A Group Memory System for Corporate Knowledge Management: An Ontological Approach

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Abstract

Organisations are increasingly recognising the importance of managing what they consider their most valuable asset: knowledge. This work is a contribution towards that end, proposing a system for representing, recording, using, retrieving, and managing individual and group knowledge: a group memory system. This paper describes the high-level objective of this research: the design and implementation of a group memory system to manage heterogeneous and distributed knowledge embedded in business process activities. This paper also discusses the role that ontologies may play in corporate competence management.

1. Introduction

It has always been true that a significant part of an organisation's knowledge resides in the minds of the people that make it up. However, in the current organisational environment, where downsizing, reengineering, restructuring and high rates of organisational turnover are common, enterprises are beginning to find that it is easy to loose a vital element of their intellectual property: corporate knowledge. Put simply, organisations are beginning to recognise that they can suffer a failure of their collective corporate memory. Unsurprisingly, one solution that is put forward to this problem is that of an Organisational Memory system (Abecker et al. 1998), (Dieng 2000).

An organisational (or corporate) memory system enables the integration of dispersed and unstructured organisational knowledge by enhancing its access, dissemination and reuse among an organisation's members and information systems. Following (Kuhn & Abecker 1997) we use the term organisational memory to mean a comprehensive computer system which captures a company's accumulated know-how, business activities, the related core competencies, and other forms of knowledge assets, and makes them available to enhance the efficiency of knowledge-intensive work processes.

The central topic of this paper is the design and implementation of a particular instance of an organisational memory system: a Group Memory System (GMS). We define a GMS as a system to manage heterogeneous and distributed knowledge embedded in business process activities. More specifically, the heterogeneous and distributed knowledge that is managed is knowledge related to the 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. The objective is the definition of a common and shared understanding of the corporate assets embedded in the organisational competencies.

The GMS design addressed in this paper is particularly focused on the support of the management of employees' competencies in an efficient and structured way. Thus, the application area of this research work might be to improve corporate competence management tasks such as, the management of people, their roles, responsibilities, skills, interests, and areas of expertise.

Ontologies are used in the first (in terms of data abstraction) conceptual layer of the system as the form of knowledge representation. The main objective of the ontological discipline is the syntactic and semantic standardisation of knowledge structures. Put simply, ontologies are used to define a shared and consensual structure for corporate competencies that will form the basis of the GMS.

Although the theoretical foundations for this research work are multidisciplinary, involving aspects of Artificial Intelligence (AI), organisational memories, process modelling, design rationale, and ontologies (Vasconcelos et al. 2000), the bulk of this paper will be a report on, and analysis of, the ongoing development of a prototype GMS system. A case study is presented centred on business process and activities of knowledge workers, such as project managers and requirement engineers, where background knowledge is distributed across the whole company.

The following section of this paper discusses the relationship between knowledge management and competence management at the corporate level. Section three introduces the GMS for competence management where the objectives, design approach, the underlying case study, and the application area are discussed. The ontological approach for competence management is presented in section four. This section includes the competence management elements and tasks in analysis, the GMS ontologies, and an ontological-inference model to be applied to reasoning procedures. Section five concludes this paper.

2. Knowledge Management and Competence Management

For the purpose of this paper, a competency is taken to mean a characteristic of an individual or group that is required to produce an effective organisational performance. That is, competency is related to the underlying knowledge and skills needed to perform a role within an organisation. According to (Nonaka 1994) the core competencies of an organisation include tacit and explicit knowledge, and should be conceived of as a mix of skills and technologies. In this context, the concepts of knowledge and competence are closely related (Lindgren 2000).

A seminal reference in competence management is the *People Capability Maturity Model* released by the *Software Engineering Institute* (Curtis et al. 1995). This model was initially designed to help software organisations to focus on the improvement of the capability of their workforces (Curtis et al. 97). Corporate maturity in the people capability maturity model represents an organisation's ability to improve the knowledge, competencies, and related skills of its workforce and align performance with the organisation's business objectives.

Several views of knowledge have been explored in Knowledge Management (KM) literature, most of them in the form of opposites, e.g. tacit/explicit (Nonaka and Konno 1998); know-what/know-how (Seely Brown and Duguid 1998), cognitivist/constructionist (Von Krogh 1998). Kimble et al (Kimble et al, 2000) differentiate between 'hard' and 'soft' knowledge

stressing that these should not be seen as mutually exclusive opposites but as two parts of a duality. That is all knowledge is to some degree both hard and soft.

