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Ontology and Business: Creating Structure for Storing and Accessing Organizational Knowledge on Intranets

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ONTOLOGY AND BUSINESS: CREATING STRUCTURE FOR STORING AND ACCESSING ORGANISATIONAL KNOWLEDGE ON INTRANETS

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Abstract

Storing organisational information on Intranets is fast becoming the norm for corporate information management, as is the provision of tools which assist locating, adding to and using organisational knowledge. The design of the storage layouts for these intranets, and the navigational principles by which the information can be found requires that the responsibility for creating and publishing information is considered, as well as the needs of others to access the information from within a variety of contexts. This article examines ways of uncovering the reality of organisational experience in order to create maps of organisational knowledge. These are derived from business process analysis to create a foundation for the design of intranets and knowledge management solutions.

Keywords: Knowledge mapping, Intranet, Ontology

1 INTRODUCTION

This article concerns itself with the interface between that part of the business which loosely calls itself 'knowledge work' and that group of assorted technologies which can be referred to as 'knowledge management systems'. The key research question is:

Out of the phenomenological flux of business activity, with its rich admixture of knowledge types and knowledge enablers, how can we construct representations which will assist us to design appropriate tools and management solutions to support the knowledge processes of creating, finding, sharing and using knowledge?

The context of this question is that of managing knowledge in corporations – not just information, reports or transactional systems – but *knowledge* in all its gritty particularity (Markus, 2001; Davenport, 1997). This knowledge is used, remembered, forgotten and enriched by experts and incompetents alike. The practical challenge is to provide management with relevant and cost effective tools and methods to enable them to leverage the knowledge assets (to "know what they know") and minimise the cost of not 'knowing that they know'(O'Dell & Grayson, 1998; Prusak, 1996).

Because Intranets and browser technology are becoming an almost ubiquitous means of information management (DTI, 2001; Gottschalk, 1999), this research has used a real life consulting case study to show how the needs of organisations can be addressed by providing rigorous classifications of their knowledge as a basis for knowledge storage and access on Intranets. The discussion space of 'ontologies' is used in its philosophical and technological sense to provide a platform of methods to try and provide a practical response based upon theory.

2 RESEARCH AREA

The general requirement confronting knowledge management is to identify, catalogue and then provide access to organisational knowledge such that it can be easily stored, found, used and enhanced (von Krogh and Roos, 1996;Leonard-Barton, 1995; Davenport and Prusak, 1998; Boisot, 1998; Bukowitz, 1999). Central to knowledge management is the notion of taking inventory of stores of organizational memory and mapping these in some diagrammatic form to provide clarity and gain intellectual mastery over knowledge stocks and how they are related to each other (Vail, 1999; Nissen, Kamel & Sengupta, 2000; Hansen, Nohria & Tierney,). Knowledge management solutions include such technology as forums, databases, organisational 'yellow pages' and knowledge bases (Alavi & Tiwana, 2002). These solutions can be grouped and made available to match the work patterns of knowledge workers in what the Gartner Group calls 'Smart Enterprise Suites" (Gartner Report AV-17-7196, 12 November 2002). Knowledge maps can be used to match a business need to an identified knowledge repository via a knowledge management system.

Increasingly, intranets are being used as a preferred mode of information management within organisations. In six out of ten industrialised countries reported in a benchmarking report by the UK Department of Trade and Industry, 56% to 61% of businesses had a corporate Intranet, the tendency being in all but one that the number of Intranets was growing (DTI, 2001). Microsoft has 3 million documents on its intranet alone (Gilchrist, 2003). In order to maintain the integrity of information, whilst maximising its availability, forms of information storage, search and selection are required which reduce the complexity of access and present responses to users, which are most likely to match the intent of a query posed by the user. This intent will be contingent upon context and work activity. Furthermore, if a user is navigating or browsing through an intranet-enabled knowledge neighbourhood, then signposts to catch the eye should be manufactured to a specification of *pragmatic serendipity*.

Generally, information taxonomies are created to classify and manage information (Gilchrist, 2001). These are conceptual hierarchies which take a divide and rule approach to gaining intellectual control over an area of knowledge. Taxonomies provide clarity and enable the development of rules and properties for its categories and allow for the inheritance of those rules to sub-classes of a category. Ontologies take a further step and embody contextual, functional and relational aspects of information or knowledge categories (McGuinness, 2003; Gilchrist, 2003). This has implications for the design of browser enabled access to corporate content on Intranets: the more formal the specification, the greater the ability of technology to sort and mediate the access to the objects within categories (Berners Lee, 1998; Maedche et al., 2003). An ontology makes a more rarefied claim than simple taxonomies: the OED says an ontology is "The science or study of being; that department of metaphysics which relates to the being or essence of things, or to being in the abstract." For computer scientists, "A specification of a representational vocabulary for a shared domain of discourse -- definitions of classes, relations, functions, and other objects -- is called an ontology (Gruber, 1993). Guarino's (1998) refines this:

