Empirical Study on Knowledge Based Systems

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Knowledge-based systems (KBSs) implement the heuristic human reasoning through specific techniques, procedures and mechanisms, in order to solve problems that do not have a traditional algorithmic solution. Research on this topic is being done in numerous organisations all over the world, from higher education laboratories to research institutes and software development organisations.

A first research project, aimed at gathering information about the State-of-the-Practice in building knowledge-based systems with practical applications, needed a preliminary study to ascertain if KBSs still exist today as a research topic, or the interest in them actually faded. The study was also required for finding organisations currently building KBSs for different domains. The project's aim was to catalogue the software and/or knowledge engineering methods employed by the listed organisations, in order to draw a comprehensive image (State-of-the-Practice) of the field. The current paper contains the results of this preliminary study only.

A second research project re-used the results of the preliminary study, focusing on the study of KBSs' successful implementations as a basis for building a method that would allow practitioners to choose the most appropriate KM tools for each organisation's specific problems and situations. A trigger for this second project was the interest in studying the causes of KBSs rejection by the end-users. An attempt to map the identified applications of KBSs to different phases of knowledge management lifecycle is also presented.

Keywords: knowledge-based systems, taxonomy, success, failure, knowledge management tools

1. Introduction

Knowledge-based systems (KBSs) implement the heuristic human reasoning through specific techniques, procedures and mechanisms, in order to solve problems that do not have a traditional algorithmic solution. Research on this topic is being done in numerous organisations all over the world, from higher education laboratories to research institutes and software development organisations. During the '80s and especially in the '90s, a huge number of projects were developed and implemented in this field, and there was an important effort to streamline the development of KBSs by creating engineering methods and tools like Common-KADS and Protégé. But in the last ten years, this attention seemed to continually fade and KBSs almost disappeared from the scene, being mentioned less and less often.

A first research project, aimed at gathering information about the State-of-the-Practice in building knowledge-based systems with practical applications, needed a preliminary study to ascertain if KBSs still exist today as a research topic, or the interest in them actually faded. The study was also required for finding organisations currently building KBSs for different domains. The project was to proceed afterwards with an inventory and the classification of software and/or knowledge engineering methods employed by the listed organisations (if any), in order to draw a comprehensive State-of-the-Practice image. The current paper contains the results of this preliminary study only (section 3), while sections 1 and 2 are intended to familiarise the reader with the domain of KBSs and to review previous research in the field.

Based on the results of the preliminary study, a second research project was developed, focused on the study of KBSs' successful implementations as a basis for building a method that would allow practitioners to choose the most appropriate KM tools for each organisation's specific problems and situations. A trigger for this second project was the interest in studying the causes of KBSs rejection by the end-users. It is well known today that even State-of-the-Art knowledge-based systems have failed in the past because of the lack of organisational concern for the adoption of the system by its intended users. Probably both research and developments emphasized too much the capturing, structuring and packaging of knowledge for reuse, neglecting the role of the human resource in the process. The findings added to the preliminary study during this second stage are presented in section 4.

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2. Knowledge Based Systems and their role

2.1 KBS definitions

The literature contains various definitions of this type of systems. From a strictly technical perspective, a KBS is:

> *"a program for extending and/or querying a knowledge base. A knowledge base is a collection of knowledge expressed using some formal knowledge representation language. A knowledge base forms part of a knowledge-based system (KBS)". (FOLDOC, 2000), or*
>
> *"A computer system that is programmed to imitate human problem-solving by means of artificial intelligence and reference to a database of knowledge on a particular subject."* (Computer User High-Tech Dictionary, 2004)

A description including both finality and functionality aspects belongs to the Elsevier Knowledge-Based Systems journal (Knowledge-Based Systems, 2004):

> *"**Knowledge-Based Systems** (the journal) focuses on systems that use knowledge-based techniques to support human decision-making, learning and action. Such systems are capable of cooperating with human users and so the quality of support given and the manner of its presentation are important issues."*

From the Artificial Intelligence perspective, KBSs are systems based on the methods and techniques of Artificial Intelligence. The knowledge base and the inference components are separated concepts. There are quite a wide range of opinions on what should and what should not be considered as being a knowledge-based system.

