KNOWLEDGE MANAGEMENT SOLUTIONS FOR PRODUCTS DEVELOPMENT IN THE ENTERPRISE BUSINESS INTELLIGENCE

Sebastian Marius ROŞU[1], Marius GURAN[2], George DRĂGOI[3]

În această lucrare se definesc conceptul de management al cunoştinţelor şi conceptul de afaceri inteligente la nivelul întreprinderii. Se analizeaza modalitatile de transfer şi de capitalizare a cunoştinţelor bazate pe resursele interne şi externe ale întreprinderii şi se propune un model metodologic original, sistem suport pentru dezvoltarea aplicaţiilor specifice managementului cunoştintelor la nivelul unui grup industrial. Se implementeaza un sistem bazat pe cunoştinţe pentru dezvoltarea unui produs atunci când se cunosc caracteristicile tehnice ale acestuia.

In this paper the knowledge management and business intelligent concepts will be defined in order to analyze enterprise internal and external resources based on the knowledge transfer & capitalization. The main goal of the paper is to propose some knowledge management solutions to support knowledge applications development at the enterprise level. An expert system for products identification when the technical characteristics are known will illustrate how this system works.

Keywords: knowledge management, knowledge capitalization, knowledge transfer, knowledge applications, business intelligence, expert system

1. Introduction

Knowledge has become the more important economical factor for permanent competitive products and services. In order to develop intelligent business to become competitive, the enterprises must increase the quality and technologic level of products and services in conformity with applicable codes and standards, to have permanent new products or to make old products bettering, to respect the customers, suppliers or partners contracts terms and conditions, to respect the market rules, the applicable laws and to have a good prices policy. These activities request a large amount of data, information and knowledge collecting from all sources and then transferring knowledge at each enterprise

[1] PhD Student, Special Communications Service, IT Department, Bucharest, Romania
[2] Professor, IMST, PREMINV Research Center, University POLITEHNICA of Bucharest, Romania
[3] Professor, FILS, PREMINV Research Center, University POLITEHNICA of Bucharest, Romania, e-mail: gdragoi@mix.mmi.pub.ro

level. This knowledge is mainly based on market demands, technical processes, customer requirements, technology improvements, laws, suppliers, competitors etc. In this new era of information, the fundamental sources of wealth are knowledge and communication, and not natural resources or labour work [1].

We consider here that knowledge is using information (as a consequence data) to generate new ideas or solutions. During the first decades of the computer science, the knowledge management was based on data management but in order to transform data into information specific tools are required and in order to transform information into knowledge time is needed.

Today, three classes of elements are defined in knowledge management [2]:

- Data (an objective group of parameters describing a certain event);
- Information (a message transferred from an originator to a receiver and whose meaning involves a new interpretation based on a group of data);
- Knowledge (a mixture of experiences, values, contextual information and intuition, forming a framework in a person's mind that enables him/her to evaluate and to obtain new experiences and information).

Based on the main studies in this area two important types of knowledge could be identified [2], [3]:

- *The tacit knowledge* (the knowledge that people possess but it is not described in any place);
- *The explicit knowledge* (the knowledge that is registered and therefore available for other people).

Some knowledge management studies are based on the successive passages from tacit to explicit knowledge and vice-versa [3], [4], [5]. These studies have suggested four basic conversion patterns to create organizational knowledge [3], [6], [7], [8]. As one can see in figure 1 organizational knowledge is based on a continuous and dynamic interaction between the tacit knowledge and the explicit knowledge:

- *From tacit knowledge to tacit knowledge*: it is a process of sharing experiences. The input for this knowledge type acquisition is experience.
- *From tacit knowledge to explicit knowledge*: it is a process of individual tacit knowledge conversion in explicit concepts. This knowledge could be: a symbolic representation of the tacit knowledge (through metaphors, analogies, models, concepts, hypotheses by using the figurative language); an oral report or film; a description of part of the tacit knowledge through spreadsheets, texts, images, illustrations, rules, scripts, design history, lessons learnt etc.
- *From explicit knowledge to explicit knowledge*: it is a conversion process of some type of explicit knowledge generated by an individual to the explicit knowledge of an organization. Individuals exchange and combine knowledge through documents, meetings, chats etc. Usually this systemic knowledge is

grouping and processing different explicit knowledge that could generate a new knowledge.