"An ontology is a logical theory accounting for the intended meaning of a formal vocabulary, i.e. its ontological commitment to a particular conceptualization of the world"

Guarino also says we can classify ontologies according to their accuracy: an ontology can get closer to the underlying conceptualization "by developing a richer axiomatization, and by adopting a richer domain and/or richer set of relevant conceptual relations". The notion that human reality can be codified in a formal definition which encapsulates all relevant meanings is powerful and seductive. Frege (1972) in the Begriffschrift (published in 1879) and Wittgenstein (1974) in the Tractatus Logico Philosophicus (first published in 1921) both wove a theory of meaning in which such formalisms could comprise 'pictures' of actual or possible realities. Frege's semantics were intended to supply the building blocks for proofs of the validity of the laws of arithmetic and were scuttled by Russell's set paradox. Wittgenstein subsequently repudiated his own picture theory in favour of a socially oriented theory of meaning predicated upon the social use of symbolic behaviour in "language games" (Wittgenstein, 1958). Guarino (1998) says that ontology needs to focus on 'meaning .. independently of states of affairs'. But like the Tractatus and Begriffschrift, formal ontologies seem to be based upon a picture theory of meaning. They focus upon truth-functional propositions: explicit knowledge stating facts or possible facts. The human meaning of those facts, the often tacit rules and behavioural signals and responses according to which those propositions are wielded within language games is not captured – and yet these are critical to meaning. How might it be possible to maintain the formality and rigour of an ontology, whilst including information about the context in which the propositions make sense?

The case study in this article demonstrates that there are components of these 'shared conceptualisations' which constitute social and organisational context, that are relevant to task performance. These can be identified through analysis and investigation and included within an ontology, such that object and context are related in the same representational formalism, enabling a fuller appreciation of meaning to be conveyed to the reader of the ontology. Ontologies are derived through an analysis of the mental models and shared perceptions of any group concerned with the performance of a particular task. One can derive rules of association, treatment, constraints and relationships of objects within a certain frame (Goffman, 1974), or within a 'language game' (Wittgenstein, 1958) and create an 'ontology' of the objects which populate the social reality of the protagonists. This is what Browning (1990, p134) defines as the 'practical stance of ontology', which he regards as the primary avenue to insight regarding reality.

3 THE USEFULNESS OF ONTOLOGIES

Guarino (1998) points out that fields such as knowledge engineering, modeling, database design, information retrieval and extraction and organizational knowledge management may use ontologies. If this is so, then there is also a role for ontologies to play in the maelstrom of knowledge management within a specific business or corporation. Abecker et al (1998) say an enterprise ontology models

information and knowledge needs in a business process context. If, as intimated earlier, the principles of ontological construction are extended to classical business analysis, then not only can structure be imposed, but a path may be opened to exposing the knowledge of the organization to others (using web services and for the building blocks within the Microsoft web services architecture ".NET" (Nakhimovsky and Myers, 2003). This might be particularly relevant for public service agencies who are responsible for the formulation and distribution of definitive regulations and policies. According to the Clinton - Gore vision of the 'Information Superhighway', public administration is indeed obliged to disintermediate access to this information to enable greater public access and participation in policy making.

McGuiness (2003) provides an overview of how ontologies can be useful. At their basic level, ontologies can be used as a controlled vocabulary, much like an organizational glossary. This can be gathered into hierarchies which reflect relationships. Hierarchies and linked concepts can be used for organizing intranet or web sites and supporting navigation over that content. The top level concepts sets a natural level of expectation about what can be found within its boundaries and supplies a structure which can coherently grow over time, either through expanding its scope to include new concepts, or the level of detail to refine concepts. Finally, the ontology can be used to support browsing of the items in the repositories in the web site, through providing support through contextualised and disambiguated search. For example, where one seeks a jaguar, memberships of the set of animals or cars will provide the exclusion data for a search for a jaguar of the feline variety.

So ontologies have a number of potential uses. But in order to be used for the design of any effective computer solution, an ontology must be a complete and correct reflection of the reality of the agents on behalf of whom it formalizes a picture of reality. The challenge is to get the requirements right and this requires moving from the ill-defined and messy problem domain of the business world to the clean representations required in the solutions domain of the information technology world (Robillard, 1999) .

