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Organizations

DESIGNING INFORMATION TECHNOLOGY TO SUPPORT DISTRIBUTED COGNITION

CEO PUBLICATION
T 93-16 (236)

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November 1993

forthcoming
Organization Science

This work has been supported by National Science Foundation Grant #IRI-9015526 and Digital Equipment Corporation grant #1111.

The authors are equal contributors to this paper and gratefully acknowledge the helpful suggestions by Jim Meindl and two anonymous revieweres

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Abstract

Cognition in organizations is a distributed phenomenon, in which individual members of an organization reflect upon their experience, make plans, or take action. Organizational learning or organizational cognition are familiar terms, but it is only the individual persons in an organization who create interpretations and test understandings, as they think and learn in their organizational setting. Coordinated outcomes emerge in organizations when individuals think and act in ways that take others in the organization and their interdependencies into account.

We argue that much of the effort to design information technology to support cognition in organizations has not addressed its distributed quality. Such systems have tended to focus either on the individual as an isolated decision maker, or on the group as a producer of a decision or policy statement in common. In distributed cognition, by contrast, the group is a set of autonomous agents who act independently yet recognize that they have interdependencies. To guide the design of information technology, we propose that distributed cognition be viewed as a hermeneutic process of inquiry, emphasizing the importance of individual interpretation and group dialogue.

Hermeneutics provides a theory of the interpretive process through which an individual gives meaning to organizational experience. Inquiry systems provide a theory of how a community of inquirers build and test knowledge representations through dialogue. Together, hermeneutics and inquiry systems are used to propose a set of design principles to guide the development of information technology that supports distributed cognition. The design principles we describe in the paper are ownership, easy travel, multiplicity, indeterminacy, emergence and mixed forms.

Applications of information technology which embody these design principles would support distributed cognition by assisting individuals in making interpretations of their situation, reflecting on them, and engaging in dialogue about them with others. The objective is to refine their own understanding of the situation and better appreciate the understandings of others, enabling them to better take their interdependencies into account in their individual actions. A project to develop such a system is discussed, along with some implications for research.

Key words: Distributed cognition, hermeneutics, inquiring systems, organizational learning, cognitive maps.

Information technologies have been applied with considerable success to the core tasks of organizations, as evidenced by computer systems for on-line reservations, order entry or integrated manufacturing. But information technologies have been applied with less success in systems that go beyond these transaction processing tasks to support the cognition and decision making of managers (Feldman and March, 1981; Preston, 1991; Silver, 1991). This lack of success becomes most evident in turbulent environments (Emery and Trist, 1965) where the need for interpreting new situations and adjusting existing practices is increased (Nonaka, 1988; Hedberg, Nystrom and Starbuck, 1976).

We argue that the decision theoretic, choice-making image of managers that has traditionally guided the design of information technologies in organizations is in part to blame. It has portrayed managers as analyzers of data who solve problems that are presented to them and has encouraged the design of systems that provide them with decision models and a pipeline of data (Boland, 1979). We propose instead that a more active, sense-making image be used to guide the design of systems that support managers as interpreters and enactors of a stream of events in their organization (Weick, 1979). Recently, developments in formatted electronic mail systems such as coordinator (Flores, Graves, Hartfield and Winograd, 1988) or information lens (Malone, Grant, Lai, Rao and Rosenblitt, 1989) and groupware such as Amsterdam Conversation Environment (Dykstra and Carasik, 1991) and Post Mechanistic Groupware (Johnson-Lenz and Johnson-Lenz, 1991) suggest such alternatives are beginning to emerge. In this paper we propose that viewing cognition in organizations as a hermeneutic process of inquiry provides a theoretical basis for designing systems that support interpretation and sense making.

Organizational cognition is a distributed cognition. As Simon (1991) reminds us, organizations do not think or learn, people do. He portrays cognition in an organization as a set of individuals exchanging information among themselves within a system of roles, or prescribed decision premises.

"Roles tell organization members how to reason about the problems and decisions that face them: where to look for appropriate and legitimate information premises and goal (evaluative) premises, and what techniques to use in processing these premises."