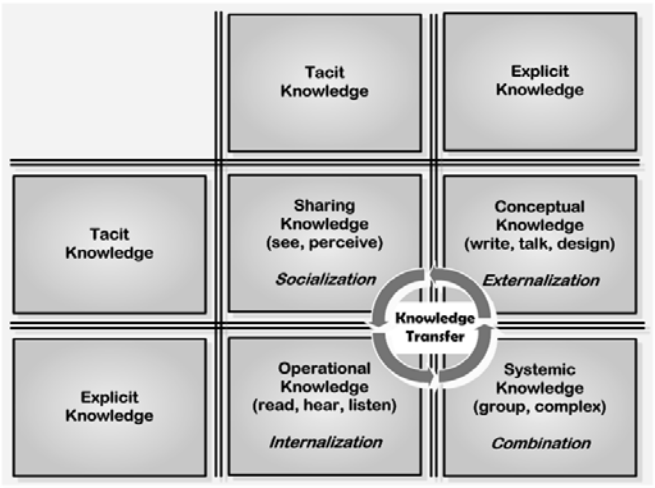

Fig. 1. The four basic standards for the knowledge creation or ways of converting knowledge

- *From explicit knowledge to tacit knowledge*: it is the process of incorporating explicit knowledge from the organization into individual's tacit knowledge. This operational knowledge is usually using: reading/visualization and individual studying of documents from different formats, individual interpretation and experimentation.

2. Knowledge management at the enterprise level

Knowledge Management (KM) is a certain form of looking into the organization in the search of points of the business process where knowledge can be used as competitive edge [6], [7]. Also, KM is not technology but it can be benefited from new technologies of the information and of communication [8], [9]. Knowledge management is not creativity and innovation but it is related to how to use the innovations generated in the company in a systematic way for a better market positioning. Knowledge management is not quality but it uses techniques and tools that have already been applied in the quality management and in the approaches of continuous improvement. Knowledge management is not marketing but it can help companies in the competitive intelligence. Knowledge management is not documentation but it is related to organizational collective memory. Knowledge management is not also administration of human resources but it only takes place with the people of the organization. In fact, knowledge management is a new area within information technology and management, a new field among the strategy, culture and information system an organization. Today,

one could define knowledge management as being the process by which the organization generates wealth, from their knowledge or intellectual capital. In this context, wealth happens when a Virtual Enterprise uses its own knowledge to generate more efficient and effective processes. Companies tend to differentiate themselves from what they know (intellectual capital) and from how they use this knowledge. The interest for knowledge within companies begins with identification that the value of market of several companies is much larger than the value of their own physical patrimony (equipments, facilities etc.). The total value of the shares of those companies incorporates an intangible data (the value of their brands, their patents, their capacity of innovation, the talent of their employees and the relationships with their own customers). Companies turned into knowledge management with the intention of understanding, organizing, controlling and profiting with this intangible value (i.e. knowledge).

Knowledge management for computer supported collaborative work in design includes:

- Mechanisms for knowledge sharing (interested actors can share both input and output knowledge - to achieve this, some communication mechanisms between actors are required);
- Operators (the operators can transform input knowledge into output knowledge and shall be equipped within actors);
- Triggers (e.g. failure or success of a design) will trigger one or more agents to learn;
- Collective memory (individual actors shall have their own memory for knowledge storage. Also, there shall be a common memory where all the actors can access to acquire knowledge and likewise actors can store their knowledge in the shared memory).

The product development process has become an intensive process of knowledge application and it consists of a process of transformation of information [9]. Each activity of the product development process should be seen as a theoretical-empiric framework, limited by the time, where a group of information is treated, transformed and passed ahead to another activity at the appropriate time. The information do not enter at the beginning of each activity and nor leave in the end of each activity, the flow of information happens at every moment of the product development process. Knowledge is created through the interaction and sharing that happens among people during the execution of those activities and the flow of information happens in a chaotic way during that process. The tacit knowledge that emerges from this process is interactive and it is the base of the process of knowledge creation within the organization.

Besides the knowledge that can be learnt individually, there are other types of knowledge that may only be learnt through collective learning [2], [9]:

- Knowledge of agents interactions;

- Common knowledge;
- Meta-knowledge (meta-knowledge is the knowledge of knowledge).

