Structuring Business Metadata in Data Warehouse Systems for Effective Business Support

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Abstract

Large organizations today are being served by different types of data processing and information systems, ranging from the operational (OLTP) systems, data warehouse systems, to data mining and business intelligence applications. It is important to create an integrated repository of what these systems contain and do in order to use them collectively and effectively. The repository contains metadata of source systems, data warehouse, and also the business metadata. Decision support and business analysis requires extensive and in-depth understanding of business entities, tasks, rules and the environment. The purpose of business metadata is to provide this understanding. Realizing the importance of metadata, many standardization efforts has been initiated to define metadata models. In trying to define an integrated metadata and information systems for a banking application, we discover some important limitations or inadequacies of the business metadata proposals. They relate to providing an integrated and flexible inter-operability and navigation between metadata and data, and to the important issue of systematically handling temporal characteristics and evolution of the metadata itself.

In this paper, we study the issue of structuring business metadata so that it can provide a context for business management and decision support when integrated with data warehousing. We define temporal object-oriented business metadata model, and relate it both to the technical metadata and the data warehouse. We also define ways of accessing and navigating metadata in conjunction with data.

Keywords Data Warehouse, Metadata, Temporal database
1 Introduction

Large organizations today are served by a large number of information systems, each often built to support a specific business activity. The operational systems, also called OLTP systems, are commonly built using commercial DBMS technology for efficient processing of business transactions. These distributed, function-specific information systems form information ‘assets’ of the organization. The concept of data warehousing (DWH) has rapidly become popular to leverage the operational data for strategic decision making across the whole organization. Data warehousing is a technology [KRRT98, MVVe94], that provides models, tools and techniques for building integrated, subject-wise data from the operational systems. It provides flexible ways to access, aggregate and visualize integrated data (possibly from across different business functions) based on selected parameters of interest, and navigate inside the data ‘warehouse’ so that business trends can be discovered and understood for better business decisions.

In the context of large number of information systems, designed and maintained by different organizational units, operating in heterogeneous computing environments, and targeted towards different business functions, it becomes essential that ways are found to correctly and consistently understand and co-relate data from different sources in terms of formats, meaning and temporal characteristics of data. For this, we need to associate comprehensive descriptions, called ‘metadata’, with the data. As [MDC99a] report observes, ‘Metadata, or information about data, has become the critical enabler for the integrated management of the information assets of an enterprise’.

[MDC99a] defines metadata as ‘descriptive information about the structure and meaning of data and of the applications and processes that manipulate data’. The metadata has traditionally been classified into technical and business metadata. The technical metadata specifies how exactly the data is structured and stored in files or databases. This metadata allows applications and tools to access and manipulate the data. The business data, expressed through modeling concepts and data constraints, help in understanding the data and their usage. In order to achieve ‘strategic advantages of on-line access to all knowledge maintained in the distributed computing environment of an enterprise’ [MDC99a], a need for a centralized on-line metadata repository has been recognized by researchers (e.g., see SMR99) and standards organizations. Such a repository needs to be centrally administered for effective use by the developers and end-users.

While the technical metadata is relatively well-defined, the business metadata has posed important challenges due to the diversity of information that needs to be captured and modeled. (e.g., OMG99 does not cover business metadata, and MDC99a standards are still being proposed for addressing some specific aspects such as Business Engineering Model [MDC99c], Business Rules [MDC99b], and Knowledge Management model [MDC99d]).

The Zachman Framework [Hay99] established different perspectives and dimensions for information systems within a 6 x 6 table. The perspectives cover directions and purpose (row 1), and the nature of business, including its structure, functions,
organization, etc. (row 2). The dimensions include the ‘what’, ‘how’, ‘where’, ‘who’, ‘when’ and ‘why’ aspects of a perspective. Thus, these two rows can be considered as defining the business metadata. The row 3 defines information system model using data models, process models and business rules. Considering the importance of identifying and specifying the constraints of a business, the IBM user Group, GUIDE, published a standard for defining business rules [IH97]. The report takes an information system perspective, where business rules express constraints on creation, updating and removal of persistent data. The report does not cover many other categories of issues (such as policies, guidelines, processes, workflows, events, etc.). The business rules conceptual model permits us to define the business rules as structural assertions (using ‘terms’ and ‘facts’), action assertions (which concern system dynamics), and derivations. The GUIDE model includes a generic ‘policy’ entity for relating rules to policies.

