CHAPTER XX

A DESIGN FOR A GROUP MEMORY SYSTEM USING ONTOLOGIES

José Vasconcelos[1, 2], Chris Kimble[1], Feliz Ribeiro Gouveia[2]
[1] Management & Information Systems Group, Department of Computer Science, University of York, York, YO1 5DD, UK, +44 1904 433242, jvasco@{cs.york.ac.uk, ufp.pt}
[2] Multimedia Resource Centre, University Fernando Pessoa

Abstract

Organisations recognise the importance of managing what they consider their most valuable asset: Knowledge. Our work is a contribution towards that end, proposing a system for representing, recording, using, retrieving, and managing knowledge. This paper begins by briefly outlining the concept of an Organisational Memory. It will then discuss the high-level conceptual taxonomy that could be used for the design of an Organisational Memory System based on a form of knowledge representation used in Artificial Intelligence: Ontologies. The paper will then discuss a specific implementation of an Organisational Memory System: a Group Memory System using Design Rationale Systems and Case-Based Reasoning. Examples to illustrate the application of such a Group Memory System in a real organisational setting are provided.

1 INTRODUCTION

With the increased quality and quantity of information available within organisations, and the increased flow of information between people and software systems, Knowledge Management (KM) has become part of the new organisational lexicon. KM sees knowledge as an asset to be managed and aims to reduce the problems of knowledge sharing and reuse across enterprise agents.

One approach to KM concerns the capture and management of the skill, expertise and competencies available to an organisation which, added to organisational structures, can be used in the construction of organisational memories. In order to represent organisational memory formally, this paper will use the emergent ontological engineering discipline. The objective of this discipline is the syntactic and semantic standardisation of knowledge structures in Ontologies. The paper will describe a specific implementation of an Organisational Memory

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System: a Group Memory System using, design rational procedures and case-based reasoning procedures. Design rationale procedures will be used to enable knowledge acquisition and elicitation and reasoning facilities will be implemented using case-based reasoning technology.

2 ORGANISATIONAL MEMORIES

A core concept in discussions about technological support for KM is that of the *Organisational Memory* (OM). Following Kuhn & Abecker (1997) we use the term *Organisational Memory* to mean a comprehensive computer system which captures a company's accumulated know-how and other forms of knowledge assets and makes them available to enhance the efficiency and effectiveness of knowledge-intensive work processes. The long-term aim of our research is to develop an Organisational Memory System using ontologies. One of the main objectives of this work is to test and implement knowledge modelling techniques using ontologies, particularly to represent less tangible knowledge assets within a business organisation.

Any organisation's knowledge assets are related to experiences of their human resources; their project experiences, problem-solving applications and the resulting lessons learned. An OM enables the integration of this dispersed organisational knowledge and enhances its reuse and dissemination. Thus, an OM is the means by which knowledge from the past is brought to the present activities (Stein & Zwass, 1995): the OM becomes a way of enabling organisational learning and continuous process improvement. This approach is seen by some as a way to minimise some of the current deficits in KM, e.g. Macintosh (1997)

These deficits, among others, have provided the motivation for the development of OM to create, acquire, access, combine, discard, and preserve organisational knowledge. Thus, we can see an OM as the core of an enterprise KM system. However, before we describe an instance of an OM with the same properties, such as a group memory, it is necessary to understand the different dimensions of knowledge within the organisation.

2.1 Organisational Knowledge Types

In a KM initiative, the first step is the categorisation and classification of organisational knowledge. In order to manage knowledge as a resource it is first necessary to understand the characteristics of knowledge. The comprehension of such types is the first step on the investigation of knowledge sharing and reusing mechanisms, needed in the process of acquiring, developing and disseminating knowledge within organisations. This process will ultimately facilitate the identification and analysis of both the available and required organisational knowledge assets and assist with their subsequent preservation and deployment across the enterprise agents. This section will therefore present a conceptual knowledge taxonomy. The purpose of this framework is to provide a definition of the vocabulary and the related semantics for the identification, categorisation and classification of knowledge assets within an organisation.

