TOWARDS A NEW DESIGN METAPHOR: SUPPORTING BOUNDARY OBJECTS AS MEANS OF KNOWLEDGE SHARING IN COMMUNITY NETWORKS

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Abstract

Working in the knowledge sector means dealing with increasing amounts of information, technology and people. Organizations as well as individuals in communities need to constantly maintain large repositories and networks of people, including colleagues, clients, experts, acquaintances and friends. This situation leads to complexity where person's cognitive capability is insufficient when dealing with huge repositories of information and interaction. Viewing it as an individual problem has resulted in applications that highlight the need for structure and organization. We here define these applications in different levels where the first level is the office application generation, referring to "desktops" metaphors. The next generation, groupware applications, offers structure and process support for collaboration, but is still a rather limited "forum" metaphor. Our main argument is that current application generations and design metaphors are too limited when supporting the sharing of thoughts and associations in different community networks. We believe that a large portion of this problem is not related to information itself, but rather to processes of information categorization, navigation and interaction within and between communities. In our results we advocate the need for a new application generation and a new design metaphor, i.e. brainware applications based on "neural" metaphors. The result is a review of three application generations based on different design metaphors. We discuss several implications for a new design metaphor and suggest a design draft that supports boundary objects as means of knowledge sharing within and between communities.

Keywords: community knowledge, knowledge sharing, application generations, design metaphors

1 INTRODUCTION

Modern organizations require sharing of information spaces that facilitate the horizontal coordination, alignments and integration of distributed activities. ICT could meet these requirements by the use of databases, document archives and other forms of shared repositories. For instance, common information spaces have been possible through the evolution of networked distributed computing and large-scale and enormously powerful tools for information management. Common information spaces, CIS, could be defined as a last repository of objects including indexing and classification of information stored. The less complex work settings, where the number of people involved is low, the more it is possible to articulate the use of common information spaces by rich interaction and communication (Carstensen & Sørensen, 1997, Bannon & Bodker, 1997). But the distributed and dynamic nature of large-scale cooperative work setting, the work needed to structure a large common information space become extremely demanding.

The use of common information spaces is quite complex as different persons in dispersed places retrieve, modify, store and distribute the information in very different ways. Today the nature of common information spaces and document repositories is in an extreme flux and more than ever demands a way of structure and classification. The relevance of ICT in this field has for a long time been tightly coupled, though too narrowed. There is a fundamental risk that ICT has been the main tool for organizing much information and knowledge into codifiable, and objectifiable entities, managed in systems as repositories of ”all-knowing" directories. (see e.g Carstensen & Snis, 1999). Constraints in systems for knowledge creation and common information spaces can for example be classified into temporal, geographical, as well as cognitive and social limitations. By levelling the temporal and geographical barriers, the CSCW field has discussed and debated the use of common information spaces, co-ordination mechanisms as well as advanced groupware technology. The use of such technologies has been reported in several studies and can be characterized in different ways. Common information spaces supports knowledge work and relates to community characteristics, as it often requires that people make sense of much common information as well as collaborative work activities.

CIS facilitates the access to information bases storing data that are relevant beyond the individual level. A CIS typically allows the user to acquire electronically a set of documents, generates an indexing system to facilitate their retrieval, allows the definition of additional intelligence to link documents (for instance by hypertext structure), and offers support for search and retrieval of individual documents. However, what has been proved to be the most difficult challenge is how these spaces are to be structured. Much studies point to the challenge of designing adequate classification schemes that is on the one hand, simple and stable, on the other hand advanced and flexible (Bennon & Bodker, 1997; Carstensen & Wolf 1998). What comes to be important in such a design strategy is the role of the classification scheme, which in this case becomes crucial as it facilitate for users to not only classify information and knowledge in a coherent way, but also to search and retrieve it effectively. That is to say, as you store it – you will find it. However, this is a rather limited way of using such an application. Some drawbacks can be identified. Much studies, related to knowledge management systems, show that the barriers for a successful use and implementation of such systems include inadequate organizational structures, organizational cultures and motivators, and, more specifically related to ICT, the un-friendly use of actual technology (Orlikowski 1992; Gunnarsson et al 2000). From here, we identify another angel from which this problem can be approached. From a human layer perspective much problems can be identified. What these applications must focus on is that many people diverse interest and needs with different mental models and knowledge representations needs to collaborate on common information (spaces). Consequently the user’s cognitive capacity is limited. Some argue that the “technological frames” are different for different users and user groups (Orlikowski, 1999). This refers to the inconsistent use patterns that users adopt in the implementation and cultivation of new systems.

Looking at the current knowledge systems studies, we realise their limited value. The actual usage often comes from an "easy to use" metaphor that the user recognizes as a mental model of how to use the application in the "right" way (Orlikowski, 1992). From this, we understand ICT as having a vital role in a kind of a knowledge media networking "space", in which nodes of both documents, emails, links to other persons and other knowledge items is connected through a net of interrelated nodes. Thus we support, and further extend the conceptualization of both the codification of knowledge as well as collaboration and interaction among and between communities of practice (Brown & Duguid 1991).