The Business Engineering Model of OIM [MDC99c] proposes models for business goals (where goals are related to vision and mission), organizational elements (which define resources and structure), business processes (which describe business activities) and business rules (which define business constraints). The OIM also proposes a Knowledge Management model [MDC99d] by which an organization can catalogue and categorize information based on a suitable taxonomy of concepts. These various sub-models will permit users to interpret data in the proper business context. For example, an information system may contain value for currency exchange rate. This value needs to be related to the basic concepts of ‘currency’, ‘exchange rate’, time, etc. It also needs to be related to business goals (such as ‘ensure stability of exchange rate’), the organizational elements (such as Exchange Control Department) responsible for (or, interested in) the goal, the related business processes, and so on.

As we move from source application systems to the DWH applications, the granularity of metadata must also be suitably altered. The operational systems process transactions and perform activities at a detailed level, affecting individual business entities. The changes must be carried out as defined by business rules. These rules specify detailed conditions and computations. At the DWH application level, detailed business rules may not be required. It will be adequate to know (in a higher-level articulation) how the processing was done and what are the policies, so that they can be monitored and evaluated.

The business metadata, like any other data, changes over time, since organizations change their missions, goals, policies, structure and processes. The business-level changes affect the source applications, which need to evolve to reflect changes in data and processing. The evolution of source applications, which feed data to the warehouse, must be captured in the warehouse metadata so that the subsequent analysis of data takes these changes into account in evaluating trends and taking new decisions. There has been extensive research [TCG+93] in temporal databases, but none of the metadata standards explicitly define temporal properties for the metadata.

While the motivation for integration is obvious, there have been a very few papers that suggest such integrated approaches. The work by Stohr et al [SMR99] makes a contribution in this direction. They define a framework in which the business metadata is related to the technical metadata at the data warehouse level. Their
business model is somewhat limited, as it is defined using a single "business concept" class. The lowest level concepts may relate to either dimensions or measures at the warehouse level. They allow DWH queries to be generated while navigating inside the business metadata.

In defining our own framework for an integrated metadata and DWH environment, we make the following contributions:

- We structure the business metadata to reflect its many aspects, so that organizations can be guided to define the metadata systematically and consistently. We are guided in this both by the Zachman Framework and the Business Engineering submodel of OIM.

- We take into account the temporal aspects of metadata. The DWH applications invariably have Time as an important dimension. By providing ‘temporal metadata’, the historical data in DWH can be correctly related to other business changes.

- We provide an integrated and navigational access to data from metadata and vice-versa. The navigation from data to metadata is not defined in other approaches. The navigation is based on the associations between various metadata and data entities.

The rest of the paper is organized as follows: In Section 2, we give motivating examples for structuring the metadata and for metadata evolution (so that their temporal characterization can be done). We bring out different metadata concepts, and also the requirements for metadata repository. In Section 3, we present our integrated model for metadata and data systems. In Section 4, we give scenarios to illustrate exploration of data and metadata. Finally, Section 5 contains conclusions.

2 Characterizing Business Metadata

In order to support the various organizational roles such as operations, monitoring, control and decision-making, the computer-based data processing and information systems are ubiquitous today. Invariably, an organization has multiplicity of such systems, each with a specific scope, purpose and functionality. The data analysis and decision support systems evaluate business performance against a set of goals, and facilitate new business decisions, policies and goals. The DWH technology [KRRT98] provides tools and techniques for efficiently organizing, browsing, querying and visualizing large amount of historical data for analysis and decision-making. The data in a DWH is typically organized either as a ‘star schema’ or a ‘multi-dimensional cube’ consisting of dimensions and facts or measures. The measures may represent transactional data (aggregated, if necessary) or snapshot data. The data in operational systems go through the ‘ETL step’, where the relevant data are extracted, transformed, co-related and finally loaded into the warehouse.

