

**Managing Knowledge in a Distributed Decision Making Context:
The Way Forward for Decision Support Systems**

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Managing Knowledge in a Distributed Decision Making Context:

The Way Forward for Decision Support Systems

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Abstract

This paper considers the role of electronic communication in the creation and distribution of knowledge, and in particular, the creation and sharing of personalised knowledge. Personalised knowledge or “intellectual capital” is perhaps a least understood but most important asset of modern organisations. This paper reveals the creation and sharing of personalised knowledge in a network organisation. The network organisation investigated in this paper relies on electronic communication in a distributed decision making context to leverage the skills and intellect of its key professionals. This paper investigates electronic group meetings that take place on this electronic social space to analyse key processes of knowledge creation. Implications for managing distributed personalised knowledge are discussed and conclusions drawn with respect to the key decision support systems functionalities required for managing knowledge in situations where decision making is distributed and takes place on an electronic social space.

Key Words

Personalised Knowledge, Distributed Decision Support, Electronic Social Space, Communication Infrastructure, Centrality, Prestige.

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1. Introduction

For modern organisations, knowledge is increasingly becoming a strategic resource that needs to be created and harnessed effectively in order for the organisation to survive and achieve competitive advantage. It is believed that managing this strategic resource can enable an organisation to achieve particular benefits such as minimisation of costs, innovation of products, product development procedures, improved quality, flexibility in a dynamic market and improved customer service. The effective performance and growth of knowledge intensive organisations requires integrating and sharing highly distributed knowledge [43]. The distributed knowledge is often personalised and resides in the pockets and communities within the organisation. This knowledge is also seen to form the core competence of the intelligent enterprise and has to be supported if the organisation is to remain competitive [32]. However, efforts to date in Knowledge Management have concentrated on codifying or explicating this tacit knowledge and propose infrastructures for storing explicit knowledge as well as refining, managing and distributing it (such as Zack [43], Hansen et al [13]). While these efforts are valuable in themselves, practical considerations such as motivating employees to add to such databases and use them in their “knowledge work” have thwarted the success of such codification strategies. The way forward is in recognising this personalised knowledge as being dynamic and in supporting its development rather than in just codifying it for storage in a database repository.

This paper investigates the creation of personalised knowledge that is distributed across a dynamic, changing network organisation. While the definition of knowledge itself is the subject of much philosophical debate [8], [19], [30], this paper uses a more practice oriented definition of knowledge put forward by Alavi and Leidner [1] who state that knowledge is information possessed in the mind of an individual: it is personalised or subjective information related to facts, procedures, concepts, interpretations, ideas, observations and judgements (which may or may not be unique, useful, accurate or structurable). Unlike codified knowledge, personalised knowledge is dynamic, changing and often very difficult to articulate. This suggests that the challenge for managing knowledge is in facilitating the communication of this personalised knowledge and its use. It has been suggested that problems which stem from traditional business environments that hoard knowledge is an obstacle which is preventing knowledge management efforts from being a complete success [15]. In addition, when this personalised knowledge has to be managed in situations where decision making takes place using electronic communications technology, human and technical forces interact to form novel work

environments. This paper uses Harasim's [14] term, *social space* to describe the way in which human communication has transformed computer networks into what she calls 'places' where people 'connect' with each other. The research presented in this paper takes the notion of the social space a step further by considering the social processes that affect interaction on the electronic medium of communication. It recognises that the technology may have an effect on the social processes and thus the patterns of relations and behaviours that emerge. Hence the term, *electronic social space*, is used in this research to describe the environment in which the phenomena are investigated. This notion of the creation of social structure on the electronic medium of communication provides a basis upon which to tackle the complex aspects of knowledge management.

Technologies that support the creation and management of knowledge are seen to fall into a pre-defined set of activities. Alavi and Leidner [1] identify an emerging line of information systems referred to as Knowledge Management Systems (KMS) that target professional and managerial activities by focussing on creating, gathering, organising and disseminating an organisation's "knowledge" as opposed to "information" or "data". In addition, Hibbard and Carrillo [15] believe the information technology that supports knowledge management, such as datamining, groupware, document management and search and retrieval, are widely available and already exist in many companies. Furthermore, it appears that decision support systems are increasingly being seen as a means of supporting knowledge management activities. There is general agreement in the Decision Support Systems (DSS) literature [36], [37], [38], [39] that the three major components of a DSS are Database Management Systems, Modelbase Management System and User Interface. A fourth, relatively new component of a DSS a Message Management System (MMS) that relates to e-mail, news and discussion groups [26]. Database Management Systems in the more specific forms of data mining and data warehousing play an important role in knowledge creation and management, by discovering patterns in large quantities of data. Model-base Management Systems are also important for knowledge management, as computer models through "what-if" analysis facilitate problem understanding, creation of knowledge about systems being modelled ultimately supporting knowledge externalisation. Message Management Systems are of particular interest for the focus of this paper as they relate to the means of electronic communication and support for managing knowledge in the context of distributed decision making.

