Business Intelligence Support Systems and Infrastructures

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Business Intelligence (BI) is the most popular concept in today's Decision Support Technologies. BI offer sophisticated information analysis and information discovery technologies (Data Warehouse, OLAP, Data Mining) that are designed to handle and process the complex business information associated with today's business environment. Only a revolutionary Business Intelligence solution, like the proposed portal-based, can solve the complex issues faced when evaluating decision support applications and ensure the availability of any business-critical information. In this paper we recommend some BI solutions in order to create a collaborative business environment.
Keywords: *Business Intelligence, Collaborative Business Infrastructure, Data Warehouse, Enterprise Portal, Federated Portals, OLAP, Data Mining.*

1 Business Intelligence Support Systems

The Business Intelligence technologies are the most appropriate to transform data into information needed in decision-making. The concept of Business Intelligence (BI) is quite new. Since the early 1990's, Business Intelligence applications and technologies have evolved dynamically and in many directions as companies access to information grew exponentially. Many of the concepts of business intelligence are not new, but have evolved and been refined based on experience gained from early host-based corporate information systems, and more recently, from data warehousing applications. The dramatic expansion of data warehousing combined with the wide-spread adoption of ERP and CRM, and the overall increase in computer literacy, fueled this exponential demand for BI reporting and analysis applications.

The BI technologies have evolved in direct link with the Business Information Systems. IBM outlines three generations in the evolution of Business Information Systems [14]:

- *First-Generation: Host-Based Query and Reporting* - this first generation of business information systems could, therefore, only be used by information providers, such as business analysts, who had an intimate knowledge of the data and extensive computer experience. Information consumers, like business executives and business managers, could rarely use these early systems, and instead had to rely on information providers to answer their questions and supply them with the information they needed.
- *Second-Generation: Data Warehousing* - the second generation of business information systems came with data warehousing.
- *Third-Generation: Business Intelligence* - Business Intelligence systems focus on improving the access and delivery of business information to both information providers and consumers. They achieve this by providing advanced graphical- and Web-based online analytical processing (OLAP) and information mining tools, and prepackaged applications that exploit the power of those tools.

BI converts data into useful information and, through human analysis, into knowledge. Some of the tasks performed by BI are:

- *Creating forecasts based on historical data*, past and current performance, and estimates of the direction in which the future will go
- *"What if" analysis* of the impacts of changes and alternative scenarios
- *Ad-hoc access to the data* to answer specific, non-routine questions
- *Strategic insight*.

To mitigate these tasks BI process implies some data storing and analysis technologies like:

- Data Warehouse
- OLAP (On-Line Analytical Processing)

- Data Mining
- Data Visualization
- GIS (Geographic Information System)

Some well-known BI approaches and tools are:

- Applications such as IBM's DecisionEdge for customer relationship management, and IBM's Business Discovery Series for data mining.
- Query tools such as Impromptu and PowerPlay from Cognos, BusinessObjects from Business Objects, Approach from Lotus Development Corp., and IBM's Query Management Facility (QMF).
- OLAP tools for multidimensional analysis such as Essbase from Arbor Software, and IBM's DB2 OLAP Server (developed in conjunction with Arbor).
- Statistical analysis tools such as the SAS System from SAS Institute Inc.
- Data Mining tools such as IBM's Intelligent Miner

1.1. Data Warehouse, OLAP and Data Mining Considerations

❑ **A data warehouse** is often a core component of a BI infrastructure within an organization. The data warehouse is a collection of integrated, subject-oriented databases designed to support DSS function, where each unit of data is non-volatile and relevant to some moment in time [8]. The main characteristics of data warehouses are:

- *Subject oriented* – Data are organized based on how the users refer to them.
- *Data integrated* – All inconsistencies regarding naming convention and value representation are removed.
- *Time variant* – Data are not current but normally time series.
- *Nonvolatile* – Data are stored in read-only format and not change over time

