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Abstract: This report presents a survey of some methods, techniques and tools aimed at managing corporate knowledge from a corporate memory (CM) designer's perspective. In particular, we analyze problems and solutions related to the following steps: detection of needs of CM, construction of the CM, its diffusion (specially using the Internet technologies), its use, its evaluation and its evolution.

Key-words: corporate memory, organizational memory, technical memory, knowledge management.

(Résumé : tsvp)

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Méthodes et Outils pour la Capitalisation des Connaissances d'une Entreprise

Résumé : Ce rapport présente une synthèse des méthodes, techniques et outils pervisant à la capitalisation des connaissances d'entreprise, cette présentation étant faite du point de vue d'un concepteur de mémoire d'entreprise. En particulier, nous analysons les problèmes et les solutions relatifs aux étapes suivantes : détection des besoins en mémoire d'entreprise, construction de la mémoire d'entreprise, diffusion (en particulier en utilisant les technologies de l'Internet), utilisation, évaluation et évolution de la mémoire d'entreprise.

Mots-clé : mémoire d'entreprise, mémoire technique, capitalisation des connaissances.

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1 INTRODUCTION

1.1 Corporate Memory: Definitions

The objectives of knowledge management (KM) in an organization are to promote knowledge growth, knowledge communication and knowledge preservation in the organization (Steels, 1993). It entails managing knowledge resources in order to facilitate access and reuse of knowledge (O'Leary, 1998a). Knowledge management is a very complex problem and can be tackled from several viewpoints: socio-organizational, financial and economical, technical, human, and legal (Barthès, 1996).

There is an increasing industrial interest in the capitalization of knowledge (i.e. both theoretical knowledge and practical know-how) of groups of people in an organization, such groups being possibly dispersed geographically. In (Van Heijst, Van der Spek, and Kruizinga, 1996) *«corporate memory»* is defined as an *«explicit, disembodied, persistent representation of knowledge and information in an organization»*. For example, it may include knowledge on products, production processes, clients, marketing strategies, financial results, plans and strategical goals, etc. (Nagendra Prasad and Plaza, 1996) define corporate memory as «*the collective data and knowledge resources of a company* including project experiences, problem solving expertise, design rationale, etc»: it may include databases, electronic documents, reports, product requirements, design rationale, etc. Its building relies on the *«will to preserve, in order to reuse them later or the most rapidly, reasonings, behaviours, knowledge even in their contradictions and with all their variety»* (Pomian, 1996). Knowledge capitalization is the process which allows to reuse, in a relevant way, the knowledge of a given domain, previously stored and modelled, in order to perform new tasks (Simon, 1996). The purpose is to *«locate and make visible the enterprise knowledge, be able to keep it, access it and actualize it, know how to diffuse it and better use it, put it in synergy and valorize it»* (Grundstein, 1995).

Several kinds of knowledge can be found in a company: *explicit* or *tacit knowledge* (Nonaka, 1991). Therefore, in any operation of knowledge capitalization, it is important to identify crucial knowledge to be capitalized (Grundstein and Barthès, 1996). It has an influence on the kind of CM needed by the enterprise. This CM should help to support the integration of resources and know-how in the enterprise and the cooperation by effective communication and active documentation (Durstewitz, 1994). As often emphasized, a CM should provide *«the right knowledge or information to the right person at the right time and at the right level»*.

As noticed in (Nonaka, 1991; Van Engers, Mathies, Leget and Dekker, 1995), the knowledge chain consists of seven links: listing the existing knowledge, determining the required knowledge, developing new knowledge, allocating new and existing knowledge, applying knowledge, maintaining knowledge, disposing of knowledge. In this paper, we adopt the definition proposed by (Van Heijst, Van der Spek, and Kruizinga, 1996), and we extend it slightly by considering a CM as an *«explicit, disembodied, persistent representation of knowledge and information in an organization, in order to facilitate its access and reuse by adequate members of the organization for their tasks»*. We propose to consider the building of the CM as relying on the following steps (summed up in Figure 1, inspired of (Dieng et al, 1998)):

1. *Detection of needs in corporate memory,*
2. *Construction of the corporate memory,*
3. *Diffusion of the corporate memory,*
4. *Use of the corporate memory,*
5. *Evaluation of the corporate memory,*
6. *Maintenance and evolution of the corporate memory.*

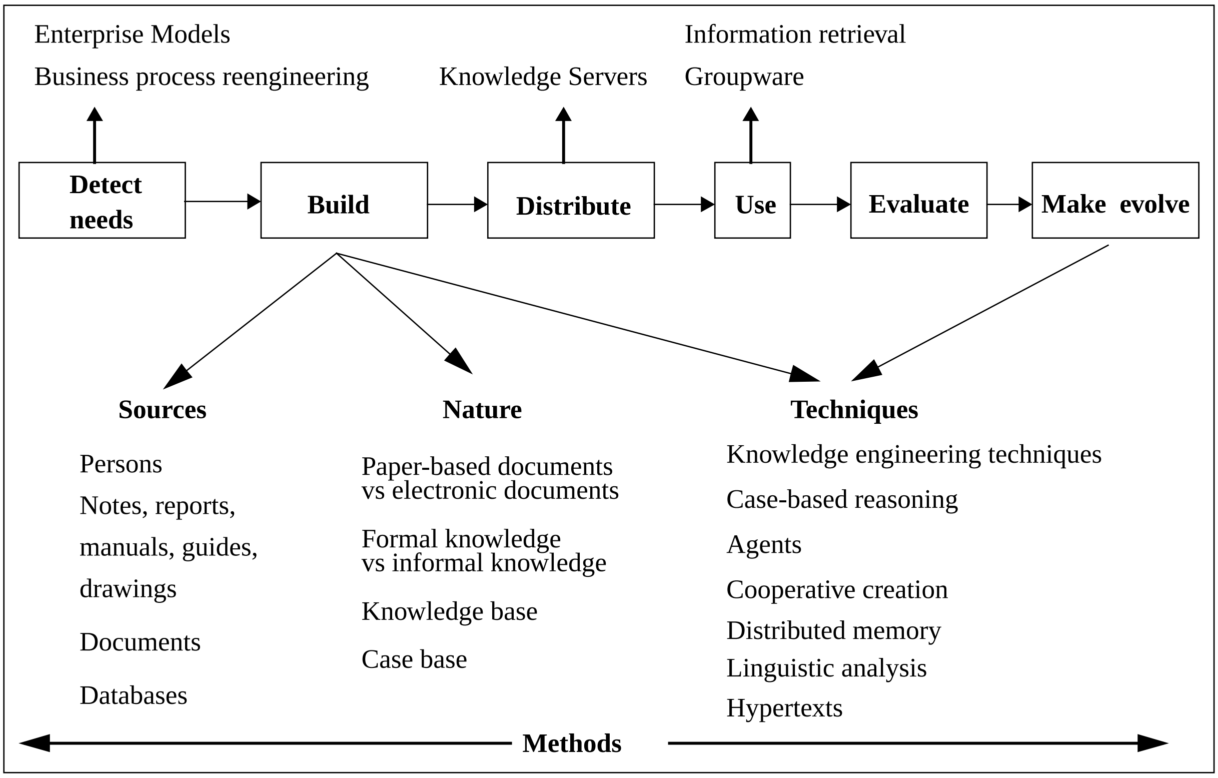

Fig.1: Corporate Memory Management

For each step, we will analyse some methodological or technical proposals offered by researchers. Let us notice that several kinds of publications can be found: survey on KM, analysis of types of knowledge available in a company, reports of industrial experiments, proposal of a general architecture for CM, thorough study of a particular technique such as some knowledge-processing techniques stemming from artificial intelligence (AI) and used here for solving a peculiar problem underlying computational CM building. The variety of research topics possibly involved in CM management is illustrated by Figure 1. Clearly, this complex problem has at least organizational aspects to be tackled, and technical aspects to be solved. According to (Kühn and Abecker, 1997), computer scientists concerned by the use of Information and Communication Technology for KM support tend to ignore the specific requirements and constraints for successful knowledge management in industrial practice while specialists in KM often treat only roughly the aspects of computer support. Therefore, building a CM requires a multidisciplinary approach.