This paper takes a predominantly 'hard' view of KM, that is that KM is principally concerned with acquiring, structuring, maintaining, and disseminating knowledge across the organisation (Applehans et al. 1999), (Macintosh et al. 1998). This viewpoint addresses the managing of knowledge from the perspective of Knowledge as an asset of a business organisation, and relates the management of business knowledge assets to business processes and objectives.

3. A Group Memory System for Competence Management

3.1. Ontologies as the form of knowledge representation

Ontologies are formal theories supporting knowledge sharing and reuse mechanisms [cf. CYC (Lenat 1995), *Ontolingua* (Farquhar et al 1996)]. The ontological discipline promotes the reuse of knowledge structures in the form of ontology libraries. The main objective of an ontological library is the description of consensual knowledge related with several knowledge domains. A typical example of such library is the *Ontolingua Library* from the Knowledge Systems Laboratory in the University of Stanford.

Ontologies provide a shared and common understanding of a domain in order to facilitate the communication between people and applications systems (Uschold & Gruninger 1996). In this sense, this paper discusses the role that ontologies play in corporate competence management. In this context, the major reason for their choice is that formal ontologies provide a way of sharing and reusing knowledge among people and heterogeneous application systems (O'Leary 1998), (Abecker et al. 98).

Ontologies can be used to explicitly represent the semantics of semi-structured information, i.e. an ontology provides an explicit conceptualisation (meta-information) that describe the semantic of the domain data in analysis (Abecker et al. 98), (Fensel 2000). 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. 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 in 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 which 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.

3.1.1. Ontology definition

An ontology is a high level formal specification of certain knowledge domain: a *formal and explicit specification of a shared conceptualisation* (Gruber 1993). 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 domain 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. 98), that is, it is not related with the individual, but accepted by a group.

3.1.2. Ontology semantics

Ontologies provide syntactic and semantic terms for describing knowledge about a domain. Although differences exist within ontologies, general agreement exists about several issues related with the structure and behaviour of real world objects (Chandrasekaran et al. 1999):

- There are *objects* in the world
- Objects have *properties* or *attributes* that can take *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*

3.1.3. Ontologies and Semantic Networks

An ontology can be seen as a domain representation in the form of a semantic network. The nodes are concepts or entities, and the arcs represent relationships or associations among the concepts. This ontological network is augmented by logic axioms, which represent a set of attributes, functions, relations, constraints and rules that specify the structure of the concepts and the representation of their behaviour. In this ontological network, the concepts are categorised and classified in taxonomies through which inheritance mechanisms can be applied.

3.2. Group Memory System Design

The GMS described in this paper is related to a specific business process with an associated project team. Following the identification of relevant knowledge, people, processes, and organisational units, the aim is to develop a practical representation or structure to store that knowledge. The group memory is seen as a complex, distributed, and occasionally overlaid set of necessary organisational elements to execute a business process, such as the human

actors in terms of their individual and group knowledge, and the used artefacts and their states embedded in the different activities.