In today’s dynamic market conditions, organizations are placing more emphasis on shorter decision times by reducing organizational hierarchies and empowering their
‘knowledge-workers’. Consequently, a larger number of business users need access to data that might cut across the boundaries of organizational units and functions. For them, the business data needs to be readily accessible at the logical level. The technical metadata, primarily meant for the developers, administrators, and the automated tools, is of little direct use for business users.

The business metadata, besides a meaningful logical-level description of data, should also include the business context of data: purpose, relevance, potential use, past usage, etc. To some extent, such a context can be provided by including in business metadata the specifications relating to the first two rows in the Zachman Framework. However, there are limited metadata standards efforts for these levels, and possibly not sufficient experience in creating comprehensive metadata repositories at these levels.

A commendable effort in building a high-level comprehensive business metadata has been undertaken at a central bank in India. The bank is involved in monitoring, planning and regulating of financial sector in the country. It proposes to build a central DWH for supporting its activities [BN99]. The bank has a large number of departments, each with a specific responsibility. However, the basic financial data received from commercial banks and financial institutes is heavily cross-referenced. Many financial parameters, such as exchange rate, liquidity ratio, etc., have ramifications across functions, and are of interest to many departments. The central bank also has to prepare extensive statistics for reviewing performance and ensuring implementation of its fiscal policies. These statistics are used by the government for macro-economic planning, and by the bank for answering important parliamentary questions. The bank realizes the need not only for a single centralized DWH, but also for a metadata repository to establish clear, consistent and complete meaning of data and other important business metadata [BN99].

2.1 Business Metadata Categories

In the following, we discuss the nature of metadata with illustrating examples taken from the central Bank case study. However, the categorization of the business metadata is fairly general, and applies to most businesses. The categorization can also be seen as an elaboration of the Zachman Framework.

- Functions: a broad classification of functions or missions, such as Financial Supervision, Credit Management, Exchange Control, etc.

- Organization Elements: define organizational structure in terms of divisions, departments, etc. These may include Department of Banking Supervision, Rural Planning and Credit Department.

- Goal: a goal statement identifies purpose for an organizational element. These are often qualitative in nature. The monitoring and control functions of the departments in the bank have explicit goals on exchange rates, foreign exchange, interest rates, lending to priority sectors, etc.
• Business Entities: an organization deals with many entities, both internal and external. A description of these should be included in the metadata along with their relevant attributes. The examples could include different types of banks, non-banking financial institutes, and business sectors. Entities may be interrelated, and also associated with goal and other metadata categories.

• Processes: these describe at some suitable level of details how the business activities are performed. A process may be decomposed into sub-processes, and be associated with other metadata such as functions, goal, business entity, etc.

• External Events: these are important happenings (beyond the control of the organization) which have impact on some metadata, such as Policy and Functions. They may be events which affect business entities directly or indirectly (e.g., merger of two banks).

• Measures: these are quantitative parameters that measure the effects of business activities. This metadata type specifies nature of measurement, the goals, business entities, and other metadata to which they are related. There are many important measures in the banking sector, such as deposits, credits, assets, incomes, expenditures, call money rates, etc.

• Evaluation: The evaluation class represents organization’s evaluation of business measures (as obtained, after suitable filtering and aggregations, from the data warehouse) against the business goals. The evaluations may be recorded periodically. They act as records of performance of the business. These could be simple (such as ‘satisfactory foreign reserves’) or detailed (such as, ‘credit to agriculture sector in northern states is not growing at expected rate’). The evaluation metadata would be associated with organizational elements, goals and measures.

• Action: The Action metadata class permits recording in the repository any specific business actions (possibly as a consequence of evaluations and external events). The actions would relate to evaluations.

