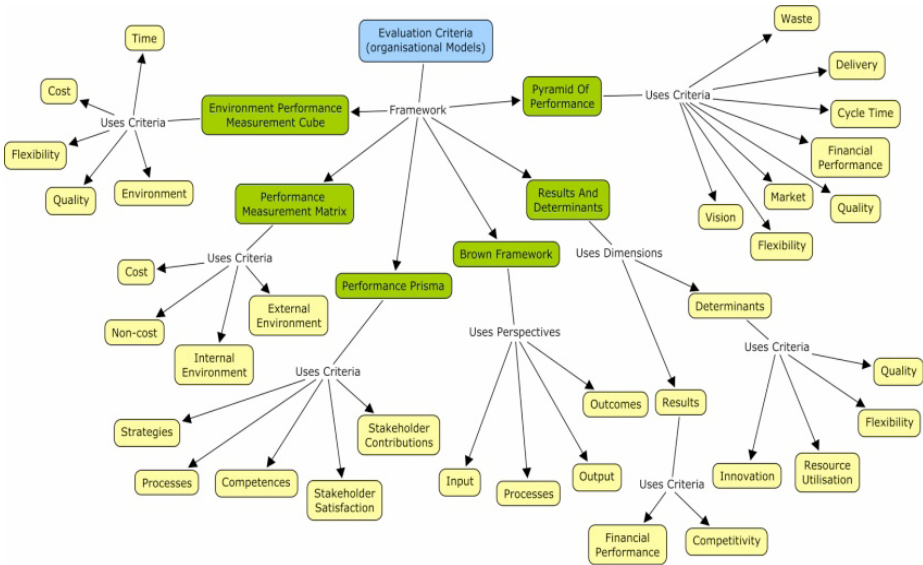


Figure 1: Reference performance evaluation model *r_PInfoModel* (extract)

For generating an individualized model for a network (*i_PInfoModel*), a two step approach was devised: (i) strategic definition (top-down): the information necessary for the development of the system must be derived from objectives set in advance; and (ii) definition of an information model (bottom-up): the information for modelling the performance evaluation system is determined from discussions and selections.

Figure 2 presents an example of the interaction of these two steps and the synthesized activity flow between them. In this example, three perspectives are used for the performance evaluation of a given network participant: member contribution, internal perspective, and external perspective. Concerning the member contribution there are three domains: social capital, measured by the indicator I_13, organizational capital, measured by the indicator I_12, and physical resources, measured by the indicators I_11 and I_15. The internal perspective must consider the criteria of quality (measured by I_36) and time (measured by I_51). The external perspective considers only the client satisfaction, as measured by the indicator I_53. This approach can be adopted to build the performance information model for each of the network participants. The individual models are then integrated, as mentioned before, during the collaborative network model construction. One should note that the network participants may suggest measurements that are not in the reference model (*r_PInfoModel*).

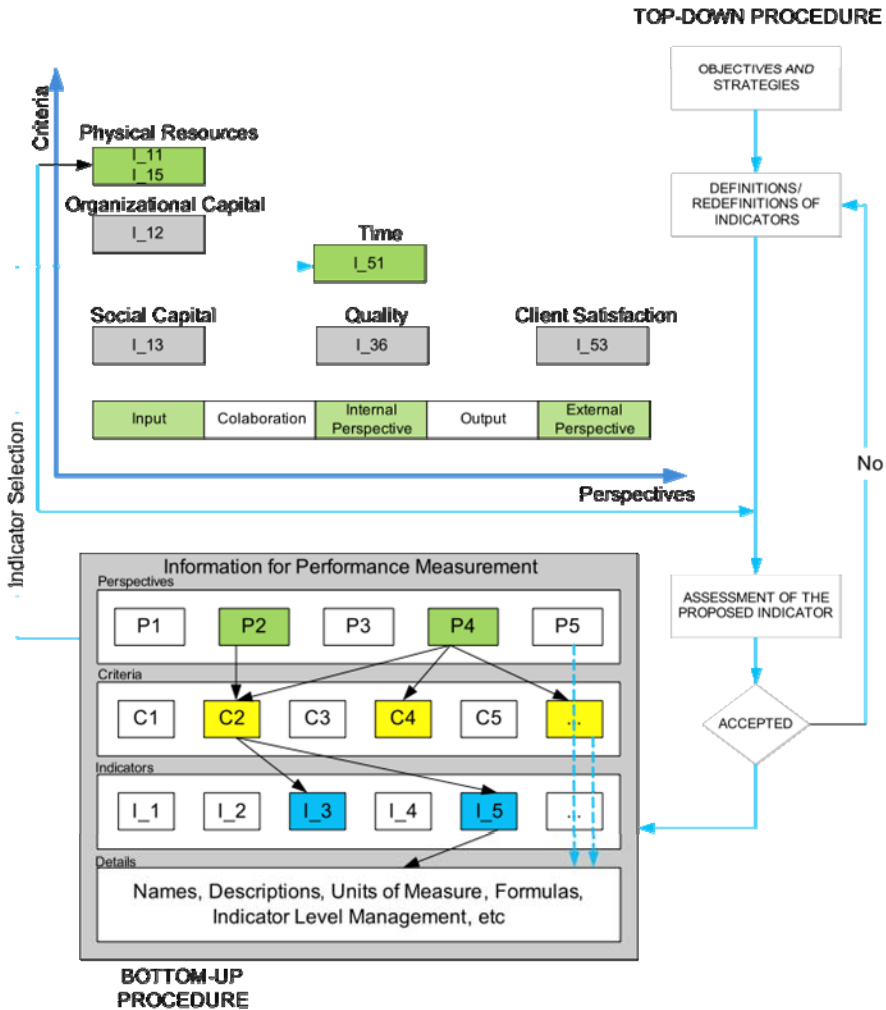


Figure 2: Process for Network performance information model elaboration

After the definition of the individual models, begins the definition of the final model, which represents the performance information for that particular network. If there is no agreement among the members concerning the performance information specification to be used and their levels of importance then the members must use a decision-support system. As such, each member proposes alternatives, which are weighted, for evaluation, criteria and, indicators. Each indicator must have maximum and minimum values that indicate success and failure. From these limits, the values can be normalized to aid in obtaining aggregated performance values.

In this model, there are one or many perspectives of evaluation, criteria and indicators, with different weightings, which reflect the importance members attach to

each measure when calculating the network's global performance. To each indicator, limits of maximum and minimum (representing success and fail) are instituted, estimated from member's suggestions. Establishing those limits allows its normalization, assisting in obtaining aggregated performance values. Once the network model is defined, the members can register this information using a platform to their management. At this stage, apart from the generic information about each indicator, the members must define a specific information set that is related to the context of that particular network, such as maximum and minimum values for the indicators (as mentioned above), measurement rate, the indication of the participant responsible for each indicator, the data source, among others. After being implemented, this initial model is then updated through a continuous cycle of proposals for new performance information and/or amending the already existent, depending on both the measurements results and network evolution.

Summarizing the above explanation, from the creation of an interaction field where the participants define their intentions, perspectives and objectives follow the creation of a consensual model of the network performance information (*N_PinfoModel*). This model is achieved through a decision process, which defines, jointly and through dialogue, what are the main elements (conceptual structures) of the model which then will be prototyped and used in the collaborative network to implement the PM system.

A fundamental step in the collaborative development of the model is the retrieval of the required indicators among hundreds, leading to the need of defining a method for organising and classifying the collection of indicators. The purpose of the classification of performance information is thus to organise the set of indicators into categories and to allow research of performance measurement information within the network of organisations.

A faceted classification was used. A feature of this classification system is the orthogonality of each tag on the others, where a number of tags can be assigned to each indicator. In the faceted classification, in turn, choosing an item from one facet limits the choice of other facets for the same resource. This feature differentiates a facet from a group of tags. The term facet can thus be defined as a group of classification items in which the attribution of a facet excludes the use of another for the same resource [Wilson, 2006]. This characteristic of the faceted classification allows greater control and less complexity in the classification and research of information. The facets are derived from analysis of collected indicators, the bibliographical research on performance information for the evaluation of organisations and networks of organisations and consultation of websites related to performance evaluation.

The analysis and the purpose of the classification, suggested the definition of the following facets: evaluation perspective, evaluation criteria, type of measure, level of decision. The to be classified resource, as already mentioned, is the performance indicator, which in addition to the attributes corresponding to the classification facets, also has the following general attributes: ID (identification of the indicator), title (indicator title), unit of measurement, direction (maximise / minimise).

The direction attribute, represents a wished change of the indicator value. Sometimes, however, in the process of performance management, it is necessary to make compromises between potentially conflicting indicators. For example, the

desired maximisation of a quality indicator might be conflicting with the minimisation of production costs, due to the fact that an increase in quality is normally associated with an increase in costs.

As mentioned before, the choice of measurement indicators is usually made on the basis of the objectives of the network. These objectives define the areas of performance measurement (criteria) and the perspectives to consider in this measurement (contribution of members, internal processes of the network, overall performance, external perspective). The choice of indicators whose measurements are objective or subjective, or the level of the indicator is also important to consider.

According to mutual exclusivity, the elements of a facet must be mutually exclusive to items of other facets. Thus, for each indicator, the attribution of an item within a facet limits the attribution of other items within the same facet. Moreover, the classification in a particular facet should be independent of other facet classifications. Other limitations are that the classification is not exhaustive, given the number of elements of the domain, and the lack of precision, when we have a particular indicator rated at more than one class.

Despite these limitations, this classification revealed a good choice because, on one hand, the results of tests concerning the search and retrieval of indicators using this model, and on the other hand, the practice in searching performance information adopted by users.

4 Negotiation method in the construction of a network performance information model

As a Group Decision Support System (GDSS), pmColNet is also used as a facilitator in the decision process. It is based on the concepts of the PROMETHEE Group Decision Support System, which is a multi-criteria decision support method that supports the use of the Internet and Web-based environments, as well as the concepts proposed by Zahir for Multicriteria Group Support System [Zahir, 02].

pmColNet decision support model has five sequential phases (Table 1). The model is designed with a special emphasis in partner interaction and “decision overriding” [Ferreira, 09]. This means that pmColNet results, as indicating in a certain way, or using certain performance elements may be contradicted by network members applying any different method at any phase. pmColNet should have the ability to incorporate this “manual” network decision and carry on to the next phase. In fact, every network decision will be supported by the structured pmColNet suggestion and by an unstructured partner’s meeting, where the partners can freely discuss and achieve a different path of the structured proposal.

Description	Method / characteristics
Phase A - Contextualisation I. Initial setup II. Partner's individual performance model III. Network Typology IV. Defining power vote	Web form / PROMETHEE GDSS framework Tree structure Private folder HFPA Commitment level
Phase B - Partner's proposals HFPA	HFPA
Phase C - Measuring preference intensity	Visual pairwise judgment AHP Veto threshold
Phase D - Negotiating and achieving the commitment package I. Network global commitment level II. Defining success and failure III. Levels of analysis IV. Performance relationships V. Index construction	Weighted Arithmetic Mean Index construction
Phase E - Monitoring performance I. Normalising indicators and achieving the dashboard / tableau de bord II. Ideal performance - TOPSIS III. Relationship between individual and network performance model	Normalization TOPSIS

Table 1: Phases of the project pmColNet

Other aspect of the model resides in its flexibility towards the chosen method to measure partner preferences. We will propose and defend a particular multi-criteria method, but pmColNet will be flexible enough to incorporate a different approach without losing its main objective: to facilitate the performance model design.

The contextualization phase (phase A) provides a private, individual characterization of the network member, made of several standardized questions and stored by Web tools. Network Performance Information of each partner may also be collected and the commitment level of the network member should be set, becoming one of the important elements of the individual's connection to the network and representing a key indicator of performance. Typology, goals and voting power in the network are also defined at this stage.

In phase B each partner defines its proposed perspectives, objectives, criteria and metrics related to the main objectives of the network, as well as their criteria and their performance metrics. Each actor may propose alternatives to the main descriptors of the network. The relevant information provided by the network participants are registered in the pmColNet platform taking into consideration a Hierarchical Framework for Performance Analysis (HFPA). This is a simple framework whose main elements are the objectives, criteria, indicators, and participants perspective (Figure 3).

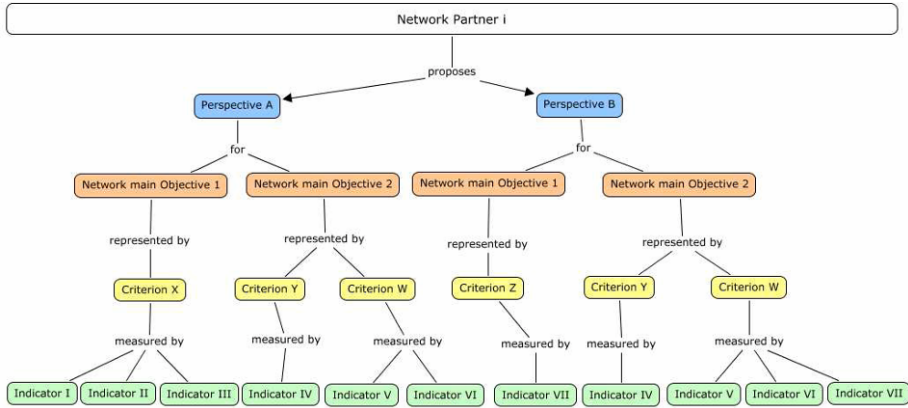


Figure 3: HFWA partner's proposals

In phase C, which must be completed by at least two actors, the intensity of preferences is measured by analyzing the combination of parity and aggregation of preferences, producing an ordered list of preferences and the veto threshold. The used approach is based on concepts from the Relational approach methods, namely the Analytic Hierarchy Process (AHP) [Saaty, 90], but also from ELECTRE (ELimination Et Choix Traduisant la REalité).

Phase D involves negotiation to establish a set of commitments within the network. At this stage it is relevant to define the criteria for measuring the performance of the network, taking into account: the general network commitment level, the criteria of success and failure, the levels of analysis, the performance relationships, and the construction of an index or "navigation chart".

In the last phase, E, performance monitoring is done, standardizing indicators and optimal performance. It also establishes the relationship between individual performance and overall network performance. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was selected to be the benchmark for monitoring the network performance.

The initial validation of pmColNet was on diverse scenarios using data from three companies that already participated in previous projects. Empirical initial studies with entrepreneurs aimed at adjustments of the methodology are also progressing satisfactorily.

5 Final considerations

The pmColNet premise is that performance management in collaborative networks is a complex and multicriteria problem that benefits from a situational approach whereas all participants propose criteria and indicators to monitor objective completeness. The construction of a shared conceptualization of performance by the network is fundamental for achieving a negotiated performance information model.

The proposed pmColNet approach provides the models and methods for the organization of performance information and knowledge and for the negotiation of specific models. To create a reference performance information model, pmColNet used the five-phase model of knowledge creation in a true constructivistic approach. Furthermore, a common language was established to meet the needs of various involved parties, within the constructivist approach, searching for interaction, mutuality and joint construction of knowledge, in an applied research. pmColNet's potential will only be accessed in real cases application. Detailed scenarios were used but cannot substitute real life interaction.

Meanwhile, an empirical study was conducted in a group of managers involved in collaborative networks. Open-ended interviews resulted in a rich set of data that will enable the fine-tuning and improvement of the pmColNet approach.

Acknowledgments

To the Portuguese Fundação para a Ciência e Tecnologia which funded the pmColNet project under the contract PTDC/GES/71482/2006. To the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES, for financial support to maintain the scholarship for post doctoral training of Prof. Dr. Faimara do Rocio Strauhs, Process: 1979-09-4, at INESC Porto, Portugal. To colleagues at INESC Porto for the support and knowledge sharing, in particular to Mr. Pedro Tiago Alves Castanheira, for his ever-present availability.

References

[Amaturanga, 02] Amaturanga, D., Baldry, D. (2002), Moving from performance measurement to performance management. *Facilities*, Vol. 20 No.5/6, pp.217-23.

[Bititci, 04] Bititci, U. S, V. Martinez, P. Albores, e J. Parung. 2004. Creating and managing value in collaborative networks. *International Journal of Physical Distribution and Logistics Management*. 34: 251–268

[Busi, 06] Busi, M.; U S Bititci. Collaborative Performance management: present gaps and future research. 2006.

[Camarinha-Matos, 05] Camarinha-Matos, Luis M. and Afsarmanesh, Hamideh (2005). Collaborative networks: a new scientific Discipline. *Journal of Intelligent Manufacturing*, 16, 439– 452. (<http://www.springerlink.com/content/vg4252751586627t/fulltext.pdf>).

[Carneiro, 07] Carneiro, Luis et al. *Redes Colaborativas de Elevado Desempenho no Norte de Portugal*. Porto: INESC, 2007.

[Ferreira, 09] Ferreira, R. Development of a multi-criteria collaborative decision model for performance management in networks of organizations. 2009. 117 f. Dissertação (Engenharia Informática). Departamento de Engenharia Informatica, Faculdade de Engenharia, Universidade do Porto, Porto, 2009.

[Neves Silva, 09] Neves Silva, J. *Gestão de Informação de Desempenho em Redes Colaborativas de Organizações*. 2009. 190 f. Dissertação (Engenharia Informática). Departamento de Engenharia Informatica, Faculdade de Engenharia, Universidade do Porto, Porto, 2009.

- [Nonaka, 97] Nonaka, I.; Takeuchi, Hi.. Criação do Conhecimento na Empresa – Como as empresas japonesas geram a dinâmica da inovação. Rio de Janeiro: Editora Campus, 1997.
- [Ollus, 06] Ollus M, Jansson K, Karvonen I. (2006). On the Management of Collaborative Networked Organizations. In Conference Proceedings from IST-Africa 2006. (Cunningham P, Cunningham M (Eds)). IIMC International Information Management Corporation.
- [Parung, 06] Parung, J. and U. S. Bititci (2006). "A conceptual metric for managing collaborative networks." *Journal of Modelling in Management* 1(2): 116-136.
- [Pereira, 06]. Pereira, C. E. N. A Criação do Conhecimento nas Organizações: uma abordagem construtivista a partir da interpretação da média gerência. 2006. 196 f. Dissertação (Mestrado), Programa de Pós-graduação em Administração. Faculdade de Economia, Administração e Contabilidade, Universidade de São Paulo, 2006.
- [Saaty, 90] Saaty, Thomas L. (1990). How to make a decision: The Analytic Hierarchy Process. *European Journal of Operational Research*. 48, pp. 9-26.
- [Wilson, 06]. Wilson, T. (2006). The strict faceted classification model.
- [Wogum, 02] P.M. Wognum, E.C.C. Faber (2002) Infrastructures for collaboration in virtual organisations, *International Journal of Networking and Virtual Organisations*, Vol. 1, No. 1, pp. 32-54.
- [Zahir, 02] Zahir, Sajjad and Dobing, Brian (2002). Designing a web-based multi-criteria group support system (MCGSS). *Journal of Computer Information Systems* 42(4), 50-60.
- [Zhao, 02] Zhao, D. F. Performance Measures for Inter-organisational Partnerships. 6. 2002.

Knowledge Services in Support of Converging Knowledge, Innovation, and Practice

Mikko V. Pohjola

(National Institute for Health and Welfare, Kuopio, Finland
mikko.pohjola@thl.fi)

Pasi Pohjola

(National Institute for Health and Welfare, Kuopio, Finland
pasi.pohjola@thl.fi)

Sami Paavola

(University of Helsinki, Finland
sami.paavola@helsinki.fi)

Jouni T. Tuomisto

(National Institute for Health and Welfare, Kuopio, Finland
jouni.tuomisto@thl.fi)

Abstract: Knowledge, innovation and practice are interrelated, but the management of their relations is far from an easy and straightforward task. Facilitating knowledge services are needed. This paper explores the theory of converging knowledge, innovation, and practice, and the implications for its facilitation. A triological approach to knowledge creation is presented as a viable theoretical starting point. Theoretical considerations are complemented with two examples of novel knowledge services: Opasnet and Innovillage. Eventually, conclusions are drawn upon the main issues to address in future development of services to support convergence of knowledge, innovation, and practice.

Keywords: Collective knowledge, Triological approach, Innovation, Knowledge practices, Pragmatism, Collaborative knowledge services, Open assessment, Opasnet, Innovillage

Categories: L.1.2, L.2.3, L.3.6, L.6.0, L.6.2

1 Introduction

Advances in knowledge and innovations are essential for the guidance and development of activity in virtually all fields of practice: policy, business, health, education, and everyday life. The development of current knowledge societies has also changed the ways of working with knowledge. Knowledge work requires producing and cultivating knowledge in collaboration with different stakeholders and transfer of practices in relation to the advances in knowledge and innovations [Knorr-Cetina, 07]. This societal change also generates challenges to which the ways of conducting knowledge work and the relating knowledge services need to answer. Issues such as the exploitation of scientific knowledge in political decision making and other kinds of science-policy interaction provide good examples of these challenges. It has been pointed out that the conventional models of linking knowledge

and action do not suffice in addressing the complexity of sustainable development [van Kerkhoff, 06]. A pervasive example of challenges in converging knowledge, innovation and practice is climate change, where advances in climate science and efforts invested in international climate policy fail to result in effective mitigation and adaptation actions [Brunner, 06], [IARU, 09] [IPCC, 07] & [Mickwitz, 09].

The general characteristics of functional science-policy interaction are identified in recent scientific literature as: i) considering the outputs of science as inputs to policy, ii) intimate interaction between science and policy, and iii) the mediation of interaction [Pohjola MV, manuscripta]. Currently, there are attempts to improve the conventional models of linking knowledge and action through increased engagement and power sharing by different means [van Kerkhoff, 06]. van Kerkhoff and Lebel [van Kerkhoff, 06] suggest regarding knowledge-action relationships as arenas where research-based knowledge and practice interact, but not necessarily in a simple or straightforward manner. Despite that the contemporary approaches to science-policy interaction and critiques of science-society relationships succeed in highlighting the main points of improvement, they mostly provide only marginal guidance on how to implement the improvements in practice [van Kerkhoff, 06] & [Pohjola MV, manuscripta]. For example, while academic discourse on environmental health assessment emphasizes the importance of dialogue with stakeholders and public, the assessment practices far too often remain a monologue of assessors, where contact with users, other experts and public is taken only when obligatory [Pohjola MV, manuscriptb].

It appears that the importance of converging knowledge, innovation, and practice as well as its main challenges are identified, but the means for a theoretical and practical implementation are missing. Facilitating knowledge services are needed. It is here argued that such knowledge services must: i) build on solid conceptual understanding about the interrelations between knowledge, innovation, and practice, and ii) possess corresponding functionalities to activate interaction between knowledge, innovation and practice. It is fundamental that these issues are considered together as intertwined aspects of the same whole. Building on the ideas of pragmatism, Brunner [Brunner, 06], for example, calls for a paradigm for practice that i) considers knowledge as intertwined with action, ii) develops context-sensitive practical knowledge, and iii) evaluates knowledge and actions according to their purposes. In this paper, our attempt is to identify the essential issues in facilitating the convergence of knowledge, innovation, and practice. We briefly present a triological framework as a potential candidate for a foundation for explicating how knowledge services to support knowledge creation and innovative activity can fulfil the three requirements mentioned above. The triological framework, adopted here as the foundation, can be developed further as an effective approach to enhancing collaborative knowledge work and learning.

2 Knowledge, innovation and practice

Shaping human activity and practices, e.g. through science-policy interaction, requires innovations and collaborative knowledge creation. Cultivation and creation of knowledge together with various stakeholders with multiple interests and perspectives is an essential part of these processes. Integration of these perspectives requires

collaboration and support that knowledge services should provide. Development of shared practices also requires innovative activity. It requires the development of new technologies, ways of using technologies or creation of new kinds of services and ways of action. In the following, the central characteristics of these kinds of processes are described and some implications that the characteristics have for the development of supporting knowledge services are discussed. It is proposed here that taking a dialogical approach to considering these issues can enhance the understanding about such processes and their facilitation.

2.1 Knowledge creation

Creation of new knowledge is rarely a cognitive process of a single individual. Typically, cognitive tasks are physically, socially and temporally distributed and the new ideas and hypotheses are materialized as external artefacts [Paavola, 06]. Approaches to distributed cognition have for long emphasized that inquirers in a search of knowledge are not usually processing things only in their heads, but use various resources from their environment to guide the search for new ideas (see [Hutchins, 95], [Salomon, 93]). In the intertwined creation of knowledge and development of social practices, practical knowledge is created in an interplay between collaborative problem exploration and collaborative development of solutions. Abductive reasoning has an important role in the interplay [Paavola, 06]. Also abductive processes of producing new hypotheses and ideas can be considered collaborative rather than happening only in individuals' head [Paavola, 06]. Abductive inference produces tentative solutions to be worked collaboratively. They can be either applied in practice until better solutions are formulated or as intermediate steps that guide and promote the search for better solutions. In pragmatic collective knowledge creation process the abductive process can be supported by, and often necessitates, argumentation [Paavola, 09a]. By means of argumentation it is possible to reason why one tentative solution should be considered as superior to others or argue about the types of a preferred solution even before such solutions are found. Argumentation also functions as a mediator between collaborators in knowledge creation and ties the cognitive processes to social practices among the collective.

2.2 Collective knowledge

The central idea deriving from pragmatism, aiming to integrate the issues of knowledge, innovation and practice, is that people through participation "continuously construct and re-construct the social meanings that shape our thoughts and actions" [Simpson, 09, 1333]. This means that knowledge creation is fundamentally a social process and this process is essentially linked with the ways we act and the kinds of practices we create and maintain. Knowledge becomes intertwined with action and especially with social action [Simpson, 09, 1334-6]. Also the tools and artefacts we use as the means of our action are a part of this continuous process of construction and re-construction. Although the idea of the social aspect of knowledge is not new, in current knowledge societies it extends from socially maintained and explicated knowledge to the machineries of knowledge construction. In this paper knowledge services are viewed as a central machinery of knowledge construction.

2.3 Innovation

In innovations knowledge becomes integrated to practice as systematically developed means for practice. The process of innovation relies on application and generation of knowledge aiming to develop something that can be grounded in practice. In recent literature, innovation has been described as the multifocal development of social practice [Tuomi, 03]. It has also been argued that the criterion for successful technical innovations is that they become social institutions, i.e. their use becomes rooted in the common everyday practice [Pohjola P, 09]. The ideas concerning systemic innovations [Andersen, 08], open innovations [Chesbrough, 03], and democratized innovations [von Hippel, 05] point out additional challenges to knowledge services supporting innovation by highlighting both the importance and complexity of networked innovation activity.

Contemporary investigations on innovation processes imply that they cannot be understood as the linear sequences of independent sub-processes, but rather as multi-directional [Pinch, 84] and multifocal [Tuomi, 03]. They are not merely processes carried out by product developers and R&D departments, but require the participation of various groups of stakeholders, from users to different kinds of professionals. For example, innovation in health care, such as new drug treatment for some disease, requires expertise and involvement of various parties: from patients, nurses and doctors to drug developers, directors of health care organizations, legislation etc. It is only in these systems or networks of different actors where the innovations become existent. Therefore it has become more common that these actors are also involved in the early stages of the innovation process. Knowledge services that support these kinds of multifaceted innovation processes need to provide support for collective knowledge creation and innovation throughout the whole process, from idea generation to normalization of practices [May, 09].

2.4 Trialogical approach to knowledge creation and learning

The “trialogical” approach has been suggested and applied especially in computer-supported collaborative learning (CSCL) as a novel way of considering the issues of knowledge creation and innovation (see [Hakkarainen, 09], [Lakkala, 09], [Paavola, 09b]). It emphasizes the role of collaborative development and reconstruction of concrete, shared artefacts in mediating knowledge creation as well as reflecting and transforming knowledge practices, i.e. the ways of collaboratively working with knowledge and execute knowledge tasks.

A basis for the trialogical approach is an epistemological distinction between three basic metaphors of learning and human cognition associated with monologues, dialogues, and trialogues. That is, monological processes of information sharing and knowledge acquisition, and dialogical processes of learning through communication and participation are supplemented by considering knowledge creation as a trialogical process of collaboratively developing epistemic artefacts and practices.

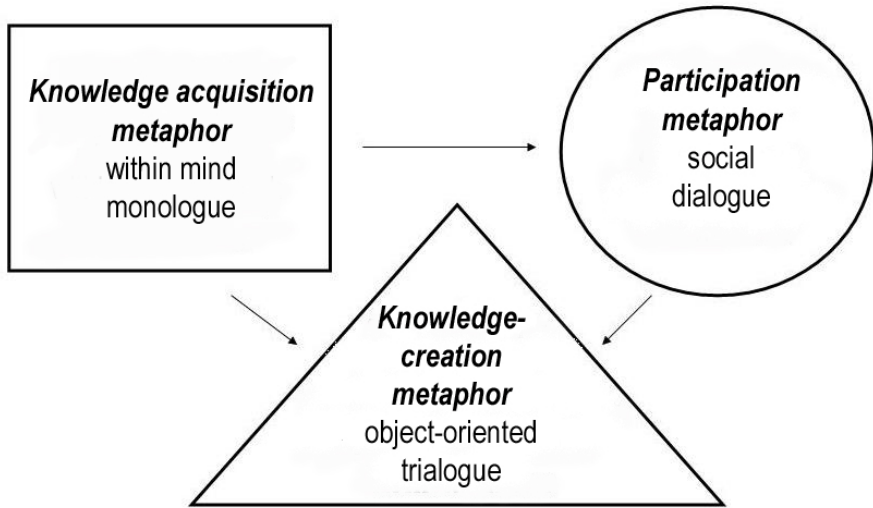


Figure 1: Three metaphors of learning

Viewing innovative activity from the trialogical learning perspective means that all relevant parties are (or should be) a part of the processes of learning and the production of concrete knowledge artefacts. This is similar to what was emphasized in the discussion about innovations above. There are various unsuccessful examples of attempts to routinise new technology that have failed to appropriately include relevant users into the development and learning processes (for an example in health technology assessment, see [Edmondson, 01]). In trialogical processes the focus is also on organizing the work around concrete artefacts and practices instead of mere information sharing or communication.

The development of trialogical approach has taken place mostly in the context of collaborative learning. We maintain, however, that by explicitly linking knowledge creation with practices (e.g. [Hakkarainen, 09]) as well as with cognitive processes and artefacts as their products and mediators, the trialogical approach is a suitable foundation for facilitating the convergence of knowledge, innovation and practice more generally.

2.5 Facilitation

Building on the theoretical considerations above, the main requirements for knowledge services facilitating the convergence of knowledge, innovation, and practice can be identified as follows:

1. Storage, representation, distribution, and manipulation of shared artefacts
2. Management of collaboration among multiple participants with plural perspectives and heterogeneous capabilities
3. Organization and synthesis of participant contributions towards convergence

4. Guidance and support for development and application of effective collaborative knowledge practices
5. Support for both individual and collective learning
6. Support for practical implementation of knowledge

For example, wikis [Cress, 08] have been identified to hold such functionalities, and the design of shared artefacts represents an interesting and important research focus on understanding individual and collective knowledge and their interaction [von Krogh, 09]. Also, e.g. the experiments and experiences of mass collaboration [Tapscott, 06] and crowd-sourcing [Noveck, 09] add to this body of knowledge. However, space for improvement still exists in the development of functional human-technology systems that sufficiently address both the technical functions and the cognitive and social functions inherent in interactions between knowledge, innovation, and practice [Pohjola P, forthcoming].

3 Two examples of novel knowledge services

Two examples below represent different perspectives to converging knowledge, innovation, and practice and developing ways of organizing triological processes. The first case, Opasnet, exemplifies collective knowledge creation aided by a collaborative web-workspace. The second one, Innovillage, considers linking knowledge and practices through a socio-technical innovation process. Opasnet and Innovillage are developed by the National Institute for Health and Welfare (THL) in Finland in collaboration with multiple partners in Finland and Europe. Both concepts aim at developing practices through collaborative processes in which the creation and cultivation of different types of knowledge has a central role.

3.1 Opasnet

Opasnet is a web-workspace for producing and providing science-based support for policy making in the field of environment and health. It provides a virtual arena for engaging experts, policy makers, stakeholders, and public at large in open collaboration on generating practical solutions to problems of societal relevance. Such facilitated processes of collective knowledge creation are organized as open assessments following three fundamental principles: 1) assessments are descriptions of reality, 2) participation in assessments is unlimited, and 3) assessments search science-based solutions to practical problems.

Main focus in the perspective adopted in the development of Opasnet is on knowledge: how it is structured, shared, and created. It links to practice by engaging both problem owners and knowledge users into the assessment process and thereby attempting to ensure relevance and applicability of the knowledge created. At the same time particular emphasis is put on guaranteeing that scientific credibility of the process and its outcomes are not compromised, but rather strengthened, by openness. Also efficiency is intended to rather increase than decrease in an open assessment process.

Technically Opasnet consists of a wiki-workspace, a database, and a modelling and simulation environment. The wiki is the main interface between the system and

its users. The database stores numerical information for and from the modelling and simulation environment used for mathematical operations and analysis. They are also essential, as quantitative data and models often form the core of the information produced in environmental health assessments. Collaboration, however, mainly takes place through textual and graphical communication that a wiki-workspace supports well. Opasnet is located in the open internet (<http://en.opasnet.org>) and access to the system is unlimited. However, in order to be able to edit contents of the system one must create a user account and log in. Anyone can create an account.

The most essential features of supporting collective knowledge creation in Opasnet relate to its ontological information structure and organization of contributions by assessment participants. In open assessments information is produced and used as formal objects: assessments and variables. Assessment aggregates information related to a particular assessment, while a variable describes an individual phenomenon considered in an assessment. One variable can relate to several assessments. Both are wiki-pages containing information related to a specified topic. The interrelations between variables in an assessment are often represented as causal diagrams displayed on the respective assessment page (Figure 2).

The screenshot shows a web browser window displaying the Opasnet assessment page. The browser address bar shows the URL [http://en.opasnet.org/assessment_on_impacts_of_emission_trading_on_city-level_\(ET-CL\)](http://en.opasnet.org/assessment_on_impacts_of_emission_trading_on_city-level_(ET-CL)). The page title is "Assessment on impacts of emission trading on city-level (ET-CL)".

The page content includes:

- Navigation sidebar:** Main Page, Discussions, All pages, Main category, Recent changes, File list, Help, Tools (Create new pages, Create ImageMap, Table to Wiki, Word to Wiki), Search (Google Custom Search), Toolbox (Vital links here, Related changes, Upload file, Special pages, Printable version, Permanent link, Main contributors), In other websites (Opasnet in Finnish).
- Main content area:**
 - Page actions:** Discussion, Edit, History, Delete, Move, Protect, Watch.
 - Assessment title:** Assessment on impacts of emission trading on city-level (ET-CL).
 - Summary:** "Impacts of emission trading on city-level is an Impact assessment taking a wide perspective over environmental issues that can be dealt with on city level. The focus is on issues affected by the requirements set by an international treaty on greenhouse gas emission reduction and its regional operationalization in the EU. It studies several contemporary ideas, plans, and pieces of legislation in an integrated and systematic way. It tries to find hidden caveats, expose policies based on popular trends rather than science, and assess the impacts of new innovative solutions. It aims to offer information and guidance to the political process for developing a new international treaty in the UN climate change meeting in Copenhagen (COP-15), December 2009. The Analytica model file can be accessed here."
 - Peer rating:** "This page is an assessment. The page identifier is Op_en0202 (for e.g. Opasnet Base). Moderator: Mikko Pohjola (See all). Peer rating (without a full review). See scale. You voted 43%. Current user rating: 43% (1 vote)."
 - Scope:** "The purpose is to evaluate the impacts of alternative greenhouse gas (GHG) emission trade systems, which aim to reduce GHG emissions and thereby affect radiative forcing. The assessment is performed on a city-level, and the emission trade system is taken as an external constraint to the societal decision making on city-level. It thus considers city-level climate change mitigation measures in the major sectors causing GHG emissions, namely power production, heating, and traffic. Three major outputs are considered: a) greenhouse gas emissions, b) health impacts within the city, and c) costs of GHG emission trade and the direct costs of mitigation actions. The health impacts of climate change are not within the focus, but rather the impacts of climate change mitigation measures that are put in action in the city within decision making context constrained by the emission trading system. Individual and societal interests and decisions, and their interplay is specifically in focus. Situations where individual and societal values are in conflict are identified and examined. Policies aiming at resolution of these conflicts are sought for."
 - Purpose:** "Especially, the assessment aims to produce useful guidance and insight into the UN climate change meeting in Copenhagen (COP-15) in December 2009. The basic research question for the assessment can be defined as **What are the impacts of emission trading on city level?**"
 - Flowchart:** A complex causal diagram showing relationships between various factors. Key nodes include:
 - City-level: public transport subsidies (green box)
 - EU ETS: road traffic included (green box)
 - EU ETS: small installations included (green box)
 - City-level: Extension of district heating system (green box)
 - City-level: heat from nuclear power plant (green box)
 - City-level composite traffic system (green box)
 - Heat production (blue box)
 - House stock (green box)
 - Citizens: energy efficiency upgrade (green box)
 - PM2.5 emission (blue box)
 - Internal cost (blue box)
 - GHG emission (blue box)
 - Citizens: mode of transport (green box)
 - PM2.5 exposure (blue box)
 - ERF of PM2.5 on mortality & morbidity (blue box)
 - Cardiopulmonary mortality & morbidity (blue box)
 - Total cost (blue box)
 - Unit cost of GHG emission permit (blue box)
 - EU ETS: lower emission cap (green box)

Figure 2: An assessment page in Opasnet.

Assessments and variables share the same basic attribute structure: name (identifier), scope (question), definition (rationale), and result (answer to the question). A unified information structure is cognitively ergonomic and aids assessment participants to target their contributions to right locations within the system. It also makes it possible to consider previously produced information objects as modules that can be re-used or re-combined in new assessments. Every object consists of the actual information about a specific issue of interest on a respective wiki page. In addition, there may be discussions about the actual content, taking place on a respective discussion page. Contributions by multiple discussants are organized by means of pragma-dialectical argumentation (see [van Eemeren 02]). Argumentation consists of a statement regarding the actual content describing the issue of interest, a hierarchy of arguments either attacking or defending the statement or other arguments, and a resolution. Once a stable resolution has been found it should be implemented within the actual content accordingly.

An important aspect of open assessment and Opasnet is its perspective to assessment performance, i.e. the goodness of assessment. So called properties of good assessment consider assessments in terms of their i) quality of information content, ii) applicability of information, and iii) efficiency of assessment process, thus integrating the aspects of making assessments as well as using their outputs into one framework [Pohjola MV, 10]. The objects in Opasnet are also available for evaluation by the users of the system. The principles of collective knowledge creation are also applied in the development of Opasnet itself. Its practices and functionalities are described as method objects, which follow the same formalism and are subject to open criticism similarly as assessments and variables. The system thus also explicitly supports development of knowledge practices. In addition to the formal objects, Opasnet also contains other supporting freely formatted information objects such as lectures and encyclopaedia articles.

The development of Opasnet started in 2006, and its functionalities have been tested in several assessments within different research projects, e.g. a benefit-risk assessment on fish consumption (<http://en.opasnet.org/w/MeHg-Omega3>). It begins to be ready for full-scale use, but experiences on broad participation are still limited. During 2009 there were approximately 8000 visits by more than 2000 individual visitors. Number of active editors is currently between 20 and 50. The development and application of Opasnet has thus far mostly taken place within the domain of scientific research, but for future development it will be necessary to attract more practitioners and public to participate in the development and particularly application of knowledge.

3.2 Innovillage

Innovillage is a concept and an environment for the development, assimilation and evaluation of social and health technology and services. Currently, it is in a developmental phase; building upon an existing platform and conceptualizations for supporting the development of practices in social and health care. The central idea of Innovillage is to support open participation in the development of service innovations (both social and technical) in the social and health care. It promotes a multi-faceted perspective to innovations where all the relevant participants should have a possibility to engage in the innovation process. This means that the participants in service

innovation process can include patients, health or social care professionals, developers, researchers and management. Innovillage workspace and supporting services aim at providing an environment for cultivating and developing social and health services.

The theoretical background of Innovillage is in a multi-perspective view of systemic innovations, founded on the Actor-Network Theory (ANT). Initially, it is developed in science and technology studies (Latour, Callon) and is here extended with the trialogical approach. ANT sees innovations and technology as embedded in a network of both human and non-human actors [Latour, 05]. It also argues that technology and innovations become defined only in these contexts of actors and their inter-relations. This nature of innovations (both social and technical) requires that the knowledge service needs to provide support for extracting information about the relevant aspects relating to the development and implementation of the practice. From the trialogical perspective, it is crucial that all relevant members of the network can contribute to a shared object of work and provide their perspectives for the innovation process. Ignoring issues of usability, practical know-how or ethical aspects, not to mention legal or economic issues, can lead into the failure of the innovation process.

In the actual knowledge service, the developmental work is carried out in a web-workspace. The work is supported with a library of methods for development and evaluation of health and social services. The system also consists of a database of (descriptions of) existing practices which can be exploited as templates in the development of a new service. In addition to a web-workspace for collaborative development and evaluation, it consists of supporting services such as consultation, tutoring and education. The Innovillage workspace has much in common with Opasnet: collaborative working environment, emphasis on open participation and involvement, aim to combine the expertise of various stakeholders into the development process, and shared objects of development. As a knowledge service Innovillage provides an environment for creating and evaluating new practices for health and social services.

One central aim in developing Innovillage has been to provide support for development and management of working practices. As experiences from the use of knowledge services show, even services with the best functionalities and affordances do not generate collaborative development and innovation activity without motivated and committed practitioners. This means that the service should enable the practitioners to construct the ways and practices of collaboration within and outside the system. It has been noted that the practitioners need to be engaged into knowledge creating processes and be motivated to work for the outcomes of the process (see [Engeström, 08]). Successful collaboration also requires the creation of the ways of working with knowledge, i.e., creating knowledge practices [Hakkarainen, 09]. By providing the support for managing work roles and work tasks, the system aims at supporting the development of effective working practices that can become normalized in the practicing community [May, 09]. Facilitation of the socio-technical innovation process of Innovillage requires thus consideration of the supporting knowledge service as a hybrid system of both technology and its users.

4 Conclusions and discussion

As knowledge, innovation and practice are inseparable, services and systems for their development need to provide support to: 1) creation of knowledge, 2) use of knowledge, 3) development of social practices, 4) development of knowledge practices, as well as 5) broad innovative collaboration among plural participants. The theoretical understanding on converging knowledge, innovation, and practice is relatively robust and the trialogical approach to knowledge creation and learning provides a good conceptual basis for supporting knowledge services. Many technical and theoretical means required in trialogical knowledge services already exist, and development and application of such services is currently taking place.

However, good functional examples of knowledge services that fluently implement all the essential aspects of conceptual understanding on converging knowledge, innovation and practice do not exist yet. A gap between conceptual potential and practical implementation appears to exist. Experiences from knowledge service development have shown that engaging people in collaborative knowledge creation can be difficult, and trialogical processes need to be developed further. These difficulties may well result from inadequate design and implementation of the pioneering knowledge services, but probably also from a conceptual discrepancy with the common contemporary knowledge practices developed according to monological and dialogical tools and means as well as a currently prevailing demarcation between knowledge creation and use.

The list of requirements for knowledge services facilitating convergence of knowledge, innovation, and practice in the facilitation chapter above provides a good basis also for organizing the future development of such services. It should be noted, however that the development efforts should not only be focused on the technical functionalities, but also to developing the concepts and practices of converging knowledge, innovation, and practice. It necessitates considering knowledge services as socio-technical systems including also the human actors that engage in creation and use of knowledge by means of the service.

Acknowledgements

This research has been funded by the Academy of Finland, the National Technology Agency of Finland (Tekes), and EU.

References

- [Andersen, 08] Andersen, P. & Dejer, I.: Systemic innovation in a distributed network: the case of Danish wind turbines 1972-2007. *Strategic Organization* 6(1):13-46.
- [Brunner, 06] Brunner, R.D.: A paradigm for practice. *Policy Sciences* 39:135-167.
- [Chesbrough, 03] Chesbrough, H.W.: *Open Innovation: The new imperative for creating and profiting from technology*. Boston: Harvard Business School Press.
- [Cress, 08] Cress, U. & Kimmerle, J.: A systemic and cognitive view on collaborative knowledge building with wikis. *Computer Supported Collaborative Learning* 3:105-122.

- [Edmondson, 01] Edmondson, A., Bohmer, R. & Pisano, G.: Disrupted routines: Team learning and new technology implementation in hospitals. *Administrative Science Quarterly* 46:685-716.
- [Engeström, 08] Engeström, Y.: Enriching activity theory without shortcuts. *Interacting with Computers* 20:256-259.
- [Hakkarainen, 09] Hakkarainen, K.: A knowledge practice perspective on technology-mediated learning. *Computer-Supported Collaborative Learning* 4:213-231.
- [Hutchins, 95] Hutchins, E.: *Cognition in the Wild*. Cambridge, MA: The MIT Press.
- [IARU, 09] IARU (International Alliance of Research Universities): Synthesis report from Climate Change: Global Risks, Challenges & Decisions, Copenhagen, Denmark 10-12 March 2009. Copenhagen: University of Copenhagen. <http://climatecongress.ku.dk/pdf/synthesisreport>
- [IPCC, 07] Intergovernmental Panel on Climate Change (IPCC): Climate change 2007: Synthesis report. Geneva: IPCC. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
- [Knorr-Cetina, 07] Knorr-Cetina, K.: Culture in global knowledge societies: knowledge cultures and epistemic cultures. *Interdisciplinary Science Reviews* 32(4):361-375.
- [Lakkala, 09] Lakkala, M., Paavola, S., Kosonen, K., Muukkonen, H., Bauters, M., & Markkanen, H.: Main functionalities of the Knowledge Practices Environment (KPE) affording knowledge creation practices in education. In C. O'Malley, D. Suthers, P. Reimann, & A. Dimitracopoulou (Eds.), *Computer Supported Collaborative Learning Practices: CSCL2009 Conference Proceedings* (pp. 297-306). Rhodes, Creek: International Society of the Learning Sciences (ISLS).
- [Latour, 05] Latour, B.: *Reassembling the social: An introduction to Actor-Network Theory*. Oxford: Oxford University Press.
- [May, 09] May, C. & Finch, T.: Implementing, Embedding, and Integrating Practices: An Outline of Normalization Process Theory. *Sociology* 43:535-554.
- [Mickwitz, 09] Mickwitz, P., Aix, F., Beck, S., Carss, D., Ferrand, N., Görg, C., Jensen, A., Kivimaa, P., Kuhlicke, C., Kuindersma, W., Máñez, M., Melanen, M., Monni, S., Branth Pedersen, A., Reinert, H. & van Bommel, S.: *Climate Policy Integration, Coherence and Governance*. PEER Report No 2. Helsinki: Partnership for European Environmental Research.
- [Noveck, 09] Noveck, B. *Wiki Government*. Brookings Institution Press.
- [Paavola, 06] Paavola, S., Hakkarainen, K., & Sintonen, M.: Abduction with Dialogical and Trialogical Means. *Logic Journal of the IGPL* 14(2):137-150.
- [Paavola, 09a] Paavola, S.: Abduktiivinen argumentaatio - hypoteesien hakemisen ja keksimisen välittynyt strategiat (Abductive argumentation - Mediated strategies for searching and discovering hypotheses). A paper (in Finnish) in a conference 'Suomalainen argumentaation tutkimus', 26-27 November 2009, University of Turku.
- [Paavola, 09b] Paavola, S. & Hakkarainen, K.: From meaning making to joint construction of knowledge practices and artefacts – A trialogical approach to CSCL. In C. O'Malley, D. Suthers, P. Reimann, & A. Dimitracopoulou (Eds.), *Computer Supported Collaborative Learning Practices: CSCL2009 Conference Proceedings*. (pp. 83-92). Rhodes, Creek: International Society of the Learning Sciences (ISLS).
- [Pinch, 84] Pinch, T. & Bijker, W.: The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science* 14:399-441.

- [Pohjola MV, manuscripta] Pohjola, M.V. & Tuomisto J.T.: Global climate change as a challenge to contemporary science-policy interaction. Manuscript.
- [Pohjola MV, manuscriptb] Pohjola, M.V., Leino, O., Kollanus, V., Tuomisto, J.T., Gunnlaugsdottir, H., Holm, F., Kalogeras N., Luteijn, J.M., Magnússon, S.H., Odekerken, G., Tjihuis, M.J., Ueland, Ø., White, B.C., Verhagen, H. State of the art in benefit-risk analysis: Environmental health. Manuscript.
- [Pohjola MV, 10] Pohjola, M.V., Tuomisto, J.T. & Tainio, M.: Properties of good assessment: The factors that contribute to assessment performance. A paper in SRA-Europe 2010 Annual Meeting, 21-23 June 2010, King's College, London. <http://www.sraeurope.org/filedown.aspx?file=3778>.
- [Pohjola P, 09] Pohjola, P.: *Technical Things. An essay on the social constitution of technical artefacts.* Cologne: Lambert Academic Publishers.
- [Pohjola P, forthcoming] Pohjola, P.: The Pragmatic Web: Some Key Issues. Proceedings of I-Semantics, 6th International Conference on Semantic Systems, 1–3 September 2010, Graz, Austria.
- [Simpson, 09] Simpson, B.: Pragmatism, Mead and the practice turn. *Organization Studies* 30:1329-1347.
- [Tapscott, 06] Tapscott, D. & Williams A.D.: *Wikinomics: How Mass Collaboration Changes Everything.* Toronto: Penguin Group.
- [Tuomi, 03] Tuomi, I.: *Networks of Innovation. Change and meaning in the age of the internet.* Oxford: Oxford University Press.
- [van Eemeren, 02] van Eemeren, F.H., Grootendorst, R. & Snoeck Henkemans, A.F.: *Argumentation. Analysis, Evaluation, Presentation.* London: Lawrence Erlbaum Associates, Publishers.
- [van Kerkhoff, 06] van Kerkhoff, L. & Lebel, L.: Linking knowledge and action for sustainable development. *Annual Review of Environment and Resources* 31:445-477.
- [von Hippel, 05] von Hippel, E.: *Democratizing Innovations,* Cambridge, MA: The MIT Press.
- [von Krogh, 09] von Krogh, G.: Individualist and collectivist perspectives on knowledge in organizations: Implications for information systems research. *Journal of Strategic Information Systems* 18:119-129.

knowCube[®] for Exploring Decision Spaces Sandwiches, Foams, and Drugs

Hans L. Trinkaus

(Fraunhofer ITWM, D-67663 Kaiserslautern, Germany
hans.trinkaus@itwm.fraunhofer.de)

Abstract: knowCube[®], a novel multi criteria decision making tool, is introduced. Its user-friendly interface assists “intuitive surfing through decision spaces” by means which are also familiar to non-experts. Causes and effects of alternatives may be examined from different points of view, and several types of criteria – like quantitative or qualitative, dependent or independent, hard or soft, and all mixed together – can be handled at the same time. The tool’s broad applicability is illustrated by some application examples from absolutely different fields: Mixed *Sandwiches* of various materials are investigated in manufacturing, ideal *Foams* are produced due to optimal parameter settings, and personalized *Drugs* could be designed by balancing conflicting effects.

Keywords: Information Exploration, Multi Criteria Decision Making, Dynamic Queries, Knowledge Discovery, Knowledge Visualization, Knowledge Management, Interactive Graphical User Interface, Software Tool, Real-life Applications.

Categories: H.0, H.1.2, H.3.3, H.5.2

1 Introduction

“Multiple objectives are all around us”, Zeleny points out already in [Zeleny, 82], but the dissemination of methods for multi criteria decision making (MCDM) into practice can still be regarded as insufficient. A principal reason for that situation might be that practitioners are just not familiar with MCDM methods, which often are difficult to understand and to work on. One way out Zionts shows in [Gal, 99] by asking for a “user-friendly” software as follows: “I strongly believe that what is needed is a spreadsheet type of method that will allow ordinary people to use MCDM methods for ordinary decisions.”

knowCube[®] mainly originates from focusing on such user-specific needs. Therefore, the system’s most important aspect is the provision of visualizations and interactivities in categories well understandable not only by MCDM professionals. All technical stuff, which is necessary for comfortable *knowledge exploration* (storage, access, selection, presentation, navigation ...) is hidden in the background.

An introduction to knowCube[®] is given in [Trinkaus, 05] – with some general information about visual data processing and human cognition. But, what may be even more interesting, that paper additionally reports on practical examples from two applications fields:

- In *industrial engineering*, the product development department had to *design best trunking devices*, to get optimal new products for an electro-technical company.

- In the *life-sciences*, a decision support system had to be developed in order to assist the physician in the *selection of an ideal therapy plan for a patient*, where (in real-time) “the best solution” had to be found out of a huge set of pre-calculated alternatives of intensity-modulated radio therapy plans.

The “excursion” to human cognition and visual data processing mentioned above concludes with the “quintessence”, that information exploration should appeal to the human visual system, and that it should transform complex situations into time-animated, spatial presentations. Additionally it is postulated there, still more specific, that continuous visual representation of objects and actions of interest should be enabled, and that furthermore physical actions (of the user) should be preferred – instead of working with “boring” queries that need complicated syntax formalisms.

These “motivations” were picked-up in [Trinkaus, 07]: Firstly, via adding some additional features to knowCube[®], and secondly, by working with the tool in the field of *Multi Criteria Knowledge Management*, too. Thereby, merely standard drawing tools are used for information exploration – because every child knows things like a *pen* or a *brush*, and (almost) everybody has some experience with a *text marker*, i.e. a German pseudo Anglicism for a felt-tipped pen. Applying such “graphical basics” interactively enables the user to perform complicated logical queries for balancing “best” multi criteria alternatives just by “drawing” on the GUI.

Now, in this paper the tool’s broad applicability is highlighted further by giving some new application examples from absolutely different fields: Mixed *Sandwiches* of various materials are investigated in manufacturing, ideal *Foams* are produced due to optimal parameter settings, and personalized *Drugs* could be designed by balancing conflicting effects. The paper’s appendix reports on a usability evaluation of the tool.

2 The Concept of knowCube[®]

In the centre of interest there is a *black-white-grey box*. This might stand for a single thing (e.g. a real physical product like a fire resistant cable channel), a complex process (e.g. the technical production of foam materials on an extrusion line), an abstract system (e.g. the behavior of individuals with respect to various influences) – or something else. The box gets “active” input influences x and suffers additionally from “passive” disturbances z . With these the box “works” according to partially known and partially unknown causalities or characteristics ch , and finally it shows “measurable” output reactions y . Fig.1 sketches the general *scenario*.

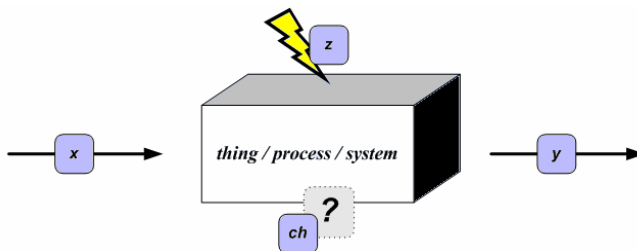


Figure 1: Black-White-Grey Box with its Environment

If there is not known anything about the inner structure (or if it doesn't make sense to think about it too much), the box is denoted as *black*. Generally, knowledge in such a scenario is gained by “random inquiries” to the box, i.e. by setting various values to the adjusting parameters x and then observing the values of the resulting parameters y . Data based methods might help here more systematically “to get insight into the box”, but knowCube® additionally could assist the *knowledge discovery* process more intuitively, as the following self-explaining example from the field of marketing and sales visualizes – with further details given later on.

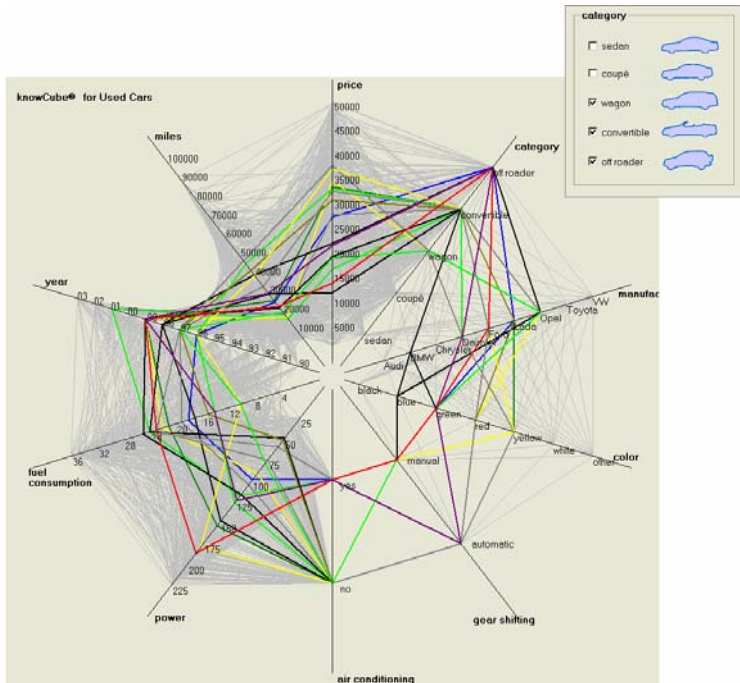


Figure 2: Fishing a Used Car out of a Big Box of Offers

If the scenario contains a *white* box, all is known completely. That's valid in theory, but there it happens only for academic or “very small” application examples. In real-life situations, “white” indicates, that it is sufficient to have a good model to work on, as in the following cases: If sets of differential and/or integral equations explain the main phenomena of a scenario, then multi criteria optimization methods can be applied for finding “best Pareto solutions”. Or, if already some pre-processing was done delivering enough data for fitting a “nice” mathematical model, then suited standard tools may be applied to get adequate information about the scenario itself.

Concerning the case of Pareto solutions, an application already was mentioned in the introduction, where all the knowledge generated had been visualized in a way to enable the physician in rating and selecting optimal therapy plans. For the other case, where according to a design of experiments all relevant “scenario coefficients” have been pre-calculated and, by using that information, certain knowledge on the scenario had to be exploited, an insight will follow in Chapter 4.

Most real scenarios, however, are *grey*, i.e. somewhere in between “black and white”, leading to “hybrid” situations. In that case, several options are at hand, like carrying out costly experiments, using approximation methods or restricting on partial aspects of the complete scenario, applying simulation methods, etc. And, very often, suited sequels and/or combinations of different methods are chosen, according to the amount of knowledge already gotten and still desired.

The next chapter will give some ideas how to handle problems of this hybrid kind, e.g. in manufacturing. A product development project demonstrates how various combinations of materials (serving as layers of the complete product) were simulated, tested, evaluated, and then finally presented to the executive board of a company for finding “the very best solution” – with respect to partially conflicting product criteria and among a group of controversially discussing decision makers.

2.1 Notations, Remarks, and Working Principles

To be somewhat more precise, a scenario as shown in Fig.1 is specified by its current *status* $s = \langle o; ch \rangle$, with a set o of *observables* (entities, with values that could be measured or estimated in principle) and with a non-observable *characteristic* ch of the box (characterizing its intrinsic way of acting). Furthermore, the observables might be distinguished between

- directly susceptible *adjusting parameters* (“set properties”) $x = \langle x_1, x_2, \dots, x_l \rangle$,
 - indirectly susceptible *resulting parameters* (“get properties”) $y = \langle y_1, y_2, \dots, y_m \rangle$,
 - not susceptible *disturbing parameters* (“event properties”) $z = \langle z_1, z_2, \dots, z_n \rangle$,
- such that the scenario-status may also be written as
- $s = \langle x; y; z; ch \rangle$.

(From an *IT point of view*, the black-white-grey box including the environment may also be seen as an abstract *class*, where its instances are *objects* with certain public/private, get/set or read/write properties, as e.g. x, y, z and ch in Fig.1.)

Now, each parameter to be taken into account is associated with an axis, on which the range of relevant values of that parameter is mapped linearly – or otherwise, on demand, thus defining an appropriate scale. (Non-ordered parameter value sets are assigned to parallel numerical scales in the background.) So, each status s finally can be represented by a set of numerical values, which are plotted as points on the related axes and afterwards connected by line segments to result in a polygon. Plotting all available statuses/polygons of a scenario at once visualizes its knowledge *horizon* as a first raw overview – on all objects, as e.g. the (~ 2010) grey polygons in Fig.2.

A decision maker at work then may choose his/her own *point of entry* into the decision horizon and follow his/her *path* walking through. This is done successively by putting *delimiters* on the axes preferred, thus restricting the value ranges of the parameters, by *zooming* in/out via changing some axes’ scales, or by clicking on/off some axes to move them to the fore/back-ground. All criteria selected are seen any time; their values may be *picked* or changed immediately, such that lengthy back-tracking does not occur. Additional knowledge, as needed by less experienced users, appears in *popup* windows via mouse clicks on the criteria axes, so there is no need to scroll or link: all information may be accessed on *one single screen*.

More details about working with knowCube[®] may be found in [Trinkaus, 05/07].

3 Simulation of Sandwiches – Comparing Compound Materials

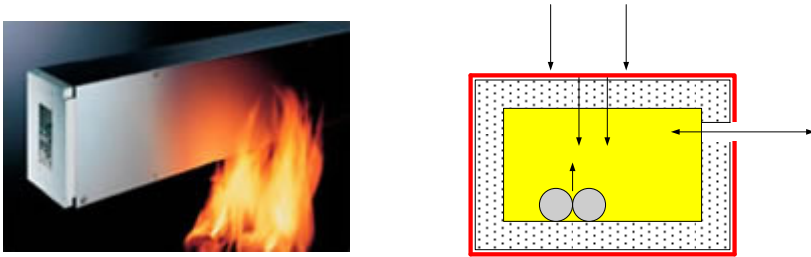


Figure 3: Decrease Weight and Costs, Increase Resistance and Turnover!

The figure’s title contains the main goals of the project. A firm of the *manufacturing industry* had asked for a novel cable duct being fire-resistant for a prescribed time span. The existing old product had turned out to be too heavy and costly. How should a new device be designed, with lower weight but longer operability – and thus with a promisingly higher turnover?

Obviously that’s a *grey-box-problem*, since “calculating solutions” with 100% accuracy is utopian, but the sketch on the right of Fig.3 already shows the essentials for a good simulation model. An outer steel sheet provides the load bearing capacity of a cable duct, and its fire protection ability is given by a layer of drywall, where the energy consumption for vaporizing the water crystallized in the gypsum keeps the inside temperature below critical values, subject to the fire’s temperature outside.

Real soon it turned out that using gypsum was inevitable, but to what extent could its layer thickness be lowered for reducing weight, and which materials were good candidates as substitutes? In order to find answers, at first different materials were investigated, focusing on their density and thermal conduction; some of them are listed in Fig.4. After that, an algorithm was implemented to simulate the heat flow through various combinations of layers, together with the phase change behaviour of the materials involved, where e.g. thermal capacity and conductivity, heat transfer coefficients and latent heat of involved materials were taken into account.

Material	Baust.kl.	Dichte	Wärmeleitf.
Gipsfaserplatte	A1 - A2	1,15	0,21 - 0,32
Kalziumsilikat	A1	0,18 - 0,38	0,06 - 0,08
Mineralfolle	A1	0,10 - 0,20	0,05 - 0,15
Perlite	A1	0,04 - 0,18	0,04 - 0,06
Vermiculite	A1	0,06 - 0,20	0,07 - 0,12
Microporös	A1	0,12 - 0,35	0,02 - 0,04
Aerogel	A1	0,003 - 0,01	0,01 - 0,02
Luft		0,0012	0,03 - 0,06
Stahl		7,85	40 - 60
Wasser		1,00	0,6

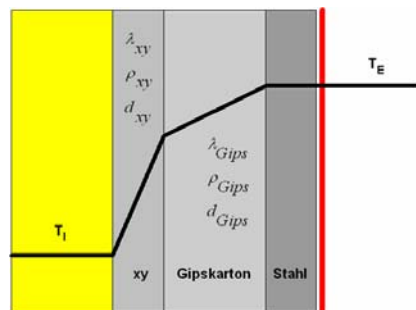


Figure 4: Material Properties –Temperature Profile through Sandwiches

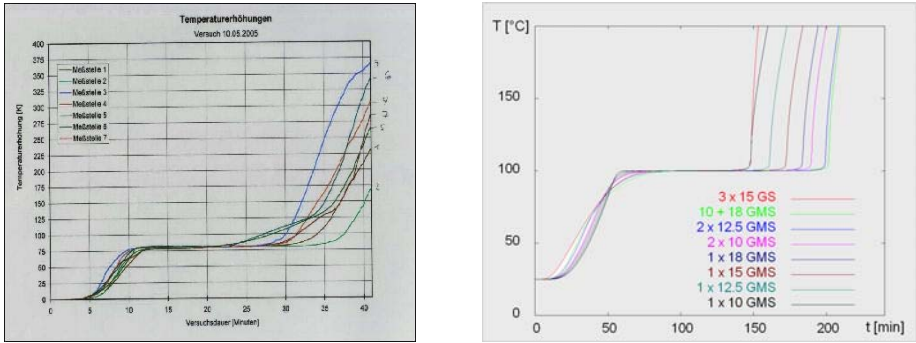


Figure 5: Old Experiments for Calibrating – New Simulations for Forecasting

The simulation program was “fitted to reality” via experimental data gained already in 2005, when the temperature development at different regions in the duct’s interior was investigated, as shown in Fig.5 (left). After that, a lot of simulation calculations were done, with varying combinations and differing thickness of materials. From time to time the results of the most promising candidates were verified again by experiments. The results of a simulation sequence are plotted in Fig.5 (right), with compound selections of gypsum (G), lightweight micro-porous (M) and steel (S).

Back to the general setting of Fig.1: Here, the output y comprises e.g. operability time (simulated), overall costs (calculated), turnover (estimated) – all as a “reaction” to the input x with e.g. inner/outer layer thickness/price (set), storage/manufacturing costs (set/derived); z and ch were irrelevant. knowCube® shows some *GMS-objects*:

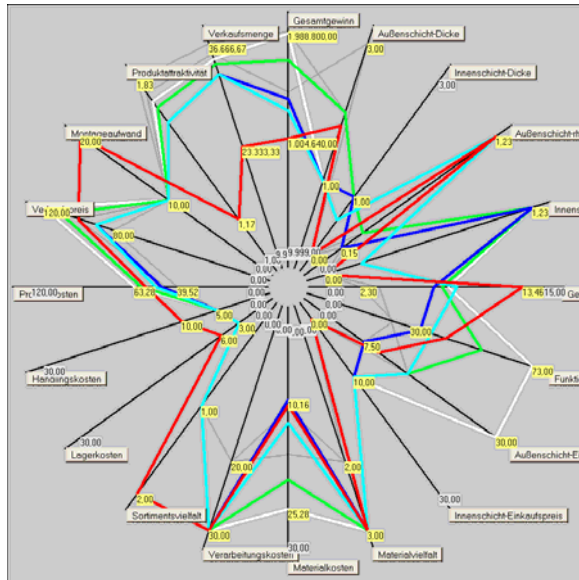


Figure 6: An Excerpt of Novel Products, as Presented to the Executive Board

4 Forecasting of Foams – Response Surface Modeling

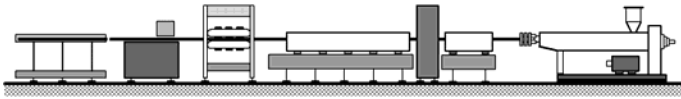


Figure 7: Extrusion Line for Producing Tubes, Profiles, Foams

In reality, *extrusion* is by no means a *white-box*. But, at an industry project, where a *design of experiments* already had been done, the resulting *response surface* was to be taken as “white”, and then to be applied for *forecasting* optimal foam production.

The ideal product/production goal to get is visualized in Fig.8 (left) by a “polygon in bold”, having high(est) compressibility and low(est) thermal conductivity. Besides these two y-outputs there are 12 x-inputs, which were identified as relevant for process control. (Unavoidable disturbances *z* and always changing characteristics *ch* play an essential role in practice, but were not taken into account at that time.) Experimental results from about 140 product/process-*statuses* are represented by *polygons*, where the highlighted ones are already selected according to user wishes.

Based on this background knowledge, some virtual statuses were simulated using the response surface data as mentioned above. The “dark corridor” on the right-hand part of Fig.8 visualizes these forecast results, where some parameter axes are hidden to give focus on the most important facts. Closest to the centre of the “star”, the sketch shows an isolated part of a polygon, pointing downwards. At a mouse-click on it (interactively!), the polygon is highlighted, and corresponding input/output-values are shown additionally, to be taken as suggestions for producing an optimal product.

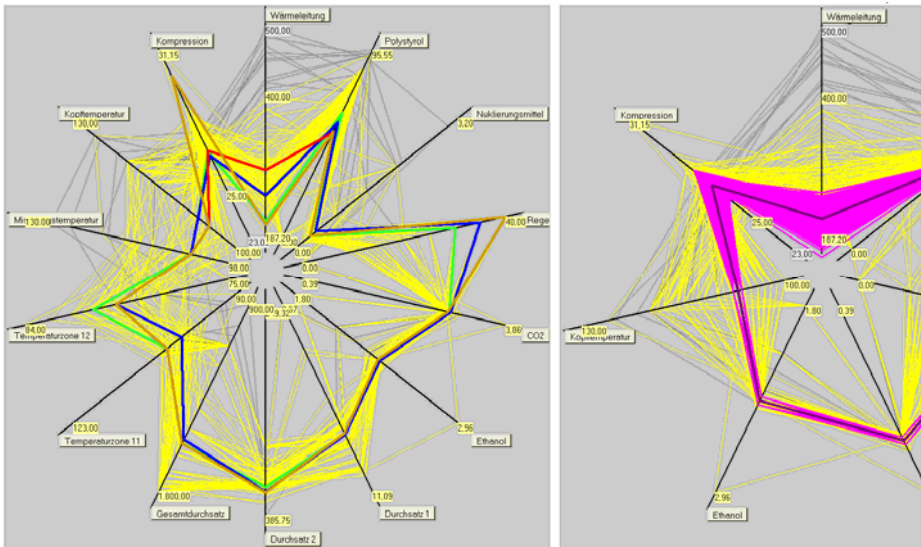


Figure 8: Production/Product Statuses – Forecasting Ideal Foams

5 Designing Drugs – An Outlook to Personalized Medicine

Spektrum und Stärke der Wirkungen nichtsteroidaler Antiphlogistika in vergleichbaren Dosen					
Substanz	antiphlogistisch	analgetisch	antipyretisch	antithrombotisch	fibrinolytisch
Indometacin	+++	+++	+++	++	++
Chinin	(+)	++	+	—	—
Flufenaminsäure	++	+++	+++	+	++
Mefenaminsäure	++	+++			
Ibuprofen	++(+)	++(+)			
Acetylsalicylsäure	+++	+++			
Salicylsäure	+++	++			
Diflunisal	+++	+++			
Salicylamid	+	+++			
Phenylbutazon	+++	+++			
Oxyphenbutazon	+++	+++			
Kebuzon	+++	+++			
Sulfipyrazon	(+)	(+)			
Aminophenazon	+++	+++			
Phenacetin	(+)	+++			
Paracetamol	(+)	+++			

Spektrum der Nebenwirkungen therapeutischer Dosen von nichtsteroidalen Antiphlogistika					
NSA	Magen	Darm	Nieren	Blut	Leber
Salicylsäure	+++	+	—	+	(+)
Acetylsalicylsäure	++	+	++	+	(+)
Diflunisal	++	+	++	+	(+)
Flufenaminsäure	+	+++	+	+	(+)
Mefenaminsäure	+	+++	+	+	(+)
Ibuprofen	++	++	+	+	
Naproxen	++	++	+	+	(+)
Chinin	+	(+)	+	+	
Indometacin	++	+	+	+	+
Phenacetin	—	—	++	++	+
Paracetamol	—	—	++	(+)	+

Figure 9: Non-Steroidal Antiphlogistics, Wanted Effects and Unwanted Side Effects

Due to space, time and project results so far, this chapter only has a bit of “foretaste”.

