

## A model for Business Intelligence Systems' Development

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*Often, Business Intelligence Systems (BIS) require historical data or data collected from various sources. The solution is found in data warehouses, which are the main technology used to extract, transform, load and store data in the organizational Business Intelligence projects. The development cycle of a data warehouse involves lots of resources, time, high costs and above all, it is built only for some specific tasks. In this paper, we'll present some of the aspects of the BI systems' development such as: architecture, lifecycle, modeling techniques and finally, some evaluation criteria for the system's performance.*

**Keywords:** *BIS (Business Intelligence Systems), Data Warehouses, OLAP (On-Line Analytical Processing), Object-Oriented Modeling*

### 1 Introduction

The main objective of our research project that we had in one of the multinational companies from Romania is to develop a decision support system for public institution, so we tried to meet the requests from the executives and managers of one national company. We based our work on previous experiences, researches, articles and studies that we'd been developed. Thus, we followed the next classical steps: analyze, design, develop and applying for the project lifecycle the framework described in the book [2]. For the implementation phase we used different BI techniques, like data warehousing, OLAP, data mining, portal and we finally succeeded to implement the BI system's prototype and to validate it with the managers and executives in one national company. The system gathers data, using the ERP system, to extract data from different functional areas or modules such as: financials, inventory, purchase, order management or production. For the executives, the system is able to provide analytical reports and dashboards. As the storage solution we designed and build a data warehouse. The major problem is that there will be many more changes in the structure of the organization and the impact of these changes may affect the BI system. So, we need to find a solution, and, based on our previous re-

searches on Object Oriented modeling, we consider it as a good option. In the last years, there have been some proposals to represent MD properties at the conceptual level. As we mentioned in our previous researches, based on the conference paper [1], we defined a set of object-oriented extensions that can be used for modeling the components and requirements of a data warehouse. Also, we had to consider the system's development lifecycle that has to be flexible and easy to fulfill.

### 2 The concept of Business Intelligence System

With rapid advances in technology, enterprises today frequently search for new ways to establish value positions. Well built Business Intelligence Systems (BIS) can provide the ability to analyze business information in order to support and improve management decision making across a broad range of business activities. They leverage the large data infrastructure investment, for example, in ERP systems made by firms, and have the potential to realize the substantial value locked up in a firm's data resources [7]. While substantial business investment in BI systems is continuing to accelerate, there is a complete absence of a specific and rigorous method to measure the realized business value, if any. BI systems have the potential to

maximize the use of information by improving the company's capacity to structure a large volume of information and make it accessible, thereby creating competitive advantage: "competing on analytics" [15].

BI utilizes a substantial amount of collected data during the daily operational processes, and transforms the data into information and knowledge to avoid the supposition and ignorance of the enterprises [14].

The main characteristics of a BIS are: the capability of providing representative information to the high-level management, to support strategic activities such as goal setting, planning and forecasting, and also tracking performance, to gather, analyze, and integrate internal and external data into dynamic profiles of key performance indicators. Based on each executive's information needs, BIS can

access both historical and real-time data through ad-hoc queries. In essence, managers at every level can have a customized view that extracts information from disparate sources and summarizes it into meaningful indicators. Executives need information for strategic and tactical decision that often requires the combination of data from ERP and non-ERP application sources. The usual reports developed from daily transactions does not satisfy the business needs, an executive cannot take a real time decision based on a hundred pages per month cash-flow detailed report. Information must be aggregated and presented with a template based on a business model. In the table below we represent the main differences between ERP reports and BIS reports [2]:

**Table 1.** A comparison between ERP and BIS reports.

Characteristics	ERP reports	BIS reports
Objectives	Analyze indicators that measure current and internal activities or daily reports	Processes optimization, analyze key performance indicators, forecast internal and external data, internal and external focus
Level of decision	Operational/Medium	Strategic/High
User involved	Operational level of management	Executives, strategic level of management
Data Management	Relational databases Data warehouse	Data warehouse/OLAP/ Data Mining
Typical operation	Report/Analyze	Analyze
Number of records / transaction	Limited	Huge
Data Orientation	Record	Cube
Level of detail	Detailed, summarized, pre-aggregate	Aggregate
Age of data	Current	Historical/current/prospective

ERP systems are transaction-processing focused and weak on analytics. Strategic and executive manager's demand for technology solutions that can extract, analyze, and visualize information from ERP and stand-alone systems, and this has provided the motivation for a new type of information systems like BIS. The components of these systems are based on innovative technologies such as data warehousing, OLAP, data mining, friendly graphical user interfaces, integrating tools capable of collecting, processing, storing and retrieving data from

different sources. The following section describes some of these techniques and the architecture of the BI systems.

