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Organisational Memory Information Systems An Example of a Group Memory System for the Management of Group Competencies[1]

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Abstract: As people transform data, information and experiences into shared corporate knowledge, the management of individual competencies has become increasingly important to knowledge intensive organisations (KIO). Knowledge gained during the normal execution of daily tasks is easily lost in the new and more dynamic business environment. The ability to find versatile employees and to be able to leverage their knowledge to meet differing corporate needs, is a matter of pivotal importance for KIOs. Employees' competencies, in the form of their technical and cognitive capabilities, are closely related to the ability of a company to exploit existing, and to create new, knowledge.
The topic of this paper is an example of the design a particular instance of an organisational memory system: a group memory system for managing corporate competencies. The system described focuses on internal competencies, in particular human knowledge sources, their competencies, as well more straightforward project experiences and related heuristics. We will show an approach for representing and manipulating corporate competencies, and highlight the main features of ontology-driven organisational memories. This research work applies ontologies as a design approach to represent organisational knowledge and ultimately to create a consensual representation of corporate competencies.

Keywords: Competence Management, Ontologies, Knowledge Management, Knowledge-Intensive Organisations, Organisational Memory, Group Memory.
Categories: H.1

1 Introduction

Knowledge Management (KM) is an emergent field in the information systems (IS) area and is one that is the source of much debate and controversy. There is a long way to go before a consensus about the nature and scope of KM is reached within the community. In line with much of the literature in this area, we view KM as being

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concerned with the management of organisational assets in the form of organisational knowledge. We view KM as being a cross-disciplinary research field and one where several theoretical and practical notions coincide. Notwithstanding this, the focus of this paper is on constructing an IS to support KM.

In order to develop an effective IS to support KM, we need a means of modelling these assets in a form suitable for the creation of an organisational IS. This in turn requires a methodology to identify, classify, represent and these corporate knowledge assets. The approach described in this paper is to use knowledge modelling techniques based on Ontologies to represent organisation knowledge assets in the form of individual and group competencies.

The main objective of the ontological discipline is the syntactic and semantic standardisation of knowledge structures. Here, Ontologies are used to define a shared consensual structure for corporate competencies and to act as the basis for a knowledge modelling and engineering technique. Here we have taken a competency to be a characteristic of an individual or group that is required to produce an effective organisational performance [Curtis 1997]. Thus, a competency is related to an individual or group's underlying knowledge and skills used in performing a particular a role within the organisation. The application of such an approach should help to enhance both the development of an enterprise's information system as well as its overall operational efficiency.

The remainder of this paper is organized in four sections: the first discusses knowledge intensive organisations by characterising their specific needs. The next section describes an approach to manage organisational knowledge based on the ideas of Knowledge Management: Organisational Memories. This is followed by a section that presents a discussion of ontology-driven organisational memories. The following section describes a framework for a group memory system focused on corporate competencies; finally, we close the paper with a section that presents our concluding remarks.

2 Knowledge Intensive Organisations

Knowledge intensive organisations (KIO) employ highly skilled staff, knowledge workers, whose role is essentially one of problem solving. Solving problems in such organisations involve complex, knowledge-intensive tasks such as dealing with abstraction and uncertainty or recognising patterns of organisational behaviour. Decisions often need to be taken in a dynamic work environment and based on data retrieved from several organisational information sources.

Knowledge in KIOs is a product of the expertise, experience and skills of the individuals and workgroups that make up the organisation; it is stored in individual's minds, explicitly encoded and documented in corporate information systems and implicitly embedded in organisational culture, rituals, policy and procedures.

To be effective workgroups must seek to exploit examples of best practice, improve their efficiency and contribute to overall organisational learning. Workgroups in KIOs need to manage their existing skills effectively, create mechanisms to elicit new ideas and innovations, and identify sources of information.

In a commercial environment, where downsizing, reengineering, restructuring and high rates of organisational turnover are common, businesses are beginning to recognise how easy it is to lose a vital element of their intellectual property: the

organisational knowledge gained during the normal execution of daily tasks. People are often unaware of key resources that lie 'hidden' in the heterogeneous knowledge repositories [Dzbor et al. 2000]. The challenge for all organisations, but KIOs in particular, is to deal with their knowledge resources effectively. Not surprisingly, many businesses are now beginning to recognise the vital importance of managing organisational knowledge to their operations.

3 Organisational Memories

A core concept in discussions about technological support for KM and organisational learning is that of the Organisational Memory [Kuhn and Abecker 1997]. Following this approach, we use the term Organisational Memory (or Organisational Memory Information System) to mean a comprehensive computer system that captures a company's accumulated knowledge assets [Fig. 1] and makes them available to enhance the efficiency and effectiveness of knowledge-intensive work processes.