Two general and related forms of knowledge classification can be found in much of the literature on KM. The first is the classification of knowledge into tacit or explicit; the second is the classification of knowledge into the declarative, procedural or heuristic. In this taxonomy, a third category has been introduced to represent the location of knowledge in the organisation: knowledge may be classified into either individual or group (collective) knowledge. Within these

three categories, it is possible to fit most forms of domain specific knowledge. The three categories are described in detail below.

Tacit Knowledge vs. Explicit Knowledge

In 1966 Polanyi used the phrase "we know more than we can tell" (Polanyi, 1966) to describe what he meant by tacit knowledge. Tacit knowledge refers to personal knowledge, i.e. the intellectual property of an individual. This is kind of knowledge we cannot articulate: because is either too complex or simply because it is internalised in people's minds. Nonaka describes tacit knowledge (Nonaka, 1995) as personal knowledge embedded in individual experience, shared and exchanged in a direct and effective way in normal social interaction. Explicit knowledge on the other hand refers to knowledge that is transmittable in formal and systematic language. It is the kind of knowledge we can easily share and articulate, because it is independent of the individual mind. Examples of explicit knowledge are information about physical aspects of an organisation, such as documents: reports, articles, software code, pictures and other kinds of reusable technologies.

Declarative, Procedural, and Heuristic Knowledge

Declarative knowledge is related to the physical aspect of knowledge. It is the knowledge type required in order to know *what, who, where and when*. It is essential in both interpreting and describing, from a certain viewpoint (conceptualisation), the physical features world. It is knowledge of objects (entities or events) and facts about the world, i.e. it is factual information about a given content area. Procedural knowledge is the knowledge required to accomplish a certain task: it provides a description of the system specific actions required to complete a particular task. It derives from the intellectual skill of knowing *how* to do something. Conventionally, procedural knowledge uses declarative knowledge to describe actions in step by step sequences. Finally, heuristic knowledge describes the knowledge related to the individual experience and implicit reasoning. As meaning that depends on the individual's experience, heuristic knowledge grows with personal work experience. Heuristic knowledge is generated by an internal process and uses both declarative and procedural knowledge to solve problems and consequently to answer the question *why*.

Individual Knowledge vs. Group Knowledge

In this paper, a third category of knowledge has been introduced to represent its location in an organisation. In the conceptualisation above, tacit knowledge is seen exclusively as a property of individuals. However, research has made it clear that a team of interacting individuals can have knowledge that transcends the knowledge of each of them individually (Walsh, 1995). According to Buckingham Shum (1998), organisational knowledge is multidisciplinary, hard to formalise, and generated in discussions with competing viewpoints. The third categorisation is an attempt to recognise this new understanding of knowledge and incorporate both individual and organisational knowledge. Thus, we can see that in the organisational environment, we need to create two additional knowledge categories that relate to the location of knowledge. One concerned with individual knowledge and the other concerned with group or collective knowledge. Walsh (Walsh, 1995) uses the term Knowledge Structure to describe a "mental template" that is used to give a complex information environment form and meaning. Knowledge structures are built on past experience and are used to order data to allow for subsequent interpretation and action. Hence, individual knowledge is concerned with personal

knowledge structures, while group knowledge is related to organisational knowledge structures.

Figure 1 below shows the different organisational knowledge types and their relation to different types of knowledge assets.

3 ONTOLOGIES

The term 'Ontology' has its origins in metaphysics and philosophy. In general, an Ontology is used to explain the nature of reality. However, in Computer Science, and in the field of Artificial Intelligence in particular, it has a precise technical meaning: it is a formal and explicit specification of a shared conceptualisation (Gruber, 1993). Ontologies are content theories about real world objects of interest (concepts, entities, events, actions or processes), the properties of objects, and the relations between them in a certain domain.

