ABSTRACT

The research work focuses on corporate memory modeling methods and design. Corporate memory will be defined as a knowledge management issue. A modeling method and related tool will be proposed. The approach is based on an a-priori paradigm, where data are stored because of their relevant degree of interestingness for the company. Enhancing corporate productivity is therefore the primary concern and result. Practical cases will validate the reverse “knowledge reuse pull approach”, and illustrate the kind of problem solved.

KEY WORDS
Corporate memory, knowledge management, information system, decision support system

I. INTRODUCTION

Knowledge management is often investigated through knowledge discovery in data (KDD), using raw data mining and algorithms tools [7]. This approach can be said to operate on an a-posteriori paradigm where data are already stored and easily available. We felt that the problem might be tackled from a different angle, closer to case-based reasoning and wondered whether knowledge could not be operated upon before being stored in an organized way. The approach results from the work done by our two laboratories in developing tools and methodologies incorporating the cognitive emergence process for corporate use and benefit. A modeling method and related tool has been developed. It is based on an a-priori paradigm, where data are stored because of their relevant degree of interestingness for the company. Practical cases will validate the reverse “knowledge reuse pull approach”, and illustrate the kind of problem solved. The enhancement of corporate productivity is the primary concern and result.

II. CORPORATE KNOWLEDGE MANAGEMENT

A company produces goods or services, and, in the process, also produces knowledge. Knowledge management (KM) is therefore of great importance for companies. The objectives of KM are to promote knowledge growth, communication and preservation in an organization and from a business point of view, to produce better business, competitive gain and greater profits. European businessmen consider it will be essential over the next few years to gather knowledge first about customer needs and preferences, and second about the performance of the company [11]. If knowledge of a given domain is to be exploited to some commercial benefit, the formal process of knowledge capitalization becomes a management issue. Managers have to organize how knowledge created through business activities is gathered and shared, and then guarantee its enhanced use when performing new tasks.

The Knowledge capitalization process is the collection of processes that govern:
• the dissemination and utilization of knowledge to fulfill organizational objectives
• the creation, capture, modeling and storage of corporate knowledge.

Corporate memory (CM) is defined as the “explicit, disembodied, persistent representation of knowledge and information in an organization” [14], which “preserve(s) reasoning, behaviors, knowledge, even in their contradictions, and with all their variety” [12]

CM content covers various fields, but what is important is deciding which fields should be covered and why. Numerous examples can be found in the Literature [4]: product requirements, project tasks and planning, human expertise involved, resources used, project cost elements and structure, monitoring and control supports, electronic documents and reports, design rationales, the technical alternatives explored, lessons learned, risk
management and control. The products of the activities (documents, etc.) and the information given by the people concerned constitute the data in each of these cases.

**CM use** makes a virtual network between company employees, at the corporate-wide level. This network helps reuse past knowledge, or supports collaboration. Shared by several collaborating organizations, it is the core of the virtual enterprise.

**CM design** involves three steps:
- knowledge acquisition, i.e. collecting distributed and heterogeneous know-how about individual or small group project experiences,
- representation and storage organization for corporate-wide knowledge,
- access to and reuse of the corporate memory during new project situations by other people.

Many KM approaches consider already acquired knowledge (such as existing documents, databases, ...) as a starting point, and follow these steps in the above sequence. They can be called: “searching for use” or “knowledge-push” approaches.

This paper focuses on a reverse process, which could be called “enhanced use” or “knowledge reuse pull approach”. It considers how a strategic business or cooperative situation can be improved, with the following steps:
- identifying a business, competition or profit situation, respecting enterprise models,
- designing the required tools (such as decision support or cooperative work) referring to knowledge and Information System management,
- designing the right CM tool as a specialized functionality of the computerized tool.

In the long run, KM process by managers may lead to business process reengineering when a particular changed situation is used as a step to another strategic situation change. This long term project is another modeling issue, at the management level, and will not be presented here in detail.

Accessing CM in order to retrieve the data nuggets that will have a relevant degree of interestingness for a company is therefore the main challenge. This leads to the problem of representing knowledge in a way that enables direct reuse in strategic situations and for end users, and this requires the development of language which is based on this knowledge representation structure.

In the formal process of knowledge capitalization, information technologies are important: online information, document management and groupware are considered as the three key technologies for KM, with the support of the corporate Intranet [11].