In designing systems solutions, there is no definitive set of rules or routines to move from requirements to design in a way which is objective or procedural. However, there are guidelines by which to organize the requirements input and then represent the design solution in a specified formalism. Measurable design goals can be formulated, such as functionality, usability, performance and serviceability (Gilb, 1988). But two 'good' designers may end up with very different designs. Solutions grow out of experience and precedent, from 'parti' to 'format', from sketch to painting (Stolterman, 1999) and this cannot be formulated as a procedure. As Nardi (1993) says… 'Of course design still is, and almost certainly always will be, a black art whose most crucial elements remain an incalculable mix of imagination, intuition, and intellectual interaction with one's fellows.' Indeed, the general consensus amongst IS design researchers is that 'Design consciousness is still pervaded by intuition, tacit knowledge, and gut reaction' (Winograd, 1996).

Design requires an appreciation not only of explicit, propositional knowledge but also of the tacit and behavioural knowledge which is used to effect work practice. To take another angle, work practice has a particular purpose and can be described as a language game (Wittgenstein, 1958). A language game is the collection of words and rules, in which the players know the meanings of allowed expressions. The rules provide boundaries to the game, defining what is a nonsensical behavior or what constitutes good play. These moves (and the skills needed to make those moves) are not limited to what can be written down or articulated for the benefit of a designer of highly explicit computer systems. When requirements and design considerations are transcribed, they become de-contextualised, alienated from their 'language game'. Meaning is lost, even though the words may appear to be clear. This context gives sense to language, actions and roles. In the context of the language game in which propositional utterances make sense, the focus is not on the orthogonal correctness of a design, but *'upon how well ways of doing things mirror the desires and needs of the users…a good design artefact...will support good moves within a specific design language game (Ehn, 1992, p121).* With similar arguments, Suchman (1987) criticizes the cognitivist paradigm behind plan-oriented artificial intelligence research using much the same observations: that human action and decision-making is situated, contextual and

interpretive. An understanding of the work that is to be done with a tool is critical if appropriate and useful tools are to be developed and all forms of work involve significant amounts of tacit knowledge. We need to understand the requirements within the context of work and communicate these to designers if we are to develop appropriate technology solutions.

4 KNOWLEDGE MAPPING

Knowledge management approaches recommend the use of knowledge mapping to establish an inventory of knowledge assets, how they cluster together, and the characteristics of those assets. They clarify the domain of interest in which the elements are relevant. In information systems development the diagrams are the basis of relational database design and software objects development . In an environment of relatively unstructured, non-routine knowledge work, where one is attempting to provide a suitable workplace of well-configured knowledge management systems within an Intranet, a well-constructed knowledge map could provide the building block for two things: the logical structure of repositories in which knowledge (or pointers to knowledge) could be stored, and the taxonomic layout of information at the user interface (Mack, Ravin & Byrd, 2001). If the knowledge map reflects organisational reality, then the groupings and relationships of knowledge in that map should reflect neighbourhoods of usage and access.

The first requirement in any mapping exercise is to make sense of the business (Checkland & Scholes, 1990). This is usually done through some form of business analysis method and process mapping, which identifies work activities and sequences, and other salient features such as the flows of information, and roles and responsibilities. The base elicitation methodology used in the case study in this article was the Soft Systems Methodology (Checkland & Scholes, 1990). It was thought that through *cognitive mapping*, one would be able to derive not only the explicit knowledge prerequisites (those pieces of information which constitute the typical grist of information systems), but also derive the tacit knowledge and contextual information within work processes (Huff & Jenkins, 2002). Therefore the soft systems process modelling in this case was enhanced by the use of causal cognitive maps (Ambrosini and Bowman, 2002). A cognitive map is a 'representation of an individual's personal knowledge, of an individual's own experience' (Weick and Bougon, 1986). A causal map is a type of cognitive map. Causal cognitive mapping uncovers those resources, including tacit routines, which are required for successful achievement of a goal. Causal maps are particularly useful in tacit knowledge mapping as this enables us to focus on action and elicit knowledge that is context dependent. Causal maps are developed by asking a series of questions geared towards uncovering what 'causes success in the organization' (Ambrosini & Bowman, 2002, p29;). After preliminary interviews and document perusal to identify key constructs which support success, a workshop is generally held to explore each construct (Johnson & Johnson, 2002). A series of 'what causes that?' questions are asked, and these causes are linked to the construct. This is continued, until no further constructs are suggested.

The previous discussion has alerted us to the tacitness of much workplace knowledge and the importance of relating contextual and tacit factors which influence work performance to designers of software solutions. We have also argued that the uses to which designers put requirements information is neither linear nor procedural: it has a strong artistic component. Two innovations (as far as the author is aware) were introduced in this project, which address the tacitness of much knowledge work and the importance of informing designers of this tacit knowledge.

Causal mapping was performed to elicit knowledge objects, but from *sub-processes* within a process model (see Figure 1). Each sub-process was identified and defined through a name or description which was the equivalent of a root definition in soft systems methodology. This description then set the boundaries and context for the cognitive mapping, which was performed based upon that process as a point of origin. The cognitive maps develop as tree structures with the process definition being the ‘trunk’. The first concept (or branch) from the process tends to be the clustering concept (this was sometimes imposed *post hoc* by the facilitator). This technique is similar to Ishekawa cause and effect analysis diagram, except the head of the ‘fishbone’ is the business process, not a problem or issue.