Pharmaceutical medications historically developed based on empirics (as indicated in Fig.9), and more recently also on some known disease mechanisms – but still the character of a *black box* dominates. Strong causalities are exceptional, and deterministic behavior cannot be expected in this field of life sciences. So, collecting tagged information of past “use cases”, like <patient, disease, anamnesis, diagnosis, therapy, drugs, effects, ...>, and then applying knowCube® for *knowledge discovery* might support intuitive decision making, particularly with qualitative parameters, too. Following up this way, the process of selecting personalized optimal drugs could turn out as *interactive graphical navigation* – like looking for a new used car in Fig.2.

6 Appendix – Usability Evaluation in a Logistics Scenario

As already mentioned at the end of the introduction, the focus of this paper lies on real-life applications. The demands of the partners from industry “for getting good solutions” gained highest priority amongst all tasks, whereas research goals alone concerning the tool and its functionalities were of minor importance.

However, then to choose another way, knowCube® was taken as candidate for a multi criteria decision support system to perform a *usability evaluation* in a *logistics scenario*. For doing so, a newer program version, that allows also “to click into the star” for identifying and highlighting objects, was used, filled with “logistics data” (without any further customizing the software) and then presented to the audience.

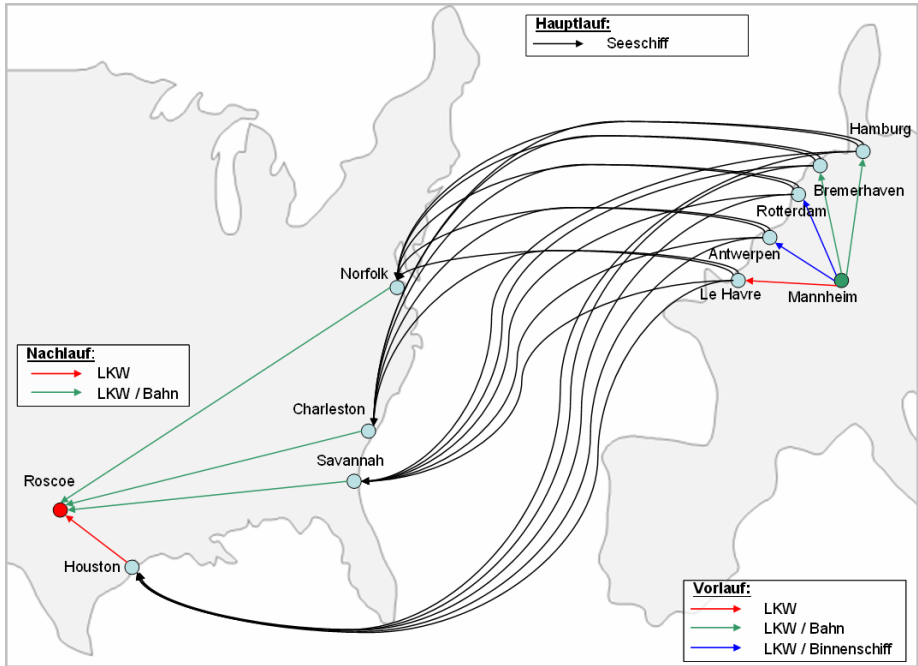


Figure 10: Various Variants of Transport Chains

Sketched in Fig.10 and Fig.11 is the background of a complex business process of delivering repair parts for wind turbines, produced in Germany and shipped to a wind park in the US. (Here this is done very roughly, of course, and in German language – but the “pictures’ message” should be obvious, anyway.) Values of 24 parameters, of quantitative as well as qualitative type, describe the potential transport chains. On a specific day, this ends up with a total of 2,559 variants. Fig.12 conveys an idea, showing an instance with some of the parameters/values that take realistic, but “faked” values.

Now, the logistics scheduler of the company has to make her/his *multi criteria decision* in finding the “optimal solution”, also taking into account expert knowledge that is not contained in the data stored. Additionally, the hectic everyday work gets a lot of dynamics by suddenly emerging events that require immediate changes within an ongoing transport chain – and to not forget: The scheduler handles more than one business process at the same time.

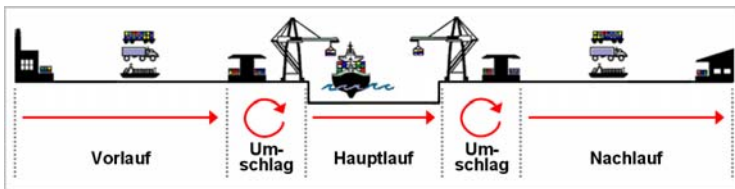


Figure 11: Main “Decision Points” within a Transport Chain

Transporttaublauf	Parameter
Vortlauf: per LKW ex Mannheim nach Umschlagsterminal Bremerhaven	Transit Time: 1 Tag Rate: € 855,- Reliability: 100 %
Hauptlauf: per Seeschiff (Hapag Lloyd) ex POO Bremerhaven nach POD Houston	Transit Time: 16 Tage Rate (all in): € 1.163,- Reliability: 95,1 %
Nachlauf: ex Umschlagsterminal Houston per Bahn/LKW im KV nach Roscoe	Transit Time: 1 Tage Rate: € 911,- Reliability: 100 %
TOTAL	Transit Time: 18 Tage Rate: € 2.929,- Reliability: 98,4 %

Figure 12: Some Parameters/Values of a Transport Chain Instance

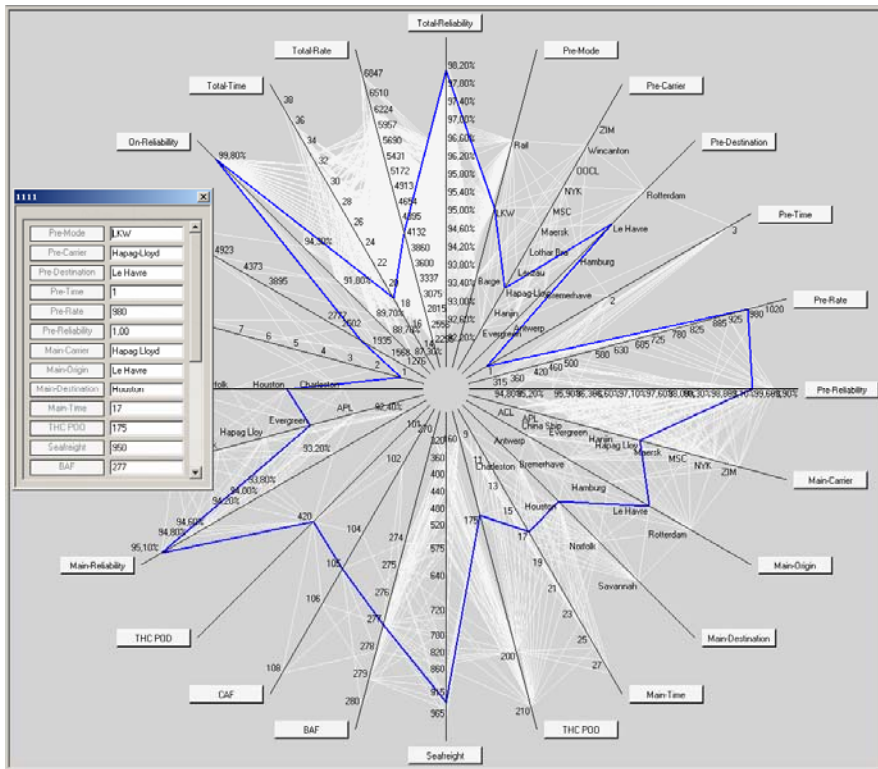


Figure 13: 2,559 Transport Chains – No.1111 Selected+Highlighted via Mouse-Click

“Expensive doesn't always mean good!” That’s a first insight the scheduler gets by merely looking onto all instances of transport chains in the overview in Fig.13, or, somewhat more detailed, by hiding some parameters and then focusing on the upper left part in Fig.14.

The six professional logistics experts taking part in the usability evaluation shared the statement given above. They further stated as major advantages of exploring the decision space interactively (besides the evaluation results contained in Fig.15):

- A quick overview is available on all information at once.
- Undetected relations and sensitivity of parameters become visible.
- Different scenarios may be compared objectively within discussion groups.
- Well-known “Excel-manipulations” (sorting, filtering, etc.) may be done by knowCube®, too – but by graphical means, and there’s much more to do.

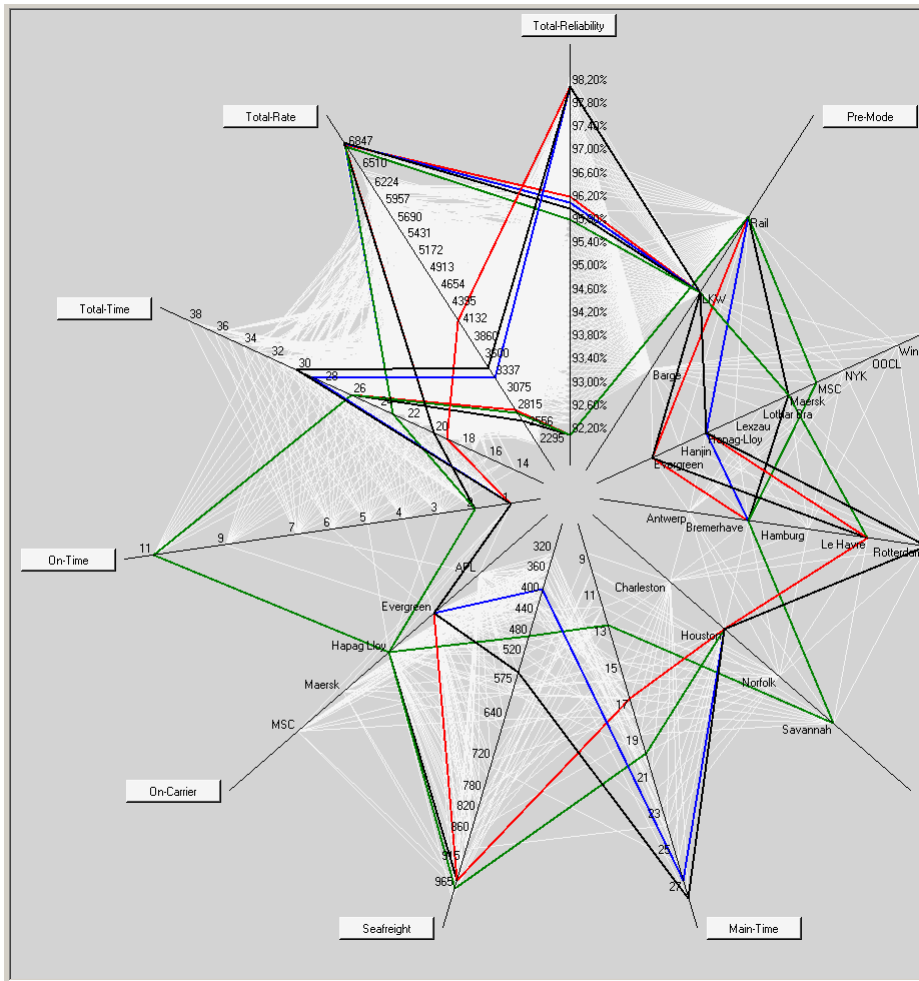


Figure 14: Some “Extreme Clusters” – Quick Overview

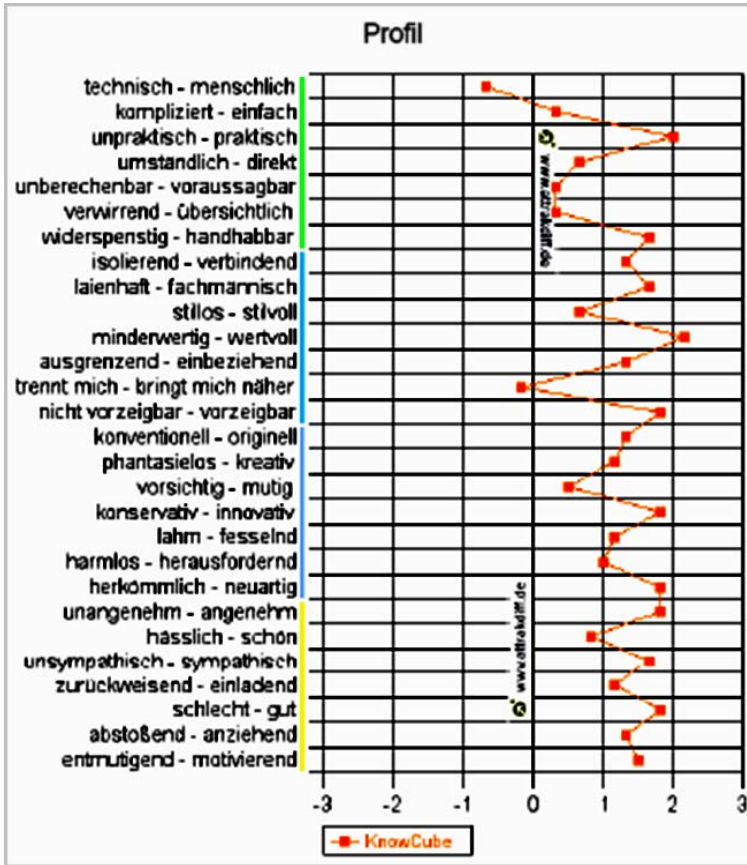


Figure 15: knowCube®, Showing Up Quite Well in an Evaluation

Finally, the author wants to say thanks a lot to Simon Schlicher, who has set up, organized, and performed the evaluation, of what parts are shown here.

References

- [Trinkaus, 05] H.L. Trinkaus, T. Hanne: knowCube – A Visual and Interactive Support for Multicriteria Decision Making; Computers and Operations Research 32, 1289-1309, 2005.
- [Trinkaus, 07] H.L. Trinkaus: Information Exploration via Pen, Brush and Text Marker: Multi Criteria Knowledge Management by Standard Drawing Tools; Proceedings of 7th International Conference on Knowledge Management, 160-167, Graz, Austria, September 2007.
- [Zeleny, 82] M. Zeleny: Multiple Criteria Decision Making; McGraw-Hill, New York, 1982.
- [Zionts, 99] T. Gal, T.J. Stewart, T. Hanne (eds.): Multi Criteria Decision Making – Advances in MCDM Models, Algorithms, Theory, and Applications; Foreword; Kluwer Academic Publishers, Boston/Dordrecht/London, 1999.

Towards Lightweight Semantic Metadata Annotation and Management for Enterprise Services

Patrick Un, Jürgen Vogel

(SAP Research, St. Gallen, Switzerland)

{patrick.un, juergen.vogel}@sap.com)

Abstract: One of the principles of managing structured knowledge of an application domain is to exploit the notion of an *ontology*. Generalization of knowledge entities using formal semantic metadata enables *classification* and *structuring* of knowledge for better metadata management. Classification serves to form *conceptual hierarchy* of ontologies to reflect relationships among entities in the domain semantically while structuring helps to position vertical domain generalizations in appropriate relationships horizontally. We present a novel approach for conceptualization of enterprise application information in such a hierarchy to structure knowledge in abstract and domain specific ontologies in RDFS forming reusable *knowledge bases*. We overcome conceptualization complexities in filigree enterprise information models by focusing on essential aspects of data types and their semantics to align relationship for business objects, enterprise data types and semantic entities with pragmatic consideration on a lightweight semantic information model to maximize flexibility and inferential efficiency service query answering as well as reuse of structured knowledge artifacts.

Key Words: semantic web, enterprise metadata, knowledge management, service oriented computing, lightweight semantic enterprise service, lightweight metadata for enterprise services, ERP services, SAP enterprise services (ES)

Category: H.1.1, H.1.2, H.2.1, H.2.3, I.2.4, M.3, M.4

1 Introduction

The business information model used in enterprise application domain incorporates a very opulent set of enterprise data types, business process entities and a multitude of structured information to cover optimally the informational need of a broad range of business applications. While exhaustive modeling of all tacit and intrinsic knowledge in a certain vertical application domain is possible, it introduces also severe difficulties in the modeling process because of the sheer scope of semantics within such domain. When designing an appropriate and correct conceptualization to reflect the domain richness, there is a tradeoff to make between scalability of the information model and expressiveness of the underlying formalism used to express logical and relational information within it. We focus primarily on the area concerning integration of explicit and externalization of tacit semantic information of SAP *enterprise services* (ES) which provide access to the rich functionalities of SAP ERP systems using standard web service protocols.

2 Overview

2.1 Enterprise Applications Information Model

Despite the fact that ES are supposed to be self-contained, modularized business logics which can be accessed using stateless network protocol, their interfaces and message types are coupled to the underlying stateful business process. Consequently their exposed operations generally incur a degree of statefulness that is hidden away behind the operation invocation. The corresponding ES information and data model also unmistakably possess peculiarities with these characteristics:

- broad application scope,
- rich service interface definition,
- access to service through unified enterprise middleware,
- process oriented service behavioral model which incurs coupleness,
- complex data parameters with sparsely documented data value range or scope information,
- intra-dependencies between data parameters within individual service message,
- inter-dependencies between data values among ES, e.g. parameters in a request require values obtained in previous service calls,
- stateful parameters are required by some ES operations, particular those performing modification operations, e.g. a change state identifier must be included in the request.

These aspects of ES not only influence the behavior of the ES but also have consequences for the design of the corresponding ontologies which must suitably reflect and deal with the above characteristics in the business information model. We briefly describe the information model of SAP enterprise applications [Snabe 2009]. Subsequently, we present ontology design issues with regard to the mentioned peculiarities. In order to structure enterprise data more transparently, we focus on creating ontologies that are vertically modularized according to a specific application domain as a set of manageable ontology units, starting from the most generic enterprise data entities to the more specific ones. The fundamental idea is to separate conceptual entities from their corresponding platform-specific implementation details. We propose to use clear abstraction layers to structure ontological artifacts in a vertical manner for each application domain and use constraints-agnostic syntax to maximize generality and flexibility of the model.

2.1.1 Business Objects

Data of SAP business processes is modeled using entities called *business objects* (BO). They constitute as fundamental entities to build data entities of enterprise processes and store relevant data in them. They mediate between the abstract definition and concrete implementation of business logics to manipulate that data. BO are introduced to enhance good modeling practice by structuring enterprise data in manageable units and externalizing transactional data processing in a series of independent operations defined by the BO interfaces. These help to avoiding duplication of data model definitions or overlapping functionality in the operations. BO represent specific views of data of a well-defined vertical business domain and are the cornerstones of data modeling used by SAP enterprise business systems. BO can be combined horizontally to form more complex data structures. ES need to manipulate enterprise data contained in a set of BO. Their information models are therefore intrinsically linked together via the application context. BO consist of a distinct semantic structure and implementation detail descriptions.

2.1.2 Date Types and Domain Objects

Data types which contribute to the fundamental BO definition are called *core data types* (CDT). They adhere to the principle of separation of type information and the corresponding business semantics in an application-wide standard manner. CDT are syntax neutral and used to represent atomic business entities. They are foundational data types based on, among others, W3C XML Schema primitive types. CDT augment the W3C primitive types by adding attributes to define composite type properties, data value range and valid scope information with uniqueness identified with a CDT identifier. CDT serve as the basic building blocks to form more complex types known as *global data types* (GDT). GDT are divided into basic and aggregated types. ES enterprise data depend on BO which draw from both the CDT and GDT as basis. Basic business semantics are contained within the semantic structure of the BO. The *node data types* and *message data types* form business process components that are built on top of GDT to support structural aggregation of types and forming message partonomies. Inheriting the incurred business semantics from GDT, node data types and message data types represent business semantics that are aligned with the enclosing business process.

3 A Lightweight Conceptualization Approach

We have described the general principles of information modeling for SAP ES using BO in correlation to domain specific vertical enterprise data types. We proceed to discuss our approach to express this rich enterprise information model

semantically with the intension of computational effectiveness. By that we strive to adapt light semantics and annotations that are suitable for efficient query answering and logical inference operation. The prerequisite is creating a lightweight ontologies to align exactly to the existing enterprise information model.

3.1 Requirements

An exhaustive listing of all existing BO and data types is out of scope here, though we have nevertheless obtained accessible documentations describing the enterprise information model that are pertinent to our conceptualization purpose. As a starting point in our attempt to derive the appropriate semantic entities from existing textual ES documentations, we resort to automatic text extraction using available text mining tools that help to speed up the extraction of terminologies; whereas the downside is that human intervention is required in order to isolate the relevant semantic entities, i.e. conceptual artifacts of the enterprise data types and BO entities which are either directly used by or indirectly referenced by the ES. We identify the following processing steps:

1. structure the core enterprise business concepts such as process model, process components, basic data types within an upper level fundamental ontology as a basic reusable layer of our knowledge base,
2. extract and identify relevant conceptual artifacts for the functional description of ES and express the corresponding data type information in a set of shared vocabularies in our ontologies in RDFS [Brickley et al. 2004].

3.2 Contextual Background of Formalisms

There are many ontology languages in the discipline of knowledge representation (KR), to name a few RDF, RDFS and the OWL [McGuinness 2004] family of languages. From an expressive power perspective ordered by increasing magnitude, for instance, OWL's sublanguages such as OWL-DL [Smith et al. 2004] [Patel-Schneider et al. 2004] is semantically aligned with description logics (DL) [Baader et al. 2007] and allows to provide a high degree of expressiveness yet retaining decidability and computational completeness [Hustadt et al. 2005]. However the downside of using this formalism incurs higher reasoning complexity in the knowledge inference process if we adopt the higher potential to express our conceptual enterprise information model. Consequently using highly expressive ontologies could hamper computational efficiency or even lead to undecidability [Hustadt et al. 2005] in worst case. Some of our evaluations show firstly that in the grassroot level of field-deployed ES, we practically just need to describe only a subset of informational semantics in our model which does not cry out for the full set-based expressive power of the abstract syntax [Patel-Schneider et al. 2004]

of OWL. For instance, we have discovered that it does not enhance service discovery discernibly even if we would have used the higher expressive constructors of OWL-DL to constraint entities to describe the ES. Secondly we focus on facilitating more efficient ES discovery supported by stateless service annotations that view the ES basically as providers of stateless operations and thus disregard the stateful aspects such as conditions and effects. This approach lies at the core of the *lightweight modeling* [Horrocks et al. 2006] of services with reduced expressiveness of the annotation formalism to favor more efficient service query answering on instances matching. Thirdly doing a survey of existing semantic service approaches, we have discovered that many of the past efforts such as WS-MO/WSML [de Bruijn & Lausen et al. 2005, de Bruijn & Heymans et al. 2007, de Bruijn & Kopecky et al. 2008], OWL-S [McIlraith et al. 2007] and FLOWS [Grüninger et al. 2008] are sound and complete computationally, they have yet failed to gain wider adoption in the service community for some reasons:

- they generally require service modelers to express service statefulness using logical axioms within a state machine based descriptions of the behavioral service interfaces,
- service state changes are described and expressed as conditions and effects bound to the state transitions of the internal abstract state machine of services,
- ES have complex data-centric messages and interfaces which are better viewed from a stateful perspective [Deutsch et al. 2009] in a process oriented usage context. However, this view also implies that one *must* write logical axioms to express conditions for state changes which is not easy for many service modelers or laymen. Moreover some real-world ES application scenarios show that such heavy-weight conditions are only helpful in stateful *service composition* supported by logical reasoners but *not* necessarily indispensable for *service discovery* using service instance matching against query in a local closed world context [Grimm & Hitzler 2008],
- WSML [Steinmetz et al. 2008] for instance is divided into different flavors ordered by increasing expressiveness. Although it is capable of using either DL or rule based logic programming to model service behavior, the drawback of a-priori axiomatizing the internal state machine of ES using archaic logical statements has pushed a large amount of complexity to the end user of semantic services which hampers wider practical usage.

Consequently drawing a pragmatic conclusion, the novelty in creating our lightweight ontologies is that they can be adequately expressed in RDFS. If one reduces the expressive power of the formalism and attempts to enhance discovery query answering speed, one utilizes the tradeoff advantageously to harness RDF

and RDFS in service annotations for speed and simplicity. By adopting the stateless view of the ES, we simplify the ES service model further to incorporate solely the input and output messages of ES as essential parts of describing them. The constituent message structure can be expressed in paronomies (structured parts) which themselves can be described conceptually in RDFS and generated on-the-fly in RDF.

3.3 A Lightweight Ontological Hierarchy

The rationale discussed above leads us to represent the essential enterprise information in our domain starting from a small set of usecase contexts driving the ES. From this perspective we identify semantic dependencies of the enterprise data types to individual ES. This is necessary to semantically annotate the functional interfaces of the ES. Due to coherent consideration, common enterprise data type are conceptualized in an upper level fundamental ontology using RDFS. Not only the business domain concepts but also relations among them are captured w.r.t. the existing enterprise information model. Detailed expertise and refined knowledge of the business data and type information are required to decide on retention and elimination of entities used by the pertinent ES. Our modeling uses the WSMO-Lite [Kopecky et al. 2008] service model and annotations to provide a lightweight mechanism to integrate a certain number of ES. We also use RDF to create enterprise data instances (in the input and output message and paronomies) according to the service model. ES annotations can be referenced using the SAWSDL mechanism [Farrell et al. 2007] to semantically link conceptualized enterprise data (in the *semantic space*) to the types in the WSDL interfaces (*service message space*). At runtime concept instances are created in RDF on-the-fly from our fundamental ontology by a semantic execution environment (SEE) which can use RDF-triplestores for persistence. Because of the close resemblance of the enterprise data with the actual XML types, we have decided to follow closely the naming scheme of these entities and name them accordingly. Provided that data type mapping and grounding information [Kopecky et al. 2008] is created to map between XML types and the corresponding semantic concepts referenced by SAWSDL, the SEE is capable of providing the necessary implementation of data transformation operations at runtime to convert conceptual instances in the semantic space to and from operational enterprise data in the service message space with properly enforced type mapping and validation. Message transformation operation can be divided into a *lifting* and a *lowering* operation [Kopecky et al. 2008]: during runtime lifting refers to transforming XML instances into the corresponding semantic concept instances and lowering vice versa. In SAWSDL [Farrell et al. 2007] 'liftingSchemaMapping' and 'loweringSchemaMapping' attributes are used to refer to the dedicated transformation services that implement such operations.



Figure 1: Fundamental upper level conceptualization excerpt

In a first attempt we have provided a set of shared conceptualizations of the pertinent enterprise entities described in a concept hierarchy of ontologies with over 570 RDFS classes of entity concepts, approximately 390 RDFS properties and roughly 690 individual instances. An excerpt of this ontology is illustrated in figure 1.

The principle of separation of abstract business semantics of enterprise data type from implementation is extensively followed. Both the business concepts and relations among one another helps to facilitate easier extension of the fundamental ontology with more specific business entities. From a reuse point of view, a middle-level application domain specific ontology can introduce more vertical concepts of the specific domain from our upper-level fundamental ontology. While the entities of an ES such as *BusinessDomainConcept*, *BusinessObject* and *BusinessObjectNode* are captured in the upper-level fundamental ontology in the shared vocabularies, the additional domain specific entities defined in future extensions should be isolated outside the fundamental ontology for best practice.

More specific vocabularies for message parts can be preferably described using existing vocabularies. We refer to this as the layering approach of structural conceptualization because the middle-level shared ontology reuses and extend the upper-level fundamental ontology. Furthermore shared middle-level ontology serves as a necessary stratum again for further extensions. In our case we

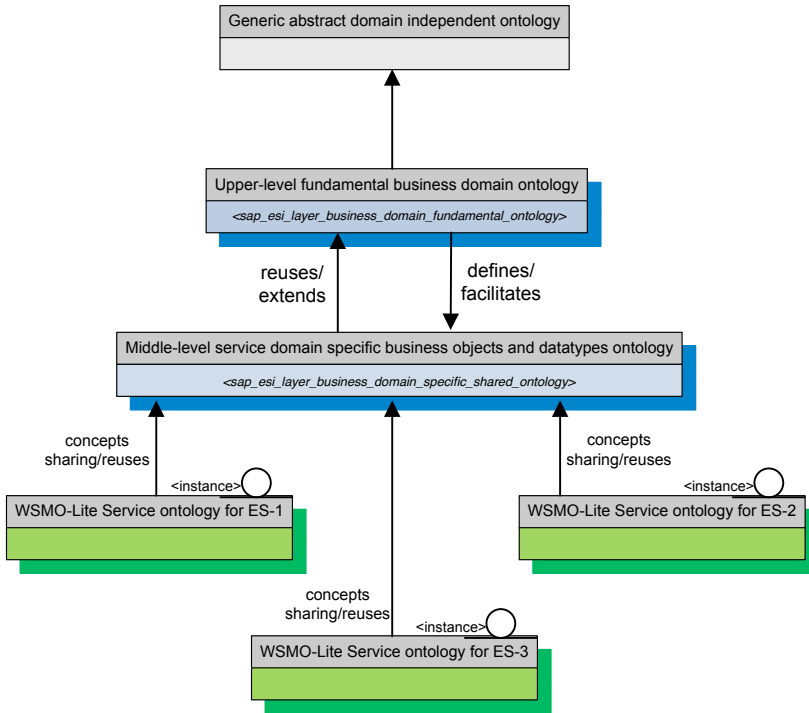


Figure 2: Ontology hierarchy of structural approach of semantic conceptualization for ES

have tried to create WSMO-Lite ES service ontologies [Vitvar et al. 2008] which extends the provisions from the middle-level shared ontology. The conceptual hierarchy of this setup is shown in figure 2.

3.4 Applicable Context

Obviously applicability of our methodology lies firstly in applying it to SAP ERP systems where a multitude of ES are deployed in scenario specific business context called ES bundles. We have attempted to define the previously described conceptual hierarchy of ontologies within the vertical domain of public sector e-government services that are backed by SAP ES. Our usecase scenario of registration process for new business in the public sector has served to guide us to decide on what enterprise data entities to conceptualize. Once that has been done, we have annotated many services in existing ES bundles to create candidate ES ontologies including message instances and the appropriate partonomies. We have linked in these artifacts in their WSDL interfaces using the SAWSDL

modelReference attribute to create pointers back to the XML syntax. All RDF artifacts go into a triplestore called the *Semantic Space* which serves as our preliminary knowledge base (KB). As a proof-of-concept regarding applicability, we have used SPARQL queries to formulate stateless ES discovery goals to attempt match on the KB as described in [Horrocks et al. 2006].

To scale horizontally better across different application scenarios (vertical domains), we need to conceive of a methodology to automate the creation of standardized and harmonized vertical middle-level ontologies so that horizontal scaling implies just seamlessly plugging together a set of predefined vertical ontologies from different application domains in order to achieve an enlarged KB. One of the main difficulties still lies in the creation of suitable vertical domain vocabularies from the ES bundle documentations. It seems easier if one has the necessary domain expertise in the respective domains. Even then manual intervention in the decision of inclusion and exclusion of certain concepts and entities still depend on human decision by the knowledge engineers and service modelers since machine aided extraction suits at most as a semi-automated approach. Therefore, scalability can only be achieved when one creates the vertical middle-level ontology for an ES bundle semi-automatically and keep track of consolidation in the horizontal dimension with other existing vertical ontologies. To avoid redundancy of information, for instance, consolidation can be achieved by keeping additional data structures and metadata on the existing vocabularies defined so far in vertical domains to ensure that no duplication or conflicts appear while adding more vertical vocabularies. Service discovery query answering has reached our expectation regarding answering speed and precision. The additional benefits of lightweight semantic service matching have been observed by continuous refining the semantics of the discovery goals in the query using more functional aspects. This refinement exceeds the expressiveness of pure traditional keyword-based matching by incorporating semantically attributed enterprise data within the query formulation corresponding to the WSMO-Lite service model.

4 Outlook and Conclusions

We will focus in our next works on providing service annotations using concepts and properties from consolidated vertical hierarchies to provide scalable and reusable entities of enterprise metadata to annotation more ES to ensure acceptable interoperability across a broader ES environment. We would also devise a generic declarative approach to utilize service annotations to express formal ES invocation conditions and execution constraints for other process oriented stateful services out there. Also a general methodology to dynamically generate service discovery query using declarative annotation artifacts embedded into

service ontologies seems to be beneficial because it alleviates service modelers from writing queries manually.

Concluding the discussion, our contribution lies in the attempt of a lightweight enterprise information model with lightweight ES annotations that are appropriate for a hitherto seemingly complex SAP ES application landscape. Until recently no similar approach is attempted in conceptualization of such an abundant enterprise information model with regard to ES integration and discovery. This methodology aligns with the WSMO-Lite service model in RDF/RDFS and can be used to provide a scalable service discovery and matchmaking framework.

References

- [Baader et al. 2007] Baader, F., Calvanese, D., McGuinness, D., Nardi, D., Patel-Schneider, P., Horrocks, I., Moeller, R., Haarslev, V., Sattler, U. (2007) *The Description Logic Handbook: Theory, Implementation and Applications*. Number ISBN 0-521-87625-7. Edinburgh Building, Shaftesbury Road, Cambridge, CB2 8RU, UK: Cambridge University Press, 2 edition
- [Brickley et al. 2004] Brickley, D., Guha, R.V. (2004) *RDF Vocabulary Description Language 1.0: RDF Schema*. W3C Recommendation 2004.
- [de Bruijn & Heymans et al. 2007] de Bruijn, J. Heymans, S. (2007) A semantic framework for language layering in WSML. In *Proceedings of the 1st International Conference on Web Reasoning and Rule Systems (RR2007)*, p.103117. Innsbruck, Austria: Springer.
- [de Bruijn & Kopecky et al. 2008] de Bruijn, J., Kopecky, J., Toma, I., Steinmetz, N., Foxvog, D., Keller, U., Kerrigan, M., Krummenacher, R., Lausen, H., Sirbu, A., Roman, D., Scicluna, J., Fensel, D., Kifer, M. (2008) *WSML/RDF*. <http://www.wsmo.org/TR/d32/v1.0/>.
- [de Bruijn & Lausen et al. 2005] de Bruijn, J., Lausen, H., Polleres, A., Fensel, D. (2005) The WSML rule languages for the semantic web. In *Proceedings of the W3CWorkshop on Rule Languages for Interoperability* Washington DC, USA. 2005
- [Deutsch et al. 2009] Deutsch, A., Hull, R., Patrizi, F., Vianu, V. (2009) Automatic verification of data-centric business processes. In *Proceedings of the 12th International Conference on Database Theory (ICDT)*, St. Petersburg, Russia 2009. Volume 361 of *ACM International Conference Proceeding Series*, p.252267. ACM Press.
- [Farrell et al. 2007] Farrell, J., Lausen, H. (2007) *Semantic Annotations for WSDL and XML Schema*. W3C Recommendation August 2007.
- [Grimm & Hitzler 2008] Grimm, S., Hitzler, P. (2008) Semantic matchmaking of web resources with local closed-world reasoning. *International Journal of e-Commerce*, Vol.12(2), p.89126.
- [Grüninger et al. 2008] Grüninger M., Hull, R., M., McIlraith, S. (2008) A short overview of flows: A first-order logic ontology for web services. *IEEE Data Engineering Bulletin*, Vol.31(3), p.37.
- [Horrocks et al. 2006] Hull, D., Horrocks, I., Zolin, E., Bovykin, A., Sattler, U., Stevens, R. (2006) Deciding semantic matching of stateless services. In *Proceedings of the 21st International Conference on Artificial Intelligence (AAAI-06)* (pp. 13191324).
- [Hustadt et al. 2005] Hustadt, U., Motik, B., Sattler, U. (2005) Data complexity of reasoning in very expressive description logics. In *Proceedings of 19th International*

- Joint Conference on Artificial Intelligence (IJCAI 2005) (pp. 466471) Morgan Kaufmann Publishers
- [Kopecky et al. 2008] Kopecky J., Vitvar T., Fischer F. (2008) CMS WG Deliverable D11 v0.3 WSMO-Lite: Lightweight Semantic Descriptions for Services on the Web. Working draft. June 2009, STI Innsbruck.
- [McIlraith et al. 2007] Martin, D. H., McIlraith, S. A., Burstein, M., McDermott, D., Paolucci, M., Sycara, K., McGuinness, D. L., Sirin, E., Srinivasan, N. (2007) Bringing semantics to web services with OWL-S. *World Wide Web Journal*, Vol.10(3), p.243277. Special Issue: Recent Advances in Web Services.
- [McGuinness 2004] McGuinness, D. L., van Harmelen, F. (2004) OWL Web Ontology Language Overview. <http://www.w3.org/TR/owl-features/>. W3C Recommendation.
- [Patel-Schneider et al. 2004] Patel-Schneider, P. F., Hayes, P., Horrocks, I. (2004) OWL Web Ontology Language Semantics and Abstract Syntax. <http://www.w3.org/TR/owl-semantics/>. W3C Recommendation.
- [Smith et al. 2004] Smith, M. K., Welty, C., McGuinness, D. L. (2004) OWL Web Ontology Language Guide. <http://www.w3.org/TR/owl-guide/>. W3C Recommendation.
- [Snabe 2009] Snabe, J. H., Rosenberg, A., Moeller, C., and Scavillo, M. (2009) *Business Process Management the SAP Roadmap*. ISBN 978-1-59229-231-8, SAP Press Series and Galileo Press, 1st ed.
- [Steinmetz et al. 2008] Steinmetz, N., Toma, I., Foxvog, D., Keller, U., Kerrigan, M., Kopecky, J., Krummenacher, R., Lausen, H., Sirbu, A., Roman, D., Scicluna, J., Fensel, D., Kifer, M., de Bruijn, J. (2008) WSML Language Reference. <http://www.wsmo.org/TR/d16/d16.1/v1.0/>.
- [Vitvar et al. 2008] Vitvar T., Kopecky J., Fensel D. (2008) WSMO-Lite Annotations for Web Services. In proceedings of 5th European Semantic Web Conference (ESWC 2008). p.674-689. June 2008.

A User-Centred Approach to Define Interactive and Dynamic Video Annotations via Event Trees

Peter Schultes

(Chair of Distributed Information Systems, University of Passau, Germany
schult16@stud.uni-passau.de)

Franz Lehner

(Chair of Business Administration II, University of Passau, Germany
franz.lehner@uni-passau.de)

Harald Kosch

(Chair of Distributed Information Systems, University of Passau, Germany
harald.kosch@uni-passau.de)

Abstract: Interactive video is increasingly becoming a more and more dominant feature of our media platforms. Especially due to the popular YouTube annotations framework, integrating graphical annotations in a video has become very fashionable these days. However, the current options are limited to a few graphical shapes for which the user can define as good as no dynamic behaviour. Despite the enormous demand for easy-creatable, interactive video there are no such advanced tools available.

In this article we describe an innovative approach, to realize dynamics and interactivity of video annotations. First we explain basic concepts of video-markup like the generic element model and visual descriptors. After that we introduce the event-tree model, which can be used to define event-handling in an interactive video formally as well as visually. By combining these basic concepts, we can give an effective tool to the video community for realizing interactive and dynamic video in a simple, intuitive and focused way.

Keywords: interactive video, event tree, video markup, hypervideo, video 2.0

Categories: H5.1, H.5.2, H5.4, D1.7

1 Motivation

In recent years, several projects came up that center on the topic of interactive video. By the means of Fraunhofer institute's "non-linear-video" project [Fokus, 10] interactive video is moving further into our living rooms. Spectators are able to interact with special objects in video by clicking on them or selecting additional material. Interactions generate new presentation layers filled with additional context information like text annotations, images or even embedded videos. The whole system is packed into a set-top-box and visualization is managed by a common television.

The ADIVI video-annotation software from [InnoT, 09] provides an integrated solution for merging video with additional resources. The main focus of ADIVI lies on documentations (e.g. technical) and enriched video reports. Here spectators are

able to configure their own information level by interacting with the given hotspot objects and additional media.

Another project is currently accomplished at the University of Passau called “SIVA Suite” (from [Meixner, 09a] and [Meixner, 09b]). SIVA seizes the idea of YouTube annotations and presents an easy way for adding interactivity to an existing video. The supported features go far beyond the capabilities of the previous mentioned annotation environments: here the user can even branch the storyline or add interactive option dialogs to the underlying video.

The pioneer in user generated interactive video is the internet video portal YouTube with its “YouTube annotations“-framework. In [YouTube, 09] you get a brief introduction on how video users can add graphical shapes to an existing video subsequently without having any further technological know how. These shapes are also applicable as hotspots and can be used for navigating the internal media library.

Especially the great success of YouTube annotations is an indication of the increasing demand for user generated interactive video. As we can see here, even the simplest capabilities – YouTube annotations only support three different, very simple graphical shapes – are used by the video community with growing enthusiasm. When browsing the video library we can find thousands of user annotated videos and, by the way, very artistic and creative ideas: an interactive piano¹, interactive games², videos which provide alternating endings³ and much more.

That raises the question, why a simple method like YouTube annotations is so successful but comparatively powerful technologies like Adobe Flash, Java FX or Microsoft Silverlight are still rarely used for user generated video annotations. There are two reasons for this apparent: first of all these technologies require a relatively high skill level and technical knowledge, which cannot be accomplished by the typical video user. And second – which also constitutes a disadvantage of the tools introduced at the beginning – the user needs special software environments before he/she can start annotating his/her video, which may also lead to deterrent practicing efforts.

As we see from YouTube annotations, tools that do not require any technical skills and are very easy to use can open the way towards user-generated interactive video – or even video 2.0. However, the standardization efforts for interactive video are still in early stages. Lots of problems are not solved until these days and because of the lack of experience with interactive video even not identified. One of these issues is dynamic video annotations. In the approaches mentioned above, we simply can show and hide graphical annotations at certain media time points. The scenario “annotation ‘xy’ becomes visible, when the user clicks on hotspot ‘yz’”, for example, is not realizable. Furthermore, interactive elements are acting statically and, for instance, are not able to change their appearance over the entire video time span.

In this article, we try to make complex dynamics and interactivity accessible for user generated video annotations. Here we will evolve standard methods for the authors of interactive video projects. These can be used to define complex interactivity screenplays by solely operating with graphical editors. The screenplay

¹ <http://www.youtube.com/watch?v=oD-sSolVDiY>

² <http://www.10000words.net/2009/06/quick-guide-to-interactive-youtube.html>

³ <http://www.youtube.com/watch?v=JFVkzYDNJqo>

controls the look and behaviour of video annotations and supports standard mechanisms for handling user-, media time and annotation specific events.

2 Introduction into video-markup and prior work

In [Schultes, 10] we introduced the term “*video-markup*”, by which we mean any sort of graphical video annotations that follow a predefined interface. Video-markup does not change the underlying video material physically, but is maintained separately and synchronously interpreted at video runtime. Contrary to common markup languages like html or xml, video-markup is less of defining but more of annotating nature. In [Ram, 98] this type of markup is called a Procedural Markup Language (PML) contrary to the declarative approach (DML) used in HTML. Video-markup adds additional information, graphical shapes, audiovisual media or interactive elements to an existing video. The impact of video-markup for one thing is that the classical consumer-producer relationship gets broken up, because owner of a video can extend it with additional markup informations during a postproduction step (without modifying the underlying video material). Besides, interactive markup dismisses spectators from their passive roles and animates them to act. Viewers are now responsible themselves for behaviour, appearance and content of their extended video presentation.

In this work our aim is to develop a common procedure for defining a markup script without any programming or technological efforts for the author. Therefore we are currently working on a video markup system, which can be used to view and edit videos containing dynamic markup information. The system consists of three basic components: first, there is a media player which plays the actual video and provides default control functions (play, pause, seek...). Furthermore there are the markup elements which are presented above the video in a separate presentation layer. And finally we have an abstract markup screenplay, which holds all dynamic instructions on the markup elements (e.g. what happens in case of a button-selection and so on).

Before we explain, how dynamics and interactivity are handled in our video markup environment, we first take a look at the markup elements itself: In [Schultes, 10] we already worked out, that a generic approach is absolutely necessary for the definition of a semantic video markup model. This is the only way to ensure, that the markup environment can deal with any new element in the future, no matter how this element acts or what it stands for. Consequently the element palette of our markup system is not limited to a set of elements, but provides a mechanism on loading required markup elements on demand (through the use of plug-ins). We think that this function is less a feature but rather a requirement. Especially from the point of view that interactive video platforms are just coming up and we do not have sufficient experiences. We just cannot predict which markup elements a markup environment must have available in the future. So to reach acceptance by the user community an extensible system is absolutely necessary.

The generic approach is based on two similar technical concepts: first, each element fully describes itself, which means that an element manages its appearance and behaviour itself. So, for example, not the environment paints an element, but the element paints itself on a given graphical context.

The other concept deals with following dilemma: the environment only has basic knowledge about an element and no detail information about its actual interface (so we can reach extensibility). But providing dynamics requires changing the state of an element from the outside and so accessing its interface is yet necessary. Our approach is based on the idea that element specific behaviour can be accessed via generic identifiers represented as string literals. We do so to abstract from a concrete implementation (in an element) towards a generic access method. So every markup element – a simple shape as well as an embedded video – can be seen as a black box which provides standardized methods for querying the graphical appearance as well as dynamically changing its current state. For that reason we identified three basic components that make up a generic markup element and can be used to access individual element state and behaviour:

- **Element-properties**

Each markup element provides a common way, to obtain the value of a given property and to assign a new value to it.

- **Element-actions**

Each markup element contains an access routine, which can be used to request the execution of a given action out of its repertoire.

- **Element-events**

Each markup element must inform the markup environment of element specific changes of its state by sending events (which contain detailed informations about the occurred change). Furthermore each element provides a common way to evaluate user interface events (for interaction).

Our “*generic element model*” is basically an object orientated design pattern, which does not depend on a particular implementation. To illustrate a concrete implementation, figure 1 shows a summary of the generic element interface in the JAVA-programing language.

```
public void paint(GraphicalContext graphics);

public String[] getProperties();
public void setPropertyValue(String property, Object value);
public Object getPropertyValue(String property);

public String[] getActions();
public void executeAction(String action, Object[] params);

public String[] getEvents();
public void addEventListener(String event, IObserver observer);
public void handleUiEvent(Event event);
```

Figure 1: A simplified summary of the generic element interface (in JAVA)

The surrounding markup environment is not aware of the nature and impact of this element components, it only has knowledge on how to access them. As a result we achieve that an existing video markup system can deal with new elements by not knowing any further details of this element. On the other hand we are already able to formally describe a scenario, where elements dynamically change their internal state. We simply have to connect an event with a property-reassign (let’s call it an event-

handler). An example scenario could possibly be: “after the spectator clicked on markup element ‘xy’ (element-event), element ‘yz’ changes its background colour into ‘blue’” (element-property). If we also consider typical environment components like media player, control panel or the embedding website to be instances of the generic element interface, we can define scenarios that exceed the actual video content: “at media time point 00:05:15 (element-event) the markup element ‘xy’ should get invisible (element-property) and the webbrowser (meta-element) should open the link ‘http://siva.uni-passau.de’ (element-action)”. Figure 2 shows a formal description of this scenario in xml notation, which can be used as a markup screenplay implementation:

```

<eventHandler eventSource="mediaPlayer" eventType="mediaTime">
  <detail name="timePoint" value="00:05:15" />
  <actionList>
    <property target="xy" property="visibiliy" value="false"/>
    <action target="browser" action="openLink">
      <Detail name="param1" value="http://siva.uni-passau.de"/>
    </action>
  </actionList>
</eventHandler>

```

Figure 2: A possible formal description for the example scenario

3 Element Descriptors

As we can see in figure 2, the presented concepts are already sufficient for formal description of instructions contained in a generic markup screenplay. But this leads us to the question on what is the advantage of an xml-based script instead of a Flash or Silverlight action script? It would certainly make no difference to the video user because both ways do not seem very vivid to him (without any further technological understandings). The main difference consists in the fact that our generic approach is a domain specific semantic model that opens extensibility and especially visual editing capabilities – which is a great advantage when designing an authoring method.

One of the main usability challenges of our authoring tool is to provide an intuitive way on how the required components (properties, actions and events) can be specified by the user. But as we have seen so far event-handlers are merely defined in a generic way. So an element simply provides information on which properties it supports but not about the actual meaning of its (eventual) property ‘background’ or ‘bg’ or ‘backCol’ etc. Authors are not able to obtain detailed information about the effects and impacts of a generic property label. The markup environment does not care of this at all, because the environment only has to ensure that a new value is correctly assigned.

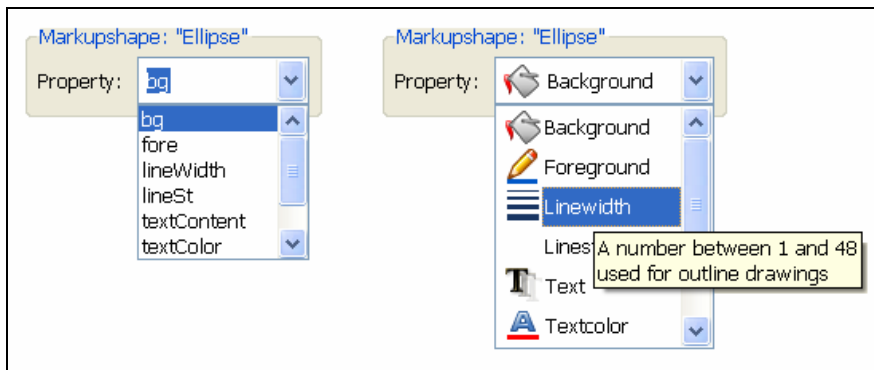
As mentioned above, the environment actually does not know anything about the particular element. But it would be a great advantage for the author of an interactive video, if the annotation tool could inform him about the features of the current markup element in readable form. For that reason we now introduce another concept which we call “*generic element descriptors*”. A descriptor is a meta object which describes its underlying element component (property, action or event) by specifying:

- Label
- Description
- Icon / preview image
- Component details

Component details differ from the particular component type:

- Properties** ➔ Value type, value scope, etc.
Actions: ➔ quantity, type and descriptions of potential parameters
Events: ➔ description of the supported event details (e.g. mouse button, mouse pointer location, media time, ...)

Descriptors are managed by a central registry and can be obtained from there by an editor specifying the element component. The presence of descriptors makes the editing process of video-markup much easier for the author. Especially the visual editing capabilities of component descriptors lead to an enormous increase of productivity (see [Horton, 94]). Figure 3 compares two potential editing tools: the left box ignores and the right box interprets the given descriptors. Another advantage of component descriptors lies in the fact, that they can be appended to an existing element implementation afterwards, because of their declarative nature.



*Figure 3: Two possible tools for specifying element properties visually.
 Left: descriptors are ignored, right: descriptors are interpreted*

Component details provided by a descriptor are very useful during editing process: in case of assigning a new value to an element property it would be pretty convenient, if the author had information about possible valid values at editing time. It would not make sense, if the editing tool allowed specifying a string for the background property of a markup shape. But if the tool already knew about the requirement of a RGB-value through a descriptor, it could offer an appropriate editing method. By interpreting the descriptor we can reduce invalid user inputs and support a faster and more intuitive working process. And as before, the usage of component descriptors still supports genericity, what ensures a maximum of flexibility and extensibility to our markup environment.

As a summary of the results made so far, the following list describes the interaction of all introduced concepts by explaining the process of inserting a new video annotation shape in a video and changing its background colour:

1. Editor palette lists up all markup elements, which are currently plugged in the video markup system.
2. User selects a markup shape and inserts it into the video at a specific media-time point.
3. Markup environment instructs shape to paint itself.
4. Editor queries all properties from the new element.
5. Editor queries all related property-descriptors from the registry.
6. Editor shows the descriptor labels as well as the current values in a table. The current values are queried from the element by using the generic element interface.
7. User double-clicks the “background-colour” row; editor shows a colour-choose dialog in response to the property-type defined in the descriptor.
8. User selects a new value.
9. Editor calls `setPropertyValue(...)` of the generic element interface and updates visually.

4 Event tree model

By now simple instructions and event-handle routines can be modelled formally as well as visually. In the next step we examine how more complex processes in the markup layer can be defined by the author of an interactive video.

Our markup screenplay consists of all actions, which will be executed at video runtime in response to certain events. In the context of video markup, an event is either a media time event occurring in the abstract media player element, a user event (e.g. through input devices) or an element event created by the markup elements themselves (such as “option selected” in a multiple choice element). A markup screenplay action is simply a container filled with arbitrary instructions on markup elements – for example reassigning element properties or executing element actions.

The problem with simple event-handler routines (which we mentioned in section 2) is that authors cannot specify conditional evaluations. For instance the event “option selected” from a multiple choice element could eventually evoke two different actions: either “signal ok” or “signal incorrect” depending on its current selection. So after receiving the target event, the markup environment should compute the resulting action by evaluating the selection-index (= element property!) of the multiple choice element. That leads us to another concept in our semantic video markup model: “*element-conditions*”.

A condition therefore is basically a couple of property-value pairs, which have to be verified at runtime. In detail a condition consist of four parts:

- target element
- target property
- value which must be verified
- operator used for verification (<,=,>, <>..)

As a special case the “ELSE”-condition must also be mentioned, which evaluates to true if all other conditions on the same level are not fulfilled.

Since conditions can be nested hierarchically, a tree structure seems to be suitable as an intuitive visualization: the root elements represent the events containing possible restrictions to event details (e.g. event source, event type, current media time point...). The next levels consist of zero or more nested conditions and finally, at the leaves-level, all actions are stored. However a tree structure also qualifies itself as an appropriate semantic model by making use of nested data items (as we can also see using the example of the Document Object Model). The question here is why shouldn't we use directed graphs instead of trees to avoid the duplication of paths? For example, if two different events evaluated to the same action we could insert a cross-edge in case of a directed graph and reuse the action. A tree structure, in contrast, does not allow us to specify multiple parent-edges, so duplication of the action-node is necessary. But the main benefit of the tree model over a graph lies again in its visible editing capability. Our application can make use of standard tree widgets, which likely everybody has already interacted with. Directed graphs require a more advanced visualization to clarify their edge structure. Since usability is possibly our principle claim, we decided to build our data model and visual design concept on a tree structure.

The following scenario demonstrates the usage of an event tree in combination with the generic video-markup interface. Figure 4 therefore illustrates the appropriate event tree with a standard tree widget and figure 5 shows the related formal description following the xml syntax introduced in figure 2:

The author of an interactive video wants to end his video with a verification question. Therefore he uses a multiple choice shape (containing a question field), some option fields, a (submission) button and a feedback text shape. After the button is selected by the user, the text shape shows feedback information, depending on the selected index in the question shape (let's say index one is the correct answer). As an additional constraint he determines that the evaluation can only be done after media time point 00:05:00. In case of a correct answer the feedback information is “correct!” and the multiple choice element has to dispose. Otherwise “wrong answer” is shown.

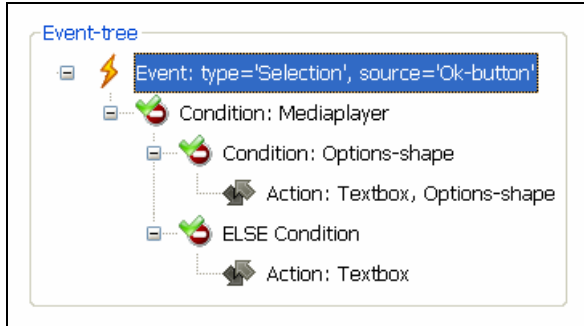


Figure 4: Visual representation of the event-tree taken from the example-scenario

```

<event source="Ok-button" eventType="selection">
  <condition target="mediaplayer" property="mediatime"
    operator=">" value="00:05:00">
    <condition target="Options-shape" property="selectionIndex"
      operator="=" value="1">
      <actionList>
        <property target="Textbox" property="text" value="correct!"/>
        <property target="Textbox" property="visibility" value="false"/>
      </actionList>
    </condition>
    <elseCondition>
      <actionList>
        <property target="Textbox" property="text" value="wrong answer"/>
      </actionList>
    </elseCondition>
  </condition>
</event>

```

Figure 5: Formal description of the example-scenario in xml notation

Furthermore, our editing tool – which is currently in realization stage – supports detail editors for specifying events, conditions and actions contained in the event tree. These editors are implemented by the use of tables and arranged around the event tree pursuant to *Master-Detail*-screen pattern explained in [Scott, 09]. First experiments showed us, that tables are a very convenient and easy to use way for specifying conditions and actions based on element properties. Descriptors (see section 3) can help to equip the tables with labels, icons and descriptions to ensure a user orientated editing process. A reliable way to select reference elements, properties or compare operators is the usage of combo-boxes (as shown before in figure 2). Specifying explicit values (in case of property assigning/constraining) must be done by suitable “in-place”-editors, which depend on the value type of the selected property: for instance a text-editor should come up in case of string-values and the operating system’s colour-choose-dialog in case of RGB-values and so on. Example-editors for event-, condition- and action-details related to the example scenario are shown in figure 6.

Event details

Event-source: ok Ok-button ▼

Event-type: 🖱️ Selection ▼

Condition details

Element	Property	Condition	Value
▶ Mediaplayer	🕒 Mediatime	>	00:05:00

Condition details

Element	Property	Condition	Value
☰ Options-shape	☑️ Selection-index	==	1

Action details

Element	Property	Value
T Textbox	T Text	"correct!"
☰ Options-shape	👁️ Visibility	False

Figure 6: Detail editors for event, action and conditions related to the given example. The displayed action relates to the condition-path in figure 4 (not the “ELSE”-path)

5 Conclusions and future work

Our studies on increasing interactivity and dynamics in user generated non linear video showed us two main aspects: extensibility and a user friendly control concept are of inherent importance to reach acceptance by a potential user community. To achieve this we are currently working on a video annotation system that supports pluggable video markup elements and a graphical authoring environment seizing the idea of YouTube annotations. The aim of this work was to present our main concepts on how we meet the given requirements in our annotation system. The main realization key points therefore are the generic element model, element descriptors and the event tree model, which we introduced in this article. By combining these techniques we are able to implement a video annotation system that fulfils our aims on extensibility, usability and technical features. Currently, our system supports a general media player and several video markup elements. A well defined interactivity screenplay model is also already developed and gets interpreted by the annotation system at start up.

Our next steps include the completion of the authoring tool design, which makes extensive use of the concepts presented in this work. At this point, we also have to consider how moving regions in a video can be modelled and visually prepared for

user editing. Since hotspots are a major feature of interactive video, moving elements will be a central aspect in further considerations. Technical questions on how we can make our system available to as many users will also be part of future work.

References

- [Fokus, 10] Fraunhofer Fokus: Non Linear Video technology which enables interactive content on TV, PC and Mobile Phones, 2010, http://www.fokus.fraunhofer.de/en/fame/_pdf/FOKUS_non-linearvideo_en.pdf
- [Horton, 94] Horton, W.: The Icon book: Visual symbols for computer systems and documentation. Toronto: John Wiley & Sons, 1994
- [InnoT, 09] InnoTeamS Global: ADIVI Instructional Guide, Version 1.0, 2009, http://www.adivi.net/Materialien/ADIVI_manual.pdf
- [Meixner, 09a] Meixner, B., Siegel, B., Hölbling, G., Kosch, H., Lehner, F.: SIVA Producer - A Modular Authoring System for Interactive Videos. In Proceedings of I-KNOW, 9th International Conference on Knowledge Management and Knowledge Technologies, p. 215-225, Graz, 2009
- [Meixner, 09b] Meixner, B., Siegel, B., Hölbling, G., Kosch, H., Lehner, F.: SIVA Suite - Konzeption eines Frameworks zur Erstellung von interaktiven Videos. In Eibl, M. et al (Hrsg.): Workshop Audiovisuelle Medien WAM 2009, p. 13-20. Chemnitz, 2009
- [Ram, 98] Ram, A., Catrambone, R., Guzdial, M.J., Kehoe, C.M., McCrickard, D.S., Stasko, J.T. - PML: Representing Procedural Domains for Multimedia Presentations. In College of Computing, Georgia Institute of Technology, Technical Reports 1998
- [Schultes, 10] Schultes, P., Lehner, F., Kosch, H.: Videomarkup - Vom Videonutzer zum Produzent. In Eibl, M. et al (Hrsg.): Workshop Audiovisuelle Medien WAM 2010. Chemnitz, 2010
- [Scott, 09] Scott B., Neil T.: Designing Web Interfaces: Principles and Patterns for Rich Interactions. Sebastopol: O'Reilly Media, 2009
- [YouTube, 09] YouTube: Erste Schritte: Erstellen oder Bearbeiten von Anmerkungen, 2009, <http://www.google.com/support/youtube/bin/answer.py?answer=92710>

Does Knowledge Worker Productivity Really Matter?

Rainer Erne

(Leeds Metropolitan University, United Kingdom
Rainer.Erne@idp-lab.org)

Abstract: Experts of specific domains form the fastest increasing workforce in the OECD countries. Since this fact has been realised by management researchers, they have focussed on the question of how to measure and enhance the productivity of said workforce. According to the author's research, it is, however, not the measurement and enhancement of an expert's productivity which is to be regarded as the crucial challenge in the management of experts. The author, moreover, has identified five success factors which impose specific challenges on the management of experts. This paper summarises the key arguments for aforementioned perspective, based on empirical research carried out by the author. It defines parameters that constitute expert performance and delineates the implications of this perspective for the theory of and the practice in managing experts.

Keywords: expert, knowledge worker, professional, performance, productivity, management

Categories: A.0, A.1, A.m.

1 Does knowledge worker productivity really matter?

One of the great achievements of Peter F. Drucker, who would have celebrated his 100th birthday on November 19, 2009, is said to have been his ability to anticipate key management challenges decades in advance. In 1969, he defined one such challenge as follows: *"To make knowledge work productive will be the great management task of this century, just as to make manual work productive was the great management task of the last century."* [Drucker, 69, p.290].

In one respect, Drucker was unquestionably right: Nearly all surveys of past decades point to a fundamental structural change in the labour markets of the OECD countries:

- There has been, from 1985 onwards, a 10 percentage-points increase in so-called 'derivative services', e.g. consulting, coaching, teaching, researching, developing and management work [Dostal, 01; Reinberg & Hummel, 02].
- The number of occupations of the categories 'manager', 'professional occupation' as well as 'associate professional and technical occupation' has increased by 10 percentage-points over the last two decades [UK National Statistics, 06; US Department of Labor, 06; Brinkley, 06].
- The demand for employees with an academic education has increased by 190 percentage-points between 1975 and 2004, whereas the demand for employees with a lower educational background is continually decreasing [OECD, 06].
- Levy & Murnane [06] noted a disproportional increase in the demand for two skill requirements within the US labour force between 1979 and 1999: 'expert

thinking' and 'complex communication'. In contrast to this development, they observed that the demand for manual and routine cognitive skills has been continually decreasing within the same time frame.

In regard to Drucker's other thesis, i.e. that the productivity of knowledge workers will be the crucial challenge for 21st century management, he initiated an abundance of research in the description, measurement and enhancement of knowledge workers' productivity [Ray & Sahu, 89; Sumanth, Omachonu & Beruvides, 90; Ahn & Chang, 04; Herman, 04; Ramirez & Nembhard, 04; Davenport, 05; Malik, 06; Stam, 07; North & Gueldenberg, 08] – a stream of research that does not seem to come to an end, neither in the near nor in the remote future.

When focussing not on knowledge workers in general, but on a specific proportion of knowledge workers, namely that of experts, one does not find much evidence in the day-to-day work routines of an organisation for Drucker's second thesis that the measurement and enhancement of its experts' productivity is regarded as a major challenge – 'productivity' understood in the traditional meaning of quantity of output in relation to amount of input' [Pedell, 85]. According to empirical research undertaken by the author, other success factors are paramount in expert work. Factors, which are to be rather assessed than measured. From this perspective, a key strategy for the management of experts can be deduced.

In the paper here presented, the design of the author's empirical study is at first being briefly depicted (chapter 2). Secondly, the key findings of the study are being summarised (chapter 3). And finally, the implications for the management of experts are being delineated (chapter 4).

2 Design of the study

The research question of the empirical study at hand is: What are the crucial challenges in the management of experts and which strategies in order to handle these challenges are being employed? Therefore, the focus is not on knowledge workers in the general, but on that proportion of knowledge workers termed 'experts'. Davenport [05] provides a useful classification for a differentiation of a specific class of experts from knowledge workers in general.

Following his approach, different types of knowledge workers differ in the way in which they transform knowledge into business value: by carrying out routine or complex tasks, by performing individual or collaborative work etc. [Davenport, 05]. The specific contribution of experts to business value consists in their capability of professional discernment, i.e. in applying a comprehensive body of knowledge to individual and rather complex cases. This is the core feature in the work of engineers and consultants as well as of researchers, teachers and physicians (Figure 1).

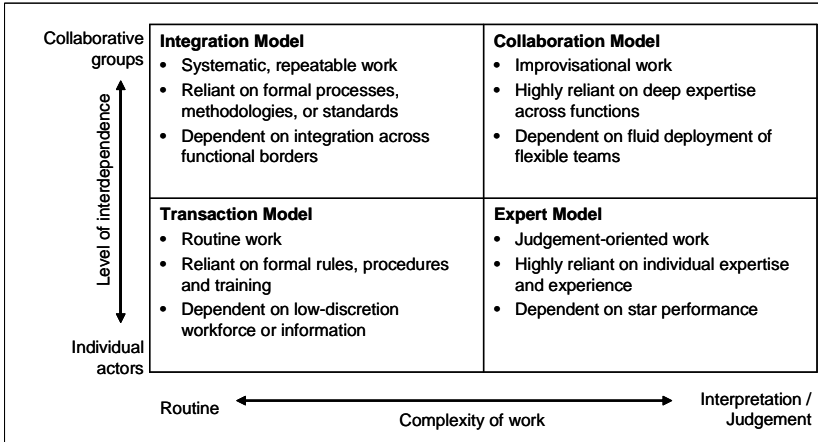


Figure 1: A classification structure for knowledge workers [Davenport, 05, p.27]

Hence, the objects of the study were five different organisations commonly regarded as ‘expert’, ‘professional’ or ‘knowledge-intensive’ organisations in previous treatises [Grossmann, Pellert & Gotwald, 97; Alvesson, 04; Davenport, 05; Brinkley, 06]: a software development company, a hardware development company, a consulting company, a hospital and a university. In these organisations, 42 semi-structured episodic face-to-face interviews [Lamnek, 05] with experts and their managers from three hierarchical levels were conducted by the author. The data gathered by means of the interviews were subsequently coded and interpreted with the aid of Atlas.ti, Version 5.5.4.

Two topics of interest in the context of every one-hour interview with managers as well as experts were: What is success in the respective field of expert work? How is this success measured?

Due to restrictions imposed by the presentation regulations for the submitted papers, the results here presented have been confined to findings with the software, hardware and consulting organisations. Furthermore, the results have been described in an aggregated and abstracted manner necessitated by confidentiality agreements with all participating organisations. Therefore, the original data cannot be disclosed, only referenced.

3 Findings of the study

3.1 What is success in expert work?

The first result of the research consists in the fact that in all knowledge-intensive organisations investigated, a number of success indicators were identified which have been named by experts and their managers independently. Therefore, it can be concluded that these indicators are being relied on collectively within the respective organisation. They may be regarded as collectively motivationally directive and, hence, part of the organisational culture.

For the software development company [Erne, 09c], the predominant success criteria are:

- a. “Good software” which can be described with terms like “correctness”, “stability”, “maintainability”, “expandability” as well as “clarity and transparency of the coding”.
- b. “Planning compliance” which is indicated by the “achievement of milestones” and “correctness of resource estimation”.
- c. “Quality of communication” can be perceived in “communication and cooperation behaviour”, in an “appropriate broaching of topics towards different stakeholders” as well as in the “proactive communication of relevant topics to management representatives”.
- d. “Personal skill development” which was basically regarded to be the “ability to move on to other topics according to business demand” and the “development of comprehension of the entire software system” beyond single functions.
- e. “Innovation behaviour” with respect to the products and processes of the organisation, measured by “patent filings”, the “integration of existing solutions”, measures in order “to reduce lead times” and to “detect software bugs earlier in the development process”.

For the hardware development company [Erne, 09b] we found a very similar picture:

- a. “Quality of results” which can be assessed in static and dynamic hardware tests, by “parts per million” (PPM) failure rates in the operational area and, moreover, by the “number of customer projects acquired”.
- b. “Organisation of work” which is represented in indicators such as “achievement of milestones”, “compliance to the planned development budget as well as the product target costs”, “adherence to customer specifications” and the “observance of internal work standards and processes”.
- c. “Quality of interaction with the relevant stakeholders”, which refers to “communication and cooperation behaviour with all internal interfaces as well as different customers”, a “low escalation rate within the organisation” and the “appropriate broaching of topics towards different stakeholders”.
- d. “Personal skill development”, which refers to an “enhancement in the appreciation of the whole circuit system” beyond the particular task.
- e. “Innovation behaviour” which is indicated by the development of “competitive solutions for the future” in regard to critical topics such as “power dissipation concepts” and “electromagnetic compatibility”.

Finally, the experts and managers in the consulting company [Erne, 09a] mentioned:

- a. “Quality of results”, which means, above all, “running systems” at the customer’s side, secondly, “identified business opportunities”, thirdly, “the number of requests for a certain consultant” and, fourthly, “increased visibility within the organisation and the professional community”.
- b. “Management of one’s own schedule” which becomes visible by the “number of projects a consultant can handle in parallel”, in the “number of identified

- business opportunities” as well as in the “number of public relation activities” of a consultant.
- c. “Quality of interaction with relevant stakeholders” which is represented by the “quality in which a consultant broaches topics within and outside of the organisation”, by “one’s visibility within the business sector” as well as by the “creation of the image of being a trusted advisor for the customers”.
 - d. “Intellectual mobility”, which means that a consultant ought to be able “to move on to new topics demanded by customers”.
 - e. “Innovation behaviour”, which refers to the ability of the consultants to take up new topics on a yearly basis like “Green IT” or “Service-Oriented Architecture (SOA)”.

In short: It is not productivity but five other key factors which are regarded as being the key success factors in the work of experts. These success factors have been named by managers as well as experts in all organisations independently (Figure 2):

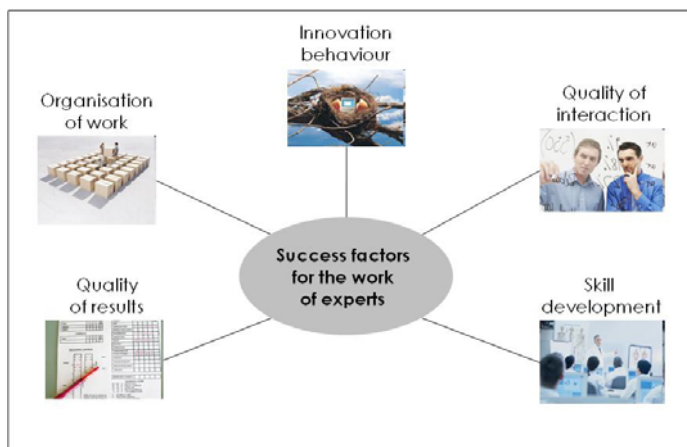


Figure 2: Success factors for the work of experts

3.2 How is success in expert work measured?

With respect to the second question of how these success factors are and can be measured, the statement of a business unit head of the software development organisation can be viewed as being paradigmatic for all other statements: “*We try to make the performance of our associates measurable. (...) But we are not in a timbering, we are in a high technology business segment. (...) Therefore we have to use auxiliary indicators.*” [Erne, 09c]. This statement shows, that the measurement of expert work only relies on quantifiable indicators, which are quite on the surface of an expert’s work: Whether milestones have been achieved, whether the budget has not been exceeded and whether test results show no deviations. The greater part of measuring expert performance is in fact not measurement, but assessment.