1.2 Corporate Memory Industrial Needs

An enterprise is not only a unit of production of goods or services conform to the expectations of clients, in the best conditions of cost, deadline and quality, but it is also a knowledge production unit (Grundstein, 1995). The nature of the needed CM and the efforts needed for building it may depend on the size of the company (cf. wide-sized groups vs small-sized and medium-sized firms). The motivations can be various: (a) to avoid loss of know-how of a specialist after his retirement or mutation, (b) to exploit the experience acquired from past projects, and to keep some lessons from past, in order to avoid to reproduce some mistakes, (c) to exploit the knowledge map of the company for the corporate strategy: a regular inventory of the firm know-how should improve the enterprise ability to react and adapt to change, (d) to improve information circulation and communication in the enterprise, (e) to improve learning of employees in the enterprise (new as old employees), (f) to integrate the different know-how of an organization.

1.3 Knowledge in the Enterprise

Several typologies of knowledge in the enterprise were proposed in literature. They can be useful to determine the essential knowledge the company needs to capitalize (Durstewitz, 1994). (Grundstein, 1995; Grundstein and Barthès, 1996) distinguish on the one hand, *know-how* (ability to design, build, sell and support products and services) and on the other hand, *individual and collective skills* (ability to act, adapt and evolve). They distinguish tangible elements (data, procedures, plans, models, algorithms, documents of analysis and synthesis) and intangible elements (abilities, professional knacks, private knowledge, knowledge of company history and of decisional contexts...). Therefore, they suggest that in a capitalization operation, tangible elements can be taken into account through KM (technical data management, document management, configuration management), while intangible elements require know-how formalization (acquisition and representation of know-how and reasoning on such know-how). Know-how, technical facts, product requirements, design rationale, experience or expertise are examples of knowledge types useful for corporate memory (Durstewitz, 1994).

1.4 Typologies of Corporate Memories

The memory of an enterprise includes not only a «technical memory» obtained by capitalization of its employees' know-how but also an «organizational memory» (or «managerial memory») related to the past and present organizational structures of the enterprise (human resources, management, etc.) and «project memories» for capitalizing lessons and experience from given projects (Pomian, 1996).

(Tourtier, 1995) distinguishes: (a) *profession memory*, composed of the referential, documents, tools, methods used in a given profession, (b) *company memory* related to organization, activities, products, participants (e.g. customers, suppliers, sub-contractors), (c) *individual memory* characterized by status, competencies, know-how, activities of a given member of the enterprise, *project memory* comprising the project definition, activities, history and results.

(Grundstein and Barthès, 1996) distinguish *company technical knowledge* (i.e. used everyday inside the company, its business units, departments, subsidiaries by the employees for performing their daily job) from *strategic corporate knowledge* used by the company managers.

In addition to these typologies, we add another distinction between *internal memory* (corresponding to knowledge and information internal to the enterprise) and *external memory* (corresponding to knowledge and information useful for the company but stemming from external world).

1.5 Outline of the Report

The report will successively analyse problems and solutions linked to detection of needs, construction of the CM, its diffusion, use, evaluation and maintenance. Then we will give several examples of dedicated methods and we will summarize the lessons of this study.

2 KNOWLEDGE MANAGEMENT

2.1 Detection of Needs of Corporate Memory

As successful information system development in general, successful CM development must be «underpinned by a clear focus on the situations of use and the needs of users» (Thomas, 1996), i.e. on the human issues of the development. The history of systems development «shows repeatedly that it is the human issues which «make or break» new methods and tools at work»

(Buckingham Shum, 1997). So detecting the «right» users' needs, or the «right» CM needed, is the first task of the CM designers.

2.1.1. Problems

Detecting the «right» needs is not a simple task. CM designers have to learn as much as possible about who users are, which tasks they have to perform, in which situations, which knowledge types they need to memorize and retrieve (for achieving the tasks), which tools they use, etc. So doing, CM designers have to face with problems about users, tasks, situations, etc. Examples of such problems are:

- *Users' types:* Who are the «right» users to consider? How to take account of the multiplicity of CM users? Is it worth considering every potential user of the CM? Concerning the first question, for example, managers of the LJC corporation (a French joint factory) claimed that the customers are important to consider, because they «have the entire knowledge of the product in situation» (Guérin and Mahé, 1997).
- *Users' characteristics and behaviours:* Which are the «right» users' characteristics and behaviours to consider? How to «take account of the users' multiple and probably incommensurate perspectives» (Kurland and Barber, 1995)? Can we ignore such «side» users' behaviours as «trusting» (Jones and Marsh, 1997)? Which meaningful knowledge storing and knowledge retrieving activities do users perform to achieve their tasks?
- *Tasks:* Which are the «right» tasks or goals to consider? For example, Simone (1996) identified the following goals of collective memory in the context of dynamic complex situations: (a) innovating; (b) increasing cooperation; (c) managing turn-over; (d) handling exceptions; (e) dealing with critical situations.
- *Situations:* Which are the «right» situations, or contexts, to consider? For example, dynamic complex situations (e.g., emergency management, traffic control, rescue services, industrial plant control) will imply CM requirements different from less dynamic situations (cf. Wærn 1996).
- *Knowledge:* Which is the «right» knowledge to consider? Where to get it? What can we do if the source users (those who have the «right» knowledge) have been transferred, or have resigned, dismissed, or retired (Guérin and Mahé, 1997)?
- *Errors:* Which are the important CM errors to consider? How to

handle them? For example, Loftus (1997) reported very interesting studies about false memories showing that «when people who witness an event are later exposed to new and misleading information about it, their recollections often become distorted».

CM developers have to face not only with such «first-order» problems (i.e., problems concerning users directly), but also with «second-order» problems (i.e., problems that directly concern designers). How these «second-order» problems are faced with may have great implications on the needs detection task. Examples of such problems are:

- *CM project ambition:* Is the project realistic? A major obstacle to the project achievement is that developers often want «too much, too soon» (Knapp, 1997).
- *CM design perspective:* Is the goal to create a brand new CM (design), or improving an existing one (redesign)?
- *CM underlying representation:* Must CM be considered as an object or as a process (cf. Bannon and Kuutti, 1996)?
- *Productivity paradox:* How to cope with the productivity paradox, «whereby the availability of more and more information has actually resulted in reducing the production of the users» (Sorensen et al., 1997)?
- *Context paradox:* How to cope with the context paradox, i.e. «the possibility that more context will be needed to interpret whatever contextual information has already been provided» (Buckingham Shum, 1997)?

2.1.2. Solutions

Here are some of the solutions currently adopted to detect CM needs.