This paper addresses these different but parallel streams of technology development by considering their relevance for managing knowledge in a distributed decision making context. The key contributions of this paper are as follows:

- 1) It uncovers the process of knowledge creation on a least understood but increasingly popular decision making environment: the electronic social space.
- 2) It outlines the role of electronic communications technology in the creation and distribution of geographically dispersed knowledge.
- 3) It provides key DSS functionalities required for managing knowledge in situations where decision making takes place on an electronic social space: an infrastructure for the management of personalised knowledge.

Many businesses do not know *what* technical, human and organisational issues need addressing, and *how* to provide the right infrastructure to support the sharing and communication of experiences. All these elements are regarded as vital components in developing an organisation that can manage knowledge well.

In the following sections a network organisation in which electronic communication is used for decision making among geographically dispersed experts is investigated. By analysing the behaviours relating to the exchange and creation of knowledge, this paper outlines the role of electronic communication technology in the creation and sharing of distributed personalised knowledge. It concludes with key DSS functionalities required for managing knowledge in situations where decision making takes place on an electronic social space.

2. Knowledge Creation and Decision Support: The Importance of Communication

The means by which we analyse the creation of knowledge on the electronic communication medium, is using Nonaka and Takeuchi's [24] theory of knowledge creation. This theory enables us to consider knowledge to be "justified true belief" or to lie in the minds of human actors. In this information is a flow of messages, and knowledge is created by that very flow of information, anchored in the beliefs and commitment of its holder. According to Polanyi [29] tacit knowledge is personal, context specific and therefore hard to formalise and communicate whereas explicit knowledge is "codified" in that it can be transmitted in formal, systematic language. The process of knowledge creation takes place through the interaction between tacit and explicit knowledge. Tacit knowledge is subjective, experiential and lies in mental models containing cognitive elements such as paradigms, perspectives and beliefs that help

individuals perceive and define their world and in lies mental models containing technical elements such as skills and expertise. Explicit knowledge is objective, rational and is about past events or objects and is oriented towards a context-free theory. According to Nonaka and Takeucki [24] knowledge maybe converted 1) from tacit knowledge to tacit knowledge which they refer to as *socialisation*, 2) from tacit knowledge to explicit knowledge, or *externalisation*, 3) from explicit knowledge to explicit knowledge known as *combination* and 4) from explicit knowledge to tacit knowledge, known as *internalisation*.

All four aspects of knowledge conversion occur in decision making environments. Socialisation occurs when experiences are shared and tacit knowledge is created such as shared mental models. Media that support processes such as brainstorming, idea organisation and the generation of creative dialogue also support socialisation. Externalisation is the process of articulating tacit knowledge into explicit concepts. This may take the shape of metaphors, analogies, concepts, hypotheses or models - all expressions of images or tacit knowledge. In decision making processes going through externalisation discrepancies may occur between articulated expressions and the images representing tacit knowledge. This process would require support for collective reflection and dialogue between individuals. Combination is a process of systemising concepts into a knowledge system and involves combining different bodies of explicit knowledge. Knowledge is exchanged and combined through documents, meetings, telephone conversations of computer communication networks. New knowledge may be created through reconfiguring existing information through sorting, adding, combining and categorising explicit knowledge - decision making tasks particularly well supported by database and groupware applications. Internalisation is the cumulative process of embodying explicit knowledge into tacit knowledge. This takes place when experiences through socialisation, externalisation, and combination are internalised into individuals' tacit knowledge bases in the form of shared mental models or technical know how. Decision support through the use of graphics, video, voice and text documents facilitate the transfer of explicit knowledge to other people thereby helping them to experience the experiences of other people thus enriching their tacit knowledge.

Underlying the above theory of knowledge creation is communication. Without communication, knowledge cannot be created and nor can it be managed and transferred. Communication is crucial for knowledge acquisition and management.