While Stelzer considers that expert systems, case based reasoning systems and neural networks are all three particular types of KBSs (Stelzer, 2003), there are other approaches considering that experts systems and neural networks are different and cannot be included in this category. Other authors also consider ontologies as belonging to KBSs. Davenport and Prusak speak of expert systems, case-based reasoning and neural networks when they gives examples of Artificial Intelligence technologies used to support knowledge management, and they never mention the concept of knowledge-based systems (Davenport, 1998).

The Artificial Intelligence and the Organisational Learning perspectives on KBSs are quite different. It seems a narrow, more technical meaning coexists with a broader one.

While from the Artificial Intelligence point of view, KBSs are "hardware & software systems which aim at supporting a specific task by using a specific form of knowledge representation (rules, frames, neural networks) where knowledge is usually highly formalized" (excluding groupware and knowledge sharing mechanisms), the Organisational Learning point of view considers them as being organisations – "a basic support for different specific tasks which includes knowledge in different representation forms (such as experiences, software, procedures, databases, process descriptions) and formalization degrees, and including groupware and knowledge sharing mechanisms" (Stelzer, 2003).

The Organisational Learning point of view sees KBSs as a larger concept and obviously includes the hardware and software systems mentioned by the Artificial Intelligence perspective.

Figure 1 presents a classification of the research sub-domains in Artificial Intelligence, based on the topics list provided by the International Journal of Knowledge-Based and Intelligent Engineering Systems (IJ KBIES, 2004).

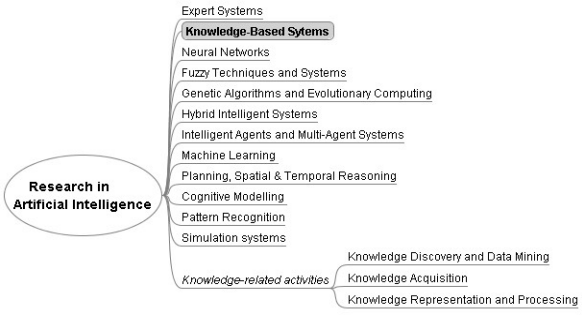

Figure 1: Research in Artificial Intelligence (based on the list of topics provided by the International Journal of Knowledge-Based and Intelligent Engineering Systems, 2004)

2.2 The relation of KBS to Knowledge Management

Compared to Knowledge-based systems, Knowledge management (KM) has a much broader scope, KBSs being only an enabler of KM.

We share Davenport and Prusak's point of view considering

> *'Knowledge management … concerned with the exploitation and development of the knowledge assets of an organisation with a view to furthering the organisation's objectives. The knowledge to be managed includes explicit, documented knowledge and tacit, subjective knowledge. Management of this knowledge entails all the processes associated with the identification, sharing and creation of knowledge. This requires systems for the creation and maintenance of knowledge repositories, and to cultivate and facilitate the sharing of knowledge and organisation learning.'(Davenport and Prusak, 1998)*

Knowledge management being studied from several different perspectives, such as: organisational learning, artificial intelligence, business informatics, sociology, psychology, information science, informatics, and so on, there are a variety of approaches to this domain. Three ideas are important in this respect: (1) KM is multi-disciplinary, (2) people and learning issues are central to KM and (3) technology is a useful enabler rather than a central tenet at the heart of KM.

Knowledge management includes:

- Processes: knowledge acquisition, codification, storage, use, transfer and dissemination;
- Technologies: KBS, groupware, intranet;
- Knowledge: tacit and explicit, formalized or not formalized;
- People;
- Organisational culture.

Another concept often employed to label an integrated combination of IT tools used to support and enable KM is that of **Knowledge Management System** (KMS). According to Ronald Maier (Maier, 2004), a KMS

> *"is an ICT system in the sense of an application system or an ICT platform that combines and integrates functions for the contextualized handling of both explicit and tacit knowledge, throughout the organisation or the part of organisation that is targeted by a KM initiative. A KMS supports networks of knowledge workers in the creation, construction, identification, capturing, acquisition, selection, valuation, organisation, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search and last but not least the application of knowledge the aim of which is to support the dynamics of organisational learning and organisational effectiveness". Besides Artificial Intelligence technologies, KMSs also include intranets, document and content management systems, workflow management systems, business intelligence tools, visualization tools, groupware and e-learning systems.*

Obviously, KBSs are just one of the applications of Artificial Intelligence included in the wide range of IT tools called Knowledge Management Systems and meant to support Knowledge Management initiatives.