A specific methodology and tool geared to analyzing corporate knowledge and to storing it on user friendly computerized platforms has been developed for the projects presented below.

### III. CORPORATE MEMORY MODELING

In developing our CM model and tools, we have drawn on cognitive science theories, the General System theory and our own method MUSIC (Management and Use of Cooperative Information Systems) [1] [3]. We have applied our model to situations such as process reengineering or innovation, cooperative work, and the virtual enterprise.

Cognitive Sciences have given rise to different modeling levels for knowledge abstraction and/or materialization: theoretical knowledge, practical know-how, implicit skills, specialized terminology, computerized systems,...

The standard categorization of knowledge distinguishes declarative knowledge from procedural knowledge. The first set might be loosely referred to as theory or as J-M Fouet [8] puts it, as “black and white” written expression on paper of simplified models that describe, or encompass reality in generalizing paradigms. By contrast, the second set is applied directly to reality and has fuzzier edges, is strongly contextualized or “situated”. It is not modeled and is “grey in color” [8].
In our projects, knowledge modeling focuses on practical know-how, tangible elements, and intangible elements. Declarative and procedural knowledge, in fact, are combined. C. Guillevic [10] proposed a cognitive flowchart showing how information is processed in order to deal with a given task. Three levels of treatment can be observed. The lower level implies that routine actions are implemented as the best answers to a stimulus. An intermediate level will activate rules that have been identified as possible answers to a series of possible situations. We are operating on known ground but a sorting/identification process is necessary before action can take place. The third or higher level is activated when a totally new situation is presented. High order mental processes must produce a new answer to the new situation offering an uncharted territory. In a company, an expert functions using the three levels. The intermediate level represents his/her charted sets of solutions to standard work situations. They result from the repetition of similar work situations. Our hypothesis is that a pocket of corporate invisible assets (called $K_{CIS}$) is to be found at this level. However, these $K_{CIS}$ are unconscious, are the result of individual and contextual constructions, can be contradictory, and may be influenced by affective elements. So, the problem is how to capture, model, store, and make them visible and usable.

The General System Theory presents a spatial model for knowledge interactions in an organized complex system. Varela’s constructivist model [16] assumes that interaction between autonomous components of knowledge creates new knowledge at the global system’s upper level, with a qualitative difference: global system knowledge possesses skills none of its components had autonomously. There is no possibility of demonstration or deduction from local knowledge, and upper level knowledge is unintelligible from lower levels (unspeakability) [11]. So the upper level has its own model, and interaction between lower and upper levels becomes a central point, which Varela [16] calls the “make-to-emerge” problem.

MUSIC is proposed for this type of complex system knowledge. Knowledge identification, acquisition, and use are the core of Cooperative Information System (CIS) modeling. The MUSIC model and method tackle the problem of cognitive cooperation between specialized and separate units or departments. Corporate Knowledge is considered as distributed in very varied systems, called Departments. They are considered independent areas of excellence, outstanding in their own context and for their local decisions: local skills, procedures, machines, Information Systems. Communication is difficult because:

- specialized expertise is at least partially unconscious, individual, contextual, and therefore not explicit,
- people of different specialization do not necessarily understand each other,
- the detailed knowledge of one unit is useless to others for effective collaboration in complementary work.

The MUSIC model postulates it is impossible for CM to be the direct gathering, plain assemblage, and open communication of units of heterogeneous knowledge and proposes the concept of cooperative corporate memory (CCM) and cooperative knowledge capitalization. CCM is quite different from corporate memory. It is a specific knowledge process including:

- acquisition through aggregation from specialized knowledge, at lower and more detailed levels. This aggregation is in itself a major issue, which cannot be achieved without pre-organization through a common collective knowledge and coherence structure. The aggregated knowledge transmitted to the global level is not derivable from the lower level [13].
- cooperation modeling and representation. This modeling is not linked to specialized knowledge modeling, as knowledge granules are at a high level of abstraction and communication, and knowledge is co-constructed at the global level with a specific and autonomous panorama.
- interpretation through reuse in specific situations.

The cooperative memory process is a central issue, whichever means and support tools are used for this process and the CIS storage (computerized, or manual).

The typology for CCM is vast [11], [15], [16]. We have focused on the following:

- at lower levels:
  - a project memory comprising definition, activities, history and results for each project
  - technical and professional information of employee’s know-how (referential, documents, tools, methods used in each given profession), and used everyday for
performing their daily job (individual or cooperative work)
◊ part of human resource memory characterized by competencies, know-how, activities of a given member of the enterprise
• at higher levels :
◊ company memory related to organization, activities, products, participants (e.g. customers, suppliers, sub-contractors)
◊ strategic CM used by the company managers for decision making.