Furthermore, there are not only management representatives who measure and assess experts' performance. According to the author's study, at least five stakeholder groups can be identified; stakeholder groups that measure and assess experts' performance: beside business management, there is always a group of technical management such as project, team or group managers supervising experts' work on a professional level. And in addition, there are colleagues and a broader expert community inside and outside of the respective organisation, who assess the work of their co-workers and – on the basis of this assessment – 'label' a certain associate as an expert or not. Last, but not least, all experts have internal and external clients using their products and services (Figure 3).

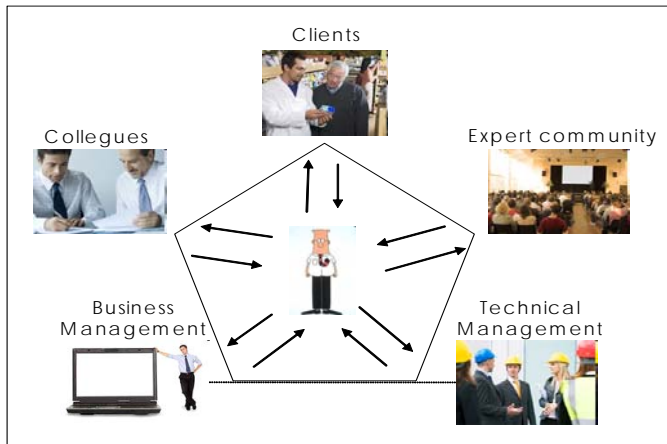


Figure 3: Stakeholders of expert work

If there are different success factors which are measured and assessed differently by different stakeholder groups who have different priorities, the specific challenge in rendering experts productive becomes very clear: Concentration on only few stakeholders and few success indicators.

4 Conclusions

According to the author's study, it is not 'productivity' in the traditional meaning of the term which imposes new challenges on managing experts, but the handling of five different success indicators, which are measured and assessed differently by different stakeholders. The specific challenge in rendering experts productive – across all organisations and business segments examined - is therefore: Concentration.

- Concentration on one or two relevant stakeholders in expert work (and line management might not belong to them),
- Concentration on three or four defined success indicators, which facilitate the focussing by experts,
- Concentration on only few tasks, avoiding multitasking and task switching, both activities verifiably constraining performance ,

- Concentration also with respect to job design and assignment control [Malik, 05], taking into account different strengths and weaknesses of individual experts, especially in the fields of work organisation and interaction.

The principle of concentration can be regarded as the overall and specific challenge in the management of experts.

One predominant task remains: That of designing a way in which “management by concentration” does actually work – and, in a second step, that of proving that this strategy enhances effective – if not productive - expert work.

References

- [Ahn & Chang, 04] Ahn, J.H. & Chang, S.G. (2004) Assessing the contribution of knowledge to business performance: the KP3 methodology. *Decision Support Systems*, 36 (4), pp.403-416.
- [Alvesson, 04] Alvesson, M. (2004) *Knowledge work and knowledge-intensive firms*. Oxford, University Press.
- [Brinkley, 06] Brinkley, I. (2006) *Defining the knowledge economy: knowledge economy programme report*. Research Paper. London, The Work Foundation.
- [Davenport, 05] Davenport, T.H. (2005) *Thinking for a living: how to get better performance and results from knowledge workers*. Boston, Harvard Business School Press.
- [Dostal, 01] Dostal, W. (2001) *Neue Herausforderungen an Qualifikation und Weiterbildung im Zeitalter der Globalisierung*. Berlin, Deutscher Bundestag.
- [Drucker, 69] Drucker, P.F. (1969) *The age of discontinuity: guidelines to our changing society*. New York, Harper & Row.
- [Erne, 09a] Erne, R. (2009) *Interview Transcripts Consulting*. Data Analysis in Atlas.ti V.5.6.3. Manuscript. Stuttgart.
- [Erne, 09b] Erne, R. (2009) *Interview Transcripts F&E_PE*. Data Analysis in Atlas.ti V.5.6.3. Manuscript. Stuttgart.
- [Erne, 09c] Erne, R. (2009) *Interview Transcripts F&E_SW*. Data Analysis in Atlas.ti V.5.6.3. Manuscript. Stuttgart.
- [Grossmann, Pellert & Gotwald, 97] Grossmann, R., Pellert, A. & Gotwald, V. (1997) *Krankenhaus, Schule, Universität: Charakteristika und Optimierungspotentiale*. In: Grossmann, R. Hrsg. *Besser Billiger Mehr: Zur Reform der Expertenorganisation Krankenhaus, Schule, Universität*. Wien, Springer, S.24-35.
- [Herman, 04] Herman, S. (2004) *Produktive Wissensarbeit: Eine Herausforderung*. In: Hermann, S. Hrsg. *Ressourcen strategisch nutzen: Wissen als Basis für den Dienstleistungserfolg*. Stuttgart, Fraunhofer IRB-Verlag, S.207-228.
- [Lamnek, 05] Lamnek, S. (2005) *Qualitative Sozialforschung: Lehrbuch*. 4. vollst. überarb. Aufl. Weinheim, Beltz.
- [Levy & Murnane, 06] Levy, F. & Murnane, R.J. (2006) *How computerized work and globalization shape human skill demands*. MIT IPC Working Paper 05-006 [Internet]. Boston, Massachusetts Institute of Technology. Available from: <<http://web.mit.edu/ipc/publications/pdf/05-006.pdf>> [Accessed 09 January 2007].

- [Malik, 06] Malik, F. (2006) *Führen, leisten, leben: Wirksames Management für eine neue Zeit*. Komplett überarb. Neuaufl. Frankfurt, Campus.
- [North & Gueldenberg, 08] North, K. & Gueldenberg, S. (2008) *Produktive Wissensarbeit(er): Antworten auf die Management-Herausforderung des 21. Jahrhunderts*. Wiesbaden, Gabler.
- [OECD, 06] OECD (2006) *OECD employment outlook. 2006 edition: boosting jobs and incomes*. Paris, Organisation for Economic Co-operation and Development.
- [Pedell, 85] Pedell, K.L. (1985) Analyse und Planung von Produktivitätsveränderungen. *Zeitschrift für betriebswirtschaftliche Forschung*, 37 (12), S.1078-1097.
- [Ramirez & Nembhard, 04] Ramirez, Y.W. & Nembhard, D.A. (2004) Measuring knowledge worker productivity: a taxonomy. *Journal of Intellectual Capital*, 5 (4), pp.602-628.
- [Ray & Sahu, 89] Ray, P.K. & Sahu, S. (1989) The measurement and evaluation of white-collar productivity. *International Journal of Operation & Production Management*, 9 (4), pp.28-48.
- [Reinberg & Hummel, 02] Reinberg, A. & Hummel, M. (2002) Zur langfristigen Entwicklung des qualifikationsspezifischen Arbeitskräfteangebots und -bedarfs in Deutschland: Empirische Befunde und aktuelle Projektionsergebnisse. *Mitteilungen aus der Arbeitsmarkt- und Berufsforschung*, 35 (4), S.580-600.
- [Stam, 07] Stam, C. (2007) *Knowledge productivity: designing and testing a method to diagnose knowledge productivity and plan for enhancement*. Ph.D. thesis, Universiteit Twente.
- [Sumanth, Omachonu & Beruvides, 90] Sumanth, D.J., Omachonu, V.K. & Beruvides, M. G. (1990) A review of the state-of-the-art research on white collar / knowledge-worker productivity. *International Journal of Technology Management*, 5 (3), pp.337-355.
- [UK National Statistics, 06] UK National Statistics (2006) *All in employment by socio-economic classification (NS-SEC) (Not seasonally adjusted)* [Internet]. London, UK National Statistics. Accessible at: <<http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=7919>> [Accessed 20 August 2008].
- [US Department of Labor, 06] US Department of Labor (2006) *Occupational outlook handbook* [Internet]. Washington, Bureau of Labor. Accessible at: <<http://www.bls.gov/oco/home.htm>> [Accessed 09 January 2007].

Industrialisation of the Knowledge Work: Business and Knowledge Alignment

Robert Woitsch

(BOC, Bäckerstraße 5, Wien, Austria
robert.woitsch@boc-eu.com)

Vedran Hrgovic

(BOC, Bäckerstraße 5, Wien, Austria
vedran.hrgovic@boc-eu.com)

Dimitris Karagiannis

(University of Vienna, Wien, Austria
dk@dke.univie.ac.at)

Abstract: An industrialisation of knowledge intensive work can be observed when analysing the transformation of the information society. This means that knowledge work reached a maturity that it can be expressed in form of processes, semantics or rules. When applying a business process oriented view - where knowledge is required to perform certain tasks – such mechanism can be used to develop a so-called knowledge conveyer belt, where knowledge is provided to the knowledge worker in a similar way like material is provided on a production belt. This paper introduces a knowledge conveyer belt as a realisation framework for process-oriented knowledge provision. This approach enables a business and knowledge alignment modelling mechanisms that keeps the “human in the loop”. Samples of projects are mentioned to show the applicability of this knowledge conveyer belt approach.

Keywords: Knowledge Management, Knowledge Management Processes, Service-Oriented Knowledge Management, Knowledge-Bus

Categories: M.4

1 Introduction

Knowledge work is becoming mainstream and emerges towards a holistic critical success factor. Focusing on the business-aspects it can be stated that almost all areas of daily work within an organisation are affected by the way knowledge is treated.

As business process management is commodity today the challenge of business and knowledge alignment can successfully be realised by applying process oriented knowledge management (POKM) [Hinkelmann, 2002]. Observing the development of POKM over last decade, it can be seen that the role of ICT changed from an “enabler” that provides a set of tools from which the knowledge worker has to choose towards an “assistant” that not only provides a set of tools and knowledge but partly handles the so-called orchestration. Hence the selection of knowledge or tools that was previously in the hand of the knowledge worker had been continuously be delegated to ICT through suggestion mechanisms, supporting or assistant systems.

The authors see this development as an evolution towards a higher maturity of knowledge work and knowledge management. Three prerequisites for the raise of maturity can be identified: (1) Knowledge management became sufficiently mature and hence can be better specified. This leads also to a better distinction from other management approaches. (2) Knowledge virtualisation - having its origin from service oriented approaches and now being part of the Internet of Things philosophy - provides mechanisms to handle the heterogeneity of knowledge and therefore enables the integrated and homogeneous management. The “knowledge product” defines knowledge in a consumable way for the worker (cmp. [Mak, 2005]) by applying virtualisation principles known from the service paradigm. Each knowledge product can be aligned with the consuming business process in a similar way like IT-Infrastructure is now aligned with business [Karagiannis, 2008]. (3) Modelling and Meta-Modelling developed sufficient mechanisms and tools – especially in the area of semantic technology – knowledge externalisation from domain experts – here the knowledge worker – is better supported and hence reached an appropriate maturity level.

This paper provides first a brief observation on these three topics, second the idea of business and knowledge alignment is presented in more detail by introducing the so-called knowledge conveyer belt approach as a realisation framework and third, some use cases from projects are described. Finally a summary and an outlook for the next research and development steps are provided.

2 Observations of Knowledge Management

This section discusses an observation of three prerequisites of business an knowledge alignment, (1) the knowledge management and knowledge engineering evolution, (2) knowledge virtualization using a service oriented approach and finally (3) the knowledge externalization applying models and meta models.

2.1 Knowledge Management and Knowledge Engineering

Before discussing the knowledge support in more detail, the interpretation of KM and KE in the viewpoint of the authors is introduced. First the area of interest called knowledge space is specified.

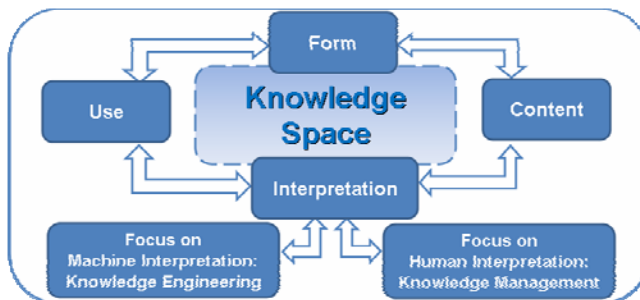


Figure 1: Knowledge Space and its Interpretation

Figure 1 introduces the knowledge space that is defined by four dimensions: (1) the form of the available knowledge, (2) the content that is provided, (3) the interpretation of the knowledge and (4) the usage of the knowledge.

The form represents the syntax and semantic of the knowledge (like group of human experts, text documents, statistics, etc.). The content is seen as the domain, in which KE is applied. The use defines how KE is applied and how the user interacts with the knowledge system. The interpretation of knowledge is either focused on machine interpretation – in terms of KE or on human interpretation - in terms of KM. KE focuses on machine interpretation, applying machine interpretable formalisms like ontologies, whereas KM focuses on human interpretation applying human-friendly notations like graphics that represent knowledge for the chosen domain.

In both cases model-based approaches provide concepts for the formalization although the level of formalisms is different. Humans have the ability to interpret incomplete and partly corrupted models – such as mind maps, processes or textual guidelines - , whereas machines require knowledge representations in a complete and correct manner – such as ontologies, workflows or rules.

2.2 Knowledge Virtualisation

The first phase was the introduction of the Process Oriented Knowledge Management (POKM) [Hinkelmann, 2002]. The second phase was discussing the realisation of POKM via introduction of the Service Oriented Knowledge Management (SOKM) [Woitsch, 2004]. The third phase cover knowledge integration using services [Maier, 2005] or mashups [Schmidt, 2009].

Process Oriented Knowledge Management Approach. Several initiatives contributed to the process-orientation in the context of knowledge [Gronau, 2003]. Today beside PROMOTE® [Karagiannis, 2000] [Woitsch, 2004], there is also the KMDL [Gronau, 2003] approach that reached commercial level for knowledge management. A reference framework is provided from EuReKI [Gronau, 2005].

Service Based Realisation of Knowledge Management. The Service Oriented Knowledge Management (SOKM) is based on the assumption that successful implementation and execution of KM relies on tools, resources and humans that can be virtualised. It introduces the usage of Knowledge Services (K-S) on a conceptual level and on a technical level [Valente, 2001], [Woitsch, 2004], [Lindsteadt, 2008], [Maier, 2005].

Knowledge Integration Frameworks. The Knowledge Bus is mentioned in MATURE [MATURE, 2009] as an integration approach for K-S that can be realised following two major integration approaches. First integration approach is the Service Oriented Approach using an Enterprise Services Bus [IBM, 2009] as technology and Virtual Organisations as a concept to manage K-S. An alternative approach are Enterprise Mashups [Jhingran, 2006], [Daniel, 2007], [Maximlien, 2008] enabling a similar frameworks to connect Web-resources and define data exchange. An interested issue in research is to “materialize” the virtualised knowledge back, especially when aiming to virtualise and materialise human knowledge like in [SkypePrime, 2009], [BPEL4People, 2009].

In the following this paper focuses on the service oriented approach.

2.3 Knowledge Modelling and Meta Modelling

Knowledge models are considered as an instrument to formally externalize knowledge. Hence a conceptual integration of knowledge models and business process models, enable the business and knowledge alignment. As a solution the meta model approach is selected, as both knowledge and business models can be formulated in meta-models. The meta model approach depicting the layered model stack by Strahinger [Strahinger, 1996], and adapted by Karagiannis [Karagiannis, 2006] defines modeling languages by syntax, semantics and notation in order to provide the necessary modeling primitives for building models. The concepts that describe the modeling language are defined in the meta meta model language. Knowledge models and knowledge modeling languages can be defined using a meta-model in order to transform, exchange, reference and integrate models [Kühn, 2004], [Kühn, 2003]. The ADOxx[®] meta model has been selected and will be focused in the rest of the paper.

3 The Knowledge Conveyor Belt

The knowledge conveyor belt approach supports the knowledge worker providing knowledge in a similar way like material is provided on a production line [Hrgovic, 2009]. In such a scenario the knowledge worker not only gets informed on tasks to be done but also gets the necessary knowledge for these tasks in a personalised manner. This enables the worker to deal with the provided knowledge as well as with required tools.

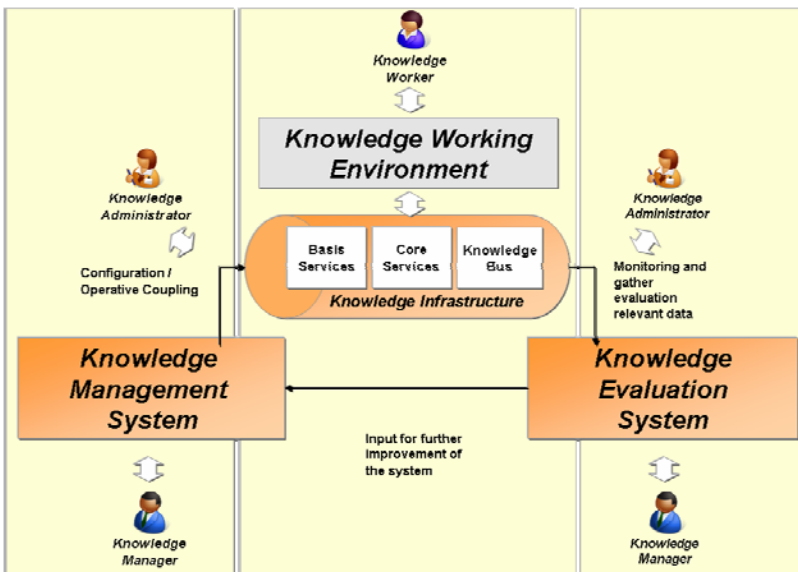


Figure 2: Overall architecture of knowledge conveyor belt

Figure 2 introduces the knowledge conveyer belt that consists of (1) the knowledge working environment that is the system the worker is interacting with, (2) the knowledge infrastructure providing the basis, (3) the KM and (4) evaluation system that is used by the knowledge manager to configure the system.

3.1 The Conveyer Belt realised with KE in the eGovernment Domain

The application scenario refers two e-Government EC research projects (LD-Cast, FIT) that realise the knowledge conveyer belt. In the case of LD-CAST project [Catapano, 2008] ontologies are used to delegate the decision on selecting appropriate services - the worker was not able to select - to the knowledge conveyer belt. The FIT approach [Hrgovic, 2008] was about configuring an adaptive system, which is able to support the knowledge work even in weakly - structured and thus changing processes. The aim in both approaches was to introduce and use the knowledge conveyer belt in order to provide available knowledge to the knowledge worker in an automatic way. Both approaches were realised applying the following three phases:

1. *Application Perspective Modelling*

The first phase is the modelling of the application domain knowledge in form of business processes and domain models. Both projects applied the modelling environment ADOegov[®] that is based on the business process management toolkit ADONIS[®] with extensions for eGovernment.

2. *KE Modelling*

The FIT project involved first the creation of the ontologies in order to use that knowledge to define business rules and to enrich the workflows. The workflow was enriched with a so-called “adaptive” workflow item. An adaptive workflow item is not represented as a sequence but as a set of rules that have to be considered. During the execution the so-called adaptive workflow item was represented as a Web-Service – so conceptually treated by the workflow engine like any other service to invoke –, which implements a rule enactor. This enactor is responsible for translation of the application data provided by the workflow engine used for the invocation of the rule engine.

The LD-CAST project involved the creation of domain ontologies and abstract workflows. The ontology was enriched with end user specific parameters. The next step was to bridge the gap between business processes and abstract workflows by using ontologies for the annotation. Finally the services required for execution had been bound to the abstract workflow via the enriched ontology. The binding of concrete services to abstract workflows took place during runtime (see [Catapano, 2008] for more details), which enables the binding of concrete knowledge resources based on the end user inputs.

3. *K-Bus Deployment Modelling*

The third phase is to deploy the executable Knowledge Bus (K-Bus) models into the K-Bus infrastructure. This includes either the use of legacy application or requires the integration of new tools like ESBs, workflows or rule engines depending on the IT-landscape of the organisation. In the aforementioned sample the K-Bus was deployed by the installation of workflow engines, rule engines, Web-Service containers and ontology management systems. There was additional effort in adapting some of the tools in order to fully realise the K-Bus (see [MATURE, 09] for details).

3.2 The Conveyor Belt realised with KM and KE in the Career Advisor Domain

This application scenario of the knowledge conveyer belt realises the K-Bus using KM and KE technologies in the domain of a career advisor in the EU-project MATURE. The aim is to support the career advisor who has to interview young people asking for career advice in coordinating the interviews in different domain and in different client situations with expert advisors. Although the procedure in holding an interview has similar structure, there are differences when it comes to prepare the interview, involve the expert for review and advices and finally write the guidance notes.

The coordination effort that followed a strict pattern was supported via workflows foreseeing business rules for adaptivity. The current prototype does not use the business rules but only the sequential workflows, but the same mechanisms like in the aforementioned FIT project are foreseen to be used on a later stage of the prototype.

The knowledge support for preparations for domain specific interviews is supported by a process stepper, where the career advisor is guided to domain specific knowledge bases like databases, Internet links and guiding documents, but has then to interpret this knowledge without the support of the K-Bus. Following three phases have been followed during the realization:

1. Application Perspective Modelling

The application domain has been modelled using ADONIS® where three business processes have been identified as being knowledge intensive (1) Create report with expert support, (2) Create report without expert support and (3) Preparation and Research.

2. KM and KE Modelling

In the second phase the aforementioned process stepper and the workflow have been configured. The communication processes have been implemented as BPEL workflows and the communication has been virtualised by services. A pragmatic approach has been selected that uses email services, entries in other person's task lists or common WIKI articles as sufficient communication services.

For the preparation and research traditional knowledge bases such as file repositories, databases and Internet pages have been identified. The search process recommends link lists to guide the user effectively through the knowledge base.

3. K-Bus Deployment Modelling

The third phase is the deployment of the conveyer belt that for test reasons has been installed in parallel to the legacy system and only web-based and file-based integration has been performed. The integration of databases was not tackled as it was technically too resource intensive and from a research point of view not challenging.

The overall deployment is a heterogeneous system, where application services run either at the client side or are provided by third party providers, whereas the K-Bus- including the workflow and the process-stepper - is deployed on a separate server.

In the current prototype the service that are used for the communication are registered and semantically described to enable a loose binding on a later stage of the prototype.

The aforementioned scenarios demonstrate that the knowledge conveyer belt can be implemented in different application scenarios and with different focus. In the KE

scenario the knowledge conveyer belt was implemented to semi-automatically produce knowledge products and decisions have been shifted from the knowledge worker towards the system. In the KM environment the knowledge conveyer belt was used as an assistant system that guided and supported the knowledge worker during software development. In the hybrid scenario both approaches have been used for one application scenario.

4 Summary

The knowledge conveyer belt can be applied for knowledge systems which take over parts of human decisions or to guide the knowledge worker as an assistance system.

Upcoming challenges are the technical evolution of the current systems. This is reflected in new workflow technologies, improved semantic technologies and the challenges of integration.

On the conceptual layer the model-based approach seems to be appropriate but needs to consider that modelling is commodity today, hence the knowledge conveyer belt needs to deal with different modelling languages within different domains and different formal expressiveness.

This paper outlines that, knowledge technologies both, in knowledge engineering and in knowledge management have reached such a maturity that industrialisation of knowledge work can be observed. As the motivation of people to contribute to the knowledge system is essential, the knowledge worker should not only stay “in the loop” of the knowledge system but also needs to get efficient knowledge support.

References

- [BPEL4People,09] BPEL4People, WS-People Extension for People, <http://www.ibm.com/developerworks/webservices/library/specification/ws-bpel4people/>, access: 22.04.09
- [Catapano, 08] Catapano, A., D’Atri, A., Hrgovic, V., Ionita, D.A. and Tarabanis, K. (2008): LD-CAST: Local Development Cooperation Actions Enabled by Semantic Technology, 6th Eastern European eGovernment Days, Prague, Czech Republic, OCG, 2008
- [Daniel, 2007] Daniel F., Matera M., Yu J., Benatallah B. Regis SP., Casati F., Understanding UI Integration. A Survey of Problems, Technologies and Opportunities. IEEE Internet Computing, 11(3):p59-66, 2007
- [Gronau, 03] Gronau N.: Modellieren von wissensintensiven Geschäftsprozesses mit der Beschreibungssprache K-Modeler, in Gronau N. Wissensmanagement: Potentiale – Konzepte - Werkzeuge, GITO Verlag, p3-30, 2003
- [Gronau, 05] Gronau, N. Bahrs, J.(Eds), Prozessorientiertes Wissensmangement – Strategien, Methoden, Erfahrungen und Werkzeuge -, GITO Verlag, Berlin (2005)
- [Hinkelmann, 02]Hinkelmann, K.; Karagiannis, D.; Telesko, R.: PROMOTE - Methodologie und Werkzeug zum geschäftsprozessorientierten Wissensmanagement. In: Geschäftsprozessorientiertes Wissensmanagement, Springer-Verlag, 2002

- [Hrgovic, 08] Hrgovic, V., Woitsch, R., Utz, W. and Leutgeb, A.: Adaptive and Smart e-Government Workflows - Experience Report from the Projects FIT and LDCAST, eChallenges e-2008 Stockholm, Sweden, IOS Press, 2008
- [Hrgovic, 09] Hrgovic, V., Utz W., Woitsch R. Knowledge Engineering in Future Internet, in Karagiannis D., Jin Z. (Eds.) Knowledge Science, Engineering and Management, Springer, Vienna, 2009
- [IBM, 09] IBM, www.ibm.com/developerworks/webservices/library/ws-esbia/, access : 22.04.09
- [Jhingran,06] Jhingran A., Enterprise Information Mashups: Integrating Information, Simply. In Proceedings of the 32nd international conference on Very large data bases, p3-4, VLDB Endowment, 2006
- [Karagiannis, 00] Karagiannis, D. and Telesko, R.: The EU-Project PROMOTE: A Process-oriented Approach for Knowledge Management, Proceedings of the 3rd International Conference on Practical Aspects of Knowledge Management, Basel, 2000
- [Karagiannis, 08] Karagiannis, D., Utz W., Woitsch R. and Eichner, H.: BPM4SOA Business Process Models for Semantic Service-Oriented Infrastructures, eChallenges e-2008, Stockholm, Sweden, IOS Press, 2008
- [Kühn, 04] Kühn, H.: PhD Thesis: Methodenintegration im Business Engineering, University of Vienna, (2004)
- [Linsteadt, 08] Linsteadt et al., Special Track on Knowledge Services, in conjunction with I-Know 2008, http://i-know.tugraz.at/about/previous_conferences/i_know_08/special_tracks/ks, access: 20.04.09
- [Maier, 05] Maier R., Hädrich T., Peinl R., Enterprise Knowledge Infrastructure, Springer Verlag, Berlin 2005
- [Mak, 05] Mak, K.: Der Einsatz des prozessorientierten Wissensmanagementwerkzeuges PROMOTE® in der Zentralkodokumentation der Landesverteidigungsakademie. Landesverteidigungsakademie Wien, (2005)
- [MATURE, 09] MATURE D5.2: Specification of the System Architecture, MATURE deliverable, April 2009
- [Maximilien, 08] Maximilien E.M, Ranabahu A., Fomadam K., An Online Platform for Web APIs and Service Mashups, IEEE Internet Computing, 12(5)p:32-43, 2008
- [Schmidt, 09] Schmidt A., Ley T., Lindstaedt S., Workshop on Knowledge Services & Mashups, in Hinkelmann K., Wache H., (Eds) WM 2009: 5th Conference on Professional Knowledge Management, March 25-27, 2009, Solothurn, Switzerland, GI-Verlag, Bonn (2009)
- [SkypePrime, 09] SkypePrime: <http://www.skype.com/allfeatures/skypeprime/>, access: 22.04.09
- [Stollberg, 07] Stollberg, M., Hepp, M. and Fensel, D.: Semantic Web-Services – Realisierung der SOA Vision mit semantischen Technologien. SWS – MKE conference, 2007
- [Strahinger, 96] Strahinger, S.: Metamodellierung als Instrument des Methodenvergleichs: eine Evaluierung am Beispiel objektorientierter Analysemethoden. Shaker, Aachen, (1996)
- [Woitsch, 04] Woitsch, R.: PhD Thesis, Process Oriented Knowledge Management: A Service-Based Approach, PhD thesis University of Vienna, (2004)

Representing an Approach to Measuring Knowledge Workers Productivity based upon their Efficiency and Effectiveness: a Fuzzy DEA Method

Ali Abdoli

(Amirkabir University of Technology, Tehran, Iran
ali.abdoli@aut.ac.ir)

Jamal Shahrabi

(Amirkabir University of Technology, Tehran, Iran
jamalshahrabi@aut.ac.ir)

Jalil Heidary

(Amirkabir University of Technology, Tehran, Iran
heidaryd@aut.ac.ir)

Abstract: By entering the knowledge age and the appearance of knowledge economy, organizations are more dependent on knowledge workers productivity. Productivity means doing the right things right. It shows how a knowledge worker makes use of resources to fulfill the goals of the organization. This definition makes productivity be the result of simultaneous existence of efficiency “doing the things right” and effectiveness “doing the right things”. Since factors influencing knowledge workers productivity cannot be definitely measured, uncertainty theory plays an important role in this area. So in this paper, first, dimensions of productivity will be introduced and then, by the use of linguistic fuzzy approach and DEA, efficiency and effectiveness of knowledge workers will be measured. Next, a model for measuring knowledge workers productivity will be presented on the basis of efficiency and effectiveness. Finally, values of knowledge workers productivities will be ranked. In the last section, the result of this five-step method is examined through a case study.

Keywords: Knowledge workers, Productivity, Efficiency, Effectiveness, Fuzzy DEA

Categories: M.9

1 Introduction

Productivity is a determinant factor for the success of any organization. This holds true also in the case of knowledge-intensive organizations, which can be defined as any organization in which "Knowledge has more importance than other inputs" [Antikainen, 05]. During recent decades, the core of organizations has moved from being capital or labor intensive to being technology intensive, and the current direction of evolution is towards becoming knowledge intensive [Chang, 09]. With the advent of knowledge economy, knowledge is known as the strategic priority and the main source of competitive advantage of the organization [Choi, 08]. As a result, knowledge workers as people with a high degree of education or expertise whose work primarily involves the creation, distribution, or application of knowledge play a

major role [Davenport, 02]. Peter Drucker (1999) states the challenge today is to measure and increase KW's productivity and declare making knowledge workers productive will be the great management task of this century [Drucher, 99]. Measuring knowledge workers productivity is the first step in this important management task. Potential advantages of measuring knowledge worker productivity include : Improved personal selection, job assignment, identification of redundant skills within an organization, rewards and bonuses, performance forecasts, identification of KW capacity based on 100 percent productivity, strategic planning, address specific needs, work balancing, reduce subjectivity from evaluation, and establish benchmarks [Ramirez, 04]. Meanwhile, it is difficult to measure the productivity of workers whose tasks are not fixed, have no standard production times, and whose task can be performed differently by various workers and not be easily observable [Davenport, 00] .

Traditional productivity measures, total or partial, have certain requirements: The outputs compared have to be similar and comparable both in characteristics and in quality and the data used in measurement has to be quantitative [Kempila, 03]. Furthermore, crisp DEA methods have been employed in cases in which the decision making units were homogeneous; therefore, they are not applicable for workers with contrasting and intangible characteristics.

Currently, there is no universally accepted method that could be used in measuring knowledge worker productivity and much of the literature focuses on differences between knowledge workers and manual workers, and does not identify specific methods for measuring KW productivity [Ramirez, 04]. Consequently, a new technique is asked for through which the knowledge-intensive organizations can measure, compare and manage the knowledge worker productivity, in different levels of any organization and even in various industries.

2 The approach to measuring knowledge workers productivity

In the section a five-step approach for measuring knowledge worker productivity is demonstrated.

First step in measuring knowledge workers productivity is to determine the dimensions of their productivity according to measured society. During recent decades, researchers have introduced various dimensions of productivity as measures of Knowledge workers productivity. The following dimensions being summarized generally are taken from the results of these studies:

- Quantity [Ramirez, 04]: The number of tangible outputs of knowledge workers which are expressed quantitatively.
- Cost / Revenue [Ramirez, 04]: Cost/revenue that enter into the system via knowledge workers directly or indirectly.
- Timeliness [Ramirez, 04]: is associated with completion of predefined times, spent overtime for performing the task and other time-related issues.

- Authority [Ramirez, 04]: The independence and power given to knowledge workers for doing a certain task and successfully employing these utilities in production.
- Quality [Ramirez, 04]: Things that are done right, and can fulfill qualitative goals.
- Creativity/innovation [Ramirez, 04]: The ability of knowledge worker in creating effective ideas to increase productivity.
- Experience [Nickolas, 00; Steward, 97]: Work experience in a certain place and familiarity with its science which affect the knowledge work.
- Education [Drucker, 94; Liebowitz, 99]: Official, analytical and theoretical knowledge which is essential for developing the products and new services.
- According to the presented approach in this paper, the above-mentioned dimensions will be categorized into two groups (figure 1):
- Dimensions influencing knowledge workers efficiency: education, experience, Creativity/innovation, quality, authority, timeliness, quantity.
- Dimension influencing knowledge workers effectiveness : cost

The above approach is a general approach. According to various factors such as the company's goals, analyzer's goals, knowledge workers tasks, etc, it is possible to make use of all dimensions or to consider and classify some of them.

Second step: measuring knowledge workers efficiency.

To do this, we should separate the inputs and outputs of effective dimensions on knowledge workers efficiency according to figure (1).

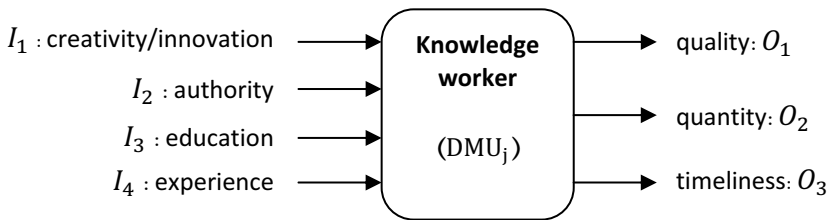


Figure 1: effective inputs and outputs on knowledge workers efficiency

Finally, accessing corresponding amounts of inputs and outputs in figure (2) for each knowledge worker in form of linguistic variables (table 1) and applying fuzzy DEA model introduced in section 3, the efficiency of knowledge workers will be calculated.

<i>Linguistic Variables</i>	<i>Corresponding TFNs</i>
Extremely high (EH)	(0.9 , 1.0 , 1.0)
Very high (VH)	(0.7 , 0.9 , 1.0)
High (H)	(0.5 , 0.7 , 0.9)
Fair (F)	(0.3 , 0.5 , 0.7)
Low (L)	(0.1 , 0.3 , 0.5)
Very low (VL)	(0.0 , 0.1 , 0.3)
Extremely low (EL)	(0.0 , 0.0 , 0.1)

Table 1: linguistic variables and their corresponding triangular fuzzy numbers

Third step: measuring knowledge workers effectiveness.

In this step, based on determined goal (minimizing cost), the analyzer assess the individual relative effectiveness of knowledge by the use of illustrated equation in section 4.

Fourth step: measuring knowledge workers productivity on the basis of measured efficiency and effectiveness in the second and third steps.

In this state by the use of efficiency and effectiveness taken from steps three and four, fuzzy productivity of knowledge workers, according to introduced model in section 5, can be measured.

Fifth step: ranking knowledge workers productivity measurements.

In final step, maintained fuzzy numbers for each knowledge workers productivity using introduced method in section four will be ranked.

3 Measuring knowledge workers efficiency

Calculating the efficiency of a decision making unit has been considered a difficult task due to its association with complex economy and behavioral inputs [13]. To solve this problem Data Envelopment Analysis (DEA) method was proposed by charnes and other [Charnes, 78] for assessing relative efficiency of decision making units with several inputs and outputs. Most of DEA models are confined to crisp numbers; however, we are faced with a lot of problems when all or some inputs and outputs are ambiguous and indefinite. For instance we are forced to use some linguistic variants such as good, bad, average, etc, when assessing the performance of knowledge workers.

Doing calculations through fuzzy numbers has countless complexities. In order to eliminate this problem, Dubois and Prade proposed a certain type of fuzzy numbers, called LR fuzzy numbers. The most predominant fuzzy numbers in this category are triangular fuzzy numbers whose characteristics and membership function are depicted in equation (1).

$$\mu_{\tilde{A}}(x) = \begin{cases} (x - L) / (M - L) & L \leq x \leq M \\ (U - x) / (U - M) & M \leq x \leq U \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Triangular fuzzy numbers are contacted as $\tilde{A} = (L, M, U)$ in this representation.

Suppose two positive triangular fuzzy numbers $\tilde{A} = (L_1, M_1, U_1)$ and $\tilde{B} = (L_2, M_2, U_2)$. According to expanded basics and specifications by Lotfizadeh [Zadeh, 65], [Zadeh, 99], the algebraic operations for these numbers are as follows

$$add = \tilde{A} + \tilde{B} = (L_1 + L_2, M_1 + M_2, U_1 + U_2) \tag{2}$$

$$subtraction = \tilde{A} - \tilde{B} = (L_1 - U_2, M_1 - M_2, U_1 - U_2) \tag{3}$$

$$multiple = \tilde{A} \times \tilde{B} \cong (L_1 L_2, M_1 M_2, U_1 U_2) \tag{4}$$

$$divisions = \tilde{A} \div \tilde{B} \cong \left(\frac{L_1}{U_2}, \frac{M_1}{M_2}, \frac{U_1}{L_2} \right) \tag{5}$$

$$reverse = \frac{1}{\tilde{A}} \cong \left(\frac{1}{U_1}, \frac{1}{M_1}, \frac{1}{L_1} \right) \tag{6}$$

$$\alpha . \tilde{A} = (\alpha L_1, \alpha M_1, \alpha U_1) \tag{7}$$

The result of equations (4-6) is not a triangular fuzzy number, yet it can be estimated by a triangular fuzzy number.

We suppose n knowledge workers (DMU) each with m inputs and outputs. x_{ij} ($i = 1, 2, \dots, m$) and y_{rj} ($r = 1, 2, \dots, s$) are the input and output of j ($j = 1, 2, \dots, n$) knowledge worker respectively.

All inputs and outputs are thought to be unknown, and they are assumed as triangular fuzzy numbers. $\tilde{x}_{ij} = (x_{ij}^L, x_{ij}^M, x_{ij}^U)$, $\tilde{y}_{rj} = (y_{rj}^L, y_{rj}^M, y_{rj}^U)$ in which $x_{ij}^L > 0$ and $y_{rj}^L > 0$ for $i = 1, 2, \dots, m$ and $r = 1, 2, \dots, s$ and $j = 1, 2, \dots, n$.

Crisp inputs and outputs are shown as a special kind of triangular fuzzy numbers in which $x_{ij}^L = x_{ij}^M = x_{ij}^U$ and $y_{rj}^L = y_{rj}^M = y_{rj}^U$. For measuring the fuzzy efficiency of the j decision making unit, the following DEA model is presupposed [Wang, 09]:

$$\text{Maximize } \tilde{\theta}_0 \approx [\theta_0^L, \theta_0^M, \theta_0^U] \quad (8)$$

$$\text{Subject to } \tilde{\theta}_j \approx [\theta_j^L, \theta_j^M, \theta_j^U]$$

$$j = 1, \dots, n$$

0 indicates the decision making unit (there knowledge worker) and $\theta_0^L, \theta_0^M, \theta_0^U$ are gained from solving the following three liner planning (LP)

$$\text{Maximize } \theta_0^L = \sum_{r=1}^s u_r y_{r0}^L \quad (9)$$

$$\text{Subject to } \sum_{i=1}^m v_i x_{i0}^U = 1$$

$$\sum_{r=1}^s u_r y_{rj}^U - \sum_{i=1}^m v_i x_{ij}^L \leq 0, \quad j = 1, \dots, n$$

$$u_r, v_i \geq 0, \quad i = 1, \dots, m; r = 1, \dots, s$$

$$\text{Maximize } \theta_0^M = \sum_{r=1}^s u_r y_{r0}^M \quad (10)$$

$$\text{Subject to } \sum_{i=1}^m v_i x_{i0}^M = 1$$

$$\sum_{r=1}^s u_r y_{rj}^U - \sum_{i=1}^m v_i x_{ij}^L \leq 0, \quad j = 1, \dots, n$$

$$u_r, v_i \geq 0, \quad i = 1, \dots, m; r = 1, \dots, s$$

$$\begin{aligned}
 & \text{Maximize } \theta_0^U = \sum_{r=1}^s u_r y_{r0}^U \\
 & \text{Subject to } \sum_{i=1}^m v_i x_{i0}^L = 1 \\
 & \sum_{r=1}^s u_r y_{rj}^U - \sum_{i=1}^m v_i x_{ij}^L \leq 0, \quad j = 1, \dots, n \\
 & u_r, v_i \geq 0, \quad i = 1, \dots, m; r = 1, \dots, s
 \end{aligned} \tag{11}$$

By solving LP models (9-11) for each knowledge worker, the best relative fuzzy efficiencies of n knowledge workers can be obtained. Many experts have confined their assessments of decision-making units just to efficiency measurements, and have occasionally regarded it as productivity. However, in this paper, after introducing models of measuring effectiveness, how effectiveness as well as efficiency has impact on productivity will be illustrated.

4 Measuring knowledge workers effectiveness

Using DEA, Asmild and others [Asmild, 07] introduced method for measuring crisp data effectiveness which are going to be stated; furthermore, applying fuzzy numbers algebraic operators equation for measuring the effectiveness of the knowledge workers will be presented in proceeding parts.

A set of decision making units (knowledge workers) with m inputs and s outputs are assumed, $x_j = (x_{1j}, \dots, x_{mj})$ and $y_j = (y_{1j}, \dots, y_{sj})$ show the input and output vectors for the j unit, $j = 1, \dots, n$. X indicates the matrix $m \times n$ for inputs and Y indicates the matrix $s \times n$ for outputs.

If the objective of the production units, or the objective assigned by the analyst, is cost minimization, then the input prices $c \geq 0$ must be known. The overall minimum cost of producing output vector y_0 is obtained by solving the following:

$$\begin{aligned}
 & \text{Minimize } c^T x \\
 & \text{Subject to } x \geq X\lambda \\
 & y_0 \leq Y\lambda \\
 & 1^T \lambda = 1 \\
 & \lambda \geq 0
 \end{aligned} \tag{12}$$

Cost effectiveness (OE_i) is determined by dividing overall minimum cost $c^T x^*$ by observed cost:

$$OE_i = \frac{c^T x^*}{c^T x_0} \quad (13)$$

Generally, it is not possible to determine the precise values of knowledge workers' cost, so by assuming the approximate values in triangular fuzzy numbers' form, we can estimate knowledge workers' cost-effectiveness through the equations (5,13) .

5 Measuring productivity based upon efficiency and effectiveness

Productivity showed how an organization makes use of its resources to achieve its goals. This definition depicts that productivity is the result of simultaneous existence of efficiency "doing things right" and effectiveness "doing right things ".productivity revenue that whether or not the performance of an organization is efficient and effective. Though the terms like productivity, efficiency and effectiveness have been used together, and practitioners sometimes alternate their meanings, however we must not identify productivity with efficiency and/or effectiveness. Productivity requires both efficiency and effectiveness, because a certain activity will not be productive if it is only efficient, but not effective, or effective, but not efficient [Rutkauskas, 05]. Thus, productivity can be defined as doing right thing right; and any knowledge worker which is doing its best to accomplish the established objectives is identified as productive. In a word, productivity is first to find the proper issues and then, to do them properly [Malbotra, 97]. Based upon this explanation, following model is introduced for productivity of any knowledge worker (DMU).

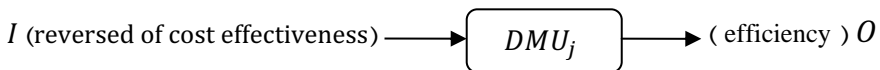


Figure 2: Productivity model (Goal: cost minimization)

Since production of the maximum output with the minimum input is aimed in DEA models, so in this represented model the reversed effectiveness is assumed as the input. Based upon illustrated model in figure (2), productivity can be measured by applying effectiveness and efficiency respectively as input and output of the knowledge worker, and utilizing DEA fuzzy model.

6 Case Study

Pooyesh pajoo consulting Engineers Company is one of the well-known companies in the northwestern part of Iran .This organization is highly ranked and serves in refinery and petrochemical fields, oil and gas transition pipes. Scientific products and service of this company show that all the workers are knowledge workers, and the company is knowledge intensive this establishment consists of seven work groups. They include the following groups: process, mechanics, safety, civil, electrical and planning. One knowledge worker has been selected from each group (table 2), and their performance are monitored for three months.

DMU_1 : process team head	DMU_5 : electrical team head
DMU_2 : safety team head	DMU_6 : process expert
DMU_3 : mechanic team head	DMU_7 : safety expert
DMU_4 : civil team head	DMU_8 : electrical expert

Table 2: the considered statistical society

We follow the stated five steps to assess their productivity.

First step: Determining knowledge workers productivity dimensions.

quality (O_1):

In this example quality means doing things right with the fewest errors and the best approval of the costumer. Estimation of this variable is presented in appendix 1 (table-app1).

Quantity (O_2):

Quantity here means the number of projects that the knowledge worker I ($i=1,2,\dots,14$) was involved in team (table-app2).

Timeliness (O_3):

Timeliness in this example means the amount of on time completed projects and the absence of delay (table-app3).

Creativity/innovation (I_1):

The significance of this dimension varies for different jobs of the statistical society, and has been estimated as described in appendix 1 (table-app4).

authority (I_2):

Authority of the experts in different work groups might be disparate as described in appendix 1 (table-app5).

experience (I_3):

In this example experience is supposed to be the years of knowledge worker's cooperation with pooyesh pajoooh company. As it has been a little more than ten years since the foundation of the company, experience is measured as follow. The maximum experience is assumed 10 years (Details are presented in table-app6).

education (I_4):

The basis for the education of knowledge workers in this example is valid educational/academic degree. This factor doesn't have the same significance for knowledge workers of statistical society and needs to be ranked as described in appendix 1 (table-app7).

Cost:

The major source for cost in this firm is its workers, yet beside knowledge workers output, the company has other source of revenue whose profit and revenue functions are not available. Therefore, minimizing the cost of knowledge workers has been selected as the strategy for their management. In this part, cost for salary, transportation, insurance, productivity reward, food and etc, are taken into account.

Outputs			Inputs				
O_3	O_2	O_1	I_4	I_3	I_2	I_1	
VH	H	H	H	F	EH	H	DMU_1
VH	VH	VH	H	H	EH	EH	DMU_2
H	F	F	F	F	VH	H	DMU_3
F	H	F	F	H	VH	L	DMU_4
H	H	H	F	H	EH	H	DMU_5
VH	VH	VH	L	F	VH	L	DMU_6
H	H	VH	H	F	H	VH	DMU_7
H	F	VH	H	L	H	VH	DMU_8

Table 3: inputs and outputs of statistical society's knowledge workers

Second step: Measuring knowledge workers efficiency

In this phase the experts 'comments about the inputs and outputs of each knowledge worker have been collected, and the results are presented in table (3).

The values for each knowledge worker's efficiency are calculated by solving the linear planning models (8-10).

Third step: Measuring knowledge workers effectiveness

The cost for each knowledge worker in the measuring period is as shown in table app8. The minimum cost is for the 8th knowledge worker, the values of cost effectiveness for each knowledge worker have been assessed. The results are shown in table (4).

Fourth step: measuring knowledge workers fuzzy productivity

By having values of efficiency and effectiveness for every equation (8-10) for efficiency as output and reversed effectiveness as input from equation (6), the values for knowledge workers productivity are measured.

productivity	effectiveness (\widehat{OE}_i)	efficiency ($\widehat{\theta}_0$)	
(0.0641,0.1243,0.1812)	(0.2564,0.3333,0.4375)	(0.2822,0.4211,0.4678)	<i>DMU₁</i>
(0.0580,0.0999,0.1447)	(0.25,0.3158,0.4118)	(0.262,0.3571,0.3968)	<i>DMU₂</i>
(0.0595,0.1405,0.2283)	(0.333,0.4615,0.5833)	(0.2016,0.3438,0.442)	<i>DMU₃</i>
(0.0578,0.1424,0.2465)	(0.2941,0.4,0.5385)	(0.2221,0.402,0.5169)	<i>DMU₄</i>
(0.0524,0.1125,0.1948)	(0.303,0.4,0.5385)	(0.1953,0.3177,0.4085)	<i>DMU₅</i>
(0.1112,0.2474,0.3341)	(0.3571,0.48,0.5833)	(0.3515,0.582,0.6467)	<i>DMU₆</i>
(0.0845,0.1791,0.2798)	(0.4167,0.5456,0.7)	(0.2291,0.3707,0.4513)	<i>DMU₇</i>
(0.0966,0.2084,0.3286)	(0.4545,0.6,0.7778)	(0.24,0.3922,0.477)	<i>DMU₈</i>

Table 4: Efficiency, effectiveness and productivity values for knowledge workers

Fifth step: ranking productivity values

In this step the fuzzy productivity values are ranked. The ultimate results are as follows:

$$DMU_6 > DMU_8 > DMU_7 > DMU_4 > DMU_3 > DMU_1 > DMU_5 > DMU_2$$

As observed, the 6th knowledge worker (process expert) has been the most productive and the 2nd knowledge worker (safety team head) has had the least productivity.

7 Conclusions

So far, a method for measuring knowledge worker productivity on the basis of its general definition (i.e. doing effective things, efficient) has not been presented. Moreover, measuring the productivity of the knowledge workers was mostly considered as traditional measurement of efficiency i.e. measuring output in relation to the input. It means that a knowledge worker might be efficient and doing the tasks properly, but he might not be able to help the company in achieving its goals. In the

cited example also, we saw that the ranking of knowledge workers productivity has been altered after application of effectiveness. Furthermore, in most of the represented methodologies, homogeneous and similar groups of knowledge workers have been considered in doing the assessments, and there was no general way for measuring knowledge workers productivity individually. Nevertheless, in this paper, while regarding the productive knowledge workers as personnel who first recognize the proper ways to achieve pre-arranged objectives of the organization and then perform these tasks with best quality on the scheduled time, we make the possibility of measuring productivity of different knowledge workers with different job descriptions, different working characteristics and conditions both in the level of individuals/groups and industries. For instance we compared two knowledge works of different educational and innovation parameters like a drafter and electrical team head, an experience never conducted by past usual methods.

In this article we suppose that knowledge workers can identify goal system themselves and they able to assess whether their activities are oriented towards this goal, while, managers can improve this goal system and a goal programming approach can be extend our method.

Furthermore, this general presented approach has the capacity to be generalized in other areas which deal with uncertainty. It is recommended that this approach be examined in other business fields. Moreover, the organizational objective considered for measuring the effectiveness of knowledge workers (minimizing cost) in this paper can be developed in future studies.

References

- [Antikainen, 05]R. Antikainen, and A. Lonnqvist, "Knowledge Work Productivity Assessment", Institute of Industrial Management, Tampere University of Technology (2005).
- [Asmid, 07] M. Asmid, J. C. Paradi, D. N. Reese, F. Tam, "Measuring overall efficiency and effectiveness using DEA", *European Journal of Operational Research* 178 (2007) 305–321.
- [Chang, 09]T.H.- Chang, T.-C. Wang "using the fuzzy multi-criteria decision making approach for measuring the possibility of successful knowledge management ", *Information Science*, 197 (2009) , 355-370.
- [Charnes, 78] A. Charnes, W.W. Cooper, E. Rhodes, "Measuring the efficiency of decision making units", *European Journal of Operational Research*, (1978), Vol. 2 No. 6, pp. 429-444.
- [Choi,08]B. Choi, S.K. Poon, J.G. Davis, "Effects of knowledge management strategy on organizational performance: a complementarity theory-based approach", *Omega* 36 (2008)235–251.
- [Davenport, 02]T. Davenport, "Can you boost knowledge work's impact on the bottom line?", *Management Update*, (2002), Vol. 7 No. 11, pp. 3-5.
- [Davenport, 00]T. Davenport, L. Prusak, "Working Knowledge: How Organizations Manage What They Know", Harvard Business School Press, (2000), Boston, MA.
- [Drucker, 94]Drucker, P., *Adventures of a Bystander*, Transaction Publishers, New Brunswick, NJ. (1994).

[Drucher, 99]P. Drucker, "Knowledge-worker productivity: the biggest challenge", California Management Review (1999) Vol. 41 No. 2, pp. 79-85.

[Kau, 00]C. Kau, and S.T. Liu, "Fuzzy efficiency measures in data envelopment analysis", Fuzzy Sets and Systems, (2000), Vol. 113, pp. 427-437.

[Kempila, 03]S. Kempila, and A. Lonnqvist, "Subjective Productivity Measurement", The Journal of American Academy of Business, Cambridge, (2003), Vol. 2 No. 2 pp. 531-537.

[Liebowitz, 99]Liebowitz, j. wright . A look toward valuating human capital, in liebowitz(ed) knowledge management CRC press. (1999).

[Malbotra, 97]Malbotra, Y., "Knowledge management, Knowledge Organization & Knowledge Workers", : <http://www.Brint.com/interview/maeil.htm> (1997).

[Nickolas, 00]Nicklos, F. "'What is' in the world of work and working: some implications of the shift to knowledge work", Butterworth-Heinemann Yearbook of Knowledge Management, (2000) pp. 1-7.

[Ramirez, 04]Y.W. Ramirez, D.A. Nembhard "Measuring knowledge worker productivity: a taxonomy", Journal of Industrial Capital, (2004) Vol. 5 No. 4 pp. 602-628.

[Rutkauskas, 05]J. Rutkauskas, E. Paulavičienė, "Concept of Productivity in Service Sector", Engineering Economics (2005) No. 3 (43).

[Steward, 97]Steward, T.A.. Intellectual Capital:The new wealth of organization. New York: Currency Doubleday. (1997).

[Wang, 09]Y.M. Wang, Y. Luo, L. Liang, "Fuzzy data envelopment analysis based upon fuzzy arithmetic with an application to performance assessment of manufacturing enterprises", Expert Systems with Applications 36 (2009) 5205–5211

[Zadeh, 65]L.A. Zadeh, Fuzzy Sets, Information and Control 8 (3) (1965) 338-353.

[Zadeh, 99]L.A. Zadeh, Some reflection on the anniversary of Fuzzy Sets and Systems, Fuzzy Sets and Systems 100 (1999) 1-3.

Appendix

<i>position</i>	<i>quality</i>	Triangular fuzzy number
<i>(Approved without project head) and (employer's correction)</i>	(EH)	(0.9 , 1.0 , 1.0)
<i>(Approved after project head' correction) and (without employer's correction)</i>	(VH)	(0.7 , 0.9 , 1.0)
<i>(Approved without project head's correction) and (After employer's first correction)</i>	(H)	(0.5 , 0.7 , 0.9)
<i>(Approved after project head's correction) and (After employer's last correction)</i>	(F)	(0.3 , 0.5 , 0.7)
<i>(Approved without project head's correction) and (After employer's 2nd correction)</i>	(VL)	(0.1 , 0.3 , 0.5)
<i>(Approved without project head's correction) and (After employer's 2nd correction)</i>	(VL)	(0.0 , 0.1 , 0.3)
<i>(more than twice correction by employer)</i>	(EL)	(0.0 , 0.0 , 0.1)

Table App-1: Definition of variable quality (O_1)

position	quantity	Triangular fuzzy number
12 and more	Extremely high (EH)	(0.9 , 1.0 , 1.0)
10-11	Very high (VH)	(0.7 , 0.9 , 1.0)
8-9	High (H)	(0.5 , 0.7 , 0.9)
5-7	Fair (F)	(0.3 , 0.5 , 0.7)
3-4	Low (VL)	(0.1 , 0.3 , 0.5)
1-2	Very low (VL)	(0.0 , 0.1 , 0.3)
None	Extremely low (EL)	(0.0 , 0.0 , 0.1)

Table App-2: Definition of variable quantity(O_2)

Position	timeliness	Triangular fuzzy number
No negative digression and no delay	(EH)	(0.9 , 1.0 , 1.0)
(average digression percentage \leq %5)And no delay	(VH)	(0.7 , 0.9 , 1.0)
(average digression percentage \leq %10)And no delay	(H)	(0.5 , 0.7 , 0.9)
(average digression percentage \leq %15)and (delay \leq $\frac{1}{10}$ predicted time)	(F)	(0.3 , 0.5 , 0.7)
(average digression percentage \leq %20)and (delay \leq $\frac{1}{10}$ predicted time)	(L)	(0.1 , 0.3 , 0.5)
(average digression percentage \leq %30)and (delay \leq $\frac{1}{10}$ predicted time)	(VL)	(0.0 , 0.1 , 0.3)
(average digression percentage $>$ %30)and (delay $>$ $\frac{1}{4}$ predicted time)	(EL)	(0.0 , 0.0 , 0.1)

Table App-3: Definition of variable timeliness (O_3)

New ideas improving outputs	career	Creativity/innovation	Triangular fuzzy number
<i>daily</i>	Team head	Extremely high (EH)	(0.9 , 1.0 , 1.0)
	expert	Extremely high (EH)	(0.9 , 1.0 , 1.0)
	planner	Extremely high (EH)	(0.9 , 1.0 , 1.0)
<i>Periodic in projects</i>	Team head	High (H)	(0.5 , 0.7 , 0.9)
	expert	Very high (VH)	(0.7 , 0.9 , 1.0)
	planner	Extremely high (EH)	(0.0 , 0.0 , 0.1)
<i>In case</i>	Team head	Low (L)	(0.1 , 0.3 , 0.5)
	expert	Fair (F)	(0.3 , 0.5 , 0.7)
	planner	Very high (VH)	(0.7 , 0.9 , 1.0)
<i>Fixed output with no change</i>	Team head	Extremely low (EL)	(0.0 , 0.0 , 0.1)
	expert	Very low (VL)	(0.0 , 0.1 , 0.3)
	planner	Fair (F)	(0.3 , 0.5 , 0.7)

Table App-4: Definition of variable Creativity/innovation (I_1)

position	authority	Triangular fuzzy number
<i>Team head- independent in decision making</i>	(EH)	(0.9 , 1.0 , 1.0)
<i>Team head- decision making by project head's approval</i>	(VH)	(0.7 , 0.9 , 1.0)
<i>Expert- independent in selection of methods</i>	(H)	(0.5 , 0.7 , 0.9)
<i>Expert-selection of methods by group's approval</i>	(F)	(0.3 , 0.5 , 0.7)
<i>Planner-independent in selection of methods</i>	(L)	(0.1 , 0.3 , 0.5)
<i>Planner-selection of methods by group's approval</i>	(VL)	(0.0 , 0.1 , 0.3)
<i>Planner- no authority ,fixed duties</i>	(EL)	(0.0 , 0.0 , 0.1)

Table App-5: Definition of variable Authority (I_2)

Experience in Organization	Experience	Triangular fuzzy number
<i>10 years and more</i>	Extremely high (EH)	(0.9 , 1.0 , 1.0)
<i>10 < Experience ≤ 8</i>	Very high (VH)	(0.7 , 0.9 , 1.0)
<i>8 < Experience ≤ 5</i>	High (H)	(0.5 , 0.7 , 0.9)
<i>5 < Experience ≤ 3</i>	Fair (F)	(0.3 , 0.5 , 0.7)
<i>3 < Experience ≤ 2</i>	Low (L)	(0.1 , 0.3 , 0.5)
<i>year 2 < Experience ≤ 6 months</i>	Very low (VL)	(0.0 , 0.1 , 0.3)
<i>Less than 6 moths</i>	Extremely low (EL)	(0.0 , 0.0 , 0.1)

Table App-6: Definition of variable Experience (I_3)

Educational/academic document	career	Education	Triangular fuzzy number
<i>Post PhD</i>	Team head	Extremely	(0.9 , 1.0 , 1.0)
	expert	Extremely	(0.9 , 1.0 , 1.0)
	drafter	Extremely	(0.9 , 1.0 , 1.0)
<i>PhD</i>	Team head	Very high (VH)	(0.7 , 0.9 , 1.0)
	expert	Extremely	(0.9 , 1.0 , 1.0)
	drafter	Extremely	(0.9 , 1.0 , 1.0)
<i>PhD student</i>	Team head	High (H)	(0.5 , 0.7 , 0.9)
	expert	Very high (VH)	(0.7 , 0.9 , 1.0)
	drafter	Extremely	(0.9 , 1.0 , 1.0)
<i>Masters degree</i>	Team head	Fair (F)	(0.3 , 0.5 , 0.7)
	expert	High (H)	(0.5 , 0.7 , 0.9)
	drafter	Very high (VH)	(0.7 , 0.9 , 1.0)
<i>Bachelors degree</i>	Team head	Low (L)	(0.1 , 0.3 , 0.5)
	expert	Fair (F)	(0.3 , 0.5 , 0.7)
	drafter	High (H)	(0.5 , 0.7 , 0.9)
<i>Associate degree</i>	Team head	Very low (VL)	(0.0 , 0.1 , 0.3)
	expert	Low (L)	(0.1 , 0.3 , 0.5)
	drafter	Fair (F)	(0.3 , 0.5 , 0.7)
<i>diploma</i>	Team head	Extremely low	(0.0 , 0.0 , 0.1)
	expert	Very low (VL)	(0.0 , 0.1 , 0.3)
	planner	Low (L)	(0.1 , 0.3 , 0.5)
<i>Guidance school</i>	Group manager	Extremely low	(0.0 , 0.0 , 0.1)
	employee	Extremely low	(0.0 , 0.0 , 0.1)
	planner	Very low (VL)	(0.0 , 0.1 , 0.3)
<i>Elementary school</i>	Group manager	Extremely low	(0.0 , 0.0 , 0.1)
	expert	Extremely low	(0.0 , 0.0 , 0.1)
	planner	Extremely low	(0.0 , 0.0 , 0.1)

Table App-7: Definition of variable Education (I_4)

DMU_4	DMU_3	DMU_2	DMU_1	
(1300,1500,1700)	(1200,1300,1500)	(1700,1900,2000)	(1600,1800,1950)	cost
DMU_8	DMU_7	DMU_6	DMU_5	
(900,1000,1100)	(1000,1100,1200)	(1200,1250,1400)	(1300,1500,1650)	cost

Table App-8: The cost of each DMU (Knowledge worker)

Optimisation of Knowledge Work in the Public Sector by Means of Digital Metaphors

Hans Friedrich Witschel, Torsten Leidig, Viktor Kaufman,
Manfred Ostertag, Ulrike Brecht, Olaf Grebner

(SAP, Walldorf, Germany)

{hans-friedrich.witschel|torsten.leidig|viktor.kaufman|
manfred.ostertag|ulrike.brecht|olaf.grebner}@sap.com

Abstract: Although most enterprises nowadays increasingly employ digital information management in all areas, there are still many organisations – e.g. in the Public Sector – where much of formal and informal information is documented on paper only. This work lays out the concept of a set of digital *metaphors* for entities in the “paper world” and argues that they will ease the adoption and acceptance of digital information and knowledge management solutions.

We furthermore describe how the metaphors are linked with each other. We place a special focus on the relationship between informal, unstructured information and formally structured one, as well as on collaboration and knowledge sharing enabled by the metaphors. These aspects have been combined into a prototype that is described and illustrated in some detail.

Key Words: knowledge management, collaboration, knowledge sharing

Category: M.6, M.8, H.3, H.4

1 Introduction

In many of today’s work environments – despite rapid digitisation and emergence of Web (or Enterprise) 2.0 solutions – rather “traditional” practices still hinder effective collaboration and knowledge sharing and management.

In such environments – of which many organisations in the Public Sector are good examples – most knowledge sharing still happens in an informal, face-to-face manner (e.g. in coffee breaks or over the desk) without knowledge being captured in any way. Even if experience is being recorded, this often happens in a paper-based way, where the means of recording range from notes on post-its over personal reference files containing work-related experience to official paper files. Figure 1 shows some of the challenges for knowledge workers that are addressed here.

It is desirable to better retain the valuable knowledge of an organisation’s workforce and to have an environment allowing internal and external participants to collaborate easily. In particular, information resulting from collaboration and personal work should be easily exploitable later on. In order to achieve that, the discrepancy between unstructured and structured information needs to be overcome and the means to capture information have to be advanced.

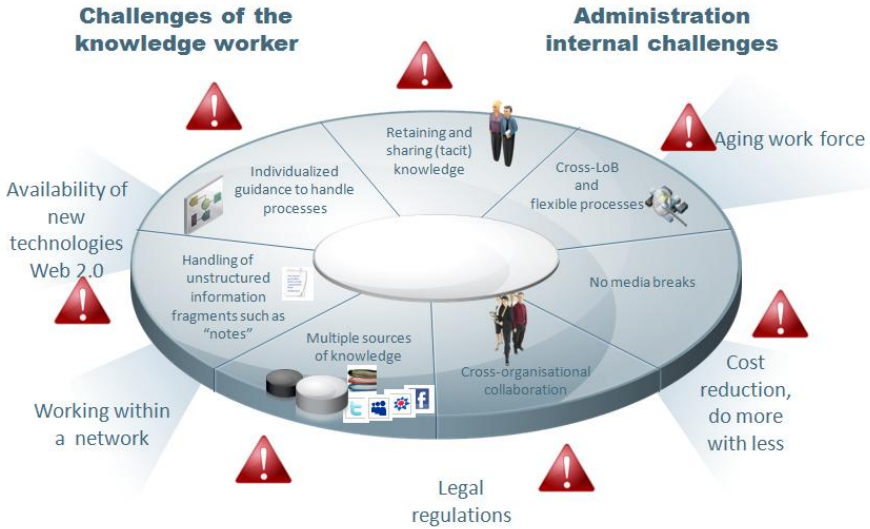


Figure 1: Summary of challenges a knowledge worker is faced with.

In this paper, we argue that a transition from the “traditional” style of work to the advantageous digitised world should be supported by creating *metaphors* that allow knowledge workers to recognise objects from their old (paper-based) working environment, e.g. notes or paper files. Thus one can expect an increase in the acceptance of a digital solution.

In addition, we suggest that these metaphors should be enhanced with light-weight ways to contribute and share information. Finally, the metaphors must enable knowledge workers to connect informal and unstructured information pieces (e.g. notes) or results of informal collaboration with formal information objects in the structured world (e.g. a record in a case management system).

More precisely, we aim to show that the following can be achieved:

- Digital equivalents and metaphors for paper-based entities appropriately model and improve business processes, e.g. in the Public Sector.
- Handy means for digitising and structuring of operational and other informal information enable both flexibility and formal knowledge management.
- An integrated environment for sharing and management of informal knowledge provides for better information reuse.

- Lightweight integration of business applications such as CRM with the informal knowledge management environment for personalised use of business applications.
- Lightweight integration of web resources enables “crowd sourcing” and leads to better collaboration and decision-support processes.
- Useful features such as contextual recommendation of information items fit very well in the scope of the same integrated environment.

We thus aim to improve the complete lifecycle of information, from informal notes to well-structured information objects, where all pieces – whether formal or informal – can be easily connected to yield a single access point to all information needed in a given work situation.

2 Concepts

In a paper-based workplace, we find several well-established ways of handling and recording information and collaboration. Before we constructed our digital metaphors, we did some investigation into these routines by visiting several people in small German municipalities and finding out about their daily work procedures.

In the following, we will describe shortly the routines of handling and recording information that we observed along with the digital metaphors that we propose for each of them. In addition, we will describe how a connection can be made between informal, unstructured information and formally structured one.

- **Notes:** Notes are usually made while receiving information, e.g. on the phone. In such a situation, the information cannot be recorded formally for various reasons – because of lack of time, lack of details or sometimes because not even the exact target location for the information is known (e.g. which paper file it should go to). Therefore, quick notes are often jotted down on scrap paper or post-its. Later, these notes are manually transferred into the right (paper) file. It may also happen that rather comprehensive information on a certain case is collected on single pieces of paper prior to (formal) filing.

The metaphor that we propose for capturing unstructured information digitally consists of two parts: a *sidebar* for making quick notes that are comparable to post-it snippets and a *notebook* with sections for filing of (inofficial) notes. The sidebar is put alongside the current work context of a user (see section 3 for details) and allows to make notes quickly without losing track of that context; it roughly corresponds to a post-it. The notebook, on the other hand, allows users to create categories – which correspond to section

dividers in paper files or coloured post-its stuck to paper sheets – where a rough order can be brought into more comprehensive, interconnected notes.

- **Reference files:** In many organisations, especially in the Public Sector, so-called reference files are used to collect generic work-related information that is valid across individual cases – i.e. an assembly of all the experience that is necessary to do a certain job. These files will usually contain sections covering various aspects of a job. They are often kept on a paper basis by individual employees, but may be passed on to an employee’s successor after retirement.

We propose to replace such files by another sidebar that manages digital reference files – henceforth called *context patterns* – for various generalised work contexts and enables users to create, modify and share such a context pattern with their colleagues. A context pattern may contain resources, such as contacts or documents, templates, letters, standard procedures, policies etc., as well as text-based information in the form of descriptions of problems (that may arise in a work context) and solutions.

- **Search:** The inconvenience of searching for information in a paper-based environment is one of the best arguments for introducing digital information management. Most applications offer the functionality to search the data they manage, but knowledge workers often need to search across many data repositories including internal and external, operational and archived, structured and unstructured data, from within various work situations.

We propose to integrate a federated search engine into the notebook solution, where both structured and unstructured information is indexed and made available through a unified interface. The so-called cabinet mimics the traditional filing cabinet in the office, with visual means to faster find the needed files.

- **Collaboration:** In most work environments, collaboration is rarely well documented since work-related information exchange happens through informal emails or during phone calls. Even if some documentation exists (e.g. notes being taken during a phone call), it is not connected to any formal documentation and often exists in various versions that are not consistent with each other.

We propose to introduce a collaboration tool that enables transparent collaboration and creation of business outcomes through decision support, involving a variety of participating roles. In our prototype, we chose an existing product [StreamWork] as an example of such a solution – where additional integration with the other parts of our prototype allow to re-use the results of the collaboration reached within that tool.

- **Formal files:** Finally and most importantly, paper-based work environments are usually characterised by the existence of formal information objects kept in paper files – where there is often still a legal obligation to do so. Applications that manage formal and well-structured information digitally are abundant – in this work, we will consider a case management system as an example of such an application. The problem that exists especially in the digital world is that the formal and structured information is kept separate from any unofficial and unstructured information that employees may collect (e.g. notes on a specific case being scribbled down during a phone call) and that there is no possibility to connect the former to the latter. However, in many situations it is desirable to be able to attach an informal note to a formal document within a file (as may happen through a post-it in the paper-based world) without changing the content of the formal document.

We therefore propose the introduction of an assistant that allows to link informal notes to any formal information object (such as a case in a case management application) through a single click. This link can be made visible to everyone and establishes a solid connection between the formal document and the note, without changing the content of the formal information object.