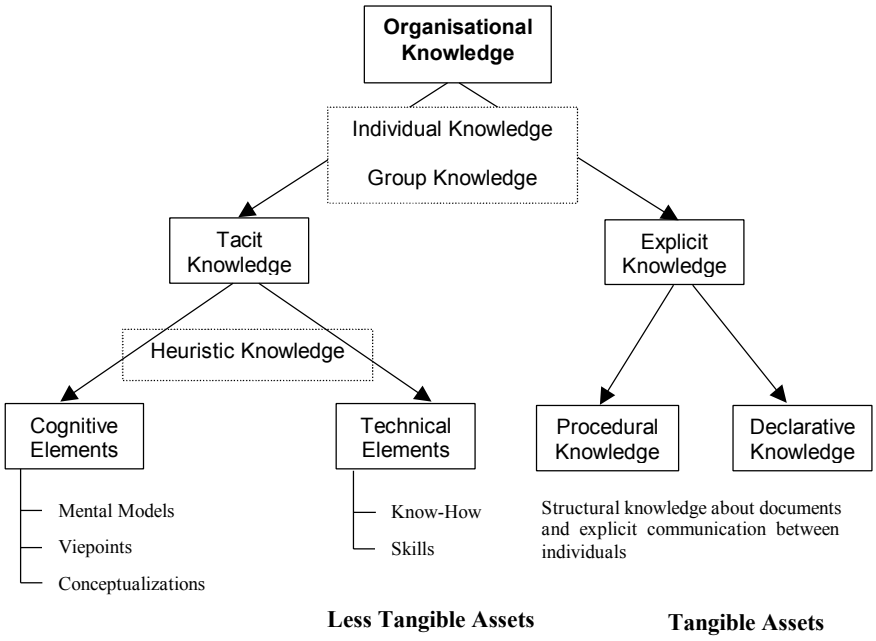

Figure 1: Theoretical Knowledge Taxonomy

In a pragmatic way, an Ontology can be seen as 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 (state) of the concepts and govern their behaviour. In this ontological network, the concepts are categorised and classified in taxonomies to which inheritance mechanisms can be applied.

By definition, an Ontology is a *formal and explicit specification of a shared conceptualisation*. A *conceptualisation* is a particular and abstract view about real entities, events and their relationships in a particular domain. *Formal* refers to the fact that an Ontology is a form of knowledge representation that has a formal software specification that is used to

represent such domain conceptualisations, i.e. an Ontology is machine-readable. *Explicit* means that all types of primitives, concepts, and constraints used in the Ontology specification are explicitly defined. For example, a *Frame-Ontology*, is an Ontology where the primitive terms are related within a frame-based language and are formally and explicitly defined. Finally, *shared* means that the knowledge embedded in Ontologies is a form of consensual knowledge, that is, it is not related with the individual, but accepted by a group, e.g. by a particular scientific community.

3.1 Ontologies as a specification mechanisms

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

To minimise the problems of knowledge sharing and reuse, Ontologies can be encoded in a reusable form in "Ontology Repositories". For example, the Knowledge Systems Laboratory at Stanford University has developed a Ontology Repository known as the *Ontolingua Server*[1]. This environment is composed by a set of tools and services that make use of the world wide web for access and provide users with the ability to publish, browse, create, and edit Ontologies stored on the server.

4 GROUP MEMORY SYSTEM

Having described the high level knowledge taxonomy used to classify all forms of organisational knowledge, and the technology that could be used to construct an OM, we will now describe a specific implementation of an Organisational Memory System: a Group Memory System using Design Rationale Systems and Case-Based Reasoning.