For CCM design, the general knowledge representation model defined by the AI research Community will be used. It comprises two components : an ontology and a logical formalism.
• The vocabulary (ontology) corresponds to knowledge classification. It is a permanent taxonomy, i.e. it does not change during problem solving.
• The logical formalism and vocabulary enable knowledge acquisition and representation. They work as a knowledge representation language.

IV. MODELING METHOD

The EVAME method (Extraction, Validation, Application, Maintenance/Enhancement) is used to detect and formalize the needs for a CCM, and subsequently the MUSIC method for the CCM design.

A. EVAME Method

The goal is to identify crucial knowledge to be capitalized, in the context of dynamic complex situations like innovation (new products production,...), complex cooperation or dealing with critical or quite new situations and knowledge co-construction.

The construction of a CCM involves many people organized within Departments with specialized knowledge.

An audit of the activities, goals, and interdependence of the departments is carried out. A stakeholder approach can be used to ensure that the memory is defined in terms of users' needs. 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" [6].

A minimum common knowledge -and therefore language- is defined, as what is common has to be normalized and be organized as a referential. It constitutes a lexicon to allow common knowledge sharing. It will be considered as a team communication norm, called collective lexicon.

However, the future cooperative work will be based on the use of specialized knowledge.

Key individual or departmental knowledge is identified complementarily, and organized in Department Information Systems in coherence with the collective lexicon.

Cooperative tasks are organized through a Cooperative Information System and generate the gradual building of the cooperative knowledge system (CCM). The process combines human extraction and machine storage, with the dynamic emergence of evolutive knowledge.

B. CCM design

The MUSIC model provides appropriate organizing of the company’s internal Information System as a knowledge representation model or Intelligent Information System [13].

It proposes a related architecture which is based on three concepts and related modeling :
• information profoundness which corresponds to differing degrees of interpretative value and use. Its different levels are :
◊ knowledge
◊ linguistics, semantics
◊ conceptual level (data, documents,...) of the related tools for the technical support for CCM

• the spatial organization of information, which takes into account knowledge heterogeneity and distribution and the related upper cooperative structure :
◊ centralization or collective information system. It is the normalized knowledge, the common language that structures the enterprise as a global unit.
◊ decentralization or departmental and individual systems. Departmental or individual information systems correspond to decentralization and project division.
◊ cooperation between decentralized and autonomous systems through cooperative systems.

• time or information diachrony, which corresponds to knowledge construction in the organization and the modeling of the temporal evolution of the organization :
◊ corporate memory and reuse
◊ management of organization change.

The CCM includes :
• knowledge ontology (semantics and data)
• and the collection of past experiences (successes or failures represented explicitly through formalisms allowing their comparison and reuse).

Data Mining and Knowledge Discovery processes can be applied:
• the ontology can be used as support for exchange of information and knowledge in the enterprise [10] and recurrent knowledge reuse
• Case-based Corporate Memory is typically the technology used for the reuse of previous experiences.

Both allow the progressive addition of new knowledge through new cases.

V. EXAMPLES : DECIDE, DECLARE, DRRT

These practical cases are centered on a better exploitation of the lessons learned and experience acquired from past projects, the improvement of information circulation and communication between geographically dispersed groups, and the integration of different know-how allowing better coordination between specialists.

A. DECIDE

The DECIDE project (European Community funding, ESPRIT n° 22298) provides a methodology and related toolkit to assist user companies to improve their overall bidding procedures by reusing their know-how. It consists in a database which brings together the four main elements usually dealt with by different departments which must be considered when elaborating a bid : product, process, resources and technical solutions. The decision support system aims at building technical solutions adapted to a specific tender, and helps to simulate and fix its price.

The database is an Information System which supports the CCM, related to what is considered a central knowledge problem in engineering activities, i.e. project cost elements and structure, with, as said above, its capability of exchanging information and knowledge in the enterprise.

The method and tool favour the exploitation of the experience acquired from past projects, the integration of the different know-how of an organization, a better exploitation of company knowledge for corporate strategy and hence improvement of the enterprise’s ability to react and adapt to change, avoidance of know-how loss due to specialist turnover, risk management by avoiding discovered mistakes, and improvement of employees’ training.

