A Knowledge Management Scenario to Support Knowledge Applications Development in Small and Medium Enterprises

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***Abstract*—Nowadays, in the European countries more than 95% of the companies are small and medium-sized enterprises (SMEs) and majority of the European Union employees work in these companies. In order to develop intelligent business to become competitive, the enterprises must increase the quality and technologic level of products and services, to have permanent new product or to make old products bettering and to have a good prices policy. These activities request first a large amount of data, information and knowledge collected from all sources and then request transferring knowledge at each enterprise level. Therefore, this work analyses the state of art of the knowledge and knowledge management (KM) and propose KM scenario to support knowledge applications (KApps) development in SMEs. In addition, the paper presents how can be knowledge bases built at the enterprise level.**

***Index Terms*—knowledge management, knowledge bases, knowledge process, knowledge application, SME**

I. INTRODUCTION

Whether we consider one enterprise or a holding, for survival, it is necessary to learn from the past, supervise the present and plan the future. An important factor for the enterprise in the products and services development is to know, to establish, to translate and to define the customer requirements using quality methods, tools and techniques. The enterprise uses IT & C support to attract, retain and cultivate relationship with customers, streamline supply-chain, manufacturing, procurement systems and automate corporate processes to deliver the right products and services to customer quickly and cost-effectively. In this new era of information, the fundamental sources of wealth are knowledge and communication, and not natural resources or labour work [1, 6]. Today, one can differentiate three classes of elements as [21]:

1. ***Data*** – a discreet and objective group of facts of a certain event.
2. ***Information*** – a message containing an originator and a receiver and whose meaning involves a new interpretation based on a group data.
3. ***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's.

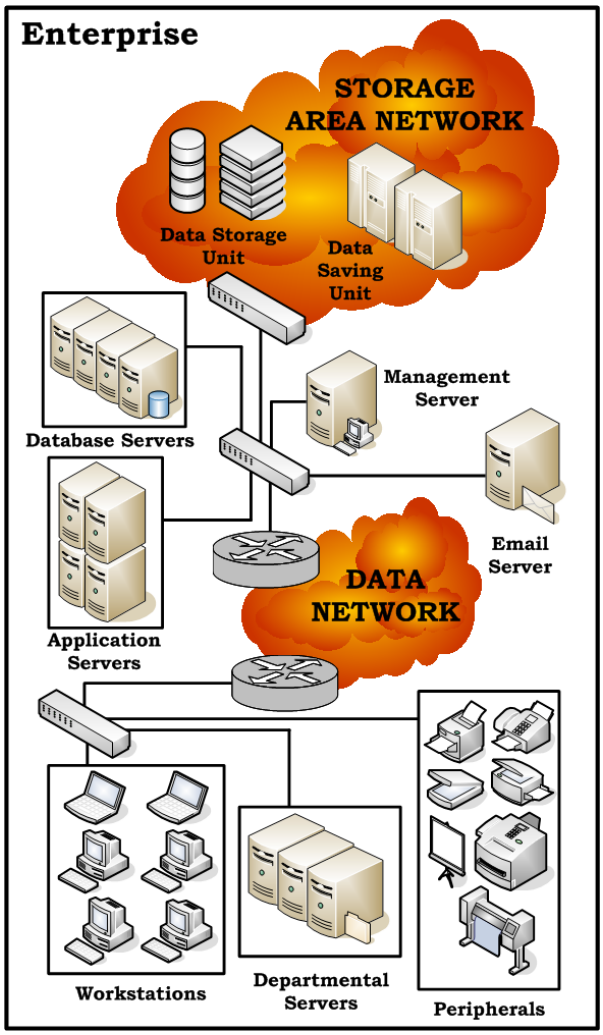

Figure 1. Enterprise data centre.

The recent studies in this area identify two main types of knowledge [20] (see figure 2):

1. ***The tacit knowledge*** (it is the knowledge that people possess but is not registered in any place. It is just residing in people heads).
2. ***The explicit knowledge*** (it is the knowledge registered in some ways and therefore it is available for the other people).