3. Business intelligence at the enterprise level

The enterprises marketplace value is represents the thing that distinguishes its business performance from all others [10]. It is generally accepted that the value of every organization falls into one of three major categories of value discipline [11], [12]:

1. *Customer intimacy,* when the companies try to understand their individual customer's needs, and will try to do everything is possible to accommodate their customers. These companies are definitely not cheap, because personal service is an expensive commodity; however their customers prefer to use them because they feel that they are sufficiently rich to justify the extra cost.
2. *Product leadership,* as companies that could be described as 'leading edge', because their value is that can keep you ahead to the customers of other similar companies. These companies are always on top with new innovative products, new ideas which can keep the customer interest.
3. *Operational excellence*, as companies that excel at operational efficiency.

All companies tend to have a stronger affinity to one of the three categories. An organization needs to understand how to interact with its customers and how it would like to interact with its customers. After this, the enterprises can start to develop a strategy to improve customer relationship management (see figure 2) and other e-business solutions, as enabling technologies and core technologies.

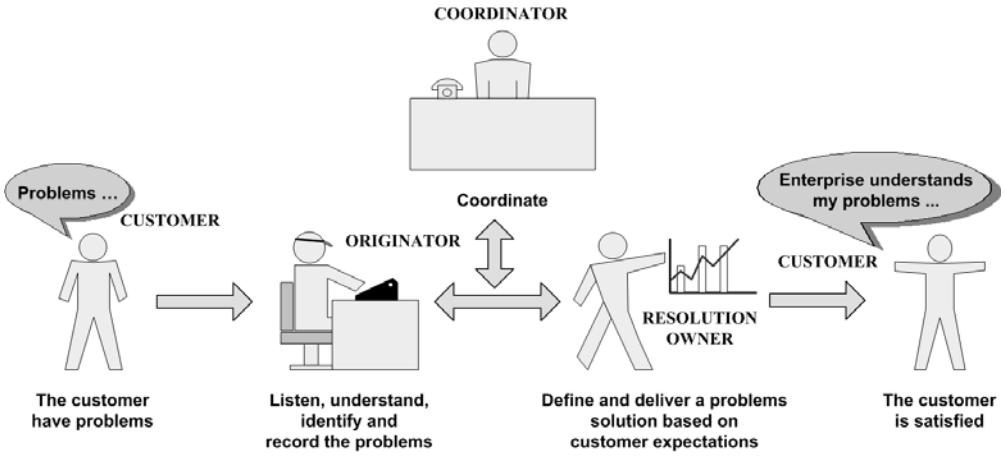

Fig. 2. Customer Relationship Management at the enterprise level

For the future, e-services and e-business, as were defined, require the enterprise re-thinking and re-modelling, with the system and applications design for an efficient use of new network technologies. The perspectives of this kind of manufacture and economy are named briefly *new digital economy* [13]. The connection between *business value* and *intelligence* can be represented as evolution (see figure 3), based on the experience in industry, where the beginning is represented by "data access" and "what happened?"

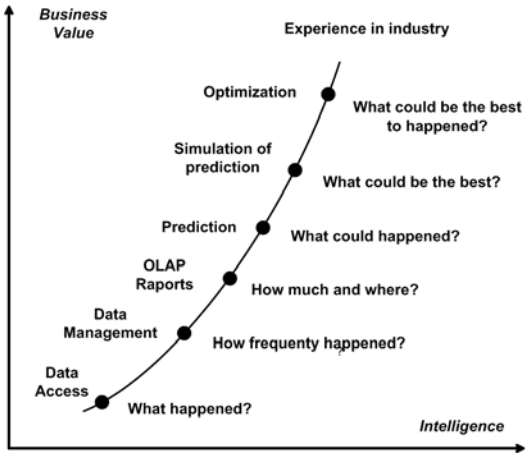

Fig. 3. Business value & intelligence evolution

4. Knowledge transfer at the enterprise level

At the enterprise level the knowledge could be found to individual, group or external resources. Professional qualifications, personal experiences, capacity to transform information in knowledge constitute the individual resources. Patent acts, models, concepts, enterprise culture and management form the group resources. Individual and group resources totality represents the enterprise internal resources. Relations set of external resources with clients, suppliers and partners, product and services credibility, offering quality. Tacit or explicit knowledge transfer between these resources and knowledge conversion from a resource to other determines value creation. There is several kind of knowledge transfer explained follow-up (figure 4):

- *Knowledge transfer between employees* – can be realized by team activities organized, meetings, show-dawn, by the employees' rotation or professional workplace qualifications or re-qualifications under enterprise expert.
- *Knowledge transfer between employee groups* – realized within projects that involve interdepartmental teams constitution or when management team try to integrate efficient the systems, tools, processes and products at the enterprise level.