2.3 The development of KBS

A KBS is a software application with an explicit, declarative description of knowledge for a certain application (Speel et al, 2001). There is no clear separation criterion between a KBS and an information/software system as almost all contain nowadays knowledge elements in them (Schreiber at al, 1999). Conventional software applications perform tasks using conventional decision-making logic -- containing little knowledge other than the basic algorithm for solving that specific problem and the necessary boundary conditions. This program knowledge is often embedded as part of the programming code, so that as the knowledge changes, the program has to be changed and then rebuilt. Knowledge-based systems collect the small fragments of human know-how into a knowledge-base which is used to reason

through a problem, using the knowledge that is appropriate.

The development process of a KBS is similar to the development of any other software system; phases such as requirements elicitation, system analysis, system design, system development and implementation are common activities. The stages in KBS development are: business modelling, conceptual modelling, knowledge acquisition, knowledge system design and KBS implementation (Speel et al, 2001).

A KBS is nowadays developed using knowledge engineering techniques (Studer et al 1998). These are similar to software engineering techniques, but the emphasis is on knowledge rather than on data or information processing. The central theme in knowledge engineering techniques is the conceptual modelling of the system in the analysis and design stages of the development process. Many of the knowledge engineering methodologies developed emphasise the use of models (Common KADS, MIKE, Protégé).
In the early stages, knowledge-based systems were built using the knowledge of one or more experts – essentially, a process of knowledge transfer (Studer et al 1998). Nowadays, a KBS involves "methods and techniques for knowledge acquisition, modelling, representation and use of knowledge" (Schreiber at al, 1999). The shift towards the modelling approach has also enabled knowledge to be re-used in different areas of one domain (Studer et al 1998). Ontologies and Problem-Solving Methods enable the construction of KBSs from components reusable across domains and tasks.

2.4 Utility of KBSs

The domain of application for KBSs is widening persistently, as new research topics emerge.

In the 90's, their foreseen usage directions were: design (the embedding of design rules within applications), diagnosis, instruction, interpreting observed data, monitoring, prediction (by inferring likely outcomes of given situation), prescription of remedies for malfunctions (Swartout, 1996).

Since 1996, the applications of KBSs extended a lot, today proliferating in speech recognition, computer vision, cognitive systems, and many others.

The original promises of Artificial Intelligence were never fulfilled – robots taking over all physical work and computer systems replacing clerks - but AI is still considered by scientists to be „the next Big Thing in science", while it is gradually moving more and more into everyday life. Today, KBSs are embedded in search engines that remember previous searches, legal software, social software – networking, automated pilots, medical diagnose, call centres, CAD applications, debugging tools.

Figure 2 contains a classification of Artificial Intelligence applications including KBSs.

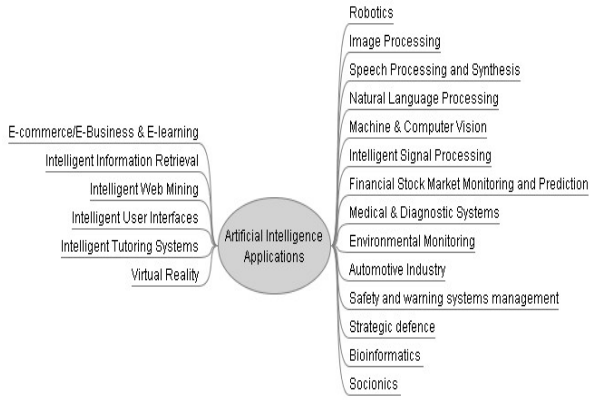

Figure 2: Artificial Intelligence Applications (based on the categories mentioned as research scope by the International Journal of Knowledge-Based and Intelligent Engineering Systems, 2004)

3. Research on Knowledge Based Systems

The preliminary study demonstrated that during the '90s, there was a special trend of using the designation "knowledge-based systems" for not only computer applications implementing Artificial Intelligence concepts, but also organisational systems that paid a special attention to knowledge acquisition, storage and retrieval.

3.1 Previous surveys

In order to get acquainted to previous research done in this direction, we examined several studies dedicated to the topic or to broader topics including references to KBSs. The conclusion was that plenty of surveys and study cases were performed, and several collections of good practices were built in the field of KM. But just few of these were focused on KBS. The reason for reviewing these studies was the attempt to identify trends and a possible comparison base.

3.1.1 Previous surveys on knowledge management

There are a substantial number of KM-related empirical studies reported in the literature. Most of these also touch the problem of different IT tools used as enablers for KM.

