Business Intelligence and Data warehouse – Technological Support for Decisional Management in Geographical Information Systems

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***Abstract*—** In a world which is in a continuous motion, in which hardware and software products almost fail to be worn-out as they are already replaced by new ones, because their generation has already become «out-of-date», in a world in which «information» is considered the main resource within a company, the need for executive information systems which lie at the basis of strategic management's decision-making is quite obvious. The viability and success of modern enterprises are subject to the increasing dynamic of the economic environment, so they need to adjust rapidly their policies and strategies in order to respond to sophistication of competitors, customers and suppliers, globalization of business, international competition. Perhaps the most critical component for success of the modern enterprise is its ability to take advantage of all available information - both internal and external. The IT solutions designed to address these challenges have been developed in two different approaches: structured data management (BI - Business Intelligence) and unstructured content management (KM - Knowledge Management). Integrating Business Intelligence and Knowledge Management in new software applications designated not only to store highly structured data and exploit it in real time but also to interpret the results and communicate them to decision factors provides real technological support for Strategic Management. Integrating Business Intelligence and Knowledge Management in order to respond to the challenges the modern enterprise has to deal with represents not only a „new trend" in IT, but a necessity in the emerging knowledge based economy. These hybrid technologies are already widely known in both scientific and practice communities as Competitive Intelligence. But, behind an executive information system there is actually a data warehouse.

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I. INTRODUCTION

CONTEMPORARY economy is not entirely based on natural resources anymore. They are gradually replaced by the intellectual ones. Intellectual capital – so called hidden assets – proves as important as financial capital while reaching objectives of an enterprise. It enables better evaluation of enterprise abilities to generate potential profits than conventional standards. Hence, there are numerous proposals to apply more adequate systems of measuring potential of an enterprise in the era of knowledge-based economy. It is manifested in attempts to include intellectual capital (consisting of all that is found in the heads of enterprise members and all that is left in an enterprise when its members leave) in the balance sheet of a company.

Table 1. Financial, material and intellectual capital and the market position of a company [11]

II. FINANCIAL AND MATERIAL CAPITAL	III. INTELLECTUAL CAPITAL
Financial assets	Ability to learn
Personnel quantity	Personnel quality
Market share	Personnel and contractors Knowledge
Mass production	Constant innovation
Power of organization	Organizational flexibility
A. Increase in the position of an enterprise on the market	

Knowledge is applied in all key business processes. It constitutes a prerequisite for development of new products and technologies, volume of sale, reaching new customers and maintaining relations with already existing one. As a result knowledge determines market performance of every enterprise. Therefore, enterprises are characterized by their strong motivation for the most complete usage of knowledge and all their worker's intellectual potential. Such approach is realized,

inter alia, by means of motivating employees to undertake creative and innovative actions and teamwork as well. Knowledge in an enterprise may originate from many different sources. They include information systems, internal documentation, press, reports, domestic and foreign statistics, Internet, corporate databases, customers, suppliers or business partners. Knowledge of the employees is an unquestionable mine of information. It results from their experience and intuition. The research on the sources of knowledge and their usefulness in business, carried out in some large enterprises, has shown that organizations enjoy relatively big awareness of the need to explore knowledge about customers, to tighten relations with them and to involve customers in the process of designing new products. Among enterprises that have been surveyed a large majority emphasized their co-operation with customers and evaluates such co-operation as useful or very useful. Analyses that have been conducted suggest that a competitive advantage depends on two factors: access to adequate and reliable information in a short period of time and high selectivity in the creation and usage of information. Hence, searching for effective tools to create, aggregate and share knowledge in an enterprise becomes a key target of management. In this situation information systems play a significant role. There is frequently no correlation between generated information and reports and a strategy that is being implemented by an enterprise.

A large volume of data from the information stored by an organization is related with various locations connected with transactions, suppliers and customers locations. As a result, the community affairs interest for the use of Geographical Information Systems to improve decision-making at both operational and strategic level has been significantly increased.

The investments which aim creating or expanding large infrastructures (e.g. building new facilities, installation of new equipment), design for infrastructure development simulations or project management (e.g. planning and monitoring of investment performance, forecasting costs) may benefit from methods and Geographical Information Systems technologies through a specific set of features. Such features may be: highlighting the area (of land) and volume (three-dimensional spaces) for the investment, retrieving neighborhoods and specific interactions with them; highlighting resources and ways of access to them (e.g. raw materials, infrastructures that supply raw materials and energy, transportation networks); adding native geographical attributes (e.g. topography, water, natural deposits), in order to exploit and protect them in the same time; calculation of distances and routes of access to providers for a better organization of the relationships with partners and minimizing costs; and studies on the economic potential of market launch (e.g. highlighting potential clients on various economic and demographic profiles)[16].

