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FROM BUSINESS INTELLIGENCE TO COGNITIVE SYSTEMS

In this paper, the authors presented an evolution of business intelligence systems and suggested that in the near future one should consider so-called cognitive systems as the next step towards more powerful and knowledgeable systems.

Keywords: systems evolution, business intelligence systems, real-time business intelligence systems, cognitive systems, real-time management

INTRODUCTION

Constant development of information communication technologies, global competition, instability of economic processes and strong dependence of contemporary companies on the retrieval and flow of information and knowledge determine the creation of the particular decision support systems - business intelligence systems (BI).

The aim of this article is to show how systems of that kind are meant to cope with the problems arising from the growing demand for successful information retrieval and knowledge acquisition (necessary in management, building strategies, getting a competitive advantage, and so on) and why these systems constitute the confirmation of a new paradigm in management – a company based on knowledge (so-called: intelligent company), in which a key factor is an effective management of information and knowledge (Kubiak 2002).

Pressure from environment, competition, together with the almost unstoppable increase of information in the company's environment (as well as the necessity for fast reactions to any changes) make the time of decision processes shorten, severely reducing them to a form of the real-time management, where decisions are generated immediately to solve occurring problems. Observing the development of management support systems, one can notice the conversion from batch (or quasi-batch) processing of the

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information and knowledge to real-time processing, where incoming information and knowledge are directly utilized in decision-making. These changes are also valid in the case of latest management support systems – business intelligence systems. Moreover, in this class of systems, there is a new form of information retrieval and knowledge acquisition arising, which leads towards so-called "cognitive systems". In this paper, we will present BI systems, real-time BI systems and enterprise analytic applications as more modern and attractive forms of their evolution. At the end, the authors would like to focus on the new and promising (however still in a phase of development) class of intelligent systems used in management, i.e. cognitive systems.

1. BUSINESS INTELLIGENCE SYSTEMS

Typical management support systems (transaction, MIS, ESS, DSS, expert) used in many companies do not necessarily create sufficient conditions for them to gain an advantage over other players in the market. Despite calling these systems "complex" or "integrated", they do not offer direct and constant access to collected information and knowledge even though they still possess limited abilities in presenting analyses and are hardly oriented to profiles of company's managers.

In the early 1990s, companies took advantage of the market's need for decision support systems to create and define a new category of application programs and technologies which is now known as business intelligence (BI). Business intelligence allows organizations to gather, store, analyse, and provide access to data (extract useful information from a rapidly growing inventory of disparate data sources, including multiple database platforms, packaged applications, data warehouses, data marts and e-business systems) to help corporate users make better business decisions.

Business intelligence systems appear to be the right solution for many of the problems of companies nowadays (Business 2001; Liautaud 2001). Among them, one can point out such as business decisions' optimization; better understanding of the dynamics of the company (based on the data from company's information resources, and knowledge and experience of its workers); or monitoring the constantly changing environment and adapting to these changes.

Business intelligence is a broad category of business processes, application software and other technologies for gathering, storing, analyzing,

and providing access to data to help users make better business decisions. By offering tools for data exploration, BI enables discovering new potential, identifying the tendencies, and registering events crucial for the business. Business intelligence can be described as the process of enhancing data into information and then into knowledge. BI is carried out to gain competitive advantage. Though this advantage is not constant, and these systems do not solve all the problems, it is hard to see their significance from the point of view of businesses.

Business Intelligence may be perceived as a specific pyramid, as seen on Fig.1.

