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CogNet: INTEGRATED INFORMATION AND KNOWLEDGE MANAGEMENT AND ITS USE IN VIRTUAL ORGANISATIONS

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As the amount of information that individuals and organisations have to deal with on a daily basis increases dramatically, new ways of information management are needed. The individual needs to effectively manage large collections of information and associated knowledge that builds up around these collections as well as to effectively share these collections of information and the knowledge with others in a collaborative environment. Current information management strategies in our view are inadequate for more intuitive browsing of information and knowledge. An innovative approach to personal information and knowledge management and sharing, based on conceptual organising principles is presented and which will support flexible working environments and help individuals to effectively share information and knowledge in the virtual organisation.

1. INTRODUCTION

With the increased competition and globalisation, companies have come to realise that what makes for their success is the know-how in their enterprise and which needs to be mobilised for ongoing activities. Dramatic changes in organisational patterns are emerging, as static and hierarchical structures are rapidly disappearing and more flexible project-team approaches are increasingly widespread. Also organisational barriers are being eroded as enterprises have to work much more closely with their business partners, customers, and clients in the virtual enterprise. Flexible teams, whether involving members of only one or several enterprises, bring together a group of individuals for the duration of a project and then disband after the project has finished. Out of the available pool of workers new teams are formed with a different membership for other projects and the information and knowledge built up in previous projects is easily lost. There also has been a noticeable increase in the use of teleworking and which despite its benefit has further disintegrated the

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social communities amongst workers in the traditional enterprise and who used to be able to rely on a common culture and shared knowledge and understanding. Finally, the proverbial exponential information growth and the resulting overload makes the life of the individual increasingly difficult as they need to keep track of information and the knowledge they create.

In this flexible and dynamic working environment flexible and dynamic solutions are needed to help the individual keep track of information and the knowledge he/she creates and to share this effectively with other team members. This information and knowledge needs to be organised in an intuitive fashion and be easy to navigate. Also, the source and original context of that information and knowledge needs to be made explicit to allow the user to correctly interpret these resources when reusing them in a next context on a new task.

In this paper ongoing work on a general purpose information and knowledge management concept is being presented, drawing on important developments in conceptual graph and ontology technologies. The solution concept is being presented and its benefits to the individual, the enterprise and in the context of virtual enterprises are described. The need for adequate organisational approaches to support effective KM in an organisation, such as (Nonaka, 1995) and others, is acknowledged but is not addressed in this paper.

2. KNOWLEDGE MANAGEMENT REQUIREMENTS

A considerable amount of information average users deal with in their everyday activities is contained in document files. Most users accumulate a considerable number of document files on their computers, and could probably not tell what most of them contained without opening them. In the course of their activities users typically reuse existing documents and import new ones and build up a considerable amount of knowledge around these documents. This knowledge could be about how these documents relate to one another as well as deeper insights about the content. This knowledge typically resides in the mind of the user and never gets recorded. As time progresses people forget this knowledge unless they keep referring back to the same documents time and time again. They may remember some useful information for the task at hand but unable to quickly lay their hand on the relevant information and have to spend time and effort in order to retrace their thoughts. In addition, few people work in isolation and need to interact with colleagues in the organisation, which is particularly significant in virtual organisations, where users are distributed geographically over a number of participating organisations and have to rely on electronic means of communication and information sharing. In order to efficiently collaborate and avoid duplication of effort, they need to communicate effectively and/or maintain comprehensive inventories to ensure that the same work has not already been done elsewhere.

There is a clear need for supporting *both* the *individual* and the *organisation* and this point is frequently missed by existing solutions, which tend to support the needs of the organisation at the expense of the individual, thus necessitating more drastic organisational strategies such as incentives and policies to cajole the individual to comply with the necessary knowledge capturing and sharing. In our view this situation is far from satisfactory, and any adequate solution should be actively

supporting the individual in their quest of keeping on top of a vast growing and evolving distributed information base and the knowledge they create. The following list highlights the most important considerations for the individual in this respect:

- The approach should be intuitive and easy to learn and use
- The use of graphical navigation techniques in preference to tabular approaches
- An integrated approach for managing information and knowledge together
- Making visible the relations between knowledge and associated documents
- Requiring minimal effort to maintain
- Facilitate the categorisation of items using predefined classification frameworks

The effective capture of knowledge in a useful format is also essential at the enterprise level and which can be effectively shared amongst the distributed workforce in the virtual enterprise. The provision of an environment that actively supports information and knowledge sharing is equally important and this presents a second set of requirements:

