Information Systems in the Knowledge Based Economy

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Abstract— In business we can deal with critical and urgent decisions every day and the performance of our work depends on their quality. Due to the modern technology and the Internet, the amount of available information has increased considerably. In order to structure this amount of information and to create knowledge from it, executive information systems became a must for each competitive enterprise. The performance of an information system which could generate complete analysis and forecasting in seconds is very important. 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). Business intelligence systems are helping answer questions that are mandatory in making good and profitable decisions. Using the knowledge within an organization can increase the competitive advantage on the market, and considering this as an important asset can be used as a production input factor for company's line of business. But, behind an executive information system there is actually a data warehouse.

Keywords — business intelligence, competitive intelligence, data warehouse, geographical information system, knowledge contribution.

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

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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]:

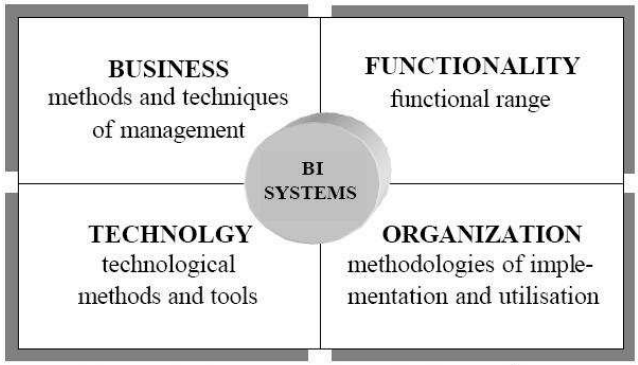

Figure 1. The four basic Dimensions of BI systems

- 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.

Knowledge based decision systems

Knowledge within the organization should be considered as an important asset for the company. [13] The aggregation of the knowledge based on the personal matrix will also convert internalized tacit knowledge into explicit codified knowledge in order to be shared and analyzed through the business intelligence system.

The main goal of Business Intelligence Systems (BIS) is to assist managers, at different levels in the organization, in taking decisions and to provide in real time representative information, to help and support them in their activities such as analyzing departmental data, planning and forecasting activities for their decision area [13][14].

A business intelligence system can improve the decision quality made by the appropriate group when analyzing the organization. Business intelligence systems are helping answer questions that are mandatory in making good and profitable decisions. Some examples of the questions answered by a BIS:

Business Intelligence: (Finance): What are the net income, expenses, gross profit, and net profit for this quarter, year?

Business Intelligence: (Accounts): What is the sales amount this month and what is the outstanding pending payment?

Business Intelligence: (Purchase): Who is the vendor to be contacted to purchase products?

Business Intelligence: (Production): How many products are manufactured in each production unit today, weekly, and monthly?

Business Intelligence: (Sales): How many products have been sold in each area today, weekly, monthly?

Business Intelligence: (Quality): How many products have been defective today, weekly, monthly, quarterly, and yearly?

Business Intelligence: (Service): Are the customers satisfied with the quality?

Another question that can be answered by the business intelligence system could be:

Is there any knowledge in our company that can support, develop and maintain our line of work?

Using the knowledge within an organization can increase the competitive advantage on the market, and considering this as an important asset can be used as a production input factor for company's line of business. The decisions made based on the business intelligence system reports of the knowledge-aggregated data will have a higher satisfying rate of income in revenue [15].

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 querying and detailed analysis of all

information" [16]. 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:

1. The initial loading of data – this operation is performed with the help of the ETL process (data retrieval, transformation and loading)

This operation has the following steps to be accomplished (the entire process is shown in Figure 2):

- Collecting data from multiple sources: web, text, databases, data warehouses (A);
- Data cleaning: done by eliminating errors, incorrect data, duplicates, inconsistencies. If a data warehouse is used, this process is eliminated because an ETL process (B) was applied to the data;
- Establishing the representative features of the data that will participate in the data mining process by selecting those properties which are of important for the field of analysis (C);
- Applying templates and discovering / analyzing new knowledge (D);
- Viewing, validating and evaluating the results obtained (E) [16].