3 An implementation

The prototypical implementation of our ideas that we present in this section consists of various parts, the concepts of which have been laid out in the previous section. Here, we will very briefly describe the technical realisation of these concepts in our prototype, along with illustrative screenshots.

Figure 2 shows the realisation of both the quick note sidebar and the notebook. Both work in a web browser and both are based on TiddlyWeb [TiddlyWeb], a Wiki-like tool for creating and managing short pieces of text (so-called *tiddlers*). As explained above, the sidebar offers the possibility to take notes quickly while working on something in the main browser window – if people are to be convinced to capture notes digitally, it is very important to ensure that this can happen very fast and without the need of preparation, i.e. starting the note-taking must be a one-click action. This is ensured by putting the sidebar alongside the work context as a sidebar. After creating a note in the sidebar, it can then be transferred into the Notebook via drag and drop (and vice versa). In the Notebook, notes can be easily organised into sections and can be additionally tagged. In that way, quick notes from the sidebar can be easily “filed” and organised into sections in the notebooks.

In some respects, the digital metaphor is not strictly analogous to paper-based note-taking: the notes taken can be made available to other persons by inviting them to a (shared) notebook and they are of course searchable. Of

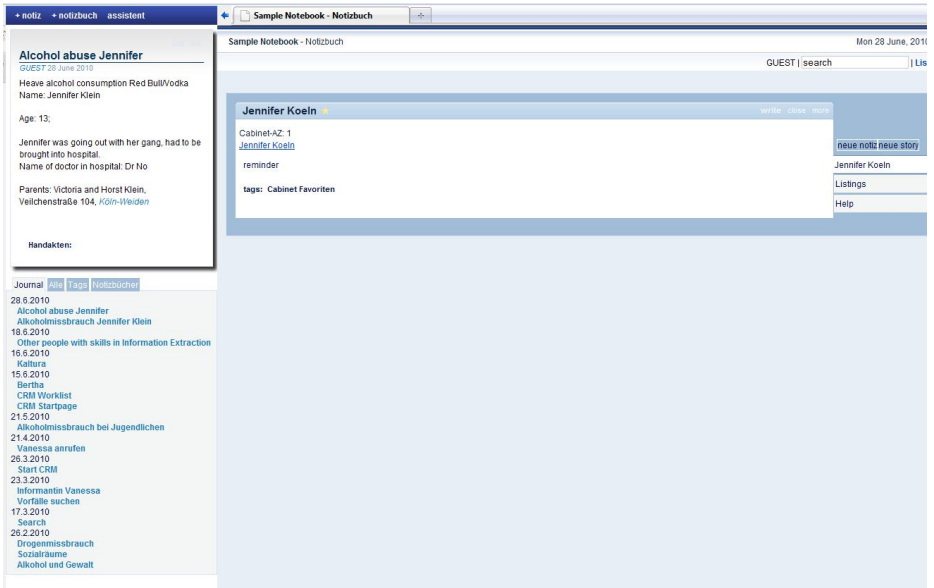


Figure 2: Realisations of note-taking metaphors: browser sidebar for quick notes (left) and notebook for organising notes into sections (main window)

course, these enhancements may – for some people – impede the perception of the analogy to the paper-based world. However, we believe that they show the actual benefit of the digitisation and that the analogy can still be made obvious by a “paper-resembling” user interface – something that may still be improved for our prototype (see section 5 below).

Figure 3 (a) shows the realisation of context patterns: it is again a browser sidebar which is organised into parts for contacts, documents and collections of problems and solutions. When translating the structure of a reference file into the paper-based world, these parts may be understood as follows: the “Contacts” category resembles an address book part of a paper-based reference file – where people often use sheets with forms containing name, phone number, address etc. The “Documents” category contains (links to) important documents – which, in a paper-based world – would be present in the form of print-outs in the reference file. Finally, the “Problems/Solutions” category offers the possibility to document experience in the form of free text.

Within each part, categories can be created and filled with resources as is shown in the picture. In order to help users to choose an appropriate pattern for their current work context, the note sidebar has an additional recommendation

feature: whenever creating or updating a note, links to relevant context patterns will be automatically displayed directly beneath the note.

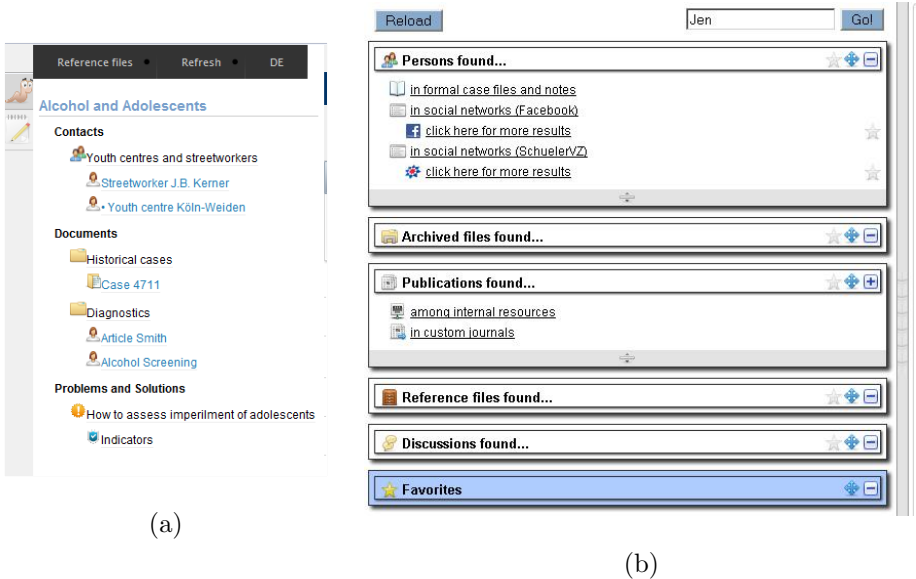


Figure 3: Realisation of (a) context patterns and (b) federated enterprise search (Cabinet)

Again, the metaphor has been enriched with some means of knowledge sharing and electronic information management: firstly, the sidebar offers a predefined *structure* for reference files by dividing them into sections for persons, documents and problems/solutions. It thus limits the flexibility of organising the content that may be present in paper-based reference files. It furthermore allows to share context patterns with colleagues and makes them searchable. Again, we believe that these enhancements make context patterns more valuable for knowledge sharing and retention than their paper-based counterparts.

Figure 3 (b) shows the *Cabinet*, a federated search engine integrated into the notebook. It allows to search both structured and public and third party unstructured sources, including social networks. Search results from the Cabinet can be easily transferred into either the context pattern or the quick note sidebar via drag and drop. The context pattern sidebar can interact in the same way with the notebook.

Finally, figure 4 shows a case management system (based on CRM) with a case as an example of a structured information object. On the top left, we see that

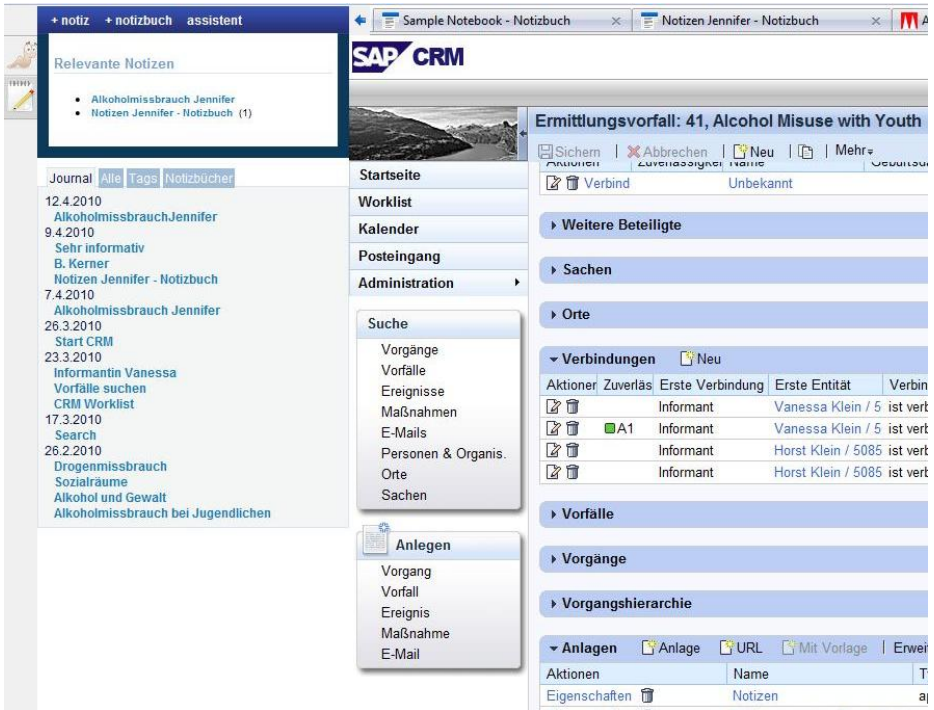


Figure 4: Linking structured and unstructured worlds via the link assistant.

informal notes are linked with that information object in the so-called assistant that is part of the quick note sidebar. For each information object in the CRM system (i.e. for each page) it displays the notes that have been associated to it. That association can be achieved through a single click on the “link” button next to a note when the page to be linked is open in the main window.

That means that attaching a note to a formal document works exactly as in the paper-based world: one opens the formal document at the right place and sticks a note (corresponding to a post-it) in that place. The only difference is that it may be explicitly controlled whether this note remains private (i.e. only to be seen by the person who attaches it) or becomes public to be seen by everyone who has access to the formal document.

4 Related Work

Since our prototype links a number of seemingly rather diverse concepts, we can find related work in various areas: The notebook metaphor we propose visually

resembles Microsoft OneNote [OneNote] and also bears some resemblance with the web-based notebook EverNote [Evernote], but is inherently more collaborative, as are the many recent approaches to knowledge management that rely on Wiki technology [Wagner 2004], e.g. semantic wikis [Schaffert 2006] or blogs [Shakya et al. 2008].

Linking of informal notes with more structured content or formal documents has been addressed by approaches that use printouts as proxies, such that notes on paper taken with a special pen get transferred into digital annotations [Liao et al. 2005]. Others support what is called active reading (taking notes while reading something) [Schilit et al. 1998] via a pen tablet display where users annotate the scanned image of a page.

The topic of federated search addressed by the cabinet has a rather long tradition (see e.g. [Callan 2000]) and it has also been realised by many researchers that enterprise search presents new challenges that call for different approaches than those applied in web search [Hawking 2004, Fagin et al. 2003]. We particularly focused on the challenge of seamless integration of search and its results with the work environment of a knowledge worker.

As far as context patterns are concerned, relevant work has been carried out in the area of task management – we have generalised the notion of task patterns [Schmidt and Riss 2009, Du et al. 1999] into context patterns, generalising from tasks to cases or general work situations.

5 Conclusions and Future work

In this work we have shown how the transition from paper-based environments into a digital world of information and knowledge management can be eased by metaphors that resemble well-known entities from the “traditional” workplace. We have also illustrated how these metaphors can be designed in order to achieve a seamless integration between structured and unstructured information and allow for lightweight collaboration and knowledge sharing.

In the future, we plan to enhance our prototype with functionalities for fine-grained, but still lightweight user rights management as well as advanced search and recommendation techniques. We would also like to investigate the possibilities of integrating Linked Open Data, especially into the Cabinet. Furthermore, we consider it necessary to put more effort into making the user interface reflect the analogies to the paper-based world. Finally, we will validate our prototype with prospective end users.

References

- [Callan 2000] Callan, J. Distributed Information Retrieval. In W.B. Croft, editor, *Advances in Information Retrieval*, pages 127–150. Kluwer Academic Publishers, 2000.

- [Du et al. 1999] Du, Y., Riss, U. V., Ong, E., Taylor, P., Chen, L., Patterson, D., Wang, H.. Work Experience Reuse in Pattern Based Task Management. In *I-KNOW '09 Proceedings of the 9th International Conference on Knowledge Management*, pages 149–158, 2009.
- [Evernote] EverNote. www.evernote.com/.
- [Fagin et al. 2003] Fagin, R., Kumar, R., McCurley, K. S., Novak, J., Sivakumar, D., Tomlin, J. A., Williamson, D. P. . Searching the workplace web. In *WWW '03: Proceedings of the 12th international conference on World Wide Web*, pages 366–375, 2003.
- [Hawking 2004] Hawking, D.. Challenges in enterprise search. In *ADC '04: Proceedings of the 15th Australasian database conference*, pages 15–24, 2004.
- [Liao et al. 2005] Liao, C., Guimbretière, F., Hinckley, K.. PapierCraft: a command system for interactive paper. In *UIST '05: Proceedings of the 18th annual ACM symposium on User interface software and technology*, pages 241–244, 2005.
- [OneNote] Microsoft OneNote. <http://office.microsoft.com>.
- [Schaffert 2006] Schaffert, S.. IkeWiki: A Semantic Wiki for Collaborative Knowledge Management. In *WETICE*, pages 388–396, 2006.
- [Schilit et al. 1998] Schilit, B. N., Golovchinsky, G., Price, M. N. Beyond paper: supporting active reading with free form digital ink annotations. In *CHI '98: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 249–256, 1998.
- [Schmidt and Riss 2009] Schmidt, B., Riss, U. V. Task Patterns as Means to Experience Sharing. In *Advances in Web Based Learning - ICWL 2009, 8th International Conference*, pages 353–362, 2009.
- [Shakya et al. 2008] Shakya, A., Wuwongse, V., Takeda, H., Ohmukai, I. OntoBlog: Informal Knowledge Management by Semantic Blogging. In *Proceedings of the 2nd International Conference on Software, Knowledge, Information Management and Applications (SKIMA 2008)*, pages 197–202, 2008.
- [StreamWork] SAP StreamWork. <http://www.sapstreamwork.com/>.
- [TiddlyWeb] TiddlyWeb. <http://tiddlyweb.peermore.com/>.
- [Wagner 2004] Wagner, C. Wiki: A Technology for Conversational Knowledge Management and Group Collaboration. *Communications of the AIS*, 13:256–289, 2004.

Clustering Technique for Collaborative Filtering and the Application to Venue Recommendation

Manh Cuong Pham, Yiwei Cao, Ralf Klamma

(Information Systems & Database Technology
RWTH Aachen University, Aachen
Ahornstr. 55, D-52056, Aachen, Germany
{pham, cao, klamma}@dbis.rwth-aachen.de)

Abstract: Collaborative Filtering(CF) is a well-known technique in recommender systems. CF exploits the relationships between users and recommends the items to the active user according to the ratings of his/her neighbors. CF suffers from the data sparsity problem, where users only rate a small set of items. That makes the computation of similarity between users imprecise and consequently reduces the accuracy of CF algorithms. In this paper, we propose to use clustering techniques on the social network of users to derive the recommendations. We study the application of this approach to academic venue recommendation. Our interest is to support researchers, especially young PhD students, to find the right venues or the right communities. Using the data from DBLP digital library, the evaluation shows that our clustering technique based CF performs better than the traditional CF algorithms.

Key Words: network clustering, venue recommendation, social network analysis

Category: H.3.3, H.3.7

1 Introduction

Recommender System (RS) is a class of applications dealing with information overload. As more and more information is published on the World Wide Web, it is difficult to find needed information quickly and efficiently. RS helps solve this problem by recommending items to users based on their previous preferences. Techniques in RS can be divided into two categories: memory-based and model-based algorithms. Memory-based algorithms operate on the entire user-item rating matrix, while model-based techniques use the rating data to train a model and then the model will be used to derive the recommendations.

Collaborative Filtering (CF) is a widely used technique in recommender systems. It operates on the entire user-item rating matrix and generates recommendations by identifying the neighborhood of the target user to whom the recommendations will be made, based on the agreement of user's past ratings. The data sparsity problem of user-based CF is well-known since normally users rate a small set of a large database of items. The similarity between users is often derived from few overlapping ratings and it is hence a noisy and unreliable value. Another problem of CF is efficiency. CF has to compute the similarity between

every pair of users to determine their neighborhoods. It is not computationally feasible for the ad-hoc recommender systems with millions of users and items.

To overcome the aforementioned weaknesses, a line of research has focussed on clustering techniques for CF. Based on ratings, these techniques group users or items into clusters, thus give a new way to identify the neighborhood. In this paper, we are concerned with applying clustering techniques on social network of users to identify the communities of similar ones. We investigate the application of this approach to academic venue recommendation. Academic venues (journals, conferences etc.) play an important role in computer science. In recent years, the number of venues has increased dramatically, as shown in data from DBWorld¹, DBLP² and EventSeer.net³. Researchers have to deal with information overload when they want to find the suitable venues to submit papers to. Venue recommendation is therefore useful, especially for young PhD students.

This paper is organized as follows. In Section 2, we make a brief survey of the related work. In Section 3, we present our approach. In Section 4, we investigate the approach to venue recommendation. The evaluation is given in Section 5. The paper finishes with a conclusion and our directions for future work.

2 Related work

Clustering methods for CF have been extensively studied by several studies. Ungar [Ungar and Foster, 1998] proposed a repeated K-means and Gibb sampling clustering techniques that group users into clusters with similar items and group items into clusters which tend to be liked by the same users. Kohrs [Kohrs and Merialdo, 1999] used a hierarchical clustering algorithm to independently cluster users and items into two cluster hierarchies. The recommendation is made by the weighted sum of the defined centers of all nodes in the cluster hierarchies on the path from the roots to the particular leaves. Sarwar et al. [Sarwar et al., 2002] evaluated a clustering approach which groups users into clusters based on their similarities. They showed that clustering provides comparable recommendation quality as traditional CF, while significantly improving the on-line performance. There are also other studies on clustering techniques for collaborative filtering [Xue et al., 2005], [Truong et al., 2007], [Nathanson et al., 2007], [Rashid et al., 2006], [Zhang and Hurley, 2009].

That research work cluster users and items based on only the rating data while ignoring the additional information, such as the interaction between users (e.g. social relationship like trust) and the interaction between items (e.g. citation between publications), which has been proved to be very useful in certain

¹ <http://www.cs.wisc.edu/dbworld/>

² <http://www.informatik.uni-trier.de/ley/db/>

³ <http://eventseer.net/>

application domains [Massa and Avesani, 2007], [O'Donovan and Smyth, 2005], [Zhou et al., 2008], [Zhu et al., 2007]. Here we propose to exploit the social relationships for recommendation: users are clustered based on the social network built from various relationships (e.g. trust, friendship or collaboration networks). When we have user clusters, traditional CF algorithms can operate on the clusters instead of the whole user-item matrix. By reducing the dimensions of user-item rating matrix and therefore avoiding the data sparsity problem, this approach can provide better recommendation result in terms of accuracy and can improve the online performance of CF algorithms.

Our study is related to social group recommendation [Backstrom et al., 2006], [Anglade et al., 2007], [Harper et al., 2007]. Kleinberg [Backstrom et al., 2006] considered the social group formation and community membership in large social networks and their use in recommender systems. Anglade [Anglade et al., 2007] proposed a complex network based approach for music recommendation and shared radio channels in P2P networks. They applied a hub-based clustering technique on the network of peers and showed that the resulting clusters identify the communities of peers that share similar music preferences. These clusters then can be used to provide music recommendations to peers in the groups. Maxwell Harper et al. [Harper et al., 2007] described an algorithm for clustering users of an online community and automatically describing the resulting user groups. They developed an activity-balanced clustering algorithm that considered both user activity and user interests in forming clusters. Users are automatically assigned to groups and have access to group-based social recommendations.

3 Network clustering for CF

The application of clustering techniques reduces the sparsity and improves the scalability of the systems since the similarity can be calculated only for users in the same clusters. Different clustering strategies can be performed based on users and items, as illustrated in Fig. 1. In general, clustering users (or items) results in creating sub-matrices of the entire user-item rating matrix. Then classical CF algorithms (user-based and item-based) can be used to generate recommendation based on these sub-matrices. In Fig. 1(a), when user-based CF is applied on user clusters, the neighbors of the active user are users in the same user cluster. If item-based CF is used, the ranking of an item is based on the items which are rated by users in the same user cluster. Similarly, in Fig. 1(b), the neighbors of the active user are users who have rated items in the same item cluster (in case of user-based CF) and the ranking of an item is based on the items in the same item cluster (in case of item-based CF).

Fig. 1 depicts the situation where each user and each item are assigned uniquely to one cluster, though users can be assigned to different user clusters

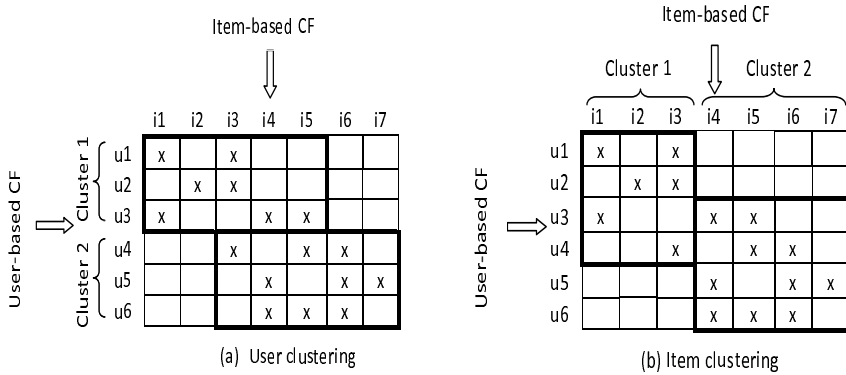


Figure 1: Clustering for collaborative filtering

(in item clustering) and items can belong to different item clusters (in user clustering). In this case, the prediction for the active user can be made by averaging the opinions of the others in the same user cluster (user-based) and the ranking of an item is based on the items in the same item cluster (item-based). However, in a real-world application, users and items can belong to several clusters, e.g one user may be interested in the movies of different genres such as horror, war, comedy or drama; one movie could also be assigned to different categories according to genre. The prediction is then made by an average across the clusters.

One simple clustering technique is to classify items based on their content, e.g movies are categorized by genre, director etc., and then the prediction for an item is made by an average of the opinions of users in the clusters that this item belongs to. However, this technique is suitable in the domains where the features of the items are hidden or hard to extract, as well as where the structure of the categories is complicated, e.g items are hierarchically classified. Consequently, several approaches have been proposed ([Quan et al., 2006], [Zhang and Hurley, 2009]) to cluster items based on user rating.

3.1 Algorithm

We argue that social relationship has an impact on user behavior in recommender systems and propose to use clustering technique on social network of users to identify their neighborhood. We present the first case as depicted in Fig. 1(a), where user-based CF is combined with user-based clustering. It differs from the traditional model-based CF clustering in two folds. On the one hand, it exploits the social relationship of users, while others techniques cluster users based on the ratings. On the other hand, the clusters are extracted from the

network topology, which are quite different to the explicit communities studied in [Harper et al., 2007] and [Backstrom et al., 2006].

Traditional CF algorithms proceed in two phases. At the first phase, calculate the similarities between pairs of users and identify their neighborhood, then recommendations are generated to active user based on the aggregate of the ratings of the neighbors. In our approach, first we cluster users (offline). Then we apply traditional CF process within clusters to generate recommendations. The algorithm is as follows:

1. Formulate the social network of users, $G = (V, E)$, where V is the set of users, $V = \{v_1, v_2, \dots, v_n\}$ and E is the set of social relations between users. G might be a weighted or un-weighted network.
2. Perform a clustering algorithm on the network G . The set of users V is divided into clusters V_1, V_2, \dots, V_q , where $V_i \cap V_j = \emptyset$ and $V = V_1 \cup V_2 \dots \cup V_q$.
3. Using clusters as the neighborhoods, items are ranked as follows:

$$R_{v_t, e} = \frac{\sum_{v_i \in V_{v_t}} sim(v_t, v_i) * r_{v_i, e}}{\sum_{v_i \in V_{v_t}} sim(v_t, v_i)} \quad (1)$$

where $R_{v_t, e}$ is the prediction rating of user v_t for item e , $sim(v_t, v_i)$ is the similarity between user v_t and user v_i , V_{v_t} is the neighborhood of user v_t and $r_{v_i, e}$ is the rating of user v_i on item e .

3.2 Clustering techniques

Methods for clustering networks can be divided into two research categories: graph partitioning and blocking modeling (or hierarchical clustering). We concentrate on the hierarchical clustering since it does not require any assumptions about the cluster structure of a network. The idea is to successively build (agglomerative), or break up (divisive) a hierarchy of clusters (called a dendrogram) with the leaves being the initial network nodes, the root representing the whole graph and the inner nodes corresponding to the clusters at different steps of the algorithm. A hierarchical clustering algorithm can stop at a certain step when the resulting partition is optimal according to some measures. One common measure is called *modularity* [Newman and Girvan, 2004]. The modularity of a given partition of a network measures the quality of that partition. Formally, the modularity Q is defined as

$$Q = \sum_{i=1}^q (e_{ii} - a_i^2) \quad (2)$$

with

$$a_i = \sum_{j=1}^q e_{ji} \quad (3)$$

where e_{ji} is the fraction of edges between nodes from group j and i , and q is the number of clusters. The fraction of edges connecting nodes in group i internally is hence e_{ii} and a_i denotes the overall fraction of links connecting to nodes in i . a_i^2 then corresponds to the expected fraction of internal edges given a random assignment of nodes into communities. Thus, if a particular clustering gives no more within-community edges than expected by random chance, Q will be equal to 0 (because then $e_{ii} \approx a_i^2$). Values other than 0 indicate deviations from randomness. Empirical observations indicate that values greater than 0.3 correspond to significant community structures.

In our study, we use the algorithm proposed by Clauset [Clauset et al., 2004], an improved version of the method proposed by Newman [Newman, 2004]. Here, a greedy implementation of hierarchical agglomerative clustering is used: two communities are joined if this join results in the greatest increase (or smallest decrease) of the modularity Q - compared to all other possible joins between pairs of communities. When the computation of the whole dendrogram is finished, the partition with maximal modularity is chosen. Clauset improves this approach by slightly modifying the join-condition so that a computation of the whole dendrogram can be avoided. The algorithm has a worst case time complexity of $O(Md \log N)$ (with d being the depth of the dendrogram), but a complexity of $O(N \log 2N)$ for sparse graphs. Since most complex networks are indeed sparse graphs, the algorithm will run in almost linear time. The algorithm is widely accepted in research community with many studies making use of it.

4 Collaborative filtering and venues recommendation

In computer science, venues are organized into series, e.g ACM International Conference on Knowledge Discovery and Data Mining. Researchers publish their work in annual events or in special issues. Our goal is to recommend the upcoming events (or special issues) in which researchers might be interested. Users are researchers and items are venues. The ratings of users can be explicitly expressed, or can be implicitly inferred from users behavior. Here we approximately infer the attention of researchers to the venues in which they participated by the number of papers they published. This measure is used as the ratings of researchers on venues and is computed as following:

$$R(r, v) = \frac{p(r, v)}{\sum_i p(r, i)} \quad (4)$$

where $p(r, v)$ is the number of papers researcher r published in venue v and n is the number of venues. The rating $R(r, v)$ thus is the fraction of papers which researcher r published in venue v . We note that this measure might be a too strong indicator for researchers' opinion, since publishing a paper in a venue or participating in a conference depends on many different aspects. One might favour a particular conference or journal. But because of some problems, they have not published any papers in it. On the one hand, this measure underestimates, and therefore, gives us the low bound of researchers opinion. However, it is an accurate measure since publishing papers in a conference or journal presents the topics of interest and the opinion of researchers on that one.

Using a social network, researchers are clustered to identify their neighborhood. Social relationships between researchers are reflected via research activities such as publishing papers (co-authoring), referencing to other work (citing) and participating in venues. That results in different types of social network, which can be used to group similar researchers: co-authorship network, citation network and venue co-participation. In this paper, we cluster researchers based on co-authorship network. We leave the investigation on the quality of the neighborhood identified by other types of network to the future work.

Using clusters as neighborhoods, a traditional CF algorithm is applied to generate recommendations. Venues are ranked according to the ratings of cluster's members and the ranked list is returned to the active researcher.

5 Experimental evaluation

5.1 Co-authorship network clustering

We performed two test cases based on DBLP dataset, each of them uses a snapshot of co-authorship network at a certain year and predicts the venues in which a researcher will participate in the next year. For example, using clusters from the co-authorship network in 2005, we recommend the venues that a target researcher might take part in 2006. DBLP data was downloaded in July, 2009. It contains 788,259 authors, 1,226,412 publications and 3,490 venues. We extract two snapshots of co-authorship network in the years of 2005 and 2006. The snapshots are created based on the publications from the considered year backwards, e.g. 2005 snapshot takes the co-authorship network of publications published in 2005 or earlier. Each snapshot is presented as weighted un-directed graph, where nodes are researchers and there is an edge between two researchers if they co-authored at least one publication. The edges are weighted by the number of co-authored publications. The 2005 network contains 478,108 nodes and 1,427,196 edges. The 2006 network has 544,601 nodes and 1,686,876 edges.

We run the density-based clustering algorithm [Clauset et al., 2004] on each network. Cluster size distribution is given in Fig. 2. Overall, the algorithm gave

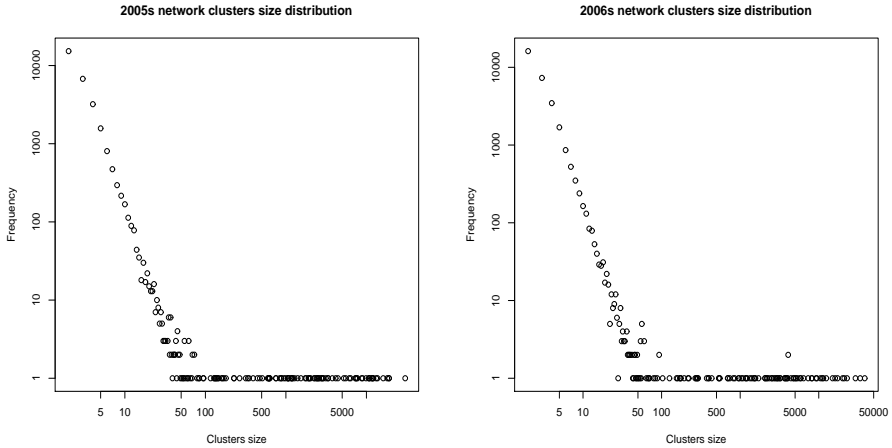


Figure 2: Cluster size distribution

us several large clusters with the size of thousand nodes and large number of clusters with the size ranging from 2 to hundred nodes. The modularity Q for the partitions of 2005's and 2006's networks are 0.829 and 0.82, respectively.

5.2 Evaluation metrics

We use two standard measures from information retrieval: *precision* and *recall*, defined as follows:

$$Precision = \frac{Relevant_venues_recommended}{Venues_recommended} \quad (5)$$

$$Recall = \frac{Relevant_venues_recommended}{Relevant_venues} \quad (6)$$

where *Relevant_venues_recommended* is the number of venues in the recommended list of venues, in which a researcher participates in the next year; *Venues_recommended* is the number of venues recommended; *Relevant_venues* is the number of venues a researcher takes part in the next year.

We evaluate our approach (we called it *CCF*) against the traditional CF algorithm (called CF) which follows the *top-k* recommendation principle. To make the evaluation fair, the number of cluster members for each researcher was recorded and we force *CF* to use the same number of neighbors for recommendation generation. Similarities between researchers are computed using cosine measure. For each test case, we randomly select one thousand researchers as active users and generate recommendations for them. For each researchers,

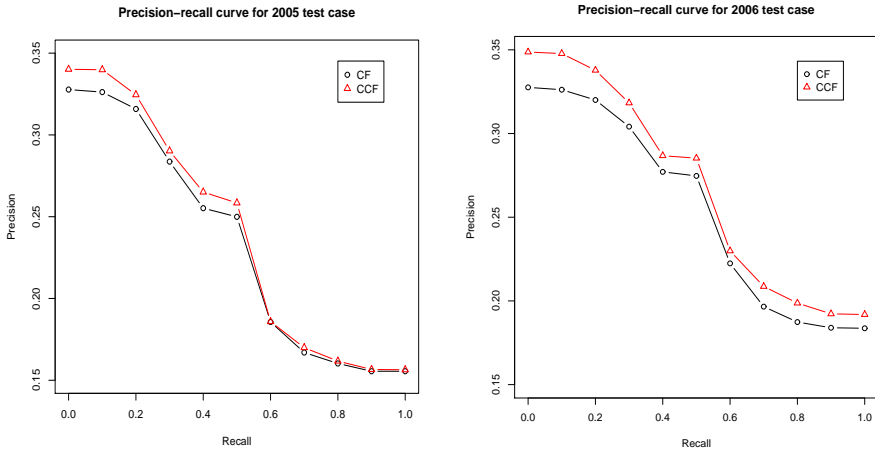


Figure 3: Interpolated precision-recall curves for test cases 2005 and 2006

the precision values are computed at 11 standard recall levels, 0%, 10%, ..., 100%. Then the average precision value of one thousand researchers at each recall level is computed. Finally, the precision-recall curve of each algorithm is plotted.

The precision-recall curves for 2005 and 2006 test cases are given in Fig. 3. Clearly, *CCF* performs better than traditional *CF*. This contradicts with the result in [Sarwar et al., 2002], where the prediction quality is worse in case of the clustering algorithm. The reason is that previous clustering approaches group users using rating data and often result in less personal and worse accuracy than classical *CF* algorithms. Here, we cluster users (researchers) based on their social relationships (the co-authorship network), which can be considered as the *trusted* relationships. Recently, there is a number of studies [Massa and Avesani, 2007], [O'Donovan and Smyth, 2005] on *trust-aware* recommender systems, which show that using trust can significantly improve the accuracy of the classical *CF* algorithms. The result we present here could be considered as an evidence of the performance of the trust-based recommendations.

However, as being observed from the chart, the precision of both algorithms is quite low (about 33% for *CF* and 35% for *CCF*). That because we evaluate the approach based on the venues participation of researchers. That might not reflect the true opinion of researchers on venues, so an online evaluation is necessary.

The recommendation quality is not significant better than traditional *CF*. There is a number of issues need to be considered. User clusters have a great impact on the recommendation in our approach. Whether the clusters reflect the true information need of users depends on the network (or the relationship) we use for clustering and also depends on clustering algorithms. Here we examine

only the co-authorship network which describes the strongest relation between authors. As mentioned earlier, other types of social relationship (e.g. citation network) could be used to identify better user clusters, which would lead to better result. Also, here we use a clustering approach which assigns users uniquely to one clusters. It would not be the case in the real-world situation where one user might participate in several clusters (communities). For example, if one author is working on different field such as Data Mining, Database and HCI, then he might participate in the communities these fields. Discovery overlapping communities and integrating them into the recommendation process is challenging and we are still working on this problem.

6 Conclusion and Future Work

In this paper, we presented a clustering approach to collaborative filtering recommendation technique. Instead of using ratings data, we propose to use social relationship between users to identify their neighborhoods. A complex network clustering technique is applied on the social network of users to find the groups of similar users. After that, the traditional CF algorithms can be used to efficiently generate the recommendations. We applied this approach on academic venue recommendation. The evaluation shows that this approach provides better recommendation quality than traditional CF and at the same time can improve the online performance.

The paper draws several issues which need to be further studied. The evaluation on different types of social network of researchers is needed in order to identify the best quality neighborhood. As mentioned earlier, the citation network and venue co-participation network are promising social networks which can be used to group similar researchers. Furthermore, an online evaluation which allows users explicitly express their opinion on recommendation results, needs to be performed to have the complete evaluation of the performance of the algorithm. Another direction is to cluster venues and apply CF on venue clusters instead of author clusters. We address these problems in our development system called AERCS(<http://bosch.informatik.rwth-aachen.de:5080/AERCS/>) which provides useful recommendation tools for researchers in computer science.

The approach should be also evaluated on other datasets where we can obtain the social relationship of users, like last.fm⁴, Epinion.com⁵, Mendeley⁶ and ResearchGate⁷. Regarding to application of recommender systems in digital libraries, we are investigating our approach to research paper recommendation.

⁴ <http://www.last.fm>

⁵ <http://www10.epinions.com/>

⁶ <http://www.mendeley.com/>

⁷ <http://www.researchgate.net>

Acknowledgments

This work has been supported by the Graduiertenkolleg (GK) "Software for mobile communication systems", the UMIC Research Centre, RWTH Aachen University and the EU FP7 IP ROLE. We would like to thank our colleagues for the fruitful discussions.

References

- [Anglade et al., 2007] Anglade, A., Tiemann, M., and Vignoli, F. (2007). Complex-network theoretic clustering for identifying groups of similar listeners in p2p systems. In *RecSys '07: Proceedings of the 2007 ACM conference on Recommender systems*, pages 41–48, New York, NY, USA. ACM.
- [Backstrom et al., 2006] Backstrom, L., Huttenlocher, D., Kleinberg, J., and Lan, X. (2006). Group formation in large social networks: membership, growth, and evolution. In *KDD '06: Proceedings of the 12th ACM SIGKDD international conference on Knowledge discovery and data mining*, pages 44–54, New York, NY, USA. ACM.
- [Clauset et al., 2004] Clauset, A., Newman, M. E. J., and Moore, C. (2004). Finding community structure in very large networks. *Physical Review E*, 70.
- [George and Merugu, 2005] George, T. and Merugu, S. (2005). A scalable collaborative filtering framework based on co-clustering. In *ICDM '05: Proceedings of the Fifth IEEE International Conference on Data Mining*, pages 625–628, Washington, DC, USA. IEEE Computer Society.
- [Harper et al., 2007] Harper, F. M., Sen, S., and Frankowski, D. (2007). Supporting social recommendations with activity-balanced clustering. In *RecSys '07: Proceedings of the 2007 ACM conference on Recommender systems*, pages 165–168, New York, NY, USA. ACM.
- [Kohrs and Merialdo, 1999] Kohrs, A. and Merialdo, B. (1999). Clustering for collaborative filtering applications. In *In Proceedings of CIMCA '99*. IOS Press.
- [Massa and Avesani, 2007] Massa, P. and Avesani, P. (2007). Trust-aware recommender systems. In *RecSys '07: Proceedings of the 2007 ACM conference on Recommender systems*, pages 17–24, New York, NY, USA. ACM.
- [Nathanson et al., 2007] Nathanson, T., Bitton, E., and Goldberg, K. (2007). Eigen-taste 5.0: constant-time adaptability in a recommender system using item clustering. In *RecSys '07: Proceedings of the 2007 ACM conference on Recommender systems*, pages 149–152, New York, NY, USA. ACM.
- [Newman, 2004] Newman, M. E. J. (2004). Fast algorithm for detecting community structure in networks. *Physical Review E*, 69.
- [Newman and Girvan, 2004] Newman, M. E. J. and Girvan, M. (2004). Finding and evaluating community structure in networks. *Physical Review E*, 69.
- [O'Donovan and Smyth, 2005] O'Donovan, J. and Smyth, B. (2005). Trust in recommender systems. In *IUI '05: Proceedings of the 10th international conference on intelligent user interfaces*, pages 167–174, New York, NY, USA. ACM.
- [Quan et al., 2006] Quan, T. K., Fuyuki, I., and Shinichi, H. (2006). Improving accuracy of recommender system by clustering items based on stability of user similarity. In *CIMCA '06: Proceedings of the International Conference on Computational Intelligence for Modelling Control and Automation and International Conference on Intelligent Agents Web Technologies and International Commerce*, page 61, Washington, DC, USA. IEEE Computer Society.
- [Rashid et al., 2006] Rashid, A. M., Shyong, Karypis, G., and Riedl, J. (2006). Clustknn: A highly scalable hybrid model- & memory-based cf algorithm. In *WE-BKDD 2006*, Philadelphia, Pennsylvania, USA.

- [Sarwar et al., 2002] Sarwar, B., Karypis, G., Konstan, J., and Riedl, J. (2002). Recommender systems for large-scale e-commerce: Scalable neighborhood formation using clustering. In *Proceedings of the Fifth International Conference on Computer and Information Technology*.
- [Truong et al., 2007] Truong, K., Ishikawa, F., and Honiden, S. (2007). Improving accuracy of recommender system by item clustering. *IEICE - Trans. Inf. Syst.*, E90-D(9):1363–1373.
- [Ungar and Foster, 1998] Ungar, L. and Foster, D. (1998). Clustering methods for collaborative filtering. In *Proceedings of the Workshop on Recommendation Systems*. AAAI Press, Menlo Park California.
- [Xue et al., 2005] Xue, G.-R., Lin, C., Yang, Q., Xi, W., Zeng, H.-J., Yu, Y., and Chen, Z. (2005). Scalable collaborative filtering using cluster-based smoothing. In *SIGIR '05: Proceedings of the 28th annual international ACM SIGIR conference on Research and development in information retrieval*, pages 114–121, New York, NY, USA. ACM.
- [Zhang and Hurley, 2009] Zhang, M. and Hurley, N. (2009). Novel item recommendation by user profile partitioning. In *WI-IAT '09: Proceedings of the 2009 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology*, pages 508–515, Washington, DC, USA. IEEE Computer Society.
- [Zhou et al., 2008] Zhou, D., Zhu, S., Yu, K., Song, X., Tseng, B. L., Zha, H., and Giles, C. L. (2008). Learning multiple graphs for document recommendations. In *WWW '08: Proceeding of the 17th international conference on World Wide Web*, pages 141–150, New York, NY, USA. ACM.
- [Zhu et al., 2007] Zhu, S., Yu, K., Chi, Y., and Gong, Y. (2007). Combining content and link for classification using matrix factorization. In *SIGIR '07: Proceedings of the 30th annual international ACM SIGIR conference on Research and development in information retrieval*, pages 487–494, New York, NY, USA. ACM.

Towards Intention-Aware Systems

Benedikt Schmidt and Todor Stoitsev

(SAP Research CEC Darmstadt, Germany
benedikt.schmidt@sap.com, todor.stoitsev@sap.com)

Max Mühlhäuser

(TU Darmstadt, Germany
max@informatik.tu-darmstadt.de)

Abstract: Intention-Aware systems are introduced as a system class which enables user support based on intention detection. Thereby, intention-aware systems build on the user-centric support approach of attention-aware systems and the environment-centric support approach of context-aware systems. A framework for intention-aware systems is proposed, highlighting the importance of a task model. We review 16 context-aware and attention-aware systems as foundation for the work on a task model for intention-aware systems.

Key Words: intention-aware systems, context-aware systems, attention-aware systems, knowledge work

Category: H.4.1, H1.2

1 Introduction

Knowledge work often is difficult to support, due to its weak structure and unpredictable information requirements. Supporting this kind of work requires situation specific adaptation of information delivery in consent to the user intention. Context-aware systems [Baldauf et al., 2007] and attention-aware systems [Roda and Thomas, 2006] are two approaches for the design of such systems. The respective realizations mainly focus on the detection of user status (attention-aware) or environment status (context-aware). We see potential in utilizing the information of both system types, integrated by a task model. The task model needs to explicate the individual and implicit intentions and plans of users, to reason about attention and context information. This integration enables work execution support reflecting the individual working process in a given situation. We call such systems intention-aware.

In this paper we discuss intention-aware systems to connect context and attention data with user intention, using a task model. Initially, we conceptualize intention-aware systems (sec. 2) by providing a human-environment interaction model. This model is the foundation of a framework for intention-aware systems. Thereafter, we focus on intention-aware systems in the domain of desktop computing. We review sixteen systems from the domain of context-aware and attention-aware applications (sec. 3). The review focuses on the task models

already applied in such systems, the population of such models with instance information and the systems' purpose. All systems work on the same information base, the tracking of user-system interaction. We show a connection between the richness of the task model and the support functionalities of the system. The outlook section finally summarizes the main aspects of our argumentation and hints towards upcoming work.

2 Towards Intention-Aware Systems

Intention is “a composite concept specifying what the agent has chosen and how the agent is committed to that choice” [Cohen and Levesque, 1990]. The statement highlights intention as something individual, only existing implicitly, as it is highly connected with an individuals' goal-directed perception of the environment. This environment is the locus of human-world interaction triggered by the commitment that results from intention. The structure of intention as organizing goals and their achievement by executing plans has been tackled by artificial intelligence research in a myriad of approaches [Cohen and Levesque, 1990]. Still, it remains a difficult task to model, detect, and process the necessary information on users and environment to actually detect intention.

Recently, user and environment information have been tackled by context-aware and attention-aware systems. Both share common ground in the detection and externalization of status information and both make use of instrumented environments. Nevertheless, they stress on different aspects. Context-aware systems focus on detection of situation-specific environmental features [Baldauf et al., 2007], whereas attention aware systems focus on situation-specific individual processes of perception and cognition [Roda and Thomas, 2006].

An intention-aware system integrates these aspects. It detects user intention based on the situation-specific user attention and the status of the environment. In the following we present a human-environment interaction model. Based on the model, we subsequently describe a framework for an intention-aware system.

2.1 Human-Environment Interaction Model

To model the interaction of human and environment we extend the K-system model [Stachowiak, 1973] which describes system-world interaction by means of a control circuit (see fig. 1). Considering the K-system as a human being, the human is organized by perceptor, operator, and motivator interrelated with the environment. We extend the model in two directions. On the one hand, we specify the motivator as the connection of intention, attention, and planning. This realizes the modeling of intention as choice with commitment in terms of planning theory [Cohen and Levesque, 1990]. On the other hand, the environment can be decomposed into three areas, following the work on context by

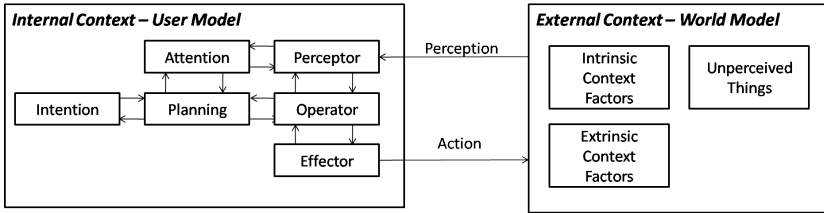


Figure 1: Human-environment interaction model

[Öztürk, 1998]. The environment consists of: i) those things which are directly related to human intention (intrinsic context), ii) those which are not related to intention (extrinsic context) and iii) those things which are not perceived.

Perception and action depend on the intention and the related planning. Focusing on awareness as top-down process, it is an instrument to guide perception based on intention. Thus, the context factors only have value once they are associated with intention and resulting plans.

Context-aware and attention-aware systems are valid in this model. An important aspect is, that they generally focus on few static intentions for which context features or awareness features are exploited. Therefore, they rely on implicit models of intention, e.g. based on the usage-scenario of an application. Once one assumes that human intention can vary, e.g. by extending the scenario beyond a single application, it is necessary to explicitly model intention, too.

2.2 A Framework for Intention-Aware Systems

The human-environment interaction model has described the connection of intention, awareness and perceived context. To realize a system which is able to reason about these aspects, it is necessary to identify methods to decide on human intention based on observable facts. In the following we propose a three layer architecture for intention-aware systems (see fig. 2).

The lowest layer, “Context-Awareness Pipeline” describes a pipeline, using sensors to detect observable facts about the interaction of the user with their environment, clusters this data and manages its storage or delivery. The layer itself is a context-aware application as proposed by [Baldauf et al., 2007, Hoh et al., 2006].

The second layer, “Intention Elicitation Pipeline” processes the context and awareness information from the base layer to identify the current user intention. Based on the detected intention and the respective plans, the system generates hypotheses about subsequent actions. Unlike context-aware or attention-aware system, this processing is based on a task model which integrates information

about user intentions, related plans, and a user model. This connects the attention information with the context information and links them to intention. As manual modeling of instances for such a task model is a tedious and error-prone task, semi-automatic approaches seem to be useful. Possible approaches are programming by demonstration [Cypher, A. And Halbert, 1993] or learning sets to train classifiers based on information from the base layer. Based on the information processed in layer 2 additional data can be obtained through extension of existing models.

The third layer “Situational Support” provides support to the user based on the intention and on the knowledge about the user (general demand and preference of support). The system can select useful support mechanisms for the identified intention. The range of support mechanisms comprises dynamic user interfaces, service provision or agents.

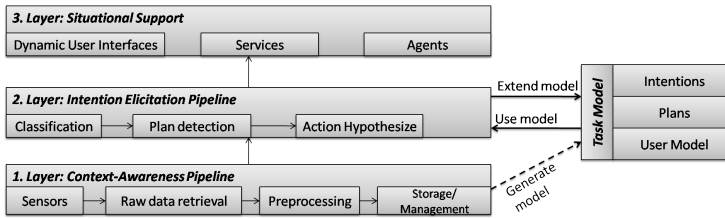


Figure 2: Framework for intention-aware systems

3 Task Model Review

In the following we focus on intention-aware desktop computing. The computer desktop is an environment which can be easily instrumented with sensors to identify context features and user awareness. We have highlighted that intention elicitation benefits from a task model, integrating user intentions, connected plans and a user model. The work on such a task model shall reflect existing efforts on task modeling.

We review task models of sixteen applications which use context and attention information for task execution support. All reviewed systems use an instrumented desktop environment to detect user-system interaction and provide support based on similar information: a sequence of classified system events. These events are classified as tasks which have a goal (an intention). In the following a task is generally referred to as an atomic unit of work [Godehardt et al., 2007]. Still, this definition results in different understanding of a task. Each system has

Table 1: Systems supporting users based in context and attention data in the domain of desktop computing

Name	Task Model	Knowledge Base	Support	Referenz
LIP	Resources with compen- tency requirements	4 Phase Context Ontology	Recommend learning re- sources	[Schmidt, 2007]
SWISH	App. Name sequences	Machine Learning (ML), PLSI	Recommend next steps	[Oliver et al., 2006]
Task Tracer	Bag of resources	ML (e.g. Perceptron)	Resource recommendation	[Shen et al., 2007]
UJCO	HTD	Action/Res. Ontology/ML	Resource recommendation	[Rath, 2009]
Dyonipos	HTD	Action/Resource Ontology and ML (e.g. SVM)	Resource recommendation	[Granitzer et al., 2008]
WIMP for ETS	HTD	Goals/Actions Hierarchy	Recommend next steps	[Cheikes et al., 1998]
Suitor	Bag of keywords	Semantic Analysis	Display topics of interest	[Maglio et al., 2000]
ActivityStreams	Application and re- source sequences	Grammar representation	Adapt User Interface	[Maulsby, 1997]
CAM	Bag of resources	Automatic resource logging	Not described in reference	[Wolpers et al., 2007]
CAAD	Bag of resources	ML (Pattern mining)	Resource recommendation	[Rattenbury et al. 2007]
Goal recognizer	Action sequence / goal	Plans as modeled grammar	Recommend next steps	[Lesh et al. 1995]
PETDL	Action sequence / goal	Manually modeled patterns	Recommend next steps	[Bailey et al., 2006]
Ap. Monitor	Action sequence/wrds	Workflows and ML (e.g. SVM)	Propose resources to goal	[Godehardt et al., 2007]
UOH	Bag of resources	ML (Case Based Reasoning)	Resource recommendation	[Schwarz, 2006]
Lumiere	Sequence of activities	ML (Bayes Models)	Recommend next steps	[Horvitz et al., 1998]
UMEA	Bag of resources	Program by demonstration	Resource recommendation	[Kaptelinin, 2003]

been reviewed with respect to the task model, the knowledge base connected to the task model and the type of support given by the system. The review is based on the respective publications. If no task model has been made explicit, the classification is inferred from the description of data models on data processing. We included systems which use collected data to generate user support. Ex-post analysis of such data (e.g. [Fern et al., 2007], [Ellis et al., 2006]) was not considered. The overview of the review is given in table 1.

3.1 Tasks as Bag of Words

The Suitor system [Maglio et al., 2000] considers a task as a set of keywords. These keywords are extracted based on resources the user interacted with and are used to identify information of interest.

3.1.1 Tasks as Bags of Resources

Many systems identify tasks as bags of resources. Such systems are the Task Tracer system [Shen et al., 2009, Shen et al., 2007], the user observation hub [Schwarz, 2006], CAM (ContextualizedAttentionMetadata) [Wolpers et al., 2007] or the UMEA system [Kaptelinin, 2003]. The approach is similar: the system tracks resources used in a task context and uses this information to generate recommendations in upcoming executions. The sequence of resource use in a task is unimportant. An extension is the LIP system, which proposes learning resources to the user: it calculates a competency gap based on the resources the user works with and on a user competency model [Schmidt, 2007]. The CAAD (Context-Aware Activity Display) [Rattenbury and Canny, 2007] follows an interestingly different approach: the system uses pattern mining to identify clusters of resources, eg. based on temporal co-occurrence. These cluster then implicitly represent a task.

3.2 Tasks as Sequences of Actions

The following systems consider tasks as sequence of actions on resources and application: Dyonipos [Granitzer et al., 2008], UICO [Rath, 2009], Aposdle (Ap.) Monitor [Godehardt et al., 2007] and SWISH [Oliver et al., 2006] use machine learning (ML) algorithms (e.g. Support Vector Machines, Graph Kernel) to identify a task based on the user interaction sequence. ML through a Bayes Model for the use of a single application has been realized by the Lumière system [Horvitz et al., 1998]. Another approach is the modeling of tasks based on automatically detected grammars. This is done by Activity Streams [Maulsby, 1997]. Unlike the previous approaches, the goal recognizer [Lesh and Etzioni, 1995] and the PETDL [Bailey et al., 2006] demand the manual creation of a grammar for a task.

3.3 Tasks as Hierarchical Work Decompositions

Hierarchical Task Analysis (HTA) is a popular approach in the domain of task analysis. A task is decomposed in smaller units of work which again can be decomposed until a preferred granularity is reached. The result is a soft decomposition of execution complexity. The WIMP system for embedded training systems [Cheikes et al., 1998] uses manually modeled task decompositions.

4 Conclusion: Intention-aware systems and their benefit

Intention-aware systems combine attention and context information to enable situation-specific work execution-support. A two phase process is realized: i) tracked context and attention information unfold user intention ii) which is used for intention-specific context transformation support and guidance of user attention.

The task model, bridging user information and context data with respect to execution activities is the central challenge for realizing intention-aware systems. The reviewed task models show that task models of high complexity often demand manual user effort for their creation (e.g. the HTA models). Automation has been realized, focusing on the sequence of actions by applying ML algorithms. Only few task models integrate user modeling or goal modeling (which can hint towards intention modeling). The effective integration of a user model and an intention model into a task model remains an open topic.

Currently, we work on the extension of a task model to enable intention-aware user support. Thereby, we especially focus on the aspect of user and intention modeling.

References

- [Bailey et al., 2006] Bailey, B., Adamczyk, P., Chang, T., and Chilson, N. (2006). A framework for specifying and monitoring user tasks. *Computers in Human Behavior*, 22(4):709–732.
- [Baldauf et al., 2007] Baldauf, M., Dustdar, S., and Rosenberg, F. (2007). A survey on context-aware systems. *International Journal of Ad Hoc and Ubiquitous Computing*, 2(4):263–277.
- [Cheikes et al., 1998] Cheikes, B., Geier, M., Hyland, R., Linton, F., and Rodi, L. (1998). Embedded training for complex information systems. *Tutoring Systems*, pages 36–45.
- [Cohen and Levesque, 1990] Cohen, P. and Levesque, H. (1990). Intention is choice with commitment. *Artificial intelligence*, 42(2-3):213–261.
- [Cypher, A. And Halbert, 1993] Cypher, A. And Halbert, D. (1993). *Watch what I do: programming by demonstration*. The MIT press.
- [Ellis et al., 2006] Ellis, C., Rembert, A., Kim, K.-h., and Wainer, J. (2006). Beyond workflow mining. *LNCS*, 4102:49.
- [Fern et al., 2007] Fern, X. Z., Komireddy, C., and Burnett, M. (2007). Mining Interpretable Human Strategies: A Case Study. *Seventh IEEE International Conference on Data Mining (ICDM 2007)*, pages 475–480.

- [Godehardt et al., 2007] Godehardt, E., Faatz, A., and Goertz, M. (2007). -Exploiting Context Information for Identification of Relevant Experts in. *LNCS*, pages 217–231.
- [Granitzer et al., 2008] Granitzer, M., Kroll, M., Seifert, C., Rath, A., Weber, N., Dietzel, O., and Lindstaedt, S. (2008). Analysis of machine learning techniques for context extraction. In *Digital Information Management, 2008. ICDIM 2008. Third International Conference on*, pages 233–240.
- [Hoh et al., 2006] Hoh, S., Devaraju, A., and Wong, C. (2006). A Context Aware Framework for User Centered Services. *intelligentmodelling.org.uk*, pages 1–8.
- [Horvitz et al., 1998] Horvitz, E., Breese, J., Heckerman, D., Hovel, D., and Rommelse, K. (1998). The Lumière project: Bayesian user modeling for inferring the goals and needs of software users. In *Proceedings of the fourteenth Conference on Uncertainty in Artificial Intelligence*, pages 256–265.
- [Kaptelinin, 2003] Kaptelinin, V. (2003). UMEA: translating interaction histories into project contexts. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, number 5, pages 353–360. ACM.
- [Lesh and Etzioni, 1995] Lesh, N. and Etzioni, O. (1995). A sound and fast goal recognizer. In *International Joint Conference on Artificial Intelligence*, volume 14, pages 1704–1710.
- [Maglio et al., 2000] Maglio, P., Barrett, R., Campbell, C., and Selker, T. (2000). SUITOR: An attentive information system. In *Proceedings of the 5th international conference on Intelligent user interfaces*, pages 169–176. ACM.
- [Maulsby, 1997] Maulsby, D. (1997). Inductive task modeling for user interface customization. In *Proceedings of the 2nd international conference on Intelligent user interfaces*, pages 236–240. ACM.
- [Oliver et al., 2006] Oliver, N., Smith, G., Thakkar, C., and Surendran, A. (2006). SWISH: semantic analysis of window titles and switching history. In *Proceedings of the 11th international conference on Intelligent user interfaces*, pages 201–209. ACM.
- [Öztürk, 1998] Öztürk, P. (1998). A context model for knowledge-intensive case-based reasoning. *International Journal of Human-Computer Studies*, 48(3):331–355.
- [Rath, 2009] Rath, A. S. (2009). UICO: An ontology-based user interaction context model for Automatic Task Detection on the Computer Desktop. *CIAO '09: Proceedings of the 1st Workshop on Context, Information and Ontologies*, pages 1–10.
- [Rattenbury and Canny, 2007] Rattenbury, T. and Canny, J. (2007). CAAD: an automatic task support system. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 696–706. ACM.
- [Roda and Thomas, 2006] Roda, C. and Thomas, J. (2006). Attention aware systems: Theories, applications, and research agenda. *Computers in Human Behavior*, 22(4):557–587.
- [Schmidt, 2007] Schmidt, A. (2007). *Impact of context-awareness on the architecture of learning support systems*, volume 2007.
- [Schwarz, 2006] Schwarz, S. (2006). A context model for personal knowledge management. *LNCS*, 3946:18–33.
- [Shen et al., 2009] Shen, J., Irvine, J., Bao, X., Goodman, M., Kolibaba, S., Tran, A., Carl, F., Kirschner, B., Stumpf, S., and Dietterich, T. (2009). Detecting and correcting user activity switches: Algorithms and interfaces. In *Proceedings of the 13th international conference on Intelligent user interfaces*, pages 117–126. ACM.
- [Shen et al., 2007] Shen, J., Li, L., and Dietterich, T. (2007). Real-time detection of task switches of desktop users. In *Proc. of IJCAI*, volume 7, pages 2868–2873.
- [Stachowiak, 1973] Stachowiak, H. (1973). *Allgemeine Modelltheorie*. Springer.
- [Wolpers et al., 2007] Wolpers, M., Najjar, J., Verbert, K., and Duval, E. (2007). Tracking actual usage: the attention metadata approach. *Subscription Prices and Ordering Information*, 10(3):106.

Improving Navigability of Hierarchically-Structured Encyclopedias through Effective Tag Cloud Construction

Christoph Trattner

(IICM, Graz University of Technology, Graz, Austria
ctrattner@iicm.edu)

Denis Helic

(KMI, Graz University of Technology, Graz, Austria
dhelic@tugraz.at)

Markus Strohmaier

(KMI, Graz University of Technology, Graz, Austria
markus.strohmaier@tugraz.at)

Abstract: In this paper we present an approach to improving navigability of a hierarchically structured Web encyclopedia. The approach is based on an integration of a tagging module and adoption of tag clouds as a navigational aid in such a system. The main idea of this approach is to apply tagging for the purpose of a better highlighting of cross-references between information items across the hierarchy. Although in principle tag clouds have the potential to support efficient navigation in tagging systems, recent research identified a number of limitations. In particular, applying tag clouds within pragmatic limits of a typical user interface leads to poor navigational performance as tag clouds are vulnerable to a so-called pagination effect. In this paper, a possible solution to the pagination problem is discussed. In addition, the paper presents a first implementation prototype developed within an Austrian online encyclopedia called *Austria-Forum*.

Key Words: Tagging, tags, tag clouds, navigation, navigability, online encyclopedia

Category: H.4

1 Introduction

*Austria-Forum*¹ is a wiki-based online encyclopedia containing articles related to Austria. The system comprises a very large repository of articles, where new articles are easily published, edited, checked, assessed, and certified, and where the correctness and quality of each of these articles is assured by a person that is accepted as an expert in a particular field [Trattner et al. 2010]. Currently, the system contains approximately 110,000 information items.

Austria-Forum can be seen as a collection of several hierarchically structured encyclopedias such as Biographies, Post Stamps, Coins, or Austrian Universal Encyclopedia. Articles from a single encyclopedia have a common source and

¹ <http://www.austria-lexikon.at>

are therefore neatly interlinked to each other. Links between articles from two different encyclopedias are sparse even though the articles might be related to each other. For example, there are several “Mozart” stamps in the Stamps encyclopedia. However, none of these articles has links to the “Mozart” biography, or “Mozart” coins because the articles are created and managed independently.

To tackle the problem of poor connectivity, we introduced a simple built-in tagging system in *Austria-Forum*. In tagging systems people use free-form vocabulary to annotate resources with “tags” [Hammond et al. 2005, Wu et al. 2006, Marlow et al. 2006, Us Saaed 2008]. This is either done for semantic reasons (e.g. to enrich information items with metadata), conversational (e.g. for social signaling) [Ames and Naaman 2007] or for organizational reasons (e.g. to categorize information items) [Körner et al. 2010]. Independent of “why people tag” [Strohmaier et al. 2010b, Strohmaier 2008], tags can be visualized in so-called “tag clouds” (cf. [Ames and Naaman 2007]). A tag cloud is a selection of tags related to a particular resource. Upon clicking on a tag, a list of resources tagged with that tag is presented to users leaving them with a possibility to easily navigate to related resources. The main idea of including a tag module into *Austria-Forum* can best be described via the previously mentioned “Mozart” example. Suppose that users tag “Mozart” stamps, “Mozart” coins, “Mozart” biography, or any other document dealing with “Mozart” with a common tag, e.g. “Amadeus”. Whenever users navigate to any of these articles a tag cloud containing all assigned tags is presented by the system. Thus, users can now click on “Amadeus” tag and this presents a list of all other articles tagged by that tag. Consequently, all articles tagged with “Amadeus” are now linked to each other, in fact, they are cross-linked across the hierarchical structure.

Due to such indirect linking capabilities, tag clouds are typically applied as a navigational support in tagging systems (cf. systems such as *Flickr*, *Delicious*, or *BibSonomy*) under the assumption that they are useful for navigation. Recently, in a number of studies tag clouds have been investigated from user interface [Mesnage and Carman 2009, Sinclair and Cardew-Hall 2008] and network-theoretic perspective [Neubauer and Obermayer 2009]. These studies agree with regard to some interesting findings, such as the observation that current tag cloud calculation algorithms need to be improved. In particular, the ability of tag clouds to support “efficient” navigation under the consideration of pragmatic user interface limits, such as tag cloud size and pagination, is very poor [Strohmaier et al. 2010a, Trattner et al. 2010].

In this paper, we present an approach to constructing tag clouds that support efficient navigation. This new algorithm is based on the idea of hierarchical network models that are known to be efficiently navigable [Kleinberg 2001]. The algorithm has been implemented in *Austria-Forum* as a general tool for improving connectivity and navigability of the system as a whole.

The paper is structured as follows: Section 2 presents a generalized model for tag cloud based navigation. Section 3 discusses the problems of tag cloud based navigation and current tag cloud calculation algorithms. Section 4 presents the idea of a new and optimized tag cloud calculation algorithm based on the ideas of hierarchical network models within an online encyclopedia system called *Austria-Forum*. Finally, Section 5 concludes the paper and provides an outlook for the future work in this area.

2 Model of Tag Cloud Navigation

In this paper, the tagging data is modeled as a pair of the form (r, t) , where r is a resource from the set of all resources R , and t is a tag of all tags T . Here, we do not take into account users as we concentrate only on links between resources imposed by tags assigned to those resources. The main navigational aid in a tagging system is a tag cloud and we denote it with TC . Formally, a tag cloud TC is a particular selection of tags from the tag set.

Due to user interface restrictions the number of tags within a tag cloud is usually limited to an upper bound. To model this situation we additionally introduce a factor n as a maximum number of tags in a tag cloud.

Usually, the most popular tags are assigned to a large number of resources – hundreds or even thousands of resources. When a user clicks on such a tag, tagging systems present a long paginated list of tagged resources. In most cases, 10–100 resources are presented to the users at once (see e.g. *Delicious* or *Bibsonomy*). To model these user interface limitation – that we refer to as the *pagination* from here on – we introduce a factor k that k -limits the resource list of tags within a tag cloud TC .

Finally, let us model the navigation process in a tagging system. Navigation in a tagging system might start from a home page where a system-global tag cloud is presented. Typically, tags with the highest global frequency are selected for inclusion in a tag cloud. Upon clicking on a particular tag a k -limited list of resources is shown. Once the user has selected a specific resource, the system transfers the user to the selected resource and presents a *resource-specific tag cloud* TC_r . The tags in such a resource-specific tag are selected according to the highest local frequency. In the next step, by selecting a tag from a given resource-specific tag cloud, the system again presents a paginated list of resources and the user might continue the navigation process in the same manner as before (see Figure 1).

3 Problems of Tag Cloud Navigation

Resource-specific tag clouds are a simple way to connect many resources within a tagging system [Strohmaier et al. 2010a], i.e. in a typical tagging system one can

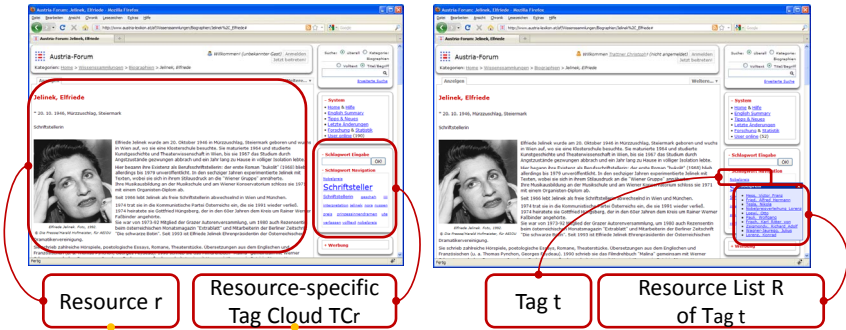


Figure 1: Resource specific tag cloud TC_r and k -limited resource list R of tag t within *Austria-Forum*

find nearly 99% of the resources interlinked with each other within a tag cloud network. However, this simple approach to building tag clouds has also certain issues. In particular, resource-specific tag clouds are vulnerable to a so-called pagination effect [Helic et al. 2010]. In other words, by k -limiting the resource list of a given tag (with typical pagination values such as 5, 10, or 20) the connectivity of the tag cloud network collapses drastically. Practically, this leads to a situation where the tag cloud network consists of isolated network clusters that are not linked to each other anymore. In other words, the users cannot reach one network fragment from another network fragment by navigating resource-specific tag clouds.

One simple solution to this problem is to select resource for inclusion in a k -limited resource list uniformly at random. For example, whenever the user clicks on a given tag the system randomly selects k resources and presents them to the user. As [Bollobás and Chung 1988] have shown this approach produces a random network that is, even for small values of k , completely connected.

However, another important question is: Are such networks also “efficient” navigable? In other words, how useful and usable are tag clouds where the resource selection happens randomly? From the theoretical point of view, Kleinberg [Kleinberg 2000] argued that “efficiently” navigable networks are networks for which efficient decentralized search algorithms exist. Such algorithms can find a short path between a starting and a destination node in a polynomial of $O(\log N)$ (N is the total number of nodes within a network). Naive random networks algorithms form network structures which require linear search time ($O(N)$), i.e. in the worst case one has to visit all N nodes within a network to reach the destination node. In [Kleinberg 2001], Kleinberg showed that a hierarchical network generation model forms networks which are navigable in

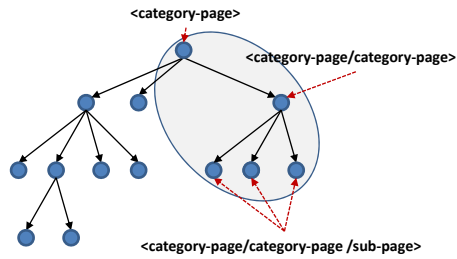


Figure 2: Hierarchical structure and URL addressing schema within *Austria-Forum*.

polynomial of $O(\log N)$. Therefore, we applied a hierarchical network generation algorithm for tag cloud generation in *Austria-Forum*.

4 Algorithm

4.1 Tag Clouds Hierarchy

We distinguish between two different types of nodes within *Austria-Forum* – category-page and sub-page nodes with sub-page nodes being hierarchy leaves (see Figure 2). Information items within *Austria-Forum* are hierarchically structured and addressable via a hierarchical URL schema.

The first component of the tag cloud generation algorithm in *Austria-Forum* simply follows the hierarchical data organization and constructs hierarchically organized tag clouds. The idea of this component is to provide more links between articles in one and the same category. Thus, in order to generate a tag cloud for a particular category-page, the tags of all sub-categories and all sub-pages are aggregated recursively [Trattner and Helic 2009]. On the other hand, in order to generate a tag cloud for a particular sub-page, the resource-specific tag cloud calculation pattern is applied. The hierarchical tag cloud generation algorithm is shown in Algorithm 1 (hereby, t_f represent a local tag frequency).

4.2 Addressing the Pagination Problem

Hierarchical network models [Kleinberg 2001] are based on the idea that, in many settings, the nodes in a network might be organized in a hierarchy. The hierarchy can be represented as a b -ary tree and network nodes can be attached to the leaves of the tree. For each node v , we can create a link to all other nodes w with the probability that decreases with $h(v, w)$ where h is the height of the least common ancestor of v and w in the tree. Networks generated by this model are “efficiently” navigable [Kleinberg 2001].

Algorithm 1 Tag cloud calculation algorithm

```

getTagCloud: url, n
if (url is category-page) then
     $TC_r^n \leftarrow$  select top  $n$  tags sorted by  $t_f$  where  $r.url.startsWith(url)$ 
else
     $TC_r^n \leftarrow$  select top  $n$  tags sorted by  $t_f$ 
end if
return  $TC_r^n$ 

```

The main idea of applying such a hierarchical network model is to reuse the hierarchical organization of articles in *Austria-Forum* as the basis for generating the link probability distribution. To put it simply, the probability that an article is linked with other articles from the same category is higher than the probability that an article is linked with articles from other categories. However, one needs only a few of such “long-range” links to other categories to obtain a connected and efficiently navigable network. Two examples of links generated by such a model are given in Figure 3.

