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Piechocki, M.; Felden, C.; and Graning, A., "Multidimensional XBRL Reporting" (2007). *ECIS 2007 Proceedings*. 75.
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MULTIDIMENSIONAL XBRL REPORTING

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Abstract

The Committee of European Banking Supervisors (CEBS) agreed on a common reporting (COREP) and financial reporting (FINREP) frameworks which are to be adopted by supervising institutions in the member countries of the EU. Due to the amount of data that needs to be received by supervising institution from financial institutions as well as standardisation of the introduced frameworks the CEBS released two eXtensible Business Reporting Language (XBRL) taxonomies. XBRL which is addressed as the de facto standard of business reporting should introduce greater efficiency, speed and integrity which will make the European financial markets more competitive. The COREP taxonomy defines common reporting of the solvency ratio and the FINREP taxonomy serves as a common reporting framework for financial data. These initiatives take advantage of the fact that Basel II and International Accounting Standards (IAS) will require all supervisors to change their reporting requirements. Both taxonomies build up not only on the basic XBRL specification but also on XBRL Dimensional Taxonomies (XDT) specification allowing multidimensional modelling of reported data. However XDT provides multidimensional approach to data modelling is not clear, what is the relation to traditional multidimensional modelling approaches. The main focus of the conducted research is the analysis of multidimensional data modelling in XBRL compared to more traditional modelling approaches.

Keywords: XBRL, ADAPT, multidimensionality, COREP.

1 INTRODUCTION

The complexity of data warehouse models based on the entity-relationship-model was one of the biggest driving forces behind multidimensional modelling. Therefore the designed models were easily understood by business experts and easily analysed by final users. Nevertheless, the evolution of the dimensional paradigm has showed that the business world is too complex that it is necessary to introduce new concepts to the models like bridge tables, heterogeneous dimensions, factless fact tables, etc. to allow a greater level of representation. As a result, the designed model lacks the desired simplicity and does not guarantee the representation of all the semantics of the domain. Parallel to the discussion about the data warehouse models there has been a discussion about standardising of business reporting. Together with the introduction of XBRL a standardisation of simple business reports can be achieved. However the requirements in the business reporting world such as CRD (Capital Requirements Directive) and Basel II increased the complexity of the reports. In order to cope with the increased requirements the XDT have been developed enabling modelling of multidimensional business reports (Boixo et al. 2005). It leads to an issue of having different multidimensional modelling approaches one for data warehouses and other for business reports which are usually transferred between the data warehouses. The presented research discusses the issues arising when introducing a new multidimensional approach. This alternative, based on XDT, is shown through a comparison with a traditional multidimensional model exploring all the limitations and ease of use derived from the XBRL. The objective of this paper is to compare the traditional multidimensional modelling approaches with the XDT approach, stressing out the semantic richness of both. In order to do so, the article explores briefly the background of a dimensional understanding of a problem domain in chapter 2. Then it demonstrates the XDT and the resulting semantic in chapter 3. Chapter 4 contains a real-world example explored using a case study. Finally, the authors conduct an analysis of the XDT approach in chapter 5. The analysis of multidimensionality is only an initial point for further research activities. Due to this reason, the conclusion gives some further research lines which are based on multidimensional thinking.

2 DIMENSIONALITY OF REPORTING

The collection, reduction and selection of relevant information for analytical tasks can only occur on the basis of consistent company-wide data retention. Due to the heterogeneous legacy systems a systematic bringing together of relevant databases is necessary (Lusti 2002). The data warehouse concept is an attempt to efficiently manage and collect relevant information derived from the vast amount of data (Lehner 2003). Some authors define a data warehouse as a collection of data (e.g. Bauer et al. 2004, Devlin, 1997, Lehner 2003). Others define data warehousing as a process of assembling and managing data from various sources for the purpose of gaining a single detailed view of the company's activities (Inmon 2002, Lusti 2002, Chamoni 1998). Whether there is an understanding of a collection of data or process, the system has to deal with a huge amount of data for analytical tasks, which implies challenges in its construction, management, and usage. Commonly, data warehouse data is stored in an n-dimensional space, allowing its study in terms of facts, subject of analysis, and dimensions showing the different points of view a user can have (Bauer et al. 2004). The following chapter presents the background of the data warehouse concept as an already accepted approach for analytical information systems and focuses on the multidimensionality of reporting to give a broad understanding about the problem domain.