Underlying Approach: «Stakeholder-Centered Design»

The approach to needs detection cannot be disconnected from the approach to the overall development of the CM, or underlying approach. The main underlying approach is the so-called User-Centered Design (UCD), or Human-Centered Design (HCD), approach. The reason for using a UC[H]D approach is «to ensure that the memory is defined in terms of users' needs» (Durstewitz, 1994). The related UC[H]D methods «cover requirements determination, design and implementation, and are concerned with the social as well as technical issues in new system development [...]. The philosophy underpinning this approach is that effective systems are created by a partnership between developers and the users and/or stakeholders in the organisation which is to operate the new system» (Eason and Olphert, 1996). The term «*stakeholders*» is worth discussing here. This term refers to «any individual within the community where the system may be implemented who has an interest or «stake» which may be affected by the system» (Eason and Olphert, 1996); it refers to «anyone who stands to gain from it [the system], and anyone who stands to lose» (Macaulay, 1996). Stakeholders include «potential users but are not restricted to them; other stakeholders may be purchasers, customers, maintainers, etc. » (Eason and Olphert, 1996). The current trend among CM developers is to consider stakeholders rather than users (strictly speaking). So CM design/development could be called Stakeholder-Centered Design/Development. As (Eason and Olphert, 1996) claimed: «Systems development should be a partnership in which developers contribute an understanding of the technical opportunities and the methods of design, and the stakeholders contribute their expertise about the domain of application and existing organisational practices and have a right to judge what is in their best interests as the potential owners of the future that is being constructed.»

Approaches to Requirements Analysis

Approaches to needs detection can be appropriately described in terms of requirements analysis, because (1) getting at the users' needs is the aim of requirements analysis (Thomas, 1996), and (2) research on CM and KM often refers to requirements analysis (e.g., Kühn and Abecker, 1997). «The earlier designers of systems understand the needs and problems of their users, and [...] the better they understand them then the more able they will be to develop systems which meet users' needs», according to (Macaulay, 1996), that describes four types of approaches to CSCW requirements analysis (cf. a great amount of CSCW work is done in the context of CM (Wærn, 1996)):

Traditional approaches. Traditional approaches are approaches such as the structured analysis approach, or the object-oriented approach (cf. OO Analysis). In such approaches users have a passive role; they are considered as the sources of information and the reviewers of models developed, and the systems analyst is considered as responsible for eliciting requirements from users.

Participation. In the Participation approach, «users are expected to contribute», by assisting in analysing their problems at work, complete job satisfaction questionnaires, etc. Participation is used «in situations in which initiators of projects do not have all the information needed to design the change, and where users have considerable power to resist».

Design Team. The formation of a design team is often recommended «to smooth the transition from requirements to design». In the design team, the roles of the technical experts and the customers are clearly identified. Technical experts «contribute their skills to the creation of a system», and customers «are concerned with the world they will have to inhabit after the change caused by the system».

Group Sessions. In the Group Sessions approach, people «jointly design systems in facilitated group sessions». Macaulay's cooperative requirements capture (Macaulay, 1996) is a stakeholder-centered approach consisting of the following steps: (1) identify the problem; (2) formulate the team; (3) group session 1: explore the user environment; (4) validate with users; (5) group session 2: identify the scope of the proposed system; (6) validate with stakeholders. Each group session has a number of steps; for example, session 1 includes: (a) the business case, (b) workgroups, (c) users, (d) tasks, (e) objects, (f) interactions, (g) consolidation. Each step includes an introduction, brainstorming, prioritisation and generation of agreed descriptions using checklists and proformas which deal with user related issues.

It is important to notice that requirements analysis is strongly related to evaluation: if for requirements analysis the aim is «to get at users' needs», for evaluation the aim is «to tune the system to make sure that it really does meet those needs» (Thomas, 1996).

Methods: Classics

Literature Review. Analysing the literature on CM is one of the classical methods used to detect CM needs. For example, from the Macintosh's (1997) work on knowledge asset management, Kühn and Abecker (1997) elicited the following «major impediments to more productivity in knowledge-based work process»: (a) Highly-paid workers spend much of their time looking for needed information; (b) Essential know-how is available only in the heads of a few employees; (c) Valuable information is buried in piles of documents and data; (d) Costly errors are repeated due to disregard of previous experiences; (e) Delays and suboptimal product quality result from insufficient flow of information. These impedements can be considered as introducers to requirements.

Interviews/Discussions. Performing interviews or discussions is another classical method used for identifying CM needs. For example, Kühn and Abecker (1997) had interviews with prospective users and discussions with IT personnel and managers to get requirements. They suggest crucial requirements for the success of a CM information system project in an industrial practice: (a) Collection and systematic organization of information from various sources; (b) Integration into existing work environment; (c) Minimization of up-front knowledge engineering; (d) Active presentation of relevant information; (e) Exploiting user feedback for maintenance and evolution.

Observations/Experiments. Observing real CM practices or conducting experiments about them, are a third classical method used to detect CM needs. For example, observing the Design Rationale activity of a real industrial project conducted in a design office of Aerospatiale, the French aerospace company, Karsenty (1996) showed that designers having to reuse a past solution elaborated by others, often asked themselves: «Why did they do so and not else?» If they had no answer to this question, experienced designers often considered the alternative solution they spontaneously found as better than the past one (even if it the later revealed itself worse). Less experienced designers often selected the past solution. These results suggest requirements such as: a CM for Aerospatiale designers should contain justification or argumentation knowledge; this knowledge must be «past-solution oriented» for experienced designers, and «present-solution oriented» for less experienced designers.

Dedicated Methods and Approaches: Some Trends

Lead User Methodology. The «lead user methodology» (Urban and von Hippel, 1988) prescribes to perform needs detection with «lead users». Lead users are «users whose present strong needs will become general in a marketplace months or years in the future».

Advisibility Analysis. The CORPUS project (Grundstein and Barthès, 1996) offers a process-centered and problem-oriented approach called Advisibility Analysis for knowledge capitalization. The purpose is to help to determine the nature and field of crucial knowledge that needs to be capitalized, the company members who have this knowledge, in which form, the members who use this knowledge, when and how, and the risks in case no capitalization operation is performed. The main steps of this approach are: (1) Determine sensitive processes essential for the company functioning; (2) Distinguish determining problems that fragilize critical activities (i.e. activities contributing to sensitive processes); (3) Determine crucial knowledge necessary to solve determining problems.

Enterprise Models. Some research focus on enterprise analysis and modelling (Fox, 1993) [http://www.aiai.ed.ac.uk/~entprise/enterprise/] and can be useful during a CM construction. For example, the evolution of the enterprise through time, its experience acquired from past projects are elements interesting to take into account. An enterprise ontology, defining concepts relevant for description of an enterprise, is proposed in (Uschold, King, Moralee, and Zorgios, 1998). Such an ontology can be used as support for exchange of information and knowledge in the enterprise (Fraser, 1994). Organizational structure, processes, strategies, resources, goals, constraints and environment of the enterprise can thus be modelled. Intra-enterprise modelling and inter-enterprises modelling can be distinguished. (Beauchène, Mahé and Rieu, 1996) models an enterprise organization, using a model stemming from quality management and focusing on «customer-supplier» relationships between the enterprise members. The interest of exploiting an enterprise model is to determine the weak points of the enterprise, that could possibly be improved by a knowledge capitalization operation.