- *Knowledge transfer from employees to employee groups and from employee groups to employees* – can be making by teaching processes, e-learning and simulations and through the Industrial Informatics Systems or Knowledge Work Systems.
- *Knowledge transfer from employees to external resources and from external resources to employees* – it takes place during meetings between customers, suppliers, partners and enterprise employees. Employees present the products, the new enterprise trends and initiate discussions about these and collect information to do better products and services.
- *Knowledge transfer from employee groups to external resources and from external resources to employee groups* – achieved using all enterprise resources, e-business, making alliances for new ideas regarding products and services or research.
- *Knowledge transfer between enterprise customers, suppliers and partners* – it does within discussions between these with show rooms, exhibitions, conferences.

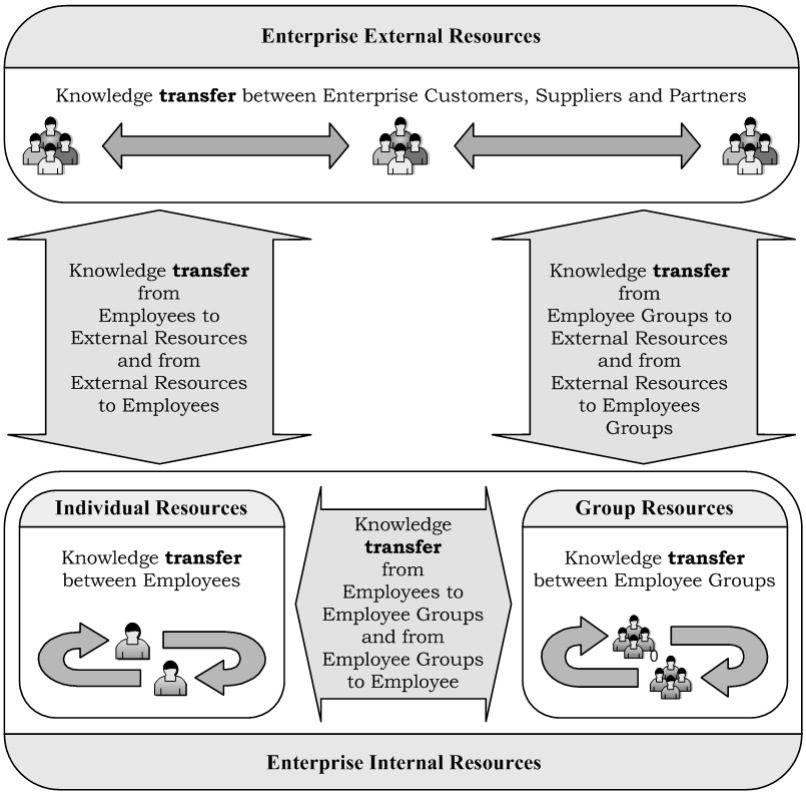

Fig. 4. Knowledge transfer at the enterprise level

5. Knowledge capitalization at the enterprise level

At the level of the enterprise, knowledge can be capitalized through (see figure 5):

1. Gathering data, information and knowledge from customers, providers and partners:

- Collecting all data, information, knowledge from clients into a knowledge base;
- Using the info on customers for product and services development and modernization purposes;
- Tight connections with customers through the Internet - maybe opening a forum for discussions;
- A thorough recording of the staff's contacts with the customers, of customers' wants for anticipations in the future.

