ISSN:0975-9646
Vijay Gupta et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (6) , 2014, 8263-8268

A Review of Data Warehousing and Business Intelligence in different perspective

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Abstract:Data warehouse is subject Oriented, included, Time-Variant and nonvolatile collection of data. This data helps in supporting decision making process by analyst in an organization. The Business intelligence is the delivery of accurate, useful information to the appropriate decision makers with necessary timeframe to support effective decision-making. This paper reviews the impact of metadata in data warehousing and business intelligence by different researchers.

Keywords: **Data Warehouse, Data Mining, Business Intelligence, Data Warehouse Model**

1. INTRODUCTION

According to Larson (2006) Data warehouse is a system that retrieves and consolidates data periodically from the source systems into a dimensional or normalized data store. It usually keeps years of history and is queried for business intelligence or other analytical activities. It is typically updated in batches, not every time a transaction happens in the source system Rainardi (2008).

The Data Mart is a subset of data warehouse and is defined as body of historical data in electronic repository that does not participate in the daily operations of the organization. Instead, this data is used to create business intelligence. The data in the data mart usually applies to a specific area of organization. (Larson, 2006) Fact Table is the primary table in a dimensional model where the numerical performance measurements of the business are stored. We try to store the measurement data resulting from a business process in a single data mart.

The Dimension Table is an integral companion to a fact table. The dimension tables contain the textual descriptors of the business. In a well-designed dimensional model, dimension tables have many columns or attributes. These attributes describe the rows in the dimension table. The Dimension tables tend to be relatively shallow in terms of the number of rows (often far fewer than 1 million rows) but are wide with many large columns. Dimension tables are the entry points into the fact table. The dimensions implement the user interface to the data warehouse Online analytic processing (OLAP) database is a technology for storing, managing, and querying data specifically designed to support business intelligence uses.

The Extract, Transformation, and Load (ETL) system is a set of processes that clean, transform, combine, de-duplicate, archive, conform, and structure data for use in the data warehouse.

1.1 Data Warehouse Concepts

The Data warehousing is the process of collecting data to be stored in a managed database in which the data are subject-oriented and integrated, time variant, and nonvolatile for the support of decision making (Inmon, 1993). Data from the different operations of a corporation are reconciled and stored in a central repository (a data warehouse) from where analysts extract information that enables better decision making (Cho and Ngai, 2003).

The Data can then be aggregated or parsed, and sliced and diced as needed in order to provide information (Fox, 2004). There are two main authors that are known in the world of data warehouse design, their approaches to some area of the data warehousing are different; William Inmon and Ralph Kimball. The approach by Inmon is top down design while that of Kimball is bottom up design. Most of the practitioners of Data warehouse subscribe to either of the two approaches.

According to Inmon (1993), a Data Warehouse is a subject-oriented, integrated, time-variant, non-volatile collection of data used in support of decision making processes. “Subject Oriented” means that a data warehouse focuses on the high-level entities of the business and the data are organized according to subject ”Integrated” means that the data are stored in consistent formats, naming conventions, in measurement of variables, encoding structures, physical attributes of data, or domain constraints. For example, whereas an organization may have four or five unique coding schemes for ethnicity, in a data warehouse there is only one coding scheme (Chan, 1999). “Time-variant” means warehouses provide access to a greater volume of more detailed information over a longer period and that the data are associated with a point in time (Chan, 1999; O’Leary, 1999) such as month, quarter, or year.

The Warehouse data are non-volatile in that data that enter the database are rarely, if ever, changed once they are entered into the warehouse. The data in the warehouse are read-only updates or refresh of the data occur on a periodic, incremental or full refresh basis (Zeng et. al., 2003) Finally,” nonvolatile” means that the data do not change Chan, 1999).

According to Kimball (2002), Data warehouse is the conglomerate of all data marts within the enterprise. Information is always stored in the dimensional model. Kimball views data warehousing as a constituency of data marts. The Data marts are focused on delivering business objectives for departments in the organization. And the data warehouse is a conformed dimension of the data marts.

According to Kimball describes a data mart as a subset of data warehouse. The data warehouse is the sum of all the data marts, each representing a business process in organization by a means of a star schema, or a family of star schemas of different granularity. The main difference between the approach of Kimball and that of Inmon (1993) is that Kimball's conformed dimensions are de normalized, whereas Inmon uses a highly normalized central database model.