A distinction is often made between process-oriented and product-oriented models of the enterprise. A process-oriented view on the organization can be inspired of research on workflow management: for example, (Maurer and Dellen, 1998) offers a process modelling language for representing knowledge upon work processes (e.g. «process, product and resource models, project plans and schedules, products developed within projects, project traces, background knowledge such as guidelines, business rules, studies»).

The MNEMOS EUREKA project (see http://www.delab.sintef.no/MNEMOS/dir.html) aimed «to develop a new generation of information systems to increase the competitivity of the enterprise through a better circulation of the corporate knowledge, a more efficient management and support to the human creativity processes». This project proposed an enterprise model based on eight dimensions: document, programme, budget, contacts, organization, material, calendar, results (Feray et al, 1998).

Cognitive Models. Theoretical models of workers' cognitive functioning and of knowledge used in work situations may be useful for needs detection purposes. (Bollon, 1997) showed the interest of these models and especially the methodological precautions they induce during field observations conducted to capitalize knowledge (see also Poitou, 1997.)

Anthropotechnology. Anthropotechnology (Wisner, 1997) refers to the transfer of organisational systems and technologies in countries having different cultures. This methodology can be applied to design within the same country or the same organisation, in which different-culture subgroups can be identified. From the anthropology viewpoint, culture-related requirements need to be identified for a successful transfer.

Knowledge Networking. From the point of view of expertise sharing between CM developers, a project which anticipates what would happen in the future of CM development practice is CERES-GKN [http://www.cerc.wvu.edu/ceres/CERESGKN_brochure.html]. The goal of this project is to construct «a global knowledge network to enable environmentally sound product and process development». CERES-GKN «will identify consumer and producer requirements and needs for an environment-oriented infrastructure and product and process application». CERES-GKN «will develop a global network of knowledge bases (both proprietary and public domain) containing a variety of knowledge -- such as best practices, case studies, and expert advisory systems -- useful for designing products and processes that are at once environmentally sound, technologically feasible, and economically justifiable».

2.1.3. Conclusion

The phase of needs detection may help to determine the type of CM needed (e.g. project memory, profession memory, organizational memory, individual memory), the potential users of the CM, and the possible modes of exploitation useful and adapted to their work environment.

2.2 Construction of the Corporate Memory

As emphasized during KAW'96 track on «Corporate Memory and Enterprise Modelling», a corporate memory is of course different from a knowledge-based system. The techniques adopted to build a CM depend on the available sources: human specialists, existing paper-based or electronic documents such as reports or technical documentation, E-mails, existing databases, case libraries, dictionaries, CAD drawings... They also depend on the nature of the needed CM according to the intended users: it may consist of paper-based documents making explicit the enterprise adequate members' knowledge, that had never been yet elicited and modelled (Dieng et al, 1998). It may also be a computational memory materialized through an intelligent documentary system, a database, knowledge base, a case-based system, a Web-based system or a multi-agent system. We note that even though paper-based or electronic documents can themselves represent a CM they are often considered as a first step in the implementation of the CM (Simon,1996).

In the next sections, we describe different approaches for the construction of a CM.

2.2.1. Non Computational Corporate Memory

A *non computational memory* is made of paper-based documents on knowledge that had never been elicited previously. The construction of such a memory may be guided by two different aims: (a) to elaborate synthesis documents on knowledge that is not explicit in reports or technical documentation, and is more related to the know-how of the experts of the enterprise, (b) to improve enterprise production through expert propositions on their tasks in a design process.

In the first aim, the memory is composed of knowledge described in existing documents and interviews of experts, or elaborated from observations of experts' activities. The KADE-TECH Company proposes a method called CYGMA (Bourne, 1997) to produce different documents that contain memory about a profession (see below section 3.1). (Simon, 1996) considers that this kind of memory provides «a global view of the knowledge of the firm», and «allows experts from different sites to describe their knowledge in the same format in order to be able, afterwards, to compare them more easily». But in (Simon, 1996), this elaboration of synthesis documents is a first step in the construction of the computational CM that it helps to implement: it enables homogeneization of know-how in different sites of an enterprise distributed geographically.

In the second aim, the firm RENAULT proposes MEREX approach (Corbel, 1997). This approach, guided by the Quality approach, is based on positive and negative experience return on previous projects. The memory is constituted by forms, where an expert can describe a solution or a decision in a task of design process. Those forms are validated by a system of check-list and stored in a form management system. They are used in the product specification phase, before the artefact design.

Remark: Notice that often such paper-based documents are put later in an electronic form, but we make a difference between simple electronic documents and an actual documentary system.

2.2.2. Document-based Corporate Memory

A document-based CM relies on the principle that all existing documents of the firm can constitute the CM. But those documents are not well-indexed or they constitute a personal bibliography for each expert of the firm. So the construction of such a CM begins by indexing all reports, synthesis documents or references used by the different experts. It requires an interface to manage documents (addition of documents, retrieval of documents...).

(Poitou, 1995) considers that: «a good documentation system is very likely the least expensive and the most feasible solution to knowledge management» and prefers a computer assistant to documentation (i.e. to writing or reading) rather than knowledge representation: according to him, a document is already a representation of knowledge. So the main need is assistance in preparing, storing, retrieving and processing documents. The notion of corporate knowledge collective management system (Poitou, 1997) answers well to this need: e.g. SG2C proposed by Poitou and DIADEME proposed by Electricité de France (Ballay and Poitou, 1996).

In his principle for knowledge management, (Ballay, 1997) distinguishes several integration levels of documents that may be exploited in a CM: (1) expertise check-lists (e.g. reference bibles in a given profession), (2) visual documents such as photos, scanned plans, iconographic documents, (3) usual office documents (such as technical reports, norms, archive documents, documents digitalized by Optical Character Recognition), (4) (multimedia) hyperdocuments (e.g. guides, dossiers of technological intelligence, on-line documentation, user manuals, digital books, business dossiers, etc).

2.2.3. Knowledge-based Corporate Memory

Knowledge engineering is naturally useful for building a CM based on elicitation and explicit modelling of knowledge from experts or even for a formal representation of knowledge underlying a document. Therefore several researchers that have been working on expert systems for years evolved towards CM building where they could exploit their past experiences. However, the goal of a CM building is less ambitious than an expert system: instead of aiming at an automatic solution for a task (with automatic reasoning capabilities), a CM rather needs to be an assistant to the user, supplying him/her with relevant corporate information but leaving him/her the responsibility of a contextual interpretation and evaluation of this information (Kuhn and Abecker, 1997). (Kuhn and Abecker, 1997) notices that «in contrast to expert systems, the goal of a CM is not the support of a particular task, but the better exploitation of the essential corporate resource: knowledge» but, however, cites some knowledge-based CM implemented through an expert system (e.g. KONUS system aimed at support to crankshaft design). In (O'Leary, 1998b), the author describes several kinds of knowledge bases useful in consulting firms: engagement knowledge bases, proposal knowledge bases, news knowledge bases, best-practice knowledge bases, expert knowledge bases.

Knowledge engineering methods such as COMMET and CommonKADS can be useful in the construction of a CM, because they allow to analyse and represent an activity on the knowledge level. (Steels,1993) notices that the organization of a production is more and more horizontal, i.e. the production is organized through activities gathering experts stemming from different departments. So the CM of such an enterprise can be based on activity description through three perspectives: task, method and information and can thus be realized using KREST. By the same way, even though CommonKADS was not primarily dedicated to CM building, some models offered by CommonKADS (organization, task, agent, communication and expertise models) give an interesting basis for knowledge-based CM (Kingston, 1994; VanderSpek, 1994; Corby and Dieng, 1997). Table 1 summarizes the CommonKADS models that seem the most useful for the different types of CM.