3. Managing Knowledge through Electronic Spaces to Support Decision Making

A concept of growing importance suggests that for organisations to be successful, they must be capable of continuously acquiring, assimilating, disseminating, sharing and using knowledge [9], [18], [34], [37]. These are the preconditions for effective decision making. Software applications for Distributed Decision Support Systems (DDSS) are designed for handling resource allocation, supporting anonymity, voting, negotiation and conflict resolution [22],[36]. These applications are gaining increasing popularity as more emphasis is placed on team-based organisations and autonomous teams that may be based in different locations [25]. An important issue to be considered in relation to DDSS is the role they play in knowledge creation and management, which is perceived to be one of the most important assets in modern organisations. According to Courtney et al [5] a good telecommunications network which supports electronic and voice mail, GroupWare, integrated databases, multimedia presentations, graphical user interfaces, and client server architectures can greatly enhance the ease with which knowledge can be acquired, shared, compared and used. GroupWare in particular used in an advanced meeting room environment, also referred to as Group Support Systems (GSS), has become a popular component of Computer Supported Co-operative Work (CSCW) is gaining much attention among researchers and practitioners for its ability to enhance decision making by making the management of knowledge more effective. Wilson [42] defines CSCW products as including message systems, computer conferencing systems, procedure processing systems, calendar systems, shared filing systems, co-authoring systems, screen sharing systems, Group Decision Support Systems (GDSS), advanced meeting rooms and finally team development and management tools. The use of computer networks in general and distributed group support in particular has opened up a myriad of possibilities to enhance interpersonal communication and cooperation and made possible new forms of work processes and radically transformed organisations. Most importantly, this type of communication is a powerful tool for capturing, exchanging and managing personalised organisational knowledge.

Vance [40] suggests that the reason information may not be easily transferred from the holder to the person needing it may be because it is inarticulable in the mind of the holder. This suggests that in order for knowledge to be useful to the organisation it has to be communicated. In order to assist individuals in communicating appropriate knowledge, an appropriate communication infrastructure is required in which decision making can occur. In supporting the development of such a communication infrastructure, it may be useful to visualise the organisation as a Lockean inquiring system [5]. Courtney et al [5] suggest that in order to support communication it is necessary not only to have proper media with which to communicate, but also a social network or "community of minds" whose

members know one another and speak the same language. Holsapple and Whinston [18] add that as organisations will be increasingly regarded as joint human-computer knowledge processing systems, they will be viewed as a societies of knowledge workers who are interconnected by computerised infrastructures.

The social network aspect of communication infrastructure appears to fit this concept of knowledge creation in network organisations well. This form of organisation may be found within traditionally structured organisations, between organisations and even among groups of organisations [33], [10]. Powell [31] suggests that network forms are particularly apt for circumstances in which there is a need for efficient, reliable information, and the sharing of experience. The network form is thus particularly useful for managing distributed personalised knowledge. It depends upon communication between its diverse units, knowledge is its key resource and functions best by leveraging the creation of this key resource (Venkatraman and Henderson [41], Drucker [10], Quinn [32]). Appropriate decision support systems for the network organisation require efficient and effective use of personalised knowledge distributed throughout the network organisation. A communication infrastructure that best supports personalised knowledge creation requires decision support tools that reside on communication networks enabling access by individuals in different geographical locations.

Research Approach

In order to investigate the role of electronic communication in the creation of personalised knowledge, electronic steering group meetings in a network organisation were studied. The network organisation used a Notice Board that enabled essentially two types of communication to take place. Using DeSanctis and Gallupe's [6] classification, the notice board enabled different time, different place communication through the discussion board facility. While its functionality was similar to that provided by Lotus NotesTM Team Room, the discussion board was more complex in that it enabled participants to air their views relating to certain topics of discussion by automatically creating menus and files for those topics. The second type of communication enabled by the Notice Board used by the network organisation was same time different place communication. This was available through the talker. The talk facility on the notice board, similar in functionality to Internet Relay Chat, enabled participants from different parts of the world to communicate with each other synchronously (at the same time). The communication was not anonymous, and comments typed by each participant were displayed next to their name on the virtual space. Communicating on the talker enabled meetings to be held without having to move the

participants away from their offices or their countries. In the course of these synchronous meetings, the talker also enabled private conversations to take place in virtual rooms. Participants could go into one of these virtual rooms, invite other selected participants and once the invited participants entered the private room it could be locked to restrict others from joining in the private conversation. The analysis of this paper is based on data collected from steering group meetings that took place on the synchronous talker within a single electronic room.