One of the main objectives of our work is to test and implement knowledge modelling techniques using ontologies. In the short term, our aim is to develop and test a prototype Group Memory System (GMS) that can be used to support business activities and knowledge dissemination between employees. It is proposed that this system will adopt an Intranet access model. The system will provide a view of the group knowledge that is embedded in processes or developed in teamwork. It will provide access to different sources of knowledge such as business objectives, business cycles, stakeholder properties and group competencies. The prototype will

[1] The Ontolingua Server may be accessed through the URL: http://www-ksl-svc.tanford.edu:5915

provide a personalised and consistent mechanism for navigation and searching. Procedures such as registration, subscription, and broadcasting will be used to enable knowledge capture and dissemination among the organisation's employees.

The particular focus of the GMS is the management of what might be termed less tangible knowledge assets (LTKAs). For example, organisational groups may have part of their knowledge codified in a form of workflow 'metaphors' that only the members of that group can understand. Such knowledge might be termed less tangible knowledge assets (LTKAs). Other examples of LTKAs might include employee's insights, particular employee's areas of expertise, specific customer relations or group metaphors. These will need to be translated to other forms of knowledge to enable knowledge sharing and reuse across enterprise agents within an organisation.

4.1 Overview of GMS Architecture

The Ontologies used for knowledge representation will form the first layer of this framework. The design rational system will store and manipulate the results of meeting with experts, executives, and other stakeholders. Reasoning procedures will be provided using case-based reasoning technology. The network access model and the related interface will provide the employees of the organisation with a view of the collaborative (group) knowledge. Figure 2 below gives an overview of the Group memory System.

4.2 Ontological Semantic Network

The organisational primitives will be chosen based on an extensive analysis of existing ontologies[2], typical business and organisational processes, and through the process of knowledge acquisition and elicitation to develop in a real enterprise setting. The ontological analysis leads to the development of different kinds of Ontologies according to their level of generality and to their level of dependence on a particular task or point of view, as shown in figure 3 below.

Group Memory Ontology

The Group Memory (GMe) Ontology will represent the organisational knowledge in the form of individual and team-based knowledge, i.e. group knowledge. The GMe Ontology will represent the different knowledge dimensions within an organisational workgroup, such as at the highest abstraction level, individual or collective knowledge and tacit or explicit, and respective combinations of these knowledge types. The first step in the design of the GMe Ontology is the definition of the workgroup ontological domain. This Ontology will contain the necessary terms for the management of individual and group competency. It will include terms to represent classes of human competency, and related concepts, such as skills and expertise.

The main goal of the GMe Ontology is the creation of a collaborative workgroup where the group members can work together in their projects. The GMe Ontology is used to analyse and evaluate levels of competence at the individual and group level and translate different dimensions of knowledge to facilitate the communication between group members.

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[2] *TOVE Ontologies* (TOVE 1995), *Enterprise Ontology* (Uschold et al. 1998), and other ontologies are stored on the Ontolingua Server at the University of Stanford.

4.3 Design Rational Procedures

Part of knowledge work is produced in teams and the participants develop their ideas under an unstable organisational environment where objectives, business processes and business rules are continually changing. Therefore, the different customer's and stakeholder's (e.g. employees, partners, and investors) viewpoints lead to the development of frameworks that enable the creation of innovative solutions. This reality requires collaborative activities in order to maintain a permanent group memory that will be useful to recover and analyse insights, viewpoints, solutions, and success stories from past business projects.

As one technique to enable the creation of structures of collaborative knowledge through the systematic analysis of LTKAs is known as *Design Rationale* (DR). Rittel and Webber (1973) introduced the groundwork of this discipline. Recently, interest in DR has been growing amongst research communities, such as software engineering (Bellotti 1993), human computer interaction (Conklin & Yakemovic 1991; Conklin 1998), and Computer Supported Co-operative Work (CSCW) (Buckingham Shum 1996).

