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1 Industry-Academe collaborations in enterprise systems: the SAP-QUT example

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Abstract

The introduction of Enterprise Systems (ES) into the curriculum at Business and IS Faculties and Schools is for many universities a major challenge. However, this problem is in various aspects of special nature: the students' demand is enormous and in many cases product-focused, Enterprise Systems are typically very comprehensive and complex, and knowledge about ES is often missing. By the time textbooks of satisfying quality are available, there are new systems' upgrades and innovation cycles to deal with. The Queensland University of Technology (QUT) is comprehensively using the market leading Enterprise System SAP R/3 within its curriculum and is also conducting research in this area. This paper briefly reports on the activities and experiences at QUT, which is now one of the few world-wide mySAP University Application Hosting Centers.

1.1 Introduction

Enterprise Systems (a.k.a. Enterprise Resource Planning (ERP) Systems) can be defined as customizable integrated application software that supports the core business processes and the main administrative areas of enterprises of different industries (Rosemann 1999; Klaus et al. 2000). Extended ES also cover the management of inter-enterprise business processes like Customer Relationship Management and Supply Chain Management as well as analytical applications (Data Warehousing).

The GartnerGroup (GartnerGroup 1999) forecasts that the ES market will be greater than $ 20 billion by 2002 (with a probability of 80 %). More than 50 % of this will be ES service revenue, while the total ES license revenue covers approx. $ 9 billion. They estimate that more than 90 percent of Fortune 500 enterprises have purchased a module or a set of modules from an ES vendor. They also estimate that the SME market is the main customer group as more than 50 % of these enterprises still haven't selected a next-generation ES. For 2002 the GartnerGroup anticipates a market growth of 28 %.

Universities reacted to the growing importance of ES with a time-lag in both of their business processes: education and research (Gable 1998). However, the number of institutions of

higher learning dealing with ES within their curriculum increased significantly over the last years. Institutions of higher learning often work closely with Enterprise Systems vendors to provide students and faculty with unique research and educational experiences. One such alliance, the SAP University Alliance, currently has over 450 universities in its global membership. This network of faculty has collectively made tremendous progress to redefine business education through the continuous redesign and delivery of their curriculum related to Enterprise Systems and E-Business.

Education in Enterprise Systems is a problem of special nature. Distracted by incredible job offers the students' demand is enormous, but in many cases product-centered. Enterprise Systems are typically very comprehensive and complex. The frequency of upgrades and innovations from one release to the other is impressive. Knowledge about ES is often missing. By the time textbooks of satisfying quality are available, there are new systems' upgrades and innovation cycles to deal with.

The IS discipline has taken this development into account and is spending more attention to the need to exchange efficiently knowledge in this area. An indicator for this is the number of panel discussions at the major IS conferences dealing with ES in general and teaching ES in particular (e.g. ACIS 1998: Gable 1998, ICIS 1998: van der Heijder 1998, ECIS 1999: Rosemann 1999, ECIS 2000: Gable 2000, AMCIS 2000: Stewart et al. 2000, ECIS 2001: Gable 2001). Most IS conferences around the globe now have a dedicated ES-track. At least eight major IS journals reacted with special issues about Enterprise Systems in 2000 and 2001 (e.g. Journal of Information Technology, Information Systems Frontiers, Communications of the ACM, Journal of Decision Systems, Journal of Management Information Systems, Business Process Management Journal, Australian Accounting Review).

The major ES providers (SAP, Oracle, PeopleSoft, J.D. Edwards) have internally institutionalized an organization that deals with universities as a customer group with special requirements. In these departments, University Alliance Managers act as regional key-account managers. They coordinate availability of software, access to training courses and material, and local networks to industry.

In order to reduce the complexity of handling the fast growing number of universities, selected ES providers currently establish Application Hosting Centers (AHCs), which handle the system administration for a group of 15-40 institutes of higher learning. These AHCs are established either at an university experienced in Enterprise Systems, at a subsidiary of the ES vendor or at an implementation partner specialised in application hosting.

1.2 Related Work

The university to Enterprise Systems vendor link has spawned new curricula at the postgraduate level, either under the banner of a new breed of MBA program (Winter 1999), or within the Information Systems area as a Master of Science program (Holmes, Hayen 1999b). Individual experiences of universities implementing SAP R/3 into there IS curriculum can be found in Elam et al. (1999), Lederer-Antonucci (1999), Watson and Schneider (1999), and Philippakis and Hardaway (1999). An overview can be found in Rosemann and Watson (2001). Foote (1999) describes a SAP-accounting class and other SAP-related courses in the US. Shoemaker (Shoemaker 1999) sketches a six hour introduction to Enterprise Systems for sales and marketing professionals. Stewart and Rosemann (2000), Rosemann et al. (2000) and Hawking and McCarthy (2000) discuss Enterprise Systems courses with industrial work experiences.

The impact of reorganising Enterprise Systems subject matter into existing curricula and the special challenges posed to faculty has been reported by Stewart et al. (Stewart et al. 1999). The benefits and pitfalls of teaching conceptual knowledge with Enterprise Systems as a learning vehicle have been critically evaluated in terms of learning outcomes and effort by Watson, Noguera and Scott (Watson and Noguera 1999, Scott 1999).

Rosemann (2001) discusses issues related to teaching Enterprise Systems in a distance education mode. An example of a syllabus for the remote delivery of an introductory subject via the Internet is given by Holmes and Hayen (1999a). They describe the design of a course consisting of 10 lessons that introduces the concepts, fundamentals and framework of Enterprise Systems (see also http://sap.mis.cmich.edu/sap-esoft00.htm). A collaboration between different Faculties of one university is disussed in a proposal by the University of Missouri (2001). An example for a global collaboration is given in Rosemann, Scott and Watson (2000). Stewart and Rosemann propose an increased international collaboration at universities in order to educate in the area of Enterprise Systems more cost-effectively (Stewart and Rosemann 2001).

1.3 History and facets of the QUT-SAP Collaboration

Beginning in 1995 QUT's Information Systems Management Research Centre (ISMRC) began shifting emphasis to the ‘supply side’, acquired software solutions, a process orientation, consultancy skills, and knowledge management; through partnering with a major application software vendor. In 1997 in conjunction with the re-badging and extension of SAP Australia’s Education and Learning Division as “Sapient College”, QUT through the ISMRC became the first member of Sapient College’s University Alliance Program (UAP).

ISMRC has since, worked closely with SAP to evolve the Sapient College and UAP concepts which aim to: facilitate university involvement in research related to Enterprise Systems and R&D with SAP client organizations and implementation partners; to encourage increased exposure to Enterprise Systems in postgraduate curriculums; and to integrate SAP's education and training and related research activity with complementary university initiatives. Since QUT's initial involvement, the UAP program has been extended to 15 universities in Australia and in June 1999 QUT was appointed the "*Australian mySAP University Application Hosting Center*" (A/UAHC) - the only SAP sponsored University Application Hosting Center in the Asia Pacific region and the first outside Germany.

Representatives from the ISMRC were invited guest presenters at the SAP user conference SAPPHIRE in Melbourne, Australia (November 1998), Nice, France (May 1999), Singapore (November 1999), Las Vegas (June 2000) and Brisbane (July 2000). They have been invited to SAP's First International Research Congress in San Diego (February 2001) and were guest presenter at the first Scandinavian workshop about teaching SAP R/3 (Lund, August 1999). Assoc. Directors of the ISMRC chaired ES-related mini-tracks at AMCIS 1999 (Milwaukee) and AMCIS 2000 (Long Beach). They also organised the comprehensive ES-track (32 accepted papers) a AMCIS 2001 (Boston). ISMRC members conducted tutorials on teaching Enterprise Systems at AMCIS 2000 (Rosemann 2000) and will conduct a similar workshop at AMCIS 2001 (Rosemann and Watson 2001). They also give commercial seminars about Customer Relationship Management and Process Management in Australia organized by SAP Australia.

The ISMRC has been working very closely with the biggest SAP customer in Queensland, the Queensland Government, both through their Office of Financial Systems and Training (Queensland Treasury), the lead agency on the implementation of SAP state government-wide, and through the individual agencies (e.g. Corporate Services Agency, Queensland Transport/Main Roads, Natural Resources and Mines).

Today, all universities running live R/3 systems (for research and teaching) face increasing complexity with management and operation, onerous costs for additional hardware and complications associated with upgrading to new R/3 versions. In, addition R/3 operation continues to be precarious. No single institution has the critical mass necessary to justify, attract and develop and sustain necessary technical support and hardware. To ensure the economic viability of R/3 related research and postgraduate training in universities, SAP conceived Application Hosting Centers to centralize the technical provision of access to the software, thereby yielding substantial economies of scale and necessary contingent redundancy of resources.

