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## Specification of fact calculations within the MetaMIS approach

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**Specification of Fact Calculations  
within the MetaMIS Approach<sup>1</sup>**

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## **Abstract**

Based on recent work on the so called MetaMIS approach we show how fact calculations can be specified from a management point of view. The MetaMIS approach's intention is to specify management views on business processes. It comprises a language, a representation formalism and guidelines to define information required for management decisions. Information in general should have pragmatic meaning for the management user. Beyond the task of specifying information in this sense, fact calculations are required to manipulate information. Respective analyzing tasks typically deal with variances, growth rates and other relevant aspects of business processes. We extend the MetaMIS approach to enable the specification of fact calculations in data mart environments.

## 1 Introduction

Defining and structuring management views is a fundamental task of the specification of data marts and reporting systems. The MetaMIS Approach<sup>2</sup> is intended to achieving support for respective development tasks. It is a business driven method comprising a language, a representation formalism and guidelines for modeling information spaces. MetaMIS models specify information required by managers from a business perspective.

Online Analytical Processing<sup>3</sup> defined by CODD ET AL. is understood as an enterprise analysis method focusing on efficiently retrieving information in large databases. Operations such as roll-up, drill-down, slicing, dicing, or ranging efficiently enable users to navigate through company reports. These operations use relations to identify the results of a query. Technically, they may be implemented based on relational or multi array technology.

The MetaMIS approach so far focuses on the specification of information by means of so called reference objects and ratios. Reference objects are hierarchically ordered within dimensions. This type of organization enables a general compliance to the evaluation methods provided by OLAP.<sup>4</sup> Traditional OLAP-Reports usually display a number of ratios (the terms figures and metrics are synonymously used for ratios) assigned to various reference objects in tables. With respect to the MetaMIS approach relations between reference objects and ratios are called facts. MetaMIS so far provides two general ways to specify manipulations of management views:

1. Reference objects can be changed by means of so called dimension scopes and dimension scope combinations. The drilling-space is customized to meet user requirements.
2. Ratio systems can be defined. Drilling operations within hierarchically organized ratio systems lead to different aspects of predefined reference objects.

Nevertheless there are additional operations relevant to management users. These operations are based on facts (as a combination of a given set of reference objects with a given ratio system<sup>5</sup>). Business analyses require, e.g., calculations of growth rates (typically in % of a given base quantity), variances (typically calculated as difference of two

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<sup>2</sup> Compare Holten (2001), Holten (2002).

<sup>3</sup> Compare Codd, Codd, Salley (1993).

<sup>4</sup> Compare Holten (2002), pp. 32.

<sup>5</sup> Compare Holten (2001), Holten (2002).

base quantities of the same dimension in %) and shares of subordinated quantities in relation to higher quantities (in %). Since these kinds of operations deal with facts they can not be specified in the ways mentioned above. Such calculations are called *fact calculations* and we show how they can be modeled within the MetaMIS approach.

This paper has the following structure: First a brief introduction to the MetaMIS approach is given in section 2. We describe how MetaMIS models are constructed and how they can be used. Based on an example scenario the need for fact calculation specifications is motivated in section 3. We show how fact calculation expressions are represented in MetaMIS models and we sketch respective guidelines in section 4. Section 5 contains conclusions and outlines our further research.



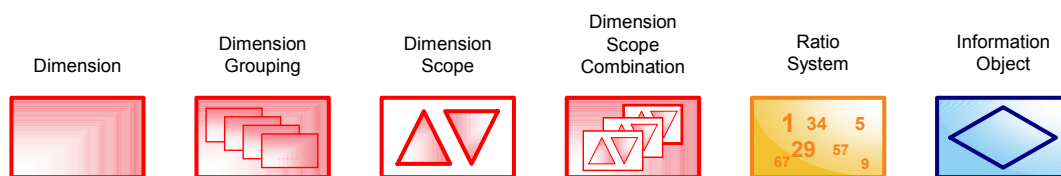
## 2 Modeling Management Views with MetaMIS

MetaMIS models focus on the specification of management views comprising well structured information. In this section we only give a brief overview on the method. See Holten (2001) and Holten (2002) for deeper discussions and examples. The first step is to identify dimensions spanning an information space. Dimensions are a set of reference objects in a hierarchical order with several hierarchy levels. If an identical set of objects is aggregated in different ways, the resulting dimensions are combined to a dimension grouping. E.g. dates might be aggregated to months and years in one dimension and to weekdays in another dimension. Both dimensions serve different analysis purposes

The hierarchical models span an n-dimensional space, where n represents the number of dimensions identified. In order to avoid information overflow, dimensions can be reduced to so called dimension scopes. All dimension scopes constructed for one analysis purpose are combined to a so called dimension scope combination allowing a maximum of one dimension scope for each dimension. Dimension scope combinations are intended to limit the drilling operations within the specified information space.