Over time, the various approaches to design a data warehouse schema that is optimized for understanding and querying information have been consolidated into an approach called a *dimensional model*. At the center of the dimensional model are the *numeric measures* that we are interested in understanding, such as sales revenue or profit margins. Related measures are collected into *fact tables* that contain columns for each of the numeric measures. There are usually many different ways that people can look at these measures. For example, they could look at totals for a product category or show the totals for a particular set of stores. These different ways of looking at the information are called *dimensions*, where a dimension is a particular area of interest such as Product, Customer, or Time. Every dimension table has a number of columns with descriptive text, such as product category, color, and size for a Product dimension. These descriptive columns are known as *attributes*. The most important dimension in any data warehouse is the *Time dimension*.

Data warehouses have several advantages over classical database systems:

- Data warehouses are designed to satisfy the needs of business users and not day-to-day operational applications.
- Data warehouse information is clean and consistent, and is stored in a form business users can understand.
- Unlike operational systems, which contain only detailed current data, the data warehouses can supply both historical and summarized information.
- The use of client/server computing provides data warehouse users with improved user interfaces and more powerful decision support tools.

❑ **On-line Analytical Processing** (OLAP) is one of the best technologies for converting data into information. OLAP tools and applications provide an interactive environment where a user can analyze business data at "thinking speed" instead of having to wait at least a day for the results of their query. In 1993 E.F. Codd define 5 rules (FASMI) for OLAP technologies and applications [4]: *Fast*, *Analysis*, *Shared*, *Multidimensional*, *Information*.

One term that is almost always associated with OLAP, but never associated with relational databases is the word ***cube***. OLAP use the word cube to describe what in the relational world would be *the integration of the fact table with dimension tables*. OLAP data-

base technology also generally includes a calculation engine for adding complex analytical logic to the cube, as well as a query language. Because the standard relational query language, SQL, is not well suited to working with cubes and
dimensions, an OLAP-specific query language has been developed called MDX (Multidimensional Expressions), which is supported by several OLAP database engines. OLAP Tools can have different architectures. According to Berson and Smith (1997) there are three main categories of OLAP Tools [1]:
▪ Multidimensional OLAP (MOLAP). These tools use specialized data structures and multi-dimensional database management systems to organize, navigate and analyze data.
▪ Relational OLAP (ROLAP). These tools support RDBMS products through the use of metadata layer, thus avoiding the requirement to create a static multi-dimensional data structure.
▪ Managed Query Environment (MQE). These tools provide limited analysis capabilities.
❑ According to Simoudis (1996) **Data Mining** is the process of extracting valid, previously unknown, comprehensible, and actionable information from large databases and using it to make crucial business decisions [13].

1.2. Data Warehouse Environment Trends

The final piece of any data warehouse puzzle are the reporting tools and *recently the enterprise portal*. Portals provide single sign-on and other infrastructure support, which eases the data warehouse developer's job. They are easily customized to provide quick access to frequently used reports, offer a convenient place to post notices, and deliver newly generated reports.
With the help of data warehouse reports, an analyst/manager my find a business problem inside the company, but these reports do not indicated why the problem occurred. *Portals, on the other hand, can help the manager to identify the root cause of the problem*. A portal can house several different analytical tools (e.g., forecasting and modeling tools that use historical data from the data warehouse as the basis for projections and complement the historical look provided by ad hoc query tools) together with other tools, like enterprise search and document management systems. Analytic services naturally complement the data-retrieval-oriented operations of the data warehouses.
The decentralization of decision making is driving the need for operational and management information throughout organizations, and portals are the delivery vehicle of choice for many business intelligence systems. *Combined with ad hoc query tools, dashboards, and visualization tools, a portal can provide the flexible access to data warehouses needed by executives and line-of-business managers throughout a organization.*

2. Collaborative Business Infrastructures

These are technology-enabled business models that optimize the extended enterprise by connecting applications, data and people to business processes and Web services. By implementing standardized business practices and technologies, proponents of CBI model contend that organization will be able to: reduce complexity in extended enterprise operations; reduce costs by limiting replicated work; create a platform for agile businesses and supply chains; and provide an anchor for ongoing strategic business initiatives. According to Hoolahen, any CBI initiative must establish a framework for rapidly and effectively delivering integrated business solutions within and beyond the enterprise [7]. Performant *CBIs based on portals are designed to enable timely, accurate decision making in support of strategic and tactical business initiatives* [6].