According to Inmon's data marts stores a second copy of the data from the centralized data warehouse tables, whereas the dimensions of Kimball used in the data marts, are not copies of the conformed dimensions, but the dimension table themselves.

According to Kimball refers to the set of conformed dimensions as the data warehouse bus. There is no right or wrong between these two ideas, as they represent different data warehousing philosophies. In reality, the data warehouse in most enterprises is closer to Ralph Kimball's idea. This is because most data warehouses started out as a departmental effort, and hence they originated as a data mart. Only when more data marts are built later do they evolve into a data warehouse.

According to Basaran (2005) reveals some of the DW characteristics to include the following.

- It is subject-oriented.
- It is non-volatile.
- It allows for integration of various application systems. It supports information processing by consolidating historical data.
- Data is stored in a format that is structured for querying and analysis.
- Data is summarized. DWs usually do not keep as much detail as transaction-oriented systems.

1.2 Statements Business Intelligence

In the literature we find lots of different approaches to a proper definition of Business Intelligence (BI). Different parties such as IT vendors, press groups and business consultants have their own approach to this subject. Below a few examples are described. Together they should illustrate the main concept of business intelligence.

Gartner Group describes BI as a process of transformation from data to information, and after a voyage of discovery transforming this information to knowledge.

According to Vriens & Philips, found out BI as a process of acquiring and processing of information in order to support an organization's strategy.

According to De Tijd, 2006, defines BI as all applications supporting analyzing and reporting of corporate data in order to improve decision making which leads to better steering of the company. The Decision makers need to be provided by reliable information, filtered from all raw data the company has acquired in the past. The main purpose is to transform these raw data into valuable, actionable information. Common transactional software automates daily based processes such as the creation of invoices and registers them into the system. Unlike this, BI sets a step backwards to provide a holistic view on these transactions. Figures from the past are not reported in a very detailed way, instead they are aggregated, analysed and linked to each other with the purpose to forecast future activities.

According to David M. Kroenke, 2006, mentions business intelligence systems fall into these broad categories, namely reporting, including OLAP, and data mining. Aronson, Liang and Turban, 2005, also divide BI tools into reporting, OLAP and data mining. In this chapter I will divide BI tools also into these 3 categories. Apparently most of the definitions agree business intelligence should support defining the fundamental direction of a company by analyzing and reporting data.

2 BUSINESS INTELLIGENCE ARCHITECTURE

2.1 Operational Applications vs. Business Intelligence Applications

Figure 2.1 illustrates the 2 main components of BI applications, and their relation with operational applications. Notice that Kroenke, 2006, defines reporting and data mining as the 2 main BI components. In my opinion OLAP is situated anywhere between reporting and data mining. Therefore, in this dissertation reporting, OLAP and data mining are described separately.

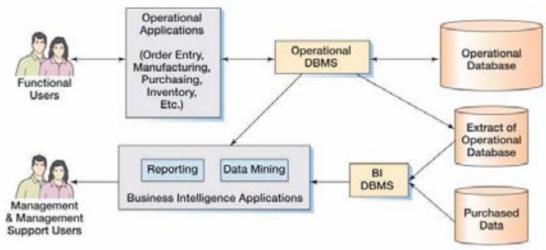

Figure 2.1 Showing Relationships of Operational and Business Intelligence Applications
(Source: Kroenke, 2006)

On the one hand, the operational business applications such as order entry, manufacturing and purchasing read from and write data to the operational database via the operational database management system (DBMS). Entering orders for example into a corporate system is mainly situated on a company's operational level and do not mainly require high level decisions to make.

According to this scheme, management, situated on tactical and strategic level, are supposed to rather use business intelligence applications to improve decision making. Notice that this distinction touches the core of this dissertation, as the main goal is to find out what corporate level(s) is BI really contributing to.

The BI applications on the other hand might only read data directly via the operational DBMS from the operational database, as long as simple reporting and/or small databases are applied. Data from extractions of this operational database as well as purchased data from external data vendors are read through the BI DBMS. BI applications then can both make reports as well as carry out some advanced analyses based upon these data. In further paragraphs a more detailed subdivision of these components will be explained (Kroenke, 2006).