After having defined dimension scope combinations of the management views, ratios and ratio systems for specific business analysis purposes are specified. Ratios define business aspects relevant to the manager. Ratios can be combined to ratio systems to structure aspects creating a realistic picture of business situations.

An information object is created by assigning one dimension scope combination to one ratio system. By means of this operation a set of so called facts is defined. Facts are types of information assigning business aspects (ratios) to reference objects. They are core components of the MetaMIS approach. Figure 1 shows an excerpt of symbols of the MetaMIS representation formalism.



**Figure 1: MetaMIS symbols (excerpt)**

MetaMIS models can be transformed into logical data warehouse schemes.<sup>6</sup> This transformation is based on the usage of MetaMIS models in the sense of data warehouse

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<sup>6</sup> Compare Holten (2002).

meta data. Thus, the MetaMIS approach supports the implementation of management information systems from a business perspective.

### 3 Calculations with Facts as Requirement

Several business decisions require complex calculations with facts. These calculations comprise more than aggregations of detailed information. Business analysts combine calculated facts in very flexible ways. Especially the possibility to involve ratios assigned to different reference objects in calculations is crucial. Additionally calculations are often based on intermediate facts produced in an ongoing analyzing process. Some types of calculations require facts based on different reference objects (percentage of total), growth analyses (percentage of an increase) or variance analyses (variance of plan versus actual figures).

All these kinds of calculations are based on facts in the sense of the MetaMIS approach. They go beyond the information set defined by MetaMIS models so far. Fact calculations are performed on the basis of data queried and aggregated from operative data sources and data warehouses or data marts.

Selected Consolidated Financial Data															
(Euro amounts in millions except share data)															
	Europe		Germany				France				UK				...
	2001	2000	2001	2000	2001 Share of Europe	Share Deviation	2001	2000	2001 Share of Europe	Share Deviation	2001	2000	2001 Share of Europe	Share Deviation	
<b>Operating Figures</b>															
Net Sales	318.711	258.156	167.801	134.241	52,65%	1,25%	84.586	69.057	26,54%	-0,79%	39.201	30.979	12,30%	2,50%	
Other Income - Net	5.639	4.680	2.312	2.247	41,00%	-14,58%	1.748	1.299	31,00%	11,71%	1.015	889	18,00%	-5,26%	
Cost of Sales	269.854	213.185	140.216	107.658	51,96%	2,89%	72.348	56.494	26,81%	1,17%	32.113	26.435	11,90%	-4,03%	
Other Expenses	34.943	30.051	20.966	18.632	60,00%	-3,23%	6.290	5.109	18,00%	5,88%	2.795	2.464	8,00%	-2,44%	
<b>Income Figures</b>															
EBIT	19.553	19.601	8.931	10.198	45,68%	-12,20%	7.696	8.753	39,36%	-11,86%	5.308	2.969	27,15%	79,24%	
Income Taxes	5.866	5.880	2.679	3.059	45,68%	-12,20%	2.309	2.626	39,36%	-11,86%	1.593	891	27,15%	79,24%	
Interest Expense	3.602	3.526	2.077	1.798	57,65%	13,04%	829	789	23,01%	2,82%	697	939	18,34%	-27,35%	
Net Income (loss)	10.085	10.194	4.175	5.340	41,40%	-20,96%	2.937	2.987	29,12%	-0,61%	2.973	1.867	29,48%	60,94%	
<b>Financial Figures</b>															
Working Capital	35.003	33.496	21.044	17.418	60,12%	15,62%	8.135	8.960	23,24%	-13,12%	4.165	4.020	11,90%	-0,83%	
Total Assets	83.361	79.532	43.890	41.357	52,65%	1,25%	16.564	21.275	19,87%	-25,72%	12.563	9.544	15,07%	25,58%	
Long-term Debt	16.191	14.551	8.686	7.567	53,65%	3,17%	3.455	3.892	21,34%	-20,22%	1.940	1.746	11,98%	-0,17%	
Return on Assets	12,10%	12,82%	9,51%	12,91%			17,73%	14,04%			23,66%	19,57%			
Return on Capital	28,81%	30,43%	19,84%	30,66%			36,10%	33,34%			71,37%	46,46%			