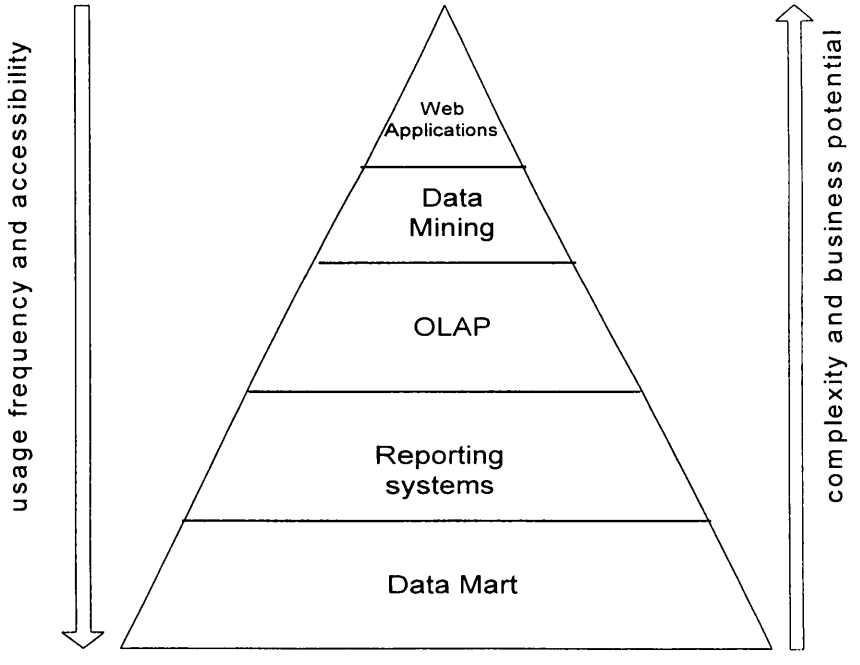

Fig.1. The Business intelligence pyramid

Source: based on van Ufford 2000

All the analytical tools – the elements of the above pyramid – have one aim, i.e. making different data analyses. Furthermore, one can observe from the Fig.1 that the higher we are in the applications' hierarchy, the more complex analyses are fulfilled, giving potentially better results. On the other

hand, the lower degree of complexity means the more frequent usage of the tool (e.g. reporting systems).

At the very bottom of the pyramid lies Data Warehouse, which constitutes a central repository of all crucial data collected by company's internal applications. Data warehousing enables efficient collecting and using data from all the company's units. To make data warehousing work properly, one needs to fulfil three tasks: extraction, transformation, and loading of data.

Using the warehouse relieves the functioning of traditional information systems mainly in carrying on analyses and creating sophisticated reports. Another advantage is the speed and simplicity in getting the access to information, as well as the ability of integration and making comparisons of data coming from different sources. The most important outcome of applying warehouses is the ability of the knowledge acquisition originated from the retrieved information. It is the intelligence and knowledge (which can be guaranteed by having the right information) that determines the success in the competitive environment.

The next level of the pyramid is Reporting Systems. They are often called "Q&R" – Query and Reports. Applications from this level aim at answering managers' questions like "what happened...?" or "what was the sale value last month compared to the similar period half a year earlier?". There are two sorts of reports: first – standard ones – concerning all the crucial numbers and figures relating to defined period of time; second – reports being the answers for "ad hoc" questions (often concerning details hidden among data).

The reports' results are usually used as input data of CRM systems.

Another group of tools included in BI systems is OLAP (On Line Analytical Processing). This is a programming technology that enables managers an insight into data through fast and reliable access to the information extracted from data. The OLAP technology makes possible the complex multidimensional data analyses. Apart from the ability to answer the questions of "Who?", "What?" and "When?", it allows to find the answers to questions like "What if?" and "Why?".

OLAP applications enable decision making regarding a company's strategy and predictions concerning the future based on the historical data.

The last but one level of the BI pyramid is Data Mining tools.

Data Mining can be viewed as the process of analysing data to identify patterns or relationships in databases to determine yet undiscovered

dependencies among the objects and processes (Morzy, 1999; Langley et al. 1992).

There are numerous methods of Data Mining; including clustering, finding similarities, and classification. For example, the aim of the classification is to find the dependencies between the characteristics describing an object and its association with a specific class.

Having historical data about previous enterprises, one can create a classification model defining the chances of success of any new activity, meanwhile avoiding potential failures.

Further evolution of BI systems leads from the client-server architecture applications to systems which take advantage of the Web. These web applications enable making analyses from BI systems using a typical Internet browser remotely from a distant place.

The functioning of BI systems is a process which may be divided into a few stages. At the beginning, data from transaction and front office systems are being reorganized and moved to the warehouse. Next, data and information packages required for making numerous analyses are extracted from a warehouse. Furthermore, BI systems possess some special ability – mechanisms of reaching deeply into dependencies between data and information, which enables them to acquire knowledge. The presentation level of BI systems offers tools of sharing information and knowledge and presenting them in a user-friendly way.