• Business Concept: The various metadata classes described above can be generalized as business concepts, which, in addition, can also be used for introducing business terminology (and other miscellaneous business concepts not captured by the above categories).

2.2 Metadata Characteristics

In this section, we highlight important metadata characteristics for an integrated metadata environment.

• Changes to Metadata: The business metadata, covered under different categories in the previous subsection, may change over time. A business user must
be aware of these changes, as the changes may alter the consistency and comparability of data over time. The meaning of a business concept may change, or there may be changes in policies, goals, and processes. While analyzing data in a warehouse, the data must be made consistent and comparable (by suitable transformations), if possible, and the user must be proactively made aware of changes in business metadata. [BN99] gives many examples of metadata changes for the central bank. For instance, the definition of term ‘non-performing asset (NPA)’ has changed recently in terms of duration of non-payment of a loan that leads to its classification as NPA.

Thus, the metadata are temporal in nature. Each metadata has a time interval of validity. This interval is specified as beginning from a certain time instant (called, FROM), and ending at another time instant (called, TO). The description is effective in the real-world during this interval. As an implication, the data in the warehouse must also be temporally characterized so that the metadata and data can be temporally co-related.

- **Metadata Abstraction Levels**: The amount of metadata that can be defined for an organization could be extensive, even if we assume some domain background among the users. Often, the metadata are not readily available (very few organizations even have detailed ‘operations and procedures’ manuals). Moreover, in many cases, the business users do not need definitions of primitive concepts, nor the details of computations and processing. Summary specifications are often adequate. The detailed specifications can be found, if required, in the source code of some application. The business metadata can provide a ‘drill-down’ into the application code for details of processes.

- **Integrated Evolution**: As business requirements change, the application systems need to evolve. The changes may affect database design as well as the processing logic. The requirements change is naturally a consequence of changes in business policies, goals, processes, rules, etc., and should also result in evolution of business metadata. Also, the metadata repository must contain all versions of metadata with appropriate temporal validities. To minimize disruptions and inconsistencies, organizations should plan integrated evolution of its metadata repositories and application systems. An evolution cycle may start with business metadata changes, application modifications, and end with capturing updates to technical metadata. When these steps are complete, the next ETL step will load data in DWH as per the new business and technical metadata. [Sar99] presents a framework for application evolution management. It defines basic application components and their temporal characteristics.

- **Navigation Across Metadata and Data**: An integrated system should support a flexible access to both the metadata and data. [SMR99] propose such an environment where the system can generate data warehouse queries while navigating within the business metadata. We propose further extension to this flexibility: it should be possible to even go from data to the temporally consis-
tent metadata, see metadata changes, record evaluations of business activities based on analysis of the data, and also record proposed business actions.

Figure 1 depicts an integrated environment for metadata management and usage. It shows linkages between the business and technical metadata, and the metadata evolution life-cycle.

3 Integrated Metadata Data Model

3.1 The UML Representation

In the previous section, we presented different categories of business metadata and also highlighted desirable characteristics to be supported by a metadata repository. In this section, we formally introduce the data model for metadata, using Unified Modeling Language (UML) as the representation language. We use UML class diagram to represent the business metadata classes and their inter-relationships. In UML notation, rectangles represent classes, with class names in the upper part and the main class attributes in the lower part (for clarity, we do not indicate class methods in the diagrams). Inheritance relationship is shown using an arc with arrow-head pointing to the super-class. Associations are represented by labeled arcs with an ‘m’ at the ends to represent many type of associations.

The overall metadata model is shown in Figure 2. The figure, in fact, shows integration of the business metadata with DWH technical metadata as well as warehouse data. The associations across the boundaries of the three segments in the integrated model represent the navigational paths between metadata and data (in either direction). In the technical metadata segment, we only show the primary metadata classes used in structuring a warehouse with the purpose to establish important relationships with business metadata. It is not our intention to propose a new model for technical metadata. This metadata specification can use any of the proposed standards, such
as OIM [MDC99a] or CWM [OMG99]. The OIM model, for example, uses technical metadata classes such as Dimension, DimHierarchy, Cube, Measure, etc. OIM also allows specifications for transformations, which can describe how data from production databases is transformed before loading data into the DWH.