**Table 1: Example Management Report**

Table 1 displays an example management report containing exclusively calculated facts. There are three types of calculations:

1. Aggregations of detailed information based on one set of reference objects and one ratio.
2. Calculations of facts of the same set or reference objects and a set of ratios. There are calculation expressions for so called calculated ratios applied to all reference objects in an identical way.
3. Calculations of facts with possibly different reference objects and different ratios.

The first type of calculations are basically aggregations of, e.g., operative cost and sales data. The columns Europe, Germany, France, and UK in 2000 as well as 2001 in the Operative Figures area contain aggregated figures. They describe business facts by assigning a ratio to a reference object and can be retrieved by aggregating detailed data from the data warehouse.

The second type of calculations is based on calculation expressions for ratios applied to the same reference object. E.g. the return on capital is calculated by dividing the net income (loss) minus dividends by all long term debt plus common and preferred shares:<sup>7</sup>

$$\text{return on capital} = \frac{\text{net income (loss)} - \text{dividends}}{\text{long term debt} + \text{common and preferred shares}}$$

This calculation expression is defined for ratios (return on capital, net income, long term debt, etc.) and has to be assigned to a reference object. In Table 1 these reference objects are given as “Europe, 2001”, “Europe, 2000”, Germany, 2001” etc.

Another example is EBIT which is defined as follows:

$$EBIT = \text{net sales} + \text{other income} - \text{cost of sales} - \text{other expenses}$$

Facts of type 2 have in common, that their calculation expressions can be described without involving reference objects. The consequence is an abstract definition of fact calculations exclusively for static enterprise analyses. The definition of EBIT implies that we always consider EBIT, Net Sales, Other Income - Net, Cost of Sales, and Other Expenses of one reference object, e.g., “Germany, 2001”.

The third type of calculated facts is more complex. These calculations are performed in several steps. Complex fact calculations comprise aggregation operations (type 1) and ratio calculations (type 2). Additionally every calculation step produces intermediate results related to possibly different reference objects. E.g. the "2001 Share of Europe" columns for the regions Germany, France and UK (Table 1) relate ratios defining the rows of the report to different reference objects differentiated by the respective regions. For every ratio facts are calculated as shares of a country in relation to Europe and expressed as a percentage rate.

Another even more complex example is given by the “Share Deviation” columns for the regions Germany, France and UK. To calculate these facts, shares of 2001 are used as intermediate results divided by the respective shares for year 2000 (second intermediate

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<sup>7</sup> Compare <http://www.investopedia.com>

result). The result is expressed as a percentage rate. Two variations of reference objects (year 2000 in relation to year 2001; country in relation to Europe) and complex ratio calculations (e.g. EBIT and return on capital as explained for type 2) are characteristics of these complex fact calculations.

Types 1 and 2 of fact calculations are specified by MetaMIS as basis ratios and calculated ratios.<sup>8</sup> For type 3 – complex fact calculations – suitable representation formalisms are introduced in the next section.

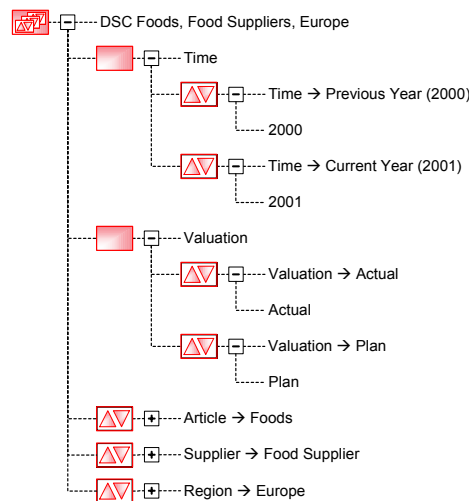
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<sup>8</sup> Compare Holten (2001); Holten (2002).