Table 1: CommonKADS Models and Types of CM

Type of Corporate Memory	Relevant CommonKADS models
Profession memory	Expertise model (in particular, ontologies and domain models)
Company memory	Organization, task, agent models
Individual memory	Agent, expertise models
Project memory	Task, agent, communication models
Technical memory	Task, agent, expertise models
Managerial memory	Organization, task models

By the same way, ontologies can be exploited for building a knowledge-based CM. Ontologies are very useful in a profession memory or in a technical memory, for representing a terminology and a conceptualization shared by a given profession in an organization. As noticed by (O'Leary, 1998b), «*ontologies provide some structure for developement of knowledge bases as well as a basis for generating views of knowledge bases*». Therefore, some companies build their own ontologies in order to construct a knowledge-based CM relying on them. In (Abecker, Bernardi, Hinkelmann, Kühn and Sintek, 1998), several kinds of ontologies are suggested for offering an «*intelligent support by context-sensitive knowledge supply*»: information ontology (for describing the information metamodel i.e. the structure, access and format properties of the information sources), domain ontology (for modelling contents of the information sources) and enterprise ontology (for describing information context in terms of the organizational structure and the process models). Research on methods or tools for building new ontologies, for reusing existing ones or for visualizing them can be exploited (Farquhar, Fikes, and Rice, 1996; Tennison and Shadboldt, 1998).

2.2.4. Case-based Corporate Memory

The exploitation of another AI technique, case-based reasoning, can also be very useful (Simon and Grandbastien, 1995; Simon, 1996). Indeed each firm has a collection of past experiences (successes or failures) that can be represented explicitly in a same representation formalism allowing to compare them. The use of a case base for representing the CM is dedicated for the following aims: (1) avoid the scattering of the expertise by concentrating knowledge of all experts in dedicated cases, (2) allow a continuous evolution of the CM thanks to the progressive addition of new cases.

Case-based reasoning allows to reason from experiences and cases already encountered, in order to solve new problems: e.g. for maintenance of a complex equipment, the collective memory of past incidents can be useful for taking a decision in case of a new breakdown. The retrieval of a similar past case can be used to suggest a solution to a new problem to be solved (this solution can be reused or adapted if needs be). Improving representation of the cases, organization and indexing of the case base is important for enhancing efficiency of case retrieval.

In (Simon, 1996 ; Simon, 1997), the author describes an example in metallurgy, where the aim was to capitalize knowledge and know-how about descriptions of production of produced steels and metallurgical defects encountered during these productions. The purpose of the CM was to exploit past successes and failures in order to minimize error risks in design of new steels. The method consisted of: (1) creating synthesis documents common to all sites and respecting an homogeneous format, (2) proposing models to implement a CM based on such synthesis documents, (3) providing capitalization processes allowing to use the CM for defects detection purpose.

2.2.5. Construction of a Distributed Corporate Memory

A distributed CM is interesting for supporting collaboration and knowledge sharing between several groups of people in an organization or in several collaborating organizations, such groups being possibly dispersed geographically. A distributed memory is essential for virtual enterprises made of distributed organizations and teams of people that meet and work together online. Generally, for such virtual enterprises, this distributed memory naturally relies on the exploitation of the Internet and of the Web (O'Leary, 1997). For example, the GNOSIS project on intelligent manufacturing (Gaines, Norrie, Lapsley and Shaw, 1996) involves several enterprises distributed through several continents. Coordination of this project and management of distributed knowledge among the participants is performed through the Web. The tools developped in the GNOSIS project are used for keeping a memory of the project.

As another approach, (Ribière and Matta, 1998) propose a guide for building a project memory with multiple viewpoints, in the framework of the virtual enterprise constituted by several designers possibly stemming from different companies and cooperating for a concurrent engineering project.

A distributed CM can be made of distributed, heterogeneous knowledge bases or of distributed, heterogeneous case bases, or of a multi-agent system. For example, in the MEMOLAB project, the CM of a research laboratory is implemented through a multi-agent system (with agents such as a bibliographic agent, a notebook agent, a «tips and tricks» agent and a proxy agent) (Vandenberghe and de Azevedo, 1995). The implementation of a distributed memory can also rely on both distributed case libraries and artificial agents responsible for information retrieval among such libraries (Nagendra Prasad and Plaza, 1996).

The construction of a distributed CM may often involve several experts. A protocol for collective knowledge elicitation is proposed in (Dieng et al, 1998). Problems of consistency of the obtained CM elements, of cohabitation of several viewpoints must be solved: a protocol for cooperative creation of a consensual CM is thus offered in (Euzenat, 1996). In the particular case of a distributed CM relying on the reuse of ontologies, research on the collaborative creation of ontologies via ontology servers such as Ontolingua (Farquhar, Fikes and Rice, 1996), APECKS (Tennison and Shadboldt, 1998) or WebOnto (Domingue, 1998) can be exploited.

2.2.6. Combination of Several Techniques

In some cases, both informal knowledge (such as documents) and formal knowledge (such as knowledge explicitly represented in a knowledge base) are needed. Therefore research on the management of links between document and knowledge base can be exploited (Martin and Alpay, 1996; Euzenat, 1996). By the same way, research on the semi-automatic extraction of knowledge (for example, terminological knowledge, etc.) from documents thanks to natural language analysis can be useful (Trigano, 1994). (Kühn and Abecker, 1997) and (Abecker, Bernardi, Hinkelmann, Kühn and Sintek, 1998) propose an interesting CM architecture where the CM can be composed of different sorts of memories: documents, databases, knowledge bases, etc. Figure 2 shows the possible techniques available according to the kind of materialization of the CM. Figure 3 shows an example of heterogeneous CM.