(Simon, 1991, pp 126-127).

Simon correctly warns against our habit of reifying organizations as when we speak of them "thinking" or "learning." But he himself appears to reify the concept of role as he speaks of a role "telling" people how to select and use decision premises. We will try to avoid this anthropomorphic usage that is so common when speaking of learning, memory and related phenomena in an organizational setting (Walsh and Ungson, 1991) by focusing our attention on distributed cognition.

Distributed cognition is the process whereby individuals who act autonomously within a decision domain make interpretations of their situation and exchange them with others with whom they have interdependencies so that each may act with an understanding of their own situation and that of others. To use Simon's role image, it is the process whereby individuals construct and reconstruct a system of roles through self reflection, dialogue and action.

When distributed cognition works well, the managers' individual actions take each other and their interdependencies into account in a way that yields a coordinated outcome. Dougherty (1992), for example, found that successful product innovators were distinguished from unsuccessful ones in that they created collaborative mechanisms that encouraged appreciation of each other's perspectives and their mutual interdependencies. Taking each other into account requires a process of surfacing and examing individual understandings. Weick (1990) has argued that in this process, managers should attempt to portray and reexamine rich displays of their thinking in order to complicate the familiar and make new interpretations possible. We propose that information technology can support distributed cognition by enabling individuals to make rich representations of their understanding, reflect upon those representations, engage in dialogue about them with

others, and use them to inform action (see Figure 1).

-----Insert Figure 1 about here -----

Organizational participants do not do particularly well at actively and openly reflecting upon their understanding of a situation or the theories-in-use in their practices (Argyris, 1982; Schon, 1983; Argyris & Schon, 1978). Weick (1990) suggests that because of this, managers have a tendency to operate on increasingly impoverished views of the world. In a similar vein, scholars concerned with organizational design (Clark, 1975; Kilman, Pondy and Slevin, 1976) have noted that organizations seldom have mechanisms for generating new structures that help to complicate the thinking of members. Complicating the thinking of managers is sometimes necessary to change interpretations and understandings that are no longer appropriate (Bartunek, Gordon and Weathersby, 1983; Starbuck and Hedberg, 1977).

In a series of influential papers, Starbuck and colleagues (Starbuck and Milliken, 1988; Nystrom and Starbuck, 1984; Starbuck, 1983; Starbuck and Hedberg, 1977) posit that a major contributory cause for organizational decline and failure is the oversimplified belief structures and stereotypes organizational actors use in dealing with the environment. Others such as Janis (1989) have traced major governmental policy fiascoes to the simple decision rules relied upon by the policymakers involved. A visible and accepted difference in 'mind sets' (Janis, 1989) allows members to be skeptical about each others' key presumptions, particularly those affecting the way the problem is formulated, the types of alternatives that are excluded at the onset, and the way cogent information about positive and negative consequences is interpreted. Likewise, Eisenhardt's (1989) case study findings suggest that faster and higher quality decision making occurs in teams that use more, not less information, and consider more, not fewer alternatives. Investing in multiple problem solving strategies and debating competing hypothesis (Eisenhardt, 1989) obviates

the possibility of oversimplification and premature decision closure (Imai et.al, 1985).

Complicating the thinking of managers is not an end in itself. Managers may find that a new, much simpler way of understanding their situation proves more effective in diagnosing and responding to events. But such a new, simpler understanding seldom comes from merely eliminating features from an existing interpretation. It comes instead from disturbing a familiar interpretive structure and adopting a perhaps simpler model but at a different level of understanding (Vygotsky, 1962) or integration (Streufert and Swezey, 1986; Schroeder, Driver and Streufert, 1967).