B. DECLARE

DECLARE, funded by the French Ministry of Research, deals with "Corporate memory and knowledge capitalization : cognitive models and information system models". It aims at organizing knowledge transfer and enrichment between scientific fields which used, independently, what appeared to be similar concepts. The interdisciplinary collaboration should result in a methodology for interdisciplinary work beginning with the development a corpus of common concepts leading to an enhancement of the initial methodologies of the two teams.

The general result of the research for the different teams involved in this project is to better theorize how to define models, formalisms, and methodology to support the creation of tools and methods able to help companies improve their efficiency, by enhancing the use of formerly acquired knowledge in their activities (either linguistic or design and production activities).

This interdisciplinary research project, by giving the researchers involved first hand experience of building cooperative knowledge, confirmed the necessity of building a collective lexicon as the first step of the process.

C. DRRT

The project involves a Regional Research Body wishing to organize cooperation between different organizations to help SME in their innovation activities and projects. At the moment, these organizations ("Valorization" Agency , Chamber of commerce,...) work separately and deal directly with individual enterprises to finance specific actions. A common knowledge sharing data-base will enhance the assistance to enterprises through a planned cooperation process. The auditing step recently began with the creation of data-retrieving tools and the definition of an approach for knowledge capture concerning the analysis of existing needs for cooperation. This has led to the first elements of a cooperative information system : common data (company file card), specific data for each company, data required for a common definition of an innovative company (cooperative lexicon).

The regional example involves several entities and is not dissimilar to the international example of company cooperation for major international projects. These projects require cooperation of different companies i.e. international consultants, engineering firms, technical and economic "observatories", insurance and banking companies. These companies master data and knowledge in their various areas but interconnecting the many representations of facts is a challenge because of the cooperation required.
VI. CONCLUSION

The link between human extraction and machine storage for knowledge management has been studied in non trivial situations:

- knowledge and know-how is distributed within different specialized units which cannot communicate easily
- cooperation to reach a common objective needs implicit and explicit high level knowledge exchange
- knowledge capitalization is required.

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<tr>
<th>Ontology</th>
<th>Technical support system</th>
<th>Procedures</th>
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<tbody>
<tr>
<td>DECLARE</td>
<td>Research concept taxonomy Thesaurus, concept dictionary Interdisciplinary cooperation</td>
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<tr>
<td>DRRT</td>
<td>Cooperative lexicon Cooperation taxonomy Database, Internet Cooperative financing procedures for SME innovation projects</td>
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<tr>
<td>Decide</td>
<td>Industrial domain ontology and hierarchy (product/process/resource) Database Decision support System Bidding process : procedure of building technical solutions and of fixing prices</td>
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<th>Problem to be solved</th>
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<td>DECLARE</td>
<td>knowledge co-construction new knowledge emergence</td>
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<tr>
<td>DRRT</td>
<td>cooperation between autonomous organizations knowledge in virtual enterprise</td>
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<tr>
<td>DECIDE</td>
<td>business process innovation technical-economical knowledge capitalization</td>
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These problems are solved through a method and tools, called CCM which organizes global expertise of all agents. In industrial engineering, this global knowledge is valuable and increases corporate productivity.

VII. REFERENCES

2. A.M. Alquier, S. Sebal, P. Zarate (97) - "A tool for knowledge capitalisation" - ISAS and IEEE World multiconference on Systemics, Cybernetics and Informatics, Caracas, July
5. R. Dien, O Corby, A Giboin, M Ribièrè, (98) - "Methods and tools for corporate knowledge management", KAW'98, Alberta, Canada, April
7. U.M.Fayyad, G.Piatetksy-Shapiro, P.Smyth, (95) - "From Data Mining to Knowledge Discovery: An Overview " - KDD 95
8. J.M. Fouet, (97) - "Acquisition et structuration de connaissances", Conférence, Grenoble University, January
10. C Guillevic, (91) - "Psychologie du travail", Nathan
12. P.Murray, A.Myers, (97) - "The facts about knowledge ", Information Strategy, sept 97
15. G. Van Heijst, R. Van der Spek, E. Kruizinga, (96) - "Organizing Corporate Memories" B. Gaines, M. Musen eds, KAW'96, Banff, Canada, November
16. F. Varela, (88) - "Cognitive Science; a cartography of current ideas", Seuil