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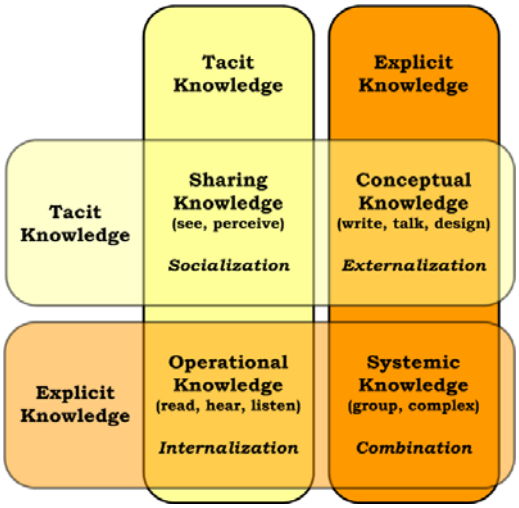

Figure 2. The four basic standards for the knowledge creation or ways of converting knowledge.

During the first decade of the computer science, the emphasis was on data management (figure 1). In order to transform data into information, tools are required. In order to transform information into knowledge, time is needed. Knowledge is to use information (and as a consequence data) to generate new ideas or solutions. Many studies on KM are based on the successive passages from tacit knowledge to explicit knowledge and vice-versa. These studies have also suggested four basic conversion patterns for the knowledge creation in an organization [5]. In figure 2 these four basic standards are presented in such a way that the creation of the organizational knowledge is based on a continuous and dynamic interaction between the tacit knowledge and the explicit knowledge:

1. ***From tacit knowledge to tacit knowledge (socialization)*** – it is a process of sharing experiences and, therefore, the creation of tacit knowledge. The based input for the acquisition of this knowledge type is experience.

2. ***From tacit knowledge to explicit knowledge (externalization)*** – an articulation process of the individual's tacit knowledge in explicit concepts. These conceptual knowledge usually happens through: symbolic representation of the tacit knowledge (through metaphors, analogies, models, concepts, hypotheses by using the figurative language), oral reports and films, part description of the tacit knowledge through spreadsheets, texts, images, rules, scripts, design history, lesson learned, etc.

3. ***From explicit knowledge to explicit knowledge (combination)*** – conversion processes of some type of explicit individual knowledge, generated for add up to organization explicit knowledge (e.g. individual's knowledge exchange and combination through documents, meetings, chats, etc.). Usually, this systemic knowledge happens by different explicit knowledge grouping and processing that could be generate into a new knowledge.

4. ***From explicit knowledge to tacit knowledge (internalization)*** – an explicit knowledge from the organization incorporating into individual's tacit knowledge process. This operational knowledge happens through: reading/visualization and individual study of different format documents, individual interpretation and experimentation.

The organizational knowledge is found not only in documents, databases and information systems but also in the business processes, group practices and in the accumulated experience of individuals.

II. THE SMEs KNOWLEDGE

Knowledge exists in the mind of people and circulates within organizations [16]. For all companies KM and innovation plays an important role [19]. Many of KM initiatives are implemented in large companies but in the last years there is a shift towards small and medium-sized enterprises (SMEs) [8].

According to some studies SMEs need a simple framework to organize their key knowledge processes: knowledge identification, knowledge acquisition, knowledge distribution and knowledge preservation [9, 18]. The ***key knowledge processes*** (KKPs) for SMEs identified by us are presented in figure 3.