BI systems enable using large data and information bases (coming from transaction systems and collected in warehouses). Typical software used in companies represents OLTP (On Line Transaction Processing) systems. Their purpose is to register business data and information. Systems based on warehouses fall into the category of OLAP (On Line Analytical Processing) systems. They differ from the previous ones in structure, functionality and users service. Due to the tasks they fulfil, these systems are optimized to acquire fast answers for sophisticated, cross-section questions made by users. Analytical bases thanks to it structure and optimization mechanisms allow for efficient calculations, analysing huge amounts of data and generating answers in a short period of time. Furthermore, they allow for fast creating of numerous forms of presentations of the results of performed analyses (Lavazza 1999).

For many years we have seen an evolution of knowledge presented in Fig.3.

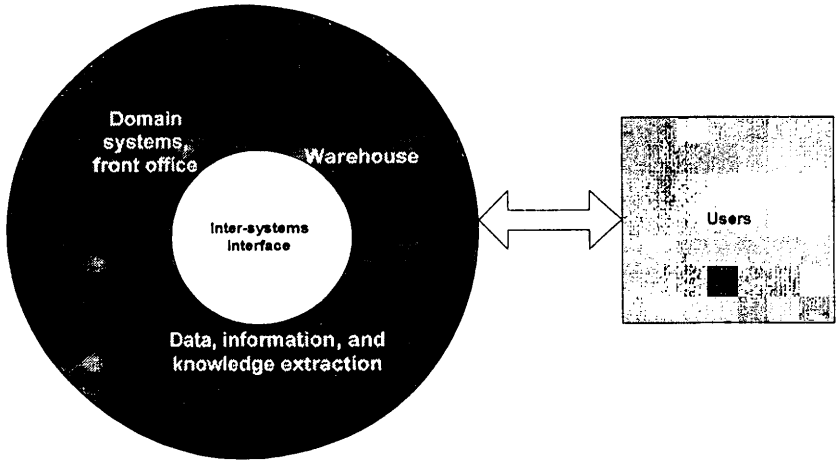

Fig. 3. Functional scheme of the real-time BI system

Source: own analysis

The idea of real-time BI systems arose as an answer to a strong need from contemporary companies for fast reacting and reliable systems. Organization and businesses with a considerable number of per day (like financial markets and stocks, e-business units, logistics companies, etc.) are particularly interested in the exploitation of such systems.

The goal of BI is to enable better, more informed, and faster decisions. Hence, any discussion of real-time business intelligence must be in the context of how close to real time the information must be to support those decisions. What constitutes real-time information can vary widely for different business activities. For example, considering a chain of retail outlets: (1) An analyst using historical data as input to the sales forecast for the next period would likely only need information as of the last month. (2) A marketing manager evaluating the success of a campaign, and responsible for deciding how long the campaign should run, would need much more timely information, probably no more than one day old, (3) A store manager might be making frequent decisions during the day; for example, deciding when to put a perishable item on sale. The manager would need information that was certainly no more than a few hours old.

Many times a combination of up-to-date and historical information is necessary. For example, while it may be useful for the store manager to know the number of sales of a particular item for today, it is more useful if he can put that information in the context of the average number of sales of that same item on the same day of the week over the last year.

Because of many different sources supplying information, users can obtain data from different systems, which, in turn, because of the difficulties with proper analysis and combining of this information, could lead to the decision making based on incorrect information.

Thus, the most crucial task for the real-time BI systems is to provide truly real-time data. This can be achieved by providing an historical view, a proper coordination with business processes and across systems, if necessary - apply a transformation process to enforce data quality, and integration of data from multiple data sources. However, continually reporting on data from a system that is constantly being updated requires that one should consider the issue of data consistency.

One of the systems that deals with the problems described above is the SQL Server 2005. This works as follows: (1) the data is pushed into the Analysis Services, (2) data drawn from different heterogeneous sources is combined and presented in a unified manner to the user, (3) the reader obtains a snapshot view of the data, (4) the content of Analysis Services is updated incrementally to reflect the new data.