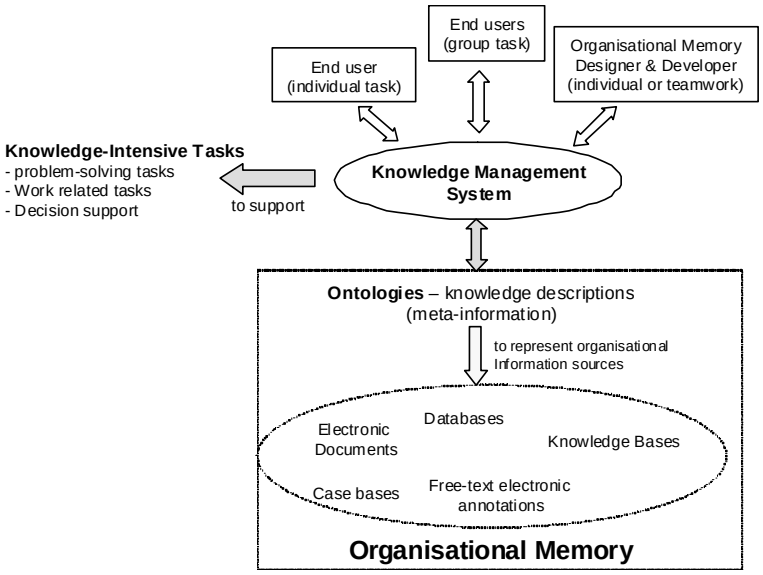

Figure 1: Organisational Memory overview

3.1 Rationale to build Organisational Memories

Analysing the literature is one of the classical methods used to detect the requirements and needs to build organisational memories [Dieng et al. 1998]. From Macintosh's (1997) work on knowledge asset management, a set of organisational impediments to more productivity and performance in knowledge-based companies were identified:

"Highly paid workers spend much of their time looking for needed information".
"Essential know-how is available only in the heads of few employees".
"Valuable information is buried in piles of documents and data".

"*Costly errors are repeated due to disregard of previous experiences*".
"*Delays and suboptimal product quality result from insufficient flow of information*".

Based in these statements, [Dieng et al. 1998] elicited possible motivations to build an Organisational Memory:

- to avoid the loss of corporate expertise when a specialist leave the company,
- to explore and reuse the experience acquired in past projects in order to avoid the repetition of previous mistakes,
- to improve the information circulation and communication across the company,
- to integrate the know-how from different sources in the company,
- and ultimately to improve the process of individual and organisational learning.

3.2 Organisational Memory Requirements

The following requirements were analysed from different OM projects and related research literature [Heijst et al. 1997], [Kuhn and Abecker 1997], [Abecker et al. 1998]. OM functional requirements that can minimise the above organisational limitations and meet some of the motivations are classified in three categories [Heijst et al. 1997]: Collecting the information, preserving the information, and retrieving and distributing the information. The following OM functional requirements are mainly concerned with the facilities that should be available in the OM to the organisational employees at the individual and group level. These functions should assist individual and group work tasks and consequently to improve organisational learning processes.

3.2.1 Collection and presentation of relevant information

Knowledge needed in work processes is distributed among various information sources, such as electronic documents, databases, emails, and private notes of employees. The primary requirement for an OM is to prevent the loss and enhance the accessibility of all types of organisational knowledge [Kuhn & Abecker 1997].

An effective strategy for collecting new knowledge assets should be applied in the organisation. This strategy should be followed by well-defined criteria for deciding if some information is considered a valuable knowledge asset for the organisation or not. The information in the form of lessons learned, best practices, or other domain knowledge assets may be collected actively or passively [Wiig et al. 1997].

3.2.2 Preserve and integrate different types of information

The preservation and integration of different but related organisational knowledge is a key requirement of an effective development of organisational memories. Different knowledge areas within the organisation should be properly classified and integrated. For example, organisational structure, company regulations, workflow procedures, employees' competencies, product and service descriptions should be integrated.

In addition to the integration level of organisational information, an OM should be engineered in order to be integrated with the existing organisational environment. An OM system should have an architecture suitable to be integrated with the existing IS infrastructure, i.e., it has to fit into the flow of information that is already happening in the organisation [Conklin 1996]. This requirement is crucial for the acceptance of the users of the OM system.

3.2.3 Retrieve and distribute the information

An OM should provide easy access, navigation and retrieval of the stored information to organisational employees. An OM should provide intelligent query mechanisms to assist the user across the information searching processes, proposing suggestions, alternatives and effective directions. Navigation and retrieval mechanisms including related documental sources to be able to access context-based information during problem-solving tasks or other work activities should be provided.

An OM should also distribute new knowledge assets to employees that really need that corporate knowledge. For example, provide domain knowledge subscription mechanisms to be informed of new information needed for a specific activity, and provide employee-profiling mechanisms to facilitate the distribution of information to the right organisational employees.

3.2.4 Minimise knowledge acquisition and maintenance activities

Although the benefits of having an OM are recognised, organisations are reluctant to invest resources into a novel technology where the practical benefits will be seen only in later stages of development [Kuhn & Abecker 1997]. The OM development process should be performed causing a minimal interference with the normal organisational workflow.

