The Relevance of Meta Modeling and Data Warehouses for Executive Information Systems

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Abstract: Applications based on Data Warehouses especially decision support systems such as Executive Information Systems (EIS) are rapidly becoming a key to gain competitive advantage for businesses. Data Warehouse allows businesses to get data from operational databases and turn that data into useful information on which users can carry out their analysis. In this paper we will discuss the importance of meta modeling for EIS and Data Warehouses as analytical base in EIS for decision support.

1. Introduction

Data Warehouses collect information from several data sources and integrate it into single database where it can be analyzed and queried by users of the Data Warehouse. The relations stored at the Data Warehouse represent materialized views over the data at the sources [1]. The base data from which the views are derived is stored in one or more data sources, where these sources may be distributed, heterogeneous and/or remote from the Data Warehouse. Because queries at the Data Warehouse are often long and complex, a Data Warehouse may contain many materialized views in order to speed up query processing [2].

As shown in Figure 1, there are two important components in Data Warehouse: the Data Pump Component, allows extraction, cleansing and integration of data from operational sources, and the Data Analysis Component, responsible for fulfilling the information needs of specific end users. Most current commercial warehousing systems focus on the Data Analysis component, providing specialized index structures at the Data Warehouse and extensive querying facilities for the end user.

Warehousing has been used successfully by many organizations to provide a single view of data across an enterprise and grant end users to answer business

questions without assistance from any specialist. It also builds an ideal base for DSS and EIS with its integrated central data store.

An EIS is designed to satisfy the unique information needs of executives by providing friendly user interfaces to access managerial information, including summarized business transaction data. In addition, an EIS also supports access to external news services, tools supporting decision analysis, and interpersonal communication software. One of the most important driving forces is that executives can use EIS to obtain relevant information on line to support their decision making in increasingly dynamic business environment [4].

Figure 1. The basic architecture of the Data Warehouse

The emergence of EIS signals a shift of emphasis from development of information systems to the delivery of information produced by information systems. Rockard and De Long [5] identify four basic functions of EIS:

- Communication tools support executives' interaction with people using phone, voice mail, electronic mail, and fax
- Organizing tools, which include to-do lists, electronic calendars, group scheduling software, and project management tools, can be used to assist executives in organizing their tasks and managing their schedules.
- Data and status access tools allow executives to have access to external information via electronic news services and external databases. Executives can monitor critical performance measures of business operations stored in the information base.
- Decision analysis tools include spreadsheets, statistic and business graph packages, and data-driven and drill-down data analysis tools

Since executives rely heavily on both external information and the analysis of information by professional staff, it is important that staff members be included in the loop to provide soft data to the information bases. EIS are becoming a mechanism for enterprise-wide information delivery to all levels of organizations. Therefore, the EIS industry is changing the meaning of the EIS acronym from Executive Information Systems to Everybody's Information Systems or Enterprise Information Systems [6].

Technical components of existing EIS include: database system, graphical user interface, personal productivity tools, direct data import/export facilities, decision support tools, text and image management systems, and communication tools. Each of these address only a part of nowadays executives need. There is no direct support for the modeling of organizational models, an important feature that should be incorporated into future EIS [4]. Another aspect is more sophisticated visualization and navigation tools. Hypertext/hypermedia systems enable the capturing of unstructured nonlinear multimedia information and provide better user navigation [7]. There is no intuitive way to build a high-level user interface to integrate the diversified sources of applications and information required in EIS.

In this Paper we first describe EIS and DSS requirements to EIS systems. Secondly we focus on Data Warehouse and meta modeling for data warehousing. Finally we combine EIS and Data Warehouse and describe our model of Data Warehouse based EIS.

2. Executive Information Systems (EIS)

The definition of EIS varies according to the weight given to the three elements in the name itself. For some "an EIS is a set of tools designed to help an organization carefully monitor its current status, its progress toward achieving its goals, and the relationship of its mental model of the world to the best available signs about what is really happening". Some others state that "an EIS gives non-technical senior executives the ability to navigate through strategic information collected from company databases and on line information services". For our purpose, an EIS is a

computerized system that provides end users with access to internal and external information that is relevant to decision making and other critical success factors.

The EIS has long promised to provide executives with the computing power and information access. The reality is that the EIS of today is moving down the organizational structure and the executive is still waiting for the benefits of the information technology. Strategic-planning capabilities, an external environment focus, ease use of learning and use, and custom tailoring to meet the unique needs of individual user are common properties of EIS.

EIS usually includes personal productivity, communication, analysis and coordination components that provide end users with a big range of services that increase productivity. It is agreed that an EIS has powerful analytical tools and the following characteristics:

- An easy to use and maintainable graphical user interface.
- Integrated capabilities for data access, security and control.
- On request drill down/roll up, slice/dice capability to lower and upper levels of detail.
- Behaving of organizational indicators.
- Functionality for decision support, ad-hoc queries and what-if analysis.
- Data analysis features
- Advanced report generation.
- Statistical analysis tools for summarizing and structuring data.
- Access to a variety of internal and external data sources.