In order to explore the knowledge creation mechanisms that operate in the network form, an interpretivist strategy using a single case study was pursued. This is in line with Pervan's [28] call for more interpretivist research and the need for more non-EMS approaches. The ontological basis of interpretivist research is that there is no objective account of events and situations [3]. This makes interpretive research synonymous with ethnographic research [21]. The case study was the research method used to examine actors within their social setting [27]. Used within an interpretive or ethnographic research strategy, the case study could not be designed because its power lies in creating an in-depth understanding of contextual factors. This interpretivist view is reflected in this paper by the way in which the single case study of a network form is described, in Argyris and Schon's [2] terms, as *a cognitive enterprise undertaken by individual members*. The aim of this research strategy is to provide explanations for why certain patterns of behaviours occur and describe the types of knowledge creation that characterise the network form. In remaining consistent with an interpretivist research strategy, the communication relations were examined in their natural setting (the electronic notice board) where patterns of behaviour emerge. These emerging patterns of behaviour, recorded automatically in computer logs, formed the transcripts of this investigation. These transcripts were then coded and analysed according to theoretical concepts derived from social network analysis. This revealed certain key processes of knowledge creation and delineated the role of technology in the creation and distribution of geographically dispersed knowledge.

4. Analysis of Knowledge Creation on the Electronic Social Space

When interacting on the electronic medium, members of the network brought with them their own perceptions and cultural backgrounds. The result was, in the case of the network organisation, an amalgamation of these norms and perceptions. The electronic communication media presented itself as a somewhat alien environment. In this respect, moderating a meeting was seen as an ordeal as the participants were not accustomed to communicating without the turn-yielding cues available in face to

face communication [16], [17]. In addition, the electronic medium presented itself as a new environment in which different ways of working, communicating and cultural norms had to be reconciled. The creation of personalised knowledge took place through essentially two types of interactions: 1) interaction among participants and 2) interaction between the participants and the technology.

From the transcripts a list of types of behaviour were identified and coded according to information exchange behaviours suggested by Rubin and Goldberg [35]. Basic communication relations of information providing and seeking were coded as IP and IS respectively. In trying to understand who initiated and who participated in these behaviours, additional behaviours were identified in the transcripts and suitable codes formulated to depict the behaviours. These were formulated as follows: requesting action, coded as RA, confirming action, coded as CA, and seeking consensus, coded as SC. These behaviours were termed by Rubin and Goldberg [35] as contractual relations in which an actor sends a message to another in order to obtain a response. Further behaviours defining contractual relations were identified in the transcripts. These were: statement of a problem, coded as SP, statement of a solution, coded as SS. Behaviours that gave an indication that there was an outcome from the discussion were: making a decision, coded as MD, Notifying that an event has occurred, coded as NE, and volunteering assistance, coded as VA. These behaviours are illustrated in table 1.

< Insert Table 1 here >

A particular feature of the steering group meetings was a set of behaviours relating to funding. It was in this set of behaviours that the various members' expectations and contributions surfaced. Behaviours relating to project funding that were identified were: raising funds, coded as RF, seeking funds, coded as SF, and providing funds, coded as PF. An additional significant behaviour was reference to other people outside the network organisation. This behaviour was coded as OP. Humour, coded as H, was also an indicative feature of the behaviour of the members. Every time the subject of the conversation changed to a new agenda item, an AI was placed next to the name of the member initiating the discussion on that topic. Agenda items (AI) alone were not considered to be behaviours and were not included in table 1.

Three meetings took place over a period of five months. On average five people attended these electronic steering group meetings from different parts of the world. An analysis of the transcripts was carried out using a tool constructed for the purpose of extracting the coded behaviours. There were 244

occurrences of the 15 different types of behaviours identified on the transcripts. In summary of the results illustrated in table 2, behaviours of information providing (IP), and information seeking (IS), were by far the most frequent and indicate that the content of most linkages relate to information sharing. The second most frequent behaviour was references to other people (OP). Behaviours of requesting action (RA) and confirming action (CA) were the third most frequent as were behaviours of statement of problem (SP). It is interesting to note that the difference between behaviours of statement of problem (SP) and statement of solution (SS) is a ratio of 5 to 1.

Properties of linkages

In order to describe the task system and the actors that comprise it, table 2 illustrates the way in which the above behaviours are distributed according to each actor and the number of times each type of behaviour is displayed by each of the four actors. In considering the most frequent behaviour, information providing (IP), it is clear that the chairman exhibited this the most followed by Actor B and Actor A. The chairman exhibited this behaviour seven times more than Actor C. It is interesting to consider these behaviours in relation to information seeking behaviours (IS). For the chairman and Actor A the ratio of IP to IS behaviours is 2 to 1 and for Actor C 1 to 1, whereas for Actor B this ratio is 4 to 1. This means that Actor B did not reciprocate his information exchange relations to the extent that the other actors did. In social network analysis, reciprocity of a linkage refers to the degree to which two people who are presumed to be linked report the same relationship [4]. In this analysis, reciprocity is used as a qualitative indication of the strength of multiple relations in which many actors are involved in the same relations. This means that knowledge created on the network is represented by the number and strength of reciprocal relations.