## 4 MetaMIS Representation Formalisms for Fact Calculations

### 4.1 Specifying Dimension Scope Combinations

The basic step of the MetaMIS approach comprises the specification of dimensions, dimension groupings, dimension scopes and dimension scope combinations. To get suitable specifications of complex fact calculations we first propose minor changes concerning the specification of dimension scope combinations. If more than one dimension scope within a dimension scope combination is related to one dimension an additional dimension symbol is introduced. The effect is that the number of dimensions involved in the definition of a dimension scope combination can be recognized more easily (Figure 2).



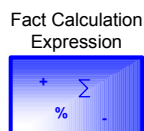
**Figure 2: Dimension Scope Combination Foods, Food Suppliers, Europe**

The dimension scope combination shown in Figure 2 spans a 5-dimensional space of reference objects. Each reference object can be understood as a cell having 5 coordinates. This is expressed by the first hierarchical level of the dimension scope combination consisting of 5 elements. Either one of the 5 elements has to be chosen as coordinates to define the reference object as a vector. The semantics of the combination of different dimensions is the logical ‘and’ ( $\wedge$ ). The sub trees beginning at the second hierarchical level combine different sub sets of one dimension. This combination corresponds to the logical ‘inclusive or’ ( $\vee$ ). These combination operations are relevant for the generation of logical data mart schemes based on MetaMIS models.<sup>9</sup>

<sup>9</sup> Compare Holten (2002), pp. 26.

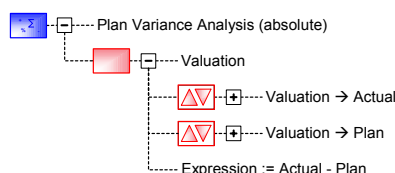
## 4.2 Fact Calculations based on Variations of one Dimension

Since fact calculations in the sense of type 3 (see section 3) require a variation of reference objects within dimension scopes and dimension scope combinations a new representational element is needed. Figure 3 shows the fact calculation expression item.



**Figure 3: Fact Calculation Expression Item**

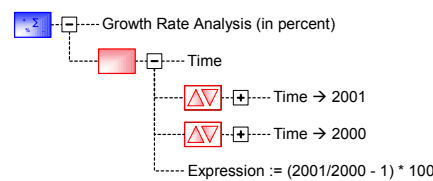
The specification of fact calculation expressions includes the dimension scopes involved in calculations as well as algebraic expressions. To perform, e.g., an absolute plan variance analysis the dimension scopes "Valuation → Actual", and "Valuation → Plan" are necessary. Both dimension scopes reduce the valuation dimension to either a "Plan" reference object or an "Actual" reference object, i.e., a reference object for results actually realized in the business processes.<sup>10</sup> The absolute variance between actual and plan facts is calculated by the algebraic expression "Actual - Plan" for all possible ratios. Figure 4 shows the specification of the absolute plan variance analysis fact calculation expression.



**Figure 4: Plan Variance Analysis (absolute)**

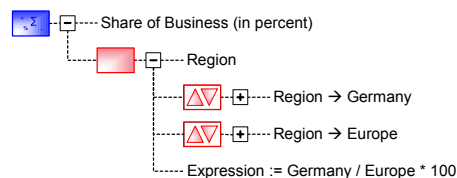
Another important fact calculation example is growth rate analysis. Regardless of the ratio itself the definition of the growth rate in year 2001 compared to year 2000 is defined by the algebraic expression "(2001/2000 -1) \* 100" within the time dimension. The two dimension scopes "Time → 2001" and "Time → 2000" reduce the time dimension to the relevant reference objects 2001 and 2000. Figure 5 shows the growth rate analysis specification.

<sup>10</sup> There are many plan scenarios possible. See Holten (2001) and Holten (2002) for deeper discussions of plan and actual business scenarios and their representation as dimensions.



**Figure 5: Growth Rate Analysis (in percent)**

Fact calculation expressions are not necessarily restricted to reference objects of the same hierarchy level. Important analyses comprise, e.g., shares of one part of business of the complete business. These analyses serve to examine the influence of, e.g., the German business within the European business or the food business within a wholesale trading company. To specify fact calculations for these purposes a set of dimension scopes is defined and combined with the respective calculation expression (Figure 6). Every hierarchy level needed is defined by means of a dimension scope.