In spite of the increasing attention being paid to more flexible organizational forms capable of dealing with unexpected and turbulent future environments (Huber, 1984; Malone, Yates, and Benjamin, 1987; Drucker, 1988; Nolan, Pollack, and Ware, 1988; Schein, 1989), not much attention has been directed to information systems that are intended to support the examination and possible change of underlying assumptions and understandings (Orlikowski and Gash, 1991). The possibility of significant change in understandings requires the capacity for organization members to regularly reflect on existing assumptions, processes, and structures (Bartunek and Moch, 1987). It requires a self-diagnostic capacity for organization members to become aware of the perspectives from which they are operating, and "the capacity to change one's point of view, and therefore to explore one's situation through a different light" (Smith, 1984, p. 290). Bartunek, Gordon and Weathersby (1983) submit that establishing mechanisms that enable members to engage different perspectives is one way to induce such change. Making representations of various perspectives enables organization members to recognize the different ways in which they understand a specific problem and to develop a working appreciation for other available alternatives (Bartunek and Moch, 1987).

Efforts to create more open, self-reflective processes in organizations may however, encounter several kinds of difficulty. Political efforts to gain power and dominance may lead to the suppression or distortion of communication in organizations in

order to manipulate or confuse colleagues (Eisenberg and Phillips, 1991). Information technologies intended to enhance performance may in fact lead to a passive, unreflective use by those adopting them (Orlikowski, 1991) and the actual effect of information technologies intended to enhance group performance will be mediated by the ways in which they are appropriated by the group using it (Poole and DeSanctis, 1990). We will discuss some of these organizational issues with the use of information technologies later in the paper, but for now we will assume a situation in which organization leaders and members are open to and supportive of attempts to create less bureaucratic, hierarchical mechanisms and more network, market like arrangements for coordinating their actions through mutual adjustment (Huber, 1984; 1990, Malone, Yates and Benjamin, 1987).

We will first review the traditional approach to designing management information systems and contrast it with the requirements of distributed cognition. We will then develop a set of design principles for systems that would support distributed cognition as a hermeneutic process of inquiry. Finally, we will describe an action research project that attempts to embody these design principles in an organizational system.

Distributed Cognition as Hermeneutic Inquiry
Images that have Traditionally Guided Information System Design

Theory and research on information systems design has traditionally followed a model-based approach, viewing decision making as choice making, both at the individual and the organizational level (March, 1978). Ackoff (1967) is a clear and frequently cited advocate of this framework, but the foundational work of Anthony (1965), Simon (1977), and Feltham and Demski (1970) is equally important. In its simplest form, the model-based approach represents how the organization works in input-output terms. The objective is to solve the model and define the conditions necessary for optimum (or satisfactory) performance. The information required by the model is, or should be, the information required by the decision maker. Information system design is then the process

of building a pipeline that will deposit the required data at the proper time to the appropriate decision maker. Advances in information technology enabling managers to interrogate a wide range of data, both internal and external to the firm, and explore a large repertoire of analytic models are the latest, high tech version of this same basic image of information technology support. Weick and Meader (1991) criticize the research on Group Support Systems for a similar emphasis on answers and decisions at the expense of questions and interpretations. Huber's (1990) extensive review of computer-aided and decision-aiding technologies does not identify any applications or design variables outside this framework.

We hold that the presumption of an obdurate, "simply given" world where information analysts can rely on a technical language to provide a valid statement of a manager's information requirements (Demski, 1980; Davis and Olson, 1985) denies that individuals are importantly sense makers (Weick, 1979) who use information in action, searching for meaning and understanding of their organizational context (Boland, 1979).

On the contrary, this objectification of information fosters an image of the world in which the human meaning of social organization and action are framed as unproblematic, predefined and pre-packaged. It presupposes a one-for-one mapping between words in an information system and objects or conditions in the world, and overlooks the fact that words are symbols whose meanings are always multiple and ambiguous (Lyytinen, 1985, 1987; Stamper, 1987). The information system is an unfamiliar text that is read, interpreted and made meaningful by those who use it in ways that will always surpass any clear picture the system's creators had in mind (Boland, 1991). Sense making is importantly an active process of making an organization and a self. In making their interpretation, the readers bring the world into being differently, and bring themselves into being differently as well (Rorty, 1982). The passive, choice maker pictured by model-based approaches to information system design fails to appreciate the truly dynamic quality of organizational life.