- A standard interface understood by all and which allows users to easily locate information
- Identification of authorship (and timestamp) of information to help maintenance and locate source of information
- Sharing control to allow users to selectively publish information and maintain confidentiality and to restrict access to information and knowledge still in draft form and/or of a sensitive nature
- Maintenance facilities to help keep the information and knowledge base up to date and monitor the usage and consumption of the corporate knowledge base
- Supporting on-line and off-line working to support teleworking and geographically distributed teams (a central repository of shared information)

In short individual information and knowledge management needs have to be combined with the needs of a shared corporate information and knowledge base. While individuals need to be supported by personal information and knowledge management tools, the effective sharing with colleagues also needs to be supported to capitalise on the assets created by individuals and teams. In this section we have sketched key requirements from an individual and enterprise perspective and the following section explores the use of ontologies and conceptual graphs as a suitable strategy for this purpose.

3. ONTOLOGIES AND CONCEPTUAL GRAPH BASED APPROACHES

It has widely been recognised by philosophers and psychologist since ancient times that human memory is associative (Tan, 1993) and we argue that humans use abstract models and classification systems to categorise and interpret their observations (Bokma, 1993). Following this mindset, information and associated knowledge should be categorised using conceptual principles and where associations are made explicit. In our view one needs to move away from approaches that are predominantly tabular and easy for the computer to approaches that work on the principle of conceptual representations and which are more intuitive to the user. We

therefore propose a conceptual framework supported by a hierarchy of concepts and where the relations amongst items of information and the associated knowledge can be recorded. As knowledge builds on data and information and cannot easily be taken out of its context and disassociated from its author; thus it is vital to maintain these connections and the interpretations that can be put on them. In recent years there have been some interesting developments in the field of ontology and conceptual graph research and which, we believe, have a considerable potential to yield a solution to the task outlined.

Ontologies, as used in AI circles, are conceptualisations of a domain and which allow the user to build a model and reason about it (Guarino, 1997). Formal specifications of a domain can be derived in this way and which can be shared amongst users and a variety of notations and semantics are available to generate such conceptualisations. A number of ontology based approaches have been developed and tools like Ontolingua (Farquhar, 1995), WebOnto (Dominique, 1998), ProtégéWin (Erikson, 1999), ODE (Fernández, 1999) have been produced (see also (Duineveld, 1999) for a review).

Though ontologies can be used to develop fine-grained models of a chosen domain, we propose to use them in a more schematic fashion to develop smaller, more coarse-grained ontologies whose complexity would otherwise easily get out of hand. We propose to develop a set of smaller ontologies that represent alternative classification principles such as a subject ontology (to classify items by subject) and other ontologies, such as an organisational ontology (to associate items with the organisational context such as the particular projects and organisational units where they originated) as well as the author. Ontologies are therefore used primarily as a document organisation principle. As knowledge will be recorded in separate documents a more detailed representation of the knowledge will not be necessary in most cases; where the user just adds new documents and items of knowledge; this will be quicker and more easy to use by the not very technically minded user. What is however important is to maintain a graphical navigation capability where the user can browse the information and knowledge space so created by navigating a graph. The users then use the supporting tool to classify documents and record links to key concepts that match the content as well as creating links directly to annotations/reflections. Some work in this direction is already under way in the KA2 initiative and that uses ontolgies as a basis for annotating documents amongst a community of geographically distributed researchers (Benjamins, 1998), but the approach is search-based, nor does it provide for a persistent, graphical navigation capability that allows contextual browsing and which is a key element in our approach.

The achievability of jointly developing definitive global ontologies of a common problem space is being questioned by some, such as (Tennison, 1999) and who propose the development of personal, evolving ontologies where the user can not only make changes to an ontology but also annotate these with the rationale behind the changes. While we agree with the principle of annotation the approach only covers the ontologies again using a frame-like approach that does not go beyond the model to make a connection to the modelled reality and which is a key aspect in our endeavors. We propose the use of extendable taxonomies as a basis for categorisation of items and which allows the user to correctly classify any new items of information and to annotate them with any reflections, criticisms or knowledge

gained. The taxonomies should include a standard repertoire of organisational and subject based categorisations and capable of being browsed and explored graphically by the users. A common taxonomy, in our view, also provides for a convenient sharing strategy between users, who through familiarity with the taxonomy, are thus able to easily explore the taxonomy and associated information and knowledge of their colleagues. This would also facilitate the eventual use of automated reasoning techniques amongst others as proposed in (Cañas, 1999).