2.1 The Data Warehouse Concept

Devlin (1997) was the inventor of data warehousing. The basic idea was to have data storage for a huge amount of data available that should give support for analysis. Inmon (2002) identified four

characteristics of a data warehouse, which are represented in his formal definition: "... a data warehouse is a subject oriented, integrated, non-volatile and time variant collection of data in support of management's decisions". The structure of a data warehouse is totally different from the structure of operational databases. A data warehouse differs due to the distinct objectives of operational databases by the type of the entered data and the way the data is supplied. The core of a data warehouse is a database, in which data from different operational systems is saved on different levels of aggregation retaining the time series.

2.2 Dimensionality

Due to the fact that, as a rule, analysts make complex queries and demand intuitive working with the database, a multidimensional data model seems appropriate. Each combination of dimensions, e.g. region, time or customer, characterises a possible analyst's query. The complexity of a multidimensional structure is result of the amount and the type of dimensions. Codd (1994) says, dimensions can be seen as the highest reduction level of data. Therefore, two characteristics of dimensions can be highlighted. On one hand, all elements of a dimension are equal; this means they all have the same granularity. On the other hand as Bulos already stated (1996, p. 33), there is a hierarchical relationship between them. One example is the time dimension. This dimension is a result of hierarchical aggregation starting from day to month, to quarter, and to year.

A multidimensional data model needs describing elements which can denote the characteristic properties of the underlying database structures. Basic elements of a multidimensional database design are sets of related dimension elements which are organized by aggregating and disaggregating operators. A multidimensional data space is spanned by the characterising data (=dimensions). Chamoni (1998, p. 233) and Holthuis (1999, p. 122) agree that business measures are loaded from the transactional systems according to the mapping between both systems and their synchronisation. Individual user queries represent manipulations within the multidimensional space, whereby the access to the business measures can be realized only via the dimensions, because the dimensions are nothing else then classes of real world objects (Chamoni et al. 1999, p. 402, Gluchowski 1997, p. 62). For example a product dimension seizes all company's product types. The query able positions within a dimension are specific real world objects which can be grouped, because of a semantic relationship between these objects (Gabriel et al. 1998, p. 495).

From a geometric point of view, a multidimensional data model can be seen as a cube in a case of three dimensions. If we have more than three dimensions, the multidimensional structure is called a hypercube. Such multidimensional structures are the basic idea of Online Analytical Processing (OLAP) to reflect analyst's queries (Schinzer et al. 1999, p. 55). OLAP supports multidimensional querying in an integrated data warehouse database (Chamoni et al. 1999, p. 403).

Each cell of the cube contains business measures which are called fact data or more briefly facts. Their meaning is determined by the characterizing dimensions of the cube structure. Querying such a database can be done by using the operations slicing, dicing, pivoting, and drill down (Chamoni 1998, p. 234). The complexity of an underlying hypercube results from the number and type of dimensions (Gabriel et al. 1998, p. 496).

Basically this kind of data structure can be realized in a non-multidimensional database. Should it be an implementation of a multidimensional data space according to the relational data model, the most used modelling technique is called star schema. It is based on the entity relationship model in order to support multidimensional analysis in a relational framework (Nußdorfer 1998, p. 18). Due to the idea of tables in such a relational model, two kinds of tables can be differentiated: fact tables and dimension tables. Fact tables contain quantitative and business oriented data which can be retrieved using database queries. Dimension tables contain characterizing elements of fact data. Relationships exist only between fact and dimension tables. There are no relationships between dimension tables (Poe 1996, p. 192).