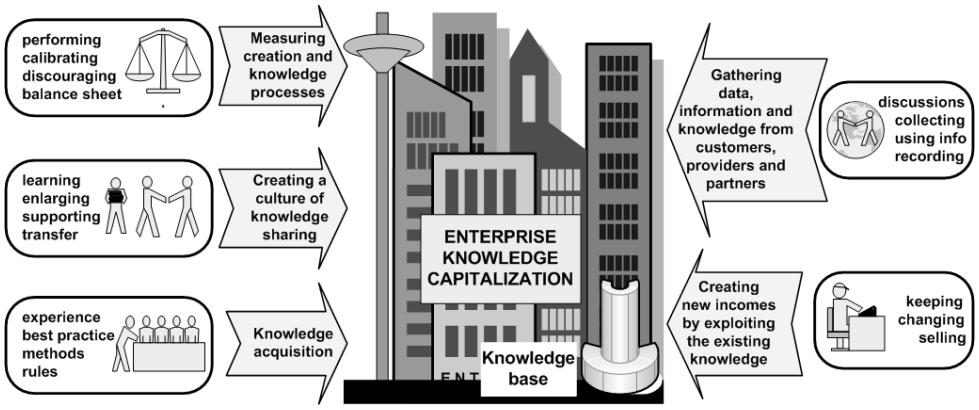

Fig. 5. Knowledge capitalization at the enterprise level

2. Creating new incomes by exploiting the existing knowledge:

- Keeping all patents, licenses, market and necessity research, technical and economic research in a database accessible to the personnel;
- In case of changing profile within the company into a similar one: keeping all methods and expertise acquired during the former one;
- Selling knowledge/expertise to other companies by means of license, patent, consultancy, etc.

3. Creating a culture of knowledge sharing:

- Encouraging learning and improvement;
- Supporting those failing their attempts;
- Upholding a competitive environment and rewarding personal initiative;

- Creating a culture of knowledge sharing from the top of the organization to all its lower levels;
- Enlarging people's knowledge area beyond their field of expertise;
- Setting goals to employees;
- Creating environment for knowledge transfer - such as teamwork, meant especially for knowledge and info transfer from experts to newly employ.

4. Knowledge acquisition:

- Keeping all experience gained in every (previous) activity in a knowledge or database;
- Creating a knowledge database comprising the best practice, methods, rules and facilitating communication through e-mail, videoconference, Internet forum etc.;
- Rewarding employees having good results in the acquisition and accumulation processes;
- Equal male and female employment, as well as of foreigners; diversity and multicultural representation lead to creativity.

5. Measuring creation and knowledge processes:

- Performing a knowledge quality audit;
- Calibrating customers, providers and partners according to the value of their contribution to the knowledge process;
- Annual balance-sheet including profit and loss in HR terms and a balance of HR investments;
- Discouraging the use of financial indices in management and mainly in knowledge management.

6. An example of Knowledge bases at the enterprise level

According with standards and technical norms, enterprises have a technical or engineering department for manufacturing, assembly, design, research, service, products quality assurance, activities support. One of these department main activities is to choose a product based on project, assembly, and data sheets requested characteristics. A library, database or knowledge base at the enterprise level to sustain this activity is necessary. In this paper is analyzed this activity and elaborated an expert system implemented in VP-Expert (we used expert system generator - VP-Expert version 2.1, by Brian Sawyer, Educational Version, distributed by Paperback Software International) to choose a product when the technical characteristics are known. To build the knowledge base, it was used an enterprise model active in design, assembly and service for water, gas and heating systems. It was established a number of water, gas and heating class elements available in the enterprise warehouse and, after that, the elements main technical characteristics, destination, constructive characteristics, has been

definted etc. For example, we considered a meter element and we established a complete meter name like below (we mark with 'C' each defined technical characteristic):

Domestic (C_3) ***Cold*** (C_2) ***Water Meter*** (C_1), ***Mono-jet with Dry Mechanism*** (C_4) → *knowledge base consults* → **ETX** Model with Nominal Diameters **DN 15 - 20 mm**

Or:

Domestic (C_3) ***Cold*** (C_2) ***Water Meter*** (C_1), ***Multi-jet with Dry Mechanism*** (C_4) → *knowledge base consults* → **MTX** Model with Nominal Diameters **DN 15 - 50 mm**

We eliminate the producer name from the complete element name to each product for advertising reason. After meters technical characteristic defined we built the knowledge base *ALEGCONT.KBS* (figure 6).