The objective of this article is to shed light on the different approaches related to computer support for human thinking and common information spaces and to demonstrate the importance of easy to use metaphors in the design of such applications. We argue that, too much of complexity in such systems makes them difficult to adapt to the human mental models of processing information and knowledge. Instead, more intelligence should be placed in the tools to facilitate search and retrieval processes of huge and complex repositories. Drawing from studies of different applications support, ranging from common information spaces and recommender systems, we would like to introduce and conceptualize the idea of brainWare applications. By using a neural hyperlinked network, we suggest a design draft that may support the actual practice of human information navigation and retrieval, and thus supports the concept of community thinking.

2 FROM INDIVIDUAL TO COMMUNITY THINKING

In this section we will describe certain theories concerning cognitive models, associative thinking, community thinking, knowledge creation, perspective making, perspective taking and boundary objects.

The relevance of the knowledge management theme particularly derives from the fact that it provides a link between the level of the individual knowledge workers, where knowledge resides (Simon, 1967), and the level of the organization, where knowledge attains its economic and competitive value (Davenport, 1997). Knowledge systems of today, tend to either be too complex or too lean, too structured or too flexible. It is hard to find systems that support management knowledge work, even though the attempt to create applications that can store knowledge has increased over the past years. A great number of alternatives has been used, from file systems to more advanced applications. To reach the aim of designing new systems, like knowledge systems, one needs to understand the human mind and the interface of a knowledge system, in relation to support a specific context of real situation needs. In understanding and using the human capacity in our application design and graphical interface, we will hopefully get more usable knowledge support systems. Thus, our rationale for designing such applications is the human's way of thinking.

The understanding of how humans think has for instance been studied by Simon as the cognitive model (Simon, 1967), where the idea is that thinking can be tested and formulated in computer programming languages. Cognitive capability is distinguished by the psychological result of perception, learning and reasoning, i.e. the underlying processes for us to learn and capture new knowledge. Furthermore Simon (1964) argues that the human being is an information processor, where human thinking can be explained without waiting for a theory of the underlying neurological mechanisms. Through logic reasoning he present the human mind to be a processor with cognitive capability that can be build in to a computerized system of reasoning.

Over the years this view has been very criticized as narrow and expert-oriented on knowledge creation, where logic and intelligent reasoning is the rationale for learning and knowledge creation. Going from the view of the world, from the context of knowledge and knowing in practice, the perspective above will never be easy to conquer, if ever possible (Dreyfus & Dreyfus, 1986). They say “we can never explicitly formulate this in clear-cut rules and facts therefore we cannot program computers to possess that kind of know-how”. Dreyfus & Dreyfus (1986) extend the conceptual model of human thinking through association. Associative thinking is the process of bringing ideas or events together in memory or imagination; it is influencing us to learn and being competent (Dreyfus & Dreyfus, 1986). To cope with problems of everyday reality, people use the mind, view pictures, intuition and experiences, then people will have problems with computerized logical systems build on hierarchical and rule based computerized systems. Holistic and flexible use and thinking will not be supported, and just left at random.

Next level of thinking is based on understanding and dynamic actions that are performed by communities of practice. This thinking is based on both cognitive and associative thinking, but consists of something more, what we present as “community thinking”. To understand this model, we take a point of departure from cognitive knowledge creation and thought sharing within a community of practice as well as between, in networks, so called networks of practice (Nonaka, 1994; Boland & Tenkasi, 1995, Brown & Duguid, 2000). As knowledge creation is a complex process where the individual knowledge is the smallest unit of our analysis, we need raise to a community level where we in our knowledge process can share thoughts and associations.

In order to understand the community level of thinking we use the concepts of perspective making and perspective taking (Boland & Tenkasi, 1995). Perspective making represent the first step, in knowledge creation and is build on the individual understanding and communication, which Nonaka (1994) argues as vital internalization and externalization knowledge building processes. Internalization is based on an inner conversation and reasoning for creating knowledge, which also can be shared within a community of practice n the perspective making process (Boland & Tenkasi, 1995). Perspective making encompass e.g. sharing stories, paradigmatic analysis and representation of knowledge. Through externalization of knowledge, i.e., making knowledge explicit, to share with others, perspective taking is possible. To make this happen, knowledge can be present as maps, models, schemes or neural objects, as boundary objects (Boland & Tenkasi, 1995). Boundary objects are the link in the externalization process between perspective making and the internalization process of perspective taking. Perspective taking processes is crucial to reflect upon, and refine knowledge individual and in the community of practice. What then is needed to make this happen is models and applications, which can serve as a boundary object system to support knowledge sharing and creation facilitating perspective taking between communities of practice, intercommunity, to other networks of communities of practice that will increase reciprocity and reach. But to reach this aim there is a need for new types of applications and interfaces that are flexible, neural and graphical without being too complex.