A workable OM is only possible to achieve after a long organisational process. In a KM context, the organisational culture, the medium and long term objectives, and current IS infrastructure all need to be properly understood before the effective OM development. The different participants in its design and development, such as domain experts, knowledge engineers, IS designers, and prospective users should be aware of the difficulties and benefits of such organisational system.

4 An Organisational Memory Information System using Ontologies

The ontological approach applied in this research follows the recent ontology-driven KM tendency within academic and business organisations [Staab et al. 2001]. This approach uses ontologies to represent and manage both organisational knowledge containers and contents. This technique allows the representation of organisational knowledge in a way that facilitates knowledge sharing and reuse between organisational agents. An Organisational Memory seeks to preserve and manage valuable knowledge assets at the corporate level. OM building is a current endeavour for many organisations, researchers and industrial practitioners.

For structuring and maintaining large amounts of heterogeneous and distributed information in the organisation, appropriate meta-level descriptions are needed to represent the higher-level layer of an organisational memory. In order to develop an

effective methodology to identify, classify, represent, and reuse the existing corporate knowledge assets, an expressive knowledge representation and modelling format needs to be chosen.

A consensual definition of an ontology says that it is a high level formal specification of certain knowledge domain: a *formal and explicit specification of a shared conceptualisation* [Gruber 1992]. A domain *conceptualisation* is a particular and abstract view about real entities and events and their relationships. *Formal* refers to the fact that an ontology is a form of knowledge representation and has a formal software specification to represent such conceptualisations, i.e. an ontology has to be machine-readable. *Explicit* means that all types of primitives, concepts and constraints used in the ontology specification are explicitly defined. Finally, *shared* means that the knowledge embedded in ontologies is a form of consensual knowledge [Benjamins et al. 1998], that is, it is not related to an individual, but accepted by a group.

4.1 Ontology Semantics

Ontologies can be used to represent explicitly the semantics of semi-structured information, i.e. an ontology provides an explicit conceptualisation that describes the semantics of the domain data in analysis [Abecker et al. 1998, Fensel 2001]. Ontologies have a similar function as a semantic data model, such as a conceptual data schema, but are a more expressive way of information modelling. In this research, ontologies as an Artificial Intelligence knowledge representation notation and semantic data models as an IS notation to define database schemas are complementary, i.e. the two notations are needed to build effective and expressive organisational models. The main differences between a conceptual data schema and an ontology are [Meersman 1999]:

- a language for defining ontologies is syntactically and semantically richer than common approaches for database schemas;
- the information described by an ontology can be presented at different levels of formalisation: using a semantic network notation, semi-structured natural language and formal definitions including logic axioms. Most of the conceptual data schemas are just tabular information;
- an ontology uses a shared and consensual terminology that makes it suitable for information sharing and reuse;
- an ontology provides formal definitions to describe the semantics of the representational constructs, i.e., all the terms used in the ontology specification are explicitly defined.

Although differences exist within ontologies, general agreement exists about several issues related to the structure and behaviour of world objects in order to represent real knowledge domains [Chandrasekaran et al 1999]:

- There are abstract and physical objects in the world;
- A set of objects denoting similar structure and behaviour is considered a *class*;

- Objects have *properties* or *attributes* that can have *values*, i.e. they can be represented as triplets (Object –> Attribute –> Value);
- Objects can exist in various *relations* with each other;
- Properties and relations can change over *time*;
- *Events* occur at different time instants;
- There are *processes* that occur over time in which objects participate;
- The world and its objects can be in different *states.*
- Events can cause other events or states as *effects;*
- Objects can have *parts.* This means there are atomic objects and composite objects.

These conceptual objects and primitive constructs are used to create domain models and they can be represented with ontologies in two different forms: at the knowledge (or informal) level and through formal software descriptions. Following accepted ontological development methodologies [Jones et al. 1998], ontologies should be represented using informal and formal descriptions.

4.2 An Ontology-driven Organisational Memory

Ontologies and data models have been used in knowledge-based systems and database management systems, respectively, to specify organisational model assumptions that will reflect the system's conceptualisation [Gruber 1993]. In this context, semantic data models can be considered as simple kinds of ontologies [Abecker et al. 1998]. The ontologies are used to describe the semantics of the different knowledge sources that can be found within an organisational memory. For example, a competence ontology can be designed to enrich the knowledge elements concerning the employees and experts of the organisation. With the same perspective, an information ontology is designed to provide factual and contextual information about the different knowledge sources in the form of electronic documents [Fig. 2].

Effective capture and reuse of less tangible knowledge assets within the organisation, such as the capture of contextual knowledge may be achieved using a well-structured common and shared vocabulary. Such common and shared vocabulary can be represented with ontologies. Such high-level organisational knowledge description is seen as a set of definitions of context-specific knowledge representation primitives consisting of domain-dependent classes, relations, functions and object constants. These primitive constructs can be applied and represented differently in several organisational domains, but should have the same meaning for human users and designers of the OM.