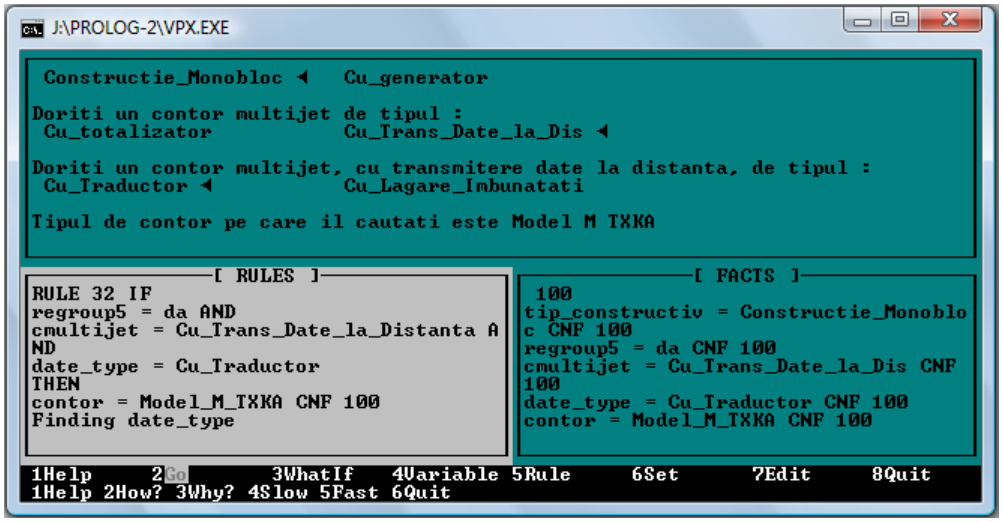

Fig. 6. The knowledge base *ALEGCONT.KBS* consults

Production rules form the knowledge representation model used in this work. In *ALEGCONT.KBS* knowledge base there are *if-then* structure rules excluding the rules for inference engine operations.

The user choose first the needed class meter (water, gas or heating meter), then follows few steeps requisite to establish the product technical characteristics and, finally, the user see the available meter name which corresponds from technical point of view. If the users wish they could see, for verification, the covered way of expert system inference engine during to knowledge base consults.

For figure 6 interrogations, the covered way is the following:

Testing ALEGCONT.kbs
(= yes CNF 0)
! contor
! ! Testing 1
! ! ! type
! ! ! ! (= Contor_de_Apa CNF 100)
! ! Testing 2
! ! Testing 3
! ! Testing 4
! ! ! regroup0
! ! ! ! Testing 38
! ! Testing 5
! ! Testing 6
! ! Testing 7
! ! ! regroup1
! ! ! ! Testing 39
! ! ! ! ! alege
! ! ! ! ! ! (= Contor_de_Apa_Calda CNF 100)
! ! Testing 8
! ! Testing 9
! ! Testing 10
! ! Testing 11
! ! ! regroup2
! ! ! ! Testing 40
! ! Testing 12
! ! Testing 13
! ! Testing 14
! ! Testing 15
! ! Testing 16
! ! ! type_calda
! ! ! ! (= Multijet_cu_Mecanism CNF 100)
! ! Testing 17
! ! ! regroup3
! ! ! ! Testing 41
! ! Testing 18
! ! Testing 19
! ! Testing 20
! ! Testing 21
! ! Testing 22
! ! Testing 23
! ! Testing 24
! ! ! regroup4
! ! ! ! Testing 42
! ! Testing 25
! ! Testing 26
! ! Testing 27
! ! Testing 28
! ! Testing 29
! ! Testing 30
! ! Testing 31
! ! ! regroup5
! ! ! ! Testing 42
! ! ! ! ! tip_constructiv
! ! ! ! ! ! (= Constructie_Monobloc CNF 100)
! ! ! ! (= da CNF 100)
! ! ! cmultijet
! ! ! ! (= Cu_Trans_Date_la_Dis CNF 100)
! ! Testing 32
! ! ! date_type
! ! ! ! (= Cu_Traductor CNF 100)
! ! (= Model_M_TXKA CNF 100)

7. Knowledge applications at the enterprise level

Traditional applications in the enterprises, mainly related to ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management), are using large amount of data on operation and customers that are unused in data warehouses [14], [15]. To turn that stored data into valuable information, companies are now questing knowledge applications (KApps). The business advantage in having KApps, lies in the ability to analyze large amounts of data from any business model, determine the personalized preferences of all potentially customers, than rich them with relevant information, wherever they may be. These serve as the driving force for new generation of applications. Traditionally, we have query-and-response paradigm for applications. For the new generation of applications, the logic is reversed: *what-if-system* didn't wait for the end user to have the question, and the system just asked the question for the end-users and sends them the answer. In this way one could anticipate a whole set of questions. This new class of applications allows companies not only to collect but to analyze data and information, in order to developed better supplier and customer relationships. It is aimed at increasing profitability through revenue growth.