When considering the ratio of requesting action (RA) to confirming action (CA), the chairman exhibited a ratio of 2 to 1, Actor A a ratio of 1 to 2, Actor C a ratio of 1 to 1 but Actor B confirmed action on 4 occasions but requested on none. It is worth noting that Actor B exhibited only 6 different types of behaviours compared to 9 behaviours exhibited by Actor C, and 11 different types of behaviour exhibited by the chairman and Actor A respectively. This suggests that there is a difference in the type of knowledge created through the different relations that each actor was involved in on the electronic meetings.

< Insert Table 2 here >

It is clear from table 2, that resources were allocated by the chairman as he was involved in all of the behaviours for raising funds (RF) and providing funds (PF). These resources appear to be allocated to Actor A and Actor C who between them demonstrated all the behaviours for seeking funds (SF). This creation of knowledge with respect to funding and use of this knowledge to allocate funds took place in reciprocal relations between the chairman, actors A and C. Actor B was not involved in any of the funding behaviours. In addition, to allocation of funds, the chairman also stated the most problems (SP) and offered no solutions. This indicates that there was the need for further knowledge sharing and this was directed as responsibilities to the other three actors. It is interesting to note however, that only Actor A responded with two statements of solution (SS). Further evidence to suggest that the chairman had driven the meetings is provided by the behaviour seeking consensus (SC) of which the chairman was involved in 5 out of a total of 6 occurrences. This indicates that the chairman directed the knowledge creation process. Other people outside the network also affected the creation of knowledge on this electronic social space. The effect of the range of these external contacts on the electronic group meetings is apparent in the way in which behaviours for other people (OP) are distributed across the four actors. The chairman brought into the meetings the most external contacts which occurred 14 times compared to Actor A's 11, Actor B's 3 and Actor C's 1.

Prominence and Influential Relations

From an initial analysis of the transcripts, it was clear that there were two actors who were involved in many relations. This in terms of social network analysis, means that the relations were stratified [4],[20]. By considering network structure, in terms of centrality, influence and the creation of knowledge can be considered in terms of the number of direct contacts each actor has with other actors [4]. Centrality can be ascertained in terms of the number of times that they speak. Knowledge is also created through prestige relations which may be identified by considering actors who may be the source or object of relations [4]. One way of identifying prestige relations is by considering the number of times actors are spoken to compared to the number of times they speak. Table 3, illustrates the number of times each actor speaks compared to the number of times he is spoken to.

< Insert Table 3 here >

Table 3 suggests that with the exception of Actor C, all three actors spoke more than they were spoken to. This is not surprising, as they had to report on their respective activities, voice concerns and shape the direction of the network organisation. It is apparent from the table that the chairman and Actor A spoke much more than they were spoken to. In particular, the marked difference in the ratio between the number of times the chairman spoke compared to the number of times he was spoken to, is a ratio that when compared to the other actors, is very high. From a centrality perspective this supports an initial observation that the chairman was primarily directing relations between actors. In a sense he was the information gate-keeper as he managed interaction between the other actors and the creation of shared knowledge. Knowledge creation within centrality relations depends upon the effective communication of information and its subsequent use – in this case to distribute funds, mobilise resources and achieve collective action.

With respect to identifying prestige relations, the actor to whom the other actors spoke most was Actor B. While the chairman, who spoke the most, was spoken to the least. In effect, the prestige relations appear to be directed at Actor B and may be interpreted in two ways: either the other actors were seeking pertinent information from Actor B, and/or they were requesting him to perform certain activities. While this does not rule out the possibility that Actor B's role is similar to that of a 'help desk' where the number of requests for information often exceeds the number of responses, the researcher's observation suggests that the types of prestige relations demonstrated by Actor B appear to be different from those of either the chairman or Actor A. Unlike the control over funds and authority structures of other organisations exercised by the chairman and Actor A, Actor B's influence was by virtue of his expertise. Although Actor B did not talk as much as the central (who also bear a degree of prestige) actors, his influence was due to his technical expertise. It was because of the value of his tacit technical knowledge to the other actors that most relations were directed towards him. This suggests that the sharing of knowledge within prestige relations is inversely proportional to its value – the greater the value of a piece of information within a particular context, the less likely it is to be shared. The knowledge created within prestige relations depends upon the communication of context specific, salient information. This form of knowledge creation is crucial to the effective functioning of the network organisation.