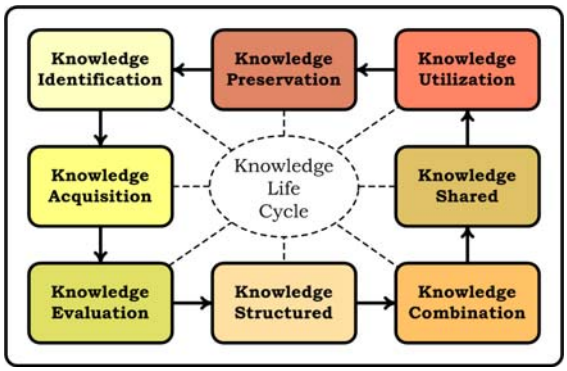

Figure 3. The KKPs for SMEs.

For SMEs it's necessary that the advantages of KM are clear and the implementation is easy otherwise they will continue to focus on their traditional way of working [17].

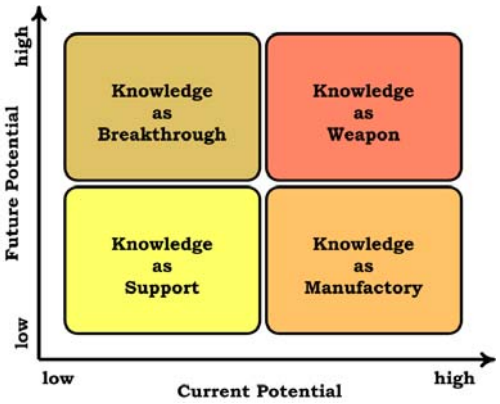

Figure 4. The knowledge roles in business.

There are four different roles of knowledge in a business (see figure 4) [7, 12]:

1. ***Knowledge as support***: There is a low current strategic position of knowledge and in future too.

2. ***Knowledge as manufactory***: Knowledge plays now an important role but the importance will decrease in future.

3. ***Knowledge as breakthrough***: In future knowledge will play a very important role for the business still it does not.

4. ***Knowledge as weapon***: Knowledge is important and the importance will increase in future.

Generally, in some SMEs activity a sector, the knowledge generates capacity exceeds the human records and process capacity, which lead to a super sized knowledge offer. In this way can be generated an inefficacy at the organizational and personal level.

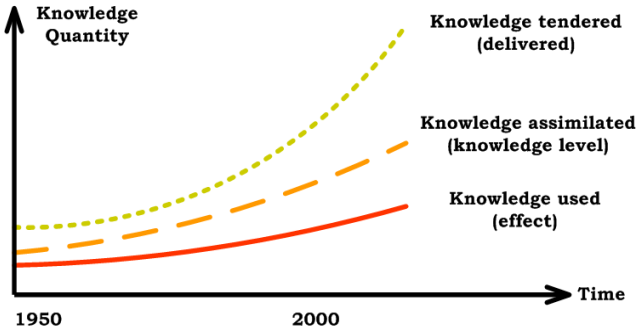

Figure 5. Knowledge flow vs. knowledge used in SMEs.

Figure 5 shows the relationship among knowledge production, knowledge assimilated and the knowledge usage effect. This figure reflects the three essential trends that characterize the new knowledge society and can influence some SMEs activities:

1. ***Knowledge offer increase***;
2. ***Knowledge assimilated increase, but in a much slow rhythm***;
3. ***Maintaining an almost constant level for knowledge used***.

Besides the knowledge that can be learned individually, there are other types of knowledge that may only be learned through collective learning [10]:

- ***Knowledge of actors' interactions***;
- ***Common knowledge***;
- ***Meta-knowledge*** (Meta-knowledge is the knowledge of knowledge).

At the SMEs level, the knowledge could be found to individual, group or external resources [20].