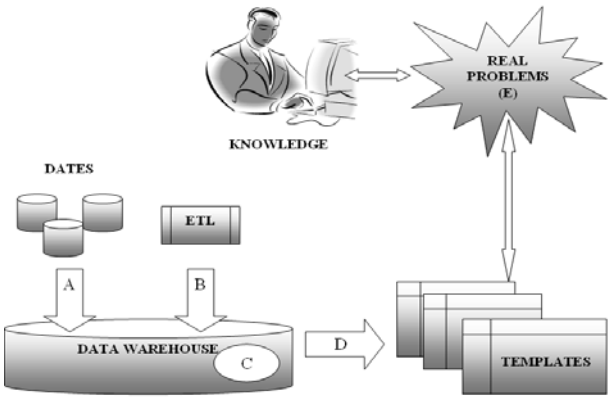

Figure 2 - The stages of the knowledge extracting process from data, Source: [21]

Although the knowledge extracting methods and techniques are applied automatically, the process claims an important human effort.

2. Updating the database at certain intervals (this operation is also performed with the help of the ETL process)

This operation has in view the incremental extraction of current data from resulted from the operational systems. The incremental extraction is used for the periodic updating of the data warehouse and captures just the changes in data sources at the last extraction [17].

3. Access to database

Data warehouses are subject to complex processing in order to obtain the reports that are necessary for the final user. This processing includes: data multidimensional analysis, higher statistical methods of forecasting, mathematical methods applied to a large volume of data. All this processing cannot be possible without the use of specialized and complex software such as data extraction (data mining), OLAP (online analytical processing), concentrated database (data mart).

Both OLAP and Data Mining are specialized software products that offer the possibility to analyze their trend, their correlation and their interpretation.

- *The OLAP software products* are based on the multidimensional representation of data (data cube) and allow the fast analysis and of data. The user will scroll through the dynamic data cube dimensions, working thus with different levels of detailing.
- *The software products* of Data Mining type ensure the extraction and the data processing in knowledge. Techniques of higher statistical analysis and of Artificial Intelligence for the discovery of correlations, rules, and necessary knowledge for decision-taking are being used.

The data warehouse – data access performance

Today, the investment in information systems represents an important percentage of the companies' expenditures and it is necessary not only to reduce these costs, but also to be obtain maximum benefits from the information administered by the IT systems [18].

Taking into account the fact that the strategic management operates with reports obtained following queries of data warehouses, therefore using huge volumes of data, it is necessary to return the results of the queries performed upon the data warehouses in a very short period of time. With a view to improving these performances, the oracle and HP companies launched, at the end of 2008, a family of storage hardware and software products of high quality which can improve over ten times the performance of the data warehouse query [19]. These products are called Oracle Exadata.

Oracle Exadata makes use of a parallel architecture in order to increse the bandwith for the data flow between the database and the storage server. Besides, the intelligent storage softwae unloads the intensive query processes from the Oracle Database 11g servers and performs the queries processing closer to the data. The result – faster parallel data

processing and lower movement of data through connections with a bigger bandwidth [19]. The HP Oracle Exadata Storage server is equipped with SAS and SATA unities which have a storage capacity of 12 TB for each server and is already provided with Oracle Exadata software product.

The advantages of Oracle Exadata Storage product are more than obvious:

- the answer of the queries over the data warehouse is a very swift one;
- several queries can be performed simultaneously;
- the scalability is unlimited (further Oracle Exadata storage servers can be connected).

The new information technologies can reduce the cost of BI systems utilization by a great variety of users, especially managers.

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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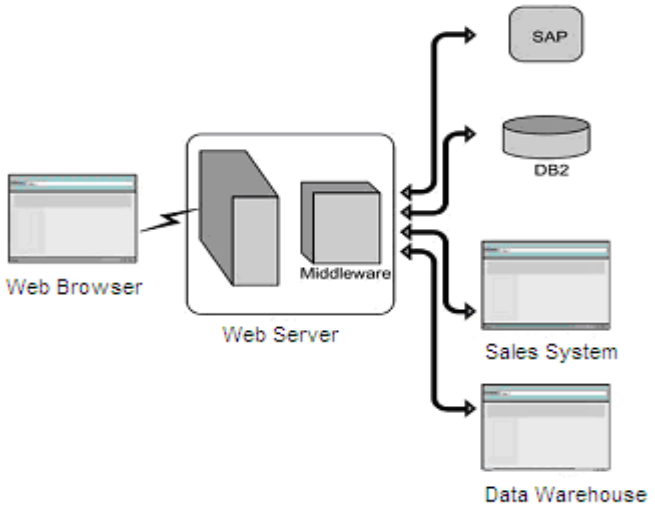

Figure 3 – Portal based integration
Source: David Linthicum, 2003

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).