3 APPLICATION GENERATIONS AND DESIGN METAPHORS

3.1 OfficeWare – The Desktop Metaphor

By tradition we have been used to desktop applications, office ware, e.g. word processors and spreadsheets, which today are invaluable tools in every day work. These applications, what we here define as the first generation, is closed and well structured and do not support human cognitive thinking and logical reasoning. Instead the aim is to store a lot of information, structured by the individual through file trees. Files containing information could form a base for building knowledge, but in desktop applications the classification schemes is highly individual and out of reach for other collaborative members.

3.2 GroupWare - The Forum Metaphor

Communication and interaction has been in focus since the Internet era has entered the every day work practices (Braa et al 2000). Information will be negotiating through interaction and visibility. Systems supporting this kind of embedded functionality for communication are built-in through different kinds of forums, what we here define as the second application generation. Group ware and Intranet are system solutions supporting functions for openness through forums, like chat, threaded discussions, linked systems, and maps. Limitations of these systems are the lack of support for associative thinking. Collaborative forums are sometimes designed along with a classification scheme that makes it possible for interdependent actors to indirectly engage in cooperative articulation activities at “arm’s length”. It mediates and stipulates by providing a conceptual structure for categorization and classification of symbolic representations of objects. This also means a provision of a structure for a special set of documentation and a structure that makes it possible, in a distributed manner, to navigate and browse this documentation. Thus it provides a protocol for the unique naming. But it is said to be a distributed nature of its use, which is not mirrored in their design and the official classification scheme often does not represent the still evolving conceptualizations of the involved actors from fields far apart, and thus classification schemes must evolve themselves.

A shared workspace is part of what Bannon and Bødker (1997) describe as a ”Common Information Space”. In common information spaces explicit actions handling inclusion, re-use and refinements are normal, and the actual structure of the information space itself will be changed and refined during use. A typical situation will be when information and knowledge is put into a common repository at one point and subsequently will be accessed by another coworker later on. According to Bannon and Bødker it is often not agreed what the structure and content should be, only that the production of it may affect its form. In knowledge transformation it is very important to come to an understanding of the background knowledge and assumptions about the actual context where the knowledge was produced. This discussion is further explored in the field of organizational memory, which has been widely developed during the last decade (Conklin & Begeman, 1988; Ackerman & Halvorsen, 1998; Kutti & Virkunen, 1994; Kristoffersen, 1996; Conklin, 1998; McDonald & Ackerman, 1998). It has been argued that common information spaces and organizational memories should also be more abstract tools reflecting a collection of social activities that are performed by skilled worker in the organization culture (Kutti & Virkunen, 1994). In this case it makes sense to relate our understanding of the concept of common information spaces to our metaphor when discussing interaction through neural nodes. Therefore, the third generation addresses issues of cognitive and associative thinking as well as community thinking.

3.3 BrainWare - The Neural Metaphor

In this generation we argue for the use of networked boundary objects as externalized representations of community thinking**.** Boundary objects are crucial nodes that via associations connect to community thoughts together in a graphical unit. These connections are observable to the members within and between different communities as well as networks of practice. The meaningful way of organizing these nodes of interrelated data stems from the thoughts of Vanavar Bush (1945). He was one of the first innovators for non-hierarchical structure of information. Now we have reached the possibilities of realizing Bush idea by the dynamic and flexible relations between nodes of data. Today we have only limited possibilities to extend these thoughts. Technology design needs to be redefined in new and more innovative ways of designing applications. Foremost, this can be argued for the graphical user interfaces. A summary of our conceptualisations so far, is given in the below table.

Model of Thinking	Unit of analyze	Design Metaphors	Application generations		
Cognitive model	Individual (=Ind)	Desktop	OfficeWare		
	Group	Forum	GroupWare		
Associative Thinking	Ind / Community	Neural	BrainWare		
Community Thinking	Ind / Community Networks				

4 METHOD

Our method is mainly inductive in a way that we, from the literature, analyze different perspectives on human thinking and ICT support for human thinking and knowledge communities. More specifically, our understanding of human thinking, community knowledge and its systems support is inspired by several studies in the KM and CSCW research literature. It includes concepts such as human mind and thinking (Simon, 1967), community knowledge (Boland & Tenkasi, 1995), common information spaces (Bannon and Bødker, 1997), classification systems (Carstensen & Sørensen, 1997; Sørensen & Lundh Snis, 2001) knowledge management - communities and technologies (Gunnarsson et al 2000, Lindgren & Stenmark 2002). These concepts have been applied as sources for inspiration in the process of identifying relevant requirements for neural community thinking.