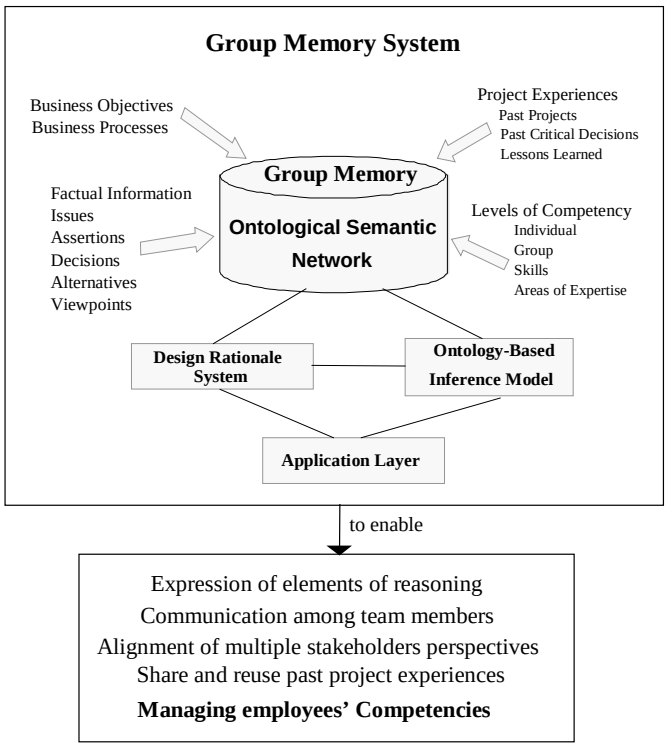

Figure 1- The group memory system: an overview

Figure 1 above gives an overview of the GMS. The high-level layer of this framework is based on Ontologies, i.e. an ontological semantic network that will represent the underlying domain knowledge in the organisational processes. A design rationale system will capture and manage employee's rational elements, such assertions, arguments, positions, decisions or alternatives. Reasoning procedures will be provided by using an ontology-based inference model. A network access model and the related interface will provide the employees of the organisation with a view of the collaborative (group) knowledge.

4. The Case Study

In order to evaluate the feasibility of this approach, the GMS is being developed and applied in a real organisational setting, a multinational telecommunications company. This company designs, produces and commercialises a variety of telecommunication products and network solutions worldwide.

The underlying case study to support this research approach is centred on the business process activities of knowledge workers such as project managers or requirement engineers. Specifically, the case study addresses a company domain problem in the competitive bidding area: the Bid Response Process (BRP). The work in this organisational setting requires a large amount of background knowledge that is distributed across the whole company.

A process is interpreted as a sequence of activities performed for a given purpose. Activities include all the work that is done to perform the tasks of an organisational unit. The

description of an activity includes the tasks, roles, competencies, and necessary procedures to perform such activity. For example, in the case study, the objective of the BRP is the production of an efficient and effective answer to the customer that have asked for a specific bid. The initial customer bid may contain several requirements, such as technical, legal, pricing, national and international standards and regulations, among others compose. Between the initial bid and the final response there exists a set of team interactions, a set of complex interdependent activities, all of which determines the outcome. The BRP will involve many different actors, artefacts, and activities; during the bid response process, several project teams work together in order to find effective answers to the different customer requirements.

This case study will help the evaluation and validation of this research approach according to the actual needs of a large corporation in terms of knowledge and competence management. The results of this work might be used in deriving new trends and techniques in corporate competence management.

4.1. The Competence Management Approach

As for almost any business organisation, looking for experienced people with specific expertise and skills is a perennial problem for the case study company,. In the context of knowledge, management, individual and group competencies of experienced employees are one of the most important knowledge assets of knowledge-work oriented enterprises (Liao et al. 1999). The competence management (CM) approach sees personal competencies of employees as an important knowledge resource in the group memory. In this context, competence elements are to be modelled and retrieved like other knowledge assets of the group memory.

One idea of this research is the adaptation of some principles of the capability maturity model and as other studies and research projects in the CM area (Lindgren & Wallstrom 2000), (Liao et al. 1999), (Lang & Pigneur 1999) to the GMS framework. To this end, we have established the following ontologies for the group memory system and specific organisational evolutionary tasks in order that a company might manage its employees' competencies in a more efficient and effective way.

4.2. The Ontologies for the Group Memory System

Organisations with significant intellectual capital, such as the case study company, must create an environment to better elicit and capture knowledge for later use in decision-making processes. Advances in information technologies and telecommunications, coupled with emerging trends in organisational learning processes, are enhancing the ability of people to communicate and co-ordinate among organisational business processes. In this context, an ontological network representation of the organisation can provide a global and integrated enterprise vision.

4.2.1. A global and integrated enterprise vision

A global enterprise vision (or group memory view) is a representation of what matters to people at different levels and positions at the organisation. The GMS will provide a group memory overview of employee's capabilities, project experiences, and essential knowledge areas of expertise. Integrated because it uses a shared representation, meaning, and

visualisation of the organisation: organisational structure, past and current projects and the related business processes, and people involved. The GMS will act as an environment where different people (at the individual and group level) with different interests and skills will manage heterogeneous and distributed knowledge embedded in business process activities.

The enterprise vision addressed in this paper is composed of five enterprise dimensions: organisational (group) structure, competence management, business processes, project experiences, and knowledge sources, including data, information and physical resources.