2.2 .Need for a Data Warehouse

For complex BI applications running on large databases difficulties might occur while reading directly from the operational database. Besides slowing down the DBMS and its applications, errors might occur when values are missing or in a wrong format.

Therefore, a separate database, an extraction from the operational database, needs to be set up and prepared for BI use. This process of data warehousing is done in 3 main steps, also known as extraction, transforming and loading (ETL).

Extraction programs retrieve data from a variety of heterogeneous operational databases based upon a certain model. The metadata describes this model and the definition of the source data elements. For example, a model describing the regional sales performance is defined by metadata containing sales data in integer format created by salespeople of a particular region. Notice that using indexes improves the speed of this extraction process. Transformation of data is sometimes needed to ensure consistency of all data in the data warehouse.

The Data need to be transformed into the right format or missing values need to be filled in. Certain aspects of operational data, such as low-level transaction information, are also removed as they slow down query times. Finally the DBMS loads these processed data into a data warehouse. This process of extraction, transforming and loading (ETL) is crucial in BI processes as they are the link to the source data. Once ETL has finished, users can start producing information or intelligence. Obviously, people preparing data warehouses are experts in data management. They consider the preparation of data warehouses as their final product. In contrast, from business point of view, data warehouses are only the beginning of a business analyst's job. People of marketing or financial departments might rather work with data marts. These are small subdivisions of data warehouses containing data on specific business components. The marketing analyst might for example analyse a data mart containing sales data of a particular market segment. Figure 9 illustrates how data warehouse DBMS links operational databases and BI tools graphically. it Notice that metadata, data concerning the data's author, format, time of creation, etc., is also stored through the data warehouse DBMS.

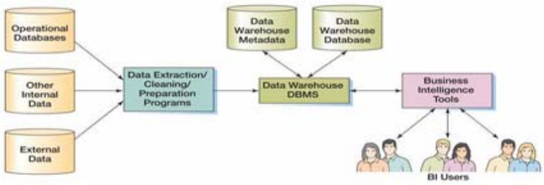

Figure 2.2 Showing Components of a Data Warehouse

2.3 Analysis and Reporting for Improve Decision Making

1. Reporting

Reporting technology in BI contains much more functionalities than just distribution of information. Reporting is applied in business processes to generate reports for applications such as logistics and financial management. Based upon user skills, BI distinguishes 3 main types of reporting tools, namely production reporting tools, desktop report writers and managed query tools.

Production reporting tools are used to generate operational reports or extremely voluminous batch tasks such as counting and printing salaries. Generating reports requires support from the IT department. As these reports cover large amount of data, queries are processed in batch mode. In contrast, desktop report writers enable users to design queries and reports quite simply and easily on their desktop, without interference of the IT department. Via a graphical interface report writers have access to multiple databases, make selections out of them and present and distribute the results via a large variety of report formats. Figure 2.3 shows examples of different types of reports. The Desktop report writers enable users to design quite simple reports, based upon a rather small pool of data. When complex source data need to be accessed, managed query tools are to be applied.

To Managed query tools enable users to access complex source data on a fairly simple way. This combination requires an interface between the data sources and the user, which defines the relation between the physical data in the databases and the user language. This interface contains a graphical SQL environment generating the SQL code according to a graphical command. Standard Query Language (SQL) is a standardized database language for data access (read, insert, update, delete) and manipulation in relational database management systems (Aronson, Liang and Turban, 2005).

the SQL enables users also to carry out some simple calculations on data such as generating overviews of past (trends), current, and likely future business activities (forecasting) (Kroenke, 2006).