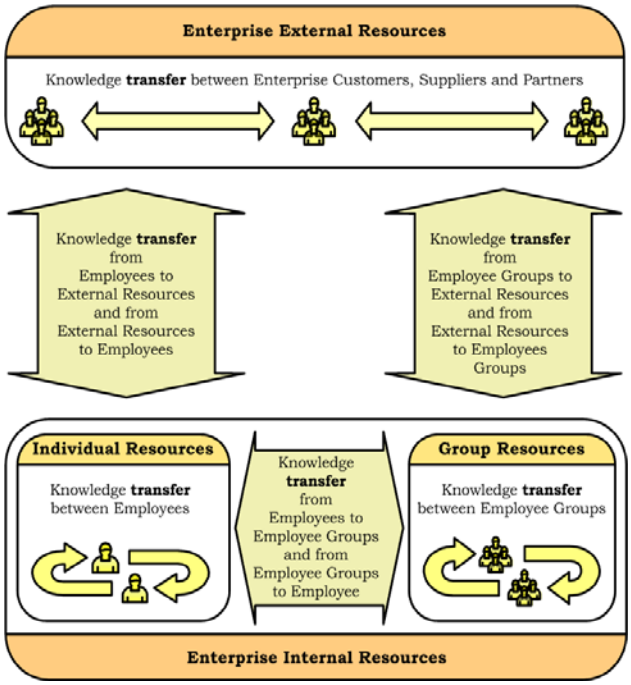

Figure 6. Knowledge transfer at the enterprise level.

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 client, 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 are several kinds of knowledge transfer explained follow-up (see figure 6) [20, 21]:

- ***Knowledge transfer between employees*** – realized by team activities organized, meetings, showdown, 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 tries to integrate efficiently 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 made by teaching processes, e-learning and simulations and by means of the Industrial Informatics Systems (IISs) or Knowledge Work Systems (KWSs).
- ***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, expositions, conferences or others exhibitions occasion.

III. THE KB MODEL FOR SMEs

There is a department designed for manufacturing, montage, design, research, service, products quality assurance activities support, department which works conform standards and technical norms named Technical Department or Engineering Department in many SMEs. This department has various activities according to SMEs activity domains. One of them is to choose a product based on project, montage, and data sheets requested characteristics. A library, database or knowledge base (KB) existence at the enterprise level to sustain this activity is requested. We analyze this activity and realized a KB to choosing products when the technical characteristics are known. To build the knowledge base, we take such as model an enterprise that have, among others, as activity domain design, montage and service for water, gas and heating systems.

We establish a number of water, gas and heating class meters available in the enterprise warehouse and, after that, we define the meters main technical characteristics, destination, constructive characteristics, etc.

For example, we established a meter complete name like (we mark with 'C' each defined technical characteristic):

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**

Or:

Hot (C_2) ***Water Meter*** (C_1) ***with Turbine*** (C_3), ***Single-jet with Dry Mechanism*** (C_4), ***with Horizontal Axis*** (C_5) and ***Improved Bearings*** (C_6) → *knowledge base consults* → **WPHMF** Model with Nominal Diameters **DN 150 - 200 mm**

We eliminate the producer name from the complete meter name to each product for advertising reason. After meters technical characteristic defined we built the knowledge base *CONTOARE.KBS* (see figure 7).

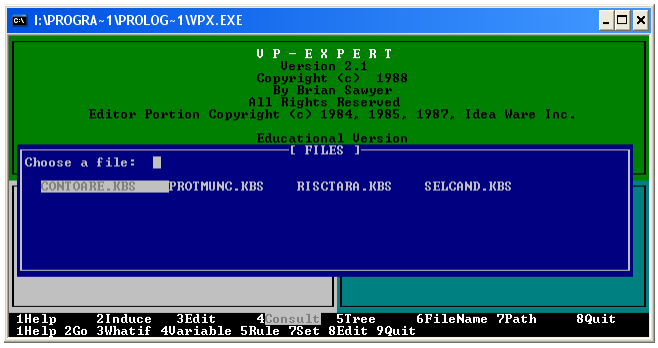

Figure 7. The KB *CONTOARE.KBS*.

For this we used an expert system generator - VP-Expert version 2.1, by Brian Sawyer, Educational Version, distributed by Paperback Software International (see in figure 8 the VP-Expert KB general architecture).