The layers of an Organizational Memory are interpreted as follows. The conceptual layer (layer 1) represents the organisational knowledge in an informal way that can be interpreted by different OM developers, such as domain experts, knowledge engineers and software engineers. This layer aims to create a shared understanding of the organisational knowledge. The creation of a common vocabulary facilitates communication in design and maintenance issues across people with different professional backgrounds. In the previous figure, this layer is made of

domain and general ontologies. For example, the Information and the Organisation ontologies can be reused in several domains, since the concepts they define are likely to be used almost universally.

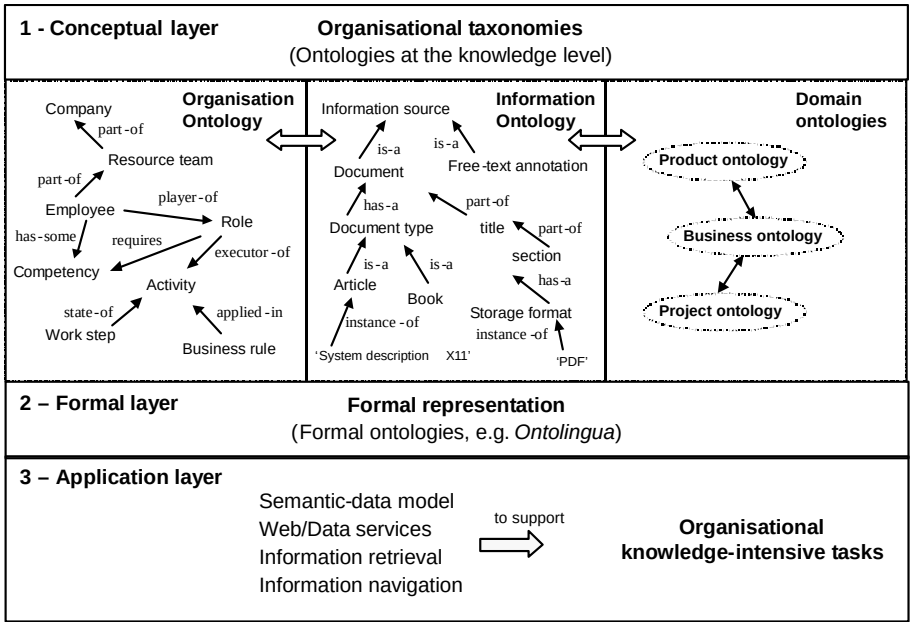

Figure 2: An example of an OM model using Ontologies

The formal layer (layer 2) enables the reuse of domain terms and constructs from other ontologies in order to facilitate future OM system maintenance tasks. The ontological descriptions provide a common vocabulary for knowledge engineers in order to develop further applications in this domain, such as an inference layer and the related reasoning mechanisms. This layer is essentially a format layer, where translators to multiple languages and environments can be hooked.

The application layer (layer 3) uses the encoded domain knowledge. The knowledge encoded with ontologies can be used in different application systems within an organization. This layer is the interface with the users, and can be tailored to different needs; as it is independent of a particular syntax and application model, changes at the previous layers do not have much impact at this layer.

4.3 The definition of a meta-model

In a previous OM implementation [Vasconcelos at al. 2002] the interface of the application layer is semi-automatically generated "on the fly", presenting the user with a standard Web page. The main goal is the definition of a unified meta-model for building organisational memories, and to allow for particular instantiations.

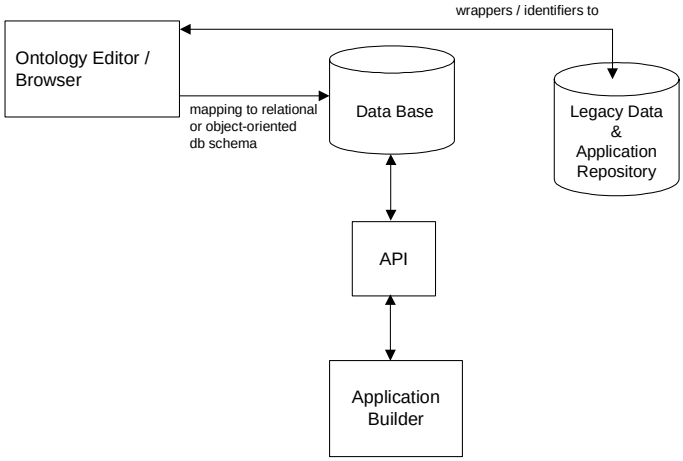

Figure 3: Ontology development environment

The integration of ontologies (formal knowledge) with data models (semi-formal knowledge) can have major benefits for the definition of precise and concise domain models. This OM development environment [Fig. 3] includes an ontological editor to specify and manage the OM ontology library. Using such an editor, the goal is to develop ontologies at the knowledge and formal levels to assist in effective data model design. This OM architecture should also include an automatic or semi-automatic tool, based on exhaustive mapping criteria, to translate ontological constructs and instances into the proper data model elements whenever possible. The creation of this meta-model is a key requirement for the effective maintenance of an OM.