3.2 Metadata Classes and Associations

The business metadata includes a generalized class called Business Concept. Most other specific metadata classes inherit from this class. Its main attributes are concept name and description. It also provides temporal validity attributes (FROM and TO) to its subclasses and instances, so that each metadata definition has a specific period of validity. The temporal attributes specify valid (i.e., real-world) time. Thus, by the accepted definition of temporal database classification [TCG+93], the metadata repository is a ‘historical’ database. This class may have instances that define basic business glossary, and that metadata which do not fall within the classifications given by its sub-classes. We next give brief description of these sub-classes (which were introduced conceptually in the previous section):

- **External Event**: It specifies some real-world happenings that have impact on the business in some important way. Its instances may represent both the descriptions of such events as well as their occurrences (as data within the metadata repository; this data may not be captured in the DWH). This class has associations which indicate how the events are inter-related, and what other business aspects these events impact. The valid-time primarily captures the definition time or occurrence time of these events.

- **Entity**: This class specifies various business entities, which may be either Internal or External. The Internal entity occurrences can also specify business’s organizational elements. Additional information about business entities can be captured by their associations with the Attribute specifications. In a more general case, it may be appropriate to define association directly between Business-Concept and Attribute classes so that additional attributes can be defined for other metadata classes also (in our case study, this flexibility was not indicated). The SubEntity association allows us to define hierarchies among business entities. For example, for Bank entity, we may define hierarchies to represent ‘Foreign Bank’, ‘Nationalized Bank’, ‘Rural Bank’, etc. The metadata repository will allow us to specify different business processes and goals for these classes of entities.

- **Process**: The business process class describes business processes and their subprocess relationships that capture business activities and tasks.

- **Goal**: The business goal class describes objectives and goals. A goal may have sub-goals. Goals are also related to business processes and entities through the P-goal and E-goal associations.
Figure 2: Business metadata model and integration with technical metadata and DWH data
• Measure: The measure class is used to describe business measures that are used to evaluate business performance quantitatively. A goal is associated with one or more measures, and a measure may relate to many goals. A measure instance may describe the computations and aggregations required to be performed on data contained in a DWH to understand how achievement of a business goal can be evaluated. Although not shown in the figure, the measure metadata class may relate to query or report entities in technical metadata.

• Evaluation: This metadata class specifies type of evaluations applicable to different Goal metadata, and also evaluations of measures at various times. Its instances can be associated with Goal and Measure instances. An evaluation may also affect business entities and processes. In the model, we capture these relationships using an association between Evaluation and the BusinessConcept classes.

• Action: This class represents meaningful business actions, and any specific actions undertaken as a consequence of particular evaluation. We define separate associations to capture evaluations which result in specific actions, and evaluations which are consequences of some actions. Relationships of Action with other metadata are captured by its association with the BusinessConcept super-class.

The business metadata repository explicitly captures the various dimensions of Zachman framework [Hay99], and even goes beyond the framework by capturing the temporal characteristics of the metadata, and also providing for recording of events, evaluations and actions, which usually have no explicit representation in business information systems. The storage of these data provides history of business achievements and decisions. We may contrast this detailed structuring of metadata with the integrated model of [SMR99] where a single Business Concept class is defined to capture business metadata.

3.3 Linkages with Other Segments

The business metadata segment has linkages with the technical metadata and DWH segments of an integrated metadata and data environment. The important linkages, as envisaged in our model, are shown in Figure 2.