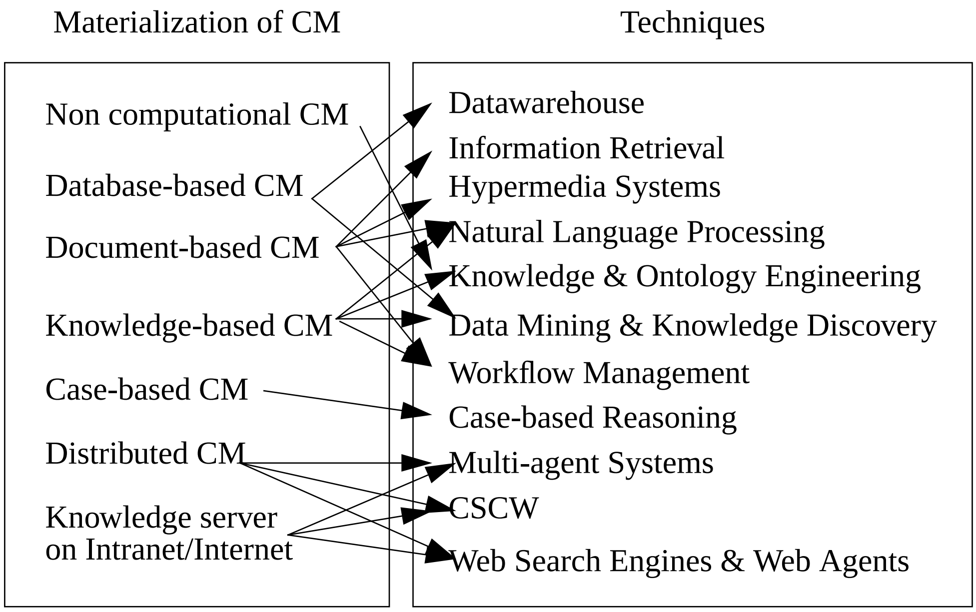

Fig.2: Links between materialization of CM and techniques possibly used

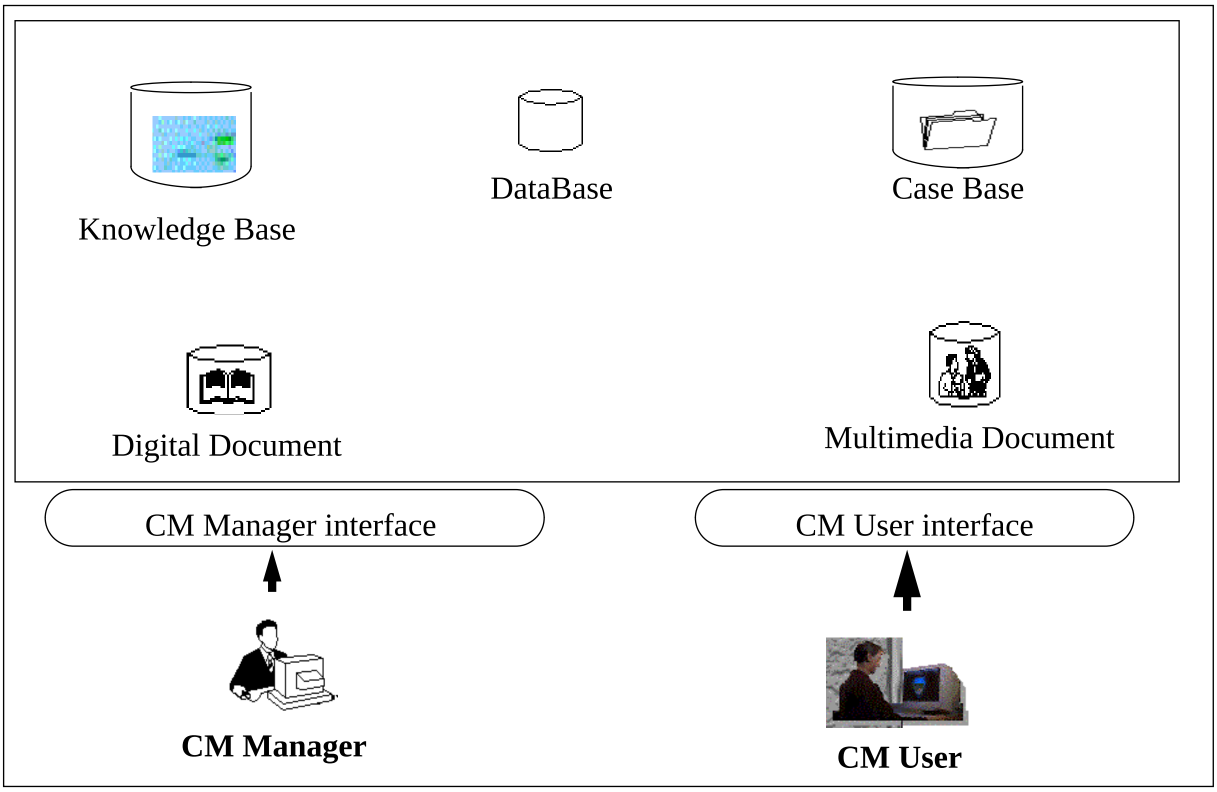

Fig.3: Example of heterogeneous CM

2.3 Diffusion and Use of the Corporate Memory

2.3.1. Possible Modes of Diffusion

Adequate elements of the CM must be distributed to the adequate members of the enterprise: this distribution may be passive or active, as either the user can search by himself needed information where it is available, or knowledge distribution can be systematically decided and taken in charge by an adequate person or group of the enterprise. When the company workers are too busy to look for relevant corporate information, a passive distribution is insufficient: (Kuhn and Abecker, 1997) recommends an active distribution (e.g. a regular recall of the existence of relevant information). (Van Heijst, Van der Spek, and Kruizinga, 1996) distinguishes several cases according to the kind of collection and of diffusion of the CM:

- *Knowledge attic:* both collection and diffusion are passive. It corresponds to the case of a CM used as an archive which can be consulted when needed.
- *Knowledge sponge:* the collection is active but the diffusion is passive.
- *Knowledge publisher:* the collection is passive but the distribution is active, as the CM elements are forwarded to people for whom they will be relevant.
- *Knowledge pump:* both collection and diffusion are active. For example, in ICARE project (Bologna and Gameiro Pais, 1997), in each department of the company, a «knowledge watcher» is responsible for planning the knowledge element collection from his/her department and for inciting the members of this department to consult the CM.

2.3.2. Diffusion via Intranet / Internet

Individuals and organizations can take advantage of the remarkable possibilities of access to data, to information and to knowledge provided by Internet. Knowledge diffusion can for example exploit the possible access to Internet or to an Intranet inside the enterprise.

Diffusion can rely on a knowledge server on the Web or on publication on the Web (Euzenat, 1996; Corby and Dieng, 1997). Different kinds of elements can be accessed through Internet/Intranet: documents (classic digital documents, HTML documents...), databases, ontologies, knowledge bases, case bases, articles of digital journals, etc. Therefore several kinds of knowledge servers can be thought out: document servers, ontology servers, knowledge base servers, database servers, journal servers or digital libraries. The main problems to be solved are (1) retrieval of elements of the CM in answer to a request and (2) adaptation of the answer to the user. Research on user profiling can thus be useful in this purpose (Sorensen, O'Riordan and O'Riordan, 1997).

Exploiting our previous distinction between internal memory and external memory, let us recall that a CM may not be restricted to the sole enterprise: an internal CM can rely on an internal competence map inside the company while an external CM rather includes information and knowledge stemming from the external world but useful for the enterprise work. Therefore, the retrieval and integration of information explicitly put on the Web by other companies working in the same area may be interesting for an external CM. The Intranet of the enterprise can be exploited for construction and diffusion of an internal CM, while an external memory can rely on (a) either an Extranet connecting the company and some privileged partners such as customers, suppliers, subcontractors, etc, or on (b) Internet and the Web in the case of «technological intelligence» purposes. (Revelli, 1998) analyses the different kinds of «intelligence» interesting for a company: technological intelligence in order to follow an existing or an emerging technology, competitive intelligence and marketing in order to know about activities, products or services of the enterprise competitors or of other actors of the enterprise market (distributors, suppliers, customers...).

Remark:

Sometimes some reticences are expressed by the managers of some enterprises w.r.t. Internet and the Web, due to potential problems such as confidentiality, security, reliability of accessed information, risk of information excess that may disturb the employees in their work. But security problems are studied actively by researchers, as they are a significant condition for success of Internet-based applications such as electronic commerce.