From an action and sense making perspective, the task of information systems is to support human inquiry as a process of subjective, interpretive, meaning making. This is a hermeneutic process of inquiry. The need is for facilities of self indication, reflection and interpretation by organizational participants (Blumer, 1969): an environment for making sense of their situation as opposed to a pipeline of data. This is a call for a movement beyond "procedural rationality" (Simon, 1978) to information systems that support reflexive dialogue. The designers of distributed cognition systems would try to use information technologies to create an environment for acting out interpretations in conversation with others. As an environment for active sense making, the information in a distributed cognition system would not be the data structures or decision models made by an analyst, but would be representations made by individuals of their changing understandings of the organization and its environment. The issues considered by such an active approach to information system design would then be: how can individuals represent an understanding of the world, how can individuals reflect upon and exchange these interpretations with others, and how can individuals grow in their understanding of the world?

Our thesis is that a distributed cognition system that improves a group's ability to represent their interpretations, to reflect upon them, to engage in dialogue about them and to inform action with them will provide the conditions for surfacing and challenging important assumptions (Argyris, 1982; Schon, 1983), for complicating their thinking (Weick, 1990) and for enabling significant change when it is required (Bartunek and Moch, 1987; Orlikowski and Gash, 1991).

Designing for Distributed Cognition

Relatively little work has been done on distributed cognition, especially as it relates to how new problem representations are developed and exchanged in organizational dialogue (Simon, 1991; Cheng, Holsapple and Whinston, 1992). Simon

suggests in this regard that our research should attend to:

...the contents of important organizational memories, the ways in which those contents are accessed (or ignored) in the decision making process, and the ways they are acquired by organizations and transmitted from one part of an organization to another. Among the contents of organizational memories, perhaps the most important are the representation of the organization itself and its goals...(Simon, 1991, p.133).

We agree with the general thrust of these remarks, but as suggested above, we will argue for an approach that emphasizes enhancing an individual's ability to make these kinds of representations, explore them in dialogue with others, reflect about their implications and incorporate them in action. Walsh and Ungson (1991) provide an extensive review of issues surrounding organizational memory, but they pay little attention to the dynamic process of dialogue among individuals as they create, draw upon, and exchange memory structures through distributed cognition.

A distributed cognition system supports interpretation and dialogue among a set of inquirers by providing richer forms of self reflection and communication. We do not mean richer as discussed by Daft and Lengel (1984), because they take richness to be a media characteristic. For example, face-to-face communication is richer than a written memo because of the non-verbal gestures that are available. Instead of media richness, we are concerned with communication richness. We seek to increase richness of communication with self and other by increasing the ability to represent and travel among layers of context, regardless of media. A system to support distributed cognition as a hermeneutic process of inquiry should enable actors to better identify, discuss and elaborate upon their understanding of context. Context, as a layering of assumptions and preferences that stand behind our views, is what makes meaning and communication possible (Levinson, 1983; Givon, 1989).

Our way of identifying better distributed cognition is similar in some respects to the work of Huber on organizational learning when he argues that organizational learning is

increased "when more and varied interpretations are developed," and "when more organizational units develop uniform comprehensions of the various interpretations." (Huber, 1991, p.90). We doubt that individual managers who actively interpret and make sense of their situation ever develop uniform comprehensions with other managers, but we recognize their felt need to communicate their understandings as effectively as possible. The environment used as interpretive context by an individual is not a presented one, that can be uniformly shared among sense-makers, but is a personally constructed, symbolic and malleable one (Giddens, 1979; Weick, 1991; Boland, forthcoming). A system to support distributed cognition, should enable a person to easily represent context in the process of constructing interpretations, and to exchange those representations in dialogue with others.

The theoretical views we will be drawing upon to describe our understanding of distributed cognition are hermeneutics and inquiring systems. Using these two as a basis, we will propose design criteria to guide the development of information technology to support distributed cognition. Together, hermeneutics and inquiring systems provide a framework for thinking about the organization task and environment as both multi variant and multi vocal, and for emphasizing an action-based and dialogical approach to supporting distributed cognition.