Of course, real-time BI systems are on the list of potential requests from the army, support systems towards on-line systems. Here, all the domains of company's activity are coupled. Sales directly influence marketing, production, logistics, finances, etc. These sorts of systems better prepare companies for a specific character of the market (compare: Stonebraker 2001).

BI systems constitute an opportunity for companies to effectively use retrieved information by acquiring valuable knowledge out of it. BI solutions support efficient management and aim at providing compact and reliable information and knowledge concerning all possible domains of a company's activity. These systems enable taking rational decisions at all management levels (particularly – strategic level, where the decision making and its time horizon are "expanded"). Moreover, BI systems have some particular mechanisms of self-adaptation of extracted information and knowledge to user preferences. Every user is able to create his or her own reports and analyses.

Business intelligence systems are the more sophisticated and complex successors of applications called DSS (Decision Support Systems) and ESS (Executive Support Systems).

Implementation of BI systems makes it possible to gain a competitive advantage in a difficult and changing market. It makes available responding to trends and find new prospects and threads in the performed activity. It constitutes an answer to the growing demand for advanced information tools and methods supporting efficient business processes management. This

tendency can be confirmed by the observed evolution from corporate applications (ERP, CRM, SCM, etc.) to BI systems. Currently, they have become the most promising and efficient management supporting tools.

BI systems enable creating a profile of disloyal and unfair customers, which in turn helps to built strategy consisting in loyalty and restriction programs, respectively.

The value of these systems which, however, may be true for nearly all current systems – can be perceived not only in the comfort of use and in corresponding with users' expectations for knowledge acquisition mechanisms, but also in the user-friendly features they possess.

One of the weaknesses of these systems is the lack of adequate solutions of unstructured data and information processing, image and speech processing, multimedia processing and operating in real-time.

2. ENTERPRISE ANALYTIC APPLICATIONS

The dispersion of data (which takes place particularly in big corporations) informing about the current state of the company, the level of stocks, production, etc. prevents efficient management. In case of financial institutions like banks, it is even more difficult to manage without properly consolidated information and data.

As the use of BI has matured, there has been increased interest in analytic applications, the logical extension of the business intelligence concept. Analytic applications provide users with prepackaged solutions to common business problems such as customer, sales and campaign analysis. Over the last few years, analytic applications have gained popularity in new areas, particularly for the analysis of e-business and clickstream information.

Analytic applications provide key additional BI benefits to specific groups of end users through the use of "best practice" analysis techniques. However, while they address a business need for a particular population, they perpetuate the problem of stovepipe information sources and may make it more difficult than ever to get an overall view of the enterprise. As Gartner noted in a May 2001 report: "Packaged BI applications may seem appealing in the context of a particular application, but organizations should ensure that they will support BI in a broader context as a strategic initiative".

Hence the notion of "enterprise analytic applications" which provide a common platform for analytic applications throughout the organization. The main business benefits of an enterprise analytic applications approach are:

- a single version of the truth across an entire enterprise,
- predefined best practice analysis techniques in a variety of different business areas,
- a consistent BI strategy that leverages existing resources.

The primary benefit of an analytic application is the ability to simplify an analysis that would otherwise require a complex series of steps. Rather than business users relying on intuition when making decisions, analytic applications can help to make analysis an automatic part of the business process.

Reichheld (2001) demonstrates that even a small increase in customer retention rates (from 90% to 95%) can result in a big increase in profits (more than 50% in this example). Using business intelligence, a marketing manager might want to identify the most loyal customer segments – and what percentage of profits came from new customers, frequent customers buying more and existing customers buying less.

But this type of analysis is surprisingly difficult for a business user in most corporate environments, and therefore is only rarely carried out. The way data is typically stored in relational databases and data warehouses requires examining each customer's purchases line by line to define the segment containing "customers who bought more".

Analytic applications embed technology that makes creating and pre-calculating useful customer segments such as these much easier. For example, complex analyses can be done with a single database query instead of thousands of queries. These applications also place analysis under the direct control of the end user, without the need for intervention from the information technology department. Users can, for example, go on to look at, create and analyse other segments such as "customers who bought less" and determine what potential profits might have been without customer turnover.