The approach to meet our objective is two-phased. First phase concerns a literature review, which include studies of human thinking and human mind as well as relevant knowledge systems for human mind and knowledge communities. A number of field studies on knowledge management and knowledge systems support in real work scenarios were studied. We concentrated on how the mapping of the human mind and the knowledge community relations could be facilitated through a computer mediated interactive design. This helped us to form a general view of the perspectives on human mind and computer support used in different thinking and knowledge community scenarios. Interdependent individuals and groups in knowledge communities face problems about their use and interaction when managing much information and communication in their daily design work activities. Specifically, we have been looking at four different systems and tools, namely AnswerGarden, KnowMan, VIP, TheBrain, and MindManager. In the second phase, we analyze and discuss implications for design. We consider how traditional systems thinking and metaphors might be transformed and redefined into new design ideas, derived from the understanding of knowledge communities and advanced computer support for such contexts. We end the discussion with a design sketch, which rationale is more specifically based on the concept of boundary objects and neural metaphors. We think that the use of a specific design project as a test laboratory setting in both analysis and design of general knowledge systems could be fruitful. This means that a specific development process may both gain from and contribute to the development of general applications, for instance neural GUI-based applications for managing nodes of information and communication in a knowledge community.

5 APPLICATION REVIEW AND DESIGN IMPLICATIONS

In this section we will review some applications that explicitly supports the two design metaphors forum and neural.

5.1 "Forum" Applications

The design rationale for recommender systems has been the fact that we rely on peers and colleagues when searching for information (Kristoffersen 1996; Ackerman & Halvorsen 1998; Lindgren & Stenmark 2002). They are mainly designed to augment the social process of giving each other recommendations and advice in different kinds of information seeking processes. Current efforts for such systems design focus on the location and leverage of expertise. For example, Answer Garden is a general hypertext system intended to support the development of an organizational memory. Some of the characteristics of the system can be recognized from an ordinary document management system as it is all about documenting in a common repository. "The Answer Garden system helps an organization solve these problems by providing a database of answers to commonly asked questions that grows "organically" as new questions arise and are answered. It is designed to help in situations where there is a continuing stream of questions, many of which occur over and over, but some of which the organization has never seen before." (Ackerman & Malone, 1990, p 31). Answer Garden can support relatively novice users in acquiring technical skills, in situations where they have been infrequent users or in training. This query handling could be seen from an "educational perspective", as Kristoffersen (1996) put it, because this is a systematic approach to educate specialists in a highly situated and professional way.

As a simple structuring mechanism answer documents can be linked to question documents. The primary way users find answer documents is by answering a branching series of multiple-choice questions. There is also the possibility of an overview line of the tree and immediately jump to any node in the tree for the advanced users, who may roughly already know where their question is answered and do not want to click their way down a long branching tree. If the users are not happy with answers they can post a message directly to the expert who is knowledgeable about the node at which the problem occurred. This mail is not only mailed to the appropriate experts but optionally to an additional notification list and when someone answers the question the answer is automatically inserted in the knowledge base. From the branching network in the graphical user interface experts can also read indications about when restructuring and clarifying the knowledge. Some experiences show that specific design issues could be considered. An editing function or an annotation function could be added in order to control the quality of the information. Also there could be interesting to let the user branch the structure of their own tree in order to get a quicker access to it.

Another application, KnowMan, is a recommenders system that supports a collection and sharing of URL's. This design study is reported in Gunnarsson et al (2000). They took the point of departure from two different case studies, both analyzing the work context of highly skilled people working in a typical knowledge intensive environment, such as quality support and ICT consultancy. Both studies clearly demonstrated the reliance on collegial trust when constantly seeking new information for keeping abreast with the latest news within their knowledge domain. Also their knowledge work activities were conducted under extremely time pressure. From these results, we derived several implications for design, whereof the particular call for IT-support when seeking information and establishing a shared understanding of different knowledge, such as link (URL's) collections, were most prioritized. In order to support the direct interaction among knowledge workers the design idea was built upon the assumption that people also wanted to communicate, not only interact with link collections. They identified the need to locate and through communication use the competence of the co-workers and their collected and shared information, as an obvious point of departure for design. Using signatures and email-lists that could be added to the bookmark collection should support this more specifically. KnowMan is built on a platform based on Microsoft IIS and the most common scripting languages such as ASP, dhtml and JavaScript. The information is stored in an MS Access database and is retrieved and stored by simple SQL statements. To use KnowMan the user need a standard browser and Internet access. From this perspective KnowMan can be divided into two parts; one contributor part and one sharing part. To contribute to the application the user can access KnowMan by one click from the browser's Personal Toolbar (Netscape Communicator) or Links Toolbar (Internet Explorer). This link opens a browser pop-up window with an html-form. The form consists of six fields where the JavaScript populates the first two fields, with the title of the page and the URL which both are editable. The next fields are two dropdown menus populated by the database with the functionality to typify and categorize the URL. A comment field and a signature field, which is populated by a cookie, is the last set. The cookie that populates the signature field is set the first time the user enters KnowMan. The signature is stored together with the user e-mail address.

According to Lindgren and Stenmark (2002) recommender systems are too much based on formal knowledge and competencies. They propose a new design rationale for such systems, a rationale that should have the potential to detect, visualize and leverage interests of organizational members. In their design efforts a system named VIP was developed. This system is an interest-activated recommender system in which users define their interests in free-test format and it applies agent technology and neural networks. The agents are used to support users in searching huge Intranet repositories that, for example, contains documents. From the free text written documents internal digital representations are defined by the system.