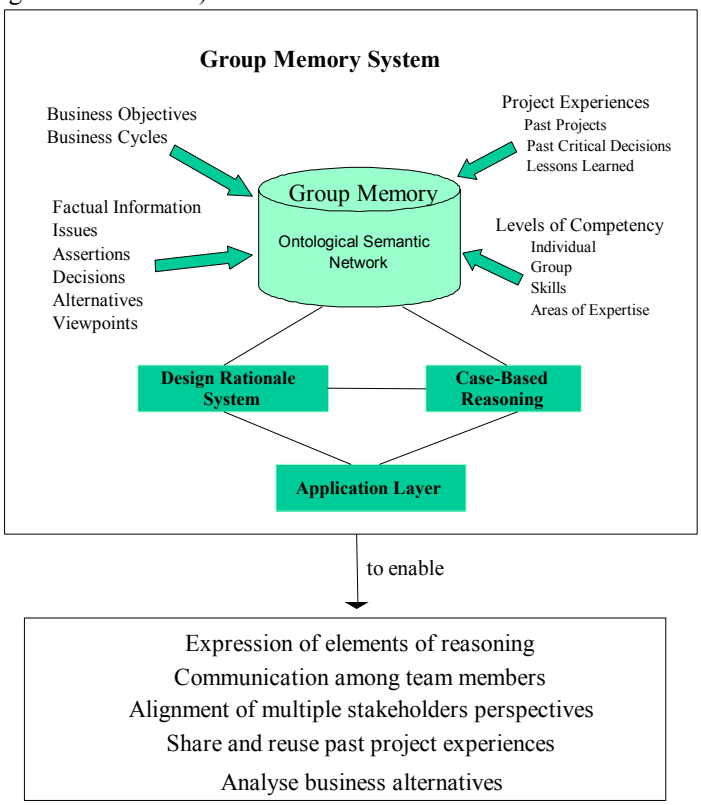

Figure 2: The Organisational Memory System

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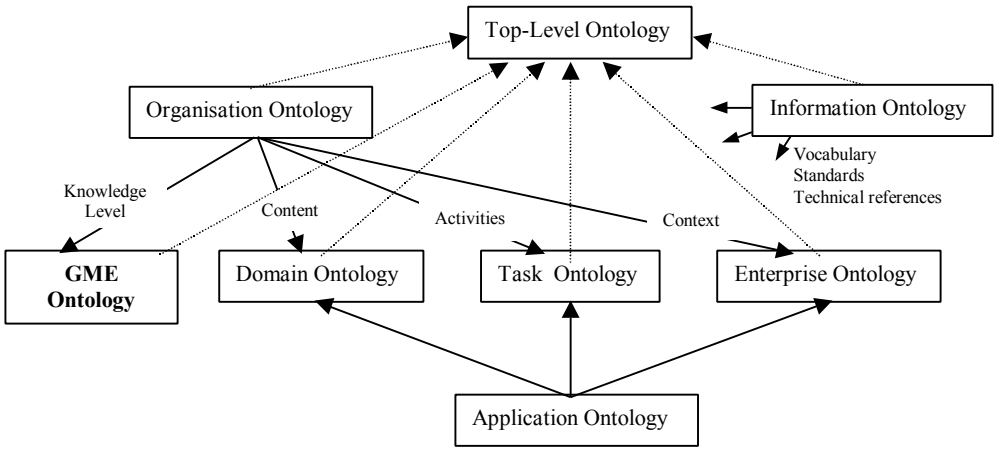

Figure 3: Kinds of Ontologies at the Organisational Level (Adapted from Guarino 1997a & Abecker, 1998)

DR procedures will be used for knowledge acquisition and elicitation. A DR system would store and manipulate the different stakeholders' perspectives during a normal team meeting. The introduction of DR techniques is fundamental for the purpose of this research. This research seeks to create mechanisms to capture organisational knowledge, namely collaborative (group) knowledge. DR allows members within an organisation to share their expertise and experiences thereby building the OM. The DR discipline is the underlying methodology to facilitate the capture of collaborative knowledge and Ontologies are the representation of such knowledge.