Example of Diffusion via Internet/Intranet

Let us detail an example of exploitation of Internet/Intranet. In our team, we have developped a component, called WebCokace, that enables to distribute expertise on the Internet (Corby and Dieng, 1997). The expertise is modelled in the CommonKADS framework (Breuker and Van de Velde, 1994) with the CML formalism (Schreiber, Wielinga, Akkermans, van de Velde, and Anjewierden, 1994). WebCokace relies on the hypothesis that CommonKADS may be useful for building knowledge-based corporate memories. WebCokace takes advantage of the Web technology to interface an expertise model development environment with an HTTP server. The expertise model environment functions in a server mode and is connected to an HTTP server (that acts here as a client of the knowledge server) by means of a CGI interface. Modelled knowledge is then available on the Net.

In order to facilitate user interaction with the system, we have developped a search engine, a query language and an interpreter for this language. Users can emit queries to the knowledge server and get CommonKADS objects in response to the queries. CommonKADS objects are pretty-printed with HTML hypertext links to related objects in such a way that hypertext navigation is possible in expertise models. For example, a concept references its super types, a task its subtasks.

The system generates interactive graphic views on the expertise. It is possible to visualize concept and task hierarchies, domain models, etc. Clicking on a node of a hierarchy leads to the corresponding object definition. So the end-user may rely on the graphics instead of CML text.

The system also manages references between expertise models and electronic documents by means of HTML hypertext links and URL. A CommonKADS model can be annotated with references to source documents (e.g. technical documentation, articles, etc.), and conversely, a document can be annotated with references to expertise models. The links are activated once loaded in a Web browser and it is then possible to navigate between models and documents in a hypertext way.

Using WebCokace, we have developped (a) a generic library for conflict solving in concurrent engineering, (b) an oncology server. We have also implemented parts of the CommonKADS modeling generic library.

WebCokace is implemented on the Centaur programming environment generator, developed in the Croap project at the INRIA. Thanks to the underlying generic technology (i.e. Centaur), WebCokace can be used as a *program server* for any programming language that is implemented in Centaur. Within Centaur, programs are internally manipulated as abstract syntax trees (AST). AST support abstract computations on programs that enable to answer to queries. A program server can be useful in companies having libraries of programs to be included in their CM.

2.3.3. Information Retrieval

The CM is supposed to be used by adequate members of the enterprise: in all cases (documentary system, knowledge base, case-based system, Web-based system, etc), we must notice the importance of information search, if possible adapted to the users' needs, their activities and their work environment. The problems to be tackled are: How can the user express his/her requests? How to improve hypertext navigation by the user? How to retrieve elements of the CM in answer to a request? Is full-text search sufficient? How to index the documents to retrieve? What additional meta-information (such as enterprise models, knowledge models, user models) could help to filter the information to be retrieved? Are inference capabilities needed in this purpose?

Research on ontology servers such as Ontolingua (Farquhar, Fikes and Rice, 1996), APECKS (Tennison and Shadboldt, 1998) or WebOnto (Domingue, 1998) could also be exploited, since a part of the CM can rely on an ontology. A CM infrastructure relying on techniques of information search on the Internet is proposed in (Huynh, Popkin and Stecker, 1994).

In (Revelli, 1998), several intelligent agents for information retrieval on the Web are compared: let us cite among others Autonomy, Umap Web, Webseeker, etc.. (O'Leary, 1998a) also cites some search engines and intelligent agents enabling searching of information on Intranet and Internet. Even though such tools are generally not explicitly aimed at knowledge management, they may be useful in the framework of information retrieval in a Web-based CM (either an internal CM or an external CM). Moreover, guiding the searching on the Web by thesaurus (Leloup, 1998) or ontologies (Fensel, Decker, Erdmann, and Studer, 1998) or expertise models (Corby and Dieng, 1997) should have promising applications in corporate knowledge management.

2.4 Evaluation and Evolution of the Corporate Memory

2.4.1. Evaluation of the Corporate Memory

As noticed in (Ermine, 1996), operational projects of CM are necessarily consuming and expensive. Therefore an evaluation of such projects is important, from several viewpoints: economico-financial, socio-organizational and technical.

From an *economico-financial viewpoint*, one aim of the CM is to improve the enterprise competitiveness. As noticed in (Durstewitz, 1994), it can be measured by a gain between the success of the enterprise products or services, and its production (and maintenance) costs. There must be an evaluation of the gain obtained thanks to the introduction of a CM, generally aimed at enhancing productivity. Return on investment is important for justifying the interest of building a CM, from the viewpoint of the managers. But methods or tools are needed to assess the actual improvement due to the introduction of the CM: it may be an improvement in safety - cf. avoidance of past errors -, in quality and in performance.

From a *socio-organizational viewpoint*, the CM can aim at improving employees' work organization (thanks to information circulation improvement, etc.) and employees' satisfaction in their work. But the criteria for such an evaluation are often qualitative and hardly quantitative: they can rely on classical criteria used for evaluating user-centered tools such as easiness of use, easiness of information retrieval, adequation of retrieved information, confidence in such information, usability for the user's activity, etc. As noticed in (Kuhn and Abecker, 1997), users' feedback should be exploited for detecting possible deficiencies of the CM and suggest improvements of the CM.

From a *technical viewpoint*, the transfer of know-how inside the enterprise seems to be an evident benefit. But an effective transfer depends on an effective use of the CM and on its adaptation to such a knowledge transfer.

There may be some bias in the use of the CM. The introduction of a CM can imply changes in individual and collective work in the enterprise. Some reorganizations prescribed by the managers may not be accepted by the employees. For example, an official procedure for storing lessons or experiences linked to a given project may be prescribed by the company managers but not respected for reasons such as lack of time, lack of motivation, etc. Moreover, a CM may be used otherwise than planned. We found very few publications analyzing reactions of CM users: for example, in (Ballay and Poitou, 1996), a survey of satisfaction of DIADEME users is presented. It relied on a questionnaire on their use of automatic bibliography and hypertext links, their experience and satisfaction of the databases, their experience and satisfaction with the full-text document retrieval TOPIC included in DIADEME, their satisfaction with the workstation. The lesson of this survey was that even though DIADEME was aimed at being a collective knowledge management system, its users rather exploited the system as a set of different specific tools.

In (Kuhn and Abecker, 1997), three case studies are analyzed: KONUS for crankshaft design, RITA for Quality Assurance for Vehicle Components and PS-Advisor for bid preparation for oil production system. The authors noticed that all three systems failed to go beyond prototype stadium and be integrated in the company daily operational work. The reasons of such failures were: «costs of customer-tailored solutions with unpredictable return of investment, insufficient experiences with CM applications, poor integration into the conventional Information Technology landscape». As a lesson learnt from these case studies, they suggested crucial requirements for a CM (see above section 2.1.2.3), they proposed a general CM architecture and a kind of methodological guide for development of a CM, insisting on requirement analysis, human factors, cost-benefit analysis, knowledge evolution and technical realization.

As a conclusion, we must distinguish evaluation by users (with criteria based on users' satisfaction) and strategic evaluation by managers (with criteria based on return on investment). At present, there are too few effective operational CM, and companies need to stand back for evaluating them precisely.

2.5 Maintenance and Evolution of the Corporate Memory

For maintenance and evolution of the CM, it is necessary to take into account the results of the evaluation of what already exists. Problems linked to addition of new knowledge, removal or modification of obsolete knowledge, coherence problems underlying a cooperative extension of the CM, must be tackled. Some of such problems were already relevant during the construction of the CM. Likewise, both organizational problems and technical problems underly the possible evolution of the CM. In the construction as in the evolution of the CM, some problems may stem from conflicts between persons, reticences, lack of motivation, lack of time.