5.2 "Neural" Applications

To further explain and put our thoughts in light, we like to present some software applicaitons that address the neural/associative thinking instead of the traditional office-metaphor systems. We choose to label them brainware, referring to the somewhat "neural" metaphor that should guide the structure and visualization of information. Products such as TheBrain and MindManager allow the user to relate and interlink nodes of information, (i.e. documents, file's and web resources as well as database data), into dynamic structures that can be visualized by charts resembling "mind-maps". Furthermore, the nodes of information are sometimes referred to as "thoughts".

5.2.1 MindManager

This is the short description of MindManager by MindJet on http://www.mindjet.co.uk/: "Mindjet offers your organization powerful tools that provide more effective ways to brainstorm, generate, document, and communicate project tasks. Mindjet's software MindManager gets team members on the same page and helps achieve project objectives and goals." Our evaluation indicates that MindManager shows some strength's to support a work process based on our neural metaphor. The prior advantage of MindManager is to support mind mapping in a smooth way. We are in the opinion that mind mapping supports a neural work process, but only in two dimensions which decreases the possibility to work with great amounts of data and information. This is even clearer when trying to visualize complex networks of associations. It is definitively clear that MindManager is designed to support documentation of creative or even innovative processes such as brainstorming. However it is difficult to find and reuse information in and between documents. This is a major con compared with our requirement to have the possibility to find data in a smooth and easy way. MindManager supports the possibility to search within a document, and even navigate, but not between documents or from databases. From a perspective of work process, we find MindManager not sufficiently in supporting the neural metaphor, because it only supports two-dimensional categorizations we assign to the desktop metaphor.

5.2.2 TheBrain

"TheBrain is an easy-to-use system for organizing information. It enables you to link files, documents, and Web pages across applications and network boundaries. TheBrain illustrates how information is related, provides a visual context for documents and data, and offers a framework for collaboration." This is the short product description (http://www.thebrain.com/Default.htm). TheBrain illustrates a sense of three dimensions. However we find it is still supported by two dimensions, which does not give the opportunity to "walking around" among thoughts and associations. Further on, it is not possible to visualize the individual or the community behind the thoughts and associations. However, TheBrain does support some of the basic requirements: drag&drop, possibility to include different types of data (i.e. documents and hyperlinks), neural navigation etc. The positive sense of the interface strengthens the usability of the application. The final judgement is that this is a nice and potential application but does not fulfill our purposes.

5.3 Application Evaluation and Design Requirements

TheBrain and MindManager give a hint of our neural approach. TheBrain 3D interface gives you a intuitive sense regarding your work process. The visualization also strengthens the interaction between the user and the application. The intuitive work process might depend on the mirroring of human thinking - associations and thoughts. Summarizing the analysis points to that some of these applications are interesting but that they lack some of our requirements. Of course, we bring these experiences further on to our design. In the following list, we present some of our primary requirement for our application design:

- Neural approach based on human and community thinking
- 3-dimensional classification: walking around among thoughts and associations
- Generic data collections
- No-math Clustering
- Neural/associative Navigation
- Multilevel associations
- Accuracy, Relevance and Reliability
- Visualization and Clustering of individual as well as community thoughts and associations

6 TOWARDS A NEURAL-BASED DESIGN METAPHOR SUPPORTING BOUNDARY OBJECTS IN COMMUNITY NETWORKS

Generally speaking, the core issues of our lessons learned so far are that we carefully need to consider neural community networks both in terms of communication channels and information archives. Information spaces that are applied and maintained by community members should have a compound nature supporting somewhat opposite requirements (Bannon and Bødker, 1997). On the one hand the structures must be simple, stable and fairly rigid in order to support actors with different background and knowledge about the subject of work in sharing (generating, maintaining, filing and retrieving) the information. On the other hand, the structures must be open and flexible in order to support the evolving nature. This conforms with findings from our previous study (cf. Carstensen and Wulf, 1998) and with the findings of Bannon and Bødker (1997) indicating that common information spaces must be open and malleable on the one hand, and immutable on the other. Furthermore, there seems to be a need for structures that can be interpreted, developed and maintained in a decentralized manner by the actors. The study of Carstensen & Snis (1999) also indicated that actors accessing shared information are often interested in references to other actors having knowledge about a certain field than in factual information or knowledge. This need refers to the requirement of communication channels. Actors both inside and outside of the knowledge community constitute a network of communities that must be able to share knowledge in a direct communicative way. From here we recognize a community thinking network in which our neural designed network should be seen as spaces in which nodes of information is exchanged, filed, retrieved, presented and refined by actors having different vocabulary and perspectives on the information. These characteristics must be taken into account when designing IT and neural-based community thinking applications.