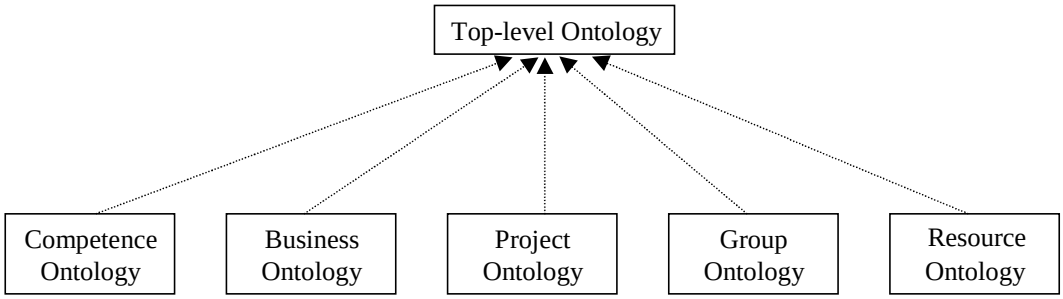

Figure 3 – Ontological enterprise vision

This particular enterprise vision is being modelled with ontologies. For this purpose, the GMS ontological network includes group (enterprise structure) ontology, a competence ontology, a business (process) ontology, a project ontology, and an resource ontology. The following ontology is initially described at the knowledge level. Secondly, it is applied an ontological network notation.

4.2.2. A Competence Ontology

The competence ontology aims to create a consensual structure of competencies within the organisational group. According a multiple case study developed by (Lindgren 2000), this task presents some difficulties, at the corporate level, concerning the approach of creating a specific (and consensual) structure of competencies. For this reason, the proposed competence ontology should have a set of representative high-level terms and should allow a dynamic evolution of its structure.

In the case study, the competence ontology (figure 4) represents the knowledge and skills needed within the workplace to perform important 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 capabilities (or 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 ontology approach that is being used in this research is based on a (ontological) semantic network level. Two abstraction mechanisms will be represented in a standard manner: generalisation / specialisation (*is-a*) with multiple inheritance and decomposition hierarchies (*part-of* aggregations). Other structural links representing associations, dependencies, and other relationship definitions, such as… will rely on the domain specific modelling process.