Maier holds the merit of reviewing the most important surveys performed by research institutes, consulting groups and prestigious publications between 1996 and 2001(Maier, 2004). Some of these studies included a few questions about information and communication technologies. Most of the surveyed organisations seemed to rely on more traditional ICT with no special focus on KM tools. Advanced KM-related technologies, such as AI technologies, were not used frequently (Maier, 2004).

Ronald Maier's own study on KMS, performed between 1997 and 2001, was targeted at KM strategy, organisation, tools and economics. The results showed that groupware technologies were the most popular, while the rest of tools were not intensively used, mostly because they required substantial organisational changes. (Maier, 2004)

3.1.2 Previous surveys on KBSs

In 1992, Germond and Niebur performed a survey on the development and experiences in using knowledge-based systems (Germond and Niebur, 1992). The study is mainly focused on the role of computers in power systems in Europe, but it also discusses the characteristics of main application areas and forecasted developments in the field. The authors used the KBSs designation to speak mainly about expert systems.

A study performed by Swartout (Swartout, 1996) and dedicated to future directions in knowledge-based systems, identified several problems such as: insufficient understanding of the structure of knowledge-based systems, expensive knowledge acquisition, focus on complete (but narrow) solutions. Swartout's study also contains notes on the solutions already in place at the time: separation of the different kinds of knowledge entered in the system, deployment of a knowledge engineering methodology for building KBSs, re-use of problem solving methods by using specific libraries, use of ontologies for supporting the building of knowledge bases, knowledge-acquisition tools meant for users (Protégé, Expert).

The 5-th Biannual Conference on Knowledge-Based Systems organised in Würzburg, Germany, published in its Proceedings four surveys dedicated to KBSs (Puppe, 1999). The surveys were focused on *Knowledge Engineering and its future directions* (Studer, Fensel, Decker and Benjamins), *Knowledge-Based Diagnostics* (Dressler and Puppe), *Knowledge-Based Configuration* (Günter and Kühn) and *Case-Based Reasoning* (Bartsch-Spörl, Lenz and Hübner). None of these studies takes into account the whole picture of KBS, focusing instead on either particular aspects of development and application, or on particular types of KBSs.

3.2 The current survey

The current paper aims at presenting the results of the preliminary study, i.e. presenting what is currently being done in different universities and research institutes under the knowledge-based systems designation, and showing that the interest in Artificial Intelligence in general, and in knowledge-based systems in particular, is still alive.

The trend is very well illustrated by the time span of "knowledge-based system(s)" mentions in research projects funded by the EU in the 1990-2004 period. From the total of 209 projects mentioning the term either in their title or in their description, 83 ended in 1993.

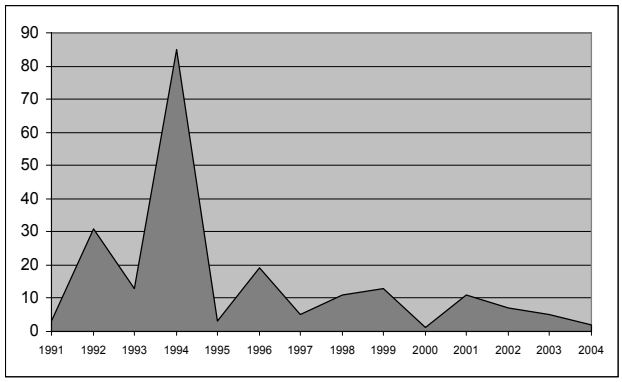

Figure 3: Projects related to KBSs funded by the EU (Source: the Projects database on cordis.lu)

Our findings showed that interest in KBSs as research topic has not ceased, but the topic itself shifted toward a more secondary role - KBSs being today generally embedded in other types of systems. They are probably here to stay, but they are not hype anymore.

Our preliminary study intended to map the current situation, by identifying institutions all over the world still using this designation and finding out what are the topics they are working on - a kind of thorough picture of

research done under this name. As mentioned in the introduction, an extensive literature and Internet research was undertaken, attempting to identify organisations still mentioning KBSs in their research agenda.

The study was aimed primarily at organisations involved in designing and implementing knowledge-based systems for practical use, and three categories of such organisations were identified: academia, research institutions and businesses. While academic and research institutions with interests in this field were relatively easy to identify, once the hype passed, there were not many businesses left to label their products with this name. There are still high class scientific publications and prestigious conferences using this name, and all these made us conclude that knowledge-based systems are still a topic of interest for both scholars and practitioners.