6.1 Design Draft

We have designed our prototype using the list of requirements mentioned earlier in this paper. The prior aim of the interface design is to visualize and give the understanding for other individuals' thoughts and associations, as well as understanding between different communities. This relates to the concepts of inter community understanding and sharing connected via boundary objects.

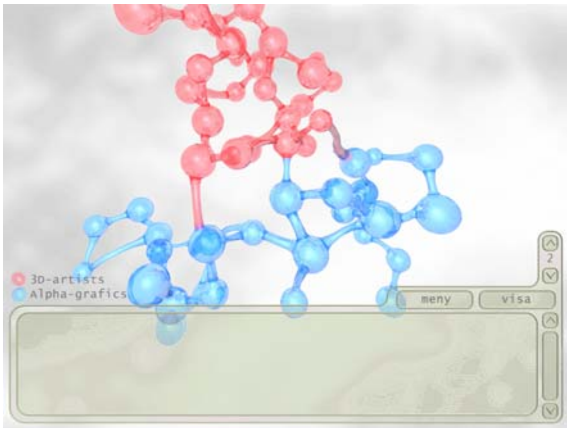

Figure 1, All thoughts

The illustration in figure 1, shows all thoughts in an unordered manner. The thoughts' positions in the room are set through an algorithm using the associations to get the best positioning from a graph theoretical calculation. There are a number of ways of representing information:

Representation	Meaning
Size/Thickness	Different attributes / *alternative to nuance*
Color/Nuance	Performer / No navigations/readings
3D-Icons	Class/Object type: representing different thoughts depending of thought type (class, object type).
Magnets/"Black holes"	SQL-query attracting corresponding thoughts in the query result
Using time	*Undefined*
Using place	This could force the thoughts moving around in the room depending on different things.

In our design the identification of nodes may be represented in several ways. When identifying the nodes in the network we can suppose that they consist of subject documents with problem-solving expertise in functional disciplines (e.g. 3D-artists), procedures of know-how, experiences, and lessons learned (e.g. Alpha-graphics) as well as emails and other communication forums. These nodes can be formal as well as semi-formal (like formatted documents) and completely informal representations. Kirn et al. (1997) argue that when understanding a specific knowledge subject, deeply integrated use of all the different types of knowledge is required. Abilities to manage disparate know-how and heterogeneous viewpoints are essential in order to make it accessible and suitable for all members of a community. Thus, linking the gaps between creating and using knowledge is a central issue in knowledge communities (Boland & Tensaki, 1995; Lundh Snis, 2002).

From the literature, we have learned that, systems that take the point of department from pre-defined categories explicitly force the user to chose among these categories. More often, one reaches situations where one does not like the categories. This reasoning is in line with the desktop metaphor that relies on files and folders in a two-dimensional, pre-defined structure. What can furthermore be discussed is the dimension of classification and storage, as well as of navigation and retrieval. As you store it – you will find it. Thus, the time needed to structure increases as the level of structure and classification increase. There is a problem finding relevant data in all these amount of data, thoughts and associations. So there is a need to have different retrieval approaches included as well:

Retreival	Meaning
Text search	Easy but often a low result relevance
Navigation	Time consuming, good to find relevant data via associations
Clustring	Finding objects and thoughts from a more vaguely defined search, patterns are browsed according to certain “magnets”, needs no math-solution
Browsing	Visual overview of flat classification
Pattern Matching	Representations created from rich text descriptions that are used as search profiles.

In our design draft, we chose to apply clustering as an approach. To fulfill the requirement of no-math-clustering, we represent queries with magnets that generate “gravity” that will position and cluster the objects in the room, as shown in figure 2. Figure 3 illustrates a detailed view of the room. On this detailed level the application will display the name of the objects and relations.

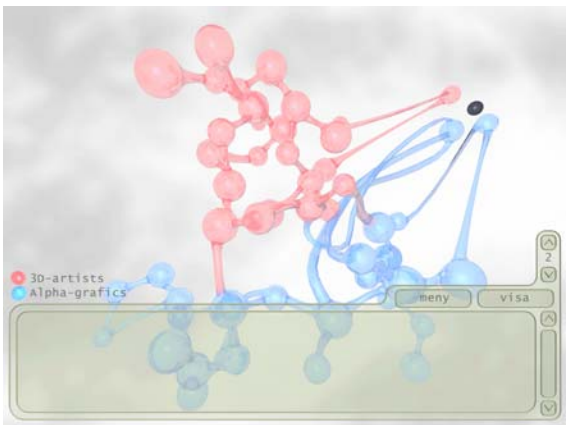

Figure 2, Clustered thoughts

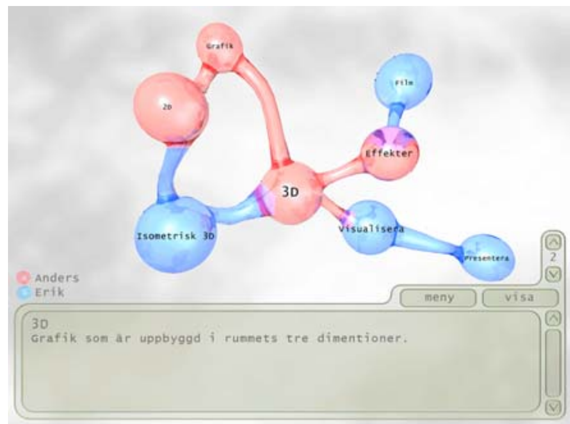

Figure 3, Focused (zoomed) cluster of thoughts

6.2 Discussion

We believe that the neural structure of common information constitutes a good foundation for creating systems that correlates to the human mental models of associative and community thinking.