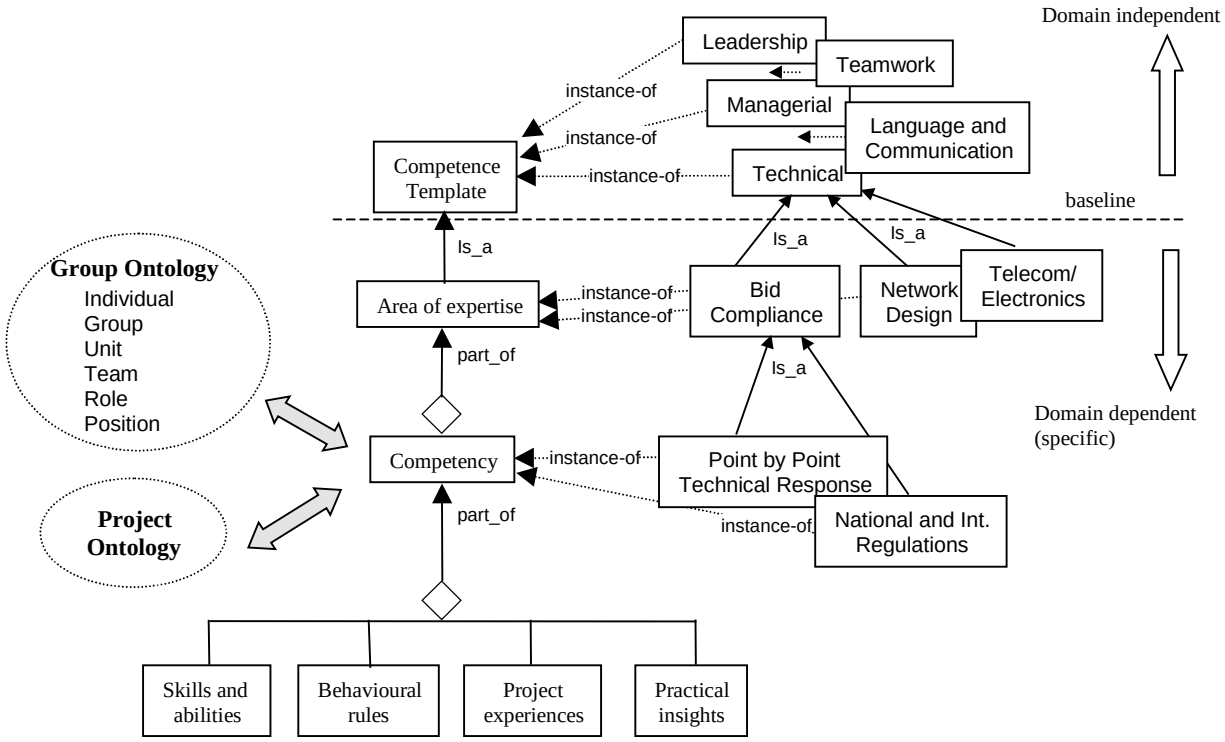

Figure 4 – A part of the competence ontology

4.3. The Competence Management Tasks

4.3.1. Competence templates representation

A competence template defines a specific area of expertise that includes a set of competencies. It is defined a conceptual baseline (see figure 4) between competence templates (areas of expertise) and corporate competencies in order to make a clear distinction between these two primitive concepts (competence template vs. competency). This baseline, depending on the granularity of the defined ontology, is intended to split domain dependent (case study specific) from domain independent competence areas.

A role is interpreted as an organisational function that can be assigned to a certain employee. Within the corporation, a role is interpreted as a set of competencies i.e. a particular employee needs to have a set of competencies to perform effectively a given role.

In order to categorise and classify these CM elements, it is necessary to identify and map different employees' competencies to past and ongoing project tasks in order to create a group competence structure. There are significant difficulties concerning the definition of a specific (and consensual) structure of organisational competencies. Therefore, the process of identification, mapping, and managing competencies needs to be dynamic and to enable different perspectives, such as the systematic declaration, analysis, and storage of competencies depending on the current business project. This will lead us to a competence taxonomy of the organisational group.

In the case study, competence templates for the representation (see figure 4) of areas of domain expertise, such as technical, operational, groupwork, language and communication, are being developed.

An ontology-driven approach for describing organisational, business processes, and competence elements allows the definition of the group memory conceptual level. Personal and group competencies are being formalised as special elements of the group memory, such as competencies, skills, roles, responsibilities, and project experiences. The following figure partially presents (domain specific) the competence, the project, and the business ontologies.