As a result of this user friendly interface, users can totally focus on defining questions without worrying about aspects such as the location of the data, consistency and the like. For example, an overview of total units sold per year, customer type and geographical area can be shown. Important to stress is this interface enables nontechnical users to create their own customized reports. As in my opinion holistic overviews are very useful at high level management, this reporting tool might contribute a lot to a company's strategic management. Sometimes managed query tools provide OLAP functionalities as well. OLAP enables users to further dig into the general overviews of managed query tools

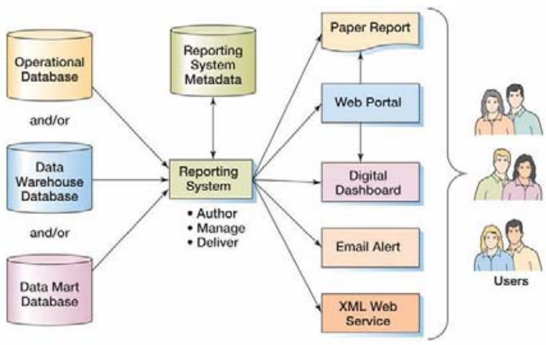

Figure 2.3 Showing Components of a Reporting System

The Report delivery and distribution is crucial in the decision making process. Reports need to be delivered to the right and authorized users, in the right format and on the right time. The report output might be delivered on paper, via a browser, over the telephone, or in any other format. Figure 2.3 shows both input and output components of a reporting system. A digital dashboard is an electronic customized display of the report (Kroenke, 2006). A financial analyst might for example prefer the company's financial stock price as well as European and American stock prices on his dashboard. Alerts are reports that are automatically triggered when an event has occurred, e.g. An e-mail is sent if the company's stock price has reached a predefined limit.

The RFM analysis is an example of such a report. This report ranks all customers based upon how recently (R) they bought something, the frequency (F) they buy, and how much money (M) they spent. This RFM technique enables users for example to identify clients tenting to go to competition (Kroenke, 2006). Although this is not a complex technique, it already unveils, in my opinion, extremely valuable intelligence for a company.

2.4 Data Warehouse Data Model

According to Inmon (1993) argues that there are three levels in data modeling process: High-level modeling (called the ERD, entity relationship level) which features entities, attributes and relationships, Mid-level modeling (called the data item set) which is data set by department, and Low-level modeling (called the physical model) optimize for performance.

After the high-level data model is created, the next level is established the midlevel model. For each major subject area, or entity, identified in the high level data model, a midlevel model is created. Each area is subsequently developed into its own midlevel model. The physical data model is created from the midlevel data model just by extending the midlevel data model to include keys and physical characteristics of the model. At this point, the physical data model looks like a series of tables, sometimes called relational tables.

According to Stuart Mullins (2007) in his blog titled "Data Warehouse Data Model Design" explains what can be used to differentiate the DW from an ordinary archive database which can easily become a dumping ground. Data is conformed (Data elements are conformed so that the definitions of "customer" or "revenue" mean the same thing no matter where the originated), Data is historical (view of the business at a particular point in time), Data is shared (Can be queried or otherwise accessed has little value), Data is comprehensive (Can be captured and consolidated from multiple systems).

2.4.1 DW Modeling Techniques

According to Ballard (1998) gave an exploration of the evolution of the concept of data warehousing, as it relates to data modeling for the data warehouse, they defined database warehouse modeling is the process of building a model for the data in order to store in the DW. There are two data modeling techniques that are relevant in a data warehousing environment are Entity Relationship (ER) modeling and dimensional modeling.

The ER modeling produces a data model of the specific area of interest, using two basic concepts: entities and the relationships between those entities. Detailed ER models also contain attributes, which can be properties of either the entities or the relationships.

The Dimensional modeling uses three basic concepts: measures, facts, and dimensions. Dimensional modeling is powerful in representing the requirements of the business user in the context of database tables. Measures are numeric values that are can be added and calculated. Ballard (1998)

2.4.2 DW Database Design Modeling

There are three levels of data modeling. They are conceptual, logical, and physical. For the purpose of this thesis, we would discuss only the first two. Conceptual design manages concepts that are close to the way users perceive data; logical design deals with concepts related to a certain kind of DBMS; physical design depends on the specific DBMS and describes how data is actually stored.