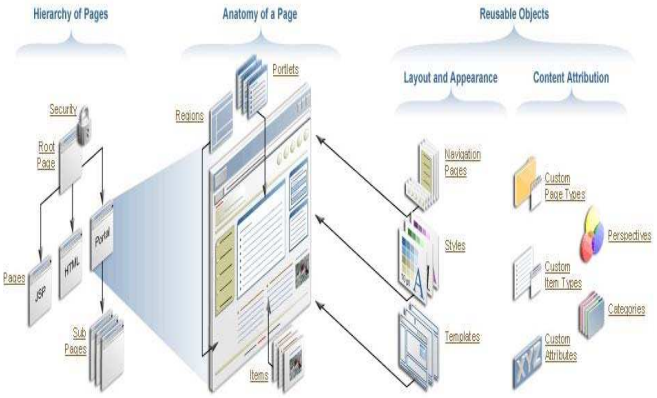

Figure 4 – The pages of a portal and their components
Source: www.oracle.com

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 [20].

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.

Administrating the system

The architecture for a administrating tool is having the fallowing components:

- the Agent – which is installed on the systems that are monitored;
- the Repository – which is a database where the information gathered from the agents is stored;
- the Console – which is the GUI from where the monitoring, control and administration is done.

The most advanced and widely used solution is provided by Oracle with the 10g Grid Control module. The Oracle 10g Grid Control architecture is having the following components:
- *The Management Repository* (OMR) which is an Oracle Database and in which is stored data received from the agents.
- *The Application Server* which represents the Management Services (OMS) and it is responsible for the communication with the Oracle Agents and for serving the Console. OMS is a J2EE Web application that orchestrates with Management Agents to discover targets, monitor and manage them, and store the collected information in a repository for future reference and analysis. OMS also renders the user interface for the Grid Control console. OMS is deployed to the

application server that is installed along with other core components of Grid Control.

- *The Grid Control Console* (GCC) - From the Grid Control console, you can monitor and administer your entire computing environment from one location on the network. All the services within your enterprise, including hosts, databases, listeners, application servers, and so on, are easily managed from one central location.

- *The Management Agent* (OMA) - is an integral software component that is deployed on each monitored host. It is responsible for monitoring all the targets running on those hosts, communicating that information to the middle-tier Oracle Management Service, and managing and maintaining the hosts and its targets.

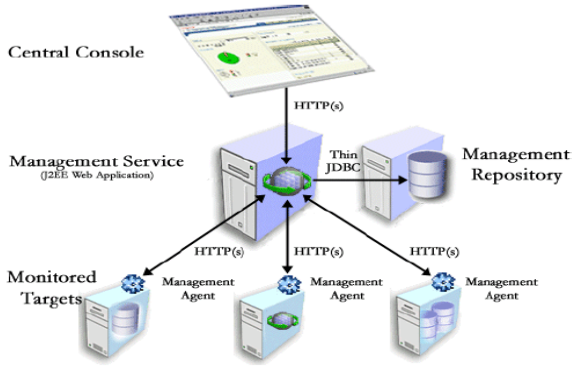

Figure 5 - Oracle 10g Grid Control architecture
Source: www.rittmanmead.com

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.

Geographical Information Systems are well known decision support systems used in solving problems related to geo-referenced applications thanks to their ability of handling geographical information together with the economical one.

GIS is used in urban and regional development through the creation of maps, in management systems utilities (e.g. electricity [21], natural gas, water), for choosing the best locations for new businesses - locating production and distribution points [22], to study the environmental impact of various factors, in land-use structure optimization [23], in healthcare (e.g. management of population health by region), commerce (e.g. market segmentation), etc.

Many companies use GIS to understand what kind of people buy their products or services. For example, McDonald's uses a GIS system that displays demographic information on maps to identify locations for promising new stores [19].

Weber and Chapman have identified the following factors contributing to the choice of future business locations: physical capital (infrastructure and facilities), human capital (labor market, demographics), the knowledge capital (demographic data on the level of education and people skills) and productive capital (competitor locations) [24]. All those factors can be easily followed through maps and geospatial analysis.

The essential role of GIS in the knowledge economy for the achievement of development objectives was the subject of annual symposium AGIT (http://www.agit.at) from 2006, whose theme was geoinformation for development (gi4dev). In this symposium specialists showed GIS usefulness for regional sustainable development, poverty reduction, water crisis and food monitoring in crisis regions.

A new approach of the interaction between KMS and GIS is presented in figure 6. 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.