### 3 Business Intelligence Systems' Architecture

BIS architecture is structured on three distinct levels [2]:

*Level 1. Data Management* – is represented by relational databases, data warehouses and other type of data sources. At this level is common to use a data warehousing solution that collects and organizes data from both in-

ternal and external sources and makes it available for the purpose of analysis. A data warehouse contains both historical and current data and it is optimized for fast query and analysis. Data warehouses extract, transform and process data for high-level integration and analysis.

Although a data warehouse can make it easier and more efficient to use the BIS, it is not required for a BIS to be deployed. Organizations can extract data directly from their host system database for their analysis and reporting purposes, but in a more difficult way.

*Level 2. Model Management* – is the level of data extraction, transformation and processing. This level is based on different type of models for statistic interpretation, analysis and forecasting data. At this level, we can find technologies like OLAP, data mining and analytical reporting. The OLAP engine is a query generator that provides users with the ability to explore and analyze summary and detailed information from a multi-dimensional database. Traditional relational database systems handle this situation by using multiple queries. In many cases, the queries become so complex that even the developer finds them difficult to maintain. OLAP overcomes this barrier by enabling users to analyze multi-dimensional data. Managers can use an OLAP engine or typical operation like “slice and dice” data by various dimensions and then drill down into the source data or roll-up to aggregate levels. OLAP provide tools for forecasting data and “what-if” analysis. OLAP can only mark the trends and patterns within the data that was requested. It will not discover hidden relationships or patterns, which requires more powerful tools like data mining (DM). These tools are especially appropriate for large and complex datasets. Through statistical or modeling techniques, data mining tools make it possible to discover hidden trends or rules that are implicit in a large database. Data mining tools can be applied to data from data warehouses or relational databases. Data discovered by these tools must be validated and verified and then to become operational data that can be used in decision process. OLAM

(on-line analytical data mining) systems are OLAP systems used for data mining, used to discover new information from multidimensional-data.

*Level 3. Data Visualization Tools* - provide a visual drill-down capacity that can help managers examine data graphically and identify complex interrelationships. BIS attempts to present data in a form that is relevant for strategic decisions. At this level, one can find tools for reporting and presenting data in a friendly manner. A very efficient solution that can be used also to integrate data is to develop a business intelligence portal [4].

The main purpose of a BI portal is to integrate data and information from a wide range of applications and repositories, in order to allow visualization of a multitude of systems, either internal or external to organizations, through a simple Web interface [5]. Therefore, a BI portal can be seen like a Web-based, secure interface, which can offer a unique integration point for the applications and services used by employees, partners, suppliers and clients of the organization. The main advantage of the information portal is that it can be easily offered as a service to the wide public [16].