The techniques used to maintain and make evolve the CM also depend on the kind of CM: according to the case, addition, removal or modification will concern elements of a knowledge base or cases in a case base or (elements of) documents in a document base or agents in a multi-agent system. The CM evolution also depends on whether the collection (resp. diffusion) of CM elements is passive or active (Van Heijst, Van der Spek, and Kruizinga, 1996). Evolution of the CM depends on both the CM builders/maintainers and the CM users.

According to (Kuhn and Abecker, 1997), knowledge evolution should be «a continuous activity performed by a CM administrator in close cooperation with the users who can make improvement / update suggestions tightly integrated into their work process». This solution corresponds to an active collection and diffusion, as for instance in the ICARE project (Bologna and Gameiro Pais, 1997). In some cases, a given service or a given person of the enterprise is responsible for the maintenance/evolution of the CM. In other cases, any employee may make evolve the CM, while respecting some constraints.

3 EXAMPLES OF DEDICATED METHODS

This section will give few examples of methods dedicated to the building of a CM. The purpose of this description is to show the principles guiding some CM-dedicated methods (in comparison to knowledge engineering methods such as COMMET or CommonKADS).

3.1 Method CYGMA (KADE-Tech)

CYGMA (CYcle de vie et Gestion des Métiers et des Applications) is a method allowing the construction of a profession memory in a manufacturing industry (Bourne, 1997). It defines six categories of industrial knowledge for design activity:

- *singular knowledge:* positive and negative, relevant or out of bound experiences;
- *terminological knowledge:* alphabetical list of terms used in the profession domain;
- *structural knowledge:* it contains the ontological knowledge, and a factual knowledge base comprising the initial data of the design problem to be solved and the initial goals describing the design problem solution to be found;
- *behavioural knowledge:* dynamic elements of profession knowledge;
- *strategic knowledge:* knowledge allowing an optimized use of structural and behavioural knowledge;
- *operating knowledge:* knowledge describing the problem solving process as a chaining of operating activities based on structural, behavioural and strategic knowledge.

The results of the method application consists of four different documents: *profession glossary* gathering singular and terminological knowledge, *semantic catalogue* describing structural knowledge, *rule notebook* comprising behavioural knowledge, *operating manual* made of strategic and operating knowledge. These documents can then be exploited by the enterprise as a way of communication with subcontractors. The method has already been applied to different professions in different firms: blacksmith profession for Rolls-Royce, turner profession for Eurocopter, automatician profession for Fiat and steel manufacturer profession for Aérospatiale.

3.2 Method REX (CEA)

REX method (Malvache and Prieur, 1993) relies on the following steps: (1) needs analysis and identification of sources of experience, (2) construction of *elementary pieces of experience* from documents, databases or interviews, (3) building up a computer representation of the knowledge domain, (4) installation of a software package on the user's workstation: this package includes a multimedia interface and a *retrieval engine* that produces information files on the basis of questions in natural language.

3.3 Method MKSM (CEA)

MKSM (Method for Knowledge System Management) (Ermine, 1996; Ermine, Chaillot, Bigeon, Charreton, Malavieille, 1996) aims at reducing complexity of knowledge system management, using different models at different grain levels. It is a systemic-based decision support method. It relies on the hypothesis that the knowledge assets of an organization can be considered as a *complex system*. Modelling such a complex system relies on several viewpoints: syntax, semantic and pragmatic, each viewpoint being itself modelled through three viewpoints: structure, function and evolution. The three components of a knowledge sytem are *information* (requiring data processing), *signification* (requiring task modelling) and *context* (requiring activity modelling). The method offers five modelling phases: knowledge system modelling, domain modelling, activity modelling, concept modelling, task modelling.

3.4 Comparison of the Methods

CYGMA is dedicated to profession memory, in the framework of a design task, while REX and MKSM do not focus on a kind of CM and do not restrict to a kind of task. REX relies on the building of pieces of experience, stemming from several kinds of sources (human, documents, databases); such pieces can be retrieved in answer to natural language request. MKSM takes inspiration of complex system theory for offering a theoretical analysis of an organization knowledge, considered as a complex system. The modelling phases proposed by MKSM are close to CommonKADS notions. All three methods were applied to several industrial applications. Criteria for comparing them more precisely could be : the complexity level of the method application, the kind of CM it enables to build, the kind of task it restricts to, the number and features of effective applications built with them, and evaluation of such applications by their end-users..

4 CONCLUSIONS

We presented a survey guided by the steps of a CM lifecycle (needs detection, construction, diffusion, use, evaluation and evolution) and different from other existing surveys (Macintosh, 1994; Kühn and Abecker, 1997; O'Leary, 1998a). It offers an analysis of research on different kinds of materialization of CM: non computational CM, document-based CM, knowledge-based CM, case-based CM and distributed CM.[*]

Our main conclusion is that in all the described research, an important aspect is that *an organization can be analyzed at several levels, according to* *several viewpoints*. Most methods focused on some viewpoints and relied on an implicit or explicit model of the enterprise, or at least of the enterprise knowledge. The analysis of the enterprise needs for a CM can help determine the kind of needed CM. According to the case, it may imply to build an individual memory (cf. an expert retires or is muted, so it is interesting to make explicit, model and store this expert's know-how in a knowledge base or to store his experiences in a case base), a project memory (cf. elements of a given project could be necessary for later projects), a managerial memory needed by the company managers for strategic decisions, etc.

As a conclusion, our survey confirms the multiple research fields relevant for building a CM - which definitively requires a multidisciplinary approach. The choice between the different construction techniques can be based on several questions that an enterprise should answer before building a CM:

1. Needs detection:
   - *Who are the potential users of the CM and what are the users' profiles?*
   - *What is the intended use of the CM after its construction: is it...*
     - a way of communication between distant groups?
     - a way of communication between an enterprise and privileged partners?
     - a way to enhance learning of new enterprise members?
   - *When will the CM be used:* in short-term, in mid-term, or in long-term*?*
2. Construction:
   - *What are the knowledge sources available in the firm:* paper-based, semi-structured or structured documents, human specialists, databases*?*
   - *Can the quality, volume, availability of the knowledge sources be assessed?*
   - *What is the knowledge map of the enterprise departments involved in the knowledge management operation?*
   - *What kind of knowledge must contribute to the construction of the*

* Remark: In spite of its rather wide spectrum, our survey is not exhaustive: for example, it does not detail research on databases relevant for knowledge management (cf. datawarehouse, data mining, etc.)

CM?:

- knowledge already described in documents such as reports or synthesis document on a project?

- elements of experience and professional knowledge not already described in documents?

- *Is it necessary to model knowledge of some enterprise members or is an intelligent documentary system sufficient?*
- *What is the preferred materialization, according to the computer environment of both future users and developers and according to the financial, human and technical means available for the CM construction and maintenance?*

3. Diffusion:

- *What is the preferred scenario of interaction between the future users and the CM?*
- *What interface will be the most adapted to the users' activity environment?*
- *What will be the privileged diffusion means (Internet, Intranet, ...), according to the computer environment of both future users and developers?*

4. Evaluation:

- *What will be the evaluation criteria ?*
- *When, how and by whom will such an evaluation be carried out?*

5. Evolution:

- *How will the evaluation results be taken into account?*
- *When, how and by whom will the CM be maintained, verified and incremented?*
- *How will obsolete or inconsistent knowledge be detected and removed (or contextualized)?*
- *Will the evolution of the CM be centralized by a department or will it be distributed among several members of the organization?*

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