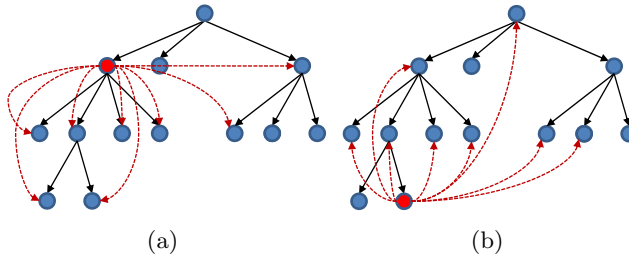


Figure 3: Hierarchical random selection algorithm

The Algorithm 2 shows our first approximation of such a network generation algorithm. In principle, for each paginated tag a different resource list is presented to users depending on the user current context, i.e. depending on the resource where the user clicked on that given tag. The resources are selected randomly following this simple heuristic: $k - j$ resources are selected from the category of the current resource and j resources are selected from other categories ($j < k/2$).

The hierarchical network model as introduced by Kleinberg takes a complete, balanced tree of nodes to obtain the link distribution. However, such an optimal model is a strong simplification because hierarchies are rarely complete

Algorithm 2 Resource list calculation algorithm

```

getResourceList: url, t, k, j
category-page  $\leftarrow$  categoryOf(url)
 $R_{category} \leftarrow$  select resources  $r$  with  $t$  where  $r.url.startsWith(category-page.url)$ 
 $R_{global} \leftarrow$  select resources  $r$  with  $t$  where NOT  $r.url.startsWith(category-page.url)$ 
 $R_{category} \leftarrow$  select  $k - j$  resources at random from  $R_{category}$ 
 $R_{global} \leftarrow$  select  $j$  resources at random from  $R_{global}$ 
 $R^k \leftarrow R_{category}^{k-j} \cup R_{global}^j$ 
return  $R^k$ 

```

or balanced. Algorithms implementing this network model need to work with heuristics and intuitions that approximate the optimal settings. The intuition which we followed with our algorithm was that linkage probability is based on the hierarchy distance between articles. To evaluate such an intuitive assumption as well as to estimate the algorithm parameters, e.g. j a detailed empirical analysis would be needed. This is, however, out of the scope of this paper and is left for the future work.

5 Conclusions and Future Work

The main contribution of this paper is the introduction of a novel, tag-based algorithm for interlinking resources in hierarchically-structured online encyclopedias. Based on a review of tag cloud limitations and an existing hierarchical algorithm for the construction of efficiently navigable networks, we sketch a new approach to tag cloud construction that improves the overall navigability of social tagging systems. While the arguments laid out in this paper are of a theoretical nature, we leave the task of empirically testing the navigability of link structures produced by such an algorithm to future work. Finally, evaluating the usability and usefulness of the proposed algorithm with end users in an experimental setting would bring new insights into the potentials and limitations of the proposed approach.

References

- [Ames and Naaman 2007] Ames, M. and Naaman., M.: Why we tag: motivations for annotation in mobile and online media. In CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems, ACM, New York, 2007.
- [Bollobás and Chung 1988] Bollobás, B. and Chung, F. R. K.: The diameter of a cycle plus a random matching. In SIAM J. Discret. Math. 1(3), pp 328–333, 1988.
- [Hammond et al. 2005] Hammond, T., Hannay, T., Lund, B. and Scott J.: Automatic construction and management of large open webs. Social Bookmarking Tools (I): A General Review, D-Lib Magazine, 11(4), 2005.

- [Helic et al. 2010] Helic D., Trattner Ch., Strohmaier M., Andrews K., On the Navigability of Social Tagging Systems, The 2nd IEEE Conference on Social Computing, SocialCom2010, Minneapolis, Minnesota, USA, 2010 (to be published).
- [Kleinberg 2000] Kleinberg, J.: The Small-World Phenomenon: An Algorithmic Perspective. In Proc. of the 32nd ACM Symposium on Theory of Computing, 2000.
- [Kleinberg 2001] Kleinberg, J. M.: Small-World Phenomena and the Dynamics of Information. In Advances in Neural Information Processing Systems (NIPS) 14, 2001.
- [Körner et al. 2010] Körner, C., Benz, D., Hotho, A., Strohmaier, M., Stumme, G.: Stop Thinking, Start Tagging: Tag Semantics Emerge From Collaborative Verbosity, 19th International World Wide Web Conference (WWW2010), ACM, Raleigh, NC, USA, April 26-30, 2010.
- [Marlow et al. 2006] Marlow, C., Naaman, M., Boyd, D., and Davis, M.: HT06, tagging paper, taxonomy, Flickr, academic article, to read, In Proceedings of the Seventeenth Conference on Hypertext and Hypermedia (Odense, Denmark, August 22 - 25, 2006), HYPERTEXT '06, ACM, New York, 2006.
- [Mesnage and Carman 2009] Mesnage, C. S. and Carman., M. J.: Tag navigation. In SoSEA '09: Proceedings of the 2nd international workshop on Social software engineering and applications, ACM, New York, 29 - 32, 2009.
- [Neubauer and Obermayer 2009] Neubauer, N. and Obermayer, K.: Hyperincident connected components of tagging networks, In HT 09: Proceedings of the 20th ACM conference on Hypertext and hypermedia, ACM, New York, 229 - 238, 2009.
- [Sinclair and Cardew-Hall 2008] Sinclair, J. and Cardew-Hall, M.: The folksonomy tag cloud: when is it useful? Journal of Information Science, 34:15, 2008.
- [Strohmaier 2008] Strohmaier, M.: Purpose Tagging - Capturing User Intent to Assist Goal-Oriented Social Search, SSM'08 Workshop on Search in Social Media, in conjunction with CIKM'08, Napa Valley, USA, 2008.
- [Strohmaier et al. 2010a] Strohmaier, M., Trattner, Ch., Helic, D. and Andrews, K.: The Benefits and Limitations of Tag Clouds as a Tool for Social Navigation from a Network-Theoretic Perspective, JUCS, 2010 (submitted).
- [Strohmaier et al. 2010b] Strohmaier, M., Koerner, C., and Kern, R.: Why do Users Tag? Detecting Users' Motivation for Tagging in Social Tagging Systems, 4th International AAAI Conference on Weblogs and Social Media (ICWSM2010), Washington, DC, USA, May 23-26, 2010.
- [Trattner et al. 2010] Trattner, Ch., Helic, D., Maglajlic, S.: Enriching Tagging Systems with Google Query Tags, In The 32nd International Conference on Information Technology Interfaces, IEEE, Cavtat / Dubrovnik, Croatia, 2010 (to be published).
- [Trattner and Helic 2009] Trattner, C., Helic, D.: Extending The Basic Tagging Model: Context Aware Tagging. - in: Proceedings of IADIS International Conference WWW/Internet 2009 (2009), IADIS International Conference on WWW/Internet, Rom, 76 - 83, 2009.
- [Us Saaed 2008] Us Saaed, A.; Afzal, M.T.; Latif, A.; Stocker, A., Tochtermann, K.: Does Tagging Indicate Knowledge Diffusion? An Exploratory Case Study, In Proc. of the ICCIT 08 - International Conference on Convergence and hybrid Information Technology, Busan, Korea, 2008.
- [Wu et al. 2006] Wu, H., Zubair, M., and Maly, K.: Harvesting social knowledge from folksonomies. In Proceedings of the Seventeenth Conference on Hypertext and Hypermedia (Odense, Denmark, August 22 - 25, 2006), HYPERTEXT '06. ACM, New York, 111 - 114, 2006.

On the Need for Open-Source Ground Truths for Medical Information Retrieval Systems

Markus Kreuzthaler

(Medical University Graz, Austria
markus.kreuzthaler@medunigraz.at)

Marcus Bloice

(Medical University Graz, Austria
marcus.bloice@medunigraz.at)

Klaus-Martin Simonic

(Medical University Graz, Austria
klaus.simonic@medunigraz.at)

Andreas Holzinger

(Medical University Graz, Austria
andreas.holzinger@medunigraz.at)

Abstract: Smart information retrieval systems are becoming increasingly prevalent due to the rate at which the amount of digitized raw data has increased, and continues to increase. This is especially true in the medical domain, as there is much data stored in unstructured formats which contain "hidden" information within them. By hidden, this means information that cannot ordinarily be found by performing a simple text search. To test the information retrieval systems that handle such data, a ground truth, or gold standard, is normally required in order to gain performance values according to an information need. In this paper we emphasize the lack of freely available, annotated medical data and wish to encourage the community of developers working in this area to make available whatever data they can. Also, the importance of such annotated medical data is raised, especially its importance and potential impact on teaching and training in medicine. As well as this, this paper will point out some of the advantages that access to a freely available pool of annotated medical objects would provide to several areas of medicine and informatics. The paper then discusses some of the considerations that would have to be made for any future systems developed that would provide a service to make the creating, sharing, and annotating of such data easy to perform (by using an online, web-based interface, for example). Finally, the paper discusses in detail the benefits of such a system to teaching and examining medical students.

Keywords: Evaluation, Text Mining, Information Retrieval, Medicine, Health Care

Categories: H.3.1, H.3.3, I.2.7, J.3

1 Introduction and Motivation

Free text consists of natural language, and the automated processing and understanding of natural language – although a research topic for more than 40 years – is still in its infancy [Gell et al., 1976]. Despite the prevalence of advanced information systems, many organizations still depend on this unstructured plain text

as a source of information. This is especially true in the medical domain, where old, hand-written documents are scanned and then read by optical character recognition systems and subsequently fed into information systems, thereby creating very large collections of unstructured text. Medical professionals, therefore, are often confronted with free texts, and these texts play an important role in clinical research, medical accounting, and quality assurance [Holzinger et al., 2007b]. Therefore, making this data more accessible, useful and useable is of high importance [Holzinger et al., 2008]. Consequently, any improvement to information retrieval systems that can assist the end user in handling these free texts is a positive advancement [Kaiser et al., 2007].

In medicine, this is perhaps more difficult to achieve than in other domains; medical texts consist of many abbreviations, synonyms, are written in several languages, and contain significant numbers of linguistic variations. A medical doctor's priority when writing a diagnosis text, for example, is not grammatical correctness and there is no compulsive need for a doctor to pay too much attention to legibility so long as the text is understandable in a medical context. Therefore, the evaluation of such information retrieval systems is a major concern. More often than not, free text retrieval is performed by simply searching the text pool for text patterns specified by the doctor. Purely statistical evaluations of such systems often make use of a ground truth, known as a gold standard, to compare the result returned by a retrieval system with that of a medical expert. Of course, there are a number of gold standard text corpora available to the information retrieval community for researching and testing purposes, but gold standards specifically for the medical domain are rare. What this paper suggests is to design and develop an open source gold standard for use by the information retrieval community working in the medical domain. If such an open source standard were available, it would promote work in this important field, spur development of better information retrieval systems, and generally help to improve medical information systems. Also of importance would be the creation of a pool of tagged medical information "objects" that is freely accessible, and an application that makes creating and publishing these pools easy to perform. Medical objects can be free text, images, electrocardiograms, MRI scans, and other such data.

The paper is organized as follows: Section 2 gives an overview of some of the information retrieval systems currently in use in the medical domain. Following this, common methods and a overview of information retrieval evaluation is given. Next, the development of an open source, community driven, gold standard is discussed, and the advantages that such a system would offer to the information retrieval community are presented. The last section concludes the paper, and presents future research topics.

2 Background: Information Retrieval in the Medical Domain

Information retrieval (IR) systems are being increasingly advocated by medical professionals in order to enhance the quality of patient care and to provide better use of evidence [Hersh and Hickam, 1998]. Much research has been done in the past in the area of information retrieval system evaluation [Robertson and Hancockbeaulieu, 1992], [Tange et al., 1998], [Brown and Sonksen, 2000] and significant progress has also been made in text mining techniques, in order to cope with the rapidly increasing

information overload in the area of medical literature [Sullivan et al., 1999], [Hall and Walton, 2004]. Interestingly, developments in text mining techniques in the area of clinical information systems and medical documentation are rare [Noone et al., 1998], [Holzinger et al., 2007b], [Holzinger et al., 2008]. The application of sophisticated medical information systems amasses large amounts of medical documents, which must be reviewed, observed, and analyzed by human experts [Holzinger et al., 2007a]. All essential patient record documents contain at least a certain portion of data which has been entered in free-text fields and its computational evaluation has very long been the focus of research

[Gell et al., 1976], [Gell, 1983], [Zingmond and Lenert, 1993]. Although text can be created relatively simply by end-users, supporting automatic analysis is extremely difficult [Gregory et al., 1995], [Holzinger et al., 2000], [Lovis et al., 2000]. Often it occurs in practice that relevant relationships remain completely undiscovered, because relevant data are scattered and no investigator has linked them together manually [Smalheiser and Swanson, 1998].

3 Evaluation of Information Retrieval Systems

The standard procedure used to measure information retrieval effectiveness comprises of the following three elements [Harter and Hert, 1997], [Zeng et al., 2002]:

- A document collection.
- A test suite of information requests, expressible as queries.
- A set of judgments for each query-document pair, which defines each pair as either relevant or not relevant.

The common approach to information retrieval system evaluation is based on the exact notion of relevant and non-relevant documents. In the context of information retrieval, relevance describes how well a retrieved set of documents (or a single document) meets the information need of the user. In other words, with respect to a user information need, a document in the test collection is given a binary classification as either relevant or non-relevant [Bemmel and Musen, 1997]. This decision is referred to as a “gold standard” or “ground truth judgment of relevance”. The test collection should be a sample of the kinds of text that will be encountered in the operational setting of interest [Wingert, 1986], and its relevance is assessed according to an information need [Robertson and Hancockbeaulieu, 1992]. Standard textbooks on information retrieval [Baeza-Yates and Ribeiro-Neto, 2006] claim that, as a rule of thumb, fifty information needs is generally considered to be a sufficient minimum. An important aspect of this is that a query for an information retrieval tool is not the information need. Rather an information need can be expressed in terms of a query language for an information retrieval tool. For example, some standard test collections that are often used by information retrieval researchers are the different tracks from the Text Retrieval Conference and GOV2 (a very large web page collection). Once a test collection to be used as a basis to test an information retrieval system has been chosen, a metric for the system comparison must be decided upon. Basically, this can be separated into two groups of pure statistical performance

measures; namely, metrics for unranked retrieval results and ranked retrieval results. Classical information retrieval metrics that are widely used in literature are the Recall, Precision, Fallout, and F-Measure metrics.

A lot of effort has been invested into finding new evaluation measures over the past few years, one of the most famous recently introduced being bpref [Buckley and Ellen, 2004]. Other common information retrieval metrics that are concerned with ranked retrieval results are R-Precision, Precision at k, Mean Average Precision (MAP), and Normalized Discounted Cumulative Gain (NCDG). A good explanation and overview of these and other current information retrieval metrics can be found in standard text books. However, other factors do exist that should also be considered when evaluating an information retrieval system. [Saracevic, 1995] identified six different levels of information retrieval evaluation:

- Engineering level
- Input level
- Processing level
- Output level
- Use and user level
- Social level

The human factor, and human information behaviour, in the context of information retrieval systems are especially important factors to consider when developing such systems. Such systems must be capable of satisfying user needs. Although getting the right answers according to an information need is one of the most important parts of an information retrieval system, human factors should also be considered [Lew et al., 2006].

4 Open Source Ground Truths in the Medical Domain

After giving an introduction to information retrieval and a brief overview about information retrieval evaluation this section will concentrate on the main content of the paper. Therefore, the reasons as to why it is thought that open ground truths might be useful are given. Then some considerations that should be made when creating such a resource are outlined. Finally, a number of ideas are presented regarding the usefulness of gold standards in the context of teaching medicine are provided.

4.1 Motivation and Challenges

The motivation for this paper can be derived from work carried out during a former project where the performance difference between a semantic-based information retrieval tool and a human expert was examined. To do this, information needs in the medical domain were translated into a query language and were compared to the results achieved using the Recall, Precision, Fallout, and F-Measure evaluation metrics.

Because no ground truth was available that contained medical diagnosis free texts in any medical area, it was necessary to create a new one. This resulted in a pool of 3542 annotated diagnosis texts in the field of pathology inflammation that were used

as a basis for a web-based evaluation framework. The framework was designed to be as flexible and extensible as possible, offering the ability to add other pools for testing at a later date. However, there are currently no such text pools available in the medical domain that could be used for information retrieval development or testing.

Text-based information retrieval is especially challenging in the medical domain, as the following example text will attempt to illustrate:

MITTELGRADIGE CHRONISCHE GASTRITS (MAGENMUCOSA VOM CORPUSTYP, UEBERGANGSTYP) MIT MITTELGRADIGER AKTIVITAET, KOMPLETTER UND INKOMPLETTER (TYP III) INTESTINALER METAPLASIE, MITTELGRADIGER ATROPHIE DER TIEFEN DRUESEN. ANTEIL EINES TUBULAEREN MAGENSCHLEIMHAUTADENOMS (INTESTINALER TYP; MITTELGRADIGE DYSPLASIE; WHO: GERINGGRADIGE INTRAEPITHELIALE NEOPLASIE). HP NICHT NACHWEISBAR.

The above text epitomizes the types of challenges that are inherent in medical free text analysis:

- The text resembles a memo more than an orthographically correct piece of text. From a doctor's point of view, however, the semantic of the text takes precedence over proper grammar or correct spelling.
- The text contains much domain specific knowledge and words that are would only be properly understood by an expert.
- Medical texts often contain abbreviations. In the text above, WHO stands for World Health Organization (which has a classification scheme for diseases), and the doctor is documenting the classification as GERINGGRADIGE INTRAEPITHELIALE NEOPLASIE. Even more frequent are abbreviations that are only resolvable when the context is known. HP in the context of gastritis stands for helicobacter-pylorii, but is often also used as an abbreviation for haptoglobin.
- Typing errors can further complicate matters when analysing text, as is illustrated by the misspelling of the word gastritis as GASTRITS.

Gold standards can also consist of images as well as text, as medical images can also be tagged with information regarding a particular aspect of a medical image.

It is the opinion of the authors, that a system should be developed that would enable creators of gold standards to make their work available to the community, using an online, web-based application. This application would allow registered users to create gold standard pools, which would contain the medical text, images, or other medical objects (such as electrocardiograms, sonograms, etc.), as well as their annotations. These objects could be used by other research groups, or extended with further annotations to create a more useful gold standard. Each pool could exist in a track, which would separate the gold standards into their relevant areas of medicine, and would also enable gold standards to be branched if a group decided to move the gold standard into a new direction. The aim of such a system would be that different sets from different medical areas could be made, accessed, and published in a

controlled way, while at the same time providing a guaranteed level of quality for the annotations. Furthermore, building gold standards is a time consuming process, and a collaborative system could alleviate some of the aspects of creating gold standards that make it too difficult for a small team to undertake. This proposal is work in progress and will be described in detail in a future paper, where a requirements analysis and framework architecture will be presented.

As mentioned previously, properly annotated medical texts are not freely available, and having access to medical texts from various areas of medicine would encourage the information retrieval community in the following ways:

- It could animate the community into working on these types of text, as they pose difficult challenges.
- Having access to more than one ground truth in a particular domain and in different languages would also make it possible to test and evaluate multi-language information retrieval.
- Because, in the experience of the authors, only semantic-based information retrieval tools tend to have the ability to solve retrieval tasks covering different areas of medicine, it would encourage the community to produce new information retrieval metrics that would take the semantic based nature of these engines into account.

A further challenge is patient privacy. Privacy laws are very strict with regards to patient information, and any gold standard data must be anonymized by the institution before adding it to the gold standard pool. Any institution that uses data that could potentially identify a patient, or data that contains personal health information, would first have to obtain patient authorization. Because applicable laws vary largely from country to country, the topic of patient privacy is large and complex and will be discussed in detail when a formal definition of the collaboration framework is made. Data anonymization is an active field of research, where the focus is on developing scientific methods for making it possible for a data holder to release a version of its private data that guarantees that the individuals who are the subjects of the data cannot be re-identified, while at the same time ensuring that the data remains practically useful [Sweeny, 2002]. A well known concept with respect to data anonymization is *k*-ANONYMITY [Sweeny, 2002], [Sweeny, 1997], where the level of privacy protection is directly proportional to the size of the anonymized data in which the data set resides. An oft cited study [Sweeny, 2000] showed that 87% (216 million of 248 million) of the population of the United States are identifiable based on only their 5-digit ZIP code, gender, and date of birth. Therefore, the application of best practice methods to protect privacy, while maintaining useful scientific data, is a topic that must be given much thought when developing this framework.

4.2 Ensuring Quality in a Community Driven Gold Standard

If a tool was created that would make available a web-based service to help content creators write gold standards, the single most important factor is to ensure the quality of the annotations made to the medical objects. This could be achieved in a number of ways, such as including a clause that forces any annotations to be reviewed by at least one external medical expert. This is especially true in medicine, as domain expertise

knowledge is required to guarantee the quality of an annotated pool. Gold standards in medicine that adhere to a certain level of quality have been discussed in previous work [Geierhofer and Holzinger, 2007], and is one of the most important features that must be considered when wanting to develop a successful annotation framework. A common measure of the agreement between judges is the so-called kappa statistic. As a rule of thumb, a value of 0.8 and above is considered as a good agreement [Manning et al., 2008]. Problems that have to be considered when using this statistics are described in [Geierhofer and Holzinger, 2007].

Another method to help increase quality would be to ensure that all objects are tagged using terms for a single terminology such as the SNOMED Clinical Terms. This would also help when searching is performed across different gold standard pools, and could make it possible to merge similar pools. For example, radiological images that have all been tagged using the same terminology database could be combined to create collections of annotated images.

This is highlighted in the following scenario: An annotator views a medical image and notices inflammation of the linings of the arteries, and tags the document using the SNOMED concept of “Arteritis (disorder)”. This is defined in the SNOMED database as having the SNOMED ID of D3-81600, which corresponds to the ICD-9 code of 447.6 – “Arteritis, unspecified”. Therefore, all images tagged with the ICD-9 code of 447.6 or the SNOMED ID of D3-81600 would appear in a search for the images that contain this characteristic. By limiting the tagging of objects to a defined terminology, errors in spelling, definition, and terminology are avoided. The same can be applied to any text tagged by the annotator. For example, if the annotator must tag a pathological text with the organ, this organ must be retrieved from SNOMED terminology database to ensure that other texts regarding the same organ appear when searching for this organ. Take, for example, the following text:

*Microscopic sections reveal an infiltrating ductal carcinoma with pleomorphic glands infiltrating through the surrounding stroma and fat eliciting a desmoplastic stromal host response. There is good tubular differentiation and the glands are lined by cells showing a mild to moderate degree of atypia characterized by hyperchromatic nuclei with prominent nucleoli.*¹

An annotator might be required to tag the text object with the organ to which the pathology report belongs. In this case, the text refers to a breast tissue pathological examination and the annotator would therefore select “Breast anatomy (body structure)” which corresponds to the SNOMED ID of T-D004F. Therefore, this text could appear in a search for “breast”, despite the word not appearing in the text itself.

4.3 Teaching Context

Education would stand to benefit a great deal from having more gold standards available to research and teaching institutes. In many different fields of medicine, such as radiology, teaching depends to a large degree on having material available that is annotated and reviewed by experts. Having quick and easy access to annotated medical images, for example, makes it easier and less time consuming to prepare

¹ The Doctor’s Doctor: http://www.thedoctorsdoctor.com/pathreports/typical_report.htm

material for teaching medical students how to recognize aspects of radiological images. Annotated radiological images would also be useful for examining students, as teachers can prepare exam material for students using the pool of annotated images, and compare students' answers to the images' peer reviewed annotations.

The advantages for education are not limited to just images, however. Annotated texts would also be useful for teaching students how to interpret medical diagnosis texts, while annotated electrocardiograms, sonograms, and magnetic resonance images could all be used for both teaching and training.

Part of the proposed architecture would be a web-based application that would use the pool of annotated objects to help educators create training material and examinations. While web-based pools of annotated images do exist, such as MyPACS (<http://www.mypacs.net>), these systems do not allow users to create examinations or teaching material for students, or allow students to use the system to take examinations. Also, by limiting the students' answers to the same terminology used to annotate the gold standard images, the students could be graded in an automatic or semi-automatic way. Therefore the proposed architecture would compliment the teaching and educational process in a more encompassing manner. With 8,913 hospitals around the world using the MyPACS system, it is obvious that there is a real need for such services.

As mentioned previously, more momentum is required to make institutions aware of the advantages of making their gold standards openly available, and to make these institutions more interested in creating gold standards in the first place. As Tim Berners-Lee has recently been advocating, governments, institutions and researchers must make available "raw data now". Making data openly available is beneficial to the entire community of developers and researchers who rely on such data for their scientific work.

5 Conclusion and Future Work

The main conclusion of this paper is that there is a lack of freely available annotated medical texts for use in research, such as in information retrieval research, and it is proposed here that this is the case because no simple and effective framework or application exists that makes this easy to do. For information retrieval, having access to good quality gold standard texts is an essential part of being able to perform analysis in this area. However, the amount of openly available gold standard texts is severely lacking in medicine, despite the fact that many institutions the world over must have created and used gold standards in their research, and that these gold standards do exist.

Therefore, this paper proposed a preliminary web-based framework for the collaborative development of gold standards. A comprehensive outline and proposal for this framework is the subject of further research, and a paper will be published regarding the design and development of this framework. The framework would help teaching and learning in medicine as properly annotated medical images and texts could be used to teach and examine students, and be used to train doctors. The teaching and training layer of the framework will also be discussed more thoroughly in future work, including a comprehensive review of what aspects of teaching could

be aided by such a system, and how a system could facilitate the examining of students in an semi-automated way.

Such a framework, the authors believe, would in fact make the process of creating gold standards quicker, as a community would be involved in its development rather than just an individual institution. Quality assurance, and how to maintain high levels of quality in a community driven gold standard, will also be discussed in detail in a future work. This may even shift the workflow from an institute based method of publishing annotated data, to a community contributed workflow involving institutes from around the world.

As well as this, the paper gave an overview of the theory behind information retrieval and outlined a number of reasons why information retrieval in medicine is a challenging and interesting area to be involved in.

References

- [Baeza-Yates and Ribeiro-Neto, 2006] Baeza-Yates, R. and Ribeiro-Neto, B.: "Modern information retrieval", ACM Press, New York, (2006).
- [Bemmel and Musen, 1997] Bemmel, J. H. v. and Musen, M. A.: "Handbook of Medical Informatics", Springer, Heidelberg, (1997).
- [Brown and Sonksen, 2000] Brown, P. J. B. and Sonksen, P.: "Evaluation of the quality of information retrieval of clinical findings from a computerized patient database using a semantic terminological model", *Journal of the American Medical Informatics Association*, 7, (2000), 392-403.
- [Buckley and Ellen, 2004] Buckley, C. and Ellen, M. V.: "Retrieval evaluation with incomplete information", *Proceedings of the 27th annual international ACM SIGIR conference on Research and development in information retrieval*, (2004), 25-32.
- [Geierhofer and Holzinger, 2007] Geierhofer, R. and Holzinger, A.: "Creating an Annotated set of Medical Reports to Evaluate Information Retrieval Techniques", *SEMANTICS*, (2007).
- [Gell, 1983] Gell, G.: "AURA - routine documentation of medical text", *Methods of Information In Medicine*, 22, (1983), 63-68.
- [Gell et al., 1976] Gell, G., Oser, W. and Schwarz, G.: "Experiences with the AURA Free Text System", *Radiology*, 119, (1976), 105-109.
- [Gregory et al., 1995] Gregory, J., Mattison, J. E. and Linde, C.: "Naming Notes - Transitions from Free-Text to Structured Entry", *Methods of Information in Medicine*, 34, (1995), 57-67.
- [Hall and Walton, 2004] Hall, A. and Walton, G.: "Information overload within the health care system: a literature review", *Health Information and Libraries Journal*, 21, (2004), 102-108.
- [Harter and Hert, 1997] Harter, S. P. and Hert, C. A.: "Evaluation of information retrieval systems: Approaches, issues, and methods", *Annual Review of Information Science and Technology*, 32, (1997), 3-94.
- [Hersh and Hickam, 1998] Hersh, W. R. and Hickam, D. H.: "How well do physicians use electronic information retrieval systems? A framework for investigation and systematic review", *Jama-Journal of the American Medical Association*, 280, (1998), 1347-1352.
- [Holzinger et al., 2007a] Holzinger, A., Geierhofer, R. and Errath, M.: "Semantic Information in Medical Information Systems - from Data and Information to Knowledge: Facing

Information Overload", Proceedings of I-MEDIA '07 and I-SEMANTICS '07, Graz, 2007a, 323-330.

[Holzinger et al., 2007b] Holzinger, A., Geierhofer, R. and Errath, M.: "Semantische Informationsextraktion in medizinischen Informationssystemen", Informatik Spektrum, 30, (2007b), 69-78.

[Holzinger et al., 2008] Holzinger, A., Geierhofer, R., Modritscher, F. and Tatzl, R.: "Semantic Information in Medical Information Systems: Utilization of Text Mining Techniques to Analyze Medical Diagnoses", Journal of Universal Computer Science, 14, (2008), 3781-3795.

[Holzinger et al., 2000] Holzinger, A., Kainz, A., Gell, G., Brunold, M. and Maurer, H.: "Interactive Computer Assisted Formulation of Retrieval Requests for a Medical Information System using an Intelligent Tutoring System", ED-MEDIA 2000, Montreal, (2000), 431-436.

[Kaiser et al., 2007] Kaiser, K., Akkaya, C. and Miksch, S.: "How can information extraction ease formalizing treatment processes in clinical practice guidelines? A method and its evaluation", Artificial Intelligence in Medicine, 39, (2007), 151-163.

[Lew et al., 2006] Lew, M. S., Sebe, N., Djeraba, C. and Jain, R.: "Content-based multimedia information retrieval: State of the art and challenges", ACM Transactions on Multimedia Computing Communications and Applications, 2, (2006), 1-19.

[Lovis et al., 2000] Lovis, C., Baud, R. H. and Planche, P.: "Power of expression in the electronic patient record: structured data or narrative text?" International Journal of Medical Informatics, 58, (2000), 101-110.

[Manning et al., 2008] Manning, C. D., Raghavan, P. and Schuetze, H.: "Introduction to Information Retrieval", Cambridge University Press New York, NY, USA, (2008).

[Noone et al., 1998] Noone, J., Warren, J. and Brittain, M.: "Information overload: opportunities and challenges for the GP's desktop", Medinfo, 9, (1998), 1287-1291.

[Robertson and Hancockbeaulieu, 1992] Robertson, S. E. and Hancockbeaulieu, M. M.: "On the Evaluation of Ir Systems", Information Processing & Management, 28, (1992), 457-466.

[Saracevic, 1995] Saracevic, T.: "Evaluation of evaluation in information retrieval", Proceedings of the 18th annual international ACM SIGIR conference on Research and development in information retrieval, (1995), 138-146.

[Smalheiser and Swanson, 1998] Smalheiser, N. R. and Swanson, D. R.: "Using ARROWSMITH: a computer-assisted approach to formulating and assessing scientific hypotheses", Computer Methods and Programs in Biomedicine, 57, (1998), 149-153.

[Sullivan et al., 1999] Sullivan, F., Gardner, M. and Van Rijsbergen, K.: "An information retrieval service to support clinical decision-making at the point of care", British Journal of General Practice, 49, (1999), 1003-1007.

[Sweeny, 1997] Sweeny, L.: "Guaranteeing anonymity when sharing medical data, the datafly system", Proceedings of Journal of the American Medical Informatics Association, Washington, DC: Hanley & Belfus, Inc., (1997).

[Sweeny, 2000] Sweeny, L.: "Uniqueness of simple demographics in the US population", Carnegie Mellon University, Laboratory for International Data Privacy, Pittsburg, PA, (2000).

[Sweeny, 2002] Sweeny, L.: "k-anonymity: a model for protecting privacy", International Journal on Uncertainty, Fuzziness and Knowledge-based Systems, 10 (5), (2002), 557-570.

[Sweeny, 2002] Sweeny, L.: "Achieving k-anonymity privacy protection using generalization and suppression", *International Journal on Uncertainty, Fuzziness and Knowledge-based Systems*, 10 (5), (2002), 571-588.

[Tange et al., 1998] Tange, H. J., Schouten, H. C., Kester, A. D. M. and Hasman, A.: "The granularity of medical narratives and its effect on the speed and completeness of information retrieval", *Journal of the American Medical Informatics Association*, 5, (1998), 571-582.

[Wingert, 1986] Wingert, F.: "An Indexing System for Snomed", *Methods of Information in Medicine*, 25, (1986), 22-30.

[Zeng et al., 2002] Zeng, Q., Cimino, J. J. and Zou, K. H.: "Providing concept-oriented views for clinical data using a knowledge-based system: An evaluation", *Journal of the American Medical Informatics Association*, 9, (2002), 294-305.

[Zingmond and Lenert, 1993] Zingmond, D. and Lenert, L. A.: "Monitoring Free-Text data using medical language processing", *Computers and Biomedical Research*, 26, (1993), 467-481.

Multimedia Documentation Lab

Gerhard Backfried, Dorothea Aniola

(Sail Labs Technology AG, Vienna, Austria
{gerhard, dorothea}@sail-labs.com)

Klaus Mak, H.C. Pilles

(Documentation Center of the National Defence Academy (NDA), Vienna, Austria
{lvak.zdok.1 , lvak.zdok.2}@bmlvs.gv.at)

Gerald Quirchmayr, Werner Winiwarter

(University of Vienna, Faculty of Computer Science, Vienna, Austria
{gerald.quirchmayr, werner.winiwarter}@univie.ac.at)

Peter M. Roth

(Inst. f. Computer Graphics and Vision, Graz University of Technology, Graz, Austria
pmroth@icg.tugraz.at)

Abstract: In this paper we describe the Multimedia Documentation Lab (MDL¹), a system which is capable of processing vast amounts of data typically gathered from open sources in unstructured form and in diverse formats. A sequence of processing steps analyzing the audio, video and textual content of the input is carried out. The resulting output is made available for search and retrieval, analysis and visualization on a next generation media server. The system can serve as a search platform across open, closed or secured networks. MDL can be used as a tool for situational awareness, information sharing or risk assessment, allowing the integration of multimedia content into the analysis process of security relevant affairs.

Keywords: Information Systems, Multimedia Computing, Speech Processing, Situational Awareness, Ontologies, Open Source Intelligence

Categories: H.3, H.5.1

1 Introduction

An ever-increasing amount of information is being produced by the second, put on the internet and broadcast by TV- and radio stations. News is produced around the clock and in a multitude of languages. The online content stored on web-pages grows massively and at a constantly accelerating rate and is estimated to already exceed 1.6×10^{20} bytes [Best 2007]. An increasingly large portion of this immense pool of data is multimedia content. To tap into this constant flow of information and make the multi-media contents searchable and manageable on a large scale, the MDL project

¹ The MDL-project is part of KIRAS: Österreichisches Sicherheitsforschungs-Förderprogramm - eine Initiative des Bundesministeriums für Verkehr, Innovation und Technologie (BMVIT)

aims to develop a framework and demonstrator which allows the flexible combination of a variety of components for the analysis of the different kinds of data involved. Information and clues extracted from audio- as well as video-tracks of multimedia documents are gathered and stored for further analysis. This is complemented by information extracted from textual documents of diverse qualities and formats. The resulting information is made available on a multi-media server for visualization and analysis.

2 Project Scope and Aim

Whereas in the past textual content was the primary source for the extraction and gathering of intelligence in the area of situational awareness, the analysis of multimedia content has been receiving increased attention over the last few years. Information presented on national as well as international multimedia sources complement and extend the information from traditional media; together they form a broad basis for long-term trend analyses and situational awareness, e.g., for conflict and crisis situations. The scope of the MDL system (and project) thus is to allow for the integration of such multi-media content into the existing infrastructure. Content is gathered in a variety of languages and from sources spanning the globe in real-time to allow for short response intervals in crisis situations. Analysis of audio- as well as video-data complements the already existing analysis of textual data. In the process, ontologies serve as the central hub to streamline concepts used by the processing of the different modalities. The goal of the MDL project is to create a demonstrator which will comprise all the mentioned technologies and components and also provide interfaces to the existing infrastructure, allowing for integration into existing workflows.

3 System Description

MDL consists of a set of technologies packaged into components and models, combined into a single system for end-to-end deployment. Together with the components, a number of toolkits are delivered to allow end-users to update, extend and refine models and be able to respond flexibly to a changing environment.

Data enters the system via so-called *Feeders* and then runs through a series of processing steps. Multimedia data is split into an audio- and video-processing track. For audio-data, the processing steps include audio-segmentation, speaker-identification (SID), language-identification (LID), large vocabulary, automatic speech-recognition (ASR) as well as named-entity-detection (NED) and topic-detection (TD). For video-data, the processing comprises scene-detection, key-frame extraction as well as the detection and identification of faces and maps. Textual data is processed by normalization steps before undergoing NED and TD processing.

The resulting documents (in a proprietary XML format or MPEG7) of the individual tracks are fused at the end of processing (*late-fusion*). The XML-files are uploaded, together with a compressed version of the original media files, onto the Media Mining Server (MMS), where they are made available for search and retrieval.

The overall architecture of the MDL System is a server-client one and allows for deployment of the different components on multiple computers and platforms (not all components are multi-platform). Several Feeders, Indexers and Servers (also called Media Mining Feeder, -Indexer and -Server resp.) may be combined to form a complete system. Fig. 1 provides an overview of the components of the MDL System and their interaction.

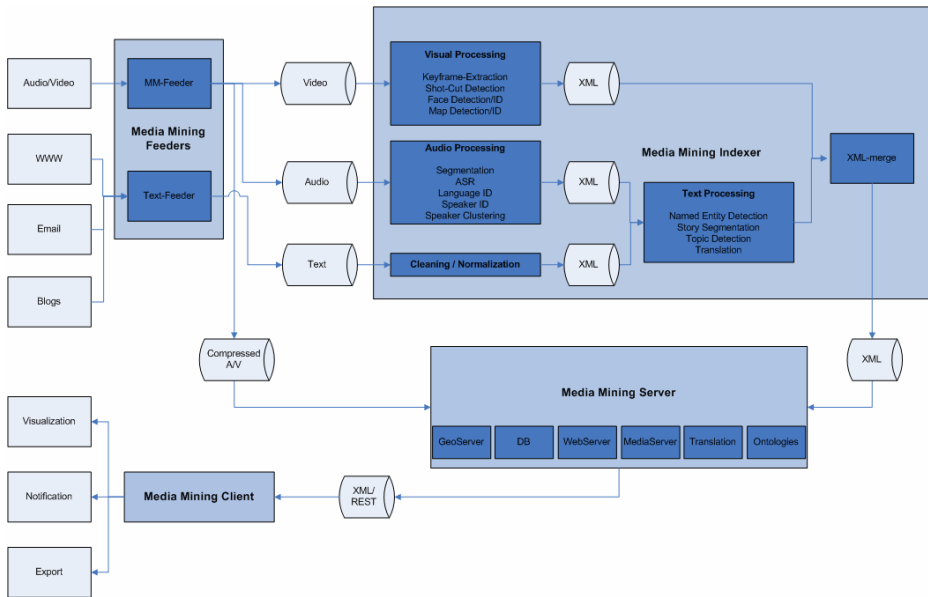


Figure 1: Architecture of the MDL System

3.1 Feeders

The feeders represent the input interface of the MDL System to the outside world. For audio or mixed audio/video input a variety of formats can be imported from external sources and processed by subsequent components. To handle textual input, such as data coming from Web-Pages, e-mails or blogs, separate feeders exist which extract the data from these sources and pass it on to the text processing components.

3.2 Multimedia Feeder

This feeder is based on the Microsoft DirectShow framework and handles a variety of different input sources and formats. Re-encoding is performed to provide Windows Media output files which are uploaded to the Media Mining Server (MMS) for storage and retrieval. The audio channel is passed on to the Media Mining Indexer (MMI) for processing. The video-channel is processed by a series of visual processing components.

3.3 Text Feeder

Text Feeders are specialized feeders which extract textual information from specific sources and pass their results on to the Media Mining Indexer. Two examples of such feeders are the Web-Collector and the e-mail-Collector which are used to gather and process data from internet sources such as web-pages, news-feeds or e-mail-accounts, respectively. The resulting text is cleaned and tokenized before being passed on to the text-processing components.

3.4 Media Mining Indexer (MMI)

The MMI forms the core for the processing of audio and text within the MDL system. It consists of a set of technologies, packaged as components, which perform a variety of analyses on the audio and textual content. Processing results are combined by enriching structures in an XML document. Facilities for processing a number of natural languages exist for the components of the MMI, e.g., ASR is available for more than a dozen languages already. A new set of models for Mandarin Chinese is being developed within the MDL project.

3.4.1 Segmentation

After having been converted to the appropriate format by the feeder, the audio signal is processed and segmented for further analysis. Normalization and conversion techniques are applied to the audio stream which is partitioned into homogeneous segments. Segmentation uses models based on general sounds of language as well as non-language-sounds to determine the most appropriate segmentation point [Liu and Kubala 1999]. The content of a segment is analyzed with regard to the proportion of speech contained, and only segments classified as containing a sufficient amount of speech are passed on to the ASR component.

3.4.2 Speaker Identification (SID)

SID is applied to the segments produced by the segmentation step using a set of predefined target models. These models typically comprise a set of persons of public interest. In case a speaker's identity cannot be determined, the SID system tries to identify the speaker's gender. Data of the same speaker is clustered and labelled with a unique identifier [Liu and Kubala 2003].

3.4.3 Automatic Speech Recognition (ASR)

The Sail Labs speech recognition engine is designed for large-vocabulary, speaker-independent, multi-lingual, real-time decoding of continuous speech. Recognition is performed in a multi-pass manner, each phase employing more elaborate and finer-grained models refining intermediate results, until the final recognition result is produced [Schwartz et al 1996]. Subsequently, text-normalization as well as language-dependent processing (e.g., handling compound-words for German [Hecht et al 2002]) is applied to yield the final decoding result in a proprietary XML format. The recognizer employs a time-synchronous, multi-stage search using Gaussian tied mixture-models, context dependent models of phonemes and word- as well as (sub-)

word based n-gram models. The engine per se is language independent and can be run with a variety of models created for different choices of language and bandwidth.

3.4.4 Language Identification (LID)

Language identification on audio data is used to determine the language of an audio-document in order to allow processing of data using a particular set of speech-recognition models. Textual analysis of language is used to classify text before passing it on to the text-pre-processing components or to the LMT.

3.4.5 Text-based Technologies

The text-based technologies perform their processing either on the output of the ASR-component or on data provided by the text-normalization components. Textual normalization includes the pre-processing, cleaning, normalization and tokenization steps. Language-specific processing of text (e.g., special handling of numbers, compound-words, abbreviations, acronyms) textual segmentation and normalization of spellings are all carried out by these components.

Named entity detection (NED) of persons, organizations or locations as well as numbers is performed on the output of the ASR component, or, alternatively, on text provided by the text normalization components. The NED system is based on patterns as well as statistical models defined over words and word-features and is run in multiple stages [Bikel et al 1997]. The topic-detection component (TD) first classifies sections of text according to a specific hierarchy of topics. Coherent stories are found by grouping together similar sections. Subsequently, the already classified sections are compared to each other and similar, adjacent sections are merged. The models used for TD and story segmentation are based on support vector machines (SVM) with linear kernels [Joachims 1998].

3.4.6 Toolkits

Currently two toolkits are available to allow user intervention: the Language Model Toolkit (LMT), which allows users to adjust or extend the speech recognition models, and a Speaker ID Toolkit (SIT) allowing users to train SID models for new speakers.

3.4.7 Visual Processing

In order to complement the information extracted from the audio stream of input data, MDL also provides facilities to extract information from the visual signal. In particular, faces of persons and maps are detected and identified. These tasks are typically performed on single images; however, for use by MDL the required data has to be extracted from video streams. Several limitations such as resolution or compression artefacts have to be handled and, due to the large amount of data, only computationally efficient methods can be applied. First, coherent data packages within the visual input referred to as shot boundary detection are identified [Smeaton et al 2001]. To cope with the large amount of data, methods providing a high accuracy such as [Kawai et al 2008, Jinchang et al 2007] are applied. These methods either use efficient multi-stage classifiers [Kawai et al 2008] or directly exploit information provided by the MPEG container [Jinchang et al 2007]. Once the shot boundaries are

identified, the recognition steps can be run on the obtained image sequences. For face detection, faces are localized [Viola and Jones 2004] and a recognition step is performed [Kim et al 2007]. The available temporal information is employed by applying a probabilistic voting over the single image results [Gong et al 2000] or by running a tracker and performing the recognition on the identified image locations [Dedeoglu et al 2007]. More sophisticated approaches inherently using the temporal information in a combined detection/ recognition process [Chellappa and Zhou 2005] will be investigated.

Since neither the position nor the appearance of maps typically change over time, a simple detection/recognition approach is applied. First, images are classified as maps or non-maps [Michelson et al 2008] and then the positively classified images are identified using a shape-based recognition procedure.

All processing is carried out in separate components, which can readily be plugged-in into the overall system. The results of the individual visual components are collected and output in XML format. This XML is merged (based on time-tags) with the XML output produced by audio- and textual-processing in a subsequent step. The combined XML is then uploaded to the server and made available for search.

3.5 Media Mining Server (MMS)

The MMS comprises the actual server, used for storage of XML and media files, as well as a set of tools and interfaces used to update and query the contents of the database. All user-interaction takes place through the Media Mining Client.

3.5.1 Media Server

The actual server provides the storage for the XML index files, the audio and the video content. It uses Oracle 11g which provides all search and retrieval functionalities. The Semantic Technologies provided by Oracle form the basis for all ontology-related operations within MDL.

3.5.2 Ontologies

An ontology model within the MDL system consists of a set of concepts, instances, and relationships [Allemang and Hendler 2008]. Ontologies form a central hub within the MDL system and serve to link information originating from different sub-systems together [Davies et al 2009]. Translations are associated with concepts in the ontology to allow for concept-based translation. During search, ontologies can be used to widen or narrow the search focus by allowing the user to navigate through the network of concepts. Related concepts can be displayed and examined in a graph according to structural information provided by the ontology. As a first model, a geographic ontology had been created. More advanced usages of topic-related ontologies are currently under development, such as for the field of natural disasters, in particular flood warnings. The goal is to provide an interface in the final version that allows users to flexibly import ontologies which are created with standard ontology tools such as Protégé [Protege 2010].

3.5.3 Translation

Different types of and interfaces to translation facilities are offered by the MMS [Jurafsky and Martin 2009]. Parallel translations can be created for a transcript as it is uploaded to the server. This is achieved via the integration of 3rd-party machine translation engines. Furthermore keyword translation and human translation, via an e-mail based interface, are supported. Translations are taken into account for queries and visualization.

3.6 Media Mining Client

The Media Mining Client provides a set of features to let users query, interact with, visualize and update the contents of the database. Through a web-browser, users can perform queries, download content, request translations or add annotations to the information stored. Queries can be performed using free text or logical combinations of terms; they can be tailored to address only specific portions of the data stored on the server. Queries can be stored and later used for automatic notification of users to allow for rapid alerting when new documents matching a particular profile appear on the server.

The results of queries are presented according to the structure produced by the MMI. Additional information, such as the names of speakers, named-entities, or detected maps is displayed along with a transcript of the associated audio. Playback of audio and video content can be triggered on a per-segment basis or for the complete document.

3.6.1 Visualization

Special emphasis was given to a series of visualization mechanisms which allow users to display data and its properties in various ways. Search results and summaries can be displayed in a variety of manners in the MDL system. This lets users view data and search-results from different angles, thus allowing them to focus on relevant aspects first and to iteratively circle-in on relevant issues. A globe-view geographically relates events to locations on the globe. A relationship-view relates entities to one another, while a trend-view, relates entities with their occurrences over time. Finally, a cluster-view relates entities and news-sources mentioning them. Further queries can be triggered from all types of visualization, allowing to e.g., summarize events by geography through plotting them on the globe, and subsequently launching further queries by clicking on specific locations on the globe. Ontologies can be used to modify and guide searches. Information derived from ontologies is used for queries (by expanding query terms to semantically related terms) and for the presentation of query results.

4 Status and Outlook

A number of components, such as the feeders, all components which are part of the MMI, and the majority of components which form part of the MMS, are already operational. Other components are currently under development or in the stage of research prototypes, such as the visual processing components or the ontology-related

components of the MMS. The existing components have been installed at the end-user's site in order to allow for rapid feedback during development and for evaluation purposes. New features and technologies are phased in as they become available.

The MDL system presents a state-of-the-art end-to-end Open-Source-Intelligence (OSINT) system. The final demonstrator will include all described audio- and video-processing components. Feeders will be used for monitoring news on a 24x7 level to provide a constant flow of input to the MMI, which continuously processes the incoming data stream and sends its output to the MMS. Likewise, text-feeders will be used to provide constant input from the Web. All processing is targeted to take place in real-time and with minimal latency. Results of all processing will be made available on the MMS and can be exported to the existing infrastructure. It is envisaged that the final version of the MDL System will serve as a core component for the existing Situation Awareness Center (SAC) of the Documentation Center/NDA.

References

- [Allemang and Hendler 2008] D. Allemang, J. Hendler. *Semantic Web for the Working Ontologist*. Morgan Kaufman, 2008.
- [Best 2007] C.H.Best, *Open Source Intelligence*, JRC, European Commission, reference to IDC
- [Bikel et al 1997] D. Bikel, S. Miller, R. Schwartz, R. Weischedel, *Nymble: High-Performance Learning Name-Finder*, Conference on Applied Natural Language Processing, 1997
- [Chellappa and Zhou 2005] R. Chellappa and S.K. Zhou, *Face tracking and recognition from video*, In *Handbook of Face Recognition*, pages 169–192, Springer, 2005
- [Davies et al 2009] J. Davies, M. Grobelnik, D. Mladenic (eds). *Semantic Knowledge Management. Integrating Ontology Management, Knowledge Discovery, and Human Language Technologies*, Springer-Verlag, 2009
- [Dedeoglu et al 2007] G. Dedeoglu, T. Kanade, and S. Baker, *The asymmetry of image registration and its application to face tracking*, *IEEE Trans. on Pattern Analysis and Machine Intelligence*, 29(5):807–823, 2007.
- [Gong et al 2000] S. Gong, S.J. McKenna, and A. Psarrou, *Dynamic Vision: From Images to Face Recognition*, Imperial College Press, 2000.
- [Hecht et al 2002] R. Hecht, J. Riedler, G. Backfried, *Fitting German into N-Gram Language Models*, TSD 2002
- [Jinchang et al 2007] R. Jinchang, J. Jianmin, and C. Juan, *Determination of shot boundary in MPEG videos for TRECVID 2007*, In *Proc. TREC Video Retrieval Evaluation Workshop*, 2008.
- [Joachims 1998] T. Joachims, *Text Categoriation with Support Vector Machines: Learning with many Relevant Features*, in *ECML*, 1998
- [Jurafsky and Martin 2009] D. Jurafsky, J. H. Martin. *Speech and Language Processing*, Pearson, 2009
- [Kawai et al 2008] Y. Kawai, H. Sumiyoshi, and N. Yagi, *Shot boundary detection at TRECVID 2007*, In *Proc. TREC Video Retrieval Evaluation Workshop*, 2008

- [Kim et al 2007] S. Kim, S. Chung, S. Jung, S. Jeon, J. Kim, and S. Cho, Robust face recognition using AAM and gabor features, In Proc. World Academy of Science, Engineering and Technology, 2007.
- [Liu and Kubala 2003] D. Liu, F. Kubala, Online Speaker Clustering, ICASSP 2003
- [Liu and Kubala 1999] D. Liu, F. Kubala, Fast Speaker Change Detection for Broadcast News Transcription and Indexing, Eurospeech 1999
- [Michelson et al 2008] M. Michelson, A Goel, and C.A. Knoblock, Identifying maps on the world wide web, In Proc. Int'l Conf. on Geographic Information Science, 2008
- [Protege 2010] Protege Web-Site at Stanford University, <http://protege.stanford.edu/>
- [Schwartz et al 1996] R. Schwartz, L. Nguyen, J. Makhoul, Multiple-Pass Search Strategies, Automatic Speech and Speaker Recognition, 1996
- [Smeaton et al 2001] A.F. Smeaton, R. Taban, and P. Over, The TREC-2001 video track report, In Proc. Text Retrieval Conference, 2001
- [Viola and Jones 2004] P. Viola and M.J. Jones, Robust Real-Time face detection, Int'l Journal of Computer Vision, 57(2):137–154, 2004

Early Experiences with Responsive Open Learning Environments

Martin Wolpers, Martin Friedrich

(Fraunhofer FIT, Sankt Augustin, Germany
{martin.wolpers, martin.friedrich}@fit.fraunhofer.de)

Ruimin Shen, Carsten Ullrich

(Shanghai Jiao Tong University, Shanghai, China
{rmshen, ullrich_c}@sjtu.edu.cn)

Ralf Klamma, Dominik Renzel

(RWTH Aachen, Aachen, Germany
{klamma, renzel}@dbis.rwth-aachen.de)

Abstract: Responsive open learning environments (ROLEs) are characterized through their openness for new configurations, new contents and new users, and through their responsiveness to learners' activities in respect to learning goals. Openness specifically encompasses the ability to include new learning material and new learning services. These can be combined either in a static fashion or dynamically, therefore allowing learners to create their own learning environments. Consequently, throughout the lifetime of a ROLE, new configurations will be created by learners, usually adapted to their needs, requirements and ideas. In this paper, we will describe first experiences using ROLEs for a course on foreign language learning at the Shanghai Jiao Tong University in China. Results of our trials are two-fold: on the one hand, widget, container and other enabling technologies are insufficiently mature to allow large-scale deployment. On the other hand, the results are encouraging as students which learn how to use ROLEs clearly benefit from their use.

Keywords: Personalized learning environment, Responsive open learning environment, language learning, inter-widget communication

Categories: M.5, L.2, L.3, D.2

1 Introduction

Responsive open learning environments (ROLEs) are characterized through their openness for new configurations, contents and users and through their responsiveness to learners' activities in respect to learning goals. Openness specifically encompasses the ability to include new learning material and services. These can be combined either in a static fashion or dynamically, therefore allowing learners to create their own learning environments. Consequently, throughout the lifetime of a ROLE, new configurations will be created by a learner, usually adapted to her needs, requirements and ideas. In addition, ROLEs respond to the actions the learners carry out within them. Such actions can be as simple as downloading a suggested reading and as complex as participating and interacting with others learners in a complete course

about a certain topic. Responsiveness then requires the system to respond to these activities, for example by incorporating previously downloaded documents into the suggestions for new readings (as kind of a recommender system) or by offering new services that better suits the needs of learners. For example, a learner might be suggested to use a simulation and conceptual mapping tool to understand a certain problem instead of reading theoretical literature as was provided before.

In the context of the research project *ROLE* (Responsive Open Learning Environments), the infrastructure is developed to enable the creation of individual open responsive learning environments. The *ROLE* project aims to enable learners to assemble and re-assemble their own learning environments which become personal learning environments (PLE) in due course. This is of particular relevance in the critical lifelong learning transition phases when inhomogeneous groups of learners are treated in a one-size-fits-all way since there is no way to respond to their individual strengths and weaknesses. Even worse, in such transition phases learners are typically required to become accustomed to working with an entirely new virtual learning environment (VLE). The *ROLE* project will enable the learner to easily construct and maintain her own PLE consisting of a mix of preferred learning tools, learning services, resources, etc. In this way the level of self-control and responsibility of learners will be strengthened, which is seen as a key motivation aspect and success factor of self-paced, formally instructed as well as informal/social learning. Especially in the *ROLE* testbed at Shanghai Jiao Ton University (SJTU) students are mostly adult learners who have limited knowledge of Web tools. The students often do not know or have difficulties using specific tools. Thus the personalization of their learning environment such as assembling tools they are familiar with is very important for them.

This paper describes a scenario regarding *ROLE* specific features and describes the technical implementation and evaluation in Chapter 2. The prototype supports language learning through a web based environment where learners use several intercommunicating widgets to learn a language. Chapter 3 describes first experiences using *ROLE* in a specific testbed. The results and insights gained from the application of the prototype in the testbed are summarized in Chapter 4.

2 Prototype description

To visualize the potential of the *ROLE* project and gather experience in using the technologies required within the project we built a first PLE prototype based upon a common language learning scenario derived from the SJTU testbed which is based on established open-standard web technologies. The resulting prototype helps to refine specifications and requirements and furthermore to validate the interoperability of the proposed technologies used within the *ROLE* project. During the development process of the *ROLE* prototype for language learning, we collected a set of valuable however negative experiences with the technical development.

2.1 Scenario

In our SJTU language learning scenario we assume that a learner wants to improve her business English skills. She wants to reach this goal by reading texts related to her

working field and by learning the relevant vocabulary. Thus she assembles her PLE by adding learning tools (integrated via widget technology) which are related to the language learning task and fit best to her preferences. She decides to add three different widgets, a *Language Resource Browser* widget, a *Translator* widget and a *Vocabulary Trainer* widget, as shown in Figure 1.

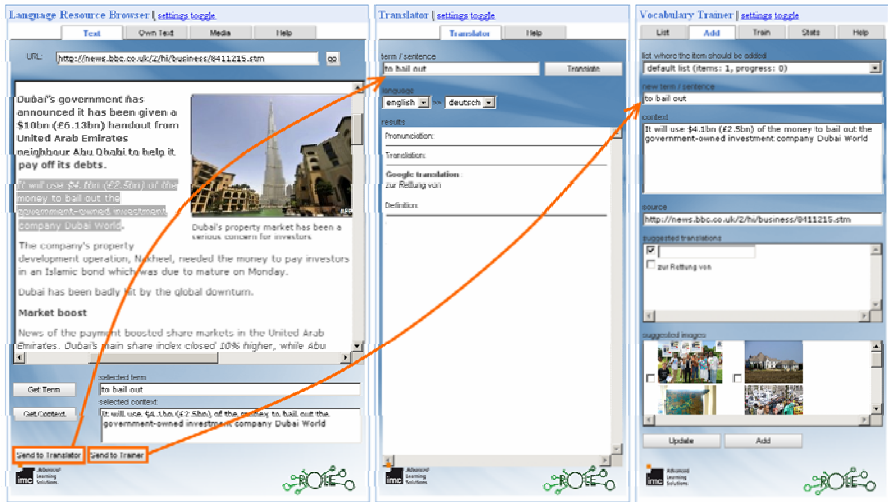


Figure 1: Set of language learning widgets

The *Language Resource Browser* is used to display resources of different media types such as texts, videos or audio files. Furthermore, it offers the possibility to trigger different actions on words which the learner is missing. For example the learner can select missing vocabularies and perform a specific action. Since the learner decided to additionally use the *Translator* and *Vocabulary Trainer* widget she can look up the selected vocabulary using the *Translator* widget or send them to the *Vocabulary Trainer* widget which gathers a list of words she considers to be important in the future. The learner repeats this procedure during the next days with different resources and later decides to test herself by memorizing those words gathered by the *Vocabulary Trainer* widget. Every time she has problems with a word she can look up its context, such as the sentence where the word occurred, which helps her memorizing the word.

2.2 Technical Implementation

As described in the scenario we have chosen a widget-based approach to enable the learner assembling her own personal learning environment. This approach makes the development of new widgets independent from specific learning platforms and previous widget implementations.

To achieve responsiveness and openness within ROLE we focussed on intercommunicating widgets which further decreases the configuration complexity of widgets for the end users. In a first step we used a Gadget pubsub channel [OpenSocial, 10] as a kind of message bus which enables widgets to publish or

subscribe events using a unified message format. Each time a user action is performed inside a widget the event is published by broadcasting a message containing all information about the user action. This message is received by all other widgets connected to the same pubsub channel. The subscribing widgets then receive those messages and decide whether they react to the event or not. This means that, regarding the language learning scenario, the *Translator* widget is able to translate words selected by the learner inside the *Language Resource Browser* widget. By pressing the "Send to Translator" button a message containing the selected word is broadcasted and reacted to by the *Translator* widget by looking up the word in a dictionary and displaying its translation. Thus, all widgets have the opportunity to receive published events and choose whether and how to react depending on the event type, message type, message content, etc. At the current stage, inter-widget communication is limited to widgets in the same local browser instance only. To be more general in future, as a long term goal we aim to realize arbitrary forms of real-time communication between learners, remote inter-widget communication, interoperable data exchange, event broadcasting, etc., by employing the Extensible Messaging and Presence Protocol (XMPP) [Saint-Andre, 09] discussed in more detail in section 2.3.

To host and render the widgets we decided to use the Apache Shindig container [Shindig, 10] which is the reference implementation of OpenSocial [OpenSocial, 10]. OpenSocial provides a common API which enables applications to use social features across multiple websites and further includes a specification for widgets. By using Apache Shindig as container to host and render the widgets, we are able to integrate them into already existing learning management systems and open virtual learning systems including the pubsub feature. Unfortunately, this prerequisite is not valid for most publicly available containers such as iGoogle. A detailed evaluation of further considered widget container technologies such as SocialSite is done in section 2.3.

For further responsiveness of the learning environment in future we aim to provide self-evaluation and recommendation mechanisms. Therefore we developed a widget which monitors the user's behaviour within her learning environment. Each user interaction inside a single widget triggering a publish event is captured to monitor the users behaviour over time. Thus, the monitoring widget receives every published message, transforms it into Contextualized Attention Metadata (CAM) [Wolpers, 07] and stores it in a central database. Having this information enables the generation of recommendations based on collaborative filtering algorithms [Linden, 03] and the provision of self evaluation mechanisms. For recommendations e.g. the current usage history of the learner can be taken into account and compared with the usage histories of other users. If other users own a usage history similar to the learner one can recommend those documents they have accessed after the current document of the learner. To provide self evaluation functionality CAM can be used to visualize and summarize the actions performed by the user per day, week or month and compare own with other users' activities. Further the CAM Information can be enhanced with manual annotations such as an evaluation of learning success which makes it possible to show the user's learning progress similar to [Wolpers, 09].

2.3 Development-related experiences

For the development of the first ROLE prototype we pursued a collaborative distributed development process on a rather small scale among consortium partners. The longer-term goal is to gain experience for a large-scale roll-out to open source and commercial developer communities outside the consortium, which is one of the main ROLE objectives. As we aim to build a web-based environment, in particular using widget technologies, we first scouted for a development environment suitable for hosting and rendering the sets of widgets and services contributed by the partners in a distributed manner. The goal was to organize our process according to the following policy:

- Every developing partner maintains a local development environment
- One partner maintains an additional integration environment
- All local development environments and the integration environment are equivalent

Especially the equivalence required in the last policy rule was not fulfilled for reasons discussed in the following. Although there exist multiple Open Source solutions for widget containers already, the biggest challenge was their immaturity, especially regarding inter-widget communication, one of the main requirements for our language learning PLE (cf. Section 2.1). During the development process we tested three different development environments, mainly consisting of container technologies for OpenSocial compliant widgets (resp. *gadgets* in OpenSocial terminology):

1. SocialSite (based on Shindig within Glassfish) [SocialSite, 10]
2. Apache Shindig [Shindig, 10]
3. OSDE (Eclipse Plugin with integrated Shindig) [OSDE, 10]

With all of the above systems we encountered at least one of the following problems:

- Lack of Forward Incompatibility
- Client Browser Dependence
- Server Platform Dependence
- Inaccessible Bugs in Generated Code
- Lack of Developer Support
- Incompatibility with External Libraries
- Instability of Draft Standard Specifications
- Missing/Changing Libraries for inter-widget Communication

The first problem was related to container installation, in particular with SocialSite. First, the current SocialSite distribution was restricted to specific, already outdated versions of Glassfish and Shindig, and thus is not forward compatible - an essential property, when working with experimental systems likely to evolve in future. Given the diversity of devices and platforms used by the different developing partners, we quickly had to find out that platform and browser independence was not given at all. Although both Shindig and Glassfish are Java-based, and all partners were using the

same installer version, some partner installations worked as expected, while others exhibited unexplainable container side errors. Another issue was browser incompatibility. Even with a working container, some browsers did not render widgets correctly, while others exhibited no problem at all. This problem is highly likely to be related to different implementations of JavaScript engines implemented in browsers. Another essential problem was the inaccessibility of bugs in JavaScript code. In many cases, problems occurred outside the source code under developer control. The reason was a malfunction in the code production performed by the container itself to render the widgets. Furthermore, error messages were cryptic and incomprehensible and thus did not provide any hint to the original location of an error. In conjunction with the above problems we had to experience that developer support by the SocialSite team was not available at all. At the time of writing this document, it seems quite obvious, that SocialSite is dead. After the initial experiments with SocialSite, we communicated possible alternatives. The alternative usage of Apache Shindig instead of SocialSite was also not successful for all ROLE developers at that point in time. However, due to the currently ongoing incubation process at Apache, we can expect to receive support and more mature versions from the Shindig team in future. The OpenSocial Development Environment (OSDE), which also uses a built-in Shindig test server, was considered as a helpful tool with respect to the development of single widgets, but proved to be impractical, when it comes to the development of multiple intercommunicating widgets. Further problems were related to the incompatibility of external JavaScript libraries with the Widget container, which resulted in strange code rewriting effects or cross-domain issues. With special regard to the publish/subscribe based inter-widget communication approach we are pursuing in ROLE, we experienced that at the current time Shindig is in a transition phase of changing from the pubsub feature included in the Google gadget API to the pubsub mechanism included in Open Ajax Alliance Hub 2.0 [OpenAjaxAlliance, 10]. Regarding all of the above issues, we can state that the collaborative distributed development process of a PLE was challenging due to the lack of a stable and reliable development environment.

With the long-term goal in mind to create a class of ROLE widgets supporting arbitrary forms of real-time communication between learners, remote inter-widget communication, interoperable data/metadata exchange, event broadcasting, etc., we put a special focus on the Extensible Messaging and Presence Protocol (XMPP) [Saint-Andre, 09]. Due to its rich set of built-in properties and features, its set of official XMPP Extension Protocols (XEPs) and the variety of application use cases in ROLE, we explored the protocol in conjunction with widget technologies and JavaScript libraries. Although there exist quite a number of XMPP libraries for JavaScript, we learned that many of them are still insufficiently mature for the realization of our goals and definitely need improvement. In particular, we experimented with a selection of libraries listed on the official XMPP website. A comparison of these libraries is presented in Table 1.

Library	Connection Technique	Code/Documentation Maturity	UI Element Support	Supported Features & XEPs
dojox.xmpp [Dojo, 10]	XMPP over BOSH	ok/weak	yes (basic)	Core: IM, Presence, Roster XEP-0004: Data Forms XEP-0030: Service Discovery XEP-0085: Chat State Notifications XEP-0206: XMPP over BOSH
xmpp4js [XMPP4JS, 10]	XMPP over BOSH	ok/ok	no	Core: IM, Presence, Roster XEP-0004: Data Forms XEP-0030: Service Discovery XEP-0049: Private XML Storage XEP-0077: In-Band Registration XEP-0085: Chat State Notifications XEP-0100: Gateway Interaction XEP-0206: XMPP over BOSH
strophe.js [Strophe, 10]	XMPP over BOSH	ok/weak	no	XEP-0206: XMPP over BOSH
js.io [JS.IO, 10]	(CSP) Comet Session Protocol	weak/weak	no	unknown

Table 1: Comparison of JavaScript Library Support for XMPP

Probably the most important notion was that libraries exhibited different levels of code and documentation maturity and different sets of core and extension protocol features implemented. The minimum level of functionality realized by all of the above libraries is the emulation of persistent, stateful, two-way connections to an XMPP server using comet techniques such as *Bidirectional-streams Over Synchronous HTTP* (BOSH) [Paterson, 08], often in conjunction with additional libraries for XMPP XML

stanza construction and parsing. The next level of functionality was the implementation of XMPP core services, i.e. instant messaging, presence, and roster lists, which were only realized by `dojox.xmpp` and `xmpp4js`. Functionality beyond XMPP core services often only include very basic XEPs, e.g. for service discovery, server ping, data forms, etc., but does in all cases not include the implementation of central XEPs supporting powerful communication techniques such as multiuser chat, publish/subscribe, etc. Although code and documentation quality as well as the set of supported XEPs in `xmpp4j` seemed superior, we decided to start the experimental implementation of further XMPP XEPs based on `dojox.xmpp`, because it provides cross domain solutions, is integrated into the well-established `dojo` toolkit, and is designed to make use of the `dojo` widget framework for the provision of custom XMPP-powered UI elements. Currently, the XMPP Multiuser Chat XEP-0045 [Saint-Andre, 10] is under development in conjunction with a pubsub enabled XMPP multiuser chat gadget. As future work, further central XEPs will be implemented and evaluated in a whole class of XMPP-enabled Widgets.

Drawing the conclusions from our experiences, we can state that the technologies we experimented with were insufficiently mature for the deployment of a stable integrated prototype ROLE PLE assembled from a set of innovative tools realized using a combination of different bleeding-edge Web technologies. We finally managed to deploy our prototype in Graaasp [Bogdanov, 10] in a rather stable version, but still with a lot of open issues to be tackled in later development stages of the ROLE project. The evaluation of our prototype in one of the ROLE testbeds is described in the next section.

3 The Shanghai Jiao University Testbed

ROLE is based on the vision that responsive open learning environments will accompany learners throughout their learning career, from during formal education to learning at the workplace. Several testbeds enable the ROLE project to collect requirements in various settings. One major testbed takes place at the School of Continuing Education (SOCE) at Shanghai Jiao Tong University. SOCE is the online branch of SJTU. Online colleges/universities such as SOCE play a particular role in the Chinese education system. Foreseeing the enormous demand for higher education, the Chinese government decided in 1998 to establish a number of online institutions that were open to those students who did not pass the university entrance exams (in 2007, 10.1 million students applied for 5.67 million places) [People's Daily Online, 2007]. The ROLE SOCE testbed enables us to learn about PLEs from the viewpoints of "average" users, that is learners who are not highly technically literate, who have limited time due to jobs and families.

3.1 Test-bed Description

The students on the SOCE (the situation is similar at the other online institutions) are mostly adult learners who have a job. They study two to three years for associate or bachelor degree courses. The courses are similar to regular university courses with the difference that teaching takes place in the evenings and weekends. Each class lasts for three hours. Our blended classrooms are based on the Standard Natural Classroom

model [Shen, 08], in which students can either attend the classes in person or attend via the live Web broadcast. Lectures can also be downloaded for asynchronous watching. During the lectures, online students can communicate with the teacher via short messages. The SOCE software system records, encodes and broadcasts each lecture in real-time. Target devices/destinations include desktop/laptop PC via ADSL broadband connections, IPTV devices via the Shanghai Educational IPTV channel, universities in western China via two satellite connections and mobile devices via GPRS. SOCE produces about 6GB of content every day. The current SOCE learning management system supports student-student communication via forums. Teachers can create exercises/homework to be completed by the students.

Some of the gaps in the current learning processes are representative for most Chinese educational settings. Students are degree/certificate oriented: the primary goal is to receive a formal acknowledgment of the mastery of the study subject, not the mastery of the subject. Group work is hard to perform as it is seldomly performed at school. In consequence, the practical application of learned knowledge is difficult for Chinese students. For instance, in language learning, the students have extreme difficulties communicating with native speakers. They are insecure, shy, and make frequent mistakes. Furthermore, in our lectures we over and over make the experience that the students do not know, have difficulties, or simply do not use existing tools such as online dictionaries, pronunciation tools or microblogging sites. Reasons given include lack of time, interest and motivation. In *ROLE*, we experiment with different scenarios to address these problems.