As the Australian UAHC, QUT received by end 2000 approximately 3 million AUD of software and support from SAP and 1 million AUD of hardware and support from Sun Microsystems to establish a showcase Enterprise System service bureau in support of research, R&D and postgraduate training activities of Australian universities. Further administration software was donated by realTech Australasia. Currently, SAP R/3 version 4.6c is installed. It is planned to implement the SAP Knowledge Warehouse, the Business Information Warehouse and mySAP Customer Relationship Mangement in the near future. The A/UAHC is managed by QUT with operating costs of approximately 1 million AUD during its initial 3-year life being seed-funded by QUT and otherwise recovered through member-university annual contributions. There are currently 15 Australian Universities in the SAP University Alliance Program. Nine of them joined the A/UAHC.

1.4 Enterprise Systems-related research at QUT

ERP-related research at QUT has grown rapidly and dramatically over the past 3 years. It is also not only conducted at the Faculty of Information Technology, but also at the Faculty of Business and the Faculty of Built Environment and Engineering.

QUT Faculty of Information Technology

Through the efforts of the ISMRC, QUT are undoubtedly the premiere institution in the Asia Pacific region, in ES-related research, R&D and research postgraduate training, and arguably amongst the top three in the world.

In total 9 PhD students are currently wotking in research areas closely related to Enterprise Systems. These topics cover a wide range including a major issue study on Enterprise Systems, the development of a prediction model for the upgrade of an Enterprise System, organisational readiness for Enterprise Systems, Enterprise Systems benefits realisation, criticial success factors of process modelling in an Enterprise Systems context, the impact of culture on Enterprise Systems management, and Enterprise Systems knowledge sourcing strategies. Furthermore, more than 10 full-time and part-time Masters students are working on topics related to Enterprise Systems.

Two comprehensive research projects funded by the Australian Reserach Council (ARC) are currently conducted at the ISMRC. The project "Enterprise Systems Knowledge Lifecycle Management" investigates in issues related to the management of knowledge between vendors, customers and implementation partners. SAP is the industry partner in this project. Prof. Tom Davenport is one of the involved external researchers. The project "Process-oriented Administration of Enterprise Systems" aims to design a comprehensive reference process model for Application Hosting Centers with realTech as the industry partner.

QUT Faculty of Built Environment and Engineering

Interests and expertise lie in the technical integration of Enterprise Systems right down to sensors and data collection instrumentation in the field or on the shop-floor. Members of this Faculty seek to better understand this segment of the value-chain, as well as the related technology transfer issues. They are also interested in systems integration of the Computerised Maintenance Management Module of SAP with Condition Monitoring and Plant Process Control Systems. They intend running several projects on the modelling of scheduling programs, reliability, project resources and inventory control with interfaces to SAP.

QUT Faculty of Business

The School of Accountancy and the School of Management are using SAP R/3 as an example for an Enterprise System and conduct research in the area of Enterprise Systems. ES-related research interests of the School of Accountancy include: ES information systems security (eg. SAP R/3 security and authorisations), computer assisted audit techniques (in particular, audit software eg. ACL, SAS, and Computer Aided Testing Tool (CATT) in SAP R/3), knowledge based systems and anomaly/intrusion detection in multi-user computer systems. The Scholl of Management is focused on Human Resource Management as a component of Enterprise Systems.

1.5 Curriculum in Enterprise Systems

Critiques argue that an ES teaching model should avoid information overload and provide a strong bridge between concepts and hands-on experience (Scott 1999). Results from a worldwide survey conducted by Gable and Rosemann (1999) on ES teaching and research activities proved that hands-on experience is the main success factor for learning ES software. Consequently, most ES-related units at QUT integrate hands-on exercises with SAP R/3.

Built on an introductory course (Issues in IT Management), which explains the basics of Enterprise Systems and SAP R/3 as an example, two main streams are offered within the Faculty of IT. In the more technical stream, students have the opportunity to gain knowledge in the areas of administering Enterprise Systems and ABAP, SAP's programming language. In a more business-oriented stream, Process Management represents besides Knowledge Management the main focus. A subject "Process Engineering" introduces the students to different approaches of process management such as BPR or Process Innovation. It is explained how business processes can be modelled. Selected SAP processes are discussed and it is demonstrated how they can be configured and executed. This subject is a prerequisite for a subject covering extended Enterprise Systems such as CRM and SCM.

Two innovative subjects related to Enterprise Systems will be dicussed in more detail. One new subject is titled “Projects in Process Engineering”. It extends the theoretical knowledge that the students gained in the subject "Process Engineering" through the participation in a practical project (Rosemann et al. 2000). This unit concentrates on designing process models for a local organization that is using an Enterprise System. The participants design as-is models describing the existing processes in the selected company. A comprehensive analysis of the current weaknesses of the processes completes these models and serves as the basis for the identification of ways to improve the process performance. In the second phase of this project, to-be process models depicting scenarios for alternative business processes are designed. The participants present their results to representatives of the organization and develop an implementation plan for some of the suggestions. The upper CASE solution ARIS-Toolset is used to model the processes and to conduct process simulations. The business process models are compared with SAP reference process models and other “best practice” approaches.

The subject Projects in Process Engineering was offered for the first time in the first semester 2000. The industry partners for this project were Corporate Services Agency (CSA), Pricewaterhouse Coopers and SAP Australia. CSA is currently running a live SAP R/3 3.1h system. Its SAP R/3 Financial Accounting system has been up since 1998. SAP's Human Resource Management solution went live in April 1999. Processes selected for the student analysis related to both the Financial Accounting (procurement, corporate card, accounts payable, asset management) and Human Resources (recruitment, leave request, travel management) modules. PricewaterhouseCoopers (PWC) contributed as an international consulting company to this subject in the form of consultants, who attended selected seminars as well as the milestone presentations. The participating consultants were available for discussions about benchmarks for the analysed processes. Moreover, they trained the students in typical consulting skills like interviewing people and presenting results. The PWC methodology for ES management was discussed and critical success factors like teamwork, and project organization were analysed. SAP Australia provides the facilities in the form of access to their software, further product information and a room for the milestone meetings. Representatives from SAP were available for presentations regarding new functionality in SAP R/3 4.6 and mySAP applications.

The student teams were officially introduced to the relevant CS Agency members at the “Kick-off meeting” held in the second week of the semester. From then on, the teams interacted with these key contact people independently, at their own pace, to gather and confirm information related to their processes. All students were provided with access to CSA's SAP R/3 system to study the configuration of the processes. The student teams also approached other external organizations that were of potential interest or relevance to the processes.

This subject is open to all postgraduate students from Post Graduate Diploma level and Masters level courses across different Faculties (Information Technology, Business and Engineering), who have successfully completed the prerequisite “Process Engineering” or an equivalent in a previous semester. Students who have completed additional ES-related courses, for example Issues in Information Technology Management, ABAP or System Administration further benefited from their knowledge about related ES issues.

In order to introduce under-graduate students of all three involved Faculties at QUT to Enterprise Systems, a new unt "Fundamentals of Enterpise Systems" was designed. In total eight different lecturers from four different Schools will guide the participants through the main modules of Enterprise Systems using SAP R/3 as an example. Students will get insights into the architcture and the lifecycle of Enterprise Systems. Lectures on Financial Accounting, Controlling, Materials Management, Production Planning, Sales and Distribution and Human Resource Management will combine the general business knowledge with hands-on SAP experiences. An entrie lecture will discuss how these functional areas can be integrated in an Enterprise System.

Enterprise Systems will be a stream in the newly designed under-grad. major on Information Systems. A new core unit will introduce to Enterprise Systems unit, while the discussed "Fundamentals of Enterprise Systems" will be an elective within this stream.

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2 Case Study - Building a Data Warehouse for Higher Education in the Course of Microstrategy's University Program

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Abstract

The public demands a close cooperation between universities and companies in order to improve the quality of students' education and to speed up the transformation process from theoretical ideas to products. This paper describes a successful cooperation between a university research project and a company. We show that both partners of the cooperation have numerous benefits. The following case study is the point of reference for an analysis of an existing cooperation. A data warehouse research project for higher education at the University of Bamberg (CEUS^{HB}) exemplifies the university's part of this cooperation. The business intelligence company Microstrategy is the other partner outlined in the paper.

2.1 Introduction

For most companies, cooperation with a university seems to be unprofitable. However, the views are changing slowly and many companies recognize the benefits they can gain from such a cooperation. Increasing research expenses and employee acquisition problems force especially IT companies to establish a close cooperation with university partners. From a university point of view such a cooperation is not only financially rewarding, but also the quality of education can be improved.

For this reason we exemplarily demonstrate a successful cooperation between a company and a business information systems chair of the University of Bamberg in the field of data warehousing.