The business entities in the business metadata link with the specification of dimensions in the technical metadata of the DWH. For instance, an (external) entity Bank (with a suitable set of attributes) can map onto a dimension called Bank. The same dimension may also cover BankType entity to represent classifications of banks into Nationalized, Foreign, Rural, etc. Similarly, the Business Concept ‘Liability’ may define another dimension. We have captured this linkage with the Dimension metadata class through the association with BusinessConcept class. We do not define any explicit linkage to the Time Dimension. There is an implicit linkage since the business metadata is temporal. The Time Dimension represents the valid time line and the calendar defined in the temporal data model.
Some business metadata may actually represent the data in the DWH itself. For example, the BankType business entity may have sub-entities NationalizedBank, RuralBank, etc. These sub-entities are also defined in the business metadata repository. However, these occur as rows in the dimension table Bank in the DWH. Another example: the ‘Liability’ business concept may have sub-concepts like Deposits, Borrowings, etc. These sub-concepts again appear as rows in the Liability dimension in the DWH. To capture these linkages, we define an association from BusinessConcept to rows in the dimension tables in the DWH.

The next linkage is between Measure business metadata class and the Fact technical metadata class. The quantitative information specified by a Measure is available in the associated Fact table (for aggregation, filtering, etc.).

Finally, a link is defined between Action metadata and specific entities which are targets of the action. The entities, in general, are rows in a dimensional table of the DWH. For example, an action might indicate that some specific banks must reduce their assets in equities.

As discussed in the next section, the metadata and linkages across the three segments allow effective navigations for understanding of business situations for evaluations and decision-making.

### 3.4 Methods Supporting Navigations

The various metadata classes have methods for not only accessing and updating data in their instances, but also for accessing other related metadata objects. To facilitate navigation, we have defined methods to follow various associations a class has. We will illustrate the navigational methods for a few metadata classes.

Consider the InternalEntity class. It has the following methods:

- `getSubEntity()`: to locate sub-entities of the entity
- `getProcesses()`: to obtain process(es) in which the entity is involved
- `getGoals()`: to obtain goals related to the entity
- `getAffectingEvents()`: to obtain external events that affect the entity
- `getActionsTaken()`: to obtain actions targeted towards the entity
- `getDimension()`: to obtain entity instances (if applicable) stored in the rows of the dimension table. This method navigates from business metadata to DWH.

For the Measure class, the following methods support navigation:

- `getGoals()`: to obtain goals which use the given measure
- `getEvaluation()`: to obtain evaluations based on the measure
- `getFacts()`: to obtain fact descriptions on which the measure is based.

Similar kind of methods are defined for all the classes in the integrated repository. These methods permit going from technical metadata to the business metadata and from data in the DWH to the business metadata. Temporal selection is possible with
these methods by specifying time interval of interest. Also, the method `getHistory()` is provided for all temporal classes. This method can be used to obtain all earlier states (i.e., descriptions) of the metadata component. The history, given by the past states, indicates evolution of the metadata. In a graphical user interface, the methods are available as a ‘drop-down’ menu by a mouse-click on a suitable class or instance.

4 Exploring Metadata and Data

In Section 2, we had highlighted importance of integrated environment for flexible access to metadata and data, as well as access to the business metadata evolution so that business activities and their performance can be understood in the context of changing business structures, processes and goals. The integrated model proposed in the previous section supports both the requirements. In this section, we briefly illustrate how the requirements are satisfied by the model.

4.1 Scenario 1: Metadata to data to metadata

This scenario illustrates navigation within metadata, then moving to the data in the DWH (transparently supported via technical metadata by the warehouse tools) and returning back to the metadata. By default, we access current instances of the metadata classes. The steps in the scenario could be as follows:

1. Locate a department, an organizational element represented by an internal entity (e.g., the department named ‘Banking Supervision Department’). We could go the subdivisions of the department, if required.

2. Get goals this entity is responsible for (through its association with the Goal class). There could be multiple goals such as fraud detection, financial supervision, etc.

3. Given a goal, locate how the goals are measured by following the Goal to Measure association. There may be multiple measures relevant to a goal (alternatively, the goal may have subgoals).

4. From a selected Measure, go the warehouse (cube or star schema) that records values. One may now perform various DWH operations like filtering, aggregations, comparisons, etc., and draw a conclusion about how well the goal has been achieved. The conclusion can be stored as Evaluation instance in the metadata repository.