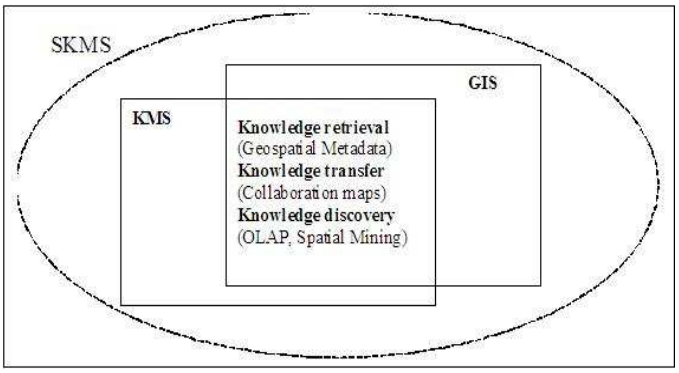

Figure 6 - SKMS (Spatial KMS)

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).

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 [25]. 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 [26].

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) [27].

V. BRING IT ALL IN PRACTICE

Next we will present the structure and the way of building a data warehouse, used to reflect on an electronic map the sales situation of a company that sells pharmaceutical products, distributed on the cities of Romania for the last 5 years. The company that sells pharmaceutical products has pharmacies in most towns (villages) of Romania.

We will build the data warehouse using a specialized software, such as Oracle Discoverer Administrator.

The starting point of the experiment were the relational databases, which contain the following tables:

- *Clients:* data about customers who bought pharmaceuticals;
- *Pharmacies:* data about the company's pharmacies (which sell pharmaceutical products to customers);
- *Time:* data about the intervals in which the sales of products to customers were performed;
- *Products_classes:* data about the classes in which products sold by pharmacies are included;
- *Products:* pharmaceutical products marketed by the company;
- *Sales:* data about sales performed by the company's pharmacies.

Description of entities and attributes of each entity:

- Clients:
  - Client code: Number, 5
  - Client name: Character, 60
  - Address: Character, 60
  - City: Character, 30
  - County: Character, 30
- Pharmacies:
  - Pharmacy code: Number, 5
  - Pharmacy name: Character, 60
  - Address: Character, 60
  - City: Character, 30
  - County: Character, 30
  - Phone: Number, 20
  - Open_date: Date
- Time:
  - Time code: Number, 5
  - Date (current date): Date
  - Day (day of week: Monday, Tuesday, ...): Character, 8
  - Month (number of months of the year in which there is data): Number, 2
  - Year (the year that was the date): Number, 4

  - Day of the month (number of days in months of date): Number, 2
  - Quarter (quarter to which belong such date belongs): Number, 1
- Products_classes:
  - Classe code: Number, 5
  - Family (family the product belongs to): Character, 60
  - Department (the department in charge with the product distribution): Character, 60
  - Category (the category the product belongs to): Character, 60
  - Subcategory (the subcategory the product belongs to): Character, 60
- Products:
  - Product code: Number, 5
  - Classe code: Number, 5
  - Brand: Character, 60
  - Product name: Character, 60
  - Bar code: Number, 30
- Sales:
  - Sale code: Number, 5
  - Product code: Number, 5
  - Client code: Number, 5
  - Pharmacy code: Number, 5
  - Time code: Number, 5
  - Quantity: Number, 10
  - Sale value (transaction value): Number, 30
  - Costs value (value of transaction costs): Number, 30

In the following we will present the conceptual scheme of the data warehouse, made by using the entities above:

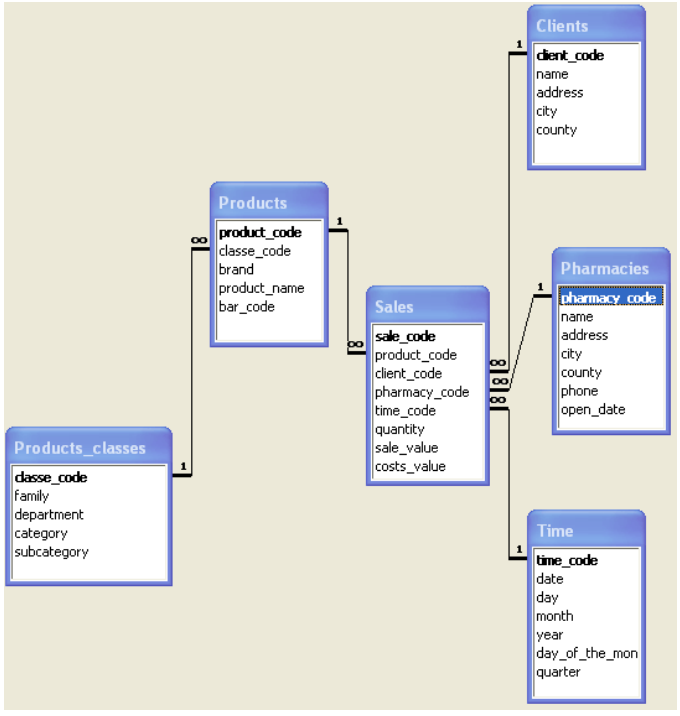

Figure 7 – Conceptual diagram of the data store

Building Data Warehouses

In order to build the data warehouse we need to determine the size and facts tables.