Classical EIS tries with help of some querying and analyzing tools to satisfy above requirements by direct use of operational sources. Operational sources are designed to provide extremely efficient data access for large number of transactions involving very few records and to automate day-to-day operations. These on-line transaction processing (OLTP) systems insert and update data in databases at fast rates, but they are not very good to deliver meaningful analysis, answer ad-hoc queries and they do not keep historical data which is very important for EIS and DSS. All these affects the performance and acceptance of traditional EIS.

On-line Analytical Processing (OLAP) has emerged as a break through technology that can provide the foundation for fast, easy and affordable EIS solutions. OLAP, when integrated with a Data Warehouse enables very fast response, drag-and-drop navigation, point-and-click drill-down/roll-up among levels of details, exception reporting, what-if analysis [8]. In our model we suggest to use Data Warehouse/OLAP/EIS solution as an alternative to the classical , EIS to satisfy the needs of today's business users.

3. Data Warehousing and Metadata Modeling

The Data Warehouse is the foundation of DSS processing [3]. Because there is a single integrated source of data in the Data Warehouse, and because the data are accessible, the job of the DSS analyst in the Data Warehouse environment is immeasurably easier than in the classical environment.

The Data Warehouse is designed specially to meet the needs of decision-makers rather than the needs of OLTP systems. Unlike an OLTP system, a Data Warehouse is specialized for retrieving and analyzing information quickly and easily. Data Warehouse is specific database which consists of extracted and transformed operational data. Because a Data Warehouse is designed to support OLAP the data model of the Data Warehouse should be in the position to reflect needs of OLAP. OLAP needs can not be satisfied with classical ER modeling. Dimensional modeling has been represented to solve problems that have been faced in ER model to support OLAP.

Dimensional modeling is a technique developed to structure data around natural business concepts and to provide a foundation for sophisticated data analysis. In dimensional modeling, data structures are organized to describe business measures and dimensions. Business measures are the numerical data being tracked such as sales, production etc. Dimensions are natural business parameters such as product, time, region etc. that define each transaction.

The physical architecture of the dimensional model is described by many techniques. One of the popular technique, which has been used in our model too, is *star schema*. Star Schema, as the name suggests, the star schema is a modeling paradigm that has a single object in the middle connected to a number of object around. The star schema mirrors the end user's view of business query: a fact such as sales, compensation, payment and invoices are qualified by one or more dimensions such as time, product, region. The object in the center of the star is called *fact table* and the objects connected to it are called the *dimension tables*.

Before Data Warehouse data can be accessed efficiently, it is very important to understand what data is available in the Data Warehouse and where that data is located. Metadata or data about data provides DSS analyst with a catalog of data in the Data Warehouse. Before getting real data from Data Warehouse, user navigates through the Metadata of the Data Warehouse and only last operation is getting needed data from warehouse. Metadata is like the roadmap to data, it points to the location and meaning of various information within the Data Warehouse.

The design of Metadata for a Data Warehouse is a dramatic shift in paradigm for information analysts who have been analyzing and designing databases to support operational systems. The focus during the design of an operational database is to create normalized data models with atomic data. The design of Metadata for the Data Warehouse needs a complete change of these thinking. The focus of the design of

Metadata for the Data Warehouse is to present a rich range of relationships to the analysts, in most cases with a large number of redundancy, Because updates are not a primary issue within the Data Warehouse.

An important aspect of Metadata is the need to maintain mappings of data from the sources to the Data Warehouse through the process of extraction, transformation and integration. These mappings need to be maintained to verify the quality of data, synchronize and refresh data in Data Warehouse, and integrate the data.

Metadata for Data Warehouses can be grouped in three categories:

1. **Technical Metadata:** Contains Metadata that can be used by Data Warehouse administrators and designers. The following can be found in this category:
 - Information on the sources of the data
 - Information on the targets of the data.
 - Transformation information
 - Data mappings from source to target.
 - Cleanup rules.
2. **Business/Analyst Metadata:** Supports business analysts who do not have technical background. It contains the following kind of information:
 - Business terms.
 - Associations between technical terms/alias and the business terms.
 - Source data, derivation rules and currency data in common terms.
 - Description of the pre-defined queries in Data Warehouse which are described in business' terms.
 - Contact information for the owner of the data.
 - Authorization requirements for access.
3. **Enduser Metadata:** Contains Metadata for browsing and querying Data Warehouse. It contains the following kind of information:
 - Information about aggregation levels.
 - Drill-Down/Roll-Up information.
 - Information about previously created queries.
 - Request information to the Data Warehouse administration staff.

4. Executive Information Systems based on a Data Warehouse

Developing an EIS based on Data Warehouse must involve more than simply loading the available data. It also must be more searching than a response to a particular executive request. Instead, the approach must be entirely pragmatic. The Data Warehouse data model must address the conflicting goals of system flexibility and data delivery performance. Flexibility is required so that additional attributes, dimensions, and metrics can be added to the warehouse, complimenting and

leveraging existing data. Quick query response is required in all effective interactive decision support systems, since it not only impacts end-user satisfaction but directly determines the number of analyses the DSS analyst can perform given limited time.