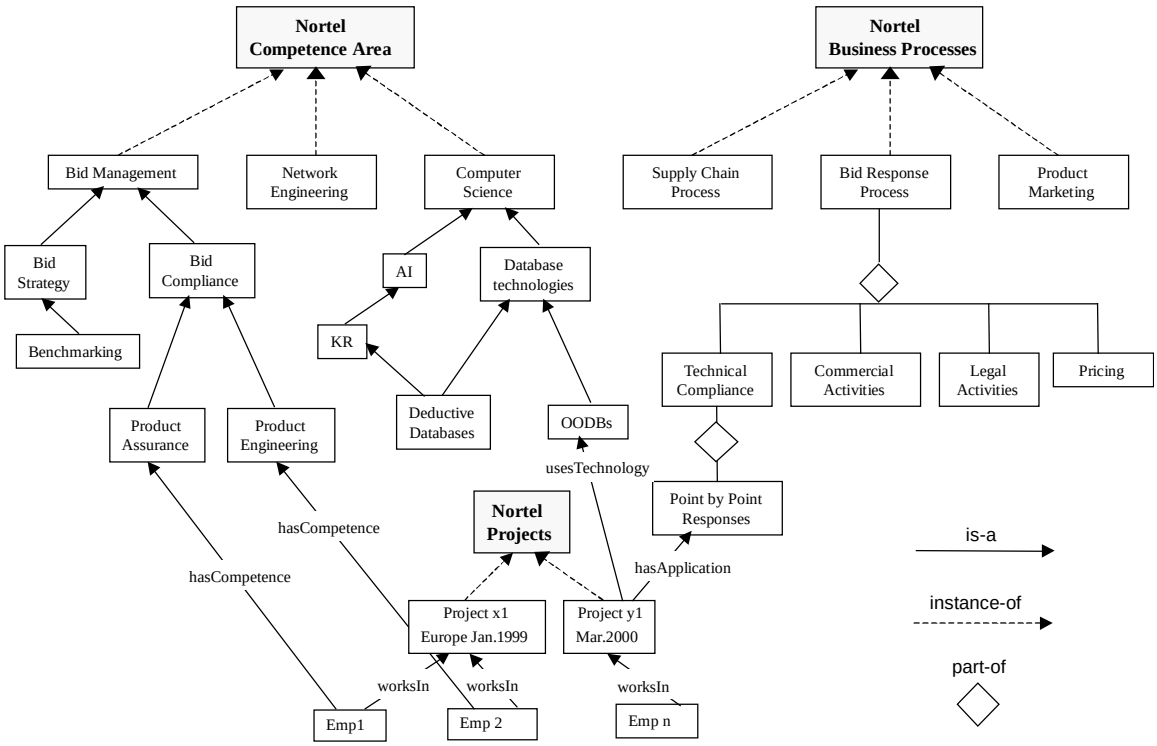

Figure 5 –Domain specific (partial) Ontologies
[adapted from (Liao et al. 1999)]

4.3.2. Competency-based practices

This CM task addresses the manipulation of the right roles, skills, experience, and area of expertise for each of the ongoing business projects. The focus is on developing the specific knowledge and skill sets that are needed for the business projects being developed. To identify and emphasise core competencies in order to define common strategies to match these competencies with different clusters of knowledge and skills.

In order to create a proper environment for developing such competency practices, we need to establish the proper requirements for each role, competency, and skill that has been defined or assigned to a certain employee. To report and evaluate the results of such assignment in a specified period of time, and to promote the interaction between employees in order to exchange personal/group experiences and the related corporate knowledge.

For example, the GMS application for competence management is being designed to support the identification, representation, and retrieval of competence requirements, needs, and

bottlenecks. To develop a tool to perform analysis of business processes focusing in the different roles and competencies that knowledge workers play in the organisation. The main objective is to assist processes of finding the right corporate expertise, at the right time, and at the right place, as well as enabling the process of routing information requests for the right corporate experts.

4.3.3. Competence profile evolution

Define competence profile evolution schemas based on individual background, project experiences, and individual or group heuristics. This complex CM task can assist processes of people turnover within the organisation and, generically, skill evolution aspects.

In order to assist such CM task, the GMS is being designed to include a design rationale system for capturing employee's reasoning elements, such as information concerning the employees' assertions, conceptualisations, objectives, directions, project experiences, individual and group heuristics, and business interests.

4.3.4. An Ontological Inference Model for Competence Management

In existing enterprise KM systems significant functions are missing [Lindgren 2000]. For example, at the corporate CM level, the applications can be described as traditional human resource systems, complemented with features that store competencies. Other CM approaches are using simple skill databases with keyword text facilities. In order to achieve higher levels of modelling expressiveness, we are using ontologies as the conceptual layer of specification for representing and manipulating corporate competence tasks.

The proposed GMS is being designed upon an ontology-based model of domain specific business processes and the 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 aforementioned competence management tasks, the domain specific GMS application prototype is intended to provide some reasoning mechanisms, such as the following inferences:

- finding knowledgeable organisational employees needed for company problem-solving tasks;
- define new competence templates based on project experiences;
- assist competency-based practices;
- define new competence evolution schemas based on project experiences.

These inference mechanisms are thus used to dynamically update the GMS ontologies. We envisage that a user interacts with the GMS in a semi-formal way, where semi-formal queries are translated into formal system commands. The translation is guided by heuristics that specify interpretations for terms used in the query that may have different meanings dependent on the project context. These heuristics can be user-defined or can be inferred from interaction with the user. Algorithms for this task are currently under development.

5. Conclusions and Future Work

Ontologies provide a shared and common domain understanding in order to enable the communication between people and application systems. To develop effective knowledge management systems, it is becoming essential the definition of shared and common domain structures in the form of organisational memories or shared information spaces. In this context, ontologies are emerging as an essential asset in knowledge representation, to describe both the structure and the behaviour of unstructured and semi-structured information.

As further research development in order to test and validate this approach, the group memory system as a theoretical concept will have a more coherent result from the current studies within the organisational field setting. It is expected that complex activities, such as bid compliance and response tasks, involving different people from different departments, geographical locations, and technical background, would benefit from access to such a group memory system.

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