In our current development environment, ontologies are translated and stored in a relational database, as tables. A set of functions was written as an Application Programming Interface that hides the relational/object conversion from the programmer. By modifying the meta-model it is possible to tailor the development environment to different needs, such as, for example, having two meta-class *class* types: one where instances are created locally (local classes), and another which refers to remote instances (remote classes), which could be located in legacy systems.

4.4 Organisational memory specification and architecture

The preservation and integration of different but related organisational knowledge is a key requirement for an effective development of organisational memories. Different knowledge areas within the organisation should be properly classified and integrated [Fig. 4]. In addition to the integration level of organisational information, an OM should be engineered in order to be integrated with the existing organisational

environment. An OM system should have an architecture suitable to be integrated with the existing IS infrastructure, i.e., it has to fit into the flow of information that is already happening in the organisation [Conklin 1996]. This requirement is crucial for the acceptance of the users of the OM system.

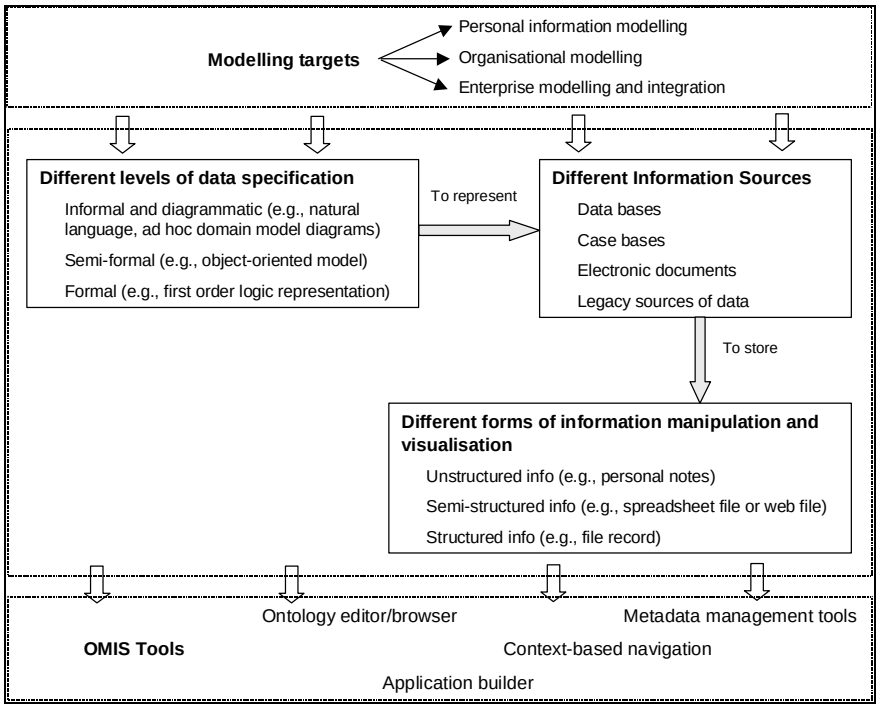

Figure 4: OM specification and architecture overview

An OM should provide means to preserve and integrate organisational information from different organisational sources in an information repository. The OM design and development should be prepared to handle different types of information and related levels of information representation [Kuhn & Abecker 1997]. Therefore, semi-structured information, structured information and formal information need to be integrated in a coherent way. Examples of semi-structured information are file documents in the form of notes, suggestions and hints. Examples of structured information are file documents in the form of manuals and technical reports. Additionally, the existing data stored in databases and data warehouses can be viewed as a particular type of structured information. Examples of formal information are business rules, design and process guidelines and corporate information that represent internal (organisation) rules and procedures concerning business processes and organisational behaviour.

5 A Case Study of Group Competencies

The material in this paper is based on research into the management of corporate competencies in knowledge intensive organisations. The practical outcome of this work was the design of a group memory system to manage heterogeneous and distributed knowledge embedded in business process activities. The specific emphasis of this work was how organisational processes can be represented in order to provide an integrated enterprise vision that will aid the efficient management of corporate competencies.

5.1 Group Memory Systems

A group memory is considered a specific example in a narrower scope of an organisational memory. To define a group memory we need to consider the work practices that include formal and informal communication that exists between people working together or geographically distributed. Group memory happens in the context of personal and managerial aspects that encourage people to share their work practices to improve organisational performance.