During the last decade, data warehouse systems have become an essential component of modern decision support systems (Anahory, Murray 1997). The data warehouse concept covers different aspects like architecture, physical optimization, tool support and modeling approaches. Both the industry and research community have paid a lot of attention to the project. Recently also public administration got involved in data warehousing and wants to benefit from this new technology. For this reason the Bavarian Ministry of Science, Research and Art funded the CEUS^{HB} project ("Computerbasiertes Entscheidungsunterstützungssystem für die Hochschulen in Bayern" / computerized decision support system for Bavarian

universities) to support the decision making process by a data warehouse system for all Bavarian universities (Boehnlein, Ulbrich-vom Ende 1999; Boehnlein, Ulbrich-vom Ende 2000; Sinz et al. 2001). Members of this project are the Bavarian state institute for higher education research under the direction of Prof. Dr. H.-U. Kuepper and the chair of information systems, esp. systems engineering and database application under the direction of Prof. Dr. E. J. Sinz. This cooperation with a well-known business intelligence vendor was intended. Thus MicroStrategy became cooperation partner because their software fully met our requirements. Furthermore, they offered a superior university program.

In this paper, we present an overview of this cooperation and mention the benefits for both partners. The following section briefly introduces MicroStrategy as one of the leading vendors of relational online analytical processing (ROLAP) solutions (MicroStrategy 1995). We mainly focus on the company's university program. In Section 3 we first outline the development of a data warehouse for Bavarian universities in the course of the MicroStrategy university program. Secondly we illustrate the use of MicroStrategy's software products in order to implement the distributed architecture of $CEUS^{HB}$. The section ends with a comparison of the benefits for both cooperation partners. Finally this paper concludes with a summary and an outlook.

2.2 Microstrategy´s University Program

In this section, we introduce MicroStrategy as a vendor of data warehousing products and explain its university program. First, we outline the company's profile and describe MicroStrategy's business intelligence software platform. Afterwards, the benefits of the university program in Europe will be shown.

2.2.1 MicroStrategy's company profile

MicroStrategy was founded as a consulting company in 1989 by Michael J. Saylor. The company specialized in building customized decision support applications in the data warehousing market. By now MicroStrategy provides a business intelligence platform (MicroStrategy 7.1™) comprising solutions for query and reporting for advanced analytical needs (MicroStrategy 1999).

The history of the main elements forming the data warehousing product suite is as follows. In 1993 the MicroStrategy Agent™ was introduced which provides a graphical window-based end user application enabling a sophisticated query and reporting solution in a relational data warehouse environment. It was extented according to a comprehensive client/server architecture capable of multi-tier support through the MicroStrategy Intelligence Server™.

With MicroStrategy Web™ in 1996 the company enabled end users to access a data warehouse via World Wide Web. A web-enabled data warehouse allows a cost-effective application based on well-known internet standards like hypertext markup language (HTML) or extensible markup language (XML) (Kimball, Merz 2000). In 1998 MicroStrategy presented the Narrowcast Server™ which extends the business intelligence area by proactively delivering personalized reports and alerts via email, wireless devices like phones, pagers, and PDAs and telephone networks based on a "publish and subscribe"-paradigm. By now MicroStrategy seems to be a strong player in the relational online analytical processing (ROLAP) market.

To get a general idea about the company some actual figures are mentioned omitting profit measures. At the beginning of the year 2001 MicroStrategy had over 1000 employees and 46 offices worldwide. There is a direct presence in the U.S., Canada, U.K., Germany, Switzerland, Austria, Italy, the Netherlands, France, Spain, Argentina and Brazil. Additionally, a network of distributors and OEM Strategic Alliances ensure their presence in 25 other countries. The customer base of MicroStrategy comprises over 1000 customers and over 300 technology and integration partners.

2.2.2 University program in Europe

Microstrategy's university program started in 1999 in Europe. Mainly two people have decisively contributed to the success of this program. These are PhD. A. Kurz (Production Consultant) and I. Moritz (Partner Manager). To get a better understanding of all aspects of the program a short overview about key elements of the program is given. In section 3.3, we show how these elements can be used to improve the quality of education and research at universities. The main elements of the program comprise:

- *Training on the products:* Members of the university program have the opportunity to take part in different courses. To avoid handling problems some of these courses are prerequisites for obtaining the products within the university program.

- *Product suite at no charge:* Universities and similar institutions can get the whole product suite for educational or research purposes for free. Only a small fee for technical support and material will be charged.

- *Certification:* Members can get involved in the Microstrategy certification program. The official title for a certified Microstrategy partner is Certified Decision Support Engineer (CDSE).

- *MicroStrategy's Summer School:* In 1999 and 2000 about 60 students from different universities in Austria, Switzerland and Germany had the opportunity to participate in the MicroStrategy Summer School. This one week education course covered not only the training on the products but also theoretical aspects of business intelligence, decision support and e-business. During this week the students had free board and lodging in a monastery (Pernegg) in Austria.

- *Research cooperation:* Cooperation for diploma and doctoral thesis is possible.

- *Industrial lessons:* Further MicroStrategy offers lectures at universities about current and relevant topics in the data warehousing and decision support area.

At the beginning of 2001, the following institutions participated in the MicroStrategy university program:

- University of technology Aachen (Germany), chair of economical computer science, Prof. Dr. M. Bastian and Prof. Dr. M. Amberg

- University of Bamberg (Germany), chair of business information systems, esp. systems engineering and database application, Prof. Dr. E. J. Sinz

- University of applied sciences Bochum (Germany), faculty of economics and business, Prof. Dr. R. Berning

- University of Fribourg (Switzerland), department of informatics, Prof. Dr. P. Haettenschwiler

- University of applied sciences Leipzig (Germany), department of business administration, business information systems, Prof. Dr. K. Kruczynski

- University of Muenster (Germany), department of information systems, Prof. Dr. J. Becker

- Technical University Prague (Czech), department of cybernetics, faculty of electrical engineering, Prof. Dr. V. Marik

- University of cooperative education Stuttgart (Germany), Prof. P. Schubert

- University of Stuttgart (Germany), faculty of computer science, institute of parallel and distributed high-performance systems, Prof. Dr. B. Mitschang

- University of Wuerzburg (Germany), chair of business administration and information systems, Prof. Dr. R. Thomé

2.3 Building a data warehouse for higher education

In this section we present the CEUS^{HB} project and the use of the MicroStrategy platform within the project. After a short introduction of building a data warehouse for higher education we will illustrate the resulting distributed data warehouse architecture of CEUS^{HB}. The end of the section deals with a list of benefits for both cooperation partners – MicroStrategy and the University of Bamberg.

2.3.1 Case study: a data warehouse system for higher education

Recently public administration has become aware of the benefits of data warehousing. This new technology enables interactive data analysis and ad hoc reporting (Inmon 1996). One area of interest for public administration is to control the higher educational system. In Germany, this system has a lot of characteristics in common with a distributed organization. The coordination within the system is a combination between market and hierarchy. Furthermore, each university acts widely autonomously and competes with other universities for students. Each federal state in Germany is responsible for setting the economical and political environment of the higher educational system.

In this context, for example, a data warehouse can help to provide a fair allocation of available funds or personal resources to the eleven universities in Bavaria based on a distribution key. A detailed analysis of the number of students at each university can be accomplished by a data warehouse system in order to build such a key.

Therefore, the CEUS^{HB} project ("Computerbasiertes Entscheidungsunterstützungssystem für die Hochschulen in Bayern" / computerized decision support system for Bavarian universities) was initiated by the Bavarian Ministry of Science, Research and Art. The project (project homepage: http://ceus.uni-bamberg.de) is realized by an interdisciplinary research group of the Bavarian state institute for higher education research (Prof. Dr. H.-U. Kuepper) and the chair of business information systems, esp. systems engineering and database application of the University of Bamberg (Prof. Dr. E. J. Sinz).

During the first period of the project, we made a requirements analysis and we evaluated different data warehouse and OLAP software product suites. Thereby we got in touch with different vendors and their opinion of a cooperation with a university. Thus MicroStrategy became cooperation partner as their software fully met our requirements. Due to space restrictions we do not mention these requirements for the software evaluation in this paper. Additionally they showed great involvement to a university program. For example, we could use all products during development and test period for free. Of course when the data

warehouse system will be established at the universities, licences have to be purchased by the Bavarian government.

2.3.2 Architecture of a distributed data warehouse system

Data warehouse systems provide information for the managers' decision-making process in a consolidated and time-oriented way. Therefore, a data warehouse brings together data from multiple operational (internal) and external data sources into a common physically separated repository (Inmon 1996).

Currently, most existing data warehouses ignore the organizational and management structures of the underlying company. Almost always a classical centralized data warehouse architecture with or without departmental data marts is applied. This data warehouse architecture follows a widely centralized and static organization and management structure of a company. Neither distributed organizations comprising autonomous sub systems with competing organizational units nor changes in the organizational and management structure over time are taken into consideration.

The management structure of universities can be understood as a distributed organization (Sinz et al. 2001). Each university acts almost autonomously and competes with other universities for students and for an outstanding reputation.