- We consider these dimensions (*dimension tables*):
  - Products_classes;
  - Products;
  - Clients;
  - Time;
  - Pharmacies.
- We consider *the fact table*: Sales.
- Acts that describe transaction are:
  - quantity sold;
  - sales value;
  - cost value.

After building the data warehouse, using appropriate software products, there will be the possibility of extracting classical reports necessary to end users, as well as reports which have the form of electronic maps. Electronic maps that have "behind" themselves data warehouse will significantly simplify for the end-user the process of analyzing and interpreting information retrieved from the BI system.

Building the electronic map

We have used Oracle Spatial Database in order to store the counties from Romania as polygons and the pharmacies as points. The spatially-referenced information is stored in a MDSYS.SDO_GEOMETRY type column.

A spatial database is an optimized database to store and retrieve geospatial data.

Oracle Spatial is one component of Oracle Enterprise Edition which offers an SQL schema with predefined functions to store, retrieve, update and analysis of geospatial data (geographic objects) from database.

The components of Oracle Spatial are:

- a new schema, MDSYS, which defines the way of storing geographic objects, the syntax and semantics of known geographic data types;
- a spatial indexing mechanism;
- a set of functions and operators for joins and query operations on geospatial data.

There were created two tables with spatially-referenced data:
Counties_ro:

- name, Oracle type: VARCHAR2 (60) (The name of Romanian county);
- population, Oracle type: NUMBER(10) (Population by county; information taken from Statistical Yearbook 2008);
- geom, Oracle type: MDSYS.SDO_GEOMETRY (The spatial information for county boundaries stored as polygons; information taken from Romanian geo-spatial.org community).

Pharmacies:

- Pharmacy code, Number(5);
- Pharmacy name, VARCHAR(60);

- Geom, MDSYS.SDO_GEOMETRY (The spatial information regarding pharmacy location, stored as a point).

Further we have used GeoServer as a web mapping server (WMS) which reads the spatial data source (the tables we have created in Oracle Spatial database) and generates the map in a style which we have defined; a detailed work flow with GeoServer can be found in paper [28].

OGC International Standard for WMS defines the output generated by a web mapping service as maps of spatially referenced data dynamically from geographic information.

We have created a Style Layer Descriptor (SLD) file in which it is defined the symbolizer of the pharmacies: the green cross.

It has been used following GeoServer WMS GetMap request with parameter Format= application/openlayers, in order to obtain an electronic map which can be embedded in any web site:

http://localhost:8080/**geoserver**/wms?service=WMS&version=1.1.0&request=**GetMap**&layers=judete_loc&styles=&bbox=20.262,43.619,29.72,48.265&width=671&height=330&srs=EPSG:4326&format=application/**openlayers**

The returned result is presented in figure 8.

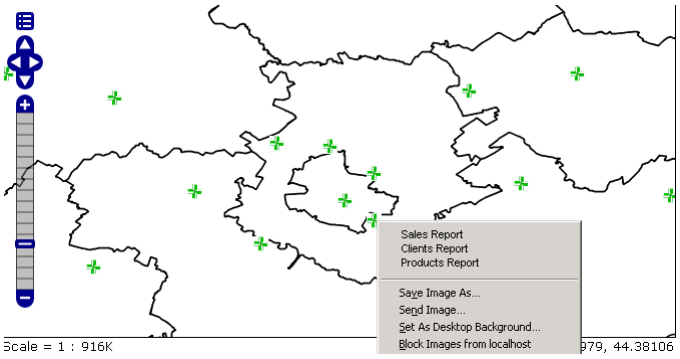

Figure 8 - Pharmacies in and around Bucharest, Romania

OpenLayers is an open source JavaScript library for displaying map data in most modern web browsers, with no server-side dependencies [29].

A new popup has been developed which will raise at a click on a certain pharmacy. From this popup the user will have access to complex reports from the data warehouse regarding sales (Sales Report), clients (Client Report) or products (Product Report).

The generated dynamic map is further intended to be imbedded in a web portal which will become the web knowledge database for the Pharmacy company.

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