**Figure 6: Share of Business (in percent)**

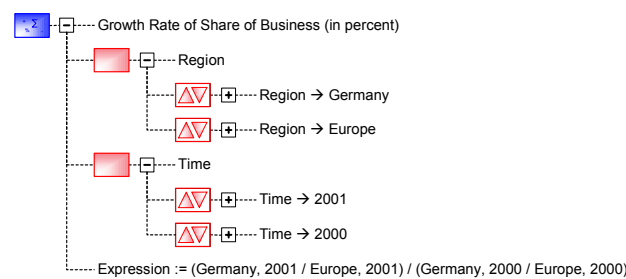
Other possible analyses might examine process performances within companies. If, e.g., a call center creates cases for all new incoming calls and logs the persons involved and time used to solve the case these data can be evaluated. The ratio of process cases where experts are consulted to all processed cases might be an indicator of the problem solving competences of call center agents. The time needed by experts to solve cases divided by the time non-experts need for the same task might indicate how much better experts really are compared to non-experts. Another example could be the ratio of complains to all processed customer orders which might be a quality indicator of production. This way several qualitative facts can be approximated by quantitative ratios which supports concepts such as the balanced score card.

### 4.3 Fact Calculations and Multi-Dimension Variations

Fact calculation expressions can be defined based on a set of dimensions. A manager might be interested in the growth rate of year 2001 compared to year 2000 of the share of turnover in Germany compared to Europe. This analysis serves as an indicator to see whether the German business gained or lost shares of the European business.



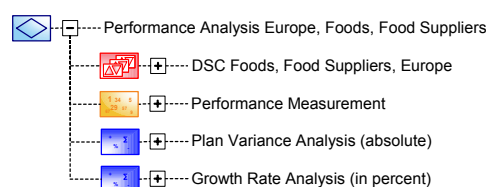
To perform this calculation a complex reference object is necessary which is characterized by consisting of more than one dimension reference object. Required reference objects vary with respect to the region scope and time scope. The expression to calculate the growth rate of share of business as described above needs to include the division of the German share of business of the European business in year 2001 by its counterpart in year 2000. Thus, the reference objects involved in the calculation vary by at least two dimensions (Figure 7). This fact calculation specification combines specifications of different dimension scopes belonging to the same hierarchy level (year 2000 and year 2001 respectively) with dimension scopes belonging to different hierarchy levels (Europe and Germany).



**Figure 7: Growth of Share of Business (in percent)**

#### 4.4 Integration of Fact Calculation Expressions and Information Objects

Having defined all necessary fact calculation expressions and dimension scope combinations an information object can be specified. Beyond the specification of information objects so far<sup>11</sup> specifications of fact calculations are added. Information object specifications are enhanced by fact calculation specifications on the first hierarchical level as shown in Figure 8. An information object specifies the information space spanned by the dimension scope combination with an assigned ratio system and fact calculation expressions. The extended information object shown in Figure 8 implies that the fact calculation expressions apply to all ratios of the involved ratio system.



**Figure 8: Performance Analysis Europe, Foods, Food Suppliers**

By defining an information object the way proposed here we gain two advantages:

<sup>11</sup> See Holten (2001) and Holten (2002).

1. A clear and easy to understand definition of the underlying information space: Every piece of information which is extracted from this information object does necessarily fit into a manager's information needs because these information needs have been the construction basis of the information spaces.
2. Structuring of the information space: Dimension scope combinations span and structure the information space. Ratio systems express relevant aspects required for business analyses and specify quantitative information. Fact calculation expressions are the means to structure shares and developments of the business.

## **5 Conclusions**

The MetaMIS approach was enhanced by the specification of complex fact calculations. The presented modeling concept enables the user to check the formal consistency relations between the dimension scope combinations involved in fact calculations and abstractly defined dimension scope combinations used to define an information object. Both dimension scope combinations must be semantically equal. The basis to formally specify fact calculation expressions will be an extension and rearrangement of the MetaMIS terminology and meta model as well. Our ongoing research deals with these topics. Additionally, further work concentrates on the development of an information system supporting the MetaMIS modeling process. Finally, the concepts of MetaMIS will be extended to allow suitable specifications of report layouts.

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