Prominence may also be described in terms of range [4],[20]. External knowledge and resources were used for the creation of knowledge within the centrality and prestige relations described above. The number of status groups that the chairman, Actor A and Actor B had access to was relevant when

attempting to determine his social influence. Just as individuals are members of relational networks of people with whom they communicate often, they are also members of networks of organisational units who share similar attitudes and meanings according to Fulk et al. [11]. In the case, of the chairman, Actor A and Actor B it was membership of other networks of organisations that enabled them to share information and resources that would otherwise be beyond the grasp of the network organisation's steering group. The creation of knowledge took place through the use of information (and people) from outside the network organisation and could be made use of in the projects carried out within the organisation.

Electronic communication supported the network organisation well. It enabled knowledge to be shared with respect to resources, problems and events. Knowledge was created with respect to the mobilisation of resources and joint action, and solutions for problems. The use of external contacts within this creation of knowledge was a key feature of this network organisation. Electronic communication helped to minimise certain barriers to communication by creating an electronic social space with distinct environment within which focussed communication could occur. In principle, better communication enabled knowledge acquisition, sharing, distribution and management of knowledge. Being a characteristic of the Lockean organisation, these social networks were supported by electronic communication and managed effectively on the electronic social space. Only, it is yet to be seen to how knowledge may be managed in decision making environments that take place on the electronic social space. This issue is addressed in the following section.

5. Implications for Managing Knowledge where Decision Making takes place on Electronic Spaces

The above analysis suggests that the electronic meetings served as a means of enabling the development of shared mental models through the exchange of information. It is also apparent from the above that the basic structure of norms, work practises and allocation of funds and responsibilities takes effect during the meetings. In her study of the adoption of Lotus NotesTM in one office of Alpha Corporation, Orlikowski [26] found that there were at least two organisational elements, cognitive and structural, which influenced the adoption, understanding and early use of the technology. Cognitive elements are the mental models or frames of references that individuals have about the world, their organisation, work, and the technology and while these frames are normally held by individuals, many assumptions and values constituting the frames tend to be shared with others. For example, individual misgivings

with using groupware may become shared when experiences are communicated regularly and the training does not address common concerns.

The structural properties of organisations encompass the reward systems, policies, work practises and norms that shape and are shaped by the actions of individuals [26]. The interpretation or collective sensemaking enables the creation of knowledge [23]. Collective sense-making can be identified on the electronic social space. Considering the transcripts of the electronic meetings from this perspective, the behaviours were seen to fall into three distinct categories of interaction. These were: 1) technology related interactions in which the content of communication comprised of the electronic medium being used, 2) work related interactions consisting of communication on the task environment, projects and other agenda items, and 3) social interactions. These are illustrated in Table 4.

< Insert Table 4 here >

Technological adaptation

The way in which the participants learned to use and become comfortable with the technology was illustrated in the behaviours displayed and the type of prominence relations that emerged. When compared to face to face meetings among the steering group members, the electronic meetings exhibited more consensus. Of the agenda items discussed in the face to face and electronic meetings, action was confirmed a number of times on the electronic meetings but action was only proposed on the face to face meetings. This is perhaps due to the nature of the electronic meetings. As the participants typed their comments on the talker, they had visual images of the discussion which they could read a number of times before responding. The technology also demonstrated a potential for inhibiting the communication process. In particular, with a lack of turn yielding cues (which are available in face to face communications) participants were faced with a rather harsh environment on the electronic medium. This environment gradually became more conducive as the participants learnt how to use the technology by modifying their mental models (tacit knowledge) using the tools and commands that were available (explicit knowledge). This process of internalisation was accompanied by behaviour modification to accommodate the capabilities of the technology. For example, the members developed a protocol for communication whereby the participants typed a "/" at the end of their statements.

It was found that in the first stages of computer mediated communication, the group processes were directed at using the technology and more importantly how to get around the numerous difficulties that it presented. In subsequent stages of group development, the technology became a means for attaining a joint objective or a means of carrying out an activity. Knowledge was created through combination and more sophisticated tools for problem solving and decision making were required and had to be learnt and internalised. The whole group had to be able to use the technology appropriately for such meetings to be successful. Overall, this process of using the technology collectively may be referred to as technological adaptation. Support for technological adaptation should be provided through training aids which group members could use to appropriate [7] the technology in a way that suits their ways of interacting and working.