Model of Thinking	Unit of analyze	Design Metaphors	Application generations	Examples of applications	Design rationale
Cognitive model	Individual (=Ind)	Desktop	OfficeWare	MS Office	Rigid, Standarized GUI
	Group	Forum	GroupWare	Answer garden, Knowman, VIP	Communication, Collaboration, Coordination
Associative Thinking	Ind / Community	Neural	BrainWare	theBrain, MindManager	Memory and Imagination
Community Thinking	Ind / Community Networks			*Our Suggested Design Draft*	Boundary Objects

In our table above, we present the full version of the table illustrating the different design generations. Our design draft is located in the last row in the column representing examples of applications, which is based on the neural design metaphor supporting boundary objects in community networks. An important challenge for the design of community thinking application is to provide support for both intra- as well as inter-community work. Viewing information and knowledge from the individual (mind/head) level, makes it difficult when trying to support communities of networks. In such context, many people interact, and there is no such group head. In our argumentation, we have moved up from the relatively loosely coupled and impersonal collaborative workspace to the more inter personal level of community building where trust and relations to colleagues' thoughts and associations will form the base, upon which community thinking and reflection helps to motivate people to understand and act in common information spaces. By viewing common information spaces from a community level there appears a need to reconstruct existing structure and move beyond the traditional design metaphors (that per se is important to understand, but not sufficient in this case). However, in order to go beyond this level and to make much more human sense out of this, there is a need for a genuine attempt of facing these challenges. Challenges of achieving design metaphors that are in line with the human mental models of association and community thinking. In this challenge we go even higher up on the groupware level, where the degree of collaboration reaches the meaning of shared thoughts and values as well as an understanding of inter-community thinking as well as intra-community thinking.

By a far stronger focus on the investment and use of advanced applications there may be a risk that research and development in knowledge communities and systems will be an extension of the mechanistic view that characterized the industrial society (Simon, 1967). Thereby certain applications in this generation may represent an obstacle for the transformation to the community society. However, this requirement proved to be a real challenge as community networks are composed of multiple communities with highly specialized technologies and knowledge domains (Boland & Tenkasi, 1995; Lindgren et al, 2003). Further, they are too complex for one person to understand in its entirety.

7 CONCLUSION

In this study our aim was review current literature and applications for human thinking and common information spaces in order to identify implications for new design metaphors. We have argued for a neural design metaphor in which nodes of interrelated information and interaction are connected through associations as external representations in order to support boundary objects for intra and inter-community networks. The purpose was not to work out a system of normative principles that can be employed as guidelines for computer support for human mind and associative thinking. Instead, drawing on some design studies, find out adequate requirements for ICT based "community thinking". Further, we need deeper investigation and empirical evidence of the implications of the reviewed applications but we hope that this initial study will provide a good basis for future work in the design space of "ICT based community thinking". A productive step forward would be to start investigating detailed scenarios, where our design sketch is further designed and put into use in an iterative focused process so that the usability could be evaluated and imply consequences to redesign.

References

Ackerman, M. S, Halverson, K. (1998), "Considering an Organisation's Memory", in Proceedings of the ACM Conference in Computer Support Cooperative Work, CSCW '98, November, Seattle, Washington, US.

Bannon, Liam, and Susanne Bødker (1997): "Constructing Common Information Spaces," in *The fifth European Conference on Computer Supported Cooperative Work, Lancaster*, edited by J. A. Hughes *at al.*, Kluwer Academic Publishers, 1997, pp. 81-96.

Braa et al. (2000) Braa, K & Sorensen, C & Dahlbom, B, (2000), *Planet Internet*, Studentlitteratur, Lund.

Boland, R. and Tenkasi, R. (1995), "Perspective Making and Perspective Taking in Communities of Knowing", *Organization Science*, Vol. 6, No. 4, July-August 1995.

Brown, J. S. and P. Duguid (1991), "Organizational learning and Communities-of-Practice: Towards a Unified View of Working, Learning and Innovation", *Organization Science*, vol. 2, No.1.

Brown, J. S. and P. Duguid (2000), *The Social Life of Information"*, Oxford University press.

Carstensen P. H. and Snis, U. (1999), "The knowledge is here - where should I place it?" In *Proceedings of IEEE Workshop Conference on Knowledge Media Networking Spaces* (Stanford CA, July 1999).