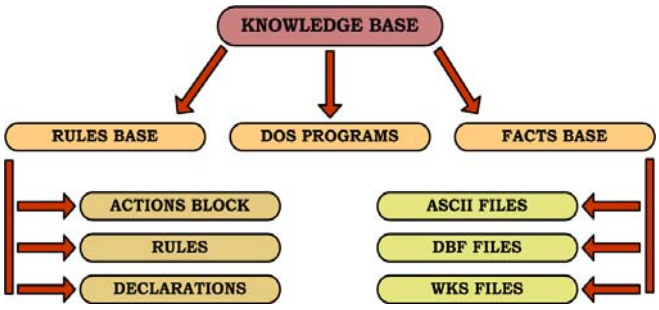

Figure 8. The VP-Expert knowledge bases general structure.

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

The user chooses first needed class meter (water, gas or heating meter) and then follows few steeps requisite to establish the product technical characteristics and, finally, the user sees the available meter name which corresponds from technical point of view (see figure 9).

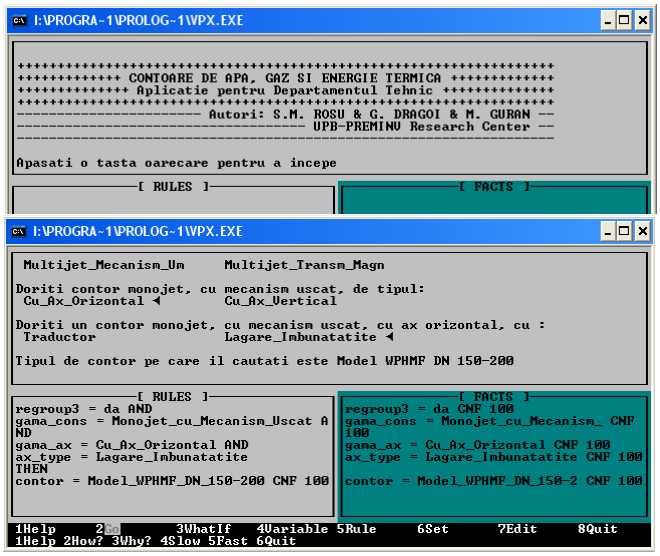

Figure 9. The KB *CONTOARE.KBS* consults.

If the users wish he could see, for verification, the covered way of expert system inference engine during to knowledge base consults.

For interrogations shows in figure 9, the covered way is the following:

Testing CONTOARE.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
! ! ! ! (= Cu_Turbina CNF 100)
! ! Testing 17
! ! ! regroup3
! ! ! ! Testing 41
! ! ! ! (= da CNF 100)
! ! ! gama_cons
! ! ! ! (= Monojet_cu_Mecanism_Uscat CNF 100)
! ! Testing 18
! ! ! gama_ax
! ! ! ! (= Cu_Ax_Orizontal CNF 100)
! ! ! ax_type
! ! ! ! (= Lagare_Imbunatatite CNF 100)
! ! Testing 19
! ! (= Model_WPHMF_DN_150-200 CNF 100)

IV. THE KAPPS AT SMES LEVEL

Traditional applications in the enterprises, mainly related to ERP (Enterprise Resource Planning), DMS (Document Management System) and CRM (Customer Relationship Management), are using massive amount of data on operation and customers that are unused in data warehouses [3, 22]. To turn that stored data into valuable information, companies are now questing ***knowledge applications*** (KApps).

The product development process has become an intensive process of knowledge application and it consists of a process of transformation of information [24]. 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 potential customers, then 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* did not 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 also to analyze data and information, in order to developed better supplier and customer relationships. Increasing profitability through revenue growth is also an important purpose. This revenue-enhancing framework focuses on an interesting mix of modelling, data processing as decision support, information retrieval, reporting and analysis, what-if-scenarios, data warehouses, and data mining.

Knowledge-driven applications have the potential to expand the use of information, by transforming existing huge data collections into revenue-generating asset [2, 11]. To take the full advantages of knowledge and information-based business models, there is a need for an integration framework that can tie together the various classes of KApps.