Subsequently to completion of a cognitive map, the participants were asked to reflect upon the elements which had been identified as prerequisites for successful work and to annotate those with any *issues* or *hindrances*. In this way, the clustering of issues around groups of concepts was highly visible, highlighting deficiencies which required focus and resolution, possibly through a knowledge management system. After the information has been elicited from staff, there remains the problem of moving it into a representational form which can be used as a blueprint for design. In the case study that follows, it will be demonstrated that although there is an element of 'black art', the cognitive map method of information capture assists the formulation of design models, in this case into UML.

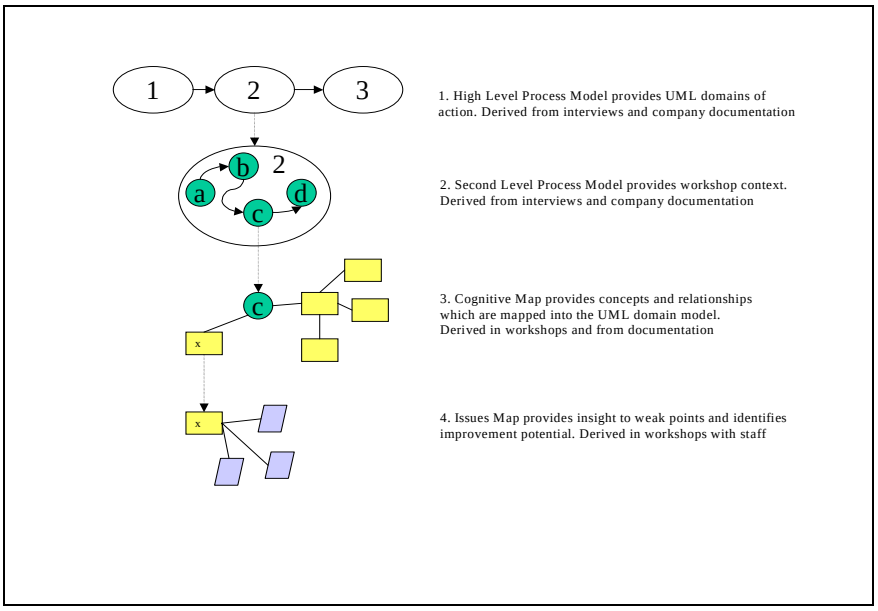

Figure 1: The Information Collection Method

5 METHODOLOGY

The research project was a commercial project, fully funded by the client. A proprietary methodology for conducting strategic information and knowledge management analysis was used in which knowledge management is perceived as an evolution of information management (Davenport, 1997). The tools of information management such as process modelling and data modelling are used extensively. It begins with understanding the strategic and business environment using the usual suspects – a SWOT analysis, Porter's five forces (Porter, 1980) and the Soft Systems Methodology (Checkland & Scholes, 1990). Process and information modelling are applied, but enhanced for knowledge management by extending the notion of 'data flow' and 'data sink' to include tacit and explicit knowledge, so a picture is reached of knowledge and skills. This is complemented by an analysis of the cultural and behavioural factors which may affect knowledge transfer and creation. A gap analysis establishes the hiatus between where the organisation is and where it must be, if it is to compete and achieve its objectives (Zack, 1999). Then the various informational and knowledge based systems (Intranet, document management, forums, data mining, mobile computing) are assessed for their applicability in overcoming the gap.

The project was conducted by the author of this article, currently a university researcher, who has 22 years experience in IT development and strategic consulting. The case study description is therefore a mixture of :

- Straightforward reporting of organisational characteristics and information from corporate documentation and workshop outputs,

- Observations of the protagonists who participated in the project and the effect of the innovations on their ability to contribute data to the requirements gathering process,
- Reflection in action regarding the ease of use of the innovations in requirements gathering workshops and the usefulness of the information in creating a high level design.

The methodology, in particular the two innovations mentioned, was not changed during the execution of the project. No interviews or research data was collected from participants, but this article has been read and verified by the client project manager.

6 CASE STUDY

The context of this research was the development of a strategic knowledge management plan for a small but highly visible public service agency, concerned with the sustainable development and management of natural resources. The intent of the plan was to identify issues in knowledge and its exploitation and propose initiatives for improvement.

The organisation has about 400 employees. The major activities of these employees are to develop strategy and policy for the sustainable use of natural resources, conduct research to ascertain the condition of the environment and ascertain sustainable levels of exploitation, develop plans for the management of those resources and instantiate those in regulations and law, monitor users of the environment to ensure they comply with the regulations and prosecute breaches of the regulations.