Figure 2.1 illustrates a corresponding architecture for a distributed data warehouse system. This architecture is implemented by the CEUS^{HB} project for Bavarian universities and the Bavarian Ministry of Science, Research and Art. It follows the hierarchical management and organizational structure of universities:

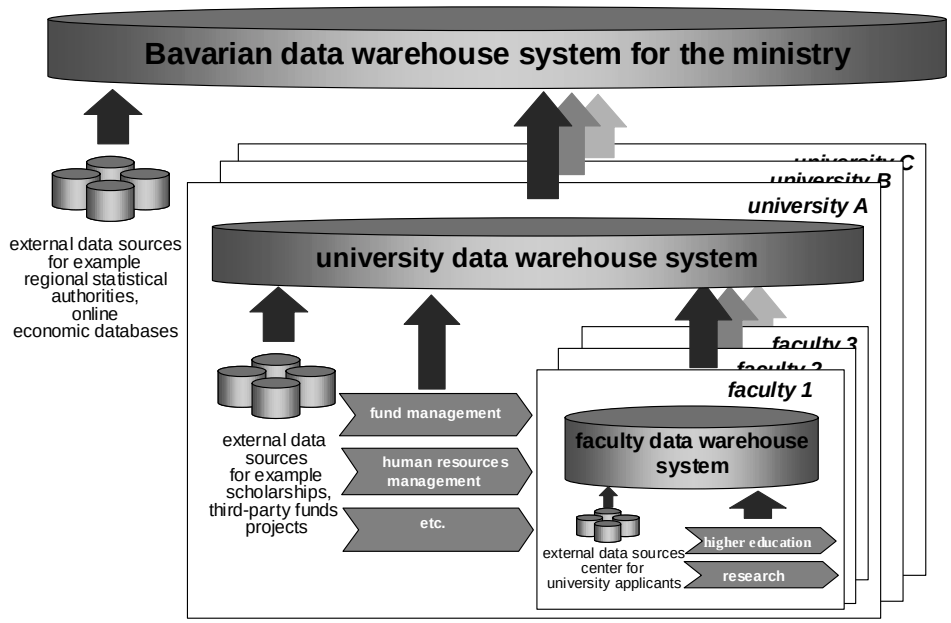

Figure 2.1 Distributed data warehouse architecture for higher education in Bavaria

- Layer 1 comprises data warehouse nodes for faculties of a university. The faculties require detailed information about the main university processes "higher education" and "research" as well as external information about university applicants.

- Each data warehouse node on layer 2 comprises an information sub system for a specific university. In addition to information from the faculty nodes these data warehouses especially contain information about service processes like "fund management" and "human resource management".

- Layer 3 contains information about all universities of Bavaria in a consistent and consolidated manner. This information can be enriched by external data sources like information from regional statistical authorities.

Each node of the distributed data warehouse system is implemented according to the classical data warehouse architecture (figure 2.2).

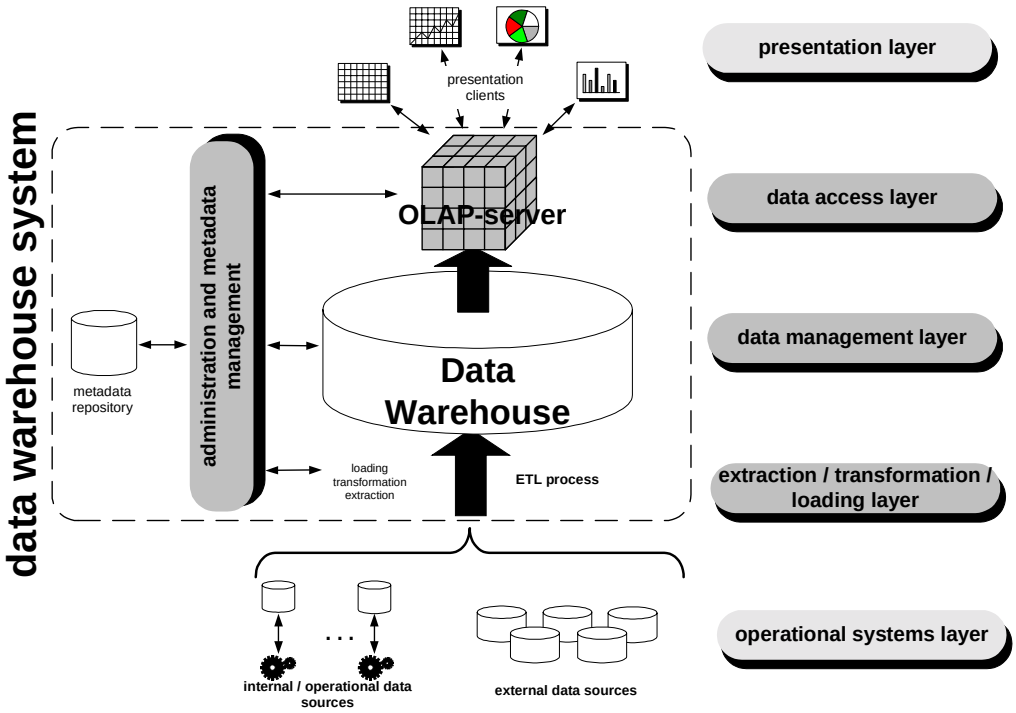

Figure 2.2 Micro architecture of a single data warehouse node

A data warehouse node has three different layers:

- *Extraction / transformation and loading layer:* This layer represents the interface to the operational and external data sources. It provides methods to extract, transform and load data incrementally into the data warehouse.

- *Data management layer:* The main task of the data management layer is to store consolidated data in an efficient and consistent way.

- *Data access layer:* The data access layer is the interface to end user applications and presentation tools. Generally an OLAP server provides a multidimensional view of the data stored in the warehouse.

An integrated metadata repository is used on all three data warehouse layers for administration and metadata management.

The MicroStrategy product suite can be deployed in this architecture as follows:

- *Extraction / transformation / loading layer:* There is no MicroStrategy product available to support this layer. We use SQL scripts and data transformation services (DTS) of Microsoft's SQL Server 2000.

- *Data management layer:* A wide range of relational database servers is supported. At the moment we focus mainly on Microsoft's SQL Server 2000 (optionally ORACLE and Informix servers can be used).

- *Administration and metadata management:* We use MicroStrategy Architect™ to specify metadata for the data warehouse structure. This metadata particularly provides a multidimensional view on the data. The MicroStrategy Administrator™ handles system management, load balancing, security issues and user access.

- *Data access layer:* The core of the data access layer is the ROLAP engine which is based on the MicroStrategy Intelligence Server™.

- *Presentation layer:* There are two different options for end user access to the warehouse. MicroStrategy Agent™ is a graphical end user application enabling a sophisticated query and reporting solution in a relational data warehouse environment. Additionally MicroStrategy Web™ provides end user access based on well-known standardized web technologies (Kurz 1999).

We tailored the MicroStrategy products to our needs. For example we customized end user access based on MicroStrategy Web API. For a detailed discussion of the data warehouse architecture and its implications see (Sinz et al. 2001).

2.3.3 Symbiotical relationship between a company and a university

In the following we outline the major benefits of the cooperation between a university and MicroStrategy. We mention the different viewpoints of both cooperation partners.

Benefits for the chair of business information systems at the University of Bamberg: We distinguish benefits for research and for education.

Research

- *Discover future research topics:* Our knowledge of a real-world data warehouse product suite enables us to discover further needs for research in data warehousing. We are able to identify deficits of data warehouse products which are available at the market. For example MicroStrategy, like almost all commercial data warehouse product suites suffers from deficits in the modeling area. There is no distinction made between conceptual, logical and physical modeling. The classical well-known star and snowflake schemas belong only to the logical modeling layer and are not suitable for modeling the analytical requirements of the end user. A new conceptual modeling technique based on multidimensional data structures used for decision support

applications is needed. Therefore we initiated a sub project called JDWToolsuite to build platform independent Java based tools as research prototypes to handle this problem. At the moment three applications are available (http://ceus.uni-bamberg.de/jdwtoolsuite) which are tightly integrated with MicroStrategy's product suite:

  - A tool for modeling data warehouse requirements on a conceptual level using the Semantic Data Warehouse-Modeling (SDWM) approach.
  - A query and reporting tool based on graphical modeling and
  - An extraction, transformation and loading tool handling periodical maintenance of a data warehouse attending versioning and incremental updates.

- *Diploma thesis*: The cooperation enables us to enrich diploma thesis by practical and urgent problems. We mention one diploma thesis exemplarily. Its goal is a tighter integration between data warehousing and data mining efforts which is often proposed in the data warehousing and knowledge discovery research community. Data mining activities based on a consolidated and time-oriented database like a data warehouse save time and lead to high-quality results. The closed loop approach between data warehousing and data mining adds a feedback component to the warehouse to insert received data mining results into the database. In that way we can not only propose new concepts concerning the closed loop approach, we are also able to show an integration approach based on a real-world data warehouse product. Other jointly supported diploma thesis cover topics like metadata management or evaluation of data warehouse product suites.