At a first stage, we performed an exploratory review of academic centres performing research in this field. We considered the academic environment to be less exposed to commercial trends and more inclined to perform both fundamental and applied research compared to research institutions and businesses, where commercial motivations could be prevalent. But today an important part of the academic research is also commissioned and funded by the industry, so a bias exists there too. We are talking essentially about designations here (names that sell better or do not) and not about the very content of the research.

In the end, it proved to be difficult to separate university research units from research institutes operating under the authority or co-operating with universities, and we did not find it relevant either, so that eventually we decided to consider them together.

Research done in companies under this title was much more difficult to identify; probably due to the influence of market trends on the product names, “knowledge-based systems” was replaced with something trendier in most of the cases. Meanwhile, we are pretty confident that KBS research and development are currently entrenched in a lot of software products on the market, and there are a lot of software companies doing research and development related to this field.

The preliminary study was mainly based on extensive literature and Internet research. We understand the risks involved by such an approach, the World-Wide-Web containing lots of outdated pages of past projects originating in the glory years of KBSs. A lot of research projects on this topic were funded at the time, and almost all of them displayed information on web sites later abandoned. We tried to avoid this by carefully checking the last update date of the web pages taken into account and taking into account only the ones updated in the last two years. We are aware of the limitations of our study and of its lack of completeness. The survey does not pretend to be exhaustive. It was used performing literature review and Internet searches using Google in five languages only, and only the most popular pages where checked. The focus was on building an inventory of organisations involved in the design and implementation of KBSs, including their location, type of organisation (academic, research, business), URL and main research topics**.**

The original research project, now stalled, planned to continue with a survey including the organisations identified as being involved in KBS research and development, in order to refine and update the collected information and to gather data on the software and/or knowledge engineering methods employed.

The criteria used for defining the boundaries of our preliminary study were:

1. from the wide range of organisations dealing with Artificial Intelligence in general, only research units mentioning “knowledge base(d) systems” either in their name and/or in the topics of interest were picked up;
2. only institutions active in researching, designing and implementing such systems were selected – there are a lot of other universities offering courses related to the topic;
3. only sources updated in the last two years (2002-2004) were retained.

The study identified 47 universities and research institutes performing research in Artificial Intelligence located in six European countries, Australia, Japan, USA and Canada.

From the 47 organisations identified as performing research in the domain of Artificial Intelligence technologies, 16 either present KBS as one of their research topics, or include knowledge-based systems in their unit’s name (e.g. “Knowledge Based Systems Group”, “Knowledge Based Intelligent Engineering Systems Centre”, “Centre for Knowledge-Based Systems”). Even if the others were not included in the focus group at this stage, we

are aware that many of them perform research on topics where KBSs are applied, so it is very possible that KBSs could be embedded in a way or another in their research.

3.3 Taxonomy of the approaches

The interesting part is that using the same name of knowledge-based systems, different research entities focus on very diverse sub-domains and applications. The name of KBS seems to be a sort of general umbrella covering both particular types of KBSs - such as Case-Based Reasoning Systems- and very general KBSs named "Intelligent Systems" and that could, in fact, be based on any other Artificial Intelligence technology. We tried to catalogue the research sub-domains addressed by these organisations in 2 different categories (KBSs and Applications of Artificial Intelligence). The numbers in brackets indicate the frequency of appearance of these sub-domains in the list of research topics of the selected organisations.

As one can see, the applications of Artificial Intelligence included range from the highest degree of generality ("Applied Artificial Intelligence"), to theoretical sub-domains such as "Knowledge Representation and Reasoning" and well known complex application such as "Document Processing". What we are trying to prove here is there are no precise limits between sub-domains leaving space for a lot of overlapping.