The conceptual graph framework developed by (Sowa, 1984) (see also (Delugach, 1998) and (Sowa, 2000)) can be used to develop a conceptualisation at an arbitrary level of abstraction and provisions exist to allow the inclusion of references to items outside the graph itself (such as references to documents and files etc). Thus we can maintain the link between the model and the modelled reality. The framework is formal and provisions are made for a display format to support graphical visualisation, the only disadvantage being that an explicit treatment of inheritance, typically present in ontology systems, is missing. Because of the greater flexibility, graphical display capability and facilities to reference links to external entities the conceptual graph is preferable for our purposes.

4. TOWARDS A KNOWLEDGE MANAGEMENT AND SHARING CONCEPT

As argued in the previous section we believe that humans understand and manage reality by devising classification systems into which observations are categorised and interpreted. In the first instance we therefore need to develop a domain classification that can contain a number of alternative viewpoints such as an abstract subject hierarchy to classify items by their content or an organisational hierarchy to indicate the organisational context in which the item originated.

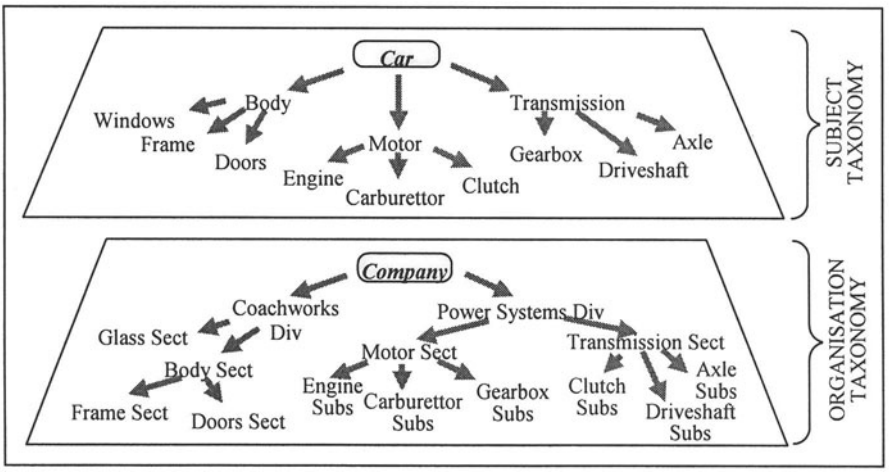

Figure 1 – Multiple Taxonomies

Figure 1 shows a sample ontology for an automotive enterprise. The subject taxonomy provides a basic classification for a car (that could be more detailed if required) and there exists an equivalent organisational taxonomy that describes the

divisions and sub-divisions of the enterprise (not exhaustive). The subject taxonomy at the top proceeds from the concept of a car subdivided progressively to its constituent parts in an iterative fashion. At the bottom the organisational ontology shows how the company is organised in terms of its departments and divisions and subgroups together with the projects associated with them (the latter not shown). The diagram is not exhaustive but serves to demonstrate the concept. This constitutes a sample core ontology and which will be used by every user.

As indicated in Figure 2, the user can use the taxonomies to record new items of information (documents, designs, diagrams, records, etc.) by linking them to one or more of the concepts in the ontology (for the purposes of simplicity only the subject taxonomy is shown). The ontology is used as a cataloguing system for information contained in documents stored elsewhere (such as wordprocessing documents, spreadsheets, presentations, databases, etc.) by reference to these documents through appropriate pointers. The user can also add reference links to other items in the system and which the new item is related to, such as to indicate another document containing background information. Alternatively, the user can record annotations containing knowledge about any item and which can represent a critical appraisal, rationale for the item in question or any additional knowledge about the item and its use for a particular purpose. These will be recorded separately in a file and for which a reference will be inserted in the conceptual structure.