We experimented with an Open Learning Environment and a variety of tools (video conferencing, micro-blogging, translation services, text-to-speech, etc) over two semesters in the courses English Listening and Speaking, German I/II, French I/II and Introduction to Computer Science. About 50-100 students attended the language learning courses, and about 1.200 students took part in the Computer Science class. From our experience we knew that the students at SOCE have limited knowledge about Web tools (RSS is virtually unknown), only limited time at their disposal, and limited technical expertise. Furthermore, in the Confucian culture of China learning is still very teacher-centered [Zhang, 07], and students are not used to actively contribute within a class. We therefore decided to build PLEs according to the suggestions of the teachers and make these pre-built PLEs accessible to the students. The teachers presented the PLEs in class, and showed example usages. In order to encourage usage, the students were assigned homework that required using the PLEs. We then observed the students' usage of the PLEs and collected feedback from the teachers and students by interviews and questionnaires.

The prototype described in Section 2 was not finalized at the time we started our experiments at the SJTU testbed. Therefore, we used a slightly different version based on the portal Liferay. While we did not offer advanced features such as inter-widget communication, the basic functionality was the same and therefore enabled us to collect information about the usage of an OLE in a higher education context.

3.2 Testbed related experiences

Here, we will briefly report on our experiences with using the PLE in the SJTU testbed for language learning support. The integration of an OLE into a course is a

complex task that does not work like clockwork, but requires careful introduction, integration into the classroom and a clearly perceived value by the students.

For the students it is not sufficient to present a single example of how to use the OLE in class. In itself, this will not enable and motivate students sufficiently to work with the embedded tools. In our experiments only a minority of students (about 10%) actually made use of the services and did the associated tasks (however, even "regular" homework to be done via the school LMS is only done by about 50% of the students). We hope to improve these figures by increasing the incentive to use the PLEs. Measures will include extra points for the final grade, but also better communication of the value of a PLE. In particular, students need to understand how the tasks and services work which can help them to achieve their goals. Each OLE usage needs to be broken down into the individual steps. For instance, the task of doing a spoken self-introduction can involve the steps of writing the introduction in the native tongue, translating it, polishing it, using a text-to-speech tool to listen to it, a recording to practice one's own pronunciation, and finally recording and publishing it. As a teacher, demonstrating this whole sequence only once or twice overtaxes the student. Each single step needs to be shown and done by the students several times. The single steps as well as the combination of services should be assigned as homework, giving the students an initiative for practicing. Breaking down the usage of an OLE helps students understand how to use it. Even more important is that the students understand why they should use a PLE. Students need to see the value of performing additional tasks which are not directly related to language learning.

For western students the access to the internet is almost as common as watching TV. Applying a web based PLE to other countries requires taking into account country-specific restrictions. For example, as SJTU is located in China the access to quite a large number of Web sites including social networks such as Twitter, Facebook and Friendfeed as well as many Web services is blocked. Furthermore, many institutions such as schools or companies restrict the access of sites deemed to be inappropriate for their scholars.

Furthermore, we experienced new directions for technical research which should be taken into account for the development of the next ROLE prototypes. This includes the necessity to create accounts for some services which require a login or the necessity to have a single sign on feature since logging in several times leads to frustration of the students. Finally, even though logging data was collected in the SJTU testbed, students did not raise privacy concerns. On the contrary, repeatedly, students uttered concerns that their contributions in the employed tools might not be noticed by the teacher.

4 Conclusions and Outlook

Responsive Open Learning Environments create enormous challenges on the psychopedagogical as well as on the technical side. Some of the challenges were sketched in this paper. The ROLE project has chosen a spiral "organic" development and deployment process to cope with the challenges mentioned above. We started with very small scale projects only covering partial requirements of the five testbeds of ROLE. This was necessary to understand the different development cultures among the developers at the different ROLE sites and also the language of the end users

stating their requirements - an experience that will surely help for the larger roll-out planned. Indeed, beside those challenges the interplay between end users of personal learning environments and developers of enabling technologies and products is crucial. It is not only a problem that the current generation of developers do not recognize the time horizons covered in the development of personal learning environments, thus making industrial scale standards deployment inevitable, but also open source developers and company developers do not understand each other. At the moment, flexibility and openness is more on the side of the company developers.

In the near future, the development process is widened to cover more than one testbed. This is due to the necessary learning experience for developers that results developed in the context of one scenario are not necessarily transferable to another scenario. As the ROLE project is targeting the transitions of learning, the future scenarios involve learners' shifts of interests and learning goals during the scenarios like leaving the university with some degree of self-regulated learning and entering a company where learning goals are only valid in the light of the company's strategy.

Acknowledgements

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 231396 (ROLE project).

References

- [Achmed, 99] Ahmed, M., Karmouch, A., Abu-Hakima S.: Key Frame Extraction and Indexing for Multimedia Databases, Vision Interface 1999, Trois-Rivières, Canada, 19-21 May 1999.
- [Bogdanov, 10] Bogdanov, E., Salzmann, C., El Helou, S., Sire, S., and Gillet, D.: Graasp: A Web 2.0 Research Platform for Contextual Recommendation with Aggregated Data. In ACM Conference on Human Factors in Computing Systems (HCI) - Work-in-Progress, 2010.
- [Chakrabarti, 99] Chakrabarti, K., Mehrotra, S.: The Hybrid Tree: An Index Structure for High Dimensional Feature Spaces, In Proc. Int. Conf. on Data Engineering, February 1999, 440-447 <http://citeseer.nj.nec.com/chakrabarti99hybrid.html>.
- [Cocoon, 02] Cocoon XML publishing framework, 2002, <http://xml.apache.org/cocoon/>.
- [Dojo, 10] Dojo Toolkit. Unbeatable JavaScript Tools. <http://www.dojotoolkit.org/>. Last visit March 2010.
- [Glassfish, 10] Glassfish Open Source Application Server. <https://glassfish.dev.java.net/>. Last visit March 2010.
- [Hunter, 00] Hunter, J.: Proposal for the Integration of DublinCore and MPEG-7, 2000.
- [JS.IO, 10] js.io. Real-time Web Applications. <http://js.io/>. Last visit March 2010.
- [Linden, 03] Linden, G., Smith, B., York, J.: Amazon.com Recommendations - Item-to-Item Collaborative Filtering, IEEE Internet Computing 7 (1), 2003
- [OpenAjaxAlliance, 10] OpenAjax Hub 2.0 Specification. http://www.openajax.org/member/wiki/OpenAjax_Hub_2.0_Specification. Last visit March 2010.

- [OpenSocial, 10] OpenSocial. A common Web API for social applications. <http://code.google.com/apis/opensocial/>. Last visit January 2010.
- [OSDE, 10] OpenSocial Development Environment (OSDE). An IDE development tool for OpenSocial applications. <http://code.google.com/p/opensocial-development-environment/>. Last visit March 2010.
- [Paterson, 08] Paterson, I., Saint-Andre, P.: XEP-0206: XMPP Over BOSH. Draft Specification. October, 2008. <http://xmpp.org/extensions/xep-0206.html>. Last visit March 2010.
- [People's Daily Online, 07] People's Daily Online: More than 9.5 million Chinese compete in world's largest examination. 2007: http://english.peopledaily.com.cn/200706/07/eng20070607_381831.html. Last visit November 2007
- [Saint-Andre, 09] Saint-Andre, P., Smith, K., and Tronçon, R.: XMPP: The Definitive Guide - Building Real-Time Applications with Jabber Technologies. O'Reilly Media. April 2009.
- [Saint-Andre, 10] Saint-Andre, P.: XEP-0045: Multi-User Chat. Draft Specification. January 2010. <http://xmpp.org/extensions/xep-0045.html>. Last visit March 2010.
- [Shen, 08] Shen, L., Shen, "The Pervasive Learning Platform of a Shanghai Online College - A Large-Scale Test-Bed for Hybrid Learning Hybrid Learning and Education", In R. Fong, J.; Kwan, R. & Wang, F. L. (ed.), First International Conference, ICHL 2008, Hong Kong, China, August 13-15, 2008, Proceedings, Springer, 2008, 5169, 178-189
- [Strophe, 10] Strophe. A family of libraries for writing XMPP clients. <http://code.stanziq.com/strophe/>. Last visit March 2010.
- [Shindig, 10] Apache Shindig. OpenSocial container reference implementation. <http://incubator.apache.org/shindig/>. Last visit January 2010.
- [SocialSite, 10] Project SocialSite. <https://socialsite.dev.java.net/>. Last visit March 2010.
- [Wolpers, 07] M. Wolpers, J. Najjar, K. Verbert, and E. Duval, „Tracking Actual Usage: the Attention Metadata Approach,” in Educational Technology & Society, vol. 10, no. 3, pp. 106-121, 2007.
- [Wolpers, 09] Wolpers, M., Memmel, M., Giretti, A.: Metadata in Architecture Education - First Evaluation Results of the MACE System, In Proceedings of the 4th European Conference on Technology Enhanced Learning: learning in the Synergy of Multiple Disciplines, 2009
- [XMPP4JS, 10] Xmpp4Js. An XMPP client library written in pure Javascript. <http://xmpp4js.sourceforge.net/>. Last visit March 2010.
- [Zhang, 07] Zhang, J. A cultural look at information and communication technologies in Eastern education, In Educational Technology Research and Development, 2007, 55, 301-314

Utilizing Semantic Web Tools and Technologies for Competency Management

Valentina Janev

(The Mihajlo Pupin Institute, Belgrade, Serbia
Valentina.Janev@institutepupin.com)

Sanja Vranes̃

(The Mihajlo Pupin Institute, Belgrade, Serbia
Sanja.Vranes@institutepupin.com)

Abstract: This article aims at providing better understanding of the applicability of Semantic Web tools and technologies in practice. It introduces a case study of the use of semantic technologies for extraction, integration and meaningful search and retrieval of expertise data, as an example of the new approaches to data integration and information management. In particular, the paper discusses the process of building expert profiles in a form of ontology database by integrating competences from structured and unstructured sources. The results of the case study show that emerging Semantic Web technologies such as the OWL 2, SPARQL, SPIN rule language, and public vocabularies such as FOAF, DOAC, bibTeX, Dublin Core and other can be used for building individual and enterprise competence models. The proposed approach extends the functionalities of existing enterprise information systems and offers possibilities for development of future Internet services. This allows organizations to express their core competences and talents in a standardized, machine processable and understandable format, and hence facilitates their integration in the European Research Area and beyond.

Keywords: Semantic Web, human resources, competencies, expertise, ICT, case study

Categories: H.4, M.0, M.3, M.4, M.7, M.8

1 Introduction

Competence management (CM) is an important research object in the more general area of human resources management and knowledge management. Two different meanings of the concept of “competence” (building blocks of competency models) within the corporate environment could be distinguished:

Expert competences are specific, identifiable, definable, and measurable knowledge, skills, abilities and/or other deployment-related characteristics (e.g. attitude, behaviour, physical ability) which a human resource may possess and which is necessary for, or material to, the performance of an activity within a specific business context. Competence modelling is thus a process of determining the set of competencies that are required for excellent performance in a particular role [Ennis, 08].

Organizational core competencies are aggregates of capabilities, where synergy is created that has sustainable value and broad applicability for an organization [Lahti, 99]. Defining competency models for an organization and performing skills gap analysis which provides essential data for the undertaking of a range of training and

development and performance improvement activities is known as Competency management.

Competency analysis within an enterprise aims at identifying the knowledge and skills on individual level required to perform the organization's business activities so that they may be developed to fit the requests of work life reality. Depending on the adopted approach to competence management, different individual competence models can be developed, e.g. job, functional, core, or leadership competency models. Core competency models identify the critical skills, knowledge, and abilities that are required for success for all individuals in a particular organization. This creates a common language and an agreed upon standard of performance among employees. Job competency models describe the behaviours, knowledge, and skills required for exceptional performance for any particular job. As a result, individuals and their managers can evaluate performance against an observable standard.

EU policy including the Bologna Process (started in 1999, see <http://www.ond.vlaanderen.be/hogeronderwijs/Bologna/>) and the European Research Area initiative (commenced in 2000, see <http://ec.europa.eu/research/era/>) underlines the importance of the transferability and comparability of competences, skills and qualifications within Europe. The European Commission and the Council of Ministers supported the development of the European e-Competence Framework (e-CF) as a reference framework of 32 ICT competences that can be used and understood by ICT user and supply companies, the public sector, educational and social partners across Europe (see <http://www.ecompetences.eu/>). In addition, European Union, through its chief instruments for funding research (FP5 - The Fifth, FP6 – The Sixth and FP7 – The Seventh Framework Programs), has financed several projects that focused on ontology-based competence management. As a result of these projects, several prototype systems have been developed [Bizer, 05], [Draganidis, 06] and few ontologies were made publicly available. Schmidt & Kunzmann [Schmidt, 06] developed the Professional Learning Ontology that formalizes competencies as a bridge between human resource development, competence and knowledge management as well as technology-enhanced learning. In [Bizer, 05], Bizer, et al., developed a HR ontology, an e-recruitment prototype and argued that using Semantic Web technologies in the domain of online recruitment could substantially increase market transparency, lower the transaction costs for employers, and change the business models of the intermediaries involved. Furthermore, the research work in the competence management domain in the last decade had a positive impact on several European Public Employment Services [Müller-Riedlhuber, 09]. Some of them have already introduced (e.g. Germany, Norway) or are at the moment working on improvements of their matching (vacancies and job seekers) processes by shifting more emphasis to competences.

This paper aims at introducing an approach to competence management based on the latest developments (tools and technologies) in the Semantic Web field, as well as presenting the results of extraction of ICT competences from existing structured and unstructured sources and their formal representation as OWL models. The approach has been implemented in a real knowledge-intensive establishment i.e. the “Mihajlo Pupin” Institute from Belgrade, Serbia. The paper is organized as follows. First, in Section 2, competency management challenges in modern organizations are discussed and the ontology-based modelling and development environment for expertise

profiling, search and retrieval is presented. Next, Section 3 explains the process of building expert profiles in a form of ontology database by integrating competences from structured and unstructured sources. Section 4 shows several examples of utilizing the implemented system for semantic expertise search and retrieval.

2 Ontology-based Approach to Competency Management

Ontology engineering is a field in information science, which studies the methods and methodologies for building ontologies (formal representations of a set of concepts within a domain and the relationships between those concepts). Ontology engineering provides standards and structures that allow information to be described in a way that captures *what it is*, *what it means* and *what it's related to* - all in a machine-readable form. This enables machines as well as people to understand, share and reason with them at the execution time and offers new possibilities for enterprise systems to be networked in meaningful ways. Ontologies form the backbone of the Semantic Web.

Motivated by the need to express the information and communication technologies' competences of the researchers and organizational units of the "Mihajlo Pupin" Institute (MPI) in a machine processable format by using standards and classifications that will allow interoperability of data in the EU research and business space, we adopted an ontology-based approach to expertise profiling and retrieval [Janev, 09].

2.1 Competency Management in ICT Domain

Information and Communication Technology (ICT) field includes the following sub-disciplines: computer science, information systems, computer engineering, software engineering and information technology. The Association for Computer Machinery, the world's largest educational and scientific computing society (see <http://www.acm.org/>) and the IEEE Computer Society, an organizational unit of the Institute of Electrical and Electronics Engineers (see <http://www.computer.org/>) have taken a leading role in providing support for higher education in ICT in various ways, including the formulation of curriculum guidelines and defining competences i.e. capabilities and knowledge expected for ICT graduate. According to the ACM high-level categorization of Information Systems graduate exit characteristics, for example, the future ICT professionals, scientists, and engineers, should have technology knowledge in the following domains: *Application Development*, *Internet Systems Architecture and Development*, *Database Design and Administration*, *Systems Infrastructure and Integration*, and *IS development (Systems Analysis and Design, Business Process Design, Systems Implementation, IS Project Management)*. *Internet Systems Architecture and Development*, for example, includes Web page development, Web architecture design and development, design and development of multi-tiered architectures and experience with Web programming languages such as Java, PHP, Python, HTML, RDF, etc.

Except technical knowledge ICT professionals, scientists, and engineers should be capable of analytical and critical thinking and have soft skills (*Interpersonal, Communication, and Team Skills*). Soft skills, sometimes known as "people skills," are personal attributes that enhance an individual's interactions, job performance and

career prospects. Companies value soft skills because research suggests and experience shows that they can be just as important an indicator of job performance as hard skills.

ICT graduates should be also familiar with business fundamentals (*Business Models, Functional Business Areas, Evaluation of Business Performance*). Based on this, ICT professionals develop management skills and leading abilities. Management skills include skills for problem solving, goals setting, organizing, and realization of decisions and enforcement of measures, performing control and evaluating results, costs planning, delegating and constant improvement. Leading abilities are skills for clear mediating of information, interpersonal conversation, notifying, activating energy, creating possibilities, motivational leading, conflicts solving, stimulating co-workers, mutual cooperation, positive treatment with others, and other. In general, we can depict the skills of ICT expert/professional as is presented in Figure1.

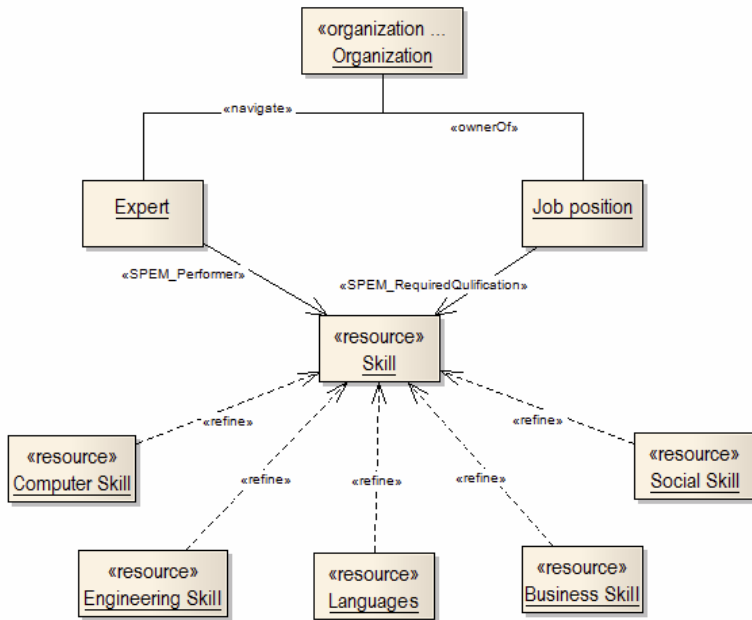


Figure 1: UML representation of competence-related business objects

2.2 Development of Job Competency Models at the Mihajlo Pupin Institute

Using the “Mihajlo Pupin” case study, we can illustrate the career development paths of the engineering staff as is presented in Figure 2. Nodes represent different employment positions, while the arcs show the possible development paths. Building a competency model means identification of the competencies employees need to develop in order to improve performance in their current job or to prepare for other jobs via promotion or transfer. The model can also be useful in a skill gap analysis, the comparison between available and needed competencies of individuals or

organizations. An individual development plan could be developed in order to eliminate the gap. Important variables to be considered during the development of a competency model are the use of skill dictionaries, or the creation of customized ones. For example, a competency model for a “Senior Research Associate” might include competencies such as analytical approach to work, excellent problem-solving skills, technical competence and experience, good organizational skills, independence and objectivity, ability to communicate, attention to detail, project-management skills, ability to distinguish between the strategically important and the trivial, negotiation.

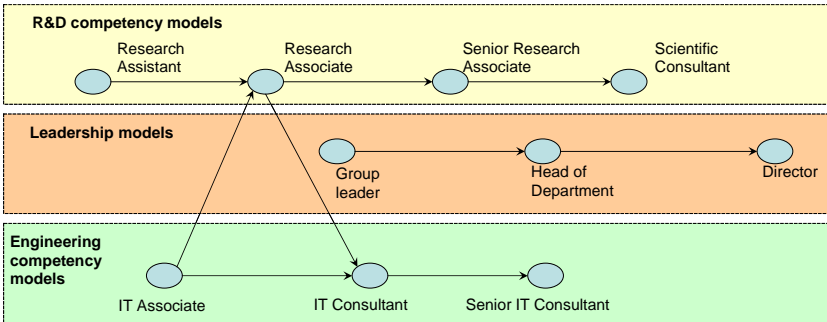


Figure 2: Career development paths

2.3 Building an Ontological Knowledge Base with TopBraid Composer

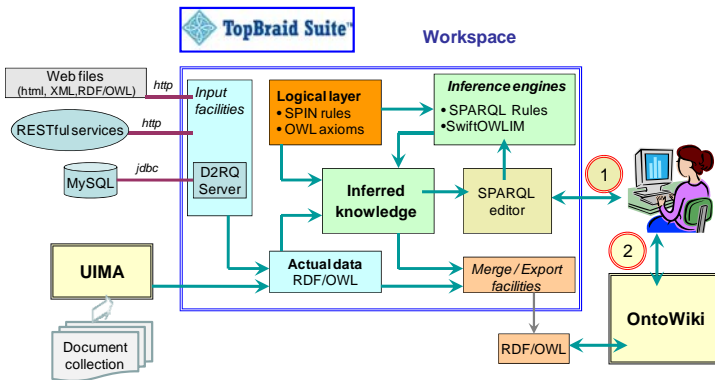


Figure 3: The TopBraid Composer workspace

For the purpose of establishing a repository of job competency models and storing the expert profiles in a machine processable format, an ontological knowledge base was designed and built using the *TopBraid Composer*, an enterprise-class modelling environment for building semantic applications (see the TopQuadrant’s Web site at <http://www.topquadrant.com/>). The tool provides powerful *Input facilities* (see Figure 1) that enables us to integrate diverse knowledge sources (e.g. the HR management

system, the enterprise document management system, RDF models of the identified ICT competences from unstructured sources, etc). It supports many inference engines that can run alone or in a sequence. The latest version of *TopBraid Composer* has introduced the SPIN rule language (<http://spinrdf.org/>) that we have used to define constraints and inference rules on Semantic Web models. Using the *TopBraid Suite Export facilities* we have merged, converted and exported the expertise data to RDF graphs and thus prepared the data for exploitation with other client applications e.g. with *OntoWiki*.

3 Building Expert Profiles Models in OWL format

3.1 Reusing Existing Ontologies and Taxonomies for Ontology Design

In order to ensure semantic integration and interoperability, one of the basic principles in ontology engineering is to use terms from existing public ontologies and taxonomies (see <http://www.w3.org/2001/sw/BestPractices/OEP/SemInt/>). The main “components” of the MPI ontology, for example, are defined as subclasses of the public concepts (*foaf:Person*, *foaf:Organisation*, *foaf:Document*, *foaf:PersonalProfileDocument*, *doac:Education*, *doac:Skill*, *doac:Experience*, *bibtex:Entry*), while links/relations between the components are defined as sub-properties of *foaf:interest*, *foaf:made/maker*, *foaf:topic*, *foaf:topic_interest*, *foaf:primaryTopic*, *foaf:homepage*, etc. Additional classes and properties specific to the MPI were defined manually with elements from the RDF Schema (www.w3.org/TR/rdf-schema/) or defined automatically in bottom-up manner via the import facilities (based on D2RQ server) of the *TopBraid Composer* engineering environment. As a result, the ontological database is a set of interlinking public ontologies and in-house ontologies in RDF/OWL format. As MPI ontology serves to describe the scientific competences of the MPI employees in different ICT domains, we adopted the CISTRANA Information Society Technologies taxonomy of European Research Areas (IST ERA, <http://www.kooperation-international.de/eu/themes/info/detail/data/2962/?PHPSESSID=c332>).

3.2 Extracting ICT Competences from Structured and Unstructured Sources

After the ontological knowledge base is designed, the next step is to populate the ontology i.e. import data into the ontology and create instances (see Figure 4). Manually creating of ontologies is a time consuming task. Semantic Web community has delivered many high-quality open-source tools (e.g. the D2RQ server) that can be used for automatic or semiautomatic ontology population i.e. to convert the facts trapped in the legacy systems or business documents into information understandable both for machines and people. Table 1 summarizes some types of competences that were extracted from structured sources (i.e. from the MPI HR management system) and unstructured sources (i.e. from documents using the MPI Competence Analysis component).

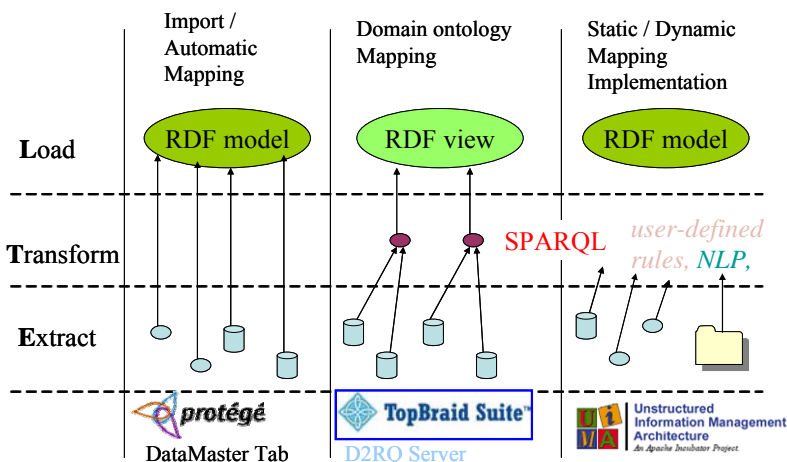


Figure 4: Populating the ontological knowledge base - Mapping sources to RDF/OWL models

Table 1: Integrating competences from structured and unstructured sources

Sources	Type of competence	Content
Structured SAP HRM system stores self declared competences of the experts	- ICT main research field	A category from a catalog defined by Serbian Ministry of Science
	ICT subfields	unlimited list of ICT areas
	Key qualifications	Free text in Serbian language
	Key experiences - responsibilities	Free text in Serbian language
	Foreign languages	Items from a catalog of foreign languages
Unstructured documents in .doc, .pdf, .txt, etc.	Computer skills	7 different competence types are extracted and transformed into structured format
	Project Experience	Major ICT fields of project expertise is identified and transformed into structured format
	Publications	An extensive list of topics of interest is extracted and transformed into structured format

3.3 Ontology Population from Structured Sources (MPI HR management system)

There are two different ways of using data from structured source in semantic web applications. In human resources domain, for example, the personal data that is often static can be extracted from the legacy system and copied into RDF/OWL format using tools such as the *Protégé DataMaster* extension. The RDF/OWL model can be queried with tools such as the *OntoWiki* (see example bellow). Another way is to use declarative languages and tools such as the D2RQ server for creating mapping files

between a relational database schemata and an OWL/RDFS ontology. On top of this, SPARQL CONSTRUCT syntax can be used for transforming the legacy data into OWL concepts and properties. Then, a Java application can query and retrieve relational data as it is a RDF source using the SPARQL protocol or the Jena/Sesame API.

3.4 Extracting Expertise Data From Unstructured Sources with MPI CompetenceAnalysis Component

In March 2009, OASIS, the international open standards consortium (see Organization for the Advancement of Structured Information Standards, <http://www.oasis-open.org/>) approved UIMA (Unstructured Information Management Architecture, <http://incubator.apache.org/uima/>) as standard technology for creating text-analysis components. UIMA defines interfaces for a small set of core components that users of the framework provide implementations for. Annotators and Analysis Engines are two of the basic building blocks specified by the architecture.

The *MPI CompetenceAnalysis* component was built upon the UIMA *ConceptMapper* Annotator. The *ConceptMapper* Annotator is a high performance dictionary lookup tool that maps entries in a dictionary onto input documents, producing UIMA annotations. The dictionary of *MPI CompetenceAnalysis* component was built using the ICT taxonomy of European Research Areas. The taxonomy structures the ICT technology areas into four main categories: C1 - Electronics, Microsystems, Nanotechnology; C2 - Information Systems, Software and Hardware; C3 - Media and Content, and C4 - Communication Technology, Networks, and Distributed Systems. In addition, the dictionary contains vocabulary of computer skills that is used for extracting expert experience with *Programming languages, Operating systems, Hardware, WEB technology, SW Solutions, Modeling environments, Development Tools*, etc.

Furthermore, the *MPI Collection Reader* was built because the source documents are coming from different parts of an expert's computer and tokens are mapped accordingly to different concepts. The *MPI CAS Consumer* was built because we wanted to customize the processing made by *ConceptMapper* annotator and prepare the output results in an OWL format suitable for integration in existing expertise knowledge base.

Currently the *MPI CompetenceAnalysis* component assumes that the input documents belong to a single person and exports an OWL file whose content looks like:

```
<ict:Person rdf:ID="ID_1526">
<Global_ID
rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">1526</Global_ID>
<ict:topic_interest_project
rdf:resource="http://www.institutepupin.com/ict.owl#Semantic_Technologies"/>
<ict:topic_interest_reference
rdf:resource="http://www.institutepupin.com/ict.owl#Imaging_Image_Processing_Pattern_Recognition"/>
...
<ict:useOperatingSystem
rdf:resource="http://www.institutepupin.com/skills.owl#Windows"/>
<ict:useDBMS
rdf:resource="http://www.institutepupin.com/skills.owl#MS_SQL_Server"/>
```

```
<ict:useSoftwareSolution
rdf:resource="http://www.institutepupin.com/skills.owl#SAP_ERP"/>
</ict:Person>
```



Figure 5: Extension of the conceptual class and property schema with rules

3.5 Using SPIN Rules for Inferring New Knowledge

The latest version of *TopBraid Composer* has introduced the SPIN rule language (<http://spinrdf.org/>). SPIN is a collection of RDF vocabularies enabling the use of SPARQL to define constraints and inference rules on Semantic Web models. SPIN also provides meta-modeling capabilities that allow users to define their own SPARQL functions and query templates. These templates are then used to dynamically compute property values even if there are no corresponding triples in the actual model. Indeed, OWL 2 RL rules can be converted into SPIN templates.

Using SPIN, for example, we first defined a class *InferReferenceCategory* as a subclass of the *spin:Templates* class. The aim of this template was to infer the main ICT areas that a person has worked in from evidence of type *Project*. The *InferReferenceCategory* class has two arguments (predicate and *mpic:hasDomain*) of type *spin:constraint*. Using the defined template, as is presented in Figure 5, we specified a rule of type *spin:rule* for the *mpi:Person* class and gave the rule a name (e.g. *hasExperienceReferenceICT*) that reflected the aim of the template. This rule aggregated the experience of a person in writing papers in specific technical areas (e.g. “Semantic Technologies”, “Knowledge technologies”) and dynamically computed the values of the property i.e. inferred the ICT ERA top categories (e.g. C2).

4 Expert Search with SPARQL and *OntoWiki*

Generally, an ontology knowledge base consists of actual data (facts) in RDF/OWL format and a logical layer that together with an inference engine enables creating new knowledge. Depending on the type of logical constructs (e.g. OWL axioms, SPIN rules, Jena rules, etc.), in *TopBraid Composer*, we configure the inference mechanism as a sequence of inference engines, e.g., using TopSPIN (SPARQL rules) on top of SwiftOWLIM. From many possibilities that exist for querying an ontology knowledge base, we will discuss:

- the on-line use of *TopBraid Composer* SPARQL editor (option 1). For resolving a SPARQL query specified by a user, the system uses a SPARQL engine with built-in TopSPIN inference engine. The TopSPIN inference engine automatically calculates user defined SPIN rules stored in a separate file (see “Logical layer” box in Figure 3).
- the use of *OntoWiki* on top of an RDF/OWL file (option 2). After running the preconfigured inference service, *TopBraid Composer* generates a separate file with the inferred knowledge. If we want to query the knowledge data base with a client application that does not support SPIN rules, we have a possibility to merge the actual data and the inferred knowledge and export the triples as a compound RDF/OWLfile via the Export/Merge/Convert facilities.

[Person]	Job	Skill	Level	Topic
Jovan_Dudukovic	ResearchAssis...	BasicSystemAnalysis	1	ict:Semantic_Technologies
Mladen_Stanoje...	SeniorResearc...	ProfessionalSystemAnalysis	5	ict:Semantic_Technologies
Sanja_Vranes	ScientificCoun...	ProfessionalSystemAnalysis	5	ict:Semantic_Technologies
Valentina_Janev	ITConsultant	ProfessionalSystemAnalysis	5	ict:Semantic_Technologies

Figure 6: SPARQL sample query against the ontological knowledge base

4.1 Searching Job Competence Models with SPARQL

Operating both in the research sector and in the business sector, the Mihajlo Pupin Institute has separately defined career paths for carrying on scientific career in engineering and engineering career in business sector. Using the job competence models, we can filter the experts that have the required engineering skills (e.g. “SystemAnalysis”) in a specific technical area (e.g. “Semantic” technologies). The SPARQL query is presented on the left and the found experts are listed in the right side of Figure 6. Proficiency levels are expressed with numbers that mean: 1-Basic, 2-Foundational, 3-Intermediate, 4-Advanced, and 5-Expert/Professional.

4.2 Querying Job Competence Models with *OntoWiki*

A far more comfortable way for querying the ontological base is, however, to use free of charge open-source tools, such as the *OntoWiki* (ontowiki.net), in order to improve the expertise search, analysis and retrieval. The main goal of the *OntoWiki* [Auer, 08] is to rapidly simplify the presentation and acquisition of instance data from and for end users. It provides a generic user interface for arbitrary RDF knowledge bases and uses SPARQL to access the underlying databases. Using the *OntoWiki* tool (see Figure 7), the RDF/OWL expertise data can be full-text searched (see the “Search” panel in the upper left corner), browsed using semantic relations (see the “Classes” panel in the lower left corner) and searched using faceted navigation method (see the “Filter” panel in the right most side).

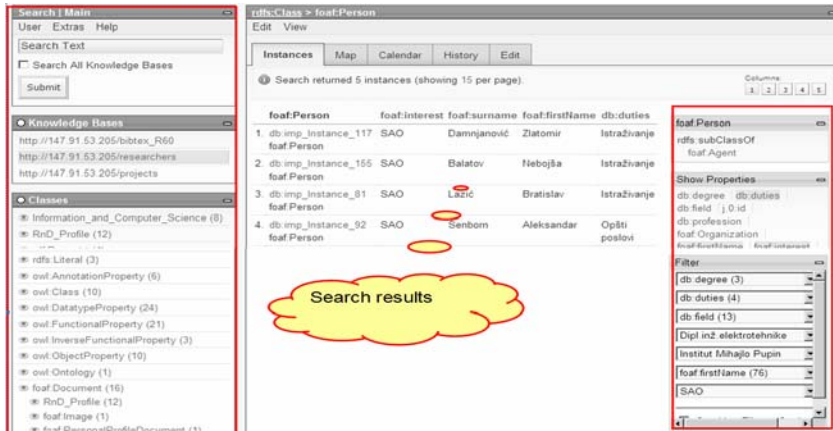


Figure 7: Expertise search with OntoWiki

5 Concluding Remarks

Virtually integrated organizations seek to link their individual core competencies through cost-sharing and risk-sharing agreements, so that these organizations can act as a larger, single entity. Competency management and finding expertise (either a person or/and accompanied knowledge items) in such a dynamic and often complex organizational structure, that is supported by an extended information system, is a challenging issue.

This paper discussed the process of building expert profiles in a form of ontology database by integrating competences from structured and unstructured sources. In particular, it presented the MPI *CompetenceAnalysis* component that was developed at the “Mihajlo Pupin” Institute in order to objectively identify and extract the key expertise of employees and automate the ontology population process. What has been achieved so far is automatic identification and extraction of skills from available structured and unstructured sources and semi-automatic population of the ontology database. Structured sources (SAP HCM knowledge pool) store expertise items that are based on evidences (e.g. certificates) or declared by the experts themselves at HR Department and entered in the knowledge pool by an officially assigned person. Once the expertises have been extracted from unstructured documents using the MPI *CompetenceAnalysis* component, the results have to be checked by the officially assigned person prior to integration into the ontology database. Automatic analysis has advantages compared to manual analysis because of the objectiveness of results. Our analysis has shown that manually created lists of expertise were not an exhaustive description of the person’s expertise areas. Introducing standard classification of ICT expertise facilitates data integration and interoperability of expertise data within the European Research Area and beyond.

Innovative enterprises interested in developing new business models are already introducing Semantic Web technologies to facilitate data integration and interoperability, as well as improve search and content discovery. The Mihajlo Pupin

Institute case study, for example, proves the maturity of these technologies for applications in HR domain.

Acknowledgements

This work has been supported partly by the EU Seventh Framework Programme (HELENA - Higher Education Leading to ENgineering And scientific careers, Pr. No.: 230376) and partly by the Ministry of Science and Technological Development of the Republic of Serbia (Pr. No.: TR-13004).

References

- [Auer, 08] Auer, S.: Methods and Applications of the Social Semantic Web, In Vraneš, S. (ed.) *Semantic Web and/or Web 2.0: Competitive or Complementary?* pp. 100 - 128, Academic mind, Belgrade, Serbia, 2008.
- [Bizer, 05] Bizer, C., Heese, R., Mochol, M., Oldakowski, R, Tolksdorf, R, Eckstein, R.: The Impact of Semantic Web Technologies on Job Recruitment Processes, In *International Conference Wirtschaftsinformatik (WI 2005)*, Bamberg, Germany, 2005.
- [Draganidis, 06] Draganidis, F., Mentzas, G.: Competency Based Management: A Review of Systems and Approaches, *Information Management and Computer Security* 14(1), 51 – 64, 2006.
- [Ennis, 08] Ennis, M.R.: Competency Models: A Review of the Literature and the Role of the Employment and Training Administration (ETA), U. S. Department of Labor, 2008, http://www.careeronestop.org/COMPETENCYMODEL/info_documents/OPDRLiteratureReview.pdf.
- [Gliozzo, 07] Gliozzo, A., et al.: A Collaborative Semantic Web Layer to Enhance Legacy Systems, In K. Aberer et al. (Eds.) *ISWC/ASWC 2007*, LNCS 4825, pp. 764–777, 2007, <http://www.springerlink.com/index/j55152064g861071.pdf>.
- [Janev, 09] Janev, V., Duduković, J., Vraneš, S.: Semantic Web Based Integration of Knowledge Resources for Expertise Finding, *International Journal of Enterprise Information Systems* 5(4), 53-70, 2009.
- [Lahti, 99] Lahti, R. K.: Identifying and integrating individual level and organizational level core competencies, *Journal of Business and Psychology* 14(1), 59—75, 1999.
- [Müller-Riedlhuber, 09] Müller-Riedlhuber, H.: The European Dictionary of Skills and Competences (DISCO): an Example of Usage Scenarios for Ontologies, In *I-KNOW '09 and I-SEMANTICS '09*, 2-4 September 2009, pp. 467 – 479, Graz, Austria, 2009.
- [Schmidt, 06] Schmidt, A, Kunzmann, C.: Towards a Human Resource Development Ontology for Combining Competence Management and Technology-Enhanced Workplace Learning, In: Meersman, R., Tahiri, Z., Herero P. (eds.) *On The Move to Meaningful Internet Systems 2006: OTM 2006 Workshops, Part I. 1st Workshop on Ontology Content and Evaluation in Enterprise (OntoContent 2006)*, LNCS, vol. 4278, pp. 1078—1087, 2006.

Facilitating Collaborative Knowledge Management and Self-directed Learning in Higher Education with the Help of Social Software. Concept and Implementation of CollabUni – a Social Information and Communication Infrastructure

Joachim Griesbaum

(University of Hildesheim, Hildesheim, Germany
joachim.griesbaum@uni-hildesheim.de)

Saskia-Janina Kepp

(University of Hildesheim, Hildesheim, Germany
keppsa@uni-hildesheim.de)

Abstract: The application of social software in higher education is often restricted to dedicated learning contexts, namely lectures or seminars. Thus their inherent potentials for fostering knowledge management and self-directed learning are usually chained to the narrow restrictions of Learning Management Systems based virtual classroom walls. This paper's focus has a different perspective: The provision of social software as an information and communication infrastructure that goes beyond lectures and encompasses the whole institution and all members of the university, respectively. Thereby an online space is provided for self-expression, information access and knowledge exchange on manifold social levels. Following this prospect, the technical and organisational concept of CollabUni, a social information and communication infrastructure, is described. First results from the implementation of CollabUni that is currently underway, delivers a differentiated, overall encouraging picture. With respect to acceptance and use of this environment, the importance of an elaborate community building approach as well as the need for gaining information and communication literacy on part of the students are evident.

Keywords: Collaborative Knowledge Management, E-Learning 2.0

Categories: H.4.3, L.2.5, L.6.0, L.6.2

1 Introduction

Interactive technologies and collaborative phenomena of Web 2.0 offer manifold opportunities for enhancing higher education. There is a wide range of possible usages of such social media to foster education and learning, for an overview cp. e.g. [Grodecka, 09]. A literature review reveals that social software is often applied for specific didactic goals in courses, for example the provision of blogs and wikis to support collaborative group work [Ramanau, 09], [Giannoukos, 08], [Sigala, 07], [Jaksch, 08]. But one can argue that the implications of social media for higher education reach far beyond the classroom metaphor. [Downes, 05] introduced the term e-learning 2.0 and contrasted the previously predominant e-learning praxis,

which he describes as course based content delivery, with a picture of a new generation of learners (“digital natives” [Prensky, 01], “net generation” [Tapscott, 97]), which is accustomed to actively participate in online conversations and the forming of online communities. For this new generation of learners the provision of tools like e-portfolios or blogs as a means for publishing, interacting and learning together in open communities, not limited to a given social group, such as a university class, would be much more appropriate. Notwithstanding the fact that this simplistic comparison should be scrutinized, cp. [Schulmeister, 08], the argument of Downes points out that social media can be seen as an infrastructure to foster free, i.e. potentially unrestricted many-to-many communication and knowledge exchange in educational contexts. [Kerres, 06] argues in a similar direction. He compares standard Learning Management Systems with isolated islands and discusses Personal Learning Environments that serve as open gateways to the internet as alternative or complementary learning tools. [Baumgartner, 06] consolidates these views and proposes the use of social software a) as a didactical tool to support and allow specific didactic scenarios, for example e-portfolios as an assessment tool and b) as an institutional infrastructure, primarily supporting informal learning.

Focusing on the last point, employing social software in higher education can be interpreted from a knowledge management perspective as a means of fostering social interaction to support individual and social learning. Based on the model of [Nonaka, 95], [Griesbaum, 09] argue that social software should be employed as a social information and communication infrastructure, thus enabling new possibilities for manifold knowledge (exchange and creation) processes across personal and organizational boundaries within (and, potentially also outside) the institution. CollabUni should be seen and serve as an effort in this context. As a case study it contributes to the question if and in which way the chances and hopes associated with social software could actually be accomplished [Baumgartner, 06]. This paper concentrates on the conceptual specification and technical implementation of the system as well as its first introduction to test users. Data yields results concerning the costs and hurdles in building such an infrastructure. The first exposition to a cohort of test users hints towards the acceptance and use of the system as well as realized added value.

The rest of the paper is organized as follows. First we give an overview of our basic concept and approach of applying social software as a personal and social information and communication infrastructure in higher education. On this basis the emergence of CollabUni is explained. The current implementation status and some preliminary evaluation data are discussed. The paper closes with an outlook of the planned roll-out of CollabUni on the social level of the whole university.

2 Social software as a personal and social information and communication infrastructure in higher education

Information and communication infrastructures in higher education are typically pre-defined in a top-down manner. Computer centers provide university members with mail or library accounts. Institutional websites, be it on a work group, faculty or university level, usually follow a unidirectional information presentation and

distribution approach, most often not providing feedback channels or bi-directional communication opportunities. Many-to-many communication environments, if at all existent, are often realized in separated, rarely interconnected “rooms” – e.g. online discussion forums in the already mentioned Learning Management Systems. Even when many-to-many communication possibilities are provided for higher social levels, e.g. the whole organization, such infrastructures are usually separated and communication spaces predefined. Therefore, one can conclude that the current state of web based information and communication infrastructures in higher education is primarily organization centric and following an information distribution paradigm. This rarely corresponds with ideas of supporting knowledge growth by fostering interpersonal interaction and knowledge exchange as argued e.g. by [Reinmann-Rothmeier, 01], [Wenger, 98], [Nonaka, 95] with the help of social software [Chatti, 07].

In our preceding work [Griesbaum, 09], a concept of a personal and social information and communication infrastructure was argued. This concept proposes the provision of e-portfolios as a tool for personal information management for all university members, supporting the management of knowledge artefacts and offering a room that lowers the threshold for self-presentation. At the same time, these individual portfolios serve as anchors to link university members among themselves. Additionally the infrastructure should consolidate the functionalities and data of other technical services and accounts within the organization. Finally, it should provide interfaces to (many-to-many) communication services and collaborative working tools or integrate them respectively. Figure 1 illustrates this concept.

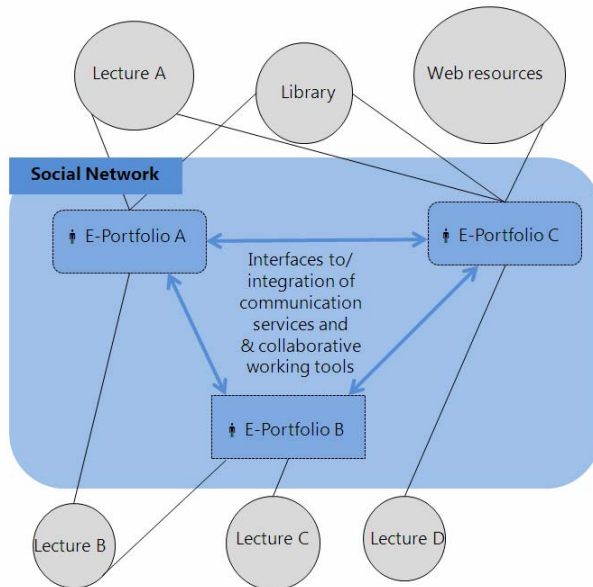


Figure 1: Concept of a social information and communication infrastructure in higher education [Griesbaum, 09]

The crucial point of such an infrastructure is that it enables free and self-determined knowledge communication, knowledge exchange and knowledge creation. Not bound by hierarchical levels or organizational units, the possibilities of knowledge sharing or learning from contributions (or resources) of others are no longer restricted to predefined spaces. A few examples, like the University of Brighton (<http://community.brighton.ac.uk>), show that the afore-mentioned ideas should not be disposed of as an escapist utopia, but be estimated as a realistic vision and a feasible option to enhance higher education.

The successful implementation of such a social information and communication infrastructure is not only depending on the provision of the necessary technical components but also on organizational and administrative aspects that arouse motivation and competence for knowledge communication on the part of the target group. This social dimension of interpersonal interaction, often referred to as “community building” is deemed to be the critical success factor for the initiation of knowledge communication. Considering the numerous literature in this field, cp. e.g. [Wieden-Bischof, 09], [Dittler, 07], [Wenger, 02], [Kim, 01], [Preece, 00] the implementation concept is based on a multi-stage process: a) Analysis of goals, needs and framework conditions, b) technical, social and content design and configuration, c) roll out, attended by initial marketing and initiation and support of knowledge communication through support mechanisms and measures like moderation, d) evolution through feedback and controlling based advance in cooperation with the participants. Figure 2 displays an overview of the implementation process.

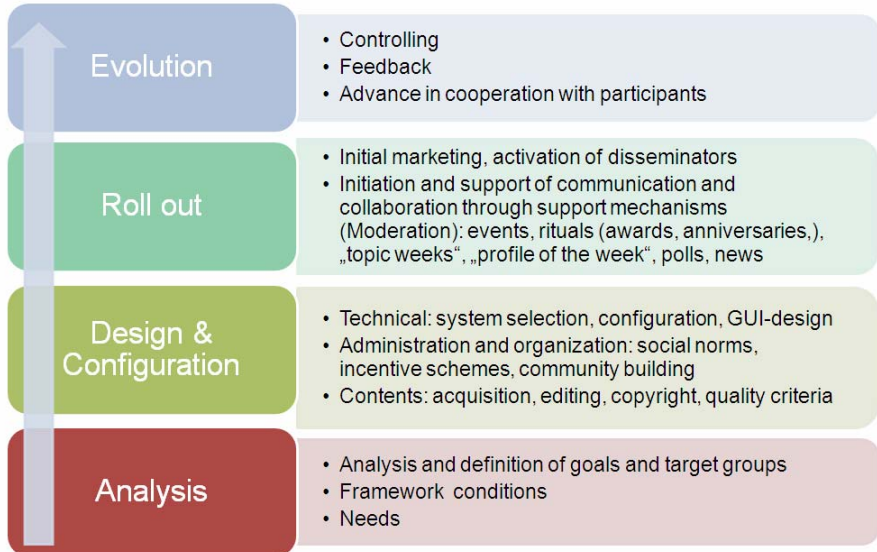


Figure 2: Implementation process approach

The following chapters cover the current state of the case study and give an overview of the phases “Analysis” and “Design & Configuration” as well as some preliminary results of the small scale pre-test “Roll out”.

3 Emergence of CollabUni

3.1 Analysis

The goals and target groups of CollabUni are already implicitly represented in chapters 1 and 2. The idea is to foster discourse, cooperation, and knowledge exchange as well as knowledge generation of all university members¹. The final goal is to support knowledge increase on individual but also on different organizational levels. Important framework requirements are the size of the organization, as well as technical and personal preconditions. The university's technical infrastructure resembles the situation described in chapter 2. With regard to personal preconditions, the degree of awareness, the level of familiarity with social software as well as the perceived need for and the willingness to participate in a university social network were measured with the help of an online survey in March 2009 [Schuirmann, 09]. 179 Students and 5 members of scientific staff participated in this survey. Results indicate that the Moodle-based Learning Management System (<http://moodle.org>) is primarily used for downloading learning material. Social Software, like the blog (<http://blog.uni-hildesheim.de>) and the Studierendenforum (<https://www.uni-hildesheim.de/studierendenforum>), provided by the university, are widely unknown and scarcely used for collaborative knowledge management and self-directed learning. Nearly all participants are members of online social networks like Facebook (<http://www.facebook.com>) or StudiVZ (<http://www.studivz.net>) and predominantly use these for private communication purposes. University members feel no urgent need for the provision of further social software application but roughly half of them answer that they would use a social network of the university with high probability (38%) or most certainly (9,8%). Resource access as well as contact management to other students and staff are judged as value adding features of such a network. To sum up, the results of the survey indicate that university members seem to be generally open for using a university-based social network. At the same time, there is little consciousness of concrete application scenarios for knowledge management or self-directed learning purposes. The results suggest that possible use cases and added value of CollabUni need to be made very clear to the target group.

3.2 Design and configuration

To make sure that CollabUni is based on real user needs and expectations, a bottom up approach to design and configuration was chosen. In the summer term of 2009, the idea and concept of applying software as a personal and social information and communication infrastructure in higher education (as described in chapter 2) was presented to a group of students in a seminar entitled "collaborative knowledge management". The students' task was to design and configure a prototype of such a system according to their own needs and ideas.

The course consisted of 14 students all enrolled in the magister program "International Information Management". From a didactic perspective, the course can be described as an open seminar. After an introduction by the lecturers that

[1] Primary target group are the approximately 5000 students but in a wider sense university staff is also included

determined the topical direction of the course, students defined learning goals, course management and work procedures widely self-directed. They started with an analysis of the requirements and the identification of use cases for CollabUni. In respect to the above-mentioned concept (cp. figure 1), the need for a seamless integration of the social network into the existing information and communication infrastructure, especially the Learning Management System, was seen as one of the most important points. On the level of use cases, especially knowledge exchange and contact management during internships and study periods abroad, the publishing and access to theses and term papers as well as the possibility to create spaces for self-determined group work, e.g. student organizations or students in their final exam phase, were seen as contexts in which CollabUni may foster an increase of knowledge. Students focused primarily on the technical implementation as well as administrative and organizational aspects of CollabUni.

The next task was the selection of the software that would serve as a basis for CollabUni. Open source systems were compared – amongst others Drupal (<http://drupal.org>), Elgg (<http://elgg.org>), Studip (<http://www.studip.de>). Finally, Mahara (<http://mahara.org>), an e-portfolio software also offering social network features, was chosen due to the fact that it could also be integrated with the existing Learning Management System, which is based on Moodle. Students configured the system and executed user tests. Finally, the system was installed on a computer center server. Due to security restrictions imposed by the computer center, single sign-on with other information and communication services of the university services could not yet be reached. The same is to state in respect to the integration with the Moodle-based Learning Management System, initially intended with the help of the Mahoodle Software [Mahoodle, 09], a project trying to integrate Mahara with Moodle. Students judged this project as too immature and the resources needed for proprietary development would have been going far beyond the scope of the seminar. In order to provide an organizational and administrative framework, students worked out norms in form of a data privacy declaration, FAQs and a Netiquette. Incentive schemes and other community building aspects were addressed with ideas like nominating topics and profiles of the week and establishing rituals (birthdays, important semester dates, exams etc.). In addition, materials were provided that can be used for initial marketing. Amongst others, e-postcards and a video podcast were produced. In one of the last plenum meetings the name of the project “CollabUni” was suggested and approved by a large majority of the participants². Figure 3 shows a screenshot of the system.

[2] CollabUni is a compound term that consists and unites “collaboration” and “university”



Figure 3: Screenshot of CollabUni

In respect to design and configuration it is to state that the students succeeded in drafting and implementing a basic system that provides the essential features of a personal and social information and communication infrastructure, i.e. possibilities for self-determined self-representation, networking and n:m-communication. Students were also successful in designing important organizational and administrative aspects of such an environment. So it is to conclude that in principle the costs of building such a social information and communication infrastructure can be kept very low. At the same time, the application of a bottom-up approach, thereby actively involving students in the design and configuration phase, should be beneficial with regard to acceptance of CollabUni on the side of the primary target group, the students.

3.3 The resulting system

The resulting system offers all functionality implemented in Mahara (<http://mahara.org>). Hence, users can create profiles and views containing information about them. For each view, users can determine whether it is accessible for everyone on the web, only to CollabUni users, only to contacts or only to invited people. Moreover, a time frame can be given during which access to a view is granted. Besides direct data input, users can upload or embed files, integrate and aggregate RSS feeds, and maintain blogs in their profile page or views. Thus CollabUni offers e-portfolio functionality, because it can be used to collect and reflect on achievements, objectives, etc. cp. i.e. [Himpsl, 09]. In addition, CollabUni can be used to connect to other people through contacts or groups. Groups can be created by

every CollabUni user and offer the functionality to build group views and forums. Thus, collaborative learning spaces can be created where sharing of individual contents, co-construction of group contents and communication through the use of forums takes place.

4 Preliminary evaluation results

Prior to the planned roll out, an evaluation was executed during the winter term of 2009/2010. The first aim was to test the robustness of the system and to get an impression of the personal resources needed for a sustainable operation. Results were very encouraging. CollabUni did never crash and was non-stop online, with the exception of one update downtime. In respect to the required administrative resources the evaluation showed that an amount of 20 man-hours per month were absolutely sufficient for technical maintenance and support.

In addition, a user test was conducted with a cohort of the first-year students in the “International Information Management” bachelor program. For this purpose, all participants of the introductory lecture “computer mediated communication” (which consisted mainly of these students) were given the assignment to create a CollabUni profile. The goal of this task was to get a picture if and in how far putting students in contact with the system serves as a catalyst for self-initiated knowledge communication and exchange. Furthermore, students became familiar with the system, so that it was possible to measure students’ assessment of CollabUni with the help of an online survey at the end of the lecture. Results show that there was little self-initiated active knowledge activity of the students during the whole semester. This is a very strong indicator that support mechanisms like moderation can be seen as an absolute necessity if collaborative knowledge management activities really should unfold. The survey asked students about the probability of using CollabUni in respect to different use cases. Table 1 shows the results of the online survey.

Question	Mean	SD
1. Presentation of competencies (e.g. as an application homepage)	1,93	0,97
2. Keeping in contact with lecturers (e.g. during study periods abroad)	3,39	1,04
3. Keeping in contact with fellow students (e.g. during study periods abroad)	2,68	1,41
4. Exchange of learning materials (e.g. term papers)	2,98	1,34
5. Discussion of current university topics (e.g. changes in study programs)	2,81	1,42
6. Setting up students-owned spaces for discussion and work	2,93	1,23

Table 1: First year students’ assessment of CollabUni. N=44. Mean values, standard deviation. Each question was measured on a 5-stage scale. The values ranged from 1 “under no circumstances” to 5 “for sure”

As one can see apart from question 2 “keeping in contact with lecturers” mean values only reach a rather neutral, or in case of item 1 even a negative assessment. The mean values of questions 3 to 6 stand for a distribution in which respectively one third of the survey participants judged the items negative, positive or neutral. In sum, results indicate that roughly one third of students see an added value in CollabUni and declare themselves ready for active participation. In addition, answers to the open question concerning students’ judgement of CollabUni reveal some interesting insights. Some students remarked that they already connect to each other in social networks like Facebook and others. Therefore, they do not see a *raison d’être* for CollabUni. Another open feedback was that E-Mail and the current Learning Management System are sufficient to support university teaching through computer mediated communication. Finally, one student deplores that CollabUni profiles are publicly accessible, not realizing that the visibility of CollabUni profiles and other contributions are dependent on the chosen privacy settings. How can these results be interpreted? First, it can be concluded that currently there is little awareness of the potentials of a social information and communication infrastructure for collaborative knowledge management and self-directed learning, at least among these first year students. Second, such an environment like CollabUni stands in competition with services and communities already in use by the members of the organisation, e.g. social networks like Facebook. Third, even members of the so called “net generation” may be overstrained with specific functionalities of such an environment, e.g. privacy preferences. Nevertheless, roughly a third of the participants of the survey judged CollabUni positively and some of the students created extensive profiles and views for collecting links that are important for their studies, like the university’s library, digital libraries like ACM and other informative sites. So far, there have only been a few cases in which students actively share artefacts created in class for informal learning purposes. So it can be concluded that it could be helpful to offer active students some use cases or best practice examples about how the system can be used. Otherwise the added value may not be obvious for them.

It can be noted that several staff members of the institute of intercultural communication as well as the institute of information science and language technology have created views containing their publications, other interesting links, literature, and external feeds, their CV, their blogs, and study related information about lectures, seminars, or projects. This poses a necessary prerequisite in respect to question 2 concerning the system’s affordance of keeping in contact to lecturers, because it shows that students as well as lecturers are using the platform and can therefore easily connect to each other. Moreover, the extensive use of CollabUni by staff members can also serve as models in terms of best practices to encourage students’ participation.

Overall the results of this preliminary evaluation clarifies the decisive importance of awareness building, marketing and the provision of knowledge communication support structures for a successful roll out.

5 Conclusions and Outlook

CollabUni shows and stands for a possible approach of using social software as a personal and social information and communication infrastructure to facilitate

collaborative knowledge management and self-directed learning in higher education. Results achieved and evaluations conducted so far, indicate on the one hand that from a technical perspective, a social infrastructure can be implemented with relative ease and little cost on the basis of open source software, at least as far as basic requirements and features are concerned. On the other hand, data resulting from the above-mentioned preliminary investigations show that there is little awareness and also little need explicitly mentioned on the part of the primary target group for an infrastructure that supports self-determined knowledge communication on possibly high social levels. Nevertheless, a substantial fraction of possible users seems to be very open-minded towards an environment that supports free knowledge distribution, resource access and self-determined n:m-communication and collaboration. Therefore, it can be concluded that there are no insurmountable obstacles for initiating the targeted knowledge processes. So far, results indicate that the success of such an undertaking is strongly dependent on knowledge communication support mechanisms like moderation. In conclusion, implementing a personal and social information and communication infrastructure in a university setting offers the opportunity to develop self-directed and informal learning skills in a secured environment. Thus, it is on the one hand possible for students to try out and experience different aspects of self-expression, self-presentation, identity and privacy without affecting their professional life. On the other hand this secured environment can employ additional support mechanisms to scaffold learning processes in order to facilitate the development of skills for life-long learning, which is crucial in today's knowledge society.

The roll out phase is the next step in implementing CollabUni at the University of Hildesheim. The already developed administrative and organizational support components as well as the incentive schemes need to be applied and refined. In addition, a beginning inventory of contents, e.g. a repository of term papers or theses that is appealing for the primary target group has to be built. Again, the active involvement of students into the roll out phase in a subsequent "collaborative knowledge management" seminar is considered an important success factor. Nonetheless, although this approach, which could also be described with a slogan like "from the students for the students" seems to be a good choice to foster the affinity of the primary target group, the knowledge management perspective of CollabUni makes it clear that this kind of infrastructure should not be seen as another e-learning application but as an environment to foster knowledge processes of and for all members of the organization, including university staff. In a long-term perspective, CollabUni also aims at fostering knowledge communication of university staff, an area currently widely unexplored.

Acknowledgements

We thank the students who participated in the first seminar on collaborative knowledge management for implementing the CollabUni environment and for giving us an insight into the needs of today's students.

References

- [Baumgartner, 06] Baumgartner, P.: Web 2.0: Social Software & E-Learning, In Computer + Personal (CoPers), Schwerpunktthef: E-Learning und Social Software, 8:20-22, 34, 2006.
- [Chatti, 07] Chatti, M.A., Jarke, M., Frosch-Wilke, D.: The future of e-learning: a shift to knowledge networking and social software, In International Journal of Knowledge and Learning 2007, 3, 4/5, 404-420, 2007.
- [Dittler, 07] Dittler, U., Kindt, M., Schwarz, C.: Online-Communities als soziale Systeme. Waxmann, 2007.
- [Downes, 05] Downes, S.: E-learning 2.0, In eLearn Magazine October 16, 2005, <http://elearnmag.org/subpage.cfm?section=articles&article=29-1>
- [Giannoukos, 08] Giannoukos, I., Lykourentzou, I., Mpardis, G., Nikolopoulos, V., Loumos, V., Kayafas, E.: Collaborative e-learning environments enhanced by wiki technologies, In Proceedings of the 1st international conference on PErvasive Technologies Related to Assistive Environments, 1-5, ACM, New York, NY, USA, 2008.
- [Griesbaum, 09] Griesbaum, J., Semar, W., Koelle, R.: E-Learning 2.0? Diskussionspunkte auf dem Weg zu einer neuen Informations- und Kommunikationsinfrastruktur in der Hochschulausbildung, In Kuhlen, R. (ed): Information: Droge, Ware oder Commons? Wertschöpfungs- und Transformationsprozesse auf den Informationsmärkten, ISI 2009 - 11. Internationales Symposium für Informationswissenschaft, Universität Konstanz, 1. - 3. April 2009, S. 429-444.
- [Grodecka, 99] Grodecka K., Wild, F., Kieslinger, B. (ed): How to Use Social Software in Higher Education, iCamp - innovative, inclusive, interactive & intercultural learning campus, 2009, <http://www.icamp.eu/wp-content/uploads/2009/01/icamp-handbook-web.pdf>
- [Himpsl, 09] Himpsl, K. Baumgartner, P.: Evaluation von E-Portfolio-Software - Teil III des BMWF-Abschlussberichts "E-Portfolio an Hochschulen": GZ 51.700/0064-VII/10/2006. Forschungsbericht. Krems Department für Interaktive Medien und Bildungstechnologien, Donau Universität Krems, 2009, http://www.peter.baumgartner.name/schriften/publications-de/pdfs/evaluation_eportfolio_software_abschlussbericht.pdf
- [Jaksch, 08] Jaksch, B., Kepp, S.-J., Womser-Hacker, C.: Integration of a Wiki for collaborative knowledge development in an E-Learning context for university teaching, In Holzinger, A. (ed.): HCI and Usability for Education and Work. 4th Symposium of the Workgroup Human-Computer Interaction and Usability Engineering of the Austrian Computer Society, USAB 2008, Graz, Austria, November 20-21, 2008. Proceedings. Springer: Berlin, 2008, S. 77-96.
- [Kerres, 06] Kerres, M., Wilbers, K.: Potenziale von Web 2.0 nutzen, In Hohenstein, A.; Wilbers, K. (ed), Handbuch E-Learning, DWD: München, 2006, <http://mediendidaktik.uni-duisburg-essen.de/system/files/web20-a.pdf>
- [Kim, 01] Kim, A.J.: Community Building: Strategien für den Aufbau erfolgreicher Web-Communities, Bonn, Galileo Press, 2001.
- [Mahoodle, 09] Mahoodle://Integrating Mahara with Moodle, 2009, <http://wiki.mahara.org/@api/deki/files/196/=Mahoodle.pdf>
- [Nonaka, 95] Nonaka, I., Takeuchi, H.: The knowledge-creating company, New York, Oxford University Press, 1995.

- [Preece, 00] Preece, J.: *Online Communities: Designing Usability and Supporting Sociability*, Wiley, 2000.
- [Prensky, 01] Prensky, M.: *Digital Natives, Digital Immigrants*, In *On the Horizon*. NCB University Press, 2001, 9, 5, 1-6.
- [Ramanau, 09] Ramanau, R., Geng, F.: *Researching the use of Wiki's to facilitate group work*, In *Procedia Social and Behavioral Sciences* 2009, 1, 2620-2626.
- [Reinmann-Rothmeier, 01] Reinmann-Rothmeier, G.: *Wissen managen: Das Münchener Modell*. Forschungsbericht Nr. 131, 2001.
- [Salmon, 04] Salmon, G.: *E-moderation: The Key to Teaching and Learning Online*, London, Routledge, 2004.
- [Schuirmann, 09] Schuirmann, A.: *Potenziale von Social Web-Applikationen zur Beförderung der Wissenskommunikation im universitären Kontext*, Magisterarbeit Universität Hildesheim, Fachbereich III, Insitut für Informationswissenschaft und Sprachtechnologie, 2009.
- [Schulmeister, 08] Schulmeister, R.: *Gibt es eine "Net Generation"?* 2008, http://www.zhw.uni-hamburg.de/pdfs/Schulmeister_Netzgeneration.pdf
- [Sigala, 07] Sigala, M.: *Integrating Web 2.0 in e-learning environments: a socio-technical approach*, In *International Journal of Knowledge and Learning*, 2007, 3, 6, 628–648.
- [Tapscott, 97] Tapscott, D.: *Growing up Digital: The Rise of the Net Generation*. McGraw-Hill, New York, 1997.
- [Wenger, 98] Wenger, E.: *Communities of practice: Learning as a social system*, In *The Systems Thinker*, 9, 5, 1-5.
- [Wenger, 02] Wenger, E., McDermott, R., Snyder, W.M.: *Cultivating Communities of Practice*, Harvard Business School Press, 2002.
- [Wieden-Bischof, 09] Wieden-Bischof, D., Schaffert, S.: *Erfolgreicher Aufbau von Online-Communitys. Konzepte, Szenarien und Handlungsempfehlungen*, Salzburg NewMediaLab, 2009.

Microblogging Adoption Stages in Project Teams

Martin Böhringer, Lutz Gerlach

(Chemnitz University of Technology, Chemnitz, Germany
{martin.boehringer|lutz.gerlach}@wirtschaft.tu-chemnitz.de)

Abstract: Social Software shows a fascinating range of usage possibilities in enterprises. Such tools are very simple and provide individual users with high degrees of freedom. This implies the need for a negotiation process, where users develop a shared understanding of how to use the tools in order to work together towards a common goal. In several case studies on organisational usage of microblogging we found that these adoption processes can be described by using Tuckman-Jensen's model of group development, proposing five generic stages: forming, storming, norming, performing and adjourning. We apply this model to describe and interpret observations of microblogging adoption and argue that this process is mainly driven by social interactions rather than technical constraints.

Keywords: Social Software, User Adoption, IS Appropriation, Microblogging, Enterprise 2.0.

Categories: H.4.3, H.1.1, J.4, K.6.1

1 Introduction

Information systems (IS) research has a rich body of knowledge on IS adoption processes. However, these studies often have classical software systems in mind. Here, the question is whether the system is actually used or not and therefore the subject of interest can be found in the individual user with her motives, threats and attitudes [Lamb, 03]. However, due to complex and quickly changing requirements in many organisational contexts, this classical approach of software design can be questioned [Truex, 99]. It can be argued that in many use cases we need more flexible information systems, which can be shaped by the users to meet their special needs. Social Software applications are an example of such tools, which are not designed for a special use case but with flexibility in mind. Hence, O'Reilly characterises them as being "platforms" rather than "applications" [O'Reilly, 05]. As our information systems become more flexible and show less structure, we can expect significant effects on the adoption process. The aim of platform applications is to give users opportunities to adopt the software to their special needs. However, in thinking of information systems used by a network of several people, they would have to negotiate together on how exactly to use these tools.

During several case studies on microblogging usage in project teams, we found evidence for such informal negotiation. While following the Web 2.0 approach, no formal rules existed at the beginning of the adoption process. However, the teams step by step created usage patterns which can be seen as their informal usage rules. We use Tuckman-Jensen's widely accepted model of group development proposing stages of forming, storming, norming, performing and adjourning as framework to discuss these observations ([Tuckman, 65], [Tuckman, 77], [Bonebrigt, 10]).

2 Cases of Microblogging Adoption in Project Teams

The first case, *Arinia*, is a unique case being a custom-made microblogging-like collaboration tool which is in use for over 10 years at medium-sized company Megware. The history of Arinia dates back to the 1990s when Megware was in the retail business and ran more than 30 subsidiaries in different German cities. At this time, the tool was developed as a fast and secure internal alternative to email. Accordingly, email-like direct messages were the main functionality of the program. However, Arinia had another feature: the so-called 'pinboard'. This was meant for the broadcasting of announcements to staff. While this played a secondary role at the beginning, the share of usage of the pinboards increased substantially until a steady equilibrium of equal usage was reached between direct and public messages. While the use of pinboards (that is, microblogging) is part of the company's policy today, its rising adoption was user-driven. Today, Arinia includes more than 100.000 postings. For a more detailed discussion of the case see [Barnes, 10].

The next case describes a microblogging scenario at *Communardo*, a medium-sized vendor for software solutions and consultancy in the context of knowledge management and team collaboration [Böhringer, 09]. As Communardo itself works in the area of Web 2.0, its employees are affiliated with the early adopters of new web services. In spring 2008 they suggested a Twitter-like tool for the company's project teams. As they did not find a suitable tool for internal microblogging, Communardo created its own microblogging application called Communote, which they later also began to market as software product. The first postings date to the end of September 2008. Communote was published internally as quickly as possible and was available to everyone via the existing LDAP logins. The tool was not officially promoted, nor were there training sessions. Usage adoption started with the project team itself and expanded virally throughout the company. Today, it is used as central information hub of the company.

The following two cases are affiliated with Chemnitz University of Technology, where microblogging is used in two independent research teams. The first, *IREKO*, is using microblogging for project communication. Especially interesting is the heterogeneous background of the different project members including social scientists and engineers, which led to different expectations towards a communication tool. By March 2010, 23 users shared over 900 status messages about their work, research interests and project administration issues. Qualitative data in this adoption case is conducted by participant observation and by text analysis; more details on the case are reported in [Gerlach, 10]. The second case is the business information systems research team *WIZ*, which uses microblogging since the beginning of 2009 for mainly two use cases [Gerlach, 10]: The first use case is team-internal collaboration within the various projects, the second application of microblogging in the research group is a special type of project spaces for student projects (i.e. master theses, seminar works). Within the first year, 57 users consisting of researchers, students and external stakeholders posted 3365 notices in 105 thematic groups.