Education

- *Enrichment of student education by industrial lessons*: The topics of university lectures can be enriched by industrial lessons. MicroStrategy offered lessons on current subjects in the data warehousing and decision support area. In fact MicroStrategy's industrial lessons also covered a lot of theoretical background. Thus students can easily form an opinion about current buzzwords and bring them in context with their university knowledge.

- *Transformation of theoretical knowledge using real-world applications*: In exercises students solve small business problems by transferring theoretical knowledge in working prototypes. Thus MicroStrategy products helped to enhance practical experience and prepare the students for professional life. In our experience practical

exercises were very popular among students and using real-world applications improved the quality of students education.

- *Achievement of further skills*: Students can achieve further skills by attending the MicroStrategy SummerSchool in Austria. The certification "Data Warehouse Engineer" was awarded for one week of practical exercising in building a data warehouse solution. Furthermore the members of the chair can participate in training and education programs to get skills on the MicroStrategy platform. For example to become an official MicroStrategy partner a three week training and certification is required. This is called the Certified Decision Support Engineer (CDSE) program.

Benefits for Microstrategy:

- *Diploma thesis:* A diploma thesis dealing with a current and urgent problem can become a competitive advantage for MicroStrategy in a fast moving and innovative market. For example the already mentioned diploma thesis about a tighter integration between data warehousing and data mining solutions can help to solve problems at business partners. Normally a diploma thesis provides a solution or the core of a solution which can be extented by the cooperation partner.

- *Publicity of the company as an employer:* A cooperation with a university increases the publicity of the company to students at this university. The company is well known as an employer in a market where not enough employees are available at the moment.

- *Publicity of the product suite:* A cooperation also increases the publicity of the company's product suite. After leaving university some students remember the experience they had using the products. Some get in positions requiring decision-making about purchasing data warehouse solutions for their companies in the future.

- *Competititve advantage by research:* Research projects can help a company to discover deficits of their current products and provide ideas for new or enhanced products. This can become a competitive advantage for MicroStrategy.

- *Research projects becoming products:* Products stemming from research projects can become a new source of income for the company.

2.4 Summary and Outlook

In this paper, we described a successful cooperation between a company and a data warehouse research project for higher education at the University of Bamberg. MicroStrategy, as one of the leading vendors of relational online analytical processing (ROLAP) solutions, is the

industrial partner. First, we outlined the company's profile and its university program. In Section 3, we briefly explained the development of a data warehouse for Bavarian universities in the course of MicroStrategy's university program. The major focus of this paper was a comparison of the benefits for both cooperation partners. We showed that such a cooperation can be valuable for the partners – both for a university's research and education as well as for the company's publicity and competitive advantage.

We hope that this example can help to change most companies' attitude towards cooperation with universities. It also points out benefits for universities to improve the quality of education and research. This results to a closer relationship between universities and companies as demanded by the public.

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3 Oracle & Academia - A Successful Strategic Partnership

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Abstract

Oracle has introduced in 1998 the OAI program to tackle the IT labour crisis. Since then over 150,000 students have been involved in courses in over 40 countries. This paper describes the components of the program and the benefits for all sides. The program is finally reviewed from an academic perspective and cornerstones of a successful strategic partnership are defined.

3.1 The IT Challenges Facing Us Today

Due to the ongoing developments and improvements in the Information Technology (IT) sector, demand for qualified students has grown well over the existing resources. One important aspect of the changes in IT is the "explosion" of E-business: An enormous amount of companies revolutionize the way, their contacts with suppliers and customers are handled. These fundamental modifications are not only technical but also organizational and have implications on nearly every business model. A company needs technicians and management staff to analyse and adapt to the new "E-world". According to the Gartner Group, a shortage in the past year 2000 of one million IT workers worldwide is estimated. For 2002 this amount will rise to one million in Europe alone. Having not enough IT workers leads to slower company growth. Therefore an enormous pressure is build up on universities to supply more students with IT knowledge. The universities are challenged to provide the software and up-to-date courses while their budgets are limited.

3.2 The Oracle Academic Initiative - Components, Benefits and Successes

Oracle Corporation realized the special situation of the universities and their important role in transferring IT know-how. A global alliance between Oracle and academic institutions worldwide is addressing the IT labour crisis since 1998. Oracle wants to supply the

universities with software, support and educational courses for its software products. Oracle describes the goals in the OAI vision:

Through the Oracle Academic Initiative, Oracle provides its state-of-the-art software and resources to the world's educators, so that they can better prepare the leaders of the new millennium. OAI will help students and faculty to develop a passion for Information Technology, education and a continuing connection to one of the world's premier software companies.

In the existing three years of the program over 600 universities across 30 countries in EMEA (Europe, Middle East, Africa) joint the program. A total of 90,000 students are enrolled in OAI classes today. The following list shows current member countries.

- Belgium
- Bosnia
- Bulgaria
- Burkina Faso
- Croatia
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Iceland
- Israel
- Italy
- Latvia
- Lithuania
- Montenegro
- Morocco
- Norway
- Poland
- Portugal
- Republic of Ireland
- Romania
- Saudi Arabia
- Slovakia
- South Africa
- Spain
- Switzerland
- The United Kingdom
- Turkey
- United Arab Emirates

In the United States 50,000 students from 1,000 faculties take part in the OAI; Asia and the Pacific region add about 10,000 from 8 countries and for Latin America the roll out phase just started. This clearly shows the international approach of the OAI program.

Within the initiative, five aspects are targeted. In the following paragraphs these steps are explained in detail.

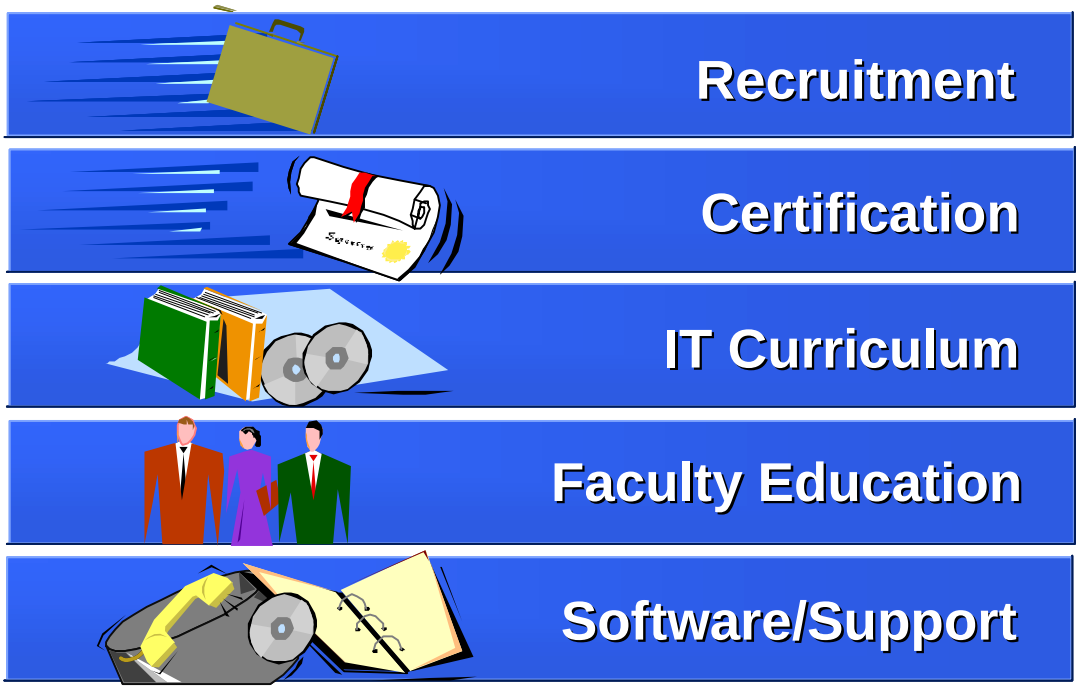

Figure 3.1: Five aspects of OAI

The first aspect covers *software and support*. For $ 1,000 annual subscription fee per faculty all software offered by OAI is available for instructional purposes on different platforms. The software is available to an unlimited amount of users (i.e. students and teachers). The usage of all Oracle product support services (telephone, web, mail) is included in the subscription fee. At the end of year 2000 eighteen program packages were offered by OAI.