#### **4 Business Intelligence Systems’ Development Lifecycle**

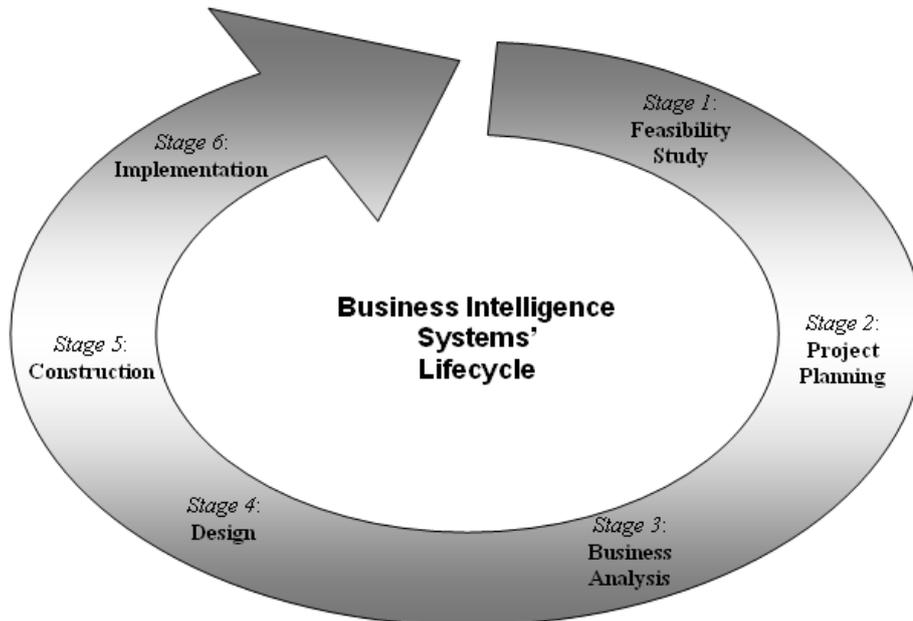
There are some major differences between transactional systems’ lifecycle and BIS lifecycle which depends on decision systems’ characteristics, but the same traditional techniques and stages are used for development: initial study, project planning, analysis, design, construction, and implementation (figure 1).

In these stages there are many steps used for modeling BIS characteristics such as [6]:

- orientation towards business opportunities rather than transactional needs;
- the implementation of strategically decisions, not only departmental or operational decisions;
- analysis based on business needs, which is the most important of the process;
- cyclical development process, focused on evaluation and improvement of succes-

sive versions, not only building and ma-

ajor delivering of a singular a final version.



**Fig. 1.** BIS development lifecycle

BIS lifecycle is divided in 6 stages and 16 steps as following [3]:

*Stage 1: Justification*

Step 1: Business case assessment - business needs and opportunities are identified and then the team proposes an initial solution justified by costs and benefits. A preliminary report is built-up.

*Stage 2: Planning*

Step 2: Enterprise infrastructure evaluation – this step estimates and values organization’s capabilities to sustain and accomplish the BIS project in terms of: infrastructure, components, devices, network and also future needs of these equipments. In this step is built organization’s infrastructure.

Step 3: Project planning – BIS involves dynamical project planning which leads to rapid changes in technology, organization and business needs, human resources and implementing team. The project plan is detailed, progressive, each stage and step has checking points and test documents and reports.

*Stage 3: Business analysis*

Step 4: Defining business needs – interviews and meetings are organized with executives and managers and business needs and requirements are identified and defined. An initial solution is proposed, discussed and

adopted.

Step 5: Data analysis – this step involves identifying and designing data sources, designing detailed ER diagrams with attributes and references between data. The logical model is designed.

Step 6: Application prototyping – An initial prototype is built and tested in order to validate business needs. After testing results are estimated and reported with positive and negative aspects.

Step 7: Metadata analysis – metadata are designed and data sources are mapped on metadata structure. CASE tools are used for designing and mapping process.

*Stage 4: System design*

Step 8: Data design – in this step the logical model is detailed and refined and physical model is designed. The data model for processing and storage are selected from the following options: relational, object oriented and multidimensional model.

Step 9: Designing the ETL process (extract / transform / load) – this step is the most difficult in the entire cycle and depends on quality of data sources. It is recommended that the process should be built in one environment which integrate all modules of the organization and not separately, on each department.

The rule should be: share one coordinated ETL process.

Step 10: Design metadata repository – if it is used a pre-defined solution for metadata repository then in this step it is adjusted for project requirements, otherwise a metadata repository is designed in terms of metadata logical model depending on data model: relational, object oriented or multidimensional.

*Stage 5: Development*

Step 11: ETL development – filtering tools, procedures, operators are used for building ETL process. Data filtering and transformations depends on data sources quality. These sources are different like: files, databases, e-mail, internet, unconventional sources.

Step 12: Application development – after prototype validation, building the final application may be a simple process. Procedures templates and interfaces are re-built; user rights and privileges are granted.

Step 13: Data Mining – executive systems have to implement data mining capabilities in order to succeed and accomplish manager's requirements. This step involves testing algorithms, data mining techniques like clustering, predictive and organizing methods.

Step 14: Developing metadata repository – if the metadata repository has to be built-up then metadata dictionary and data access interfaces are developed.