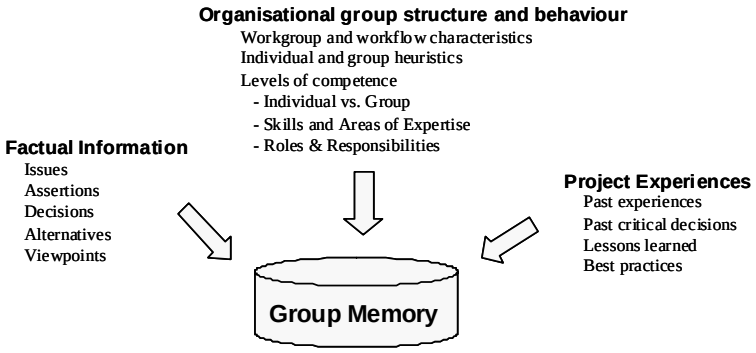

Figure 5: An example of a Group Memory

The Group Memory System described below focuses on corporate competencies, in particular human knowledge sources, their competencies, such as cognitive elements, technical expertise as well as project experiences and related heuristics. At a general level, it includes written and spoken communication, face-to-face meetings, shared information and co-ordinated work.

The main role of the group memory is to act as a shared conceptualisation to facilitate communication between group members and to function as a common schema for software applications. Thus, the group memory supports both structurally and dynamically, a shared representation of knowledge that allows a consensual understanding of shared purposes, roles and competencies.

5.2 Representing Corporate Competencies

People are what make organisations so complex. People have different and conflicting motivations, perceptions and attitudes, all of which change over time. As people transform data, information and past experiences into knowledge, the management of individual competencies will become more important in knowledge-intensive organisations. To find versatile employees and leveraging their competencies to meet different corporate needs is a matter of pivotal importance for knowledge intensive companies as competencies, in the form of technical and cognitive capabilities of their employees, directly affect the company's knowledge creation ability. To build an effective group memory, it is necessary to address these less tangible aspects of human behaviour within the organisation.

The main goal of corporate competence management is a better usage of human skills and knowledge. In knowledge-intensive companies, most daily work tasks require professional expertise and the management of a large body of knowledge. The construction of descriptions for these competencies poses both organisational and design challenges.

Firstly, there is the issue of identifying what competencies are relevant in real-world organisations. According to [Nonaka 1994] the competencies of an organisation include tacit and explicit knowledge, and should be conceived of as a mix of skills and technologies. Earlier we defined a competency as a characteristic of an individual or group that is required to produce an effective organisational performance. However, in practice these characteristics often intangible and difficult to define as they are not only related to the characteristics of the individual but also to the organisational context they work in, such as the people they know and group they work with. There have been a number of attempts to use techniques such as Social Network Analysis to define these groups [e.g. Tomlinson 2002], however for the purposes of this work a clearly defined business activity or work step have been used to define the context for the description of the related employee's competencies.

Secondly, there is the problem of representation. Our aim is that any representation will eventually form a consensual model for corporate competencies within the workplace. However, once identified, specific competencies can differ in fine but significant detail e.g. [Tab. 1]. At the organisational level, an employee's competency can have different levels of granularity depending on the business activity or problem-solving task. For example, a *technical* competency can be described in terms of different competencies, such as *analysis*, *modelling* and *engineering*. In addition, each of them can be further defined by competencies such as *test*, *review*, *assess* and *analysis*. Competence granularity means a hierarchy of competencies and their areas of application that can be defined for a specific workgroup. Depending on the domain under investigation, different levels of competence granularity can be defined in a consensual manner. Viewed in this way, competence elements are to be modelled and retrieved like other knowledge assets of the group memory.

Title	**Competence Ontology**
Domain	Workgroup competency taxonomy and a model for expert annotations
Creation Date	February 2001
Modified in	June 2001
Ontology Engineer	JBV
Main goal	Represent a consensual workgroup structure of competencies to assist business process activities
Scope	Portfolio Engineering - a process-oriented company workgroup
Knowledge sources	• Domain experts • Interviews results • Questionnaire focusing in competence management • Active participation – communication patterns within the workgroup • Technical documentation
Applications	GMS Prototype
Users	• Corporate managers • Industrial practitioners • KM & OM researchers
Usage Scenarios	• Profiling people • Dynamic creation of competencies within a company workgroup • Routing information needs to the right experts • Project teambuilding analysis • Expert annotation systems
Reused ontologies	• Enterprise Ontology [Uschold et. al 1997] • Agent Ontology (*Ontolingua* Library) • Ontology of capabilities [Stader and Macintosh 1999]
Reusable ontologies	Product Ontology
Domain questions (some examples)	Question: What competencies are needed to install a TN-16XE optical interface? Concepts: Competency, Install, Optical Interface Relation: Has-skill-of (Install, Optical Interface)
Classes specified	- 7 Classes
Relations	- 12 Relations
Functions	- 17 Functions
Instances	- 23 Instances
Logic Axioms	No axioms defined

Table 1: An example of a knowledge description of the Competence Ontology

5.3 A Competence Taxonomy

Personal and group competencies are formalised as special elements of the group memory, such as competencies, skills, roles, and project experiences. The competence ontology (using a taxonomic notation) represents the knowledge and skills needed within the workplace to perform certain business functions of the organisation. A competency can be stated at a very abstract level. In this way, competencies can be decomposed to more granular competencies, such as competencies in designing network solutions, or writing product technical documentation. A competency can also be decomposed in the skills required to perform the business processes underlying the business function for which the competency is maintained.