We suggest a three layer, *database / analysis / presentation*, model to satisfy the needs of the executives. This model has been successfully implemented in our WWW-DWH-EIS project. As it is shown in Figure 2, Data Warehouse is the bottom line of the model. It contains information from external and internal operational sources and presents them in a way that supports easy analyzes and querying. Data in Data Warehouse is organized into categories or subjects that are meaningful to business end user.

Figure 2. Three Layer EIS

The information that has been stored in the Data Warehouse is decoupled from operation sources. This issue makes loading new information into Data Warehouse very important. If data flow form operational sources to Data Warehouse is not satisfactory, the whole system will not give desired results. The Data Warehouse should be supported by tools to read, process and store significant data from operational sources into Data Warehouse quickly without being taken off-line. In our project we used Oracle as DBMS and *start-schema* for dimensional modeling to realize the Data Warehouse.

Analysis Layer is the connection between Data Warehouse and EIS-application. It merges data requests, Metadata and its own query building algorithms to create SQL queries to send to the Data Warehouse. Upon query completion, the Analysis Layer performs necessary data manipulations, such as cross-tabulations, before sending the data to the EIS-application. This layer requires a criteria set from the user, which specifies the attributes and metrics to be hold from Data Warehouse. It also uses a data rotation to specify how to orient Data Warehouse data on the X and Y axes for the EIS-application.

In our project we used a special meta script language to describe all user requirements to be performed by Analysis Layer. The meta script description of user requirement is processed by the layer and based on this process SQL-queries generated, data from Data Warehouse retrieved and all data manipulations done. Before sending data to the Presentation Layer again a meta script form of data is generated. The Presentation Layer interprets this script and generates appropriate screens for end user.

The Presentation Layer is the interface between business end user and the Analysis Layer. By using only standard input devices the user is in the position to formulate his wishes in this layer. This user input is transformed to a meta script language to send Analysis Layer. The prepared data by the Analysis Layer is interpreted and presented to the end user by using pre-defined user interfaces. This interfaces give the user the possibility to navigate through the data and get more detailed/global information. (drill-down/roll-up).

In order to have a common interface that can be used easily by any user we used Web browser as visualization tool for the Presentation Layer. The main task of the Presentation Layer in our model is to interpret and visualize pre-defined EIS-Screen, which are described by using meta script language. Meta script language of the EIS-Screen describes all screen components and data to be prepared by the Analysis Layer. This description is interpreted at run time and on fly HTML-pages are generated. The interpretation is done by Information Server(IS) which is the heart of the Presentation Layer.

During interpretation IS checks if data needed from Data Warehouse, if it the case, the description of the needed data is sent to the Analysis Layer and the received information is integrated into generated HTML page. We have implemented three ways of data visualization on the screen; regional map, cross-tables and graphical(bar charts). Each of these enables the user to navigate through the Data Warehouse. An important function of the Presentation Layer is the traffic lightening, which draws the attention of the business end user where to concentrate.

5. Summary

The data warehousing revolution has finally acknowledged the requirements of business users for easily accessible, accurate and timely information. Previous efforts have been worried with difficulties, both from a business politics and technology

perspective. With the changes in business and managerial structure, coupled with technology advances, the realization of easy access to business oriented information has become easier.

The existence of a Data Warehouse allows organizations to retain multiple years of historical data. Standard query/report tools can access that data but performance and functionality of analysis will not be satisfactory for the today's executives. EIS supported by OLAP and Data Warehouse appear to be the best solution to enable executives to interact with one of their most valuable resources, information.

The Executive Information Systems (EIS) has long promised to provide executives with the computing power and information access. The reality is that the EIS of today is moving down the organizational structure and the executive is still waiting for the benefits of the information technology. By using Internet/Intranet in our project as Presentation Layer we tried to make use of current technology. This is a great step from Executive Information System to Everybody/Enterprise Information System.

6. References

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SnowNet: An Agent-Based Internet Tourist Information Service

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Abstract SnowNet is a project to provide Internet access to a variety of existing information services concerning snow and avalanche conditions in the Swiss Alps. To provide regular users, such as mountain guides, with access to the latest information without typical network delays, we use a combination of client and server agents. These agents cooperate to reduce network traffic and ensure that current pages are always available in the user's local cache.

1 Introduction

For tourist information services on the Internet to be effective, it is essential that the requirements of regular users can be met without the typical delays currently experienced using Internet browsers and the World Wide Web (WWW). The main reasons for such access delays are overloaded networks and servers and these problems are likely to remain with us in the foreseeable future. We have addressed these problems by developing an agent-based architecture for access to Internet databases. We are using this architecture to construct an integrated tourist information service (SnowNet) for snow and avalanche data in the Swiss Alps in conjunction with the Swiss Federal Institute for Snow and Avalanche Research (SLF) in Davos.

SLF currently provides a range of information services in support of the Swiss tourist industry and also the scientific community. These services include the generation of avalanche forecast warnings, snow cover maps and statistical summaries of snow and avalanche data. All of these services are of interest to some provider or customer of the Swiss tourist industry. For example, a tourist may be interested in general information on snow conditions, whereas mountain guides