Multidimensional concepts and relationships are useful for analytical tasks. But it should not imply that other data modelling concepts should be ignored. Almost all existing multidimensional models are limited, because the modelled data warehouse architecture is too poor regarding semantics. Moreover, besides the lack of semantic relationships there is no agreement on the definition and properties of multidimensional concepts. All models merely impose the properties and structure of aggregation hierarchies in the analysed dimensions which reflects the dimension description of Bulos (1996). Another important issue in multidimensional modelling is the implementation of aggregability or summarisability. The data schemas should show how data of a given granularity can give rise to data of coarsest granularity. The importance of aggregation hierarchies is recognized. Thus, most multidimensional models provide mechanism to define them. Nevertheless, none of the authors proved nor justified the characteristics of those hierarchies. Based on the structure of aggregation hierarchies and data dependencies, the structure of the fact data has been studied. In the recent years, several multidimensional models appeared (Schelp 1999, p. 281). Each of those models uses a different nomenclature and was conceived for a different purpose so that their comparison becomes difficult. There is a need for a framework in favour of the comparison of such different models. It is quite common in analytical tasks that information used or obtained from the study of a given subject is valuable for the analysis of another subject. However, existing models do not pay enough attention to this and allow representing isolated star schemas. Thus the following chapter analyse a recent approach to the multidimensionality with the use of XBRL standard.

3 DIMENSIONAL XBRL

The data model behind XBRL is based on taxonomies expressing metadata and instance documents referring to the taxonomies representing business reports. The eventuality of realising a multidimensional XBRL reporting demands a data model which defines the existing elements in its different expressions. This results in the multidimensional modelling concerning only XBRL taxonomies. The reported numbers in the instance documents refer to the elements and their expressions modelled in the XDT not being a part of the multidimensional data model. In order to model a real-world problem three kinds of taxonomies are used. The *primary taxonomies* represent business fact data which are later reported according in instance documents. The *domain member taxonomies* model the content of the explicit (finished) dimensions and the holder properties for the typed dimensions. The *template taxonomies* amend the multidimensional model connecting the primary items with dimensions using hypercubes (Hoffman 2006). In order to model the relationships between various elements (primary items, hypercubes, dimensions and domain members) the following connections (arcroles) are used:

- all or notAll (primary item – hypercube),
- hypercube-dimension,
- dimension-domain,
- domain-member.