Another key benefit of these applications is best-practice analytics. For example, a customer intelligence analytic application might contain pre-defined routines based on customer segmentation and segment migration analysis techniques that represent the cutting edge of customer relationship management. Thus, analytic applications help end users with the most fundamental and vital steps in the BI process, prompting them on which questions to ask and directing them toward the proper techniques for a specific type of analysis.

Finally, because analytic applications are designed for a specific business or functional area, the results of the analysis can be tied directly back to the operational systems. For example, the results of an analysis of soon-to-churn

customers can be used to drive an e-mail marketing campaign using a packaged CRM application.

Just as packaged applications have helped streamline and standardize company operations, analytic applications help organizations make consistent decisions based on all the relevant data. Businesses can move ahead faster without having to relearn what others already know. This saves them time and money – and helps them strengthen their competitive position.

Although analytic applications represent a logical next step in the deployment of business intelligence, they also come with several pitfalls.

The most insidious pitfall is that unless analytical applications are carefully implemented, organizations can end up with different "stovepipe" BI applications using different or loosely integrated technologies and data structures.

In some cases, these stovepipes are a natural extension of a precise need. In other cases, analytic applications are provided by the large packaged application vendors who make it financially tempting to purchase the reporting and analytics tools that correspond with their different applications.

The problem is that most organizations have a combination of differently packaged applications. According to Gartner: "Through 2005, broad-scale adoption of packaged applications will prevent more than 50 percent of large organizations from establishing complete perspective through BI." Thus, Gartner recommends implementing an application neural data warehouse.

Thanks to the potential offered by analytic applications, more and more companies take advantage of them. Systems called Supply Chain Intelligence (enabling supply chain and orders analysis) make it possible to adapt the production and logistics to the market needs.

3. REAL-TIME BUSINESS INTELLIGENCE SYSTEMS

BI systems are oriented towards a support of strategic decision-making processes. They are less valuable in making decisions with a short time-horizon – tactical and operational (so-called real-time decisions). Delays during knowledge and information processing constitute the weakest point of these systems. Fig. 2 presents the processes taking place in BI systems.

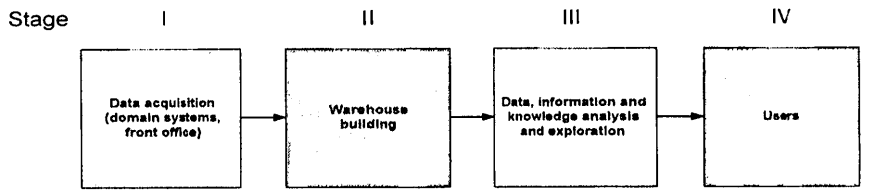

Fig. 2. Processes taking place in BI systems
Source: own analysis

The basic way to handle the inconvenience of "not keeping up with time" is to incorporate stages II and III into stage I. Technologically this is performed by "overlaying" acquisition processes with succeeding integrated software's layers. All the software used for information and knowledge retrieval allows for a real-time extraction of acquired data from the warehouse. After that, a system generates reports and analyses for users. These sorts of applications are called real-time BI systems.

Real-time BI systems constitute an efficient management-supporting tool at the tactical and operational level (Hune 2001). Together with information function, their purpose is also to carry out monitoring and to keep the safety of transactions. Meanwhile, through the ability of building various analyses of information and knowledge dynamics (depending on the pre-defined time-horizon), they may be seen as a reliable and professional tool in strategic decision-making (Hune 2001; Sifakis 2003; Verber 1998).

Because of the huge amounts of transaction data, and multithread of retrieved information and knowledge with a significant number of users, these systems require hardware of the highest possible quality and performance together with excellent software (including proper interfaces, as shown in Fig.2). This trend of improving BI systems undoubtedly has good prospects.

4. COGNITIVE SYSTEMS

In BI systems, analytical tools generating reports go hand in hand with mechanisms of intelligent data and knowledge mining in the form of information filters, neural networks, fuzzy sets and logic, etc. (compare: Olszak 2002). Domain-oriented expert systems and intelligent software agents constitute another indication of BI systems' "intelligence".