II. Business Intelligence in the Management of an Enterprise

BI is currently one of the fastest developing directions in information technology. Nowadays BI systems are connected with CRM systems (Customer Relationships Management) and ERP (Enterprise Resource Planning) to provide an enterprise with a huge competitive advantage. BI is a set of concepts, methods and processes that aim at not only improving business decisions but also at supporting realization of an enterprise's strategy. Main tasks that are to be faced by the BI systems include intelligent exploration, integration, aggregation and a multidimensional analysis of data originating from various information resources. Systems of a BI standard combine data from internal information systems of an organization and they integrate data coming from the environment e.g. statistics, financial and investment portals and miscellaneous databases. They are meant to provide adequate and reliable up-to-date information on different aspects of enterprise activities. The structure in question consists of the following modules:

· *tools* to extract and transfer data–they are mainly responsible for data transfer from transactional systems and Internet to data warehouses;

· *data warehouses* – they provide room for thematic storing of aggregated and already analyzed data;

· *analytic tools* (OLAP) – they let users access, analyze and model business problems and share information stored in data warehouses;

· *tools* for reporting and ad hoc inquiring–they enable creation and usage of different synthetic reports;

· *presentation layer* – applications including graphic and multimedia interfaces whose task is to provide users with information in a comfortable and accessible form.

It seems indispensable to realize these processes taking into consideration the following four dimensions (Figure 1) [6]:

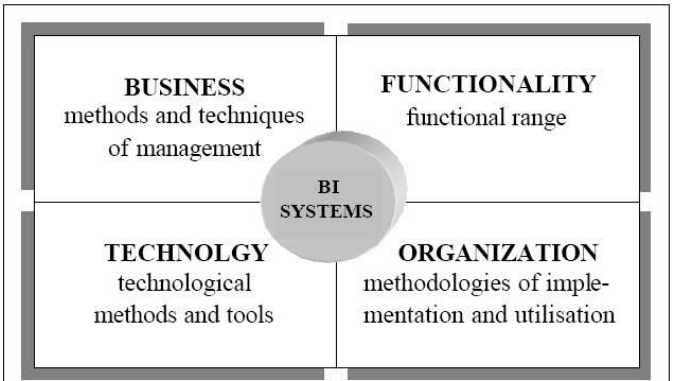

Figure 1. The four basic Dimensions of BI systems

· involves a selection of management methods and techniques that include aspects of knowledge and can be used while building BI;

· functional – based on the function determination of the BI systems in an enterprise;

· technological – based on the selection of information tools, methods and solutions to build BI systems;

· organizational – based on the methodology determination of the BI systems implementation in an enterprise.

Many Business Intelligence (BI) applications require historical data or data collected from various sources. Often the solution is found in data warehouses. A data warehouse is a relational database that is created more for query and analysis than for transactional processes. It contains historical data, but may also include data from other sources. Data warehouses often integrate data from multiple transactional systems, making possible comparisons and analysis of data from a large database. Once data is inserted into a data warehouse, they can not be modified in order to correct errors. Historical data stored in data warehouses are important for business intelligence, because the performance analysis is done based on them.

Traditionally, BI applications have been used to present data so that the managers can try to figure out what happened after the fact. Reports deliver the facts about what has happened to help managers see the overall health and status of the business. Analysis lets them further explore the data, in order to determine trends or uncover root causes of successes and failures.

To become more intelligent and remain competitive, organizations need to understand the whole picture: the current state of their business as well as where it's been and where it's headed. This information can only be gleaned through a combination of reporting and analysis, both via corporate reports developed by technical users and delivered to employees across the organization and via ad-hoc analysis that is performed on demand, in order to answer unpredictable and immediate questions.

Today, corporate employees expect dynamic, interactive business applications on the Web. They want to get at their business information whenever and wherever they need it. Delivering pure Web-based BI provides this universal accessibility and availability.

The BI solutions must give users the ability to interact with the reports and graphs and even change their report layouts dynamically, on-the-fly.

Traditionally, BI tools have been criticized for being overly complex and less than usable. Various technologies can be applied to improve the entire user experience in BI tools, including:

- Flash and AJAX-enabled user interfaces, which offer more seamless interactivity and dynamic updates on-the-fly;
- Innovative and more powerful data visualization tools which show patterns and trends and allow users to interact with data more easily;
- Accessibility for the mobile devices currently available;
- Access to relevant information only based on the users' roles. [12]

To most effectively reach more users, BI features and functionality must be built on an open, pure Web-based industry standard platform that lets developers quickly and easily integrate them into business applications.