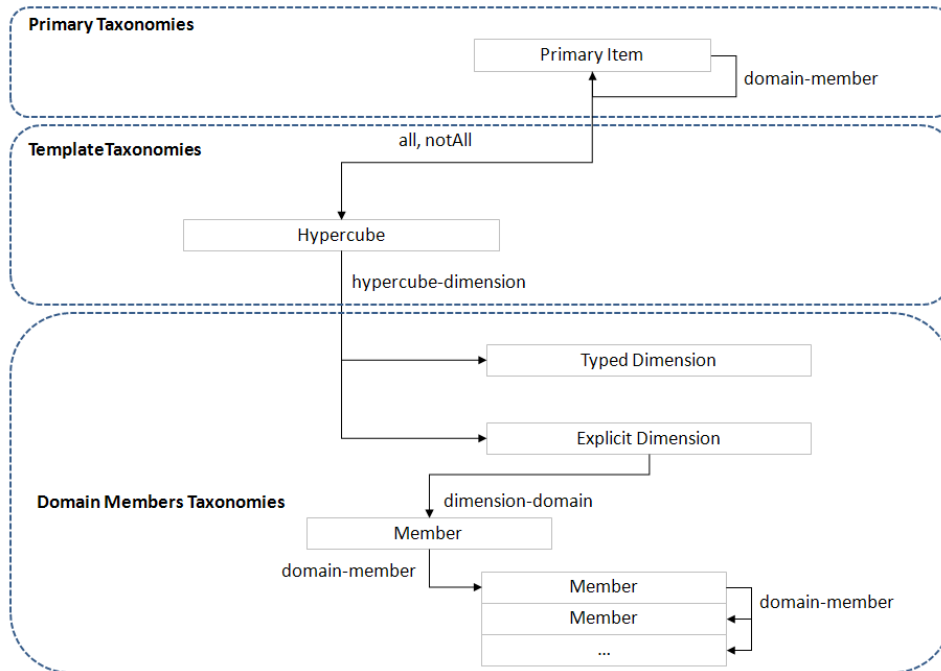


Figure 1. Dependencies in XDT

Figure 1 represents the usage of the taxonomies, elements and connections among them. XDT differentiates between explicit and typed dimensions. In case of explicit dimensions all domain members are known and grouped into exactly one dimension. Typed dimensions are used, if the amount of members is too large so that it cannot be expressed with a finished number of members. Examples are longitudes and latitudes within a geographical dimension, because such a dimension would contain a huge amount of numeric values. So, the precise definition of these values would cause enormous effort. The content of the typed dimension is to be defined in the instance document (Hernández-Ros et al. 2006, p. 19). The domain members within explicit dimensions are connected using the arcrole domain-member creating dimensional hierarchies. Further the explicit dimensions are connected to the domain members via dimension-domain arcrole. Both explicit and typed dimensions are gathered in hypercubes using the hypercube-dimension arcroles (Hoffman 2006). Finally the arcroles all and notAll show the relationship between a primary item and the concerned hypercube. All is used, if all dimensions of a hypercube are related to the primary item. NotAll is used, if all dimensions of a hypercube are excluded from the primary item (Hernández-Ros et al. 2006). Due to the reason that not each primary item has to be linked to the hypercube, the arcrole domain-member can be used not only within domain members taxonomies, but also within the primary taxonomies. This offers the possibility to link a full tree hierarchy of primary items to the respective hypercube. Differently to the traditional approaches the time aspects are not modelled in XDT as an individual dimension. They are reflected in the contextual information in an instance document for all the reported data. It is due to the nature of business reporting as well as XBRL specification (Hernández-Ros et al. 2006).

4 EXPERIMENTAL MEASUREMENTS

In our research we analysed the approach suggested by CEBS in the area of multidimensional reporting for the financial institutions in the EU. CEBS released a multidimensional data model in COREP taxonomy. Financial institutions in many member states are obliged to report in the form of instance documents based on the COREP taxonomy. The required data that has to be reported in the instance document is mostly stored in the data warehouse systems of the financial institution and needs to be extracted and mapped to the XBRL data model. The created instance document is sent to a

national banking supervisor, validated according to the COREP taxonomy and usually stored in the data warehouse of the supervisor (Boixo, Flores 2005). Figure 2 presents the multidimensional data flow in the COREP reporting. The arising issues are the differences between multidimensional data models in the data warehouse area and in the XDT.

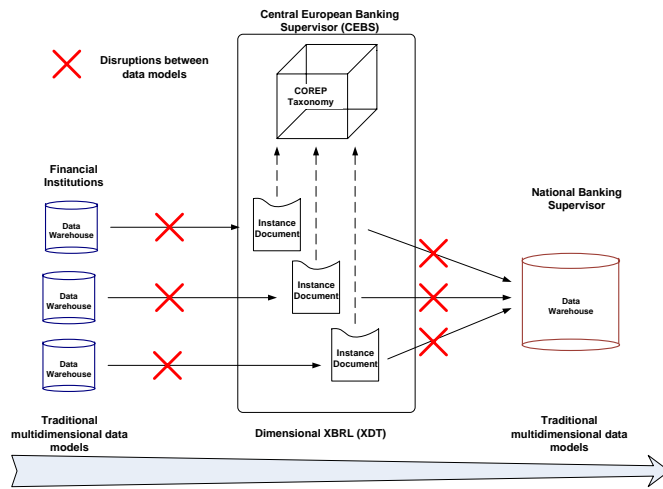


Figure 2. *Multidimensional data flow in the COREP reporting*

We are going to use the multidimensional COREP taxonomy created by the CEBS. Especially we will focus our measures on one of the 19 templates available in the COREP taxonomy so called t-me template. The choice of the t-me template is supported by the fact that this template unites the explicit and typed dimension within one hypercube which increases the comprehensiveness of the research. First we describe the template using graphical convention and then we model the template structure using ADAPT approach.