The following sections demonstrate how we moved from the messy problem space of the business to the solution space, an enterprise ontology diagram to be used as a basis for designing an Intranet knowledge portal. The route from one to the other was by way of process and cognitive mapping.

The first exercise was to understand the nature of the organisation: its mission, key processes and values. These were gleaned in the first instance from the annual report and a series of strategic departmental plans, which cascaded down from the overall corporate plan. A workshop was conducted with senior management in which the major knowledge objects, communities of practice and issues in knowledge management were identified. A corporate process model was developed, which presented the nine most important business processes and their interactions. For each process, interviews and workshops were conducted to identify the major activities and develop a second level process model.

Having completed this, cognitive mapping workshops were conducted for each second level process model. Each process step was defined to the group as establishing the given context, for example the process ‘Prepare Policies And Plans’ establishes the work routine of consulting with stakeholders, gathering research, physical and environmental data and developing a management plan. Then the participants were asked to identify all things which led to successful completion of that work. This could be information, experience, stakeholders, resources or conditions such as time and space. These were written on yellow post-it stickers by each participant and stuck on the white board, fanning out from the process, which had been drawn on the middle of the board. The post-its were clustered together in meaningful collections (see Figure 2).

The next step was to identify issues with the process and information on the board. Participants were asked to write inhibitors to the yellow post-its (the success factors) on green post-its, which they then connected to the appropriate point. What was gained from this exercise therefore was a list of resources required to perform the task (giving a clear context) and a list of issues which inhibited good performance. For the purposes of ontological mapping, this provides us with a domain (the process or sub-process), elements in the domain, their relationship with each other and work issues.

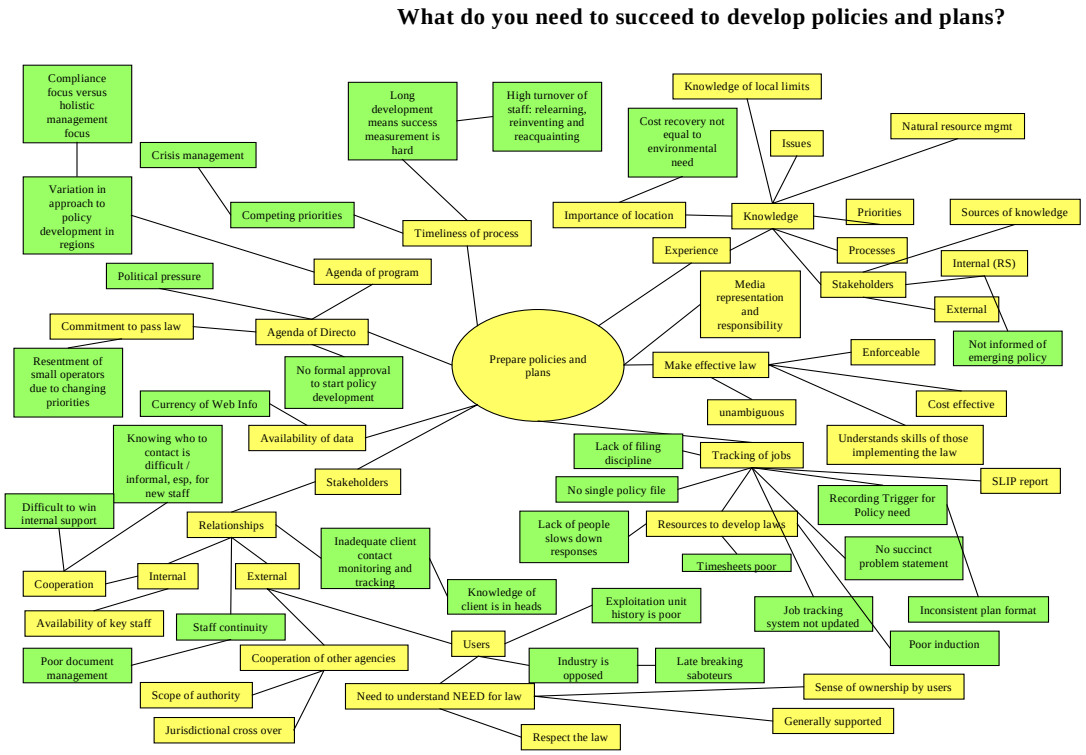

Figure 2: A Process-centric cognitive map annotated with work issues

An analysis of the clustering of the knowledge elements reveals insights into reality which may escape the positivist, object-oriented systems analyst. For example, in cognitive maps for two discrete processes ("Prepare Policies and Plans" and "Manage Compliance") there was a clustering of elements around the concept of 'relationships' with stakeholders. This relationship pertains to inbound and outbound information flows, which are to be nurtured if the public are to be seen as genuine partners in the development of policy and also providers of operational information to compliance officers. The knowledge flows which pass policy, regulations and general information to the stakeholders and record their inputs and submissions are explicit and formal. Knowledge flows consisting of information concerning breaches by other members of the resource-exploiting communities are informal and sometimes "tacit" (i.e. shown or suggested).