4.4 Case-Based Reasoning Facilities for GMS

Case-Based Reasoning (CBR) is an approach to problem solving based on the retrieval of similar cases. Case-Based Reasoning should allow new knowledge to be discovered using the existing knowledge from the system. CBR is an approach to problem solving based on the retrieval of cases (business experiences), or episodic descriptions of problems and their associated solutions. These systems, with refinements of current case retrieval front-ends, may form the basis for *Organisational Memories* capable of storing and distributing the experience of an organisation to all its members (Allen 1994).

CBR can provide the technology to perform some KM tasks (Aha 1998). In this context, CBR systems can capture and share an organisation's related knowledge capital for future use (Becerra-Fernandez 1999), by retrieving and adapting relevant cases (*problem-solution*) from the case base to solve new organisational problems. The reasoning facilities for the group memory system will be implemented using case-based reasoning technology. Some examples related with the creation of new knowledge assets within the organisation are presented in the next section.

5 EXAMPLES OF THE APPLICATION OF THE GMS IN THE BUSINESS CONTEXT

The application layer will provide access to different sources of knowledge, a personalised and consistent mechanism for navigation of the knowledge base and appropriate search mechanisms.

A target platform will be chosen to test and assess the validity of this approach. Some aspects of the interface that will be provided are summarised below:

- access to different sources of knowledge (KM sources, business objectives, business cycles, stakeholder properties, group meetings, and competency management issues);
- personalised and consistent navigation;
- search mechanisms (keyword based and through the use of metadata to add semantics and to enable more precise searching);
- knowledge dissemination mechanisms (registration, subscription, and broadcasting).

In the business context, a company has several valuable knowledge assets that need to be managed, e.g. long range plans, SWOT statements, vision statements, stakeholders' properties, employees' experience, skills and areas of expertise. Additionally, a company has other knowledge assets in the form of management methodologies, project experiences and lessons learned, which also need to be managed. A Group Memory System should aid the management of such assets.

5.1 The identification and management of existing knowledge assets

A specific example of this might be a Best-Practice Knowledge Base. Best Practice Knowledge Bases are often generated during benchmarking activities. They aim to capture knowledge concerning the best business practices worldwide. The objective of such systems is to facilitate the use of known 'best practices' in a given organisational setting. In the organisational context, the identification of best practices (or lessons learned) across all enterprise agents will help with the co-ordination of business activities. This should also help the promotion of the organisational culture.

5.2 The creation and management of new knowledge assets

Each project developed by a business organisation can be understood as a business experience. Case-Based Reasoning procedures could be used to index a library of business experiences (cases) in order to find problems similar to the current problem. It should then be possible to adapt the previous solutions to fit the current problem and hence create new knowledge assets. Examples of the form such reasoning might take are:

- Given a business objective, which are the business cycles that need more attention?
- Given a business cycle which are the activities and events (business points) where people need to act?
- Given a business point which are the most experienced people to handle the problem?
- Given a business objective/cycle/point what are the similar past projects that can help in the solution of the current situation?

6 SUMMARY AND CONCLUSION

Part of the organisational knowledge (*Corporate Memory*) is in people's minds. Through the new management styles, such as downsizing, reengineering processes or increasing organisational turnover, the enterprise looses part of its intellectual property. Thus, enterprises have to adopt new strategies, such as the application of Knowledge Management techniques to retain individual and group intellectual property within the company, and consequently the

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maintenance of its corporate knowledge. Thus, a Group Memory System as an instance of an Organisational Memory System will provide in-depth knowledge of the less tangible knowledge assets of the organisation that can be used to support the other tangible assets.

This research aims to develop a Group Memory System using ontologies. The first layer will be the Group Memory Ontology as a high-level specification of terms and their relationships concerning self-managed teams in the organisational workplace. The design rational system will store and manipulate the results of meetings with experts, executives, and other stakeholders. Reasoning procedures will be addressed using the case-based reasoning technology. A network access model and the related interface will provide to the employees of the organisation a view of the different dimensions of group knowledge.

Due to the size constraints of this paper the practical application of this work, concerning a bid generation process in a multi-national company, will be described in detail at the conference.

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