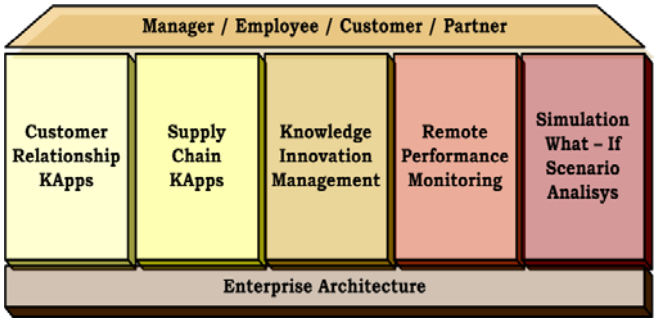

Figure 10. The emerging classes of KApps.

Some of the emerging classes of KApps (that can be found or developed at the SMEs level) are (figure 10) [13]:

- ***Customer Relationship KApps*** - offer companies tools for mining customer data and information, having outcome 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*** - assures 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*** - provides information to operating managers throughout an enterprise that enables them to improve performance on a routine basis, by bridging operations and strategy using key performance indicators.

- ***Simulation 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).

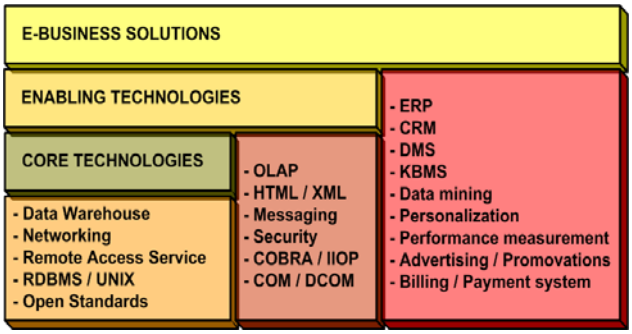

Figure 11. Knowledge based applications architecture.

To create an integrated decision framework, the organizations have to implement a number of KApps built on a platform (see figure 11) that is composed of three layers:

- ***E-business decision*** – support solutions that include 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 became interconnected via private networks and Internet. These increasing interconnections are facilitating development of KApps in three phases [11, 23]:

1. ***Corporate Intranets***, in which the companies are creating complete and uniform linkage of information and knowledge resources distributed through the organization. For the knowledge creation to occur, data aggregation needs also data analysis. Moving from departmental solution, in which data and reports are, developed for small, specialize communities of users, to corporate intranets, opens up data

resources to a broader base of users, by using the browser as a standard interface.

2. ***Extranets***, that are focusing on supply chain partners, in the conditions when the companies are moving parts of the internal corporate information infrastructure, so that suppliers and trading partners can access them (through fire-walls). The key business drivers are: fast access, customized data, and responsiveness. Standardized reports and interfaces are minimizing services requirements imposed by the management of huge data volumes, cross-platform coverage and support, response time speed, and a broad range of interface choices.

3. ***Commercial Internet Applications***, which focuses on new business models, created for capturing, consolidating, and reselling consumer information, business transaction records, and financial data.

At the present, most companies and corporate strategy is in phase I, with the emphasis on creating the ability to imitate decision-making through all levels of an organization.

Nevertheless, they are facing the challenges of performing complex computational analysis on collected data and of disseminating the information and knowledge not only to employees, but also to customers, suppliers, and business partners.

V. A KM SCENARIO FOR SMEs

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 [14].

The KM has received attention from designers responsible for the product development process because many of the design activities require a creative thought and is highly dependent on individual's or collective knowledge [15].

Also, KM is not technology but it can be benefited from new technologies of the information and of communication. KM 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. KM 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. KM is not marketing but it can help companies in the competitive intelligence. KM is not documentation but it is related to organizational collective memory. KM is not also administration of human resources but it only takes place with the people of the organization.

Figure 12. The essential questions at the SMEs level.