Elements connected to the latter relationship include trust, confidentiality, rapport, empathy and equity. These are forms of tacit behavioural knowledge and knowledge of a stakeholder's character and needs, built up over long periods, which the organisation as a whole needs to understand if stakeholders in the community are to be treated consistently and appropriately over time. This knowledge should be captured in some form to render it less vulnerable to attrition and loss.

So for example, a significant issue registered in the preparation of policies and plans was the transfer of policy officers to other duties: this interrupted the continuity of the plan. Knowledge of the causal reasoning and the relationships with stakeholders was lost. Some of this can be addressed by improved information management procedures. Indeed a recommendation of the final strategy report was to use intranet forums to conduct public policy discussions, so that such information was captured. However, the relationship and rapport established with public policy partners is a 'knowledge' which is deeply tacit and not transcribable. Management procedures which mandated the regular transfer of officers between rural regions (for reasons of probity) also eroded the relationships and knowledge of the relationships which were important for the flow of compliance information.

An ontology, the map which reflects the social reality of the agency officers in this area should reflect this stock of deep knowledge and show how to access it, should it be required in another location in the organisation, or by someone else in the future. The rules for accessing this knowledge must include strict confidentiality and recognise the limits to codification. But it must be acknowledged and mapped as it is of major importance. Furthermore, these objects are in a sense 'contextualising objects'. That is, they give additional information and meaning to the objects with which they are associated. So, for example, in Figure 3 there is a relationship depicted between 'information and requirements' and 'stakeholders', showing that stakeholders submit information to the Department. 'Information and requirements' are further related to 'compliance implementation' and 'laws and plans for use', which are the main objects to which the information contributes. But 'information and requirements' are also related to the contextual variable of 'quality of relationship'. Unless this relationship is of a certain standard, with high trust, empathy and physical closeness, little information will be received to assist compliance management. This is of great management and possibly information systems design significance

We have argued that an ontology is a useful basis for design of systems, but that the movement to that blueprint is something of an art. The UML diagram was derived from the information elicited from the workshops and the organizational documentation.

- Domains – the definition of domains was driven from two directions. First, natural domains were circumscribed by the corporate process models. Then domains were derived from clusters of classes which appeared to be used in several processes, such as stakeholder or location information.
- Relationships – were derived from the links instantiated in the cognitive maps. The annotation of these links, whether they were 'of a kind' or associations, was done subsequent to the workshops based upon an analysis of the outputs and using other organizational documentation following standard data and object modeling techniques.
- Classes – the definition of classes, or the elements within the ontology, was a process of abstraction from the concepts raised in the cognitive mapping workshops and deriving concepts from clusters where necessary (for example 'Relationships' and 'External' and 'Trust' were combined to be 'Quality of Relationship').

The UML diagram can be enriched over time with formalisms describing the rules and attributes of the respective classes, such that where appropriate, access and extraction of information can be automated through the intranet or internet. This UML diagram is to be taken as the basis for further design work in preparing an Intranet Knowledge Portal.

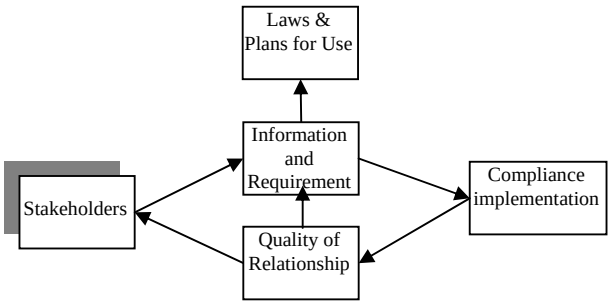

Figure 3: Extract from the indicative high level ontology diagram

7 DISCUSSION

The result of this project was a full knowledge management strategy for the organisation, developed by the researcher. The substantive component of this research however is the method of ontological mapping and the resulting ontology, which contains contextualising social elements. The basic ontology provides the foundation for an information repository, an intranet knowledge portal structure,

the beginnings of an organisational taxonomy and a detailed set of issues which could be addressed by management decision.

Process modelling was used to arrive at the taxonomy and the relevant issues. This enabled a clear definition of the context within which the ontology could be developed and was most effective. Developing a process model has the advantage of capturing the most important activities in a clear and easy to understand format. The model was developed as a result of reviews of key organisational documentation, such as the annual report and strategic plans, and interviews with senior staff. The next task was gaining agreement from the operational participants in the workshops that the process model was accurate. In the particular example, this was the first time this modelling had been performed and was found to be most useful and possibly usable as tool to assist in induction.