- Oracle 8i Enterprise Edition
- Oracle 8i Personal Edition
- Forms Developer
- Forms Services
- Reports Developer
- Reports Services
- Oracle Change Management Pack
- Oracle Tuning Pack
- Oracle Diagnostics Pack
- Oracle Application Server
- Portal
- Oracle Designer
- Oracle Application Server
- Oracle Discoverer User Edition (NT, Win 95/98 ONLY)
- Oracle JDeveloper (NT ONLY)
- Oracle Personal Edition 8i (with JServer)
- Oracle Discoverer Administration Edition (NT, Win 95/98 ONLY)
- Oracle 8i on Linux

Most of this software is available on NT/Win2000, Solaris, HP-UX, Compaq Tru64 and AIX. The free operating system Linux with its growing amount of supporters is well respected within Oracle. The first product for this OS is Oracle 8i on Linux. More software for Linux is expected to be included in the future. All these software CDs can be copied for students so that they can "play" with the products at home. It is only necessary for the Student to sign a one-page agreement with terms and conditions.

Secondly *faculty education* is focused by OAI. A 50% discount on Oracles IT courses enables faculties with tight budgets to keep their teachers well informed about the products. Oracle as a world leader in short-cycle training for IT professionals uses the "teach-the-teacher principle" to achieve huge benefits for the OAI program. The better the instructor is informed, the more students can learn form him/her. Courses are offered for a great variety of topics: database technology, data warehousing and data mining, UNIX, HTML and Java programming, etc.

Oracle has included a selection of 30 courses from the Oracle curriculum covering different areas. The *IT curriculum* and the *certification* are open to students and teachers to obtain internationally accepted qualifications and degrees.

The courses from the following areas are available as "courseware" ($ 200 each). Courseware consists of CD-ROM sets with technical documentation, manuals, editable presentations, PDF files and scripts for sample database applications. The courseware also includes a 40% discount voucher for the associated course that leads to an Oracle certification exam. The Oracle certification offers a high value in every CV (for teachers and students).

- Introductory Database Operations
- Introductory Database Management
- Advanced Database Management
- Systems Analysis
- Systems Design
- Introductory Internet Application Development
- Advanced Internet Application Development
- Data Mining and Data Warehousing
- Applications Development

The fifth aspect of OAI covers all questions concerning *recruitment*. Oracle and its partners will help students to get in touch with IT career services. This goes as far as including students' resumes in the worldwide Oracle IT career database. A student who took part in the OAI and obtains his/her university degree can then choose from a wide range of possible employers (Oracle Corporation is only one of them). The aim of OAI is not to "produce" new Oracle employees; the goal is far broader. Oracle wants to take its part in solving in IT labour crisis. Only some students will start working within Oracle, a higher percentage will go to Companies working with Oracle products and another share students will only occasionally work with Oracle software in the IT sector. But all of the students have learned to understand how software can help you to move the company towards the new strategic "E-targets".

The benefits for the students are obvious. By having access to latest technology they will expand their knowledge resulting in highly marketable job skills. Institutions and faculties get industry recognition for transferring technology skills to students. Due to the partnership with Oracle, extensive financial savings can be realized. Using the faculty education, the staff will build or maintain its good knowledge.

3.3 Oracle Software in Academia

From a universities perspective, the OAI program offers a good strategic fit. Oracle is interested in a long-term relationship. No immediate short-term benefits are expected and the relationship has time to grow. A cornerstone of the Oracle Academic Initiative's success is the understanding and the respect for university culture. No monopoly commitments are expected. A faculty can use a competitor's product (i.e. IBM's DB/2) in one course and Oracle's core database product in another. The OAI is a global program and supported by the American headquarters of Oracle and the main goals are the same in the US and in EMEA. In Academia international projects a frequent and the OAI offers the possibility of work in different countries with the same software. Researchers can concentrate on doing their studies instead of trying to connect different programs from various vendors together.

The involvement of students, teaching staff and the faculty offers each of them adequate possibilities to use the components of the program according to their needs. Even very small faculties can take part in the OAI due to fair conditions ($ 1,000 per year). Oracle offers software for all phases of software creation. Figure 3.2 shows the mapping of some tools to different phases.

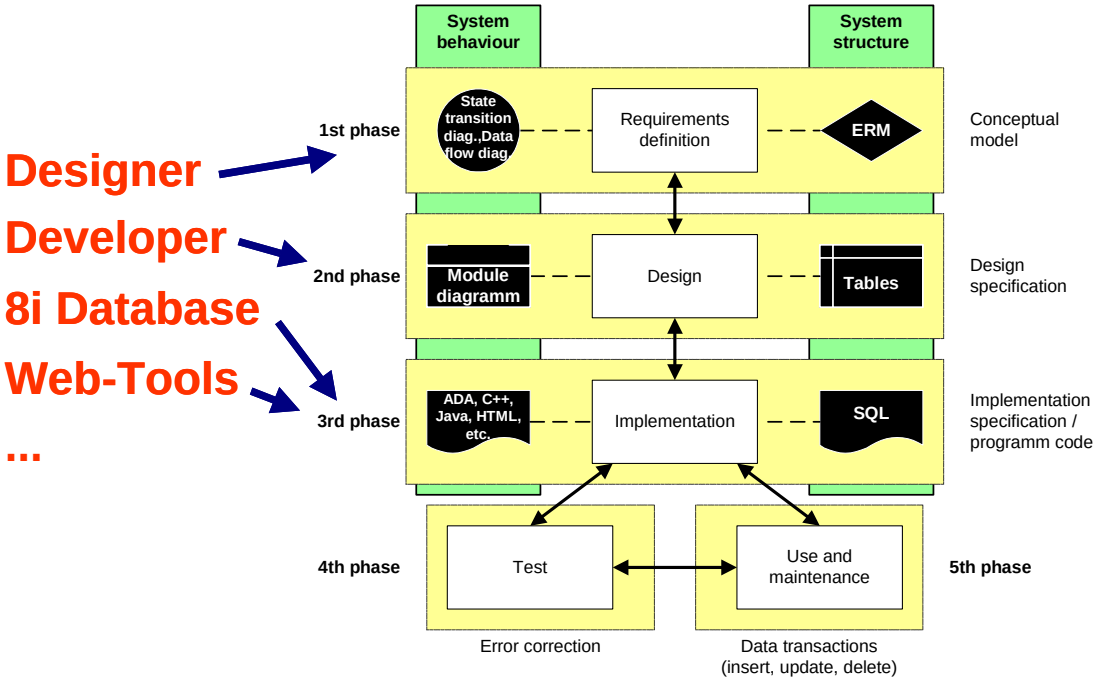

Figure 3.2: Oracle tools and phases of software creation

Universities benefit from participating in the OAI in many ways as shown above. The high numbers of participating institutions and the new aims from the OAI (i.e. build an OAI community for interchange of ideas or the inclusion of the Oracle Application software in OAI) have shown the existing and ongoing need for the OAI program. OAI proofed that a partnership between a software Vendor and universities can be successfully build. Working in a friendly atmosphere together and respecting each other's needs and culture enhances the benefits for everybody. A strategic program like the OAI is not possible without the people behind it. Many thanks for an enjoyable work-environment must therefore go to the people involved on both sides.

4 Improving Productivity using analytical techniques – an Example of SAS BIS Software Exploitation

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Abstract

The availability of decision support and productivity software is providing the opportunities for smaller manufacturing or non-manufacturing companies to develop systems which utilize operations research models to support decision-making and address issues such as product mix, efficient production methods, network flow optimization, inventory and stock management, resource scheduling and capital allocation. The model of such a business decision support system, which incorporates linear and integer programming, is presented. The system is based on the SAS software which has been widely used in operations research area. The graphic user interface (GUI) is developed to assist users in making effective management decisions without requiring extensive technical training. Some decision making problems in an integrated production management context are pointed out and a simple example of product-mixed problem is shown to illustrate the usage of the decision support system in a practice.

4.1 Introduction

The transformation of the former Slovene economy, known as an agreement economy, to a free-market economy creates new demands for the Slovene manufacturing or service companies. They are just beginning to be faced with the problem of the increased competition and operate in a difficult environment which is desperately short of capital. Therefore, acceptance of changes in manufacturing methods and manufacturing philosophy is a vital prerequisite for continued progress. An increasing number of the Slovene managers are quite aware that the knowledge is needful to effectively use new information technology that represents a key to competitiveness. They realize that changes are necessary to enhance the competitive advantage of manufacturing or non-manufacturing organizations.

Computer Integrated Manufacturing (CIM) technology helps to meet strategic business objectives, such as: fast response to market demands; better product quality; reduced production costs; enhanced performance; shorter lead times; reduced inventories; minimum work-in-progress and market flexibility. Effective CIM requires computer software to control

automated processes, regulate production facilities, and generate information to support operational, tactical, and strategic decision making.

In line with the objective of better decision making, a skillful solution represents the SAS System for the information delivery with Business Intelligent Software (BIS). It can be applied for developing various types of the decision support systems (DDSs) which incorporate the traditional operations research modeling technique.