The competency taxonomy includes two hierarchies (primitive competencies and application areas) illustrated in [Fig. 6]. The main classes in this classification are the competency and the entity. The class competency allows the representation of

different levels of competency granularity through the creation of sub-classes of competencies. In the same way, the class entity represents the different application areas in which a specific competency can be applied.

These hierarchies are combined through a set of competence relations (e.g., has-experience-of) that allows the combination of terms between these hierarchies. Other competence elements, such as skills, roles, responsibilities, background knowledge, and project experiences are represented with these formal relations (competence relations) between the hierarchies.

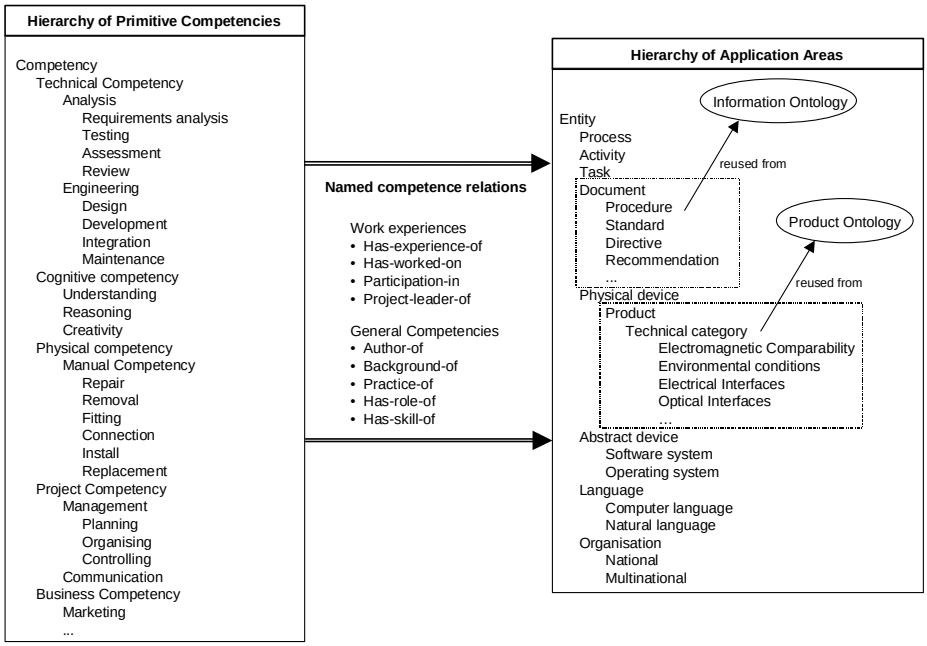

Figure 6: Competence Taxonomy (adapted from [Stader & Macintosh 1999])

The hierarchy of primitive competencies is an agreed set of competence terms relating to a workgroup. This taxonomy of competencies needs to be dynamic considering organisational changes and technical developments. New terms in both hierarchies and new relations must be created during the execution of work-related tasks. Some terms and their instances are reused from the previous ontologies. The idea is to create and reason with competence expressions. For example, to be able to represent that a specific domain expert *Has-skill-of* (competence relation) in *Design* (primitive competence) of *Optical interfaces* (application area). This expression example written in a formal notation is Has-skill-of (Design, Optical Interfaces).

5.4 The GMS Prototype

The GMS prototype provides a common framework for describing technical and personal knowledge from the existing data sources within the organisational group and adds an interface for cataloguing, indexing and retrieving information. The GMS

uses ontologies as a common and consensual vocabulary that overcomes the heterogeneity of existing information sources. The GMS acts as a single front-end to existing sources, adding a conceptual view of the domain and the vocabulary used in the domain.

The domain specific GMS functions allow the sharing of unstructured knowledge about technical characteristics and expert information entered and updated by company (project group) personnel. It provides mechanisms to perform queries, to navigate across the information sources and to perform retrieval operations about compliance information. Generically, the GMS provides a central repository [Fig. 7] for information about products and people.

The GMS prototype functions are performed in one of three modes.

1. Entering and updating the technical descriptions of products, compliance statements, norms, standards and skills. Trained personnel on technical compliance activities (domain area) must perform this input data task.
2. Browsing product specifications through a dynamic web navigation process.
3. Information retrieval about compliance statements concerning a product or parts of it, retrieving knowledge about compliance statements, expert annotations, skills involved, and expert identities. This is done by all people involved in the compliance phase of the current bid response process.