4.1 Multidimensional XBRL-Model for COREP

There exists no graphical modelling technique in the field of XBRL as they are already known in database or software engineering. The graphical modelling technique used in this paper refers to the specification XBRL Dimensions 1.0 describing XDT (Hernández-Ros et al. 2006). Although being no formal modelling approach the shown rules are appropriate to design a model graphically and to analyse the model as a set of taxonomies in the further steps.

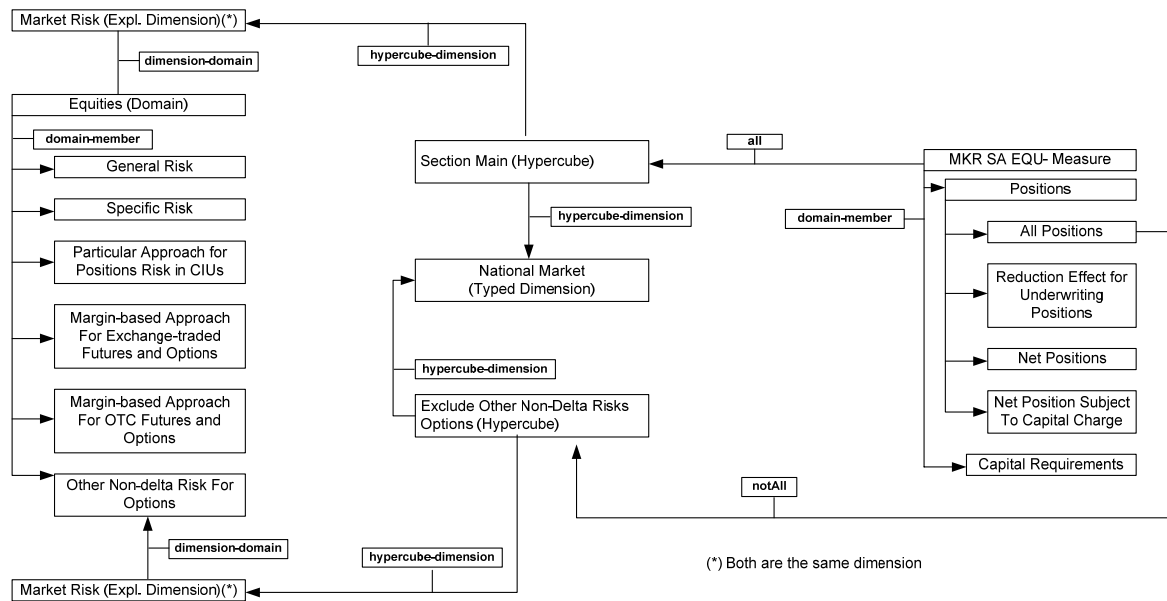


Figure 3. Multidimensional COREP data model according to XDT

Figure 3 shows the elements relevant for the multidimensionality as well as arcroles for their connection. The hypercubes and miscellaneous arcroles represent a logical linkage between the elements. The arcroles hypercube-dimension link the hypercubes Section Main and Exclude Other Non-Delta Risks Option to the dimensions Market Risk and National Market. The arcroles all and notAll link these hypercubes to the primary items MKR SA EQU. The result is a relationship of the hypercube to all other elements in this data model. The hypercube Section Main is linked to both dimensions. The modelling of the explicit dimension Market Risk represents the relationship between the dimension and individual domain members. The Market Risk has one domain which is Equities and a number of domain members such as General Risk, Specific Risk, etc. Second dimension is the National Market dimension. National Market is a typed dimension which means it has no explicit members defined. Possible characteristics of the dimension are defined in the submitted instance document individually by each financial institution. The Section Main hypercube is linked to the MKR SA EQU which is the main measure. Since the measure is in domain-member relation with all the children in the hierarchy the hypercube applies for all of them. The second hypercube Exclude Other Non-Delta Risks Option is linked to the National Market in the same way as Section Main hypercube. But the link to the Market Risk dimension is different. In this case only member Other Non-delta Risk For Options is connected to the hypercube. Using notAll arcrole for the connection to the primary item All Positions the hypercube excludes the combination of the explicit member Other Non-delta Risk For Options with each typed member of the National Market for this primary item and all its sub items. In the following the same problem domain is modelled as ADAPT.