3 Discussion: Stages of Microblogging Adoption

The Tuckman-Jensen model of team development describes a staged developmental process leading to team performance ([Tuckman, 65], [Tuckman, 77], [Bonebright, 10]). Each stage is characterized by specific interpersonal activities on the one hand and by specific task oriented activities on the other hand. Interpersonal behaviour is about establishing the group as a cohesive social entity by building interpersonal relationships, cultivating a shared language, setting communication rules, defining role models and values. Task oriented behaviour is aimed at effective group task completion. This includes problem solving, shared responsibilities, knowledge transfer and mutual support. From a general point of view, every team needs to go through phases of testing, conflict and cohesion from a social as well a task-related view in order to achieve performance. Depending on the configuration of social and task oriented group behaviour at a given point of time, the five typical stages of “forming”, “storming”, “norming”, “performing” and “adjourning” can be described. Given the openness and flexibility of social software platforms, our hypothesis is that these generic mechanisms of team development will strongly influence also social software adoption processes. Thus, phases of forming, storming, norming and performing should be empirically observable. By cross-checking four cases of microblogging adoption, we discuss our observations of microblogging adoption.

3.1 Forming

The initial stage of “forming” is characterized by careful orientation and testing. During this stage, each member of the team tests very carefully what interpersonal behaviour is acceptable in the group, based on the reaction of the other members. Also, first task orientation is taking place. The group members try to identify and describe the task and establish “ground rules”. While doing so, everybody tries to avoid conflicts. The IREKO case shows similar behaviour in the beginning of microblogging adoption. Avoiding all sorts of criticism and conflict, users did set up user profiles and begun to post neutral and unemotional content, such as questions about the microblogging system itself and about administrative issues. Also some simple ground rules were defined, e.g. user names and some simple tags (e.g. #support). Similar behaviour could be described in the Communardo and WI2 case. While in these three cases microblogging functionality already existed, in Arinia the forming stage included also the “discovery” of this feature.

3.2 Storming

The time of careful orientation and testing ends with the “storming” stage. Group members often disagree and conflicts arise, affecting both social and task oriented behaviour. This storming stage is very similar in all four cases. Once familiar with the platform, users start groups, write postings and generally test boundaries and use cases of the system. In the WI2 case for example only half of the originally created groups in the storming stage have been adopted in long-term usage. Further, IREKO shows that after three weeks of active microblogging, users explore the discussion feature more heavily to address each other in a direct and in the same time public way. In general we identified two types of users: the focused structure-oriented vs. the

broad generalist. The structure-oriented type tries to shape the communication by well defined rules of commitment. The generalist on the other hand understands microblogging as a broad information flow with no need to read and respond to every single posting. These two positions are not compatible and led to group polarisation. Due to its heterogeneous project structure, IREKO showed these characteristics most clearly. However, all cases give evidence for “hot” (in discussing behaviour explicitly) or “cold” (in just stopping system usage or ignoring others) fighting for implicit rules.

3.3 Norming

The third stage of team development is “norming”. This stage is primary about developing group cohesion to establish the group as a social entity and ensure the group’s existence. On a task level, the group members discuss opinions very openly and tolerantly, task conflicts are avoided. IREKO shows some signs of a norming stage right after storming. Discussions were more tolerant, constructive feedback and self organising took place. A project language finally emerged, accepted by structure-oriented users as well as by generalists. On a task level, knowledge sharing increased a lot, and more complex rules were tested to organise complex tasks (such as special subjects, more tags and direct links to wiki and shared devices).

Besides this general way of using the tool, an important matter of norming in the case studies is structuring of information. While Arinia uses a more static category-approach, the other cases leverage bottom-up tagging using #hashtags which lead to folksonomies. From previous research we already have some knowledge about emergence and shared vocabulary building in folksonomy systems. Muller reported from four tag-based systems in an enterprise and found that tagging use is only consistent inside one system [Muller, 07]. Interestingly, same people used different tags in different systems, which provides evidence for user's possibilities of adapting certain rules in special contexts. Other researchers found similar patterns and describe folksonomy building as “negotiated process of users” [Paolillo, 07] and “self-organizing systems towards a shared vocabulary building” [Maas, 07] which develop towards a group consensus [Robu, 09]. In our cases we found a rich spectrum of different approaches for norming tag usage. Examples range from emerged tag patterns (WI2), team-related tag norming (Communardo, IREKO) to usage standardization by management order (Arinia).

3.4 Performing

The fourth phase of team development is labelled as “performing”. On a social level, performing means that the social entity created in the prior stage now can be used as instrument for problem solving. Members can now rely on strong and flexible role models accepted by the group. In a task oriented development view, the group shows constructive action, channelled to the task. After three months of usage, IREKO has not reached the performing stage yet, but some stable behaviour can be described as potential patterns of performing. Using the tag “#jourfixe”, the team collects issues that need to be discussed in the weekly meeting. During the meeting, postings tagged with #jourfixe are visualised using a projector. They also use the “@user” operator to distribute tasks to specific group members. We expect more complex performance

patterns to emerge during further project work. The other three cases have stabilised in the performing stage. In the Arinia and Communardo case microblogging can be considered the central information sharing hub which internally substituted email. WI2 shows that storming stage also can lead to a lower usage of microblogging. While it is accepted part of the research group's communication infrastructure, other mediums like email and phone still are relevant. Interestingly, even in these settled systems, there are constantly evolving new forming-storming-norming-performing processes, e.g. when a new group is created or new kinds of tasks occur.

3.5 Adjourning

The fifth and final stage in Tuckman-Jensen's model is "adjourning". Based on the idea of a lifecycle concept, they propose a phase of group termination, resulting either because of task competition or simply members leaving the group. Due to these events the group's existence as a social entity and therefore its characteristics as effective task solving instrument ends. Team members now share their experiences and improved processes with others, starting a new life cycle of team development. We are not aware of any case studies on successfully implemented, yet already finished microblogging cases. However, we can derive assumptions based on effects like the termination of certain project groups in studied microblogging systems. In such cases, microblogging postings become part of the project documentation and are exported in order to archive them. Though, project-internal rules (e.g. tag norming) lose their existence.

4 Conclusions

The aim of our discussion was the motivation of a new view on the adoption process of social software tools beyond classical IT adoption models. While being limited in terms of the small sample size, our cases provide some insights into microblogging adoption and strongly suggest understanding adoption processes as a matter of team development rather than a matter of individual software adoption. This finding is based on the observation, that in microblogging platforms users are forced to develop shared norms, opinions and role models in order to collaborate in a productive way - just like in "real life" settings. From a management point of view, identifying stages and managing stage transitions seem to be highly important tasks. Based on the Tuckman-Jensen's model we know that especially the shift from storming to norming is considered to be the most critical step. Therefore, software design should support this step with functionalities like tag management or the offering of standard-tags in the user interface.

More generally, it can be questioned if such user-driven adoption processes are acceptable at all. Davern & Wilkin state that user innovation of information systems might be "functional at an operational level but dysfunctional at a managerial level" [Davern, 04]. However, current economic developments and trends in information systems clearly show that in many parts of our enterprises emergent bottom-up systems might be the only suitable solution for user support [Hagel, 08]. Therefore, recognising possible mismatches of such applications with strategic goals, we have to find ways to manage these user-driven adoption processes without destroying them.

To sum up, Tuckman's model is the foundation for a rich body of knowledge in organisational studies on group initiation and methods of influencing these processes. Based on this paper's findings we suggest that in a world with a rising number of social IS, we have to increase equivalent research in the IS context in order to learn about conditions and consequences of this development. Existing organisational research could provide a rich body of knowledge for this task.

References

- [Barnes, 10] Barnes, S. J., Böhringer, M., Kurze, C., Stietzel, J. (2010). Towards an understanding of social software: the case of Arinia. Proceedings of the HICSS-43.
- [Bonebright, 10] Bonebright, D. (2010). 40 years of storming: a historical review of Tuckman's model of small group development. *Human Resource Development International*, 13(1), 111-120.
- [Böhringer, 09] Böhringer, M., Richter, A. (2009). Adopting Social Software to the Intranet: A Case Study on Enterprise Microblogging. Proceedings of the Mensch & Computer 2009.
- [Davern, 04] Davern, M., Wilkin, C. (2004). Innovation with Information Systems: An Appropriation Perspective. In Proceedings of the Fourteenth Australasian Conference on Information Systems (ACIS).
- [Gerlach, 10] Gerlach, L., Hauptmann, S., Böhringer, M. (2010). 'What are you doing' im Elfenbeinturm? - Microblogging im universitären Einsatz. Erfahrungen aus zwei Pilotprojekten. Tagungsband der Multikonferenz Wirtschaftsinformatik 2010, 1485-1491.
- [Hagel, 08] Hagel, J., Brown, J. (2008). From push to pull – emerging models for mobilizing resources. *Journal of Service Science*, Third Quarter, 1(1).
- [Lamb, 03] Lamb, R., Kling, R. (2003). Reconceptualizing Users as Social Actors in Information Systems Research. *MIS quarterly*, 27(2), 197–236.
- [Maas, 07] Maass, W., Kowatsch, T., Münster, T. (2007). Vocabulary Patterns in Free-for-all Collaborative Indexing Systems. In International Workshop on Emergent Semantics and Ontology Evolution, 45-57.
- [Muller, 07] Muller, M. J. (2007). Comparing tagging vocabularies among four enterprise tag-based services. Proceedings of the GROUP '07, 341.
- [O'Reilly, 05] O'Reilly, T. (2005). What Is Web 2.0, <http://www.oreilly.de/artikel/web20.html>.
- [Paolillo, 07] Paolillo, J., Penumarthy, S. (2007). The Social Structure of Tagging Internet Video on del.icio.us. Proceedings of the HICSS-40, 85-85.
- [Robu, 09] Robu, V., Halpin, H., Shepherd, H. (2009). Emergence of consensus and shared vocabularies in collaborative tagging systems. *ACM Transactions on the Web*, 3(4), 1-34.
- [Tuckman, 65] Tuckman, B. W. (1965). Developmental Sequence in Small Groups. *Psychological bulletin*, 63(6), 384-99.
- [Tuckman, 77] Tuckman, B. W., Jensen, M. A. C. (1977). Stages of Small-Group Development Revisited. *Group & Organization Management*, 2(4), 419-427.
- [Truex, 99] Truex, D., Baskerville, R., Klein, H. (1999). Growing systems in emergent organizations. *Communications of the ACM*, 42(8).

DL based Subsumption Analysis for Relational Semantic Cache Query Processing and Management

Tariq Ali

(CDSC, Department of Computer Science Mohammad Ali Jinnah University, Islamabad,
Pakistan
tariqali.1982@gmail.com)

Muhammad Abdul Qadir

(CDSC, Department of Computer Science Mohammad Ali Jinnah University, Islamabad,
Pakistan
aqadir@jinnah.edu.pk)

Abstract: Efficiency of semantic caching is based on reusing of already retrieved data. Reusing of already retrieved data depends on finding the containment of new queries with the older/stored queries. Advantages of semantic cache query processing (Satisfiability and implication in database domain) have already been demonstrated in the published literature. Description Logic (DL) has never been applied for checking relational query subsumption/containment. Sound and Complete subsumption algorithms exist for reasoning facts represented in Description Logic. DL is a formalism used to model knowledge of a domain in the form of concepts and a rich set of associations between these concepts. Reasoning on the knowledge base can be performed in order to discover implicit relations. The most important reasoning is the determination of a subsumption relation between the logical expressions. Relational queries are also a form of knowledge description. In this paper, we discuss Subsumption analysis of semantic cache query processing and its advantages in semantic cache query management by using tableau algorithms of DL. In particular, Subsumption algorithms are used to perform reasoning from the previously stored queries in the semantic cache. Query containment can be found by transforming relational queries into DL. Based upon this reasoning, a query can be divided into cache (probe) and server (remainder) queries. This will not only contribute towards cache query processing but have a significant contribution in the cache management, too. Previously, the implication and satisfiability techniques in database domain were handling only conjunctive queries. In our algorithms, we handle disjunctive queries, too.

Keywords: Semantic Knowledge Modelling, Semantic Knowledge Processing, Information Search and Retrieval, Description Logic, Reasoning, Subsumption, Semantic Cache Query Processing, Semantic Cache Query Management,

Categories: M.4, M.7, H2, H3.3

1 Introduction

Cache is typically used to decrease data access latency, fault tolerance, data security and to reduce network traffic [Godfrey, 97]. In semantic cache, semantic descriptions along with actual data are stored in the cache. Incoming user queries are compared with the semantics of previously executed queries [Ren, 03] [Dar, 96]. The contained part (probe query) is answered locally, whereas the remaining part of the user query

(reminder query) is sent to the server. The results of both queries are combined to answer the user query. In literature, satisfiability and implication is used to find query containment. A formula is satisfiable when there is an assignment which remains true under the assigned value. In implication one formula is checked to be contained in another formula. Problems with the existing approaches [Hollunder, 90] are not including disjunction operator in relational queries. They also do not consider the removal of redundant semantics from the cache for efficiently utilization of the space for cache. In this paper, we mainly focus on implication problem (subsumption) of relational queries. In some other paper we will present our result for the satisfiability.

Description logic (DL) could be very useful for semantic cache query processing and management. The relational queries can be modelled / translated in DL and DL inference algorithms can be used to find query containments. The translation of relational query to DL may have not the same spirit as that of querying languages for DL systems, but is sufficient for finding the query containment of relational queries [Ali, 10]. The subsumption reasoning (containment) of the semantics of the data to be cached is very useful in eliminating the redundant semantics and minimizing the size of semantic cache for the same amount of data.

Rest of the paper is organized as: Section 2 contains related work of semantic cache query processing and reasoning of DL facts; Section 3 discusses the proposed scheme for translating relational queries to DL and query processing over them; Section 4 contains the semantic cache query management and Section 5 contains Case study to validate the proposed scheme. Finally Section 6 concludes the paper and provides future directions.

2 Related Work

Maintaining semantic cache is more efficient to decrease the data latency as compare to other cache schemes [Ren, 03] [Bashir, 06] [Ahmed, 09]. User queries can be answered partially or fully from the semantic cache [Ahmed, 08]. One of the major challenges is to make the semantic caching efficient from both query processing point of view and cache management point of view. Most of the approaches focus on one aspect of the semantic cache. Organizing cache query processing in such a way that cache management becomes trivially easy is mostly ignored in most of the schemes. Partial data retrieval based on Cross Attribute knowledge to retrieve maximal data from cache is discussed in detail in [Abbas, 09].

Description logic (DL) is a knowledge representation formalism based on First Order Logic (FOL) [Donini, 91]. DL has a set of constructors and axioms which are used to make complex concept descriptions and to specify relations between them. To model a domain of interest, designers need to specify concepts and the relationship of those concepts with other concepts and to specific individuals [Baader, 96]. The relationship between concepts can be restricted by imposing cardinalities restriction on them. For examples, a concept *manger* can be defined in terms of a concepts *employee* with a restriction on property *hasSalary* more than or equal to 20,000 as ($manager \doteq employee \sqcap hasSalary. \geq 20000$).

For such concept representation and restriction we need a concept language extended with concrete domain as proposed for $\mathcal{ALC}(\mathcal{D})$ [Baader, 91b]. In this

scheme subsumption is checked in terms of (un)satisfiability, i.e. $C \sqsubseteq D$ iff $C \sqcap \neg D$ is unsatisfiable [Baader, 91]. The satisfiability problem is itself checked by solving the consistency problem for A-boxes. In our approach we use $\mathcal{ALC}(\mathcal{D})$ for our work because we need both concept language \mathcal{ALC} and concrete domain \mathcal{D} .

DL makes implicit knowledge explicit by using efficient inference mechanisms. It provides a variety of reasoning services like subsumption and instantiation [Baader, 03]. Basic inference through DL reasoning is subsumption of concept expressions ($C \sqsubseteq D$), where D is more generic concept than C and is called subsumer, where as C is more specific than D and is called subsume. Subsumption denotes that the interpretation of concept C is a subset of the interpretation of the second concept D with the given terminology τ .

Many DL systems use structural algorithms for computing subsumption relationships [Woods, 91] [Borgida, 94]. Structural algorithms compare the syntactic structure of different concept expressions. Structural algorithms for the subsumption problems are normally sound but are not always complete. Therefore Subsumption through structural algorithms is weaker than logical subsumption. DL with negation and disjunction is not handled by structural algorithms [Baader, 03].

The tableaux algorithm [Baader, 91a] [Hollunder, 90] is instrumental to devise a reasoning service for knowledge base represented in description logic. All the facts of knowledge base are represented in a tree of branches with intra-branch logical AND between the facts and inter-branch logical OR, organized as per the rules of tableaux algorithm [Baader, 03]. A clash in a branch represents an inconsistency in that branch and the model in that branch can be discarded. The proof of subsumption or unsatisfiability can be obtained if all the models (all the branches) are discarded this way [Baader, 03].

3 Semantic Cache Query Containment

Our proposed solution consists of two basic steps: First user query (relational) is translated into DL by using the approach presented in [Ali, 10]. The translated query subsumption is then checked with previously stored query in the cache by using the sound and complete subsumption algorithm given in [Baader, 91b] [Lutz, 05].

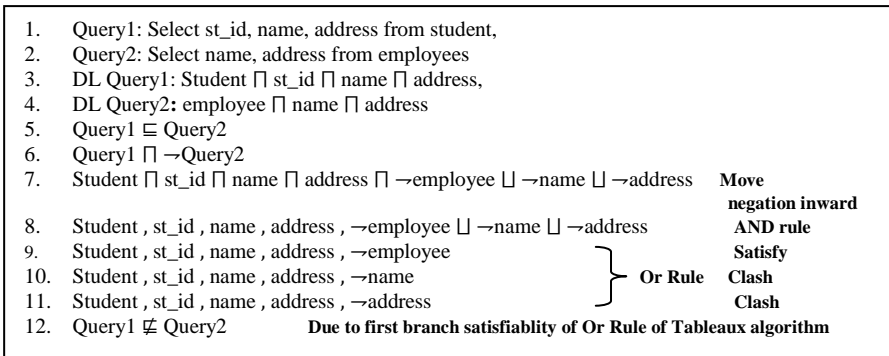


Figure 1: Simple Query Containment

In [Baader, 91b] the reasoning is performed both on the T-boxes with A-boxes. In our approach we need reasoning only on T-boxes. We use similar syntax discussed in [Baader, 91b] for knowledge representation of relational queries. The rules for translating relational query into DL are completely discussed with examples and case study in reference to the operator set and domain in [Ali, 10]. These rules will transform a relational query into a DL fact. For example we have a simple relation queries (line 1 and 2 in Figure 1) without predicate part and its translated DL queries (LINE 3 And 4 in Figure 1) and result of applying tableaux logic (Line 5 to 11) for subsumption analysis (Line 12 in Figure 1). Bold text in the Figure are comments for readability.

Considering, another scenario having predicates conditions with disjunctive operator in Figure 2. All the three branches yields to clash in checking $Q3 \sqsubseteq Q4$; therefore, $Q4$ contain $Q3$. In first branch (Line 8 in Figure 2) after applying the *Or rule*, Emp and $\neg Emp$ yields to clash. In second branch (Line 9 in Figure 2) $ename$ and $\neg ename$ yields to clash, and in third branch (Line 10 Figure 2), $\geq 30k(sal)$ and $\leq 19k(sal)$ yields to clash. All tree branches (Line 8, 9, 10 of Figure 2) yield to clash in opening the tableaux algorithm; therefore, $Q3 \sqsubseteq Q4$.

1.	$Q3$: Select $ename, age$ from Emp where $sal \geq 30k$	
2.	$Q4$: Select $ename$ from Emp where $sal \geq 20k \sqcup age \geq 20$	
3.	$Q3 \sqsubseteq Q4$	
4.	$Q3 \not\sqsupseteq \neg Q4$	
5.	$(Emp \sqcap ename \sqcap age \sqcap \geq 30k(sal)) \sqcap \neg(Emp \sqcap ename \sqcap \geq 20k(sal) \sqcup \geq 20(age))$	
6.	$(Emp \sqcap ename \sqcap age \sqcap \geq 30k(sal)) \sqcap (\neg Emp \sqcup \neg ename \sqcup \leq 19k(sal) \sqcap \leq 19(age))$	
		Move negation inward
7.	$(Emp, ename, age, \geq 30k(sal), \neg Emp \sqcup \neg ename \sqcup \leq 19k(sal), \leq 19(age))$	AND rule
8.	$Emp, ename, age, \geq 30k(sal), \neg Emp, \leq 19(age)$	Clash
9.	$Emp, ename, age, \geq 30k(sal), \neg ename, \leq 19(age)$	Or Rule Clash
10.	$Emp, ename, age, \geq 30k(sal), \leq 19k(sal), \leq 19(age)$	Clash
11.	$Q3 \sqsubseteq Q4$	All branches leads to Clash

Figure 2: Disjunctive Query Containment

4 Semantic cache query Management

The same techniques can also be used to reduce the storage by eliminating the redundant semantics in the cache, e.g., if a concept/query is subsumed by another concept/query, then store only the subsumer. These will speed-up the matching process by eliminating the redundant semantics, too. The ideas are depicted in Figure 3 and Figure 4, where each box represents a query/concept. In Figure 3, all other semantics are discarded and only the semantics of query $Q8$ and $Q9$ are stored. The same can be represented in a different way as in Figure 4. Adding more conditions in user query predicate with conjunction operator don't affect the containment problem. For example if a user query is contained in cache query, by adding more conditions to user query predicate, do not affect the user query containment with cached query. But the converse may not be true. In case of disjunction in user query, we will check each branch of user query predicate, and if all the branches lead to clash, the user query will be subsumed. From checking $Query_{user} \sqsubseteq Query_{cached}$ and $Query_{cached} \sqsubseteq Query_{user}$

partial containment can easily be calculated. Combining conjunction and disjunction in user query and cached query if cached query contains conjunction and user query contains disjunction this situation will produce many branches while opening with tableaux algorithm, where each branch should lead to clash for containment of user query in cached query. Similarly if cached query contains disjunction and user query contains conjunction then this will yield to one branch which should lead to a clash for containment.

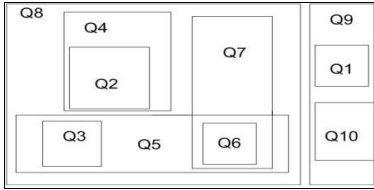


Figure 3: query subsumption

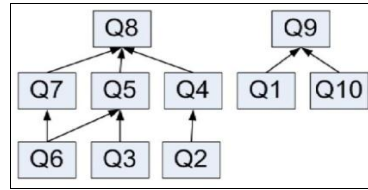


Figure 4: Acyclic directed graph

5 Conclusion and Future Work

Description logic (DL) is a formalism used to model knowledge of a domain in the form of concepts and a rich set of associations between these concepts. The associations could be of different types of restrictions in additions to hierarchical. Reasoning on the knowledge base can be performed in order to discover implicit relations. The most important reasoning is the determination of a subsumption relation between the logical expressions. We have demonstrated with examples and with case study the applicability of DL inference in semantic cache.

We translated relational query into DL and check subsumption analysis on the translated queries. With the demonstrated examples, this technique is useful to reduce the storage by eliminating the redundant semantics in the cache, beside this DL and tableaux algorithm is very useful for cache query processing and management. In future, we want to check satisfiability test in semantic cache with translating relational queries in DL. Another extension to the current work would include other types (complex) of relational queries and its implementation with proposed technique.

References

- [Abbas, 09] Abbas, M. A., Qadir, M. A., Cross Attribute Knowledge: A Missing Concept in Semantic Cache Query Processing, 13th IEEE International Multitopic Conference INMIC 2009.
- [Ahmed, 08] Ahmad, M., Qadir, M.A., Sanaullah, M., Query Processing over Relational Databases with Semantic Cache: A Survey, 12th IEEE International Multitopic Conference, INMIC 2008, IEEE, Karachi, Pakistan, pp: 558-564, December 2008,.
- [Ahmed, 09] Ahmad, M., Qadir, M.A., Sanaullah, M., An Efficient Query Matching Algorithm for Relational Data Semantic Cache, 2nd IEEE conference on computer, control and communication, IC409, 2009.

- [Ali, 10] Ali, T., Qadir, M. A., Ahmed, M., Translation of Relational Queries into Description Logic for semantic Cache Query Processing, International Conference on Information and Emerging Technologies (ICIET) 2010.
- [Baader, 91a] Baader, F., Hollunder, B., A terminological knowledge representation system with complete inference algorithm. In: Proc. Workshop on Processing Declarative Knowledge, PDK-91Lecture Notes in Artificial Intelligence, Springer, Berlin, pp. 67–86, 1991.
- [Baader, 91b] Baader, F., Hanschke, P. A schema for integrating concrete domains into concept languages. In Proc. of the 12th Int. Joint Conf. on Artificial Intelligence (IJCAI'91), pages452–457, 1991.
- [Baader, 96] Baader, F., Buchheit, M., Hollunder, B., Cardinality restrictions on concepts. Artificial Intelligence, V. 88, issue1-2, pp: 195-213, 1996.
- [Baader, 03] Baader, F., McGuinness, D., Nardi, D., Patel-Schneider, P., The Description Logic Handbook: Theory, Implementation and Applications. Cambridge University Press, 2003.
- [Borgida, 94] Borgida, A., Patel-Schneider, P. F., A semantics and complete algorithm for subsumption in the Classic description logic. Journal of Artificial Intelligence Research, 1:277-308, 1994.
- [Bashir, 06] Bashir, M.F and Qadir, M.A., HiSIS: 4–Level Hierarchical Semantic Indexing for Efficient Content Matching over Semantic Cache, INMIC, IEEE, Islamabad, Pakistan, pp. 211-214, 2006.
- [Dar, 96] Dar, S., Franklin, M.J., Jonnson, B.T., Semantic Data Caching and Replacement, Proceeding of VLDB Conference, VLDB, pp. 330-341, 1996.
- [Dean, 04] Dean, M., Schreiber, G., OWL Web Ontology Language Reference, W3C Recommendation, 10 February 2004. <http://www.w3.org/TR/2004/REC-owl-ref-20040210/> . Latest version available at <http://www.w3.org/TR/owl-ref/>
- [Donini, 91] Donini, F. M., Lenzerini, M., Nardi, D., & Nutt, W., The complexity of concept languages. In Allen, J., Fikes, R., & Sandewall, E. (Eds.), Principles of Knowledge Representation and Reasoning, Proceedings of the 2nd International Conference (KR'91), pp. 151–162 Cambridge, Massachusetts, USA. Morgan Kaufman Publishers, Inc.
- [Doyle, 91] Doyle, J., Patil, R., Two theses of knowledge representation: Language restrictions, taxonomic classification, and the utility of representation services. Artificial Intelligence, 48:261-297, 1991.
- [Hollunder, 90] Hollunder, B., Nutt, W., Subsumption algorithms for concept languages. Research Report RR-90-04, Deutsches Forschungszentrum fur Kunstliche Intelligenz GmbH (DFKI), April 1990.
- [Horrocks, 97] Horrocks, I.: Optimising Tableaux Decision Procedures for Description Logics, Ph.D. thesis, University of Manchester, 1997.
- [Lutz, 05] Lutz, C., Milicic., M. A tableau Algorithm for Description Logics with Concrete Domains and GCIs, Tableaux 2005, LNAI 3702, pp. 201-216, 2005
- [Ren, 03] Ren, Q., Dunham, M.H., and Kumar, V., Semantic Caching and Query Processing, IEEE transaction on Knowledge and Data Engineering, IEEE Computer Society, pp. 192-210, 2003.
- [Woods, 91] Woods, W. A., Understanding subsumption and taxonomy: a framework for progress. In Sowa , chapter 1, pages 45- 94, 1991.

OntoBox: An Abstract Interface and Its Implementation

Anton Malykh

(Irkutsk State University, Russia
anton@makykh.com)

Andrei Mantsivoda

(Irkutsk State University, Russia
andrei@baik.ru)

Abstract: In this paper we consider OntoBox, an implementation of a simple description logic called the oo-projection, as a persistent knowledge storage. OntoBox is a mediator between the knowledge management systems and conventional information techniques (like OOP languages and data bases). The abstract interface of OntoBox and its basic implementation (OntoBox Storage) are considered. Some implementation issues are discussed, and the potential of the approach is overviewed.

Key Words: knowledge management, object model, ontology, Libretto, OntoBox

Category: H.3.2, H.1.1, M.4

1 Introduction

In this paper we consider OntoBox, an abstract storage system based on a description logic, and its basic implementation OntoBox Storage. OntoBox is aimed at bridging the gap between high level knowledge management approaches and 'conventional' web development activities, as well as 'conventional' web developers. Conceptually, the idea of OntoBox is based on constructing a simple logic

- which can be embedded as a sub-logic in stronger knowledge formalisms, and allows for building sub-models within general models;
- the components of which have a straightforward interpretation as conventional datatype structures, and allow interfaces to popular techniques like web technologies, data bases, and object-oriented programming.

This idea is useful in many situations, for instance, if we need to apply knowledge management tools to large amounts of concrete data, or develop various metadata techniques. If this simple logic allows for efficient implementations with persistent storage, then we have a new data storage technology, which can be naturally embedded in knowledge management applications.

We propose in [Malykh et al. 2009] such a logic, which is a logical equivalent of the object oriented approach. This logic is called an object-oriented (oo-) projection, and constructed as a sub-logic of the description logic $SHOIN(D)$

[Horrocks et al. 2003]. We prove there that logical descriptions in the oo-projection can be considered as object sub-models within descriptions in $SHOIN(D)$. On the other hand, they can be interpreted as object-oriented storage systems intended for programming purposes. This means that the oo-projection can serve as *a mediator* between the upper level of advanced knowledge management approaches and the lower level of simpler but more efficient and popular information technologies. To work on the lower level, the oo-projection must be represented as a certain information structure. In this paper we represent it as a special programming interface – *OntoBox*.

Actually, we need to provide interfaces of two kinds: *a programming interface*, which interprets the basic constructs of the oo-projection as familiar information structures, and *a user interface*, which allows content developers to work with logical descriptions in a familiar style. In order to solve the latter problem, we have developed the query language *Libretto*. Queries in *Libretto* are 'encoded' formulas of $SHOIN(D)$, though the user can never suspect this: the logical backgrounds are hidden, since many conventional users do not know, and are afraid of explicit logical means. A detailed *Libretto* tutorial can be found in [O&L]. Its interpreter in Java also can be downloaded from there. In [Malykh et al. 2010] we introduce the denotational semantics of *Libretto* based on $SHOIN(D)$.

In this paper we are mainly focused on the abstract programming interface *OntoBox* and its basic implementation *OntoBox Storage*. Any system, in which *OntoBox* is implemented, can be interpreted as a particular case of the oo-projection.

2 *OntoBox*

OntoBox is an abstract programming interface to knowledge bases interpreted as object models. It is formed as a programming representation of the oo-projection. *OntoBox* provides an environment allowing the user to work with data and knowledge descriptions as object models. If for any data/knowledge storage system an *OntoBox* interface is implemented, this storage system can be handled by all *OntoBox* tools including the query language *Libretto*.

Conceptually, *OntoBox* is *not*: a relational database, because it is object-oriented; a map system, because it is more expressive and has the hierarchy of classes; a general ontology system, because it is more efficient and simple for the user; an object database, because it is simpler and can be embedded in various knowledge management systems; an XML or proprietary format, because it has its own storage with a high-level API. Actually, *OntoBox* is an unified abstract object-oriented environment (derived from the logic of the oo-projection), which can be 'plugged' into very diverse data/knowledge storage/management systems.

Technically *OntoBox* consists of Java interfaces and classes, which serve as the basis for (numerous) implementations. These interfaces describe the basic

operations of reading, creating and changing in the store. *OntoBox* operates with standard notions like concepts (classes), datatypes, roles (object properties), attributes (datatype properties) and objects. Each ontology is treated in *OntoBox* in a separate namespace. Ontologies play the role of 'packages' containing a certain portion of the domain description. In particular, the terminological description of the domain and its objects can be stored in different ontologies. Thus, the oo-projection can contain the (segments of) several ontologies.

The query language *Libretto* [O&L] works with knowledge bases, in which *OntoBox* is implemented. The interpreter of *Libretto* uses *OntoBox* as the interface to the data storage it currently works with. This in particular means that *Libretto* can work as a query language in any implementation of *OntoBox*: its interpreter, which is implemented as an independent Java library, interacts through abstract *OntoBox* methods.

Now we are developing three *OntoBox*' implementations. They are

- *OntoBox Storage*, the basic persistent implementation of *OntoBox*, its priority is efficient data handling.
- *OntoBox DB* is the implementation in which databases are dynamically interpreted in *OntoBox* (and thus, in the oo-projection). In particular, this implementation allows for the construction of object models over databases, in which *Libretto* can play the role of SQL.
- *OntoBox Net* is a special implementation of *OntoBox* for distributed knowledge bases, integrated by *OntoBox* through a special protocol. In this implementation queries in *Libretto* can also be exchanged over the protocol.

3 *OntoBox Storage*

Here we consider *OntoBox Storage*, an efficient implementation of *OntoBox* in Java. The style of work with *OntoBox Storage* resembles database techniques, in which SQL is substituted by *Libretto*. The current version of *OntoBox Storage* is available at [O&L].

Storing data. The current *OntoBox Storage* implementation is the third one. The initial implementation was built over a relational database. The structures of *OntoBox* were mapped to DB tables, and a portable code was developed, which could work with numerous DBMS like MySQL, HSQLDB, Apache Derby/IBM DB2. But, we failed to achieve satisfactory efficiency, because the *OntoBox*'s overhead was multiplied by the overhead of databases. Some optimizations including memory caching improved the situation a little bit, but not sufficiently.

Thus, we got rid of databases and implemented a version with the heavier usage of the memory. This solution is justified by the tremendous progress in memory capacity of computers. Now the components of *OntoBox* are stored in

special structures based on bi-maps and hybrids of lists and mappings, which resemble multi-maps. The full names (URIs) of entities and ontologies are indexed. Knowledge stored in OntoBox is checked and changed by *actions* of two kinds: *asks* (data reading actions) and *tells* (data editing actions). The persistence of data stored in OntoBox between work sessions is provided by a disk log, which contains the sequence of writing actions (tells).

Attributes of objects can contain large amounts of passive data (e.g. images or book texts) not involved in active data processing. For such cases a Disk Map (DMap) technology has been implemented. The DMap separates attributes and large attribute values, which are saved in external data storages like disks. DMap works on the implementation level and is not seen in OntoBox. It is based on its own object model, which allows experiments with various implementations of DMap.

Transactions. A transaction mechanism is also implemented in OntoBox Storage. It plays a role similar to that in DBs. Transactions are very useful for efficient error handling, and for concurrent data processing to avoid data and access conflicts. The transaction mechanism also allows implementation of versioning.

An OntoBox' transaction comprises a sequence of operations, which perform one logical step of data processing. A transaction can be rolled back with full restoration of the knowledge base (e.g. in case of incorrect operations), or committed, if correct. Auto-commit of transactions (when any operation is considered as a mini-transaction committed automatically) is also supported. Transactions in OntoBox are fully isolated (through Java's forced synchronization), that is, intermediate results of transaction's operations can not be accessed or seen from outside.

Event handling. For better integration of OntoBox with various systems and external modules, an event handling system has been implemented. In particular, event handling is useful for implementation of reasoning strategies, and for user's interface development, in order to keep reasoners and interfaces informed about the changes in the knowledge bases of OntoBox. Event handling is included in the abstract interface of OntoBox and thus any system, in which OntoBox is implemented, can trigger event handling. Events are handled within a special event thread. This thread works with a special buffer/queue of tells, which calls the registered listeners to handle the caught events.

Portability. OntoBox Storage provides several export/import services. First, OntoBox Storage has an interface to the OWL API [OWL API], which allows export to a number of standard formats, e.g. OWL/RDF. Second, ontologies can be imported/exported as the scripts in *Libretto*. There are other possibilities. Ontologies can be imported and exported in a light-weight XML format (resembling OWLX) adjusted for encoding data in the oo-projection. A convertor from database dumps in DDL/SQL to flat ontologies in OntoBox is also

available. Another module translates the contents of OntoBox Storage into a Java program. An execution of this program rebuilds the knowledge base within a new copy of OntoBox Storage. Last but not least, OntoBox Storage can dump out its content and state, and this dump can be loaded into another copy of OntoBox Storage.

4 OntoBox Applications

A number of applications is being developed now based on the OntoBox technology (see [O&L]). They include an interdisciplinary natural-science ontology about Lake Baikal together with a collaborative research support system based on this ontology, the knowledge base "Flora of Baikal Region", OntoForum (a thematic-forum support system providing intelligent metadata tools for published data reuse), an ontology formalization of the IMS specification 'Question and Test Interoperability' coupled with a test management system based on this ontology, a number of smaller but useful projects based on OntoBox/Libretto (a scientific research classification handbook, a personal organizer, a home library system etc.)

The efficiency of the basic OntoBox implementation established in this paper, is comparable with that of databases – see evaluations in [Malykh et al. 2010]). The following advantages of OntoBox appeared important in practice: reusability of object models as ontologies, direct mapping between data structures in the OntoBox storage system and OOP languages (cf. OOP languages and relational databases), the substitution of the standard couple XML + DB by OntoBox object models in web applications, encapsulating logical tools to ease incorporation of general information resource developers.

5 Related Works and Conclusion

The problem of efficient simple-structured-data handling within knowledge management approaches is important, because in many applications it is necessary to combine high level knowledge management with ordinary data processing. The mainstream here is to incorporate in logic environments relational data bases. A number of works are focused on this idea, e.g. see [Haarslev et al. 2008] and [Hustadt et al. 2007]. We think that description logics have great potential for simple data handling, so the incorporation of outer techniques (like databases) brings unnecessary complications. Our approach is closer to that in [Motik et al. 2008], in which graph-like data structures are considered, but these structures are handled on the abstract terminological level, whereas we try to work with concrete objects. The idea of mapping between description logics and object models was partially inspired by [Puleston et al. 2008]. While developing

the query language *Libretto*, we were guided by the experience and ideas of a number of query languages working in logical environments, including SPARQL [Seaborne et al. 2008].

The beta version of *OntoBox Storage* is freely available for experiments on [O&L]. In particular, it is possible to use it as an object data management system, or even for the development of your own *OntoBox* implementations, in which *Libretto* can run. It is also worth noting that this technology has potential for handling concrete domains in semantic web applications. Now we are pushing the approach in several directions. A *Libretto* compiler is being developed, other implementations of *OntoBox* are being created (including *OntoBox DB* and *OntoBox Net*). Also we try to embed *OntoBox* in stronger logical formalisms, in order to incorporate in them efficient simple-structured data handling.

References

- [Baader et al. 2003] Franz Baader, Diego Calvanese, Deborah L. McGuinness, Daniele Nardi, Peter F. Patel-Schneider (Eds.): *The Description Logic Handbook: Theory, Implementation, and Applications*. Cambridge University Press 2003.
- [Cardelli 1988] Luca Cardelli. *A Semantics of Multiple Inheritance*. *Information and Computation*, v.76 n.2-3, p.138-164, February/March 1988.
- [Haarslev et al. 2008] Haarslev, V., Moeller, R.: *On the Scalability of Description Logic Instance Retrieval*. *Journal of Automated Reasoning* 41(2) (August 2008) 99-142.
- [Horrocks et al. 2003] Ian Horrocks, and Peter F. Patel-Schneider. *Reducing OWL entailment to description logic satisfiability*. In Fensel, D., Sycara, K. and Mylopoulos, J., eds., *Proc. of the 2003 International Semantic Web Conference (ISWC 2003)*, number 2870 in *Lecture Notes in Computer Science*, 17-29. Springer.
- [Hustadt et al. 2007] Hustadt, U., Motik, B., and Sattler, U. *Reasoning in Description Logics by a Reduction to Disjunctive Datalog*. *J. of Automated Reasoning*, 39(3):351-384, 2007.
- [Malykh et al. 2009] A. Malykh, A. Mantsivoda and V. Ulyanov. *Logical Architectures and the Object Oriented Approach (in Russian)*. *Vestnik, Novosibirsk State University*. 2009, v. 9, Issue 3, P. 64-85. In English: <http://ontobox.org/materials/vestnik2009.pdf>.
- [Malykh et al. 2010] Anton Malykh and Andrei Mantsivoda. *A Query Language for Logic Architectures*. LNCS, v. 5947, pp. 294-305, Springer-Verlag, 2010.
- [O&L] *The OntiBox/Libretto Project*. <http://ontobox.org>
- [Motik et al. 2006] Boris Motik and Ulrike Sattler. *A Comparison of Reasoning Techniques for Querying Large Description Logic ABoxes*. M. Hermann and A. Voronkov (Eds.): *LPAR 2006*, LNAI 4246, pp. 227-241, 2006.
- [Motik et al. 2008] Boris Motik, Bernardo Cuenca Grau, Ian Horrocks, Ulrike Sattler. *Representing Structured Objects using Description Graphs*. *KR 2008*, p.296-306.
- [Seaborne et al. 2008] E. Prudhommeaux and A. Seaborne. *SPARQL Query Language for RDF*. *W3C Recommendation*, 2008.
- [OWL API] *The OWL API*. <http://owlapi.sourceforge.net/>
- [Puleston et al. 2008] Colin Puleston, Bijan Parsia, James Cunningham, Alan L. Rechter. *Integrating Object-Oriented and Ontological Representations: A Case Study in Java and OWL*. *ISWC 2008 (2008)*, pp. 130-145.

Semantic Structuring of Conference Contributions Using the Hofmethode

Oliver Michel

(Arbeitsgruppe Angewandte Kognitionspsychologie, Universität Zürich, Switzerland
o.michel@psychologie.uzh.ch)

Damian Läge

(Arbeitsgruppe Angewandte Kognitionspsychologie, Universität Zürich, Switzerland
d.laegel@psychologie.uzh.ch)

Abstract: The similarity relation of a number of texts is important not only for congress organizers (who need to group the proposed contributions to meaningful sessions) but to everybody who wants to find certain information within a larger number of texts. Existing information retrieval methods compare texts according to their similarity. Because these methods mostly remain on the surface of the words, the resemblance is not primary a semantic one, but a stylistic and vocabulary dependent one. Based on psychological considerations we have developed an algorithm called Hofmethode, which compares the semantic 'environment' of key words. Using the example of the SGP congress we show in this paper how the Hofmethode can be used to help both congress organizers and participants to find the appropriate contributions.

Keywords: Information Retrieval, Semantic similarity, machine text understanding

Categories: H.3.3, I.1.2, I.2.7, M.7

1 Introduction

The similarity relation of a number of texts is important not only for congress organisers (who need to group the proposed contributions to meaningful sessions) but to everybody who wants to find certain information within a larger number of texts.

One key difficulty in building a semantic structure is to tell the computer, what there is 'behind the words': What is the meaning of a certain word? Most information retrieval methods stay on the surface of the words (e.g. the overlapping coefficient [Marx, 1976]), directing in the known synonym/homonym problems. These methods treat words as patterns. If the same word/pattern occurs several times, it counts as a hit, no matter what the word means. Other methods are highly dependent on the style of the author (e.g. the trigramming method [Nohr, 2000]).

To solve the problems stated above, we have developed an algorithm called Hofmethode, which computes the semantic similarities of short to medium-sized texts. The resulting matrix of pairwise similarity values are then used to generate a semantic map by means of NMDS (nonmetric multidimensional scaling) [Borg, 1997], in which the texts are ordered according to their semantic relationship.

The concept of the Hofmethode was proven to work in [Michel, 2006]. A comparison of an alternative computing method of the semantic map (Kohonen map)

with the NMDS was analyzed in [Daub, 2002]. The metaphor of the map provides a comprehensive and intuitive way to display similarity related data. Therefore we did not apply further categorization procedures (like cluster analyzing) and limit ourselves to the face validity of the map. In this paper, we describe how the Hofmethode works and how it could help congress organizers in finding useful symposia topics, based on the abstracts of congress contributions of the SGP (Swiss Society of Psychologists) congress, held 2007 in Zurich [SGP, 2007].

2 How the Hofmethode estimates similarity between texts

2.1 The basics of the Hofmethode

The Hofmethode is an algorithm (based on psychological considerations) used to determine whether the meaning of a word in one text resembles the meaning of the same word in another text. Because the meaning of a word does not necessarily correspond to its shape, more information is needed. In fact, the word itself is almost useless if it is considered as an isolated string. It is the context that gives the meaning to the word in this specific situation [Wittgenstein, 1960]. Language utilization is fluid, not fixed [Hörmann, 1976]. Therefore, the context of this word – referred to as target word¹ – also has to be taken into account.

First we denoise the text by removing stop words and the like. Then, we extract the context of all target words in the text (some reflections on the compilation of the target word list are presented below). We define the context of a target word as the five words before and the five words after the target word. Because these words lie around the word like a halo, we call it the Hofmethode («Hof» is the German word for halo). These words are written into a table together with a value, which is dependent on their distance from the keyword: If it is the direct neighbour, the value is close to 1; if it is further away, the value lowers towards 0 (see Fig. 2), following a cosine function.

The context of the same target word in another text is also written into a table with the same procedure as described above. Now, the words in the two tables are compared: If there are identical (or even similar) words in the two tables, their multiplied (and summed up) values compose a similarity value between the two target words. If the value is high, then the meaning of the target word in these two contexts is regarded as similar.

¹ We use the term target word to avoid confusion with the term keyword, which often denotes the keyword field in metadata descriptions.

structural processes correlates intelligence models structure attitude			based general estimated intelligence process emotional ratings		
Text A	Association	Value	Text B	Association	Value
	structural	0.71		based	0.71
	processes	0.87		general	0.87
	correlates	0.97		estimated	0.97
	intelligence	1		intelligence	1
	models	0.97		process	0.97
	structure	0.87		emotional	0.87
	attitude	0.71		ratings	0.71

similarity value of the target word
 «intelligence» in text A and text B:
 $0.87 * 0.97 = 0.84$

Figure 1: Simple example of the Hofmethode with a halo size of three words: In the two contexts of the target word «intelligence» there are similar words. Their values are multiplied. The resulting value represents the semantic similarity of the target word in these (and only these) two contexts.

This procedure is carried out with every target word in every text of a defined set of text items: We determine its context and compare it with the context of an identical (or similar) target word in another text. In the end, we have a triangular matrix of summed up similarity values. These values are transformed into Euclidian distances by means of NMDS and arranged in a semantic map. Similar texts will be positioned close together, thus building clusters, while dissimilar texts will be positioned further away. The wonderful aspect of NMDS is that even texts which do not share any similarity between themselves, but which share a covariance over other texts, can be positioned close to one another.

The compilation of the target words is not dealt with in this paper, so some general thoughts on this aspect suffice here: As mentioned above, our approach should focus on semantically relevant words. The more common a word is, the better we can compare its halos. On the other hand, if a word is too common, its semantic significance lowers. Therefore, we need common words with a wide variance of denotative meaning. To detect such kinds of words, we use statistical approaches. There is also the possibility to use (additionally) the common keyword field. Furthermore, we do not want a large list of target words, because this slows down the halo computing. Of course, if we have too few target words, some texts might have no target words at all and will therefore have minimum similarity.

In the example of the SGP congress we extracted the nouns from the titles and subtitles. This resulted in a list of 800 (!) words. In later works we used the more efficient statistical approach.

2.2 Applying the Hofmethode to congress contributions

The congress consisted of 352 contributions, which were either talks (249) or posters (103). Most of the talks (170) were also attributed to one of the 36 symposia subjects. We manually chose 10 symposia with regard to a broad variety of themes and identified the abstracts of the corresponding talks. In the resulting 46 abstracts we determined the target words (based on the noun target word list), computed the halos and compared them. The resulting triangular similarity matrix was transformed into a semantic map by robust NMDS.

Since the congress organizers have to be considered as experts in the field of psychology, their attribution of the talk to one of the 10 symposia is our quality measurement: The semantic map, computed by the Hofmethode, should reflect the groups given by the congress organizers.

3 Results

Figure 2 shows the semantic map of the 46 abstracts. The colours represent the 10 symposium themes. The numbers specify an internal Id and will help us in the discussion of the map. The red circles indicate the items, which we discuss below.

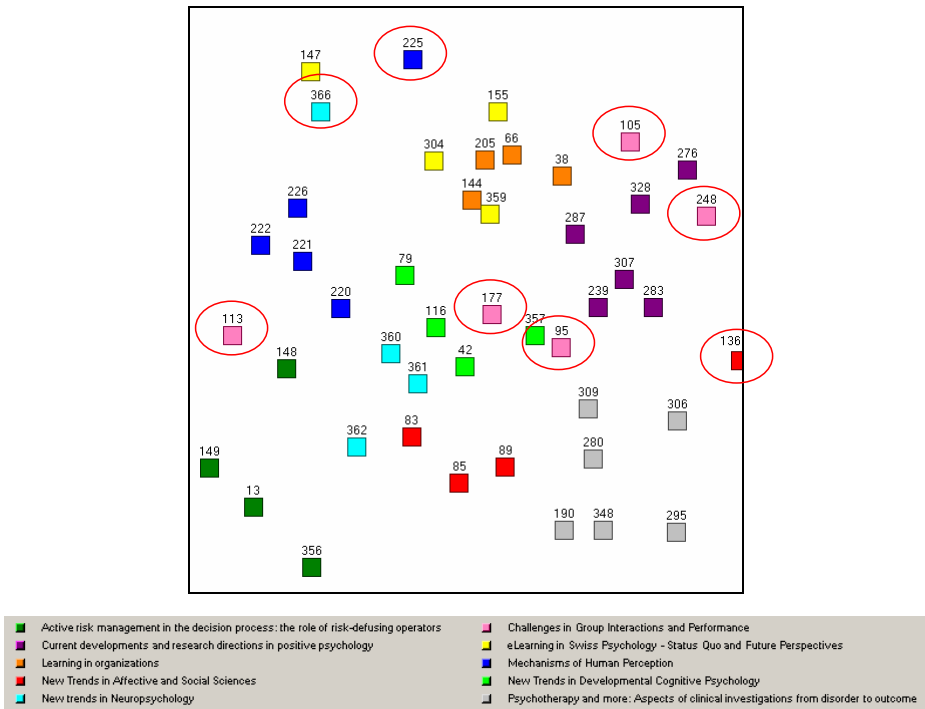


Figure 2: The resulting semantic map of the 46 abstracts. The colours represent the symposium subjects. The overall structure corresponds very well to the attribution of the talks to the symposia by the congress organizers.

As it can be seen, the presented structure matches very well with the attribution (of the talks to the symposia) done by the congress organizers. The different topics are quite well separated, even though they do not cluster in a narrow sense.

There are some discrepancies though. We comment on some of them:

- The four pink items, which belong to the symposium 'Challenges in Group Interactions and Performance' are scattered all over the map. Let us look at them more closely: Items 105 and 248 seem to be in wrong group. They are

in the 'Positive Psychology' group instead a group of its own. Why? Item 105 is a study about 'fair leadership' and the influence on employees' commitment. Its closeness to 328 'Positive Psychology at the Workplace' is unquestionable. Also item 248, which is about 'Core Self-Evaluations and Transformational Leadership' and the influence on job satisfaction, is well placed, so the *mélange* of the two symposia themes is quite correct and reflects the semantic mixture. Item 95 is about interpersonal sensitivity; its closeness to the developmental psychology makes sense. Item 113 is about the strategic use of information in group decision making and therefore semantically correctly close to the 'active risk management group'. Item 177, about the 'reflective group' is misplaced, indeed.

- The red item 136 is apart from its group. But since it is about diary studies the neighbourhood of the grey psychotherapy group suits, too.
- Item 366 is far from its group and therefore, on the first sight, seems to be misplaced. But because its content examines the spatial presence (e.g. in virtual reality), the position close to the eLearning group and item 147 (online exercises) is perfect.
- All the four light green items of the developmental group are in the centre of the map. This is no surprise: Developmental psychology deals with various themes within psychology; their only common denominator is the aspect of the development.
- Item 225: It's called 'Top-down and bottom-up processing in perceptual learning' and is clearly misplaced. It should be right in its blue perception group.

4 Conclusions

Scientific abstracts belong to a special category of texts: They are written very dense; a lot of information is packed in few words with no redundancy. Even though the advantage of the Hofmethode is its handling with redundant text, the Hofmethode computed semantic similarities, which correspondent very well to the structuring of the congress organizers. This means congress organizers could use the Hofmethode as a tool to identify the right contributions for certain congress themes or to form the right sessions. Furthermore, visitors of the congress could use the map to gain a fast overview of the available themes. And last but not least: Contributors might find easily other contributions, which are semantically close to them.

References

- [Borg, 1997] Borg, I., & Groenen, P.: *Modern Multidimensional Scaling. Theory and Applications*. New York: Springer, 1997.
- [Daub, 2002] Daub, S., Schnyder, F. & Läge, D.: *Kohonen-Netze NMDS: Die Überführung zweier Repräsentationsformen*. Universität Zürich, Zürich, 2002.
- [Hörmann, 1976] Hörmann, H.: *Meinen und Verstehen*. Frankfurt am Main: Suhrkamp, 1976.

[Marx, 1976] Marx, W.: Die Messung der Assoziativen Bedeutungsähnlichkeit. Zeitschrift für Experimentelle und Angewandte Psychologie, 23(1), 62-76, 1976.

[Michel, 2006] Michel, O. & Läge, D.: Die Hofmethode: Auf dem Weg zum maschinellen Textverständnis (AKZ-Forschungsbericht No. 34). Zürich: Angewandte Kognitionspsychologie, 2006.

[Nohr, 2000] Nohr, H.: Automatische Dokumentindexierung. Fachhochschule Stuttgart, Stuttgart, 2000

[SGP, 2007] SGP-Kongress 2007, 2007, <http://www.ssp-sgp2007.ch/~confcms/~pages/~congressnews.aspx>

[Wittgenstein, 1960] Wittgenstein, L.: Philosophische Untersuchungen. Unpublished manuscript, Frankfurt, 1960.

Social Computing: A Future Approach of Product Lifecycle Management

Andrea Denger

(Virtual Vehicle, Graz, Austria
andrea.denger@v2c2.at)

Michael Maletz

(Virtual Vehicle, Graz, Austria
michael.maletz@v2c2.at)

Denis Helic

(Graz University of Technology, Graz, Austria
dhelic@tugraz.at)

Abstract: Industrial challenges in the automotive industry are more and more focused around the optimization of the development process which requires new integrated instruments of communication and collaboration. To face challenges of business communication and collaboration, the industrial multi-firm research project “FuturePLM” applies a series of methodologies in industrial and scientific environments. First, relevant topics were elaborated within an expert panel followed by qualitative interviews to gather the industrial as-is situation of product development. Afterwards, scenario planning was applied to create possible pictures of product development in the future. The key is seen in the analysis of the gap between the as-is situation and possible future scenarios. Some of these gaps include aspects such as the proposition to integrate Web 2.0 technologies in the daily business environment of product development (social networking, micro blogging, etc.), as well as the analysis of other upcoming topics with high relevance (e.g. complexity management, representation of data or implementation strategies). However, the major focus is the consideration of human behaviors. The goal is the identification of opportunities and threats, as well as the development of concepts and solution approaches to establish a sustainable strategy for future-oriented product development and Product Lifecycle Management (PLM).

Keywords: Product Lifecycle Management (PLM), Social PLM, Product Development Process, Scenario Planning, Corporate Social Computing, Knowledge Management, Representing of Data and Information

Categories: H.4

1 Introduction

Future success in the automotive industry depends on the ability to reduce time to market and development costs. Current product development, where requirements and variety of products increase to satisfy more and more customers, requires sustainable methods for information and knowledge management.

IT support in the area of virtual product development is state of practice. Especially Product Data Management (PDM) represents a major backbone hereby.

PDM is a system used in product development to store and retrieve design data with the goal to ensure information consistency throughout the engineering design of a product. The product life cycle describes the process from the idea of a product, through concept, design and manufacture, to service and disposal [Eigner, 09]. Product Lifecycle Management (PLM) in the scope of this paper is seen as a strategic approach for the management of the intellectual property of a product along its entire lifecycle. This concept includes methods, processes and organizational structures, as well as IT systems. From today's point of view the role of the human/user in terms of dependencies between human, environment and tools is not considered sufficiently [Schleidt, 09]. Challenges in future product development include the *effective management of the entire lifecycle of a product* and the *collaboration between different disciplines and cultures in globally distributed development locations*.

Especially the availability of integrated PLM properties and services is a prerequisite for successful integration approaches [Maletz, 08].

2 The research project Future PLM

The multifirm research project "FuturePLM" aims at overcoming above mentioned challenges. One of the research questions of the project is: "*What preconditions have to be created, and what competences and values are relevant for the involved people in order to use PLM successful and efficient?*" Another aspect is to outline domain and company interdependencies that offer potential to improve cooperation and collaboration. In this paper we describe how the project handles the role of humans and potentials to integrate innovative Web 2.0 technologies the field of PLM.

The analysis of the strong correlation between PLM functions, processes and methods to e.g. handle complexity and improve acceptance & understanding is important for PLM implementations. The developed solution approaches are verified within future scenarios under the consideration of the industrial as-is situation and state of the art technologies [Schmeja, 10/2].

Summarizing, the goal of the project FuturePLM is the development and verification of needed PLM methodology's and a generic PLM implementation strategy.

3 FuturePLM project methodology

To face the challenges of future-oriented PLM several methodologies have been applied in industrial and scientific environments. First, an expert panel defined a scope with topics of most interest and industrial environments. As a next step, the industrial as-is situation of product development has been elaborated with a series of qualitative and quantitative interviews to capture the needs of individuals in all development phases. After that different possible future scenarios of product development have been generated. These scenarios outline how product development may change until the year 2020.

3.1 Expert Panel: Future PLM - Specific Needs of People and Organization

In the course of the expert panel at [GSVF, 09] a series of topics in the field of product development in general and specifically PLM has been generated and discussed. Based on that, literature research and experience from other projects has been included in the development of a topic landscape. Figure 1 shows an overview of defined topics. It is seen that the “human factor” builds the center for all topics taken into consideration.



Figure 1: Topics in the field of Future PLM

Among technical topics such as Web 2.0 technologies, representation of data and information, or handling of complexity, social and cultural topics are also taken into consideration. In particular, there is a strong agreement among project participants that PLM needs to incorporate social computing.

3.2 Industrial As-is Situation

The industrial as-is situation has been elaborated with a series of quantitative and qualitative interviews [Schmeja, 10].

Industrial partners in the research project come from the field of automotive tier 1, general supplier, and consulting of PLM. Interviewees came from the field of engineering, sales and IT. The goal of the interviews was to take the needs of individuals along the product lifecycle into consideration. Within the interviews the focus was laid on the different phases of the product development process (i.e. strategy finding, concept and serial development, production planning and after sales). In earlier phases, such as strategy or concept development, individuals need to participate in people-centric creative process of product design to determine product development targets. The success in this phase can be measured by the maturity of the developed concept, especially a clear risk analysis. The success is based upon experts networking in a multi-domain team. Following phases such as serial development, production planning, and after sales require a rigid and forced approach to verify the results of earlier product developing phases [Schäppi, 05].

A detailed analysis of all results and factors [Schmeja, 10/1] taken into consideration leads to the quintessence that there is a desire for a simple use of PLM

supporting systems. Further on a new people-oriented strategy in process and organizational planning is required. There is a need to elaborate, under which conditions e.g. a simultaneous engineering team works most efficient and how it can be supported by a refined sustainable PLM process. Strategies for a more relaxed procurement of information in order to maximize the project result are required.

3.3 Scenario Planning

Scenario planning is a strategic planning method used to make flexible long-term plans. It is a method for learning about the future by understanding the environment and impact of the most uncertain and important driving forces affecting the system in focus. The method is based on creating a series of 'different future scenarios' generated from a combination of known factors [Steinmüller, 03].

The scenario planning process starts by defining the scope of the scenario exercise. In this case it stands for the expanding information and process management in the field of heterogenic development environment that outline how product development may change by the year 2020. The goal is to create different views of the world by extrapolating these influencing driving factors (i.e. drivers and indicators). The ambition hereby was not to predict the future, but to show possible pictures that allow the project partners to prepare themselves for the future. Figure 2 outlines the method of scenario planning in the project "FuturePLM" [Schmeja, 10/1].

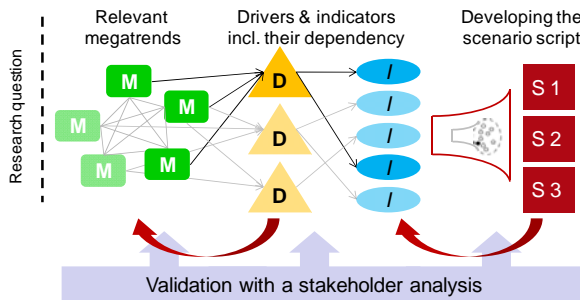


Figure 2: From megatrends to scenario scripts.

[Schmeja, 10/1] summarizes the results of the scenario planning method. In short the first scenario informs about extreme globalization and why companies reach an enormous level of complexity ("globalization extreme"). The second scenario gives an account of the opposite of globalization – "disconnecting". A third scenario focuses around data and information representation in highly cross-linked companies ("ride the information wave"). In the fourth scenario people are seen as the most important factor within product development ("people take center stages").

Summarized, it can be said that two scenarios inform about the possible tendency of employment of modern technologies in business communication and collaboration. In particular the third scenario deals with data and information exchange in strongly interconnected and dependent companies. Furthermore it deals with stronger product individualization and influence of customers into the development process. The fourth

Scenario deals with modern working conditions in the field of product development and that the mutual trust within companies increases acceptance and understanding of PLM. This is due to the deployment of new technologies (i.e. social networking, micro blogging), processes and organization forms in business environments.

4 Result of the Analysis of the Gap of the As-is Situation and Possible Future-oriented Scenarios of Product Development

It is not essential to forecast the future, it is important to prepare for the future.

(Perikles ca. 450 BC)

Next to the results of the as-is situation and possible future scenarios, this paper describes a synthesis methodology how to prepare for the future by taking several aspects into consideration. For example continuing globalization and globally networked companies require new technologies and the necessity of enhanced but yet simple information and knowledge management concepts centered on real needs of people.

An important step in this approach is to derive assumptions in order to be able to define, develop and verify potential responses to fill the gap between today's challenges and tomorrow's environment. On one side there are assumptions based on as-is situation and on the other side there are assumptions based on possible future-oriented scenarios [Schmeja, 10/01]. For the scope of this paper the assumptions for modern product development were subsumed to the following aspects:

- The engagement in human behavior will improve working conditions.
- New technologies (such as Web 2.0) and flexible organization forms will improve communication and collaboration.

These illustrated assumptions indicate a proposition to integrate Web 2.0 technologies in the daily business environment of product development. Examples are social networking, micro blogging or Wikis in order to support the handling of upcoming topics with high relevance (e.g. complexity management, representation of data or implementation strategies). Basic elements of Web 2.0 technologies are services, content and community [Gissing, 07], the core of identified topics in the project FuturePLM. Furthermore Web 2.0 facilitates interactive information sharing, user-centered design and the ability to co-operate [Hoegg, 06].

Although social computing will get a higher priority in the future business environment [Blumauer, 09] it is understood that proposed solution approaches will not solve all PLM-relevant issues. However, the authors represent the opinion that mentioned aspects will be of enormous benefit to raise acceptance and manageability of PLM supporting systems. Derived consequences are findings of environmental challenges and the identification of opportunities and threats to establish a necessary strategy for future-oriented product development.

5 Summary and Outlook

The desire for a simple use of PLM supporting systems in the future, as well as people-oriented implementation strategies from process and organizational

perspectives were discussed in this paper. These was done by evaluating the industrial as-is situation of product development, evolve possible and consistent pictures of the future, and describe a methodology of how to close the gap between today's challenges and tomorrow's disputes. From the technology trend perspective a proposed solution approach could be the integration of Web 2.0 technologies and social computing in the daily business environment of product development.

Next steps include the development of concepts and solution approaches to close the gaps as discussed. Closing one gap may be done by an approach for better communication and collaboration supported by social computing techniques. The approach will be verified in form of use cases with industrial project partners.

Acknowledgements

The authors would like to acknowledge the financial support of the "COMET K2 - Competence Centres for Excellent Technologies Programme" of the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT), the Austrian Federal Ministry of Economy, Family and Youth (BMWFJ), the Austrian Research Promotion Agency (FFG), the Province of Styria and the Styrian Business Promotion Agency (SFG).

We would furthermore like to express our thanks to our supporting industrial and scientific project partners, namely "AVL List GmbH", "MAGNA STEYR Fahrzeugtechnik GmbH & Co KG", "CSC Computer Science Consulting Austria GmbH", "CSC Deutschland Solution GmbH", Vienna University of Technology, University of Kaiserslautern, and to the Graz University of Technology.

References

- [Blumauer, 09] Blumauer, A., Pellegrini, T.: *Social Sematic Web, Web 2.0 – Was nun?*, Springer Verlag, 2009
- [Eigner, 09] Eigner, M., Stelzer, R.: *Product Lifecycle Management: Ein Leitfaden für Product Development und Life Cycle Management*, Springer Verlag, 2009.
- [Gissing, 07] Gissing, B., Tochtermann, K.: *Corporate Web 2.0 - Web 2.0 und Unternehmen: Wie passt das zusammen?* Shaker Verlag, 2007.
- [GSVF, 09] Workshop: "Future PLM - New Demands on Collaboration and Information Exchange", 2. Grazer Symposium Virtuelles Fahrzeug, Graz, 27. - 28.04.2009
- [Hoegg, 06] Hoegg, R., et al.: *Overview of business models for Web 2.0 communities*, Proceedings of GeNeMe 2006, page 23-37, Dresden, 2006.
- [Maletz, 08] Maletz, M.: *Integrated Requirements Modeling – A Contribution towards the Integration of Requirements into a holistic Product Lifecycle Management Strategy*. PhD Thesis, Department of Virtual Product Development, University of Kaiserslautern, 2008.
- [Schäppi, 05] Schäppi, B., et al.: *Handbuch Produktentwicklung*. HANSER Verlag, 2005.
- [Schleidt, 09] Schleidt, B.: *Kompetenzen für Ingenieure in der unternehmensübergreifenden Virtuellen Produktentwicklung*. PhD Thesis, Department of Virtual Product Development, University of Kaiserslautern, 2009.

[Schmeja, 10/1] Schmeja, M.: Quo Vadis PLM? Anforderungen an ein zukünftiges, erfolgreiches Product Lifecycle Management, ProSTEP iViP Symposium, Berlin, 2010.

[Schmeja, 10/2] Schmeja, M.: FuturePLM: Blick in die Zukunft, virtual vehicle magazine, No. 6, II-2010, Kompetenzzentrum – Das virtuelle Fahrzeug, Graz, page 16 – 17

[Steinmüller, 03] Steinmüller, K., Schulz-Montag, K, B.: Szenarien – Instrumente für Innovation und Strategiebildung, Z_punkt GmbH, Essen 2003.

Expert Recommender Systems: Establishing Communities of Practice Based on Social Bookmarking Systems

Tamara Heck

(Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany
tamara.heck@uni-duesseldorf.de)

Isabella Peters

(Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany
isabella.peters@uni-duesseldorf.de)

Abstract: Recommender systems have established mostly in e-commerce, whereas in companies or scientific institutions the recommendation of experts und possible colleagues has yet been discussed mostly theoretically. We propose a recommender system on the basis of Social Bookmarking Systems and Folksonomies, which may help to find communities of practice, where people share the same interests and support each other in their working or scientific field. The paper reports research in knowledge management and information retrieval, and therefore offers new insights and fields of studies in information science.

Keywords: recommender system, social bookmarking, communities of practice, folksonomies

Categories: M.5, M.7, H.3.3

1 Introduction

The Web 2.0 offers great innovative possibilities: By using 2.0 technologies, new behaviors and innovative collaboration methods can develop [Delic, 08]. Scientists and researchers can use these new ways to gain scientific knowledge, share it, offer their results and collaborate on Web 2.0 platforms. In scientific environments the term "Science 2.0" has established as a definition for new forms of communication. [Waltrop, 08] says that Science 2.0 isn't anymore a "competition" between scientists but gets even more "collaboration". On the other hand [McAfee, 06] coined the term "Enterprise 2.0" which describes the use of Web 2.0 in companies "to make visible the practices and outputs of their knowledge workers" [McAfee, 06, p. 23].

In the following we describe a current research project which aims at developing an expert recommender system, i.e. a software tool which recommends similar users based on same bookmarks and tags within Social Bookmarking Systems. This prototype should find possible colleagues for establishing Communities of Practice (CoPs). It's the basis for further research to analyze how Web 2.0 applications can be used more effectively for scientific and business communication. An important part will be the evaluation of our system. Therefore the development of the tool is accompanied by a qualitative survey in which researchers report their attitude towards CoPs and Social Bookmarking. First results of this survey and exemplary user recommendations will be presented in section 3.

1.1 Communities of Practice (CoPs)

It seems that beneath the recommendation of similar resources in a collaborative system the recommendation of similar or relevant users is far more important [Diederich, 06]. [Panke, 08] asked approximately 200 users about their tagging behaviour: Two-thirds of them use tags to socialize with other users. CoPs are groups of people, who have the same interests, change information and knowledge and cooperate with each other [Wenger, 00]. Three aspects are important: First, members of a CoP have a joint enterprise of what their community is about. Second, the community is built on mutual engagement, and third, the members produce a "shared repertoire of communal resources" such as language and tools. CoPs in companies and institutions can exist of division-intern or -extern members, members who work at the same location or on different places or even members, who don't belong to the same company. The important factor is that CoPs establish and organize themselves. CoP-members meet willingly and are not ordered by leadership because enforcement could lead to refusal of cooperation [Blair, 02]. That is the main difference between them and teams established by company managers [Wenger, Snyder, 00]. The modern web with its social networking systems or web-based tools like SBS may support the cooperation of CoP-colleagues. The "virtual meeting" cannot replace the face-to-face meeting of the members [Gust von Loh, 09]. But maybe the contact via internet is the first step to develop a CoP.

1.2 Social Bookmarking Systems (SBS) and recommender systems

SBS offer platforms, on which users could archive their references to have access to and manage them from any web-accessible device. Examples of SBS are BibSonomy, CiteULike and del.icio.us. Another important aspect of SBS is collaboration. The users' bookmark lists are made public and can be used by any other participant of the platform. Every bookmark can be tagged by keywords. Users can tag bookmarks of others and help each other to organize their database. So SBS is not only an individual resource management system, it's a collaborative system, where community users act through combined resources. SBS exploit the main features of social networking. That is why companies nowadays embed SBS in their intern systems [John, 06].

Recommender systems make use of collaborative filtering, that means to restrain a quantity of information with the help of a user community: "Collaborative filtering simply means that people collaborate to help one another perform filtering by recording their reactions to documents they read" [Goldberg, 92]. This is based on the idea of a "referral chain", i.e. a user requires on his relations and contacts to get relevant information or find an expert to solve a problem. [Kautz, 97] alludes to a great advantage of collaborative filtering systems: "A user is only aware of a portion of the social network to which he or she belongs. By instantiating the larger community, the user can discover connections to people and information that would otherwise lay hidden over the horizon." In information retrieval we use the tripartite structure of terms, resources and users to filter information. The principle herewith is: "Co-occurrence means similarity." Collaborative filtering systems are often used in e-commerce, for example in the online catalogue Amazon (user similarity based on similar resources).