*Stage 6: System implementation*

Step 15: Implementation – it is the delivering process in which the development team organize training sessions for managers, final documentations and technical support are prepared, data loading process and application setup is accomplished

Step 16: System testing – after system implementation preliminary conclusions are made, costs are estimated and the development team build a final report in which are describe system performances and also some parts which have to be improved or re-built-up.

## **5 Business Intelligence Conceptual Design Model**

In order to gather data from various sources and ERP systems those are implemented in

an organization from different functional areas or modules such as: financials, inventory, purchase, order management, production we need to analyze and design the business model and strategic requests. This model have to be mapped on a logical model and physical model in the data warehouse and also used for extracting and presenting data through OLAP technology. These models are known as multidimensional models and basically, they represent an extension of the relational model or ER schema or a multidimensional view over facts.

Multidimensional models are classified in two major types: models that are an extension of ER model are based on a star schema and consist in the relationship between some dimensions and facts or measures and n-dimensional cube based models that use a multidimensional view over an individual situation or data.

In Business Intelligence Systems, the multidimensional model that is used has to be able to overhear the business requests. All we need is a business vision over data structure so the star schema or the n-cube based models have to design and incorporate business aspects or demands not only the facts or the relationship between data. The managers and executives request a synthetic view over facts and indicators and these key performance indicators are built from the entire organizational data or even external data.

Also, the system have to provide a friendly graphical interface with advanced capabilities of slicing and dicing through data and easily get a new perspective over data by rotating dimensions and drill down or roll up over hierarchical levels. So we need a multidimensional model in which these operations can be made easily, in real time and that can it overhead the entire business model with relationship between dimensions, facts and hierarchies and it is based on the entire organizational data at operational level, tactical level and strategically level.

Based on these considerations we propose an extension of the star or the constellation schema but with aggregate data and hierarchies in fact tables not only in dimension

tables. The model is structured over three distinct levels and we can call it a pyramidal model with the following structure (for detailed description see the book [2]):

- *Organizational level (or the base of the pyramid)* – containing dimensions and facts with an organizational scope, at a general level, that shape and are common to the entire activities. Such dimensions can be: <time>, <zone>, <product>, <currency> and facts: production, purchasing etc. Data are at a detailed level with multiple hierarchies over each dimension table.
- *Departmental level* – containing dimensions and facts for the departmental levels of the organization and particular activities in these departments or field of interests, group by data marts or data centers. Such dimensions can be: <account>, <client>, <vendor> and facts: stocks, payments, sales etc. Data are at a detailed and aggregate level with specialized hierarchies over each dimension table.
- *Strategically level* – containing dimensions and facts derived from the base dimensions and facts, with specific elements for the strategic analysis, like <intercompany>, <plan>, <budget> and facts: cash-flow, KPIs. Data are at an aggregate, synthetic level with specialized hierarchies over each dimension table.

The main characteristic of the model is that between the dimension tables and the facts from different levels of the architecture can be establish a relationship and also the fact tables can have hierarchies and class attributes that can be used for drill down or roll up.

***Advantages of the model:***

*Flexibility* – new elements or objects like new dimensions or facts can easily be included in the model without affecting the existing architecture or remodeling the system and the loading process for a specific level can be made without refreshing the whole data;

*Real model of business requirements* – the three level architecture is based on the real model of business requirements thus this

model can be mapped on the each level of the pyramid;

*Performance in the drill-down or roll-up operations* – because the dimensions and facts are separated at each level we can easily navigate through hierarchies from a level to another;

*Incremental development* – the model can be built in stages and each stage can be validated and used before the next stage;

*EIS, MIS and DSS support* – the top level can be used to implement an Executive Information System (EIS), the bottom and middle levels can be used for design and realized a Management Information System (MIS) or a Decision Support System (DSS) because these systems can use the specific dimension and fact tables from these levels.

***Disadvantages of the model:***

*High complexity* – because it is containing three different levels, the business model need to be careful analyzed and designed in order to identify the proper and suitable dimensions and facts and also the hierarchies at each level. An inadequate choice can have a major effect on the performance of the entire system;

*Moderate performance of the interrogation process* – in order to perform a complex query the model need to establish many relationships and joins between the fact and dimension tables and this can reduce the performance of interrogation;

*Top-down and bottom-up development* – In order to overhear the entire aspects of the business process we need to build the systems in two directions: first top-bottom to model the strategic requirements and second, bottom-up for validating and setting up the hierarchical flux of data.