4.2 Multidimensional ADAPT-Model for COREP

ADAPT (Application Design for Analytical Processing Technologies) is a modelling technique in favour of developing multidimensional data structures (Bulos 1996). ADAPT was developed for the support of multidimensional data structures in the OLAP area. This approach is not related to any specific database or data warehouse. Also there is no special modelling tool for the implementation of ADAPT (Schelp 2000, Totok et al. 1998). According to Hahne (2006, p. 81) it reflects more a methodology that was developed during the practical project with data warehouses and OLAP systems.

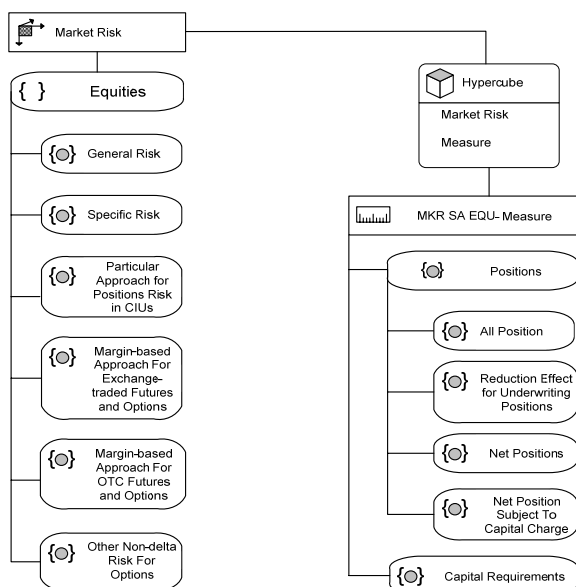


Figure 4. Multidimensional COREP data model according to ADAPT

The data model presented in the figure 4 reflects the Market Risk dimension and the MKR SA EQU measures structure. Due to the limitations of ADAPT it is not possible to model the typed dimension National Market and the exclusion of the combination of explicit member Other Non-delta Risk For Options with each typed member of the National Market for All Positions and its sub items.

It can be clearly stated that the XDT approach offers more flexibility allowing not only modelling the elements of the data model but also relationship among them. An important aspect is modelling of the time dimension which is not usual in XDT (due to the nature of reporting information) but almost always modelled in ADAPT. Due to the lack of time modelling in XDT the ADAPT model does also not reflects this aspect in our research.

5 COROLLARIES AND CONSEQUENCES

In order to compare the different modelling techniques described in chapter 4 it is essential to set appropriate evaluation criteria. In favour of this we use the standard DIN ISO 9126 (1991) which defines software quality criteria. The standard contains six main criteria with sublevels in order to gain an abstract conclusion about software quality. Some of the defined criteria are not taken into account, because they do not bring any contribution to this research. But software quality aspects alone are not enough while analysing multidimensionality. Due to this reason it is obvious to use Codd's twelve OLAP rules as enhancement to the six DIN ISO 9126 criteria. This has to be done with the limitation that Codd's rules are strongly related to the analytical software tool of his consulting company (Hahne, 2005). So we propose the restriction of the five criteria which are already known as Fast Analysis Shared Multidimensional Integration (FASMI) (Pendse 2005). These five aspects fit into the DIN ISO 9126 standard so that they can be used for the following evaluation.

5.1 Evaluation Criteria

The following figure 5 shows the categories taken from the DIN standard and their relevant features.

First of all it has to be examined, whether the technique generates correct results, or that the modelling-technique delivers appropriate construction elements, and that there is an interaction support for distributed information systems to evaluate the functionality of a conceptual modelling

technique. Furthermore, the multidimensional point of view has to be considered. Especially this aspect is included in the FASMI criterion multidimensionality.