A service-oriented architecture (SOA) enables distributed software to work together based on standard interfaces, reducing the cost of deployment and integration. Web Services is a method of designing applications so that, rather than running as a standalone piece of code on one system, their functions can be made available as "services" for any server or application linked to the network. When properly implemented, this makes it easier to share information among multiple systems.

The data warehouse – the classical way of operating

A definition of data warehousing made by OLAP Council is as follows: "A data warehouse is a centralized storage of detailed data from all relevant sources within the organization and allows for dynamic dynamic querying and detailed analysis of all information" [21]. The data warehouse is, in fact, a database used for decision-making, totally separate from the operational database of a company. As probably expected, data warehouses are of several types:

- Data Warehouse: this type of warehouse is made up of information concerning the entire organization, obtaining a huge volume of data;
- Data Mart: this type of warehouse is made up of information concerning a certain department of the organization or only a certain domain of the company;
- Virtual Warehouse: this type of warehouse is made up of a series of virtual tables or views created upon the company's operational database.

The information within a data warehouse has a historic character and comes from all the operational database of a company and/or from various files. The main operations that are performed over a warehouse are:

- the initial loading of data: this operation is performed with the help of the ETL process (data retrieval, transformation and loading);
- updating the database at certain intervals (this operation is also performed with the help of the ETL process);
- access to database (and its analysis using OLAP technology).

III. KNOWLEDGE CREATION THROUGH BUSINESS INTELLIGENCE TECHNOLOGY

Technological aspect of the BI systems primarily involves methods of knowledge creation, sources of knowledge and information technology tools.

Knowledge in order to be used effectively in the process of decision- making should be stored and created according to already tested research methods. Solutions based on artificial intelligence including fuzzy logic, intelligent agents, genetic algorithms, processing of a natural language or CBR are nowadays of particular significance.

Case Base Reasoning (CBR) is one of numerous available suggestions. It provides for solving of new problems by means of adopting solutions that have been previously applied to solve similar problems.

Referring to the question of knowledge centers, it is difficult not to appreciate the role of Internet, Extranet and Intranet. Extranets bind an organization with its customers, suppliers and constitute an electronic platform for the development of e-economy. They are used to get a rapid localization and contact with branch experts who have knowledge on already existing analyses and expertise. Due to this, it is easier to use knowledge and offer new products. The Group Support Systems (GSS) and CRM systems provide a precious source of knowledge for an enterprise. It turns out that relations of an organization with customers may be an important source of knowledge. Customers become partners in the development of knowledge and stimulation to undertake innovative activities. CRM systems provide aggregated intelligent knowledge on customers, competitors, their preferences, etc.

Creating systems of a BI standard requires application of adequate information technology tools. It is a data warehouse that is a core of the BI system. Such a warehouse stores aggregated and historical data. Taking utilized data into consideration a warehouse may mostly take a relational form (Relational On Line Analytical Processing – ROLAP) or a multidimensional one (Multidimensional n Line Analytical Processing – MDOLAP). The former is built on the basis of the relational system of database management equipped with mechanisms of effective processing enquiries of an OLAP type. Such a data warehouse is usually of a star or snowflake structure. On the other hand a data warehouse designed by means of the MDOLAP technology utilizes multidimensional tables containing preliminarily processed data originating from various sources.

The user-interface for Business Intelligence system could be an internal portal that can be accessed by all employees and display general statistical reports of the knowledge based in the organization. The specific matrix and the specific queries on the knowledge database should be made available using an account. This way only authorized managers and decision groups can use this information.

The primary purpose of a portal is to integrate data and information from a wide range of applications and Repositories, and to create and manage a volume and variety of composite applications from that integration [5].

Portal oriented-integration allows visualization of a multitude of systems, either internal to organizations or external to them, through a simple user interface. This integration type brings an added benefit of avoiding problems due to integration and adaptation of user interface of each disparate system to a common one (aggregated user interface), which is often a Web site.

An information portal can be seen like an Web based, secured, interface, which can offer an unique integration point for the applications and services used by employees, partners, suppliers and clients. The main advantage of the information portal is that it can be easily offered as a service to the wide public.