The main goal of conceptual design modeling is developing a formal, complete, abstract design based on the user requirements. DW logical design involves the definition of structures that enable an efficient access to information. The designer builds multidimensional structures considering the conceptual schema representing the information requirements, the source databases, and non functional (mainly performance) requirements. This phase also includes specifications for data extraction tools, data loading processes, and warehouse access methods. At the end of logical design phase, a working prototype should be created for the end-user. Basaran (2005)

2.4.3 Developing Data Warehouse

According to Demarest (2008) was explicit when it say that planning the developing and deployment of a standard data warehouse should be taken as an IT project, hence what made IT project failapplies also applies when developing data warehouse; thus the need for Project Planning and following the system development life cycle. There is the need for careful planning, requirements specification, design, prototyping and implementation. The cyclical model entails five stages which are described below;

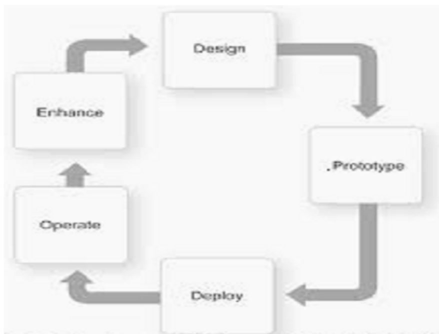

Figure 2.4 Showing DW Development Lifecycle (DWLC) Model

Where the Design stage takes information from both available data inventories and analyst requirements and analytical needs, of robust data models and turns it into data marts and intelligent information. The Prototype deployment stage, where group of opinion-makers and Certain end-user clientele, are brought in contact with a working model of the data warehouse or data mart design, suitable for actual use. The purpose of prototyping shifts, as the design team moves back and forth between design and prototype. Deploy stage is the stage of formalization of user-approved prototype for actual production use. The Operation is the day to-day maintenance of the data warehouse or mart, the data delivery services and client tools that provide analysts with their access to warehouse and the management of ongoing extraction, transformation and loading processes that keep the warehouse current with respect to the authoritative transactional source systems. Enhancement stage is where external business conditions change discontinuously, or organizations themselves undergo discontinuous changes enhancement moves seamlessly back into fundamental design, if the initial design and implementation didn't meet requirements.

2.5 Business Intelligence Concepts

Initially, BI was coined as a collective term for data analysis tools. Meanwhile, the understanding broadened towards BI as an encompassment of all components of an integrated decision support infrastructure.

In BI systems, data from OLTP is combined with analytical front ends to "present complex and competitive information to planners and decision makers". A central component of BI systems is the data warehouse (DW), which integrates data OLTP for analytical tasks. From the managerial approach, BI is seen as a process in which data from within and out the organization are consolidated and integrated in order to generate information that would facilitate quick and effective decision-making.

The role of BI here is to create an informational environment and process by which operational data gathered from transactional systems and external sources can be analyzed and to reveal the "strategic" business dimensions. From this perspective emerge concepts such as "intelligent company": One that uses BI to make faster and smarter decisions than its competitors (Liautaud, 2000). "Intelligence" means reducing a huge volume of data into knowledge through a process of filtering, analyzing and reporting information.

The technological approach presents BI as a set of tools that supports the storage and analysis of information. The focus is not on the process itself, but on the technologies that allow the recording, recovering, manipulation and analysis of information. For instance, Scoggins (1999) classifies data mining (DM) as a BI technique;

According to Hackathorn (1999) includes all resources (DW, DM, hypertext analysis and web information) in the creation of a BI system; and finally, linking BI and the Internet, Giovinazzo (2002) posit the integration of DW and customer relationship management (CRM) applications.

Whether managerial or technological, there is one shared idea among all these studies are given below

The core of BI is information gathering, analysis and use the goal is to support the decision making process, helping the company's strategy. Taking into account the scarce literature, we looked for other areas that could help us reach a more comprehensive understanding of BI.

We find contributions in three distinct topics: information planning, balanced score card and competitive intelligence. Here are some benefits that business intelligence offers and how they can help the entertainment industry to make and distribute creative substance and stay aloft of the game:

Product profitability: How much profit does a particular item contribute? How does item's profit break down across business units, media and distribution channels? What are the specific costs and expenses associated with producing the item? What percent of revenue or profit do they represent?

Customer and market analysis: What are the key demographic characteristics of customers by product? Which other products do they tend to buy? Does the data indicate that an underserved market segment has greater revenue potential?

Channel analysis: Which channels reach what types of consumers? How profitable is each channel? How will channels be affected by changing technologies, as well as the emergence of new channels?

Forecasting and planning: What are the market potential of a new product, and how much investment should be made? How will a new release perform and what will its profit contribution be? What level of supply will adequately meet demand?