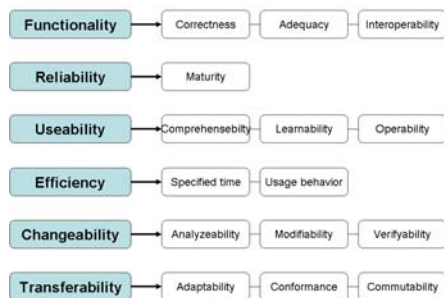


Figure 5. Evaluation criteria according to DIN ISO 9126 (Schlenker 1998, p. 26)

Reliability is the system's ability to be a standard solution in a specific problem domain. A criterion to validate reliability is the maturity level of the standard. For example the Gartner Group Lifecycle-evaluation (Fenn et al. 2005) is such a validation. Usability describes the modelling effort due to the respective technique. This is validated by using the criteria comprehensibility, learnability, and operability. FASMI, for example, is using these criteria in context of Analysis and Shared as well. Hence, there is a need for appropriate query and retrieval mechanisms to use OLAP-systems without a specific knowledge about the underlying database. Efficiency is describing the proficiency level of the used method and the amount of the necessary system's resources. Commonly, the criteria specified time and runtime behaviour are used to evaluate this. Resources are reflecting the used system volume, storage volume, and model size. Changeability is the headline for describing the effort to realize changes within the model. Changes are corrections, improvements or just modifications of the model. The evaluation is done by using the criteria analyzeability, changeability, and evaluation ability. Transferability, the final DIN category, describes the model's ability to be transferred (on a conceptual, logical, and physical layer) from one architecture to another. Adaptability, conformity, and compatibility are the used criteria.

5.2 Evaluation of the XDT Modelling Technique

The evaluation goes over three stages. The highest stage (+) informs about the complete fulfilment of the analysed criteria. In case the criteria fulfilment level is insufficient the middle stage (o) is assigned. The third stage (-) represents the situation when the criteria is not fulfilled or not concerned. The following figure 6 illustrates the evaluation of the used modelling techniques.

The evaluation of the category *Functionality* (+) shows that XDT can be used to represent a multidimensional model. All other necessary elements as well as relationships among them can be correctly modelled. In total, the FASMI criterion multidimensionality is fulfilled. The relationships between dimensions and their respective hypercube are described by the means of arcs. Furthermore, hierarchies are displayed explicitly. Basically, XDT does not have the ability to be interrelated to different systems. But XBRL is, similarly to XML, platform independent. Due to this reason, a usage in different systems is (theoretically) possible and supported.

Reliability (o) is the second evaluated criterion. Reliability refers to standardisation in this context. The level of establishment of the XDT is not known yet. Countries such as Spain, Belgium or USA already use common, flat XBRL as an accepted (or mandatory) reporting standard. According to this, the standardisation of XDT seems to be in the matter of time.

Growing need and usage of multidimensional data will positively influence XDT giving a positive rank to the *usability* criteria (+). The modelling technique itself is easy to understand. In case of this evaluation it has to be weighed up, whether the user should have knowledge about multidimensional aspects or not. This aspect is also relevant for the learnability. If the user has a multidimensional

knowledge, XDT is intuitive. However for many technical aspects increasing the complexity of XDT a deeper understanding seems to be appropriate.

Efficiency (-/0) and the related subcriteria time consumption and usage behaviour are examined in the following section. The time needed for developing a data model is strongly dependent to the size and complexity of the specific problem domain. It is not surprising that the larger the model, the larger the necessary database storage is considered as result. The development of the XDT model and its validation demands the usage of a so called taxonomy editor. The editor is responsible for the translation from the logical layer to the internal layer. The conceptual layer is integrated in the logical layer, so there is no need for different layer descriptions. An advantage is that the real word image is described understandable with the technical background of XDT. A visual examination of the model has to be done by using XDT conformant taxonomy editors. Due to this reason, a software aided analysability of model errors does not exist. A visual presentation and a visual maintenance support reduce the maintenance effort of such a reporting system (0).

Changability (0) of XDT to all other modelling steps cannot be stated. A specific technology and a specific architecture is developed which has to be implemented. A modification, so that there is a usability of different modelling techniques can just be realized by changing the developed models. Thus, an interchange of developed models is problematic. In this context, it has to be stated that this problem basically occurs by doing a model-interchange, because there is no common sense of model semantics (0) referred to *assingability*.