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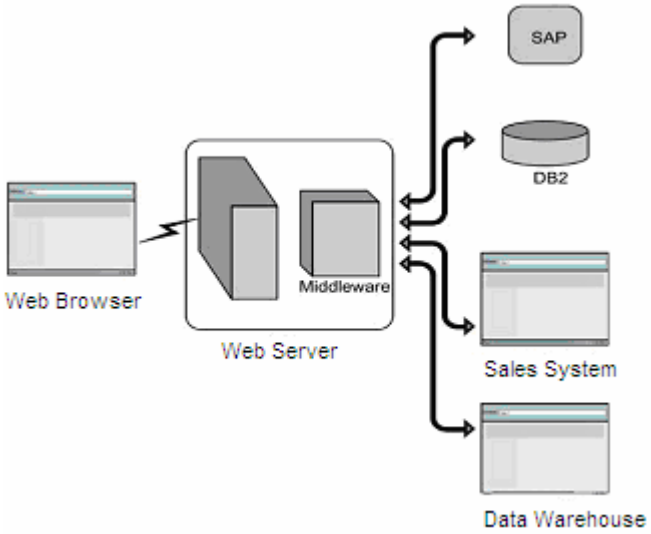

Figure 2 – Portal based integration
Source: David Linthicum, 2003

A portal is a collection of one or more groups of pages, which are hierarchical collections of pages. A page is the interface between users and the portal through which they can access and use the integrated applications. The pages of the portal developed with the Oracle Application Server Portal can integrate any type of HTML content, can be created with the help of wizards accessible through the browser or can be set programmatically as Java Server Pages (JSP).

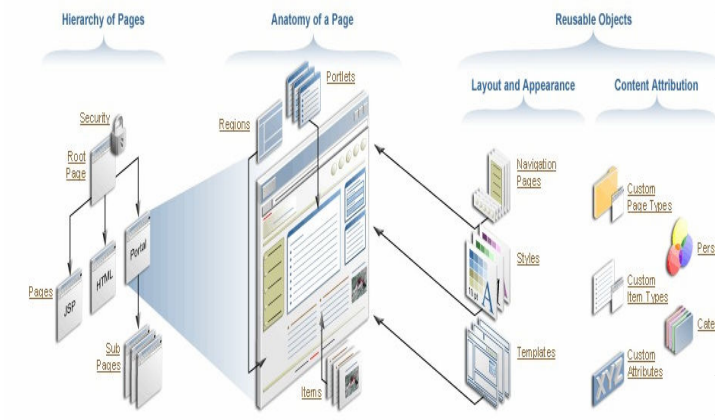

Figure 3 – The pages of a portal and their components
Source: www.oracle.com

A group of pages require the use of common attributes and mechanisms for defining the component pages behavior. The entire portal may actually be a single group of pages, or can be built more groups of pages as sub-portals for organizational structures identified. In a commercial organization, for example, can be defined the sub-departmental structures and for each of them we can realize a sub-portal.

Another way to realize the user-interface for a Business Intelligence system could be through an ERP (Enterprise Resource Planning) solution.

In time, ERP systems have evolved from isolated back-office accounting systems to enterprise wide solutions that touch not only every employee, process, and asset in a company but also reach outside the firewall to customers, prospects, suppliers, and partners. With the right ERP system as the backbone for a midsize company, operational, manufacturing, distribution, and engineering systems can be integrated into one cohesive and productive environment across the value chain [14].

When businesses are first formed, they often start with simple software applications, which typically utilize a combination of paper documents and electronic spreadsheets. At the next phase of business growth, these firms usually incorporate in-house developed software or plug-in modules with features to handle the business processes.

Growing companies rapidly exceed the capabilities of these simple heterogeneous applications and find themselves with a mixture of data and processes. When companies realize that this solution is inhibiting growth and causing unnecessary costs, they consider implementing an ERP system. The transition to ERP for midsize companies is often the catalyst for faster growth and improved profits. The key to making this transition successful is careful evaluation of ERP options. There are hundreds of ERP systems available today (Oracle e-Business Suite and SAP are the most used in the large companies), and often the midsize companies have only one chance to make a good decision. The wrong decision can potentially collapse a company.

An ERP solution is based on a unique data model. By accessing an application from any departments (sales, marketing, administration, agreement etc) all data will be stored, updated and accessed from same place, providing like that a complementary guarantee, oneness and accuracy of the image that the client will perceive.