The paper indicates a set of decision making problems which can be decomposed from a CIM architecture. Each one should find solution thanks to many models and methods of Operational Research tools. We present then typical linear programming problems that can be modelled and solved by the specific business DSS which is developed to support an easy to use of the linear programming. Finally, a simple example of a product-mix problem is represented, and its solution is discussed to illustrate the usage of the DSS that employs the capabilities of SAS software.

This paper represents an example of cooperation which is going on between Slovene University of Maribor, Faculty of Organizational Sciences (Kranj) and SAS Institute (Ljubljana) for more then five years.

4.2 Decision Making in CIM Context

It is shown (Widmer M. 1995) that the CIM architecture can be partially decomposed along two main axes: the production management aspect (from the customer order to the bill) and the logistics aspects (from the supply to the distribution). A very nice hook here for Thomas – on the one side it can serve as the distinct definition of transactional versus the intelligence world, on the other it can be broken down into the SOC chain (supplier, organization, customer). This approach ensures that the complete production process can be defined as a production planning hierarchy, including integrated production management which can be specified with several modules, such as: order management, forecasting, product design, planning and scheduling, shop floor control with quality control and maintenance management, supplying management, inventory management, distribution management and invoicing module that are illustrated in Fig. 4.1.

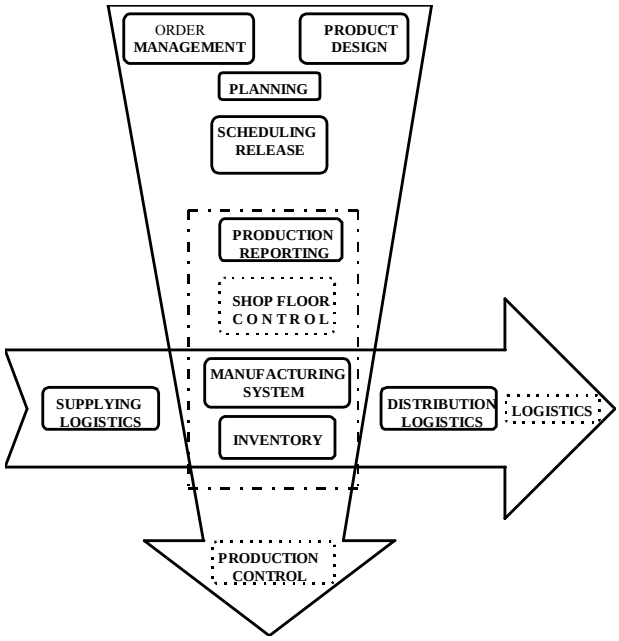


Figure 4.1 The model of Integrated Production Management

These modular notions, which appear in every production system, independently of the size or of the factory functionality, involve a set of Operations Research problems at various levels throughout the organization, which require the implementation of DSSs utilizing OR models and methods to improve the effectiveness of business decision making.

An effective solution in this case provides the use of the SAS System for the information delivery (see Fig. 4.2). It includes Business Intelligent Software (BIS) which comprises a sophisticated suite of tools and technologies to support all dimensions of organizational decision making. This is accomplished in the most modern organizations by providing a powerful access to all kinds of data (data warehousing), easy-to-use data exploitation tools, and capabilities for presenting useful information. Only the SAS System provides a complete end-to-end data warehousing solution. In this case the decision support data are derived from the operational data, but are continually refreshed and readily accessible to managers.

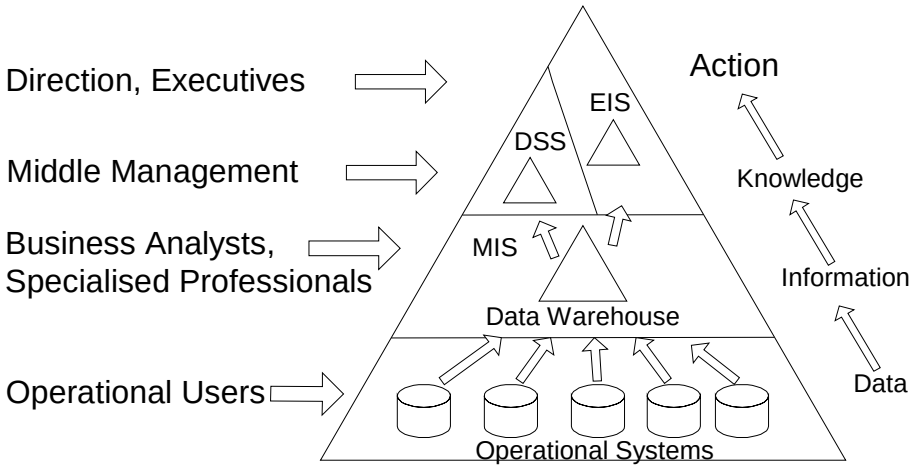


Figure 4.2: The SAS enterprise Wide Information Delivery System (IDS)

Diverse business goals such as improving productivity, reducing costs, increasing return of investment, maintaining quality, maximizing profitability can be achieved by the SAS data warehouse exploitation including a large range of powerful tools (BIS) such as the operations research, query, graphics, data visualization, EIS (executive information system), OLAP (online analytical processing), forecasting, Internet exploitation and so on. Operations research tools handle everything from the decision analysis, and project management to mathematical programming. These comprehensive tools can be used for strategic planning, production and operations management, project management, distribution planning and more.

4.3 The DSS Application Areas

Modular notions of CIM architecture show a set of decision making problems which can be solved by optimization techniques such as integer, mixed-integer, nonlinear, quadratic, and network flow programming. In practice, there are a wide variety of problems that can be modeled as linear programs such as:

- Product-mix problems, which find the mix that generates the largest return when there are several products that compete for limited resources.
- Blending problems that find the mix of ingredients to be used in a product so that it meets minimum standards and minimum costs.
- Network flow problems which find the optimal flow of material through a network -- networks have to provide supply and demand at nodes, cost and capacities on arcs, and multiple products flowing through the arcs.

- Transportation problems that find the optimal assignment of source nodes to demand nodes.

- Time-staged problems are models whose structure repeats as a function of time. Production and inventory models are classic examples of these problems. In each period, production plus inventory carried minus current demand equals inventory carried to the next period.

- Scheduling problems that assign people to times and places so as to optimize peoples' preferences while satisfying the demands of the schedule.

- Capital budgeting and project selection problems that ask for the project or set of projects that will yield the greatest return.

- Cutting stock problems that find the partition of row material that minimizes waste and satisfies demand.

In this paper, the main point is in tailoring the DSS to these classes of the above mentioned application areas. In this case the BIS capabilities is used for the development of a flexible computer-based DSS which incorporates linear modeling technique. To support an easy to use and effective exploitation of the linear programming capabilities, the graphic user interface (GUI) was designed and developed. It is one of three essential components of the DSS - other are model analysis and data management. With this GUI - this Windows application is based on object-oriented programming - managers navigate through a linear programming application by pointing and clicking with a mouse on appropriate selections. GUI menu choices are icons that users can select instead of typing numbers and letters (see Fig. 4.3).

The prototype of DSS provides data management and modeling capabilities to assist managers in making effective decisions, such as: planning for operations and capacity, plant sizing and location, distribution logistics, inventory management, etc. It also enables managers to access all data in a manufacturing organization, from flat files to database management systems, such as DB2, ORACLE, SAP/R3, etc. which is an important advantage of such a DSS.

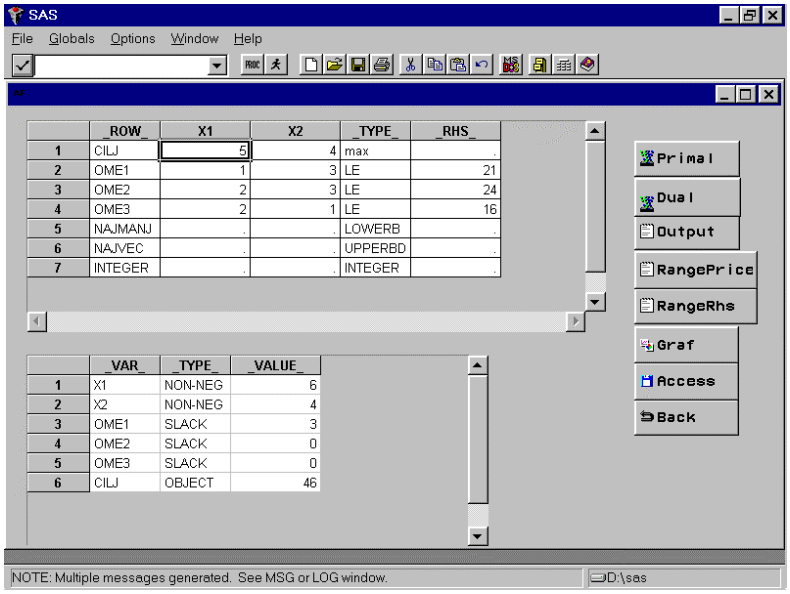
The following example of a simple product-mix problem (see Table 4.1) shows the usage of DSS for effective applications development. Table 1 shows that a firm produces two items, P1 and P2, that are assembled by three components: A, B, and C. The first item (P1) consists of 1 unite of the component A, 2 units of the component B and 2 units of the component C. The second item is composed of 3 units of the component A, 3 units of the component B and 1 unit of the component C. The objective is to determine the product mix (decision variables X1 and X2) that maximizes the profit (Z) of the firm while not exceeding available inventory of

the components in the warehouse. Each of both items P1 and P2 contributes C1=5 and C2=4 monetary units to profit.