Table 1: Taxonomy of sub-domains mentioned in connection with KBSs

A. KBSs	**B. Applications of AI Knowledge**
KBS (7) Case Based Reasoning (1) Knowledge Based Intelligent Systems (1) Intelligent systems (1) Fuzzy systems (2) Multi-Agent systems (2) Neural Networks (2) Distributed KM (1) Decision support systems (1) Genetic algorithms (1) Semantic Web (2)	Representation and Reasoning (2) Applied Artificial Intelligence (1) Automatic Programming (1) Automated Translation (1) Cognitive Systems (3) Deduction and Multiagent Systems Document Processing (1) Image processing (1) Intelligent music processing (1) Intelligent software agents (1) Knowledge-based computer vision (1) Knowledge Discovery (1) Knowledge management support (1) Machine Learning (1) Natural Language Learning and Processing (1) Neural Computation (1) Pattern recognition (1) Planning and workflow (1) Robotics (3) Qualitative Reasoning (1) Spatial Semantic Hierarchy (1)

The fact that the concept of knowledge has different meanings for different specialists – it is *application of data and information* or *information in context* for the technologists, while some of the social and organisational scientists claim there can be no knowledge outside human heads – creates a lot of problems with names such as "knowledge base" and "knowledge-based system". What is stored in knowledge bases is actually knowledge or simply data organised on a higher level of abstraction? Does robotics and computer-vision involve the use of knowledge-based systems, if we consider knowledge as being strictly related to humans?

Another difficulty we encountered was the translation of the title in different languages and the possibly different scope and understanding of these translations. The fact that institutions that perform research and development in the field did not publish information on it in English, French, German, Italian or Spanish made us unable to locate them.

Despite a number of scientific magazines that include KBSs in their title and/or topics, we were not able to locate any joint repository pointing to most of these resources. While research on KBSs is just a small part of the Artificial Intelligence research performed in the world, the fact that different research groups focus on different matters makes it extremely heterogeneous. In order to encourage the building of such a repository in the future, a page dedicated to KBSs was created in Wikipedia (http://en.wikipedia.org/wiki/Knowledge-based_systems) and part of the results were added there.

As of the target readership of the current study, we expect it to be of interest for academics and practitioners involved in both KBS research and in building KBSs.

4. The deployment of KBSs in organisations

This section of the paper refers to another research project aimed at building a method for identifying the most appropriate KM tools in general (and KBSs in particular) for different situations in the real life. From the perspective of the narrow definition of a KBS, that of *a program for extending and/or querying a knowledge base collection,* we are examining the concrete situation of Knowledge Based Systems' deployment from the organisational point of view. Some KBSs successful implementations are briefly reviewed - followed by an analysis of the potential causes of KBSs rejection by their users. A first approach on the proposed methodology is presented and a presentation of the forecasted trends for the KBS domain is given in the end.

4.1 Successful implementations of KBSs

A number of application areas seem to profit the most from the deployment of KBSs. This type of systems, stand-alone or embedded in other tools, proved to be very useful in domains such as: natural-resource management, environmental monitoring and cleanup, construction, manufacturing, transportation, aerospace/defence, communications, electric-power generation, wholesale/retail distribution, financial services, logistics, law enforcement, medicine, pharmaceutics.

The experience of successful organisations showed that KBSs are likely to succeed when they focus on well-established, limited sub-domains, where knowledge can be properly modelled. In order to ensure their success, Hanley suggests that such systems should only be implemented in places where they can solve an identified problem (Hanley, 2003). The project must be (a)"do-able", (b) supported by management, and (c) accepted by people in the organisation.

4.2 Implementation failures and their possible causes

Several failures of technically sound knowledge-based systems in the past are today attributed to the lack of appropriate organisational measures to stimulate users in adopting the system. Probably both research and development activities put too much emphasize on knowledge capturing, structuring and packaging, neglecting the role of humans in the process.

One of the most difficult problems is to help users to employ the KBS and understand its advantages. If it doesn't fill a direct need and if the use of the systems means supplementary work, it is very probable that users will reject it unless they perceive a clear and direct advantage to balance the extra-work.

Knowledge has to be usually captured shortly after the experience occurrence, as close to the source as possible and in a structured way. This operation requires dedicated time and skills, and many users are reluctant to invest in it. Imposing a structure enhances retrieval, but hinders users in contributing experiences, as contributing is perceived as complicated and time-consuming. If the content of a knowledge base isn't properly filled and updated, there is a high risk of hampering its use after few unsuccessful attempts of getting advantage of it.

Lack of management sponsorship is another factor reported to be frequently leading to KBSs implementation failures. Appropriate training, a system of incentives or enforcement rules, together with the identification of possible champion users and the appointment of facilitators can prevent failure and avoid rejection. Another potential failure factor, in close connection with the previous, is the company culture - that should encourage knowledge sharing and clearly demonstrate its benefits. Feedback for contributing and re-using knowledge should be integrated in the organizational structure. There are numerous companies that while management declares it promotes knowledge sharing, actually encourages knowledge hoarding and do not pay proper attention to possible communication barriers.