2.1. Enterprise Portal With BI Sub-Portal

According to Crolene, a sub-portal paradigm is a group-level portal that allows specific groups within an organization to administer and manage their own content and components [5]. *A BI sub-portal, incorporated as a distinct entity inside the enterprise portal, supports all e-business processes by manag-*

ing all Business Intelligence objects with the help of the portlet technology. In the Delivery Layer, portlets are the first way to access to BI objects. Portlets, in essence, are the active visible components that end users see within their portal Web pages.

From the user's perspective, a portlet is a content channel or an application window within an overall portal view. All portal server vendors offer prebuilt portlets to expedite the user's portal implementation cycle. Since most of the servers that promote the portlet concept are Java-centric, they all offer a JavaServer Pages (JSP) portlet for portal development [9]. Beyond the JSP portlets there are also other commonly available and highly useful portlets. A portlet can be thought of as a "building block" of a portal. It is a user-interface for presenting data and functionality from multiple application on a single Web page. Portlets encompass the presentation layer and the business logic, but also tie into the back end data sources.

2.2. Federated Portals

Federated portals have the potential, thanks to the widespread adoption of portal standards JSR 168 and WSRP, to radically change the concept of collaborative enterprise. *A federated portal architecture involves separately managed portals, each portal may act as either a portlet producer (for other portals), or a consumer of portlets (from remote servers), or both*.

While local portlets can be expected to provide a large part of the base functionality for portals, the remote portlet concept allows dynamic binding of a large number of remote portlet services without any installation effort or code running locally on the portal server. Portal servers enable organizations to deploy comprehensive solutions - that enable and foster collaboration and coordination across communities of employees, customers, and partners - by providing a framework to develop performant federated portals.

A federated portal strategy based on a distributed architecture model reduces the time and consensus building required in the planning stages. With departmental control and leadership from the organizational IT group, planning and budgeting issues are more manageable, the purpose and expectations of the portal are more clearly defined, and the portal strategy is seen by department level executives as having clear, tangible benefits for their short and long term needs. Federated portals facilitate the distribution of knowledge, improve planning and development cycles and create more functional and productive relationships within teams. This in turn increases productivity and company understanding of internal and external environments. Overall, employees will begin to have a better view of corporate information and the power to make informed decisions more effectively.

Gartner calls the next generation, fourth generation portals: *"in order to provide a single business platform for all enterprise resources, portals have to be integrated in such a way that content is location-transparent to users without users having to remember numerous URLs and identities for access"*. In essence, federated portals provide federated content, identity and single-sign-on. On the other hand, federation is not possible without standards that facilitate easy integration of business into the portals.

3. Conclusions

Business Intelligence is the art of gaining business advantage from data - therefore BI systems and infrastructures must integrate disparate data sources into a single coherent framework for real-time reporting and detailed analysis by anyone in the extended enterprise – customers, partners, employees, managers, and executives. Without any doubts, b*usiness decisions are only as good as the information on which they are based*.

New information technologies like enterprise portals and federated portals help reduce the cost of deploying business intelligence systems to a wider user audience, especially information consumers like executives and business managers. Selecting, developing, and implementing the right BI systems and infrastructure are complex and challenging tasks. *The presented portal-based BI solu-*

tions like Collaborative Business Infrastructure and Data Warehouse Environment ensure the availability of business-critical information. Competitive organizations accumulate business intelligence in order to gain sustainable competitive advantage, and may regard such intelligence as a valuable core competence in some instances.

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