Knowledge-driven applications have the potential to expand the use of information, by transforming existing huge data collections into revenue-generating asset [11], [16], [17]. To take the full advantages for knowledge and information-based business models, there is a need for an integration framework that can tie together the various classes of KApps. Some of the emerging classes of KApps are (see figure 6):

- *Customer Relationship KApps* - offer companies tools for mining customer data and information, having as outcome of this data mining process improved pricing, greater market share, longer customer retention, or a new revenue flow. For this, the companies must to do more real-time relationship management, the trend known as personalization (better understand and respond to each customer's needs, behaviour and intentions.
- *Supply Chain KApps* - encourage trading partners to improve profits by managing inventories in the supply chain; by obtaining the information that enables visibility and certainty, offering more favourable terms, increased levels of supplies, invests in co-marketing.
- *Knowledge / Innovation Management* - assure the companies to push technologies farther, giving their employees instant access to information and reports that previously took days or week to obtain.
- *Remote Performance Monitoring* - provide information to operating managers throughout an enterprise enabling them to improve performance on a routine basis, by bridging operations and strategy using key performance indicators.

- *Simulation by using what-if scenario analysis* - encompasses advanced simulation and scenario modelling, based on information from diverse internal and external sources. This enables management to participate in developing strategies and learns risk management (by modelling of future risk and returns).

To create an integrated decision framework, the organizations have to implement a number of KApps built on a platform that is composed of three layers:

- *E-business decision-support solutions* - includes the ability to deliver views and queuing, reporting, and modelling capabilities that go beyond current offerings.
- *Enabling technologies* - data mining, query processing, and result distribution infrastructure, which mean the ability to store data in a multidimensional cube format (On-Line Analytical Processing – OLAP), to enable rapid data aggregation and profound analysis.
- *Core technologies***,** as data warehousing, and data markets, that get all company data working together so that user can see more, learn more, and make the organization to work better.

Because information access and control drive business competition, it is obvious to consider the lack of boundaries in modern business and that fact that corporations and consumers are becoming more interconnected via private networks and Internet.

8. Knowledge increased model at the enterprise level

The knowledge of the organization is composed by the sharing knowledge of each individual [13]. For increase the knowledge in the enterprises for an efficient KM system of the intellectual capital a methodology is defined in ten steps: obtains and uses, learn and contribute, evaluates, sustain, support, exchange, combination, transfer, recovery and discharge (see figure 7):

1. The steps obtain and uses are well known within organizations. People always seek information and use them later to solve their problems, to take decisions or to create new products. Therefore, new technologies (e.g. intranet/internet/extranet) allow that the large amount of information flowing within organizations can be correctly managed.

2. The steps learn and contribute are relatively new for organizations. For example, it has been difficult to convince employees to contribute to the organization's knowledge base. New technologies have helped companies easily to organize, send and transfer certain types of information. However, the employee has seen this facility as a threat for his/hers own job security. The most difficult task is to convince individuals that their contribution will give return to their organization as well as to themselves.