In fact, KM is a new area within information technology and management, a new field among the strategy, culture and information system an organization. We define KM as being the process by which the organization generates wealth, from their knowledge or intellectual capital. In this context, wealth happens when a SMEs 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.). Anyway, before start to collect and use knowledge, the companies need to have a good defined answer at the essential SMEs questions shows in figure 12.

The elements for a design activity include design goal, input knowledge and output knowledge. Collective learning elements [25] can be input knowledge, output knowledge, and collective learning goal, based on learning operators, and learning triggers. Once learned the information is stored in Collective Memory, used for current or future design practice and defined as the sum of individual memories and shared memories. Individual memories can be the memories of individual designers or computers. Shared memories can be the design documents, drawings, etc, shared by team members.

The similarities and differences between the individual and the collective designing are analyzed today with the focus on the what (input and output knowledge), the why and the how. In individual design, an actor carries out learning activities without interactions and sharing information with other actors, although an actor can learn based upon multiple knowledge sources. What is learned is stored in individual memory. However, in the context of collective design, the design process becomes more complicated in which actors can share their knowledge and collaborate in the design process [14]. KM for computer supported collaborative work in design includes [5]:

- ***Mechanisms for knowledge sharing*** – interested agents can share both input and output knowledge (to achieve this, some communication mechanisms between agents are required).

- ***Teach operators*** - the learning operators can transform input knowledge into output knowledge and shall be equipped within agents.

- ***Learning triggers*** – it's (e.g. failure or success of a design) will trigger one or more agents to learn.

- ***Collective memory*** - individual agents shall have their own memory for knowledge storage. Also, there shall be a common memory where all the agents can access to acquire knowledge and likewise agents can store their knowledge in the shared memory.

The knowledge of the organization contains the sharing knowledge of each individual [21]. For increase the knowledge in the enterprises for an efficient KM system of the intellectual capital, we define a methodology in ten steps: obtains and uses, learn and contribute, evaluates, sustain, support, exchange, combination, transfer, recovery and discharge (figure 13):