Work adaptation

The work process was shaped to a large extent by the content of the linkages or type of information exchanged. Processes of task structuring, resource allocation, and the coordination of geographically dispersed but interrelated activities were significant components of the work process. In this, the work process required support in terms of the content of interpersonal communication but also in terms of supporting the leadership function. Moderation of discussions was an important feature, and was necessary to enable the participants to focus their discussions. In view of this, prominent members required support in their roles as leaders and/or moderators. Centrally prominent members required speedy and efficient information exchange. Faulty connections, bad transmission and a rigid interface could make it difficult for such a member to perform their information providing role. In the case of the network organisation, there was ample support for centrality relations that required information exchange capabilities but not for prestige relations. Only one decision was actually made. Actor A sought more information than he provided and was the only actor to provide solutions. The difference in ratio between confirming action and requesting action suggest multiple feedback loops in which the chairman, Actor A and Actor C are most involved. Knowledge creation took place as actors reported to the group on their respective projects, through externalisation. This knowledge was then used in combination with other related explicit knowledge to moderate the discussion and calls for further action.

This process of adaptation to a work environment supported by computer mediated communication, may be referred to as work adaptation. Work adaptation implies that there is a process of attaining synergy

between behaviours of the participants and the ways of working that they are accustomed to. This means that in addition to knowledge creation through the processes of externalisation and combination, internalisation is also necessary for work adaptation to take place. While certain types of behaviour are enabled by the electronic medium of communication, the changing work process also influences behaviour. In this, knowledge creation modifies the way of working and the norms underlying the work practices. Supporting these processes of work adaptation requires a combination of information exchange tools and a means of storing information for access at a later stage.

Social adaptation

The electronic media enabled a social system to manifest itself. The identity of the group took shape in accordance with the social norms that emerged on the electronic social space as the knowledge was created through socialisation. The exchange of tacit knowledge on the electronic social space, in particular, the sets of rules and knowledge that the group members brought with them in their social encounters on the electronic medium can be seen in Giddens terms as, *combined human action* [12]. This, he claims, brings about patterns of interaction that then become established as standard practices. An example of standard practise on the electronic social space was that participants made it a point to tell the group when they logged off even though the system automatically made this known. In the steering group meetings, certain norms and procedures developed and changed the ways in which communication took place. This process, of using tacit, embedded knowledge of concepts and procedures in order to communicate is identified by Giddens [12] as being the process of *signification*. This tacit knowledge of concepts, procedures and norms of behaviour was in the process of being eternalised on the electronic social space. Signification was identifiable in that interaction was in its formative stages and mechanisms of communication were in the process of being acquired. In particular, communication etiquette, and norms of good behaviour on the electronic social space were still developing.

6. Decision Support Systems Functionalities: Towards a Communication Infrastructure

Two types of processes affecting knowledge management in network organisations have been identified thus far. In the first, the processes of knowledge creation, as defined by Nonaka and Takeuchi [24], have been uncovered through a social network analysis of distributed group meetings. This related to the individual processes of knowledge creation. The second of these processes related to the dynamic changing nature of the organisation itself: its collective sensemaking structures. These were identified

while analysing the coded transcripts and were termed technological, work and social adaptation. In order to support the creation and sharing of distributed personalised knowledge in situations where decision making takes place on electronic spaces, decision support systems should address both types of processes: the processes of individual knowledge creation and collective adaptation processes. The management of knowledge within electronic spaces requires the use of currently available DSS technologies within an informed understanding of the knowledge creation and adaptation context. Table 5, below provides the basic building blocks upon which a communication infrastructure for the management of personalised knowledge may be developed.

< Insert Table 5 here >

Table 5, illustrates some of the DSS functionalities that support management of distributed personalised knowledge and provides examples of DSS technologies that provide these functionalities. Before selecting a technology, the knowledge creation and adaptation processes of a particular distributed decision making environment have to be ascertained. Then the relevant adaptation procedures should be developed and implemented (see section 5). Table 5 provides a list of technologies that are appropriate for the identified knowledge creation and adaptation processes. Some DSS technologies can support several different types of knowledge creation and adaptation processes. For example, as illustrated in table 5, videoconferencing supports socialisation and social adaptation well. For work environments which do not require concrete outcomes, videoconferencing may also support externalisation and work adaptation. However, it is important to note that a technology used inappropriately will do more harm to the decision making environment than the good that it is intended to do. For example, video conferencing may not be appropriate to support a task intensive environment in which work and technological adaptation are the norm as it reduces the group's focus.