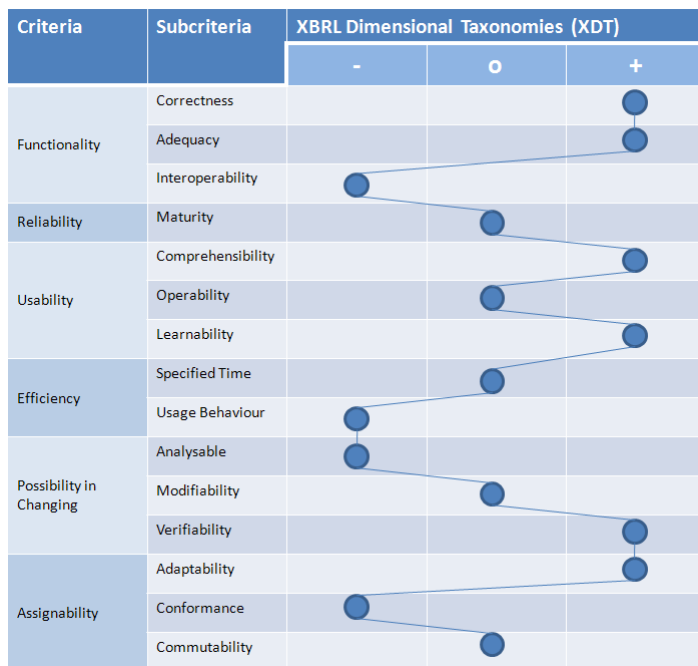


Figure 6. Evaluation results

To summarize the results, multidimensional data can be modelled by using XDT. This is shown by the fulfilled evaluation criteria. Due to the graphically representation of the model elements, data warehouse engineers have an improved understanding of the multidimensional data of this approach because the model elements have more comprehensive semantics. Thus the main advantage is the possibility of mapping between the modelled XBRL taxonomies and the data warehouse schemas.

6 CONCLUSIONS

Multidimensionality was not born in the research community, but as a response of tool vendors to the demands of analysts. Thus, there was not a strong mathematical foundation for it, like that of the relational databases. Concepts were not clearly stated, and most efforts were devoted to improve performance and presentation. In the recent years multidimensionality captured the attention of researchers. Data models have appeared without a standard and not even well accepted nomenclature. This makes it complicated to compare the data of different implementations in an automated way. XDT is an appropriate attempt to model multidimensional aspects. It has to be stated that, of course, the same real world problem can be modelled with different modelling techniques. XDT can represent everything as well as ADAPT can. It has to be examined, if XBRL is overcoming the traditional multidimensional approaches. To summarise the evaluation, not all the criteria are marked positively. But the main criteria like multidimensionality and the model ability are fulfilled. In case of the negative aspects it has to be stated that this result is often also valid for traditional multidimensional modelling approaches. So finally XDT is an appropriate modelling technique to be used in favour of multidimensionality for supporting analytical tasks.

From the managerial point of view it is interesting to consider XDT in the broader context of business intelligence (BI). Whereas XBRL tries to describe the meaning of reporting data and to standardize the data exchange, BI aims at analysis and reporting of decision-relevant business data. Both come from different perspectives, XBRL from semantic description of data (Debreceeny 2001) and BI from search of knowledge in data, but both help to find information in a data overflow. So a possible consideration would be to use the semantic layer of the multidimensional taxonomy to go beyond reporting and do more in-depth analysis of reported data.

The implementation of multidimensionality is reflecting analysts' queries. But it is an initial point for further research activities, too. This article can be continued by different research lines. It can be related to other areas like database security, temporal issues, query optimization, and translation to logical/physical level methodologies, or just studying modelling problems at conceptual level. A semantically rich schema is useful to help users understand data. Semantic optimisation should be considered, especially for drilling across and drilling down. Moreover mathematical formulas could also be used for query optimisation. An essential issue is that multidimensional structures should be identified and captured from a non-dimensional schema. Furthermore, the definition of multidimensional views should also be studied in order to support symmetric usage of factual and dimensional data as well as ad-hoc hierarchies.

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