Carstensen, P. H. and Sørensen, C. (1997) From the Social to the Systematic: Mechanisms Supporting Coordination in Design. *Computer Supported Cooperative Work: Journal of Collaborative Computing*, vol. 5, no. 4, December, pp. 387-413.

Carstensen, Peter H., and Volker Wulf (1998): "Common information spaces in engineering design: An analysis of the structure and use of a project file," in *Advances in Concurrent Engineering - CE'98, Tokyo*, edited by S. Fukuda and P. L. Chawdhry, Technomic, 1998, pp. 127-135.

Conklin, J. E. (1998) Orgaizational Memory and QuestMap, http://www. gdss.com/OM.htm.

Conklin, J, Begeman, M. L. (1988) "gIBIS, "A Hypertext Tool for Exploratory Policy Discussion", *In Proceedings of CSCW'88 Conference on Computer-Supported Cooperative Work*, Portland, Oregon, September, NY, ACM Press, pp 140-152.1988.

Conklin, J. E. (1996) Designing Orgaizational Memory: *Preserving Intellectual Assets in a Knowledge Econom*, http://www.gdss.com/DOM.htm. 1996.

De Michelis, G. (1997) "Cooperation and Knowledge Creation", *In Comparative Study of Knowledge Creation*, edited by Nonaka, I. & Nishiguchi, T., Oxford University press, New York, 1997.

Dreyfus H. and Dreyfus, S. (1986), *Why Computers May Never Think Like People*, Technology Review, Vol. 89, January. Reprinted in Ruggles, R. L. (ed) Knowledge Management Tools, Boston: Butterworth Heinemann, 1997.

Firebaugh, M. W. (1989), *Artificial Intelligence - A Knowledge-Based Approach.* Boston: PWSKENT Publishing Company. Gunnarsson, M, Lindroth, T, Magnusson, M, Snis, U (2000) Less is More When IT Comes to Knowledge Management, In Proceedings of IRIS 23, Information Systems Research Seminar in Scandinavia, Uddevalla, Sweden, August 2000.

Kirn, S. (1997), "Cooperative Knowledge Processing - Research Framework and Application Perspectives", *In Cooperative Knowledge Processing - The Key Technology for Intelligent Organisations*, Springer Verlag. 1997.

Kristoffersen, S. (1996), "Organisational Memory - Support for Query Resolution in a Customer Service Center?", *Technical Report CSEG/11/1996*, at Lancaster University, UK

Kuuti, K, Virkkunen, J. (1994), "Organizational Memory and the Learning Network Organization: Perspectives from Cultural Historical Activity Theory", Chapter 5 *In A Conceptual Framwork form Describing Organizations*, COMIC Deliverable 1.2, October.

Lindgren, R. and Stenmark, D. (2002), "Designing Competence Systems: Towards Interest-Activated Technology", *Scandinavian Journal of Information Systems*, Vol. 14, pp. 19-35.

Lindgren, R., Stenmark, D. and Ljungberg, J. (2003). "Rethinking Competence Systems for Knowledge-based Organizations". *European Journal of Information Systems*, Vol. 12, Issue 1., pp. 18-29.

Lundh Snis, U. (2002), *Codifying Knowledge*, Informatics, Göteborg University, Sweden.

McDonald, D. W, Ackerman, M. S. (1998), "Just Talk to Me: A Field Study of Expertise Location", *in Proceedings of CSCW '98*, Seattle, Washington, US

Nonaka, I., Takeuchi, H (1995)*.: The Knowledge-Creating Company - How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New York, US, 1995.

Orlikowski, W.J. (1992), "Learning from NOTES: Organisational Issues in Groupware Implementation", *In Proceedings of CSCW '92, Conference on Computer-Supported Cooperative Work*, Toronto, Canada, ACM Press, pp. 362-369.

Orlikowski, W., J. & Gash, D., (1994), *Technological Frames: Making Sense of Information Technology in Organizations*, ACM Transaction Information Systems, Vol 12, No. 2, 1994.

Simon, H., (1964), *Information Processing in Man and Machine.* American Scientist, vol. 2, no. 3, Reprinted in Ruggles, R. L. (ed) Knowledge Management Tools, Boston: Butterworth Heinemann, 1997.

Sorensen, C. and Snis, U. (2000): Innovation through knowledge codification, In Journal of Information Technology, no 16. pp 83-97.

Snis, U. (2000): Knowledge is Acknowledged? A Field Study about People, Processes, Documents and Technologies. In Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS-33), Maui, Hawaii, ed. Ralph H. Sprague Jr. IEEE.

Spender, J. (1996): Organizational knowledge, learning and memory: three concepts in search of a theory. Journal of Organizational Change, vol. 9, no. 1, pp. 63-78.

Spender, J.-C. (1998), "The Dynamics of Individual and Organisational Knowledge", *In Managerial and Organisational Cognition - Theories, Methods and Research*, edited by Eden, C. & Spender, J.-C, SAGE Publications. 1998.

Webreferences

http://www.mindjet.co.uk/

http://www.thebrain.com/Default.htm