This allows the integration with existing information sources, which relies on indexing documents and directs experts to the relevant sources. This GMS view is shown below:

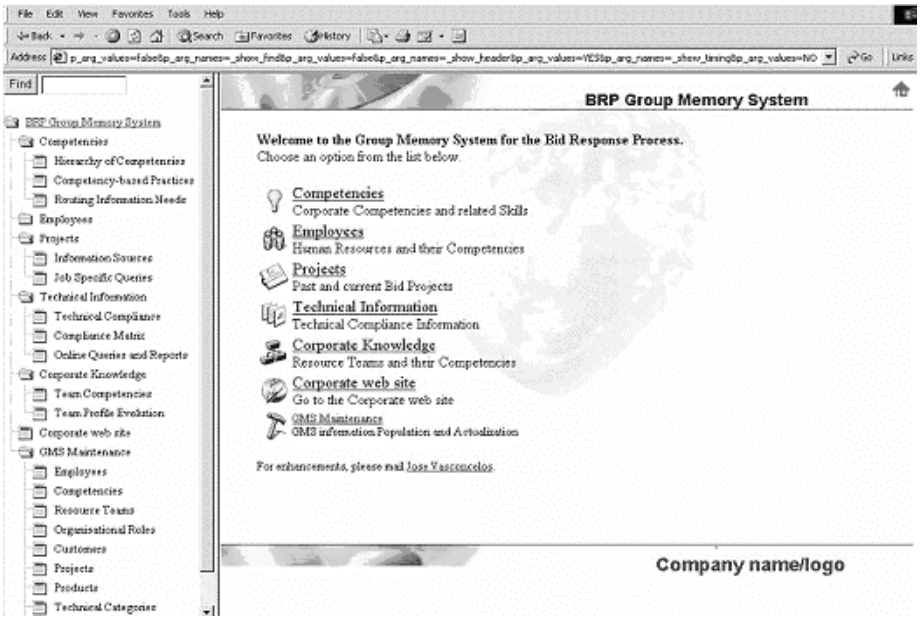

Figure 7: GMS Prototype

The proposed GMS is designed using an ontology-based model concerning a domain specific business process and related individual and group competence elements. This ontology-based approach allows the definition of formal elements of a domain specific ontology. In the context of the previous competence ontology, the domain specific GMS application prototype is intended to provide some retrieval mechanisms, such as the following inferences:

- finding knowledgeable organisational employees needed for company problem-solving tasks;
- routing information needs to knowledgeable people.
- define new competence templates based on project experiences;
- define new competence evolution schemas based on project experiences.
- competency-based practices, such as the semi-automatic identification of competence gaps and its classification.

The GMS prototype was developed to assist the project member (user) through the following steps:

- Identifying and describing a lack of specific expertise;
- Providing a set of guidelines to assist the user in such problem-solving task;
- When possible, giving the solution for the problem (competence gap) reusing past project (bid) experiences and related technical information; and
- If necessary (and agreed by the project member), a new competency element and its description can be classified in the existing hierarchy of competencies.

6 Conclusions

Advances in information and communication technologies, and the emerging trends in knowledge management and organisational memories, are extending people's ability to collaborate and co-ordinate activities between business processes. To remain competitive, organisations with significant intellectual capital must create an environment that facilitates the better reuse and deployment of existing corporate knowledge.

The problem of managing knowledge in large companies has grown with the increasing complexity of organisations and quantity of information that flows within and between them. An organisation's knowledge is built upon the experience of their human resources and the lessons they learn. As we outlined in section 5.2, the effective management of this knowledge is a considerable challenge. The successful development of group memories requires a careful analysis of the existing organisational work practices and the available information technology infrastructure.

In section 3.2, we identified several functional requirements for the successful construction of an organisational memory in a KIO. Underlying these requirements are a set of problems that represent knowledge management deficits at the organisational level. These deficits, as described in section 3.1, constitute the rationale to build the group memory system described in this paper.

This system was a particular instance of an organisational memory system: a group memory system for managing corporate competencies. The system described focused on internal competencies, in particular human knowledge sources, their competencies, project experiences and the related heuristics.

Our current work has focussed on a specific domain (the telecom industry) and was mainly concerned with the development of effective information systems in ill-structured domains. Here, ontologies provide a technique for creating a high-level domain clarification and a representation that can be moved between platforms and systems that is dynamic and capable of evolving over time.

Our future research aim is to define a domain-independent model to represent corporate competence elements: an ontology-driven organisational memory to manage group competencies. The goal is to define a competence model that can be tailored to a variety of knowledge-based organisations. However, further research is needed in order to test and validate our approach. The group memory system as a theoretical concept can only be evaluated as a practical solution to the problems outlined in the introduction to this paper through further studies in different organisational settings.

Notwithstanding this, we believe that knowledge-intensive activities in organisations, such as problem-solving tasks involving people from different departments, geographical locations and technical backgrounds, would benefit from access to and use of systems such as the one described in this paper.

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