Besides these human-related and organisational matters, user requirements being properly taken care of and usability are two other important aspects that if neglected could generate rejection.

4.3 Toward a methodology for selecting the most appropriate KM Tools

The technology has already undergone an adoption-rejection cycle, fed by initially unrealistic expectations and hype. A number of early adopting companies witnessed large-scale KBSs disasters, most of which occurred precisely because of the companies' overly ambitious faith in the concept of Artificial Intelligence rather than in the reality of KBS technology. However, another class of users—

the companies that implemented the technology on a smaller scale and treated it as just another tool with its own unique assets and limitations—has seen significant benefits. Success stories are still largely in the shadow of early disappointments, but the list of systems with impressive return-on-investment numbers is growing. The point seems to be selecting the right technologies for solving specific problems, paying attention to parameters such as the problem's scale, the risks involved, the objectivity degree of the involved knowledge.

Attempting to build a methodology for KM tools selection, we picked up the "regions of KM practices" model (Despres and Chauvel, 1999) and tried to map the different types of KBS technologies and applications on it.

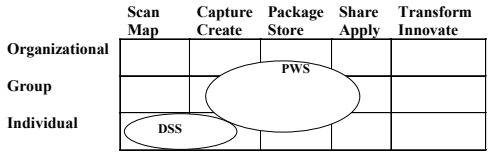

Figure 5: Regions of Practice in KM Source: Despres, Ch., Chauvel, D. (1999). "Knowledge management(s)"

The original model contained a third dimension, separating tacit and explicit knowledge, but we decided to give it up as being irrelevant for this particular case, because by focusing on KBSs, we implicitly take into account explicit knowledge only.

While attempting to map the different techniques and applications resulted from the preliminary study and connected to KBSs on this model, we realised that it is very difficult to locate the exact phase in the knowledge lifecycle and the level where they would fit. For example, Decision Support Systems (DSS) seem appropriate to be used on the individual level and during the scan/map and capture/create phases, but, depending on the implementation, they could as well support teams for making decisions and could contribute to knowledge transformation by proposing an alternative nobody thought of. Planning and workflow systems (PWS) are useful at all three levels and throughout the capture/create, package/store and share/apply phases. But what can we do about generic titles -such as Expert Systems or Document Management? They are too general for finding their place in that table. Certain techniques are never visible to the users, as they are embedded in search engines remembering our preferences, in automated translation tools we access on the Net or in educational software or computer games.

4.4 Current trends

The future appears to be bright for hybrid systems that derive their "expertise" by combining automated extraction of knowledge from data with human experts in specific knowledge domains. These hybrid systems will become increasingly popular as the increasingly digital world gives rise to massive amounts of data that require analysis and as people turn to experts to help them deal with greater complexity and uncertainty (SRI Consulting Business Intelligence, 2003). The signs show that the traditional marketplace for KBSs vanished. Nowadays, they are intrinsically integrated in various Knowledge Management tools, and there is a strong tendency of seeing them as accessories of knowledge workers, rather than a possible substitute for their role.

According to SRI Consulting Business Intelligence, some of the trends of the moment involving KBS deployment are: distributed Artificial Intelligence; real-time KBS; visualization software; standards development; the semantic web; open knowledge bases (SRI Consulting Business Intelligence, 2003).

5. Conclusion

As a result of the study, we can conclude that KBSs have not fallen out from the research agenda, but became a basic technique applied in various current research developments, such as ambient intelligence, artificial vision, pattern recognition etc. The study confirmed that the interest in KBSs as research topic has not ceased, but the topic itself shifted toward a more secondary role - KBSs being today generally embedded in other types of systems. They are probably here to stay, abut not holding the main stage anymore - the list of selected research entities and their associated topics attesting it.

Together with the article on KBS created in Wikipedia, we posted there our shortlist of research entities focused on this field, and we pointed at the most important journals dedicated to the topic, as a starting point for a central repository of information on KBSS.

A first step was made in building a method that would allow practitioners to choose the most appropriate KM tools for each organisation's specific problems and situations. Further, the existing tools will have to be catalogued, the

alternatives for each situation have to be found, and the first guidelines drawn.

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