One of the ways of the evolution these systems will follow is relying their structure on a set of intelligent software agents (Kościów 2003). Such systems are called MAS (multi-agent systems), or emphasizing a key role of intelligent agents - I-MAS (intelligent multi-agent systems). Even the most advanced and

versatile collection of I-MASes does not necessarily lead the system to behave intelligently as a whole.

The above problem was noticed a few years ago. As a consequence, there were many research problems initiated during the last two years, which provoked the formulation of the idea of so-called "cognitive systems".

The most important and fundamental study in this area constitutes a report by R. Brachman from DARPA-IPTO (Defence Advanced Research Projects Agency – Information Processing Technology Office) from 2003 formulating basic assumptions, attributes and requirements for these systems (Brachman 2003). Other studies confirming a growing interest in this new idea are: Johnson 2003; Shachtman 2003; and Architecture 2004.

The inevitability of creating a new class of systems is encouraged by the need for solving the following problems (compare: Brachman 2003):

- systems and networks constitute a critical backbone of economies (local, as well as international),
- the majority of transactions processed in virtual reality provokes involving numerous systems and networks,
- previous systems were not effective enough to process an almost exponentially growing amount of data and information together with the knowledge originated from these sources,
- the growing abilities of processing do not translate into an increase in productivity,
- the growing size of systems (software, hardware, networks) stays in sharp asymmetry with their vulnerability against attack (one person may destroy a whole network infrastructure).

To deal with the above inconveniences, one should take into account the design and implementation of cognitive systems, which are supposed to possess the following characteristics:

- an ability of real-time processing of huge amounts of data, information and knowledge,
- own intelligence (inference, learning, self-explaining, advising, reactivity in atypical situations, adaptability to changing conditions and environments and to users),
- an ability to cooperate with partners (other cognitive systems, external agents and users), a skill of creating "group" intelligence,
- all available forms of communication (internal and external), perceptual and behavioural anthropomorphisms,
- an autonomous ability to detect dangers, self-defend against attacks, self-repair and self-reconstruction (compare: Brachman 2002; Architecture 2004; and Shachtman 2003).

A functional scheme of the cognitive system is presented in Fig. 4.