The result – employees can now access detailed sales data from around the world, which was previously not possible, and they are also able to run sophisticated self-service reports that provide granularity and a near real-time view into sales performance, ultimately helping these users make informed decisions that drive the results of the business. In addition to sales data, Media companies can measure marketing and promotion effectiveness and monitor corporate performance and results. BI not only converts raw data into intelligent information, but also allows business users to access the right information at the right time and able to transform it into smart decisions.

Media companies with its business processes based on such intelligent information can disrupt its competitor's moves, strategize a sustainable competitive edge, tap into new customer bases, retain existing customer bases, increase operational efficiencies and be better prepared for the future.

2.6 Data Warehousing Online Transactional Processing (OLTP)

Data warehouse are also known as Online Analytical processing (OLAP) system because they serve managers and knowledge workers in the field of data analysis.

The Online transaction processing (OLTP) systems or operational systems are those information systems that support the daily processing that an organizational does. The OLTP system's main purpose is to capture information about economic activities of an organization. On might argue that the purpose of OLTP system is to get data into computers, whereas the purpose of data warehouse is to get data or information out of computers Han and Kamber

(2001) argue that an OLTP system is customer-oriented as opposed to a data warehouse that is market-oriented. It is a bit difficult to combine data warehousing (OLAP) and OLTP capabilities in one system.

The dimensional data design model used in data warehouse is much more effective for querying that the relational model used in OLTP systems. Furthermore, the data warehouses may use more than one database as a data source. The dimensional design is not suitable for OLTP systems mainly due to redundancy and loss of referential integrity of the data. Organizations choose to have two separate information systems, one OLTP and One OLAP system

According to Poe (1998) stress the fact that analysis using OLAP systems are primarily done through comparisons, or by analyzing patterns and trends. For example, sales trends are analyzed along with marketing strategies to determine the relative success of specific marketing strategies with regard to sales patterns; such analysis may not be possible with OLTP.

According to Kimball supported same idea but Inmon (1993) was a bit different on the approach to the development of data warehouse system. He argue that although OLTP are developed from requirements as a starting point, data warehousing starts at implementing the data warehouse and ends with a clear understanding of the requirements. The data warehouse development lifecycle is data-driven and OLTP are requirements driven. Kimbal (1996) differ from this approach by following a requirements-driven development lifecycle.

2.7 Data Warehouse and Business Intelligence High Level Architecture

According to Eckerson (2003) from the Data warehouse institute did study on the success factor in implementing BI, systems in organizations and the role of data warehouse in this process. Eckerson (2003) views the BI process holistically as a “data refinery” Data from different OLTP systems are integrated, which leads to a new product called information. The data warehouse staging process is responsible for the transformation. Users equipped with program such as specialized reporting tools, OLAP tools and data mining tools transform the information into knowledge. Kimball (1996) includes this as part of the data warehouse.

According to Kimball, the aim of the data warehouse is to give end-users (mostly managers) easy access to data in the organization. In order to do this, it is necessary to capture everyday operational data from the operational systems of the organization. These are the OLTP system. The data from the source systems go through a process called data staging to the presentation servers (Kimball et al 1996). The data at the staging process involves four processes namely Extract, Transformation, Loading and finally presentation. It is on the presentation stage that the data marts, which represent business areas in the organization is build on.

The data in the data mart or data warehouse is stored as star schemas consisting of FACT and DIMENSION tables. This is different from the entity relational diagram (ERD) used in traditional systems.

There is a difference between the data warehouse and business intelligence architecture as advocated by the two known scholars in the industry, (Inmon, 1993) advocates the use of data-driven method. This means that the Decision Support System process begins with data and ends with requirements. In contrast to Inmon’s approach, advocate the use of requirements-driven methods. The data warehouse starts with the project planning to determine the readiness of the organization for a data warehouse and to set the staff requirement for the data warehouse team. A clear understanding of business requirements is the most important success factor and Kimball, (1996) state that this process of requirements

Collection differs substantially from data-driven requirements analysis. The business requirements establish the foundation for the three parallel tracks focused on technology, data and end user applications.

CONCLUSION

This paper discusses about data warehousing, business intelligence, OLTP, their architectures, need of data warehouse, different modeling techniques and their uses to develop data warehouses in different perspective.

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