The pyramidal model is suited for business needs and can be developed and implemented through an object oriented approach, defining classes for dimensions and facts, following the rules of the OO design. The prototype will have the main functionalities of the business model and when there will be any change in this model and a new business requirement appear then new functions or new attributes can be added to the main

classes to complete the demands.

## 6 Criteria for Evaluating Business Intelligence Systems

A problem of BI systems is measuring success. There are some case studies evidencing benefits generated by organizations that are successful with the use of BIS like the one shown in [8] and [9], but with limited empirically validated measures. There have been several studies calling for the development of a measure for evaluating the business performance effects of BIS ([10], [11], [12]).

In deploying a BIS there are many risks involved: system design, data quality, and technology obsolescence. System design risks stem from poor conceptualization of an enterprise's true business needs before the technology is deployed. Data quality risks relate primarily to whether or not data has been properly cleansed. Technology obsolescence refers to the failure on the part of the vendor to anticipate new technologies.

Large budgets and strategic information are involved in deploying BIS systems – this is the reason to establish rigorous criteria for evaluating such systems. These criteria are discussed below.

### *Decisions based on business process*

BIS should not be viewed only as a data repository or a large set of data. Instead, system's implementation should be concern on conceptualizing new data models, processes, and indicators that form the content of BIS; also it should provide extensive understanding of the benchmarks that are useful to evaluate business processes.

### *Performance*

This feature typically refers to the response time that a system provides to its users. Most responses should range from a few seconds to a maximum of 30 seconds for routine queries. Response times depend on the complexity of the database and the queries being requested.

### *Flexibility and scalability*

Flexibility determines whether a BI solution can continually adapt to changing business conditions after the system has been delivered. BIS should be able to accommodate

changes in any type of business process and functions like personnel, services, and processes, as well as new mandates, laws, and regulations requiring the capture of different types of data. BIS should be expandable to accommodate data growth and changes to organizational structure. EIS also should allow contributed content to grow without a slowdown in performance.

### *Integration*

Integration involves two types of issues: *data integration* and *system integration*.

Data integration is the ability to access data from much different type of systems, so BIS will be particularly effective if it can overcome the challenge of information fragmentation, allowing executives to measure features of business processes that involve information from inside and outside of the organization. System integration refers to two things: the ability to extent the BI software with new capabilities and modules and the system's ability to coexist with other enterprise solutions.

### *Friendly user interface*

BIS should be designed to allow managers who are not trained to use query languages and advanced technologies, a fast, easy, and understandable way to navigate into data and identify trends and patterns. BIS should permit the user interface to accommodate different degrees of technical knowledge.

## 7 Conclusions

BI systems have a powerful impact on strategic decisions quality to reduce the time for making decisions and thus these systems must have the ability to allow managers to view data in different perspective, to drill-down and roll-up to aggregate levels, to navigate and on-line query data sets in order to discover new factors that affect business process and also to anticipate and forecast changes inside and outside the organization. BIS improve the quality of management in organization through new type of technology and techniques for extracting, transforming, processing and presenting data in order to provide strategic information.

One of the major risks in the process of de-

veloping a BIS is the system design that stem from poor conceptualization of an enterprise's true business needs before the systems is deployed and for every change in these requirements the prototype must be also revised. A solution for covering this risk is object oriented modeling of a data warehouse that helps us to improve the designing phase and the development cycle and also we can re-use some parts of the prototype that it was implemented in an organization in order to design and implement another prototype in other organizational environments. So, object types can store structured business data in its natural form in object tables and then allow applications, such as OLAP applications, to work in a multidimensional way using the object oriented properties and facilities.

### Acknowledgement

This paper presents some results of the research project PN II, Ideas Program, Code 820: *Informatics solutions for decision support and for the development of knowledge management in public institutions*, financed within the framework of IDEI research program.

This article is a result of the project *Doctoral Program and PhD Students in the education research and innovation triangle*. This project is co funded by European Social Fund through The Sectoral Operational Program for Human Resources Development 2007-2013, coordinated by The Bucharest Academy of Economic Studies.

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