A folksonomy [Peters, 09] is a set of user-generated keywords, called tags, in a collaborative information system. Folksonomy-based filter- or recommender-systems are able to suggest two kinds of information: "Recommendation systems may, in general, suggest either people or items" [John, 06]. The recommended resources are generated with similarity measures and clustering methods [Shardanand, 95].

2 Establishing CoPs based on SBS

The question is: How can the process of establishing CoPs be supported and initiated? How can companies and institutions advise their colleagues to each other without enforcing their cooperation? [Wenger, 2000, p. 144] claims: "The task is to identify such groups and help them come together as communities of practice." Collaborative information systems with their inherent networking structure [Peters, 09], such as SBS and folksonomies, are able to visualize CoPs and make the sharing of knowledge more effective. The claim to get relevant information is now: "More like me!" – find users, who are similar to me so that I may get relevant information from them. We suppose, that users are similar to each other when they use equal or similar tags for indexing a resource ("thematic linkage"), or when they index, edit and save the same resources ("bibliographic coupling") [Kessler, 63].

So far there are a few empirical studies, which examine the adoption of recommender systems based on folksonomies and their advantage in information retrieval and knowledge management. It should be mentioned the study by [Jäschke, 07], which analyzes the effect of recommended search-tags on retrieval efforts (based on BibSonomy and the music recommendation system Last.fm).

2.1 Method

We first chose the SBS CiteULike to develop an expert recommender system which analyzes the tripartite relation between users, tags and bookmarks. As we cooperate with the Forschungszentrum Jülich (FZJ), whose scientists helped us setting a relevant database, we chose a set of 45 relevant journals of solid-state physics (bookmarked between 2004 till 2008). Physicists don't use SBS more often than other scientists, but they are used to bibliography reference systems like JabRef. This was one relevant aspect for us, as the physicists will evaluate our recommender tool.

The first step to recommend users is to measure the similarity using one of the common coefficients Dice, Cosine or Jaccard-Sneath, which calculate the similarity between one user and the other users of a SBS. Using the Dice coefficient [Dice, 45] for example, D_i and D_j are users, a the number of bookmarks (or of tags) of user D_i , b the number of bookmarks (or of tags) of user D_j and g the number of bookmarks (or of tags) which both users applied:

$$S_{D_i, D_j} = \frac{2g}{a + b}$$

As we suppose an elaborated method and not the k-nearest-neighbour algorithm, the second step is to calculate the coincidence of the users and transfer the results into a cluster structure applying the single-link-, complete-link- or group-average-link-

method [Knautz, 10]. In this way we gain similar users who can be recommended to each other in order to establish a user-community, a possibly first step to build a CoP.

After the implementation of the recommender system an evaluation, which focuses on the quality of the system, will follow. Thus, we send a survey to FZJ-employees, which got us a first impression of the handling and understanding of SBS and CoPs. The same participants will also evaluate our recommender tool.

3 Results

3.1 Use of SBS and CoPs in Science

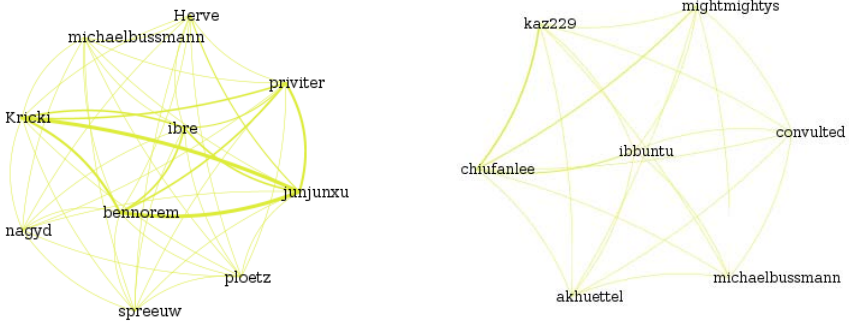
The survey sent to 363 employees yields to following results: 43 employees (25 till 62 years old) attended the survey, which is 11,85 %. The questions to SBS showed appalling, but also revealing results: Only one participant really uses one SBS (del.icio.us). We also asked why they use/don't use SBS. One answer was: "For me, search engines, normal bookmarks and literature databases like JabRef work fine." It seems that several systems for information management and retrieval have established and the new services have difficulty to convince users of their advantage. 7 respondents thought that SBS are "less important", 14 that they are "not important".

2 out of 27 said that they work in a CoP. One CoP was founded through "contact through a conferences or a colleague", the other one "through connections by people formerly working at the same institute." This shows us, that CoPs, although not common between researchers, have found their way into scientific work. 8 % out of 25 said, that CoPs and working groups could facilitate their work well, 16 % said that they could. We also asked if SBS could help to socialize with other colleagues and researchers and to establish working groups, which 4 out of 12 answered with "yes". One comment was that the "communication is made easier." 10 out of 28 thought a recommendation system that proposes scientists with same interests for possible cooperation could be helpful. Comments on this questions show, that most participants prefer the personal contact as the most important factor for cooperation. But a "serious structured" recommendation system could support the work, "especially for younger scientists."

3.2 Clustering Experts

In the SBS CiteULike there were 1,006 users and 2,861 bookmarks for our database. We forgo an aggregation of both similarity values (user-bookmarks and user-tags) in order to better recognize the different users who would be recommended by the system based on the different calculations. Users who have put only one bookmark into the SBS were left out of calculation because they would show improper results, i.e. the similarity between them and other users would be calculated very high. To visualize our results and gain recommendation candidates we built up clusters. Figure 1a shows the resulting cluster (with a threshold of 0.1) for the user "michaelbusmann" based on similar bookmarks. It can be seen that this user belongs to a group, where the users "Kricki", "bennorem" and "junjunxu" show the strongest similarity (shown by the thickness of the edges between the users). In figure 1b the complete-link cluster for user "michaelbusmann" based on tags (threshold set on 0.1)

is displayed. It is obvious that both generated clusters show great differences in the recommended users. Users who were recommended because they put the same bookmarks into the SBS do not appear in the cluster based on tag similarity, and conversely users with similar tag-behaviour often have not indexed the same bookmarks. It is striking that some users seem to be "tired of tagging", i.e. they often use one tag, which makes it difficult to calculate similarities based on tags.



Figures 1a/b: Complete-link cluster based on similar bookmarks (left) and based on tags (right) for the user "michaelbusmann", threshold = 0.1, similarity measure: Dice, source: CiteULike

4 Conclusion and future work

Using users-tags-resources relations as in SBS for analyzing similarities provide a lot of opportunities for establishing CoPs and improve cooperation and socialisation of members. Yet, our survey confirms results of other studies [Bernius, 09] that usage ratio of SBS in Science 2.0 is rather rare. Enterprises 2.0 show a different picture [Lai, 08] and can document slightly higher usage statistics. For proper expert recommendations as well as establishment and support of CoPs more intensive user activity in SBS is necessary and will bring better results.

To forego the lack of user activity we will use the publications and references of our interviewees as basis for similarity calculations. The interviewees become "simulated users" as we assume that they have entered their own publications and references into the SBS. Resulting recommendations will suggest our interviewees "real users" of the SBS. Evaluation of the recommender system will follow via half-standardized interviews with the FZJ researchers.

Still open to research are analysis of threshold values for cluster-size regulations and the implementation of weighted similarity relations. The roles of concepts like "centrality", "betweenness" and "degree" [Wasserman, 94] and their representation in CoPs have not yet been discussed as well. Furthermore there is to be discussed the conditions to build a real CoP and how the members should cooperate to make their group work effectively.

Acknowledgements

We would like to thank the researchers at the FZJ, the members of the team project "SoBoCops" and Wolfgang G. Stock for their support in preparing this paper. Parts of this work are supported by the DFG (STO 764/4-1) and the Strategischer Forschungsfonds of the Heinrich-Heine-Universität Düsseldorf.

References

- [Bernius, 09] Bernius, S., Hanauske, M., Dugall, B.: Von traditioneller wissenschaftlicher Kommunikation zu "Science 2.0", *ABI-Technik* 29, 2009, 214-226.
- [Blair, 02] Blair, D.: Knowledge Management: Hype, Hope, or Help, In *Journal of the American Society for Information Science and Technology*, 53/2, 2002, 1019-1028.
- [Delic, 08] Delic, K. A., Walker, M.A.: Emergence of The Academic Computing Clouds In *ACM Ubiquity*, 9/31, http://www.acm.org/ubiquity/volume_9/v9i31_delic.html.
- [Dice, 45] Dice, L.R.: Measures of the Amount of Ecologic Association between Species, In *Ecology*, 26/3, 1945, 297-302.
- [Diederich, 06] Diederich, J.; Iofciu, T.: Finding Communities of Practice from User Profiles Based on Folksonomies, In (E. Tomadaki; P. Scott, eds.) *Innovative Approaches for Learning and Knowledge Sharing, EC-TEL 2006 Workshops Proceedings, Crete, Greece 2006*, 288-297.
- [Goldberg, 92] Goldberg, D.; Nichols, D.; Oki, B. M.; Terry, D.: Using Collaborative Filtering to Weave and Information Tapestry, In *Communications of the ACM*, 1992, 35(12), 61-70.
- [Gust von Loh, 09] Gust von Loh, S.: *Evidenzbasiertes Wissensmanagement*, Wiesbaden: Gabler, 2009.
- [Jäschke, 07] Jäschke, R.; Marinho, L.; Hotho, A.; Schmidt-Thieme, L.; Stumme, G.: Tag Recommendations in Folksonomies, In *Lecture Notes in Artificial Intelligence*, 2007, 506-514.
- [John, 06] John, A.; Seligmann, D. (2006): Collaborative Tagging and Expertise in the Enterprise, In *Proc. 15th Int. Conf. on World Wide Web, Edinburgh, Scotland 2006*. ACM Press, New York, NY, 2006.
- [Kautz, 97] Kautz, H.A., Selman, B., Shah M.A.: Referral Web: Combining Social Networks and Collaborative Filtering, In *ACM* 40/3, 1997, 63-65.
- [Kessler, 63] Kessler, M. M.: Bibliographic Coupling between Scientific Papers, In *American Documentation*, 16/3, 1963, 14, 10-25.
- [Knautz, 10] Knautz, K., Soubusta, S., Stock, W.G.: Tag clusters as information retrieval interfaces, In *Proceedings of the 43th Annual Hawaii International Conference on System Sciences (HICSS-43)*, IEEE Computer Society Press, 2010.
- [McAfee, 06] McAfee, A.P.: Enterprise 2.0: The Dawn of Emergent Collaboration, In *MIT Sloan Management Review*, 47/3, 20-28.
- [Panke, 08] Panke, S.; Gaiser, B.: Nutzerperspektiven auf Social Tagging – Eine Online Befragung, 2008, www.e-teaching.org/didaktik/recherche/goodtagsbadtags2.pdf.
- [Peters, 09] Peters, I.: *Folksonomies: Indexing and Retrieval in Web 2.0.*, De Gruyter, Saur, München, 2009.

[Peters, 08] Peters, I.; Stock, W.G.: Folksonomies in Wissensrepräsentation und Information Retrieval, In *Information - Wissenschaft & Praxis*, 59/2, 2008, 77-90.

[Shardanand, 95] Shardanand, U.; Maes, P.: Social Information Filtering: Algorithms for Automating "Word of Mouth", In *Proc. Human Factors in Computing Systems*, Denver, Colorado, USA 1995, 210-217.

[Waltrop, 08] Waldrop, M.M.: Science 2.0 - Is open access science the future? In *Scientific American*. 2008, <http://www.sciam.com/article.cfm?id=science-2-point-0>.

[Wasserman, 94] Wasserman, S.; Faust, K.: *Social Network Analysis: Methods and Applications*, Cambridge University Press, Cambridge, 1994.

[Wenger, 00] Wenger, E.: *Communities of Practice and Social Learning Systems*, In *Organisation*, 7/2, 2000, 225-246.

[Wenger,Snyder, 00] Wenger, E., Snyder, W.: *Communities of Practice? The Organizational Frontier*, In *Harvard Business Review*, 78/1, 2000, 139-145.

Semantic Methods to Capture Awareness in Business Organizations

Marcel Blattner

(Laboratory for Web Science, University of Applied Science, Brig, Switzerland
marcel.blattner@ffhs.ch)

Eldar Sultanow

(University of Potsdam, Germany
eldar.sultanow@wi.uni-potsdam.de)

Abstract: In multifarious offices, where social interaction is necessary in order to share and locate essential information, awareness becomes a concurrent process that amplifies the exigency of easy routes for personnel to be able to access this information, deferred or decentralized, in a formalized and context-sensitive way. Although the subject of awareness has immensely grown in importance, there is extensive disagreement about how this transparency can be conceptually and technically implemented. This paper introduces an awareness model in order to visualize and navigate such information in multi-tiers using semantic networks, and Web3D. To support this concept we introduce two different algorithms. The first algorithm is able to guide individuals to relevant information and topics. The second one is able to infer hidden groups (clusters) in a large company network, representing various communication channels between individuals. Both algorithms produce very promising results.

Keywords: Distributed organizations, collaboration, visualization, semantic networks, hypergraphs, spectral clustering, random walk

Categories: M.6, M.7, H.3.1

1 Introduction

The principle motivation for this article lies in resolving the problem of major disagreement on how to capture awareness [Gross, 1998]. Awareness is an integral CSCW (computer Supported Cooperative Work) research component, which [Dourish, 1992] defines it as follows: "...awareness is an understanding of the activities of others, which provides a context for your own activity."

There is a majority consensus on the use of semantic networks in order to portray objects including their relations to each other. A concrete implementation of semantic networks is Topic Maps (TM). A Topic Map consists of Topics, Associations and Occurrences (the so-called TAO principle). Topics illustrate things that exist in reality, which are connected to each other through Associations in their relationship. Occurrences are references to further information on Topics in external documents. The informational content is not included in the Topic Map itself.

In the course of this contribution a layered model for capturing RWA will be initially defined. To this end, collaboration data will be collected and finally evaluated during the final step, the network generation. Figure 1 shows the organization of this article.

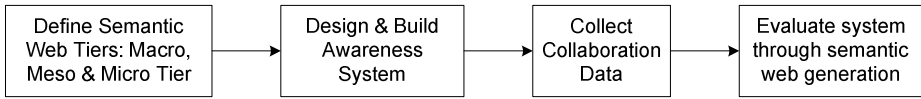


Figure 1: Procedure for implementing global Awareness with Semantic Networks

2 Three Tiers of Awareness

The model distinguishes three presentation layers, which all serve as a type of detail:

- World view (macro view): Core members of the global network and channels between them;
- Location of view (meso view): Local offices, located partners and relevant site-related infrastructure;
- View of an organization unit (micro view): workplace, roles, responsibilities and artifacts.

Personnel and activities are specifically presented to particular cases at each corresponding layer. Entities in the micro view (roles) are atomic. The elements of a layer are wired in a semantic network. An element may, in turn, be described again by elements of a semantic network in a subordinate detail [Sultanow, 2010].

2.1 Macro & Meso View

The macro view displays the locations of the core members, including their connections and available channels between these locations. It shows topics such as engineering offices and testing divisions overseas with a transfer of artifacts.

The second presented layer provides a detailed view of individual sites. It lists those sites and channels that are only noteworthy for establishments of network development at any one particular regional site. These include agencies, suppliers and depots, which are only interested in this particular regional site to implement and maintain its work. For a detailed discussion on macro and meso view along with an evaluation of requirements and benefits in business organizations, see [Sultanow, 2010].

2.2 Micro View

The third and lowest level is semantically linked to the places of employment, positions, roles and artifacts. This level details the view of individual organizational units. It further displays the principle as well as all of the available channels. Jobs are associated with artifacts (documents), whereby job descriptions or access rights act as additional information, which can be complemented in the form of occurrences.

As a topic people are assigned to their according jobs, positions and roles. Links may be between jobs, positions, given roles and separate actors. Actors have the ability to use the channels that are visually available in the macro, meso and micro views. When they are in the relevant period of use in any one given channel, then they

will be visualized. Additional information about the current activity will then be treated as an occurrence, and suitably displayed.

Activities are always addressed by at least one actor and are treated as Topics. The visualization not only show those as directly neighboring objects of the involved actors, but also at the depicted connection lines that offer the channel for this activity. Topics, and in particular, activities, may vary according to their temporal occurrence and can be faded in and out. This provides an opportunity to visualize temporal relationships.

Figure 2 shows the structure of a business unit in a Micro View. Two view-types can be made out, a static and dynamic view [Sultanow, 2010]. The static view illustrates employees, roles and artifacts. The dynamic view serves to show how actors interact with each other. This could be, for example, a phone call or a sent fax.

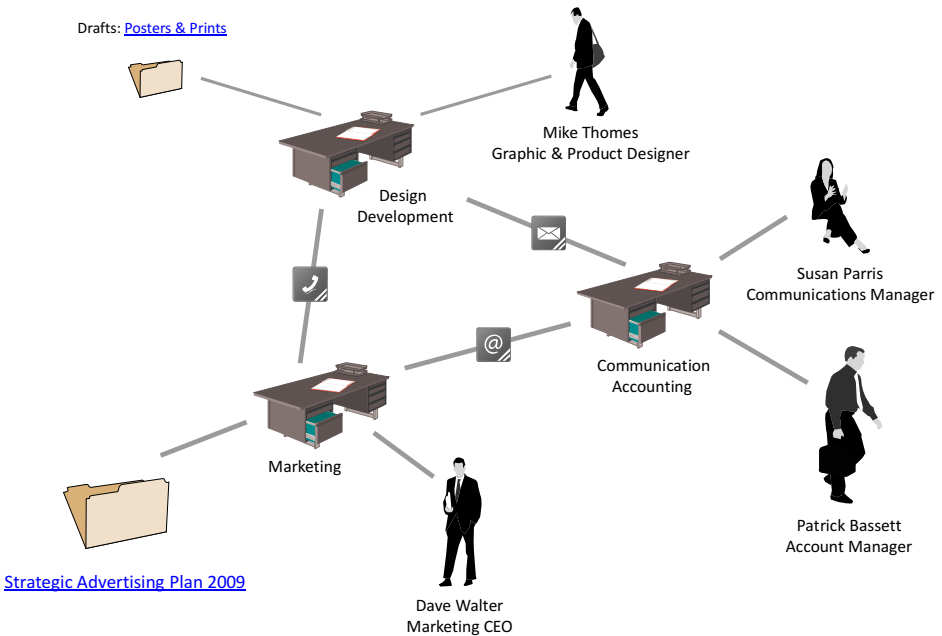


Figure 2: Semantic Network showing employees, artifacts within an institution (static view).

3 Collection of Collaboration Data

Collaboration data are very useful to infer the ‘true’ information channels in large organizations. Information, based on real communication channels is useful in optimizing processes, team building and detecting redundancies. There are various sources for such collaboration data: internal blogs, emails, Instant Messaging (IM) logs and others. Inferred data may then contain knowledge on: “who is the expert in what area” and “who is asking for what”. Methods and technologies described in this section allow setup of a system, where organization members are able to find

information and experts in an efficient way. Moreover, the presented methods allow people to cluster in groups with similar interests/questions, and to summarize similar objects/information in groups, where the similarity is intrinsically extracted from the data. This means: people can be grouped according their real communicational behavior and similar objects/information in a group is perceived as related concepts by organization members. The raw inferred information can be enriched by extracting Meta Data from structured information stored in databases or archives.

The process of data accumulation in such environments is mainly based on Data Mining and Natural Language Processing techniques.

4 System Evaluation

To illustrate a possible procedure, firstly the technical-mathematical concepts are introduced. Then two different cases are investigated:

- a) Query-Answer inference (extracting information from communications systems)
- b) Cluster inference (e.g. grouping according to role, skills and interests)

Mathematical concepts can be described as follows: Going forward, the assumption is made that relevant data has already been extracted from various channels. An efficient representation of an 'Information-Human' network is a hypergraph. A hypergraph $G(V,E)$ is a finite set V of vertices, together with a finite multiset E of hyperedges, which are arbitrary subsets of V . The incidence matrix H of a hypergraph $G(V,E)$ with $E = \{e(1),e(2),\dots,e(m)\}$ and $V = \{v(1),v(2),\dots,v(m)\}$ is the $m \times m$ matrix with $h(ij) = 1$ if $v(j)$ in $e(i)$ and 0 otherwise. Such a hypergraph can be visualized as shown in Figure 3.

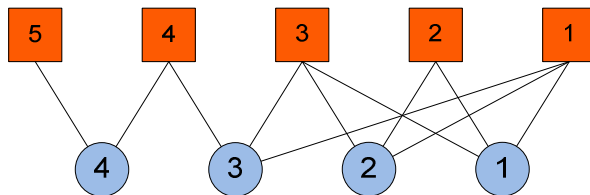


Figure 3: Hypergraph - Squares represent hyper vertices (topics) and circles represent hyper edges (people).

Red squares are the hyper vertices and represent topics or information. The blue circles represent people. In the hypergraph framework they are represented as hyperedges. Note: each edge connects more than two nodes. The interpretation of the connections is context dependent: they may represent people's special interests with regard to specific information or they may show who is the expert in what topic (information) or even who 'owns' what information. For example: node 1 (blue) is expert in topic 1, 2, 3 (red).

For instance, in 'case a' a relevant question related to the 'Information-Human' network (Figure 2) may be: if somebody is interested in information 4 and 2, what are

the related topics to those? The presented technique to answer this question is based on a random walk model on hypergraphs. The calculation for an ordered ranking list, which consists of relevant concepts/information, requires a propagation matrix P . This matrix is defined as follows:

$$P(a,b) = [1 - \delta(a,b)] \frac{1}{k(a)} \sum_i [w(i)h(a,i)h(i,b)] \quad \text{with} \quad k(a) = \sum_{b,i} [w(i)h(a,i)h(i,b)]$$

as the normalization constant. $\delta(a,b)$ is the Kronecker Delta and $w(i)$ are the connection weights, $h(a,i)$ denotes the (a,i) the incidence matrix element.

Then, the algorithm consists of four steps [Blattner, 2010]:

- Forward propagation: $F(i) = P' \chi_i$
- Backward propagation: $B(i) = P \chi_i$
- Final rank: $f(i) = F(i) * B(i)$
- Sort $f(i)$ in descending order

P' is transposed from the propagation matrix P , while $*$ denotes the element-wise multiplication of two vectors and χ_i is the seed or starting information/topic (the one which is fixed to look for related concepts). To make things more clear, assume the simple case where somebody wants to infer related concepts to topic 4. Using the above algorithm and the outlined network, the final ranking list is: $f = [5, 1, 3, 2]$, (topic 4 excluded). We see that topic 5 is the most related concept. This makes sense in the above network setup, since topic 4 is only maintained by user 4 and user 3. Moreover, user 4 is elusive, only being connected to the crowd through object 4. Therefore user 4 has the strongest influence and because he is also expert in topic 5, we can expect that topic 5 is the topic that is most related to topic 4. In this simple setup we used only one seed. The algorithm reveals its real power, when choosing different seeds at the same time - mixing influences from different nodes.

To illustrate the potential of the second case, 'case b', we use a spectral graph theory [Chung, 1997] based approach. This technique is reported as superior compared to other methods like K-Means or ordinary PCA [Ding, 2001]. Spectral based methods have been applied in many fields like bio-informatics, recommender systems and image recognition. The clustering mechanism consists of the following steps:

- Project the hypergraph to a unipartite graph $G \rightarrow$ adjacency matrix A
- Calculate the corresponding Laplacian Matrix $L = D - A$, D is diagonal node degree Matrix
- Calculate the eigendecomposition from L
- Embed the first k non-trivial eigenvector in a k -dimensional metric (Euclidian) space
- Infer partition in this space

Here we only show how this technique is able to find network partitions (clusters), based only on the projected network structure. The projection is problematic and exceeds the scope of this paper and is omitted here.

To demonstrate the algorithm's ability to find clusters, we use a subset of the email corpus from the Enron dataset, prepared by [UC Berkeley]. Each email in the dataset is labelled with at least one of eight possible topics. In order to perform the spectral clustering method we need to calculate the adjacency matrix A . Two emails 'i' and 'j' have a weighted connection, if they are similar. A standard procedure in Natural Language Processing (NLP) has been taken to calculate similarities between each pair of emails by the use of a vector space model [Manning, 2000]. A total of 834 emails were used to group them applying the generated adjacency matrix A and the described spectral clustering algorithm. The result is shown in Figure 4. The first three non-trivial eigenvectors of the Laplacian matrix L span the metric space for the clustered emails. We observe 6-8 separated groups (clusters).

Afterwards Berkley's label-based cluster has been compared to our NLP-based cluster. Since emails have in general more than one label in Berkley's Enron dataset, we count the highest weighted label as the significant one. To be precise, it has been checked, how many emails in one of our cluster belong to the appropriate Berkley's group. Here we observed an average matching of 80% for all 834 investigated emails. In other words, the probability that an email has been classified the same as by Berkley is 80%.

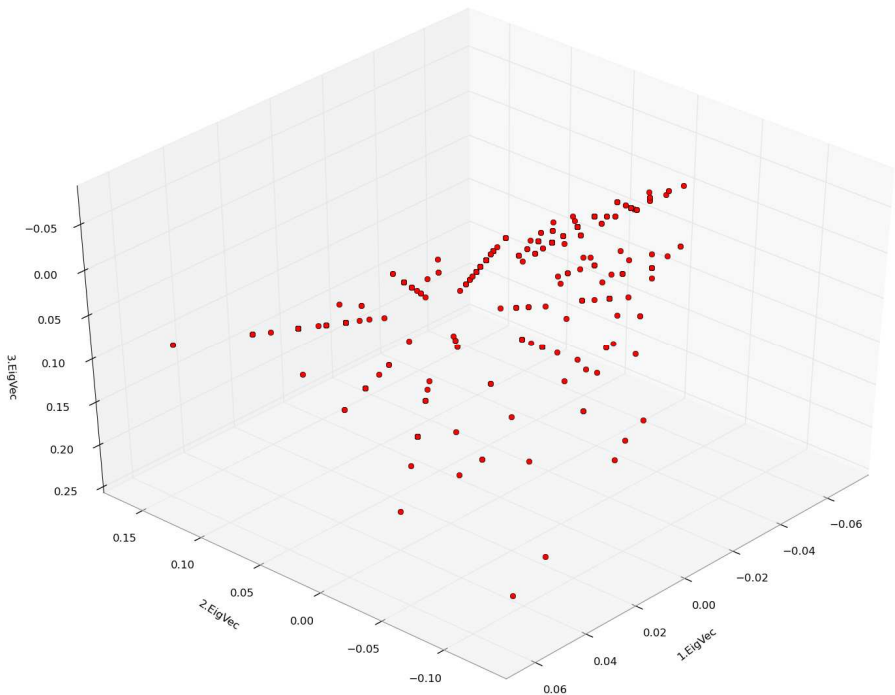


Figure 4: Clustered emails from the Enron Dataset projected in the eigenspace spanned by the first three non-trivial eigenvectors of the Laplacian matrix.

5 Conclusions

The conception in this study shows a proven method for capturing Awareness. The above methods depend on the quality of the accumulated data. That is, on the process of data accumulation as a function of space and time. The proposed methods allow visualization and optimization of processes in order to gain insight into information and knowledge flows in large organizations, one has to conduct experiments and elaborate on the data accumulation processes. This process consists of extracting information from various communication channels. The main techniques are based on Natural Language Processing and Data Mining. The methods used in this study proved powerful and efficient in the following data-capture methodologies: Query-Answer inference and Clustering detection.

References

[Blattner, 2010] Blattner, M: "B-Rank: A top N Recommendation Algorithm", IMCIC Conference on Complexity, Cybernetics and Informatics, Florida USA, 2010.

[Chung, 1997] Chung, F.: Spectral Graph Theory, American Mathematical Society Providence, RI, 1997.

[Ding, 2001] Ding, C., He, X., Gu, H., Simon, H.: A min-max cut algorithm for graph partitioning and data clustering, in: Proceedings of the first IEEE International Conference on Data Mining (ICDM), Washington, DC, USA 2001, pp. 107-114.

[Gross, 1998] Gross, T.: Von Groupware zu GroupAware: Theorie, Modelle und Systeme zur Transparenzunterstützung, German CSCW Congress: Groupware und organisatorische Innovation. September 1998.

[Dourish, 1992] Dourish, P., Bellotti, V.: Awareness and Coordination in Shared Workspaces, Proceedings of the 1992 ACM conference on Computer-supported cooperative work, ACM, 1992.

[Sultanow, 2010] Sultanow, E.; Weber, E.: Multi-Tier Based Visual Collaboration - A Model using Semantic Networks and Web3D, WEBIST 2010 - 6th International Conference on Web Information Systems and Technologies, 2010.

[UC Berkeley] http://bailando.sims.berkeley.edu/enron_email.html.

Ontology based experience Management for System Engineering Projects

Olfa Chourabi

(CEDRIC Laboratory, Sempia team, Paris, France/ Riadi Laboratory, La Manouba, Tunisia
Olfa.chourabi@voila.fr)

Yann Pollet

(CEDRIC Laboratory, Sempia team, Paris, France
pollet@cnam.fr)

Mohamed Ben Ahmed

(Riadi Laboratory, La Manouba, Tunisia
Mohamed.benahmed@riadi.mu.tn)

Abstract: System Engineering (SE) is becoming increasingly knowledge intensive. Knowledge Management is recognized as a crucial enabler for continuous process improvement in engineering projects. Particularly, capitalization and sharing, of knowledge resulting from experience feedback are valuable asset for SE companies. In this paper, we focus on the formalization of engineering experience aiming at transforming information or understanding gained by projects into explicit knowledge. A generic SE ontological framework acts as a semantic foundation for experience capitalization and reuse. This framework is operationalized with Conceptual Graphs formalism and applied to a transport system engineering use case.

Keywords: Knowledge reuse, Information Search and Retrieval, Systems and Software, Reusable Software, Artificial Intelligence

Categories: M.8, H.3.3, H.3.4, D.2.13, I.2

1 Introduction

System Engineering (SE) is an interdisciplinary approach to enable the realization of successful systems. It is defined as an iterative problem solving process aiming at transforming user's requirements into a solution satisfying the constraints of: functionality, cost, time and quality. [Meinadier, 2000]

System engineering process begins at a high level of abstraction and proceeds to higher levels of detail, until a final solution is reached. This process is usually composed of the following seven tasks: State the problem, Investigate alternatives, Model the system, Integrate, Launch the system, Assess performance, and Re-evaluate. These functions can be summarized with the acronym SIMILAR: State, Investigate Model, Integrate, Launch, Assess and Re-evaluate. [Bahill, 1998]

Transitions between these tasks stem from decision making processes supported both by generally available domain knowledge and experience. Engineers usually

integrate diverse sources and kinds-of information about system requirements, constraints, functions, and extant technology. In doing so, they make certain assumptions and develop criteria against which alternatives are evaluated for suitability. Unfortunately, much of this process is implicit, making later knowledge reuse difficult if not impossible. Valuable design knowledge situated in the context of a concrete problem and solution is usually lost. The analysis of current engineering practices and supporting software tools reveals that they adequately support project information exchange and traceability, but lack essential capabilities for knowledge management and reuse [Brandt, 2007]. The recent keen interest in ontological engineering has renewed interest in building systematic, consistent, reusable and interoperable knowledge models [Kitamura, 2006]

Aiming at representing engineering knowledge explicitly and formally, and sharing and reusing this knowledge among multidisciplinary engineering teams, our work builds upon ontological engineering as a foundation for capturing implicit knowledge and as a basis of knowledge systematization.

The research presented in this paper is a follow-up of our prior work involving the proposition of a generic ontological framework for system engineering knowledge modeling [Chourabi,2008]. The framework sets the fundamental concepts for a holistic System Engineering knowledge model involving explicit relationships between process, products, actors and domain concepts.

Here, we focus on problem resolution records during project execution. We address this problem through the use of the formal framework for capturing and sharing significant know-how, situated in projects context.

The main contributions of this paper are:

- Knowledge capitalization model : we introduce the concept of Situated Explicit Engineering Knowledge (SEEK) as a formal structure for capturing problem resolution records and design rationale in SE projects
- Knowledge sharing model: we propose a semantic activation of potential relevant SEEK(s) in an engineering situation.

Both models are illustrated in a transport system engineering process.

This paper is organized as follows: the next section presents a motivating research example. Section 3 analyses related works concerning ontological engineering in SE. In section 4, we detail the formal approach for Situated Explicated Engineering Knowledge capitalization and sharing. Section 5, illustrates our proposal in a transport system engineering process.

2 Background and motivation

In this section, we focus on decisions related to component allocation choices and parameter configuration phase in SE process. In this setting, the main objective is to find configurations of parts that implement a particular function. Practically, system engineer team must consider various constraints simultaneously, the constituent part of a system are subject to different restrictions, imposed by technical, performance, assembling and financial considerations, to name just a few. Combinations of those

items are almost countless, and the items to be considered are very closely related. Figure 1, shows the intricate interplay of constraints in a system engineering process.

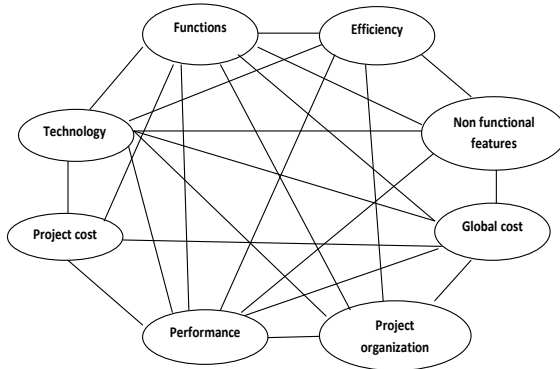


Figure 1: *System Engineering process as a multi-objective decision problem*

As an example, we consider a typical component allocation process of a transportation sub system: an automated wagon.

We assume that the system's functional view comprises the following functions: capture speed, capture position, control movement, propel, break, and contain travelers.

These functions should be allocated to physical components to configure an engineering solution. Allocation process can be one to one or many to one. In addition, Physical component choice is constrained with non functional requirements (or soft goals) such as: system performance, facility, acceleration limitation, comfort, and reliability.

The global requirements are traded-off to find the preferred alternatives solutions. An intricate interplay usually exists among alternatives. For example, the functions speed capture and position estimation choosing *inertial station* that delivers the speed as well as the position, for implementing the function *speed capture* would restrict the engineering choices to exclude specific transducers.

In practice, these choices are scattered in a huge mass of engineering documents, and thus not explicitly modelled. Engineers usually wish to adapt past solutions to new project context. In this context, a machine readable representation of engineering decision trace could enable effective reuse of previous decisions. To address these issues, we draw upon ontological engineering to provide a systematic model for engineering background knowledge and we use it as a foundation for describing engineering choices emanating from previous engineering projects.

3 Ontological Engineering and System Engineering

Ontologies are now in widespread use as a means formalizing domain knowledge in a way that makes it accessible, shareable and reusable [Darlington, 2008]. In this

section, we review relevant ontological propositions for supporting engineering processes.

In the knowledge engineering community, a definition by Gruber is widely accepted; that is, “explicit specification of conceptualization” [Gruber,1993], where conceptualization is “a set of objects which an observer thinks exist in the world of interest and relations between them”. Gruber emphasizes that ontology is used as agreement to use a shared vocabulary (ontological commitment).

The main purpose of ontology is, however, not to specify the vocabulary relating to an area of interest but to capture the underlying conceptualizations. [Gruber,1993] [Uschold, 1996] identifies the following general roles for ontologies:

- Communication between and among people and organizations.
- Inter-operability among systems.
- System Engineering Benefits: ontologies also assist in the process of building and maintaining systems, both knowledge-based and otherwise.

In particular,

- o Re-Usability: the ontology, when represented in a formal language can be a re-usable and/or shared component in a software system.
- o Reliability: a formal representation facilitates automatic consistency checking.
- o Specification: the ontology can assist the process of identifying a specification for an IT system.

One of the deep necessities of ontologies in SE domain is, we believe, the lack of explicit description of background knowledge of modelling. There are multiple options for capturing such knowledge; we present a selection of representative efforts to capture engineering knowledge in ontologies.

[Lin et al, 1996] propose an ontology for describing products. The main decomposition is into parts, features, and parameters. Parts are defined as a component of the artifact being designed". Features are associated with parts, and can be either geometrical or functional (among others). Examples of geometrical features include holes, slots, channels, grooves, bosses, pads, etc. A functional feature describes the purpose of another feature or part. Parameters are properties of features or parts, for example: weight, color, material. Classes of parts and features are organized into an inheritance hierarchy. Instances of parts and features are connected with properties component of, feature of, and sub-feature of.

[Saaema et al, 2005] have proposed a method of indexing design knowledge that is based upon an empirical research study. The fundamental finding of their methodology is a comprehensive set of root concepts required to index knowledge in design engineering domain, including four dimensions:

- The process description i.e. description of different tasks at each stage of the design process.
- The physical product to be produced, i.e. the product, components, sub-assemblies and assemblies.
- The functions that must be fulfilled by a particular component or assembly.

- The issues with regards to non functional requirement such as thrust, power, cost etc.

[Mizoguchi, 2004] has developed a meta-data schema for systematizing engineering products functionalities. This schema was operationalized using Semantic Web languages for annotating engineering design documents.

An ontology that supports higher-level semantics is Gero's function-behaviour-structure (FBS) ontology [S'gero et al, 2006]. Its original focus was on representing objects specifically design artifacts. It was recently applied to represent design processes.

For ontology reusability, hierarchies are commonly established; [Borst et al, 1997] have proposed the PhysSys ontology as a sophisticated lattice of ontologies for engineering domain which supports multiple viewpoints on a physical system.

Notwithstanding the promising results reported from existing research on SE ontologies, the reported ontological models don't provide a holistic view of the system engineering domain. They are either too generic or only focus on specific aspects of system representation.

As development of ontologies is motivated by, amongst other things, the idea of knowledge reuse and sharing, we have considered a coherent reuse of significant ontological engineering work as complementary interrelated ontologies corresponding to the multiple facets of system engineering processes. [Chourabi, 2008]

In the next section, we briefly remind our proposed ontological framework for SE knowledge modeling and we show how it is applied for experience capitalization and sharing.

4 Situated explicit engineering knowledge capitalization and sharing

Our generic ontological framework for system engineering knowledge modeling has been detailed in [Chourabi, 2008]. The main objective was to provide a holistic view on system engineering discipline through a layered ontological model covering engineering domain knowledge i.e (system context, system functions and system organic components) and organizational knowledge i.e (project processes, actors and project resources).

In this paper, we study the potential application of this framework for describing SE project experiences. We address the dynamic aspect of engineering process with the aim to capture implicit knowledge, decision and argumentation, in order to provide relevant knowledge items to system engineers.

To this end, we introduce the concept of SEEK : Situated Explicit Engineering Knowledge to model formally engineering situation, engineering goals, engineering alternatives and decisions as well as their mutual relationships. These dimensions are formalized as a set of semantic annotations defined over the ontologies defined in our framework.

A semantic annotation is defined as a set of ontological concepts and semantic relations instances. We use semantic annotation to express a particular modeling choice or a particular engineering situation. Figure 2, shows an example of semantic annotation defined over a system organic component ontology fragment.

The association of a formal knowledge description to the engineering artifact (e.g.: requirement document) in figure 2, allows to retrieve it by a semantic search. Semantic search retrieves information based on the types of the information items and the relations between them, instead of using simple String comparisons [Brandt, 2007].

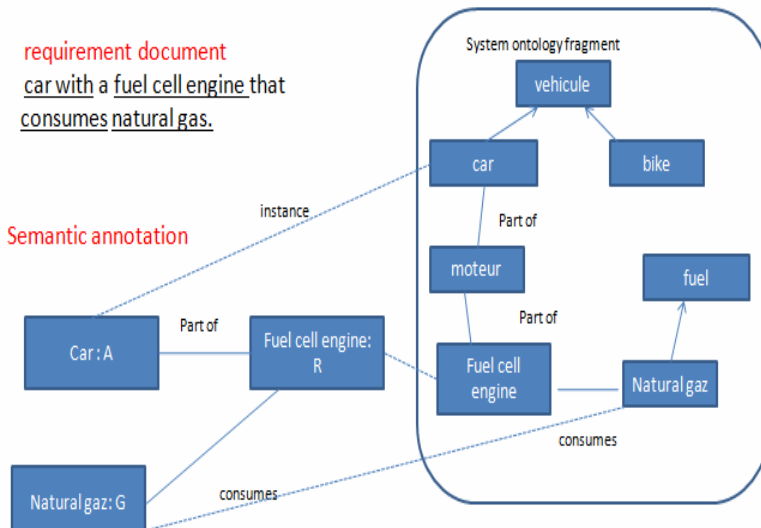


Figure 2: Relationships between semantic annotation, ontology and engineering product

To provide operational use of SEEK (s), must rely on solid theoretical foundations requiring an appropriate representation language, with clear and well-defined semantics. We choose conceptual graphs [Sowa, 1983] as a representation language. The attractive features of conceptual graphs have been noted previously by other knowledge engineering researchers who are using them in several applications [Chein et al, 2005][Corby et al., 2006][Badget et al,2002]. Conceptual graphs are considered as a compromise representation between a formal language and a graphical language because it is visual and has a sound reasoning model. In the conceptual graph (CG) formalism [Sowa, 1983], the ontological knowledge is encoded in a support. The factual knowledge is encoded in simple conceptual graphs. An extension of the original formalism [Badget et al, 2002] denoted “nested graphs” allows assigning to a concept node a partial internal representation in terms of simple conceptual graphs.

To represent SEEK (s) in conceptual graph formalism we rely on the following mapping:

- The set of system engineering ontologies are represented in a conceptual graph support
- Each semantic annotation is represented as a simple conceptual graph.

– A SEEK is a nested conceptual graph, where the concepts engineering situation, engineering goal, alternative solution, engineering solution are described by means of nested CG. This generic model has to be instantiated each time an engineering decision occurs in a project process.

To share the SEEks, we aim to provide a proactive support for knowledge reuse. In such approaches [Abecker et al., 1998] queries are derived from the current Work context of application tools, thus providing reusable product or process knowledge that matches the current engineering situation.

Finding a matching between an ongoing engineering situation and goal and a set of capitalized SEEK(s) relies on a standard reasoning mechanism in conceptual graphs: the projection operator.

Let's remind the projection operation as defined by [Mugnier and Chein, 1992]

Mugnier and Chein Projection

Given two simple conceptual graphs G and H , a projection from G to H is an ordered pair of mappings from (RG, CG) to (RH, CH) , such that:

- For all edges rc of G with label i , $\Pi(r) \Pi(c)$ is an edge of H with label i .
- $\forall r \in RG, \text{type}(\Pi(r)) \leq \text{type}(r); \forall c \in CG, \text{type}(\Pi(c)) \leq \text{type}(c)$.

There is a projection from G to H if and only if H can be derived from G by elementary specialization rules.

Using the projection, the reasoning system is able to find not only descriptions of experiences that are annotated by exact concepts and relationships but also those annotated by subtypes of these concepts. Besides, to search with imprecise and/or incomplete experiences or to answer a vague query, approximate projections [Corby, 2006] can be used. We also work on an extension to conceptual graphs projection in order to take into account partial (part-of) engineering situation matching. Our ultimate goal consists in defining an approximate situation matching, having as result a lattice (partial ordering) on the SEEK (s) according to their degree of relevance for the current engineering situation facets.

5 Case study

This section presents a case study of ontology based modeling for SEEks. The application domain is automatic transport sub system: the automated wagon described in the motivation section.

To illustrate the use of the proposed ontological framework to define a Situated Engineering Knowledge, we use the ontology excerpt depicted in figure 3.

This ontology formalizes three domain engineering facets :

- Contextual facet: it formalizes transport systems typology , system features such as physical features e.g. (weight), functional features e.g. (path type for the transport system).
- Functional facet: it formalizes transport system function as well as their subsumption relations.
- Organic facet: it formalizes the physical components and their relationships such as “part of”, “is a”, “communication relations”.

This ontology is operationalized with conceptual graph support i.e a concept type lattice and a relation type lattice [Sowa, 1983].

The SEEK capitalization model is operationalized with a nested conceptual graph, and instantiates concepts and relations from the support c.f figure 4. In our use case we consider the following nesting dimensions:

- Engineering situation: a system engineer aims to configure a physical solution for:
 - the functions capture speed and capture position
 - an automated wagon that should operate in a complex path
- Engineering goal: functional allocation
- Engineering alternatives : inertial station or GPS component
- Engineering decision: GPS component is more suitable, and provides better precision for complex path.

If we consider a new engineering situation, described by the same contextual ontology, and aiming at allocating the function “capture” for an automated wagon. The capitalized SEEK is matched with this engineering situation by taking the specialization relation between ontological concepts into account.

We use the Cogui¹ platform for ontology editing, SEEK capitalization and sharing

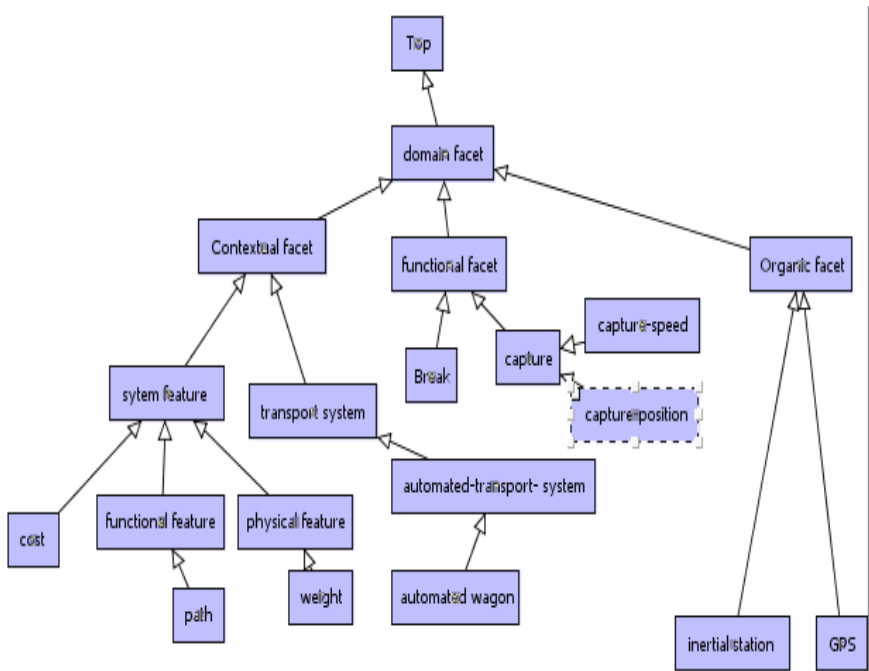


Figure 3: Transport system ontology excerpt

¹ www.lirimm.fr/cogui/

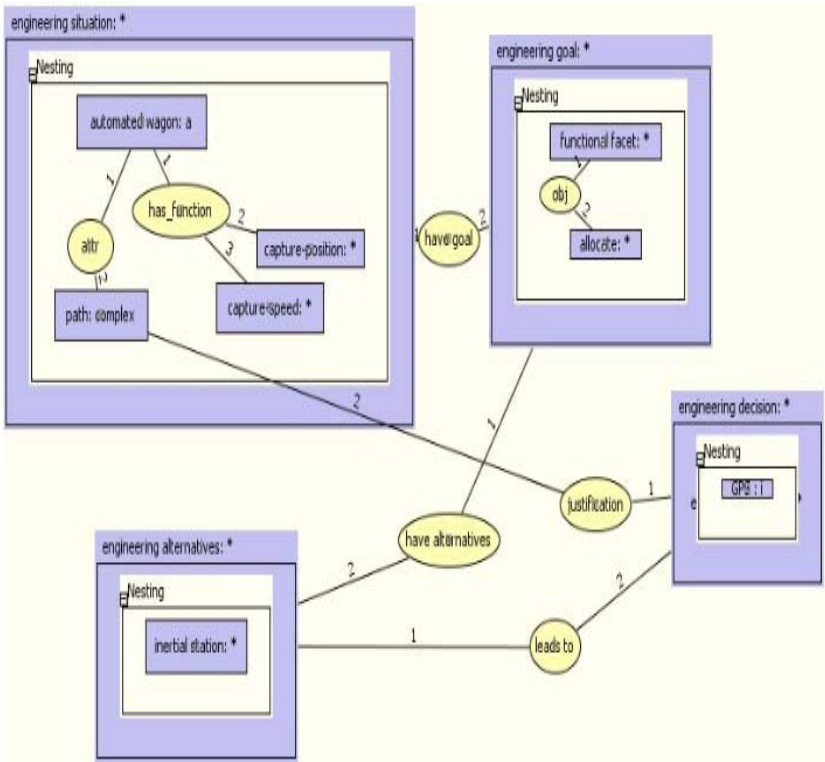


Figure 4: SEEK instantiation for an automated wagon.

6 Conclusion

System engineering processes implies the management of information and knowledge and could be considered as a knowledge production process. In this paper we presented our ongoing work aiming to validate our proposed ontology-based framework for engineering experience capitalization and reuse. A principal strand of future research is the application of this modelling framework in the context of an engineering organization to trigger further improvement. We plan also to use the same framework for capturing “best practices” knowledge. We are investigating the way to build up a knowledge management integration interface for existing system engineering support tools.

References

[Abecker et al., 1998] Abecker, A., Bernardi, A., Hinkelmann, K., Kühn, O., & Sintek, M. Toward a technology for organizational memories. *IEEE Intelligent Systems*, (1998)13(3), 40–48.

- [Badget et al., 2002] J.F. Baget, M.-L. Mugnier, Extensions of simple conceptual graphs: the complexity of rules and constraints, *Journal of Artificial Intelligence Research (JAIR)* 16 (2002) 425–465.
- [Bahill, 1998] A. T. Bahill and B. Gissing, Re-evaluating systems engineering concepts using systems thinking, *IEEE Transaction on Systems, Man and Cybernetics, Part C: Applications and Reviews*, 28 (4), 516-527, 1998
- [Borst et al, 1997] Borst, P. Akkermans, H., and Top, J, *Engineering Ontologies*, *Human-Computer Studies*, 46(2/3), 1997, pp. 365-406.
- [Brandt, 2007] Sebastian C. Brandt, Jan Morbach, Michalis Miatidis ,Manfred Theißen, Matthias Jarke , Wolfgang Marquardt. An ontology-based approach to knowledge management in design processes. *Computers and Chemical Engineering* (2007).
- [Chein et al., 1992] CHEIN M. & MUGNIER M.-L. (1992). Conceptual Graphs : Fundamental Notions. *Revue d'Intelligence Artificielle*, 6(4), 365–406.
- [Chein et al, 2005] D. Genest, M. Chein, A Content-search Information Retrieval Process Based on Conceptual Graphs. *Knowledge And Information Systems*, vol. 8, no. 3, Springer, 2005, pp. 292–309.
- [Chourabi, 2008] O.CHOURABI, Y.POLLET, M.BENAHMED. Knowledge Modeling Framework for System Engineering projects. Second IEEE International Conference on Research Challenges in Information Science (RCIS). Marrakech, Maroc, juin 2008.
- [Corby et al., 2006] O. Corby, R. Dieng-Kuntz, C. Faron-Zucker, F. Gandon, Searching the Semantic Web: approximate query processing based on ontologies, *IEEE Intelligent Systems Journal* 21 (1) (2006) 20–27.
- [Darlington et al, 2008] Darlington, M. & Culley, S. Investigating Ontology Development for Engineering Design Support. *Advanced Engineering Informatics*, 22(1): 112-134, 2008.
- [Gruber, 1993] Gruber, T. R., What is an Ontology?, <http://www.wksl.stanford.edu/kst/what-is-an-ontology.html>.
- [Kitamura, 2006] Yoshinobu Kitamura. “Roles Of Ontologies Of Engineering Artifacts For Design Knowledge Modeling”. In *Proc. of the 5th International Seminar and Workshop Engineering Design in Integrated Product Development. (EDIProD 2006)*, 21-23 September 2006, Gronów, Poland, pp. 59-69, 2006C.
- [Lin et al, 1996] J. Lin, M.S. Fox, T. Bilgic, A Requirement Ontology for Engineering Design, in: *Proceedings of the Third International Conference on Concurrent Engineering*, 1996, pp. 343–351.
- [Meinadier, 2000] J.Meinadier. *Le métier d'intégration de systèmes*. Hermes Science Publications, décembre 2002.
- [Mizoguchi et al, 2004] Yoshinobu Kitamura, Riichiro Mizoguchi: *Ontology-Based Functional-Knowledge Modeling Methodology and Its Deployment*. EKAW 2004: 99-115
- [Saema et al, 2005] Ahmed, S., Kim, S., Wallace, K. M., A Methodology for Creating Ontologies for Engineering Design, In *Proc. Of ASME 2005 DTM*, 2005, DETC2005-84729
- [S'gero et al, 2006] John s'gero and Udo kannengiesser. A function-behaviour-structure ontology of processes. *Design Computing and Cognition '06*. Part 6,407-422.
- [Sowa, 1984] J.F. Sowa, *Conceptual Structures: Information Processing in Mind and Machine*, Addison-Wesley Publishing Company, Reading, MA, 1984

[Ushold, 1996] M. Uschold, M. Gruninger, Ontologies: principles, methods and applications, Knowledge Engineering Review 11 (2) (1996), June.

Conveying Strategy Knowledge Using Visualization vs. Text: Empirical Evidence from Asia and Europe

Sabrina Bresciani

(University of Lugano (USI), Switzerland
Sabrina.Bresciani@usi.ch)

Martin J. Eppler

(University of St. Gallen (HSG), Switzerland
Martin.Eppler@unisg.ch)

Margaret Tan

(Nanyang Technological University, Singapore
Mtan@ntu.edu.sg)

Klarissa Chang

(National University of Singapore, Singapore
Changtt@comp.nus.edu.sg)

Abstract: In this study we look at an innovative approach to knowledge management, namely the use of graphical representations for conveying a specific type of knowledge. We focus on business strategy and investigate how this type of knowledge can best be communicated by comparing textual and visual representations. Through a controlled experiment we examine the effect of knowledge representation on understanding and recall of participants in Europe and East Asia. The results show that knowledge visualization is superior to text, independent of culture, and that culture does not have a negative mediating role on the reception of knowledge. However, we also find that subjects underestimate the benefits of visual representations of information for building up knowledge in both cultures. We believe that these findings reveal the hidden benefits of visualization for knowledge work. Communicating knowledge with visual formats or representations thus seems a promising, but undervalued practice for international, intercultural contexts.

Keywords: Knowledge communication, Visual representation, Cross-cultural communication, Strategic knowledge visualization, Recall.

Categories: M.0, M.9, H.m

1 Introduction

A key objective of knowledge management is to apply information and knowledge which resides within an organization to achieve a company's goals most efficiently and cost-effectively. Inspired by an increased attention on the use of visualization for improving decision making, this study focuses on a specific knowledge content - regarding business strategies, and on the benefits that visual representations can achieve. The power of knowledge visualization has been identified as its ability to enhance comprehension, to foster problem solving and to ease communication - all

crucial elements for successful implementation [Burkhard, 05; Platts, 04]. The first objective of our study is to evaluate the *reception* of a business strategy in the form of a visual representation compared to a classic PowerPoint-based bullet point text (with identical content). The second objective is to compare these results *across cultures*, as a growing number of companies are operating internationally and thus have to communicate their strategies across different countries. Often organizations employ the same visual representations in various branches that are located in different continents. The novelty of our research lies in the application domain (strategic knowledge communication), in the methodology (experimental), and in the cross-cultural comparison of Asia and Europe.

2 Research Questions and Methodology

The purpose of this study is to answer the following research questions: *Can visualization improve the reception of strategic knowledge compared to text? And is this relationship moderated by culture?* We seek to understand if the format in which we represent knowledge has an impact on its reception, and if culture has a moderating role on the outcomes. We hypothesize an impact of knowledge representation on *understanding* and *recall*, as predicted by the Dual Coding Theory [Paivio, 69]. This theory posits that information is processed through one or two channels: verbal and visual, and when both channels are used, cognitive abilities are enhanced. We therefore aim to extend the application of this theory and findings on the advantages of visualization to knowledge-based domain work.

In our research model, the *independent* variable is the representation modality of knowledge: textual or visual. The *moderating* variable is culture: Europe (Individualistic, Low-context) and East Asia (Collectivistic, High-context) [Hofstede, 01]. The *dependent* variables are understanding and recall. We measure them objectively as the count of correct information units described by the subjects, and then recalled after a distraction task – as evaluated by external coders blind to the hypothesis. In addition we measure them subjectively, through a questionnaire (self-assessment of understanding and remembering).

2.1 Methodology

To assess the impact of visualization compared to text for conveying knowledge in different cultures, we conducted a series of experimental sessions. We compared the results of Europeans and East Asians, exposed to a textual or to a graphic representation of strategic knowledge. In particular, besides the control condition with text, we implemented two treatment conditions with largely different visual forms, in order to be able to discern the effect of visualization in general from the effect of a specific visual format. The experiment follows a 3x2 between group design: 3 forms of knowledge representations and 2 cultures.

In each culture, subjects were randomly assigned to one of three conditions: (1) a control condition with text, or (2) a visualization condition with a linear diagram as background, or (3) a visualization condition with a visual metaphor as background (Fig. 1). The content is a typical business strategy with 21 information units (corresponding to bullet-points). In all conditions the textual information units are

identical; the difference is to be found in the different visualization of the text on the background, and consequently the spatial distribution of information on the page.

The selection of the two visual representations for the treatment conditions aimed at maximizing the difference between the two representations, among all the visual formats available [Eppler, 07], and they had to be typically used in organizational settings. The selected linear diagram is an abstract representation with a linear flow of time, a sequence, from left to right. In the mountain visual metaphor, the information is distributed in a holistic form [Nisbett, 05].

The experiment lasted about 50 minutes: subjects were exposed to one of the representations and were asked (on 7-point Likert scales) several check questions, as well as questions about perceived understanding (a self-assessed measure of how much they feel they have understood the strategy) and perceived recall (how much they feel they can remember about the strategy). Next, they were asked to describe the content of the representation in their own words (to measure understanding, coded as how many correct information units were described). Then the representations were recollected, and for 20 minutes the subjects were given a diversion task which included a short video on an unrelated topic. Finally they were given a plain recall test, where they were asked to write down all they could remember about the strategy. This was coded by counting how many of the original 21 information units were correctly recalled by the subjects.

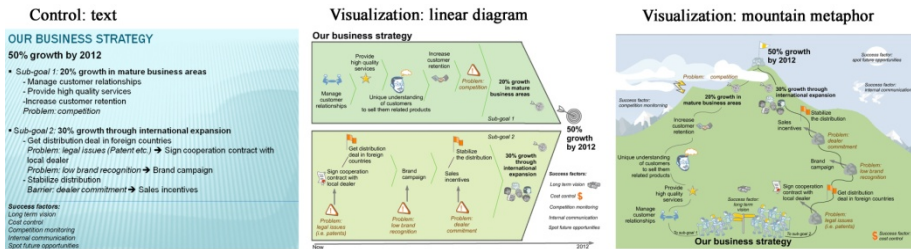


Figure 1: Experimental treatments

3 Results and Analysis

There was a total sample size of 118 participants, 87 from Singapore, and 31 from Switzerland. The mean age was 27 with 5.3 years of work experience; 60 percent of subjects were males. The subjects were part-time and full-time master students. In particular the Asian sample consisted of subjects who lived most of their life in China (31), Singapore (30) and other countries in South East Asia (26). The European sample had subjects who lived most of their life in Switzerland (14), Germany (7), and other European countries (10). The aggregated results of the experiment are shown in Table 1 and Figure 2 that report the mean and standard deviation (SD in parenthesis) of the outcomes for each condition. It can be readily inferred that the visual representation of knowledge has a positive effect on most of the objective outcome variables, compared to text. The textual information is identical in all

conditions: the two visualization treatments only add a visual background, with a consequent different positioning of the information on the surface.

Mean (SD)	Understand.	Recall	Perceived Understand.	Perceived Recall
Text [Control]	9.60 (5.58)	8.44 (3.24)	4.68 (1.49)	4.24 (1.41)
Diagram [Visual 1]	9.71 (4.87)	9.25 (3.90)	4.82 (1.52)	4.08 (1.40)
Metaphor [Visual 2]	11.15 (5.82)	10.06 (3.90)	4.66 (1.45)	3.84 (1.42)

Table 1: Experiment results for all cultures

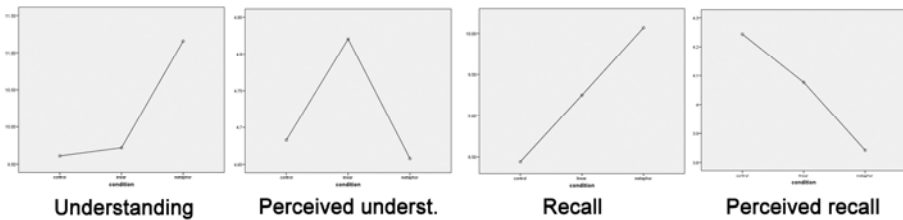


Figure 2: Experiment results for all cultures

For the aggregated results (of all cultures) the *objective understanding* and *recall* was higher when the subjects were exposed to a visual background and in particular to a visual metaphor. For both these objective measures the mountain visual metaphor leads to better performances than the linear diagram. The figure shows a clear mismatch between the *perceived* and the *objective* results, both for *understanding* and for *recall*. Subjects perceived the visual metaphor as the less useful representation format for *understanding*, but the objective measures showed that the opposite was true. For *recall* the results were even more extreme: the effect on the real and the perceived recall were inverse; the subjects presumed that they could remember better when exposed to a textual representation, followed by the linear diagram and only lastly when exposed to the mountain visual metaphor. The objective count of the correct recall elements showed that the opposite was true: the highest rate of recall was achieved by the subjects exposed to the visual metaphor, followed by the diagram and finally by the text. These results clearly show that participants in all cultures underestimated to an enormous extent the benefits of visualization, especially regarding recall.

We then compared the results of the experimental treatments for Europe and East Asia (Tab. 2 and Fig. 3). Subjects exposed to a visual representation have objectively better results in both cultures, but the magnitude of this effect is greater in Europe. Performing a Multivariate Analysis of Variance (MANOVA), we found that Europeans could recall significantly more ($p < .05$) than East Asians. In other words, visualization is more beneficial for Europeans than for East Asians. For the subjective measures of *perceived understanding* and *perceived recall*, the results between the two cultures were not only different in magnitude but also in the direction of the preferences. While Europeans perceived the linear diagram to be greatly better than the other representations for understanding, we found the opposite results for East

Asians. However, none of the cultures had a correct match with the *objective understanding*, which was actually enhanced by the visual metaphor.

Mean (SD)	Culture	Underst.	Recall	Perceived Underst	Perceived recall
Text [Control]	Europe	10.54 (5.71)	8.47 (2.81)	4.27 (1.49)	4.09 (1.57)
	E. Asia	9.26 (5.59)	8.42 (3.45)	4.83 (1.48)	4.30 (1.36)
Diagram [Visual 1]	Europe	11.27 (6.11)	10.70 (4.60)	5.64 (1.02)	3.73 (1.61)
	E. Asia	9.10 (4.26)	8.61 (3.47)	4.50 (1.57)	4.21 (1.31)
Metaphor [Visual 2]	Europe	12.22 (4.54)	12.55 (3.64)	4.44 (1.23)	4.00 (1.50)
	E. Asia	10.82 (6.19)	9.24 (3.68)	4.72 (1.53)	3.79 (1.42)

Table 2: Experiment results comparing Europe and East Asia

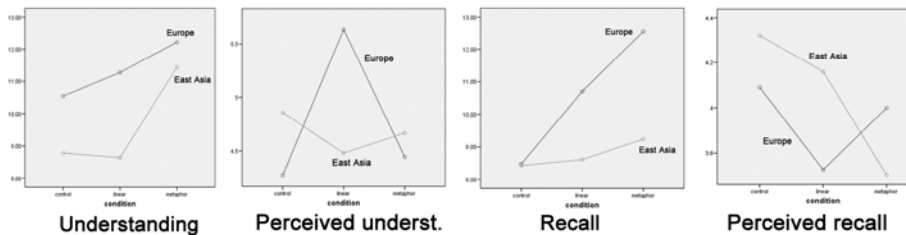


Figure 3: Experiment results: interaction of Representation and Culture

4 Implications

The empirical results lead to three main findings. First, *the visual representation of information objectively increases understanding and recall in both cultures*. These findings confirm the hypothesis based on the Dual Coding Theory [Paivio, 69] and it allows us to extend this theory to the sharing of business knowledge. From a practical perspective, the results imply that visualization can be highly beneficial for conveying strategy-related knowledge in organizations and could be further exploited for the design of Knowledge Management Systems.

Secondly there is a marked mismatch between perceived and real performances in both cultures, with the constant underestimation of the real benefits of visualization. In other words, conveying knowledge with visual representations leads to objectively better results, but subjects are not aware of this. We believe that these findings are highly revealing regarding the *hidden benefits of visualization for knowledge work*. The results lead us to hypothesize that visualization is seldom exploited in organizations and knowledge work because its benefits are largely underestimated.

Thirdly, we find that *there are cultural differences in the reception of visualization, but they are not very marked*. A visual representation of information provides significantly greater recall for Europeans, but not for Asians. As a practical implication, given that there is no interaction of information representation and culture, we propose that such visualizations can safely be used in all cultures for conveying knowledge. A visual representation seems more beneficial for Europeans

though. Nevertheless employing visualization is never worse than text, neither in Europe nor in Asia. The results of this study have implications for knowledge work, as they show that using a visual representation for conveying knowledge enhances understanding and retention, compared to text-only representations.

5 Conclusions and Future Work

There are a number of limitations on the preliminary results of this study. The experimental task is a simplification of a real strategy communication process in organizations, due to the strong focus on internal validity of the experimental methodology. We started with the present study as a first and necessary step to isolate the effect of visual representation compared to text in a static environment. In future we plan to build on these findings and test the effect of visualization in a more elaborate interactive environment for knowledge tasks. Based on the positive results of this study, we also plan to test if and how similar findings can be extended to interactive visualizations and collaborative knowledge-based work. Secondly we have considered the textual control condition only in the form of schematic bullet points (as typical in business presentations). However, different types of language or textual form can lead to different effects. The results on the mismatch of perceived and real understanding and recall leave the question open of the rationale of such wrong perceptions. Further research could focus on this issue. It would also be relevant to further investigate why visualization is less beneficial for East Asians than for Europeans.

In conclusion, this study has contributed to the understanding of the effect of visualization for knowledge-based work and has shown that employing a graphic format for conveying strategy-related knowledge leads to considerable benefits for understanding and recall. It has also shown that subjects underestimate the advantages of visualization to a great extent, and that a visual representation of information is valuable in all cultures.

References

- [Burkhard, 05] Burkhard, R.A.: Strategy Visualization: a New Research Focus in Knowledge Visualization and a Case Study, Proceedings of I-KNOW '05, Graz, Austria, June 29 – July 1, 2005.
- [Eppler, 07] Eppler, M.J. Burkhard, R.: Visual Representations in Knowledge Management: framework and cases, *Journal of Knowledge Management*, 4(11), 112-122, 2007.
- [Hofstede, 01] Hofstede, G.: *Culture's Consequences, Comparing Values, Behaviors, Institutions, and Organizations Across Nations*, Thousand Oaks CA: Sage Publications, 2001.
- [Nisbett, 05] Nisbett, R. E.: *The Geography of Thought*, Finland: Bookwel, 2005.
- [Paivio, 69] Paivio, A.: Mental Imagery in Associative Learning and Memory, *Psychological Review*, 76(3), 241-263, 1969.
- [Platts, 04] Platts, K., Tan, K. H.: Strategy visualisation: knowing, understanding, and formulating, *Management Decision*, 42(5/6), 667-676, 2004.

Author Index

A

Abdoli, A., 317
Ahmed, M., 472
Ali, N., 94
Ali, T., 433
Aniola, D., 382

B

Babic, F., 231
Backfried, G., 382
Bentayeb, F., 81
Bertoni, M., 105
Bischof, N., 162
Blattner, M., 465
Bloice, M., 371
Boppert, J., 218
Bouras, A., 69
Boussaid, O., 81
Brecht, U., 333
Bresciani, S., 483
Böhringer, M., 427

C

Cao, Y., 343
Casanovas, P., 117
Chang, K., 483
Chirumalla, K., 105
Chourabi, O., 472
Comi, A., 137
Cummings, J., 186

D

Demartini, C., 50
Denger, A., 451

E

Ehms, K., 11
Ehrlich, S., 19
Eppler, M., 137, 162, 483
Erne, R., 301

F

Fahad, M., 69, 81
Farukh, M., 69
Ferreira, R., 243
Friedrich, M., 391

G

Gatteschi, V., 50
Geißler, P., 19
Gerlach, L., 427
Gloor, P., 9
Granitzer, M., 198
Grebner, O., 333
Griesbaum, J., 415

H

Hearst, M., 6
Heck, T., 458
Heidary, J., 317
Helic, D., 363, 451
Holzinger, A., 371
Hrgovcic, V., 309

J

Janev, V., 403

K

Kammergruber, W., 11
Karagiannis, D., 309
Kaufmann, V., 333
Kepp, S., 415
Kern, E., 218
Klamma, R., 391, 343
Kosch, H., 290
Kow, W., 175
Kreuzthaler, M., 371

L

Lackner, G., 41
Lamberti, F., 50

Law, E., 150
Lehmann, L., 186
Lehner, F., 290
Leidig, T., 333
Lin, D., 19
López-cobo, J., 117
Lukose, D., 175
Läge, D., 445

M

Maiz, N., 81
Mak, K., 382
Maletz, M., 451
Malykh, A., 439
Mantsivoda, A., 439
Maurer, H., 1, 10
Michel, O., 445
Mittelbach, A., 186
Moalla, N., 69
Mühlhäuser, M., 355
Müller, J., 29
Mödrischer, F., 150

N

Nagy-Rothengass, M., 8
Neumeier, K., 126

O

Ostertag, M., 333

P

Paavola, S., 255
Paralic, J., 231
Peters, I., 458
Petrushyna, Z., 150
Pham, M., 343
Pilles, H., 382
Poblet, M., 117, 207
Pohjola, M., 255
Pohjola, P., 255
Pollet, Y., 472

Q

Qadir, M., 60, 69, 433

Qazi, N., 60
Quirchmayr, G., 382

R

Racek, M., 231
Rensing, C., 186
Renzel, D., 391
Retzer, S., 126
Richter, C., 231
Roth, P., 382

S

Sanna, A., 50
Schmidt, B., 355
Schoop, E., 19
Schultes, P., 290
Shahrabi, J., 317
Shahzad, S., 198
Shen, R., 391
Sidi, R., 7
Silva, J., 243
Simonic, K., 371
Soares, A., 243
Solis, C., 94
Steinmetz, R., 186
Stocker, A., 29
Stoitsev, T., 355
Strauhs, F., 243
Strohmaier, M., 363
Sultanow, E., 465

T

Tan, M., 483
Teufl, P., 41
Tochtermann, K., 1, 10
Trattner, C., 363
Trinkaus, H., 267
Tuomisto, J., 255

U

Ullrich, C., 391
Un, P., 279

V

Vogel, J., 279

Vranes, S., 403

W

Wiersema, E., 243

Winiwarter, W., 382

Witschel, H., 333

Woitsch, R., 309

Wolpers, M., 391