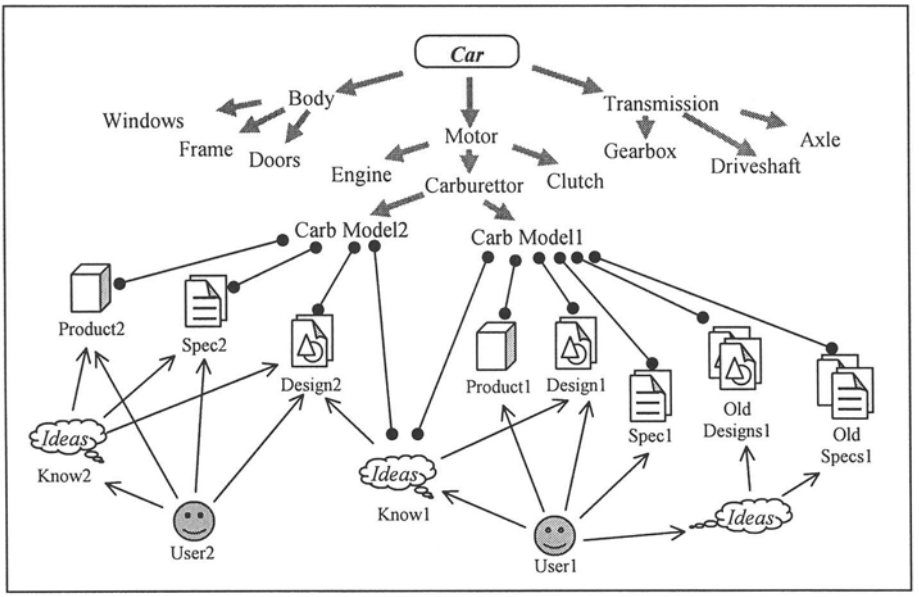

Figure 2 – Cognitive Network Segment

The user should be able to browse and explore this conceptual structure on-screen by progressing through nodes and arcs. Thus when looking for a specific document the user will progress through the core ontology using those keywords that match the content of the document or through the projects they are associated with. In Figure 2, User1 is shown to be associated with a number of documents

indicated by arrows including Product1 and it's associated design and specification. The lines with bullet ends indicate the semantic association with concepts in the core ontology. User1 also has some thoughts about previous designs and specifications as indicated by a thought-bubble. In addition Design1 is in part based on reflections and design critique of Design2 developed by User2 and this design critique is contained in a separate document Know1. User2 is associated with a set of documents, designs and products and in addition his rationale for the specification and design he developed and which is the basis for Product2 is contained in a document Know2 with the associations as indicated by the arrows. The documents referred to are not to be stored in the system and reference links will point to the actual file. The knowledge management system will however contain additional information about associations shown as arrows. Icons are used to indicate the nature of the item and different types and different types of arrows to indicate different types of links. The user will navigate the structure through a point-and-click interface and where the properties of items can be inspected and are to be displayed in a pop-up window.

Current document organisation approaches rely on a meaningful document hierarchy in the form of a filing hierarchy with meaningful directory and file names. Few users are methodic enough to develop meaningful and failsafe approaches for the structuring and naming that allow the user to effortlessly locate files as time progresses. In addition, while users will tend to look for previous documents according to thematic considerations (i.e. what the document was about), the organisation of the typical filing structure will tend to follow organisational contexts and patterns. This requires the user to retrace the context in which the document originally fitted in (e.g. a particular project and one of the project phases), in order to be able to locate it. The proposed approach has the advantage that the information can be accessed directly in a thematic fashion and that other items with the same "theme" are immediately available as well by inspecting the immediate neighbourhood or by moving up to the subject taxonomy to view other items connected with it.

One problem experienced by many ontology approaches and tools is that they are far from easily readable for the average typically presenting ontologies in a tabular form which is difficult to comprehend and operate by a non-technical user. In that form it is also difficult for the user to understand the totality of the ontology and where a given concept fits into the order of things. Consequently a more intuitive graphical interface will remedy that shortcoming.

5. BENEFITS OF THE PROPOSED APPROACH FOR VIRTUAL ENTERPRISES

The virtual enterprise poses some interesting problems with respect to successful collaboration and interaction between the participants. In fact, despite the growing interest in this organisational form, there is still a lack of systematic support features and the often quoted success stories frequently rely on pre-existing working relationships and sufficient common understanding to make them work effectively. If the virtual enterprise is to be a viable business model also for collaboration between business partners that have not previously been working together there is a

need for adequate support technologies that will facilitate the communication and support shared workspaces between the participants. Consequently there is a need in the virtual enterprise to manage a body of shared documents and to quickly establish a shared understanding about these documents. This is precisely the objective of the CogNet approach. Though many of the groupware suppliers are extending their technologies to work in distributed environments, there is still a lack of functionality that help users to generate intuitive strategies for the organisation of sets of documents and to record and share knowledge about these sets of documents within the virtual team or virtual enterprise. There is a need to help users locate relevant documentation, to understand the interrelation between documents and to share knowledge about them. Process support technologies doubtlessly have their role to play in supporting distributed processes where the mode of interaction is of a process-based nature, but when this is not the case and collaboration revolves around the evolution of a joint piece of work recorded in sets of documents there is a need beyond mere document management functionality to:

- effectively share these documents among the members and
- to help organise and locate documents effectively
- to show the interrelation between sets of related documents
- to communicate knowledge about these documents
- to record and visualise the sources and authorship
- to be able to explore the information and knowledge space so created in a graphical form

As we argued previously there is a need for an approach that is easy to pick up and use, capable of graphical representation and navigation rather than presenting information merely in tabular form. The latter presents in our view a much more intuitive interface to the user and allows items to be easily categorised and located by navigating through taxonomies and conceptual structures. This in turn leaves the task of how to provide or devise suitable taxonomies.