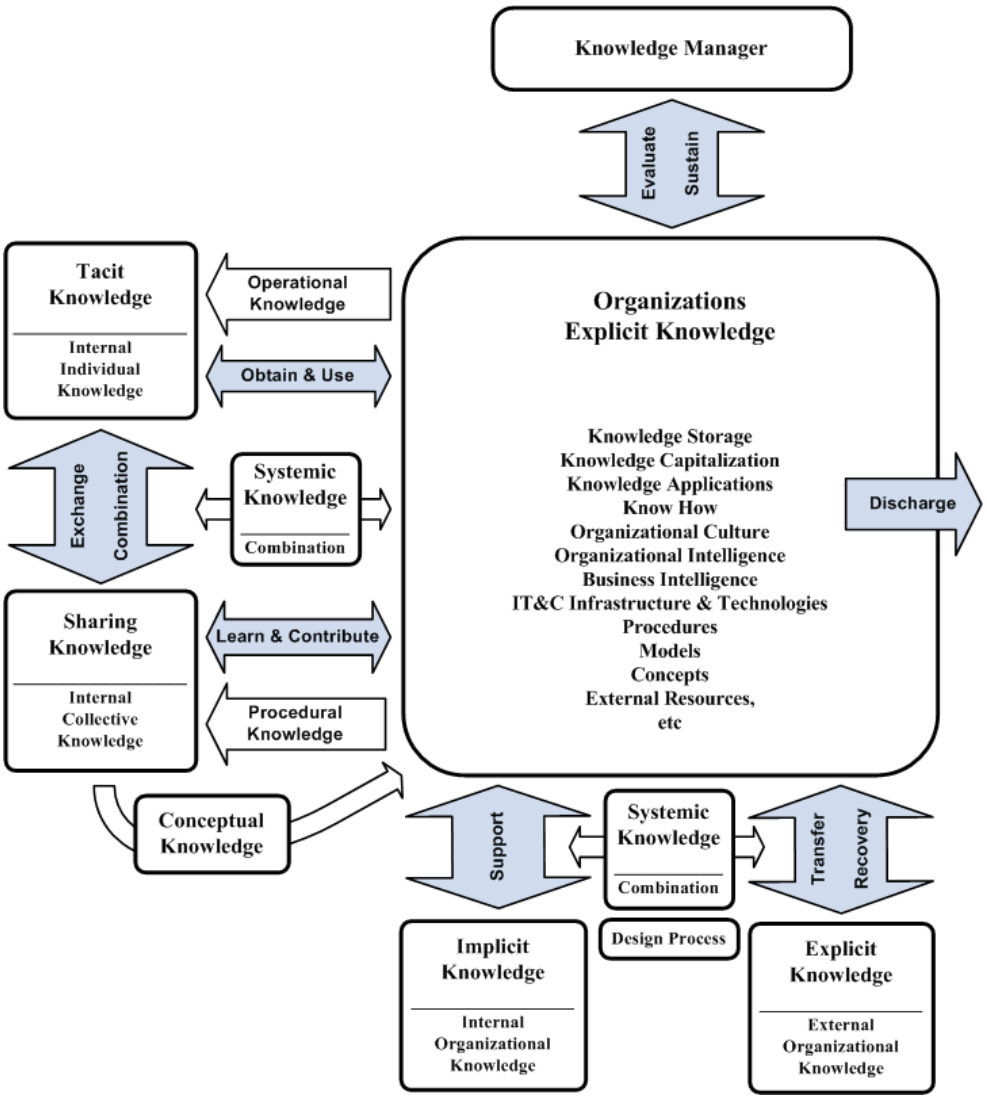

Fig. 7. The knowledge management at the enterprise level

3. The step evaluates indicate that the organization should define its own necessary knowledge for its mission and classify its own currently intellectual capital. In other words, the knowledge manager does more than to organize the content in system on-line; he/she should understand and foresee the community needs.

4. The step sustain or maintain should assure that the future intellectual capital would maintain the organization viable and competitive. Organizations tend to build their own intellectual capital through their relationships with

customers, employees, suppliers etc. The knowledge manager should also be responsible for the maintenance of the organizations knowledge base.

5. The step support can be used for the continuous improvement of the product design process.

6. The step exchange represents an intelligence and creativity combination of organization employees to find better solutions to their problem. Knowledge exchange involves interaction between decision makers and researchers or project development teams and results in mutual learning through the process of planning, disseminating, and applying existing or new research in decision-making.

7. The step combination can be done by means of Industrial Informatics Systems or Knowledge Work Systems.

8. The step transfer realized by teaching process, e-learning and simulations. At the organization level the knowledge could be found to individual or group (collective) resources.

9. The step recovery utilized when the organization must re-create knowledge which disappears due to the fact that documentation is not adequate or experts do not pass along knowledge before they leave.

10. The step discharge excludes any useless knowledge from the organizations knowledge base. However, some knowledge can be more valuable if it can be transferred to outside of the organization.

9. Conclusions

We believe that the knowledge modeling techniques that exist to support the use of the knowledge, along with traditional physical assets management techniques, provide a starting point to manage fully the knowledge assets within a company. We considered in that paper, knowledge management very important for product development process designers because design activities require individuals or collective knowledge. We propose here a methodological approach based on the UPB-PREMINV platform to support knowledge applications using the principal internal and external knowledge resources during the product development process and business intelligence strategies elaboration.

Our knowledge capitalization & enterprise transfer based case study is a part of a research project implying a SME's & UPB-PREMINV Research Centre partnership. The aim of this project is to establish the methodological steps for outsourcing and integrating industrial partners into a virtual enterprise medium. We emphasized on how a knowledge base can be built in the enterprise as part of an expert system to support a department activity. The case study presented in this paper is an expert system used to support knowledge applications development at the enterprise level for products identification when the technical characteristics are known.

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