IV. KNOWLEDGE FLOW IN GEOGRAPHICAL INFORMATION SYSTEMS

This section is an overview of how web GIS (Geographical Information Systems) and KMS (Knowledge Management Systems) can be used together and what are their common fields and relationships. A new approach of the interaction between KMS and GIS is presented in figure 1. Further we propose the concept of Spatially-enabled Knowledge Management Systems (SKMS) as, probably, the natural step in software development, after spatially-enabled databases and SDSS (Spatial Decision Support Systems) availability.

Knowledge retrieval in GIS

Knowledge retrieval in GIS is made possible by using geospatial metadata, lists of geographical names or smart maps.

Metadata management is very important in GIS knowledge retrieval. A record of metadata is data describing another source of information which can be also called "data about data". U.S. Federal Geographic Data Committee (FGDC) defines metadata as data availability (data needed to determine the data set that exists for a location), opportunity to use (data needed to determine if the data set fulfils certain needs), access (data needed to buy a set of data identified) and transfer (data needed to process and use a data set).

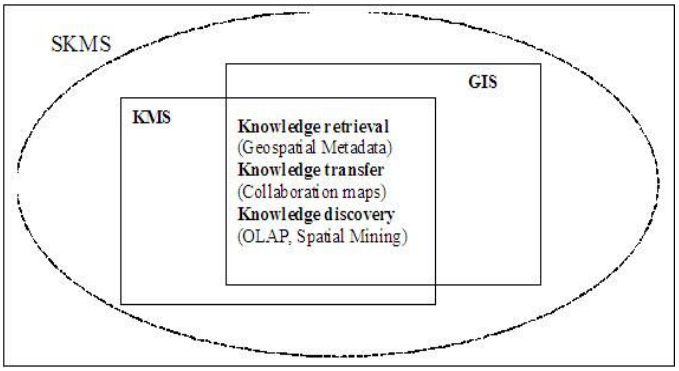

Figure 4. SKMS (Spatial KMS)

A list of geographical names is usually used to relate the name of a place with a location. The lists of geographical names are the base of traditional atlases. The atlas index contains a list of names for a place and page and square grid where it can be found.

Another example of knowledge retrieval is the Alexandria Digital Library Project (ADL, http://www.alexandria.ucsb.edu) which has tried to build a geo-library (a library indexed by location, rather than indexed by topic or author). The developers recognized that a list of geographical names was the primary requirement for a geo-library search. ADL provides HTML clients to access its collections and gazetteer;

and also specific information management tools, such as the Feature Type Thesaurus for classing types of geographic features.

The concept of smart maps is defined as a concept of visualization of one or more relationships between information resources and places on a map [19]. For example, the description of a McDonalds store can be correlated to a region on a map representing the physical location of the store. This reference is animated(e.g. in form of a popup menu) by a sensitive area on the map, which appears when the users moves a pointing device over the map and enters the region. A popup menu can show the users the titles of all information resources linked to the respective region. Selecting a title will retrieve the information resource. The implementation of smart maps requires linking all relevant information related to a named region on the map of interest.

Knowledge transfer in GIS

Collaborative mapping refers to Internet projects to collect and share free geographic data for the creation of basemaps. The most known collaborative mapping project is www.openstreetmap.org. The online community collect GPS tracks which they upload to the web site. All the streets that are mapped in this website are collected by the members of this community. Users do not share only geographical data, but they also share their thoughts, opinions and ideas about physical places, local knowledge, community needs and specific social histories.

The collaborative mapping has appeared because of the lack of free geographic data. Governments have spent large amounts of money for the acquisition of large-scale geographic data and for this reason in most countries geographic data is not available for free. The exception is made only by US and Canada where copyrighted geospatial data is available for free, in order to facilitate the use of GIS for decision management in business and administration. Recently, the collaborative mapping concept has been presented by Hassan in a detailed study [17].

Knowledge discovery

In the last years, GIS and OLAP began to be used together by adding digital cartography features in OLAP systems and the other way around, by implementing OLAP functionality in GIS. In OLAP/GIS applications, information on company operations (e.g. sales related information) and geospatial information (e.g. demographic density, population structure, income, cultural attitudes) can be found or collected simultaneously and all can be combined in advanced analysis.

The core of any GIS is represented by spatially-enabled databases. Advanced databases, such as Oracle Spatial, allow automatic discovery of knowledge from a database using its spatial mining techniques. The spatial analysis and mining features in Oracle Spatial exploit spatial correlation by using the location attributes of data items in several ways: for binning (discrediting) data into regions (e.g. categorizing data into northern, southern, eastern, and western regions), for materializing the influence of neighborhood (e.g. number of customers within a two-mile radius of each store), and for identifying collocated data items (e.g. video rental stores and pizza restaurants) [18].

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