Product-mix problem: **maximize the profit** **Z = 5X + 4Y**	**Items** **----------** **P1 P2**	**Inventory** **constraints**
A **B** **C**	**X1 + 3X2** **2X1 + 3X2** **2X1 + X2**	**<=21** **<=24** **<=16**
Price Coefficients: C1, C2 **Decision (structural) variables**	**5 4** ***X1 X2***	

Table 4.1: Input data and the structure of a simple product-mixed problem

Figure 4.3 represents the input/output screen of GUI which shows the input data of the problem and it's solution in the form of numerical results (output data) that represents optimal values of the production i.e. the number of items P1 and P2 that maximize the profit. The results are later generated of the »Primal« button selection and show that the maximum profit (return) Z of a manufacturing company will be 46 monetary unit if an operations manager decides to produce 6 articles of the item P1(X1= 6) and 4 articles of the item P2 (X2 = 4) which represent the optimal solution (product - mixed program) in this circumstances.



	ROW	X1	X2	_TYPE_	_RHS_
1	CILJ	5	4	max	.
2	OME1	1	3	LE	21
3	OME2	2	3	LE	24
4	OME3	2	1	LE	16
5	NAJMANJ	.	.	LOWERB	.
6	NAJVEC	.	.	UPPERBD	.
7	INTEGER	.	.	INTEGER	.

	VAR	_TYPE_	_VALUE_
1	X1	NON-NEG	6
2	X2	NON-NEG	4
3	OME1	SLACK	3
4	OME2	SLACK	0
5	OME3	SLACK	0
6	CILJ	OBJECT	46

Figure 4.3: The Input/Output screen of GUI

The graphics report which is shown on the Fig. 4.4 can be activated by "Graf" button selection.

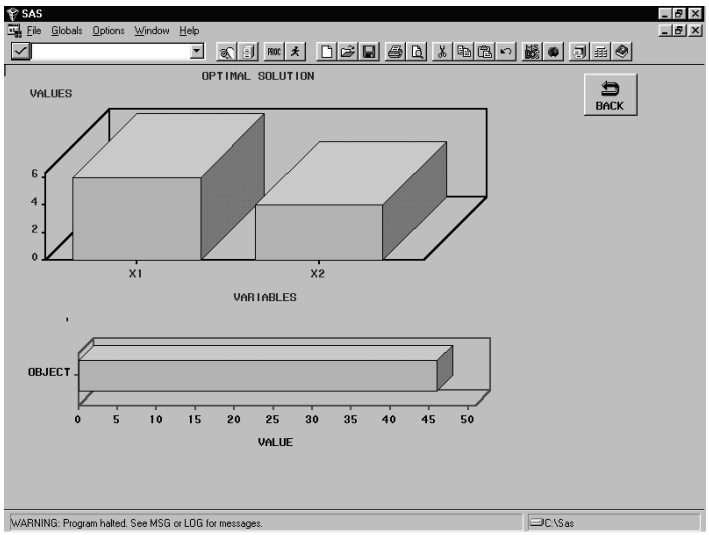


Figure 4.4: The graphic report

Moreover, if the manager needs to evaluate how sensitive is a solution to change assumptions (what if or sensitivity analysis), he can simply select the »RangePrice« or »RangeRhs« icons (see Fig. 4.3). This option enables managers to examine the size of a perturbation to the price (objective) coefficients or right-hand-side constants (limited resources, production time, minimum standards, etc.).

The output screen on Figure 5 shows the results of Price Range Analysis for the supposed product-mix problem. Each objective function coefficient (C1) and (C2) can vary (separately)

in the range from 2.66$ (C1-2.3$) to 8$ (C1+3$) or from 2.5$ (C2-1.5$) to 7.5$ (C2+3.5$), without changes of the optimal production program (decision variables remain unchanged).

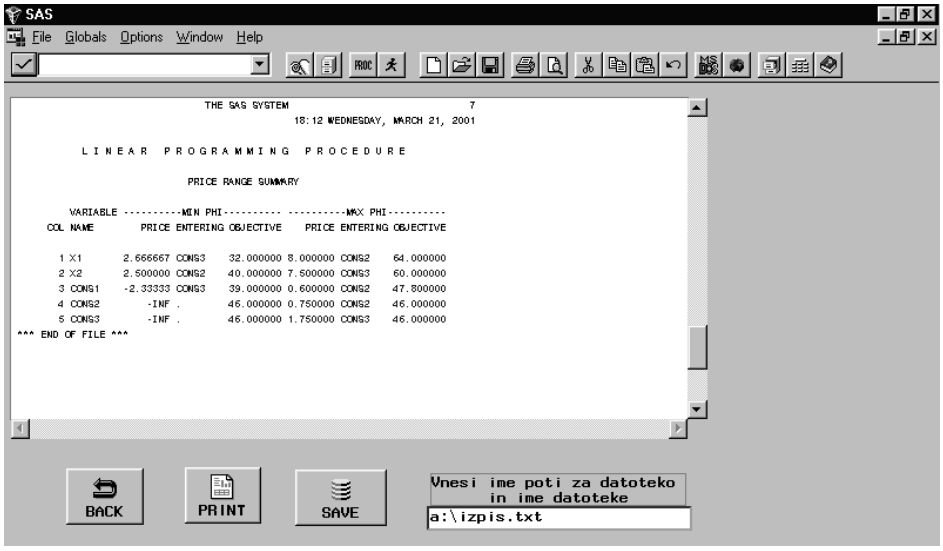


Figure 4.5: The results of the Price Range Analysis

The results of Right Hand Side (RHS) analysis deliver additional information to a manager. He or she can reduce the inventory of the component A in a warehouse for 3 units (reduction of the inventory cost) without changing the optimal production program and reducing the optimal profit. Thus, we can say that the sensitivity analysis enhances the efficiency of production and inventory management which has an important impact on the manufacturing efficiency improvement according the CIM objectives .

Linear models that are assumed to be continuous, however, may be used to approximate a wide variety of problems. When the problem is not appropriate for general linear programming technique (nonlinear problems), perhaps another DSS utilizing sophisticated set of BIS tools, such as nonlinear (quadratic) programming methods, can be applied along with an adequate friendly GUI.

4.4 Conclusion

Diverse business goals such as improving productivity, reducing costs, increasing return of investment, maintaining quality, maximizing profitability can be completed by adaptation of DSSs which incorporate a more sophisticated set of software. A hypothetical example shows that BIS tools of the SAS System provide a comprehensive framework for developing of several types of the specific DSSs that are needed to generate information relevant for the managerial decision making at various levels of the organization.

An effective application of DSS for solving linear programming problems is achieved by the user-friendly GUI. Rather than requiring users (i.e. managers) to remember a series of commands and options, this interface prompts apply for the next choice or action. As a result, managers are productive sooner because they can master the application by little training and documentation. The what-if analysis capability provides a comfortable learning experience for managers. The resistance to the use quantitative models for the decision making by managers can be reduced by the decision support environment which provides an easy access to models and model management and presents the opportunity to experiment with models (modeling and simulation).

In the Republic of Slovenia, as well as in other countries, a need for building up new information systems increases each year to help organizations to achieve business objectives through the improved production efficiency. One solution for this situation is Enterprise Resource Planning (ERP) system which requires data integration. In Slovenia many companies are implementing SAP R/3 or TRITON BAAN4 ERP systems. Beside those world known trademarks we have many Slovenian vendors with their own ERP solutions, which are satisfying need on Slovenian market.

Operational systems create a lot of raw data, which has the potential to tell organization a lot of very useful things about its business performance, its customers, its competitive environment, its sales channels and so on. Some of the features that are key strengths of ERP systems are precisely the barriers that prevent them from becoming effective for information delivery, what is defined as “the process of turning raw data in the meaning full information to support successful decision making”. So while ERP systems are good at reflecting and electronically capturing operational processes, they have failed to deliver on the reflection of how these processes can add value to the management decision-making process. This is where the separate market segment for business intelligent software comes in.

SAS System and other appropriate packages for information delivery and decision support are needed to see and predict company’s trends and achieve historical information from ERP system. This is necessary for decision making support on tactical and strategically level.

In the framework of Operations Research Course on the University of Maribor, Faculty of Organizational Sciences in Kranj this model of business DSS is being employed also for training students for practical work.

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