The formulation of each process within the model represented a 'root definition' (Checkland & Scholes, 1990). The "CATWOE" was performed to establish some base data about the overall process such as the customers, activities, transformation, worldview outputs and environment of the overall process model. This assisted both the facilitator and the audience in focussing them upon the context of the process and making the decisive components in the process present in the mind. Then a key process within the model was taken and formed the basis of the question: 'What do you need to achieve success in the activity of X'. The information collected in the example was consistent, comprehensive and rich. The formulation of question of 'what causes success" in terms of the process is useful because it is very direct and reflects an activity which the staff perform and understand well. The question is direct and practical. A lot of post-its were written and each participant could explain clearly how their post-its fitted in to the whole. This information could be sorted and was most useful.

The issues underscored the importance of problematic access to information and are useful for showing where management can apply leverage to improve a situation. For example, staff continuity was the most important reason why uniform information and knowledge management solutions were required. When a single staff member develops a management plan, the knowledge is internalised and available on demand through personal memory: no external repository is required. But if that person leaves in 'mid-flight', the information is gone. So some form of consistent management of explicit information must be introduced into the process if attrition is high.

Moving from the data to the ontology modelling is the 'design process' and so more of a 'black art'. This was done by examining the cognitive maps and abstracting or splitting the concepts as appropriate. Other concepts were derived from the documentation, using nouns as candidate objects for diagramming. This process arrived at an indicative UML class diagram, which is fairly easy to understand and can be used for further refinement. There are several things to be hoped from the diagram:

- It raises knowledge objects which would not normally be visible (such as the quality of the relationships and trust) to the level where designer and possibly management attention is focussed. Contextual information becomes available to the designer at the object level within an ontology, even though that information may never be a candidate for codification.
- It forms the basis for thesaurus / taxonomy and designing the Intranet storage and access paths.
- It could lead to electronic web services later on, if required.

To return to the element required for a design defined previously, the work performed in this case study demonstrates:

- That through the process of cognitive causal mapping in a workshop environment, the tacit elements (skills and relationships) which function as enablers of an effective work environment, can be identified and documented. This suggests that appropriate design solutions can then be developed.
- That it is possible to introduce 'contextualising objects' into ontology diagrams.
- That through process modelling and associated soft systems analysis, a clear work context can be defined for the purposes of conveying understanding to the designer and providing a context for subsequent knowledge elicitation through cognitive mapping.

- That a representational convention like UML can be used to capture tacit information (in the form of classes), relationships (through associations, is-a-kind-of and part-of formalisms) and contextual information through the linking to process models and domains.
- The process of identifying and contextualising issues pinpoints breakdown in the current system, which will aid systems design into the future.

8 FUTURE RESEARCH

At this stage, only the first stage of the knowledge management strategy has been performed, namely an examination of the working environment and the derivation of a high level design. This has been read and endorsed by the participants in the project and organisational management. Future research, which is continuing, will focus upon the development of a detailed knowledge map and the development of a knowledge portal based upon the map.

After the portal has been developed, we will need to measure its effectiveness. For example, what is the difference between the portal we have arrived at based upon the ontology and a portal developed simply upon departmental lines? The further point of research will be to identify the usefulness of the knowledge maps for pointing management to the importance of components of the ontology which are not programmable. Perhaps elements of the UML diagram can be differentiated to show whether or not they are a programmable object (for semantic web purposes), a static object (such as a document) or a contextual object (such as trust or a close relationship).

What was not demonstrated in this research were other methods of identifying the 'knowledge objects' within a subjects knowledge domain, for example participant-observation. The methods were classical workshops and interviews. It would be interesting to pursue those forms of knowledge elicitation to identify further stocks of tacit knowledge for inclusion in UML-modelled ontologies.

Bibliography

Ambrosini, V. & Bowman, C. 2002, 'Mapping Successful Organizational Routines', in A. S. Huff & M. Jenkins, (eds.), Mapping Strategic Knowledge, Sage Publications, London, pp. 19-45.

Alavi, M. & Tiwana, A. 2002, 'Knowledge Integration in Virtual Teams: The Potential Role of KMS', Journal of the American Society for Information Science and Technology, vol. 53, no. 12, pp. 1029-1037.

Ambrosini, V. & Bowman, C. 2002, 'Mapping Successful Organizational Routines', in A. S. Huff & M. Jenkins, (eds.), Mapping Strategic Knowledge, Sage Publications, London, pp. 19-45.

Berners- Lee, T. 1998, Semantic Web road map., Available: [http://www.w3.org/DesignIssues/Semantic.html] (28th October).

Checkland, P. & Scholes, J. 1990, Soft Systems Methodology in Action, John Wiley and Sons Ltd, Chichester.

Davenport, T. 1997, Information Ecology: Mastering the Information and Technology Environment, Oxford University Press, Oxford.