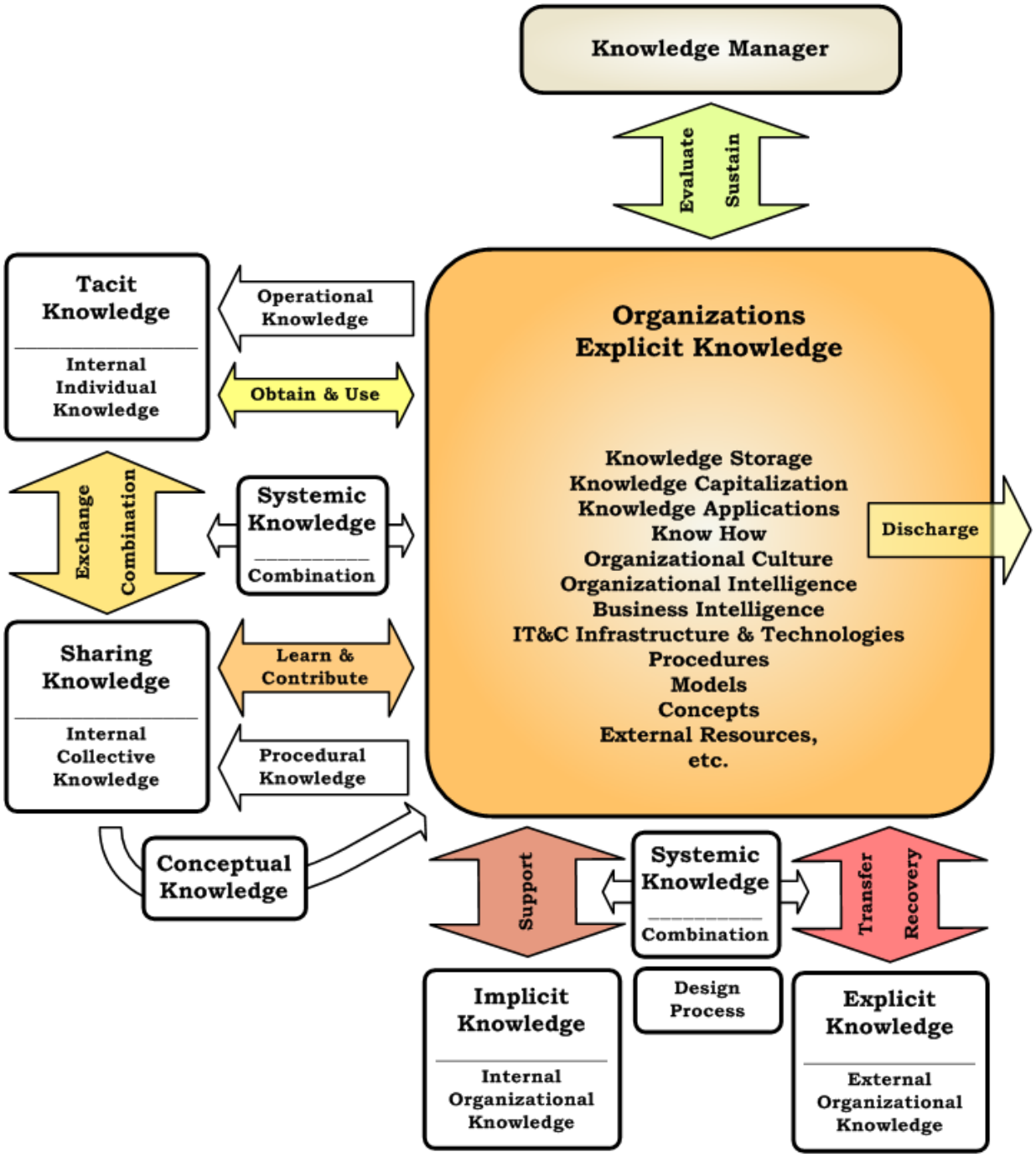

Figure 13. A KM scenario for KApps development.

1. ***The step obtains and use*** is 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 that flows within organizations can be correctly managed [4].

2. ***The step 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 organize, send and transfer certain types of information. However, the employee has seen this facility as a threat for his/hers own job security [4, 5]. The most difficult task is to convince individuals that their contribution will give return to their organization as well as to themselves.

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 organize the content in system on-line; he/she should understand and foresee the community's 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 making by means of the 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 that disappears because documentation isn't adequate or experts don't 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 transferred outside the organization.

VI. CONCLUSION

We could describe as follows the market situation of the European countries: 99% of companies in the EU are SMEs (companies with a maximum of 250 employees and a maximal turnover of € 50 million). In the European Union (Europe have 23 million SMEs and 41 000 large companies) SMEs employ more than 65% of all employees. During past years, SMEs have created 80 % of the new jobs in the EU (IP/08/1003, Brussels, and 25th June 2008). However, in the last time, a lot of research in the field of knowledge management is dedicated to large companies or international concerns and the small and medium-sized enterprises were forgotten. This is the main reason why in this paper was analyzed the knowledge conversion, the KKPs and the knowledge transfer at the SMEs level.

The paper also proposes a scenario used in the PREMINV platform to support KApps, based on the main internal and external SMEs knowledge resources used during the product development process and business strategies elaboration. Finally yet importantly, the paper presented how a knowledge base can be built at the SMEs level to support an enterprise department activity. This work realized at the UPB-PREMINV Research Center, in University "Politehnica" of Bucharest, is focusing on a university - SMEs partnership. The validation of this methodology by a case study in the CESICED project is to determine the new organization type for integrating the virtual enterprise medium and to outsource shared resources from UPB-PREMINV research centre to industrial partners.

We intend that our future work in this area includes building other knowledge bases (see figure 7) to support eventually all SMEs departments activities.

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