It will not be meaningful to use universal taxonomies although it should be possible to perhaps provide generic ones that can be easily adapted by the users. The taxonomies will have to be agreed by the users in the virtual team or organisation and may be evolved as the need arises. The proposed system allows the managing of both information and knowledge in the same framework and to create relations between knowledge and the underlying information/data upon which it builds, as indicated in the diagram above. This allows items of knowledge and indeed items of information to be seen in their context and which may be crucial for subsequent reinterpretation or use on a new task or project. The subject of taxonomy design merits further investigation and which is not addressed in this paper. However, in our view, these ultimately need to be devised by the organisation or group of individuals involved in order to tailor the taxonomy for the domain at hand rather than to confuse users with an excessive generic taxonomy that is not specific enough in the target domain while containing a large amount of categories that are never used where the user has to remember how to get to those categories he/she wants. What is in our view necessary is to provide a framework with basic building blocks (i.e. such high level categories like people (individuals), organisations, organisational divisions/departments, teams, projects, documents/files, relationships (links between items), knowledge (as collections of annotations/comments) and

taxonomies). This should allow the users to quickly devise common taxonomies, containing the subject hierarchy and organisational hierarchy, and start using the tools to catalogue documents, relate them to each other and their authors and annotate them to reflect knowledge about them.

The type of iconic representation shown in the diagram are in the process of being specified in detail and will be provided in a tool which will have editing and inspection capabilities. While following ontological principles, the approach we propose operates at a less detailed and sophisticated level of detail as is the case with ontologies that have been developed for instance with Ontolingua, like the enterprise ontology (Uschold, 1998) or the mineral ontology (Tennison, 1998). We hold that our proposed system will be easier to operate by the average user; where speed and ease are essential if users are to be convinced to use the system. Also this level of detail may not always be strictly necessary for general purpose use. By providing the user with a basic repertoire of building blocks with which to quickly, and safely, incorporate new pieces of information and knowledge into the conceptual framework a solution is provided that is both easy to use and where the consistency of the emerging structures are ensured.

While the proposed approach will lead to significantly smaller structures than those used typically in semantic nets the problem of scalability of graphs persists and needs to be contained in the interest of viability. While one might want to implement such a technology enterprise wide, there are usually functional or operational divisions across which the sharing of information and knowledge will not be necessary and thus provide the scope of shared workspaces. Rather than implementing a singular system it will be more meaningful to implement a set of smaller workspaces in this fashion. In addition, the shared workspace, while they may appear to be uniform to the user are in fact divided in sections where the subject and organisational taxonomy are different in nature from the artefacts (documents, annotations and relationships) added and maintained by the user. The taxonomies are largely static and are used for reference purposes and constitute a section (or separate level) in the overall structure. Also they are usually a tree rather than a graph and would be expected to comprise upto several hundred nodes only, while the user generated part is likely to reach a complexity of several thousand items. While this would still generate a substantial overall graph, only sub-sections would be displayed on screen and be explored by users on an item by item basis. There will consequently not be a need to search the graph and which could create computational problems. It is currently envisaged for storage purposes to save the graph in a set of tables in a traditional database and while searching facilities will still need to be provided searching algorithms would therefore make use of the database for that purpose, thus circumventing the known search problems associated with graphs.

Especially in a distributed environment such as a virtual project or virtual enterprise there will be a need to adequately support on-line and off-line modes of working and to selectively share items with collaborators/colleagues and to manage editorial control on documents that are jointly authored. The proposed approach is currently being experimented with and will eventually be implemented in two parts, a personal information and knowledge organiser resident on a potentially mobile PC and which interfaces with a central enterprise server where shared components/items are available for other team members to use at any time thus necessitating automatic transfer/updating functions. In this way personal access control can be maintained

while providing adequate access to other tam members while the owner is not connected. The ability to make selected items available for sharing will ensure that materials still in draft form are not accidentally made available to others. Making a distinction between shared and not-shared components allows the user to control access and use the technology in general for their information and knowledge management purposes. In that way the user has the benefit of a singular organising tool for all their information and knowledge management needs.

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