5. From the measures visited earlier, move to other goals that the measure is relevant for.
4.2 Scenerio 2: Metadata evolution

Since the metadata as well as DWH data have temporal validities, the integrated model permits us to access changes that have taken place in the business environment. It may be noted that most facts recorded in the DWH have temporal validities given by the corresponding time dimension. For example, the ‘Income Interest’ is a measure recorded for every quarter for every bank. We can observe how this measure has changed over time for a bank. The metadata evolution, on the other hand, would show if the definition of the concept ‘Interest Income’ itself has changed over time.

Let us illustrate this scenerio with a few steps:

1. Access and examine the data in a DWH cube.
2. Access the Measure metadata associated with the cube.
3. Access the goals associated with any of the measures encountered above. Select one of the goals (e.g., one which prescribed that NPA (non-performing assets) be less than some percentage of gross assets).
4. Display NPA of Bank entities over time (possibly in a convenient spread-sheet format).
5. Choose an NPA value, and access its metadata description.
6. For the NPA business concept, get its history (i.e., evolution) over the last 2 years. Note any major changes in NPA definition (which may explain the trend of NPA values seen in the earlier step).
7. For a selected entity, say XYZ Bank, get its history. This may show changes in the bank’s attribute values.
8. For the selected bank, get external events that might have affected it in the last 6 months. This may, for example, show that it acquired another bank.

This scenerio illustrates that the model allows to access changes in business metadata both at concepts level and at entity levels. One may explore not only the DWH data, but also business environment changes.

5 Conclusions

Large organizations today need flexible access to various kind of information that is present in its operational systems. The data warehousing technology facilitates creation of integrated and subject-wise history data, and provides flexible ways to access, aggregate and visualize the information in the DWH. In order for users to know the meaning and structure of the available data, we need to build ‘metadata repositories’ that contain comprehensive descriptions of the data. The metadata has been broadly classified into the business and technical metadata. It is the business metadata which provides appropriate business context for the understanding and analysis of data and
for decision-support. Considering the importance of metadata, major standardization efforts, notably the OIM of MDC [MDC99] and CWM of OMG [OMG99], have been undertaken with primary focus on the technical metadata. The business metadata poses many challenges in terms of scope, abstractions and structure. The Zachman framework [Hay99] has provided guidelines, and the Business Engineering Model proposals, covering business goals, organizational elements, business processes, business rules and knowledge management, of OIM emerge as a comprehensive effort in this direction.

In an attempt to build an integrated DWH environment for a central bank, the structuring of business metadata has merged as a major challenge [BN99]. Unlike the integrated model of [SMR99], where all aspects of business are generalized in a single metadata class, called Business Concept, we considered it necessary to explicitly structure the business metadata into many categories. The other challenges included changes to metadata itself over time, and navigational access between metadata and data in either direction.

The integrated metadata and DWH model proposed in this paper emerged as a solution for the bank’s requirements (although it is clear to us that a few iterations, after the initial implementation and subsequent user feedback, would be necessary to fine-tune it). The model achieves integration of the three segments, business metadata, technical metadata and the DWH, to allow the users to interpret, understand, access and analyze the data in the DWH, taking into account the temporal characteristics of both the metadata and data, and then evaluate achievement of business goals and plan future business actions. These are the essential requirements for the bank for its regulatory and planning functions. Like the most emerging metadata standards, we use object-oriented modeling using the UML representation. We define temporal validity for all classes, and navigational methods so that all related metadata and data for any entity can be obtained.

The future work consists of fine-tuning the model based on the experience, and bring it closer to the OIM’s Business Engineering Model (BEM), but at the desired level of abstractions for the application. It may be noted that BEM in some respects is too detailed (e.g., in the specification of business rules and processes), and it does not support evolution and changes. We also plan to facilitate ad-hoc query support as in [SMR99] from navigation and selections in the business metadata.

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