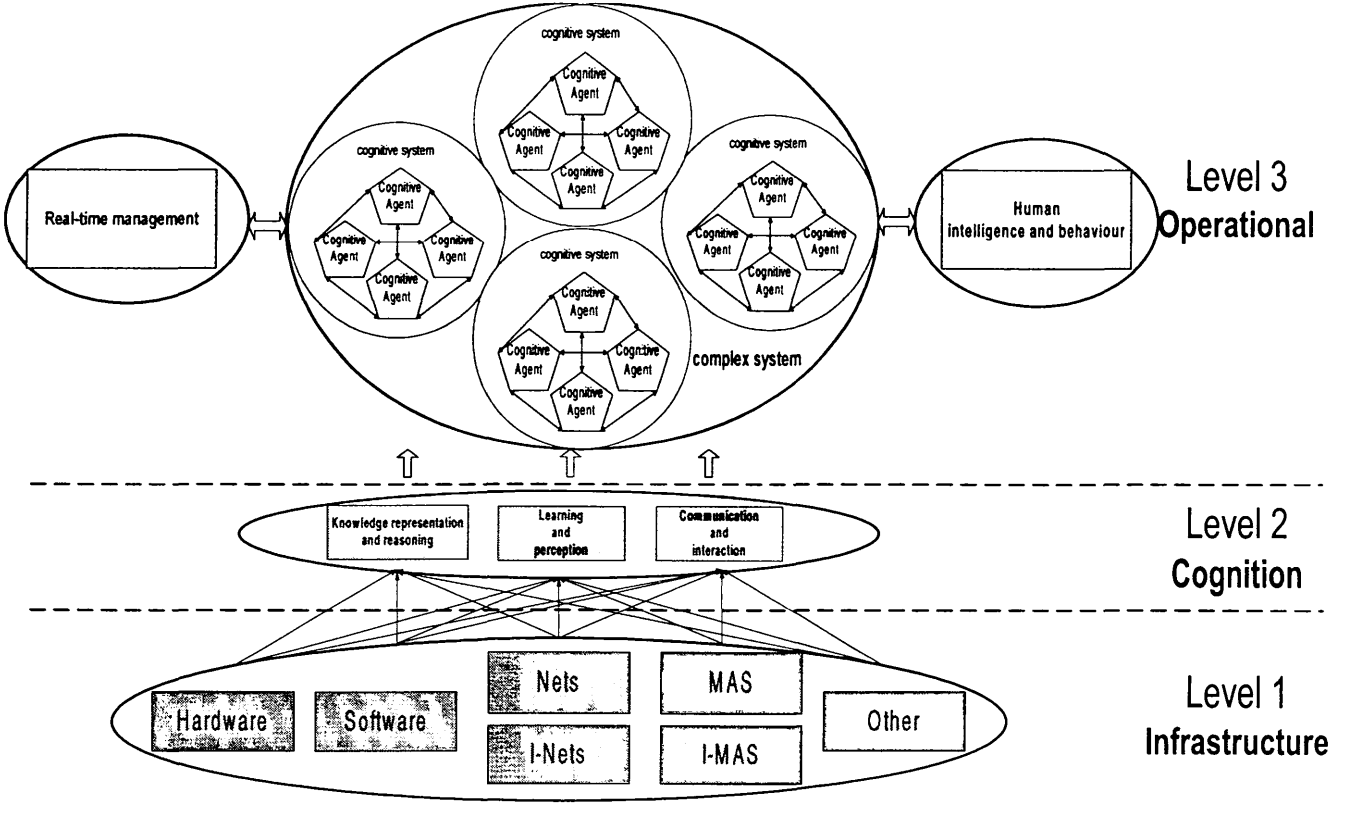

Figure 4. The functional scheme of the cognitive system

Source: own elaboration based on (Brachman 2003)

Here, cognitive agents are a sort of intelligent software agents equipped additionally with such skills and abilities as logical probabilistic reasoning over particularly large knowledge bases and learning techniques to improve their work over time.

It can be seen that the basic characteristics of cognitive systems are roughly the same as in real-time BI systems. So, what new "quality" values do cognitive systems provide?

First of all, it is a real-time processing and communication with the environment. Second, it is a new paradigm of intelligence, which forces a radical acceleration of research over the nature of human intelligence (particularly in the sphere of "highest levels" of the human brain – including perception, functioning of memory, emotions and intuition) and transposing them into the systems' intelligence. Third, it is a breakthrough in communication barriers within intelligent agents community and solving/removing conflicts (concerning mainly contradictory decisions agents may generate). To achieve the above goals, cognitive systems will have to open for the efficient cooperation with their partners (other cognitive systems, external agents and users) and build so-called "group intelligence". The last of the qualities provided is the creation of intelligent networks capable of self-defence and eliminating damages resulting from attacks.

One expects that the implementation of these systems will constitute a breakthrough in IT comparable to the Internet. Not only governments and corporations are interested in such systems, but also numerous organisations and companies from IT sector.

CONCLUSIONS

The speed of changes in new paradigms and applications of IT, particularly in the domain of intelligent systems is not only impressive, but also surpasses and revalues laborious "organic work", which aims at a dissemination of current, yet insufficiently verified solutions. As an example one can show an unfinished attempt to implement the complex, integrated expert system built into all the management processes. It had to be exchanged by a proposal of business intelligence systems with Intelligent Multi-Agent Systems in particular.

As shown in this paper, Business Intelligence systems have been constantly evolving since their very beginning, mainly to meet the

expectations of more and more demanding users. Unfortunately, these changes do not necessarily go in parallel, though as a consequence of this evolution and constant pursuit of satisfying users with their information needs, the real-time BI and cognitive systems may constitute the solution. The first of the two systems mentioned above assures having up-to-date information, while the latter type of systems may represent the complex solution of problems concerned with the acquisition, storing, analysing, understanding, and utilizing of the information.

For today, one can see more and more intense works over cognitive systems. It seems that they are going to be ready to prove their value in the near future.

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