DTI 2001, Business in the Information Age. International Benchmarking Report 2001, Available: [http://www.ukonlineforbusiness.gov.uk/main/resources/publication-htm/bench2001.htm] (27th October).

Geroimenko, V. 2003, 'The XML Revolution and the Semantic Web', in V. Geroimenko & C. Chen, (eds.), Visualizing the Semantic Web. XML-based Internet and Information Visualization, Springer-Verlag, London.

Gilb, T. 1988, Principles of Software Engineering Management, The Bath Press, Avon.

Gilchrist, A. 2001, 'Corporate taxonomies: report on a survey of current practice', Online Information Review, vol. 25, no. 2, pp. 94-102.

Gilchrist, A. 2003, 'Thesauri, taxonomies and ontologies; an etymological note', Journal of Documentation, vol. 59, no. 1, pp. 7-18.

Goffman, I. 1974, Frame Analysis, Penguin Books, Middlesex.
Gottschalk, P. 1999, 'Knowledge management in the professions: lessons learned from Norwegian law firms.' Journal of Knowledge Management, vol. 3, no. 3, pp. 203-211.
Gruber, T. R. 1993, 'A Translation Approach to Portable Ontology Specifications.' Knowledge Acquisition, vol. 5, no. 2, pp. 199-220.
Guarino, N. 1998, 'Formal Ontology in Information Systems', in Proceedings of FOIS'98, Amsterdam, IOS Press, Trento, Italy.
Hansen, M. T., Nohria, N. & Tierney, T. 1999, 'What's your strategy for managing knowledge?' Harvard Business Review, vol. 77, no. 2 (March-April 1999), pp. 106-116.
Huff, A. S. & Jenkins, M. (eds.) 2002, Mapping Strategic Knowledge, Sage Publications, London.
Johnson, P. & Johnson, G. 2002, 'Facilitating Group Cognitive Mapping of Core Competencies', in A. S. Huff & M. Jenkins, (eds.), Mapping Strategic Knowledge, Sage Publications, London, pp. 220-236.
Mack, R., Ravin, Y. & Byrd, R. J. 2001, 'Knowledge portals and the emerging digitial knowledge workplace', IBM Systesm Journal, vol. 40, no. 4, pp. 925-955.
Maedche, A., Staab, S., Stojanovic, N., Studer, R. & Sure, Y. 2003, 'SEmantic portAL: The SEAL Approach', in D. Fensel, J. Hendler, H. Lieberman & W. Wahlster, (eds.), Spinning the Semantic Web, The MIT Press, Cambridge, Mass, pp. 317-359.
Markus, M. L. 2001, 'Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success', Journal of Management Information Systems, vol. 18, no. 1, pp. 57-93.
McGuinness, D. L. 2003, 'Ontologies Come of Age', in D. Fensel, J. Hendler, H. Lieberman & W. Wahlster, (eds.), Spinning the Semantic Web, The MIT Press, Cambridge, Mass, pp. 171-194.
Nardi, B. A. 1993, A Small Matter of Programming, The MIT Press, Cambridge, Massachusetts.
Nissen, M., Kamel, M. & Sengupta, K. 2000, 'Integrated Analysis and Design of Knowledge Systems and Processes', Information Resources Management Journal, vol. 13, no. 1, pp. 24-43.
O'Dell, C. & Grayson, C. J. 1998, If Only We Knew What We Know: The Transfer of Internal Knowledge and Best Practice, The Free Press, New York.
Porter, M. 1980, Competitive Strategy: Techniques for Analysing Industries and Competitors, Free Press, New York.
Prusak, L. 1996, 'Introduction to Series - Why Knowledge, Why Now?' in P. S. Myers, (ed.) Knowledge Management and Organizational Design, Butterworth-Heinemann, Newton, MA.
Robillard, P. N. 1999, 'The Role of Knowledge in Software Development', Communications of the ACM, vol. 42, no. 1, pp. 87-92.
Stolterman, E. 1999, 'The Design Of Information Systems: Parti, Format And Sketching', Information Systems Journal, vol. 9, pp. 3-20.
Vail, E. F. 1999, 'Knowledge Mapping: Getting Started with Knowledge Management.' Information Systems Management, vol. 16, no. 4, pp. 16-23.
Winograd, T. 1996, 'Introduction', in T. Winograd, (ed.) Bringing Design to Software, ACM Press, New York.
Wittgenstein, L. 1958, Philosophical Investigations, Basil Blackwell & Mott Ltd, Oxford.
Wittgenstein, L. 1974, Tractatus Logico-Philosophicus, Routledge and Kegan Paul Ltd, London.
Zack, M. 1999, 'Developing a Knowledge Stategy', California Management Review, vol. 41, no. 3, pp. 125-146.
Zuboff, S. 1988, In the Age of the Smart Machine, Basic.