7. Summary and Conclusions

This paper has investigated a social network on an electronic social space within a network organisation. It began by coding and analysing behaviours using social network analysis to reveal knowledge creation on the electronic social space. The processes of individual knowledge creation were revealed as the content or properties of the of linkages surfaced through the analysis. The content of linkages referred to decision making behaviours relating to information exchange, exchange of resources (such as funding), problem solving, and taking action. The manner in which these decision making behaviours took place occurred

through 1) centrality relations in which effective communication and exchange of information was paramount to the assignment of tasks and resources; 2) prestige relations in which the salience of the information exchange was key to achieving collective action and determining the outcome of the meetings; and 3) range or the use of people outside the electronic social space. While the processes of individual knowledge creation enabled information and resources to be exchanged, the collective processes of sensemaking lead to the distribution of resources and mobilisation of collective action. Further analysis of the data illustrated that underlying this collective sensemaking were three processes of adaptation: technological, work and social. The processes of individual knowledge creation took place in conjunction with the collective sensemaking processes of adaptation.

The results of this research further suggest that the role of electronic communications technology in the creation and distribution of dispersed knowledge was central to knowledge management. The electronic media affected the way in which knowledge was created and was an important mechanism required to manage the knowledge. The electronic social space helped to remove cultural barriers amongst project participants and supported the network-based organisational structure. This is fundamental for the effective management of personalised knowledge. These findings led us to conceive a communication infrastructure to support the management of such distributed personalised knowledge. Managing knowledge in situations where decision making takes place on electronic social spaces, requires careful consideration of the processes of individual knowledge creation and collective adaptation. Because personalised knowledge is dynamic, the choice of technology is specific to the knowledge creation and adaptation processes that take place within a particular organisational context. The resulting communication infrastructure would thus have to reflect these contextual factors if it is to be appropriate. We thus mapped the knowledge creation and adaptation processes to DSS functionalities and technology support. This formed the basic building blocks upon which a communication infrastructure for the management of personalised knowledge may be developed.

Future research into effective knowledge management practises to support knowledge creation and adaptation in distributed work environments would be valuable. Especially since this can result in improved working environments, competitiveness, effective utilisation of software tools that support knowledge management and the development of new methods of work within organisations. In addition, organisations can harness the power of their human networks if they support the relevant knowledge creating behaviours with appropriate decision support technologies. Furthermore, organisations that

implement effective knowledge management strategies can increase their competitiveness in the global marketplace and contribute to the creation of a self-sustaining, wealth enhancing “knowledge economy”.

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Table 1: Behaviour Codes

Types of Behaviour	
IP	Information Providing
IS	Information Seeking
RA	Requesting Action
CA	Confirming Action
SC	Seeking Consensus
SP	Statement of Problem
SS	Statement of Solution
NE	Notifying occurrence of Event
MD	Making a Decision
VA	Volunteering Assistance
RF	Raising Funds
SF	Seeking Funds
PF	Providing Funds
OP	Other People
H	Humour

Table 2: Breakdown of Behaviour per Actor

Behaviour	Chairman	Actor A	Actor B	Actor C	Total per behaviour
IP	28	12	15	4	59
IS	14	18	4	4	40
RA	9	7		3	19
CA	6	13	4	3	26
RF	4				4
SF		2		1	3
PF	2				2
SP	12	5	3		20
SS		2			2
SC	5			1	6
MD	1				1
VA		1			1
OP	14	11	3	1	29
NE		1		1	2
H	2	4	1	1	8
Total per actor	97	76	30	19	224

Table 3: Prominence Indicators

	Chairman	Actor A	Actor B	Actor C	Total
Times spoken	224	128	76	21	449
Times spoken to	14	23	33	21	91
Ratio	17:1	6:1	3:1	1:1	2:1

Table 4: Behaviour by Category

	IP	IS	RA	CA	SP	SS	OP	RF	SF	PF	SC	NE	MD	VA	H
Technology	18	6	5		12	1					1	2			5
Work	37	29	15	23	6	4	17	2	1	2	4		1	1	2
Social	8	5		1	2		10	2	2		1				2
Total	63	40	20	24	20	5	27	4	3	2	6	2	1	1	9

Table 5: Knowledge Management for Distributed Decision Making

Knowledge Creation	Adaptation	DSS Functionalities and Technologies
Socialisation	Social	Brainstorming, generation of creative dialogue. Development of norms and communication etiquette. Telephone conferencing. Videoconferencing. Computerised bulletin boards. Idea generation systems.
Externalisation	Work	Collective reflection – model building. Distributed communication: information exchange and storage. Electronic mail. Electronic Data Interchange (EDI). Computer-based models. Multiple criteria decision making software products. Negotiation support systems.
Combination	Technological, Work	Database and groupware applications, distributed communication: information exchange and storage. Distributed problem solving tools. Workflow systems. Workgroup project management tools. Database management systems. Data mining and data warehousing tools
Internalisation	Technological	Graphics, video, voice. Protocols for distributed communication. Voice technologies.

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