Hermeneutics

Hermeneutics is the study of interpretation. It originally referred to the problem of interpreting ancient religious texts. Because the writer, the language, and the culture behind these texts is quite obviously alien and unfamiliar to us, it is easy to see the need for interpretation. But today, hermeneutics is seen as a universal interpretive problem each of us faces every day in achieving human understanding in our social and organizational lives (Taylor, 1971; Gadamer, 1975, 1976, 1981). Our interpretation of the world is an historic act, grounded in our traditions. Gadamer calls the traditions we draw upon in interpreting

the world our prejudices and celebrates prejudice as a positive, not a negative element in our ability to understand the world.

"It is not so much our judgments as our prejudices that constitute our being" (Gadamer, 1976, p.9).

Our prejudice cannot disappear, nor should we want it to. Our prejudice is the way we are "open to" the world and the search for meaning through interpretation is a dialogue in which we push to the horizon of our tradition and attempt to open ourselves to the horizon of others in active reciprocity. Understanding of the world is not an end point that we reach when our prejudice is stripped away, but is rather a moving dialectic process of dialogue that always takes place anew at the horizon of our prejudice. As new understandings emerge, new questions arise. Our horizon may change, but the process of interpretation continues. There is no fixed or final interpretation of a text or a situation to be "got right." The attitude of play is important for hermeneutics (Gadamer, 1975). It is an attitude of engagement, yet openness: an appreciation for self renewal and learning through interpretation (Starbuck and Webster, 1991) and an enjoyment in playing the game again and again.

The process through which we come to an understanding of the world is an interplay of our tradition and the world-as-a-text, an interplay known as the hermeneutic circle. The hermeneutic circle is the recognition that in understanding a text, we depend on a comprehension (or anticipation) of the whole in order to identify and understand the parts, and, at the same time, we depend on a knowledge of the parts to guarantee our comprehension of the whole. We know the details we attend to in light of a theory, but we hold the theory as valid because of our knowledge of the details we attend to. Gadamer is careful to point out that the hermeneutic circle is not something that disappears once a situation is "perfectly" understood. It is not simply a method, but is the essential underlying

structure of understanding.

Thus the circle of understanding is not a 'methodological circle,' but describes an ontological structural element in understanding (Gadamer, 1975, p.261).

Tacking back and forth between theory and details, comprehensions and particulars, is a phenomenological description of how we create and sustain understanding. Tacking back and forth, setting layer upon layer of reciprocally validating relation between the overall grasp and the immediate instance is the play dynamic in hermeneutics that characterizes management cognition (Pondy, 1983). It is not just a technique for gaining an understanding, but is constitutive of our understanding.

Hermeneutics emphasizes that we should stop searching for objective, ultimate foundations to our knowledge of the social world and accept that humankind both makes and knows itself and its world through social practice. Accepting the hermeneutic, conversational quality of social practice helps us to see "man as a self changing being, capable of remaking himself by remaking his speech." (Rorty, 1985, p.104).

Hermeneutic Implications for Supporting Distributed Cognition

Hermeneutics provides a starting point for understanding some structural features of distributed cognition and a starting point for saying in general terms what kind of activity we are trying to support. First, our focus should not be on the individual as a decision maker, as in most attempts to design decision support systems (Keen and Scott Morton 1978; Silver, 1991) but on the individual as a conversation maker. Decision support systems have traditionally focused on the individual decision maker as she interacts with decision models and data bases. Here we wish to focus on the individual's interpretive conversation with self and others.

The traditional image of the lonely decision maker has recently been supplemented by attempts to support decision making groups (DeSanctis and Gallupe, 1987), but that work has primarily been oriented toward aiding the process of group meetings, and

includes features to help the group conduct brainstorming, create ranked lists of priorities, or allocate resources among competing projects. It is a discrete group decision that is being supported, not the continuous individual sense making of distributed cognition (Weick and Meader, 1991). A hermeneutic perspective directs our attention to the ongoing, day to day sense making dialogue among organization members. To date, this aspect of organization life is only minimally supported by information technology through free form electronic mail (Sproull and Kiesler, 1986; Eveland and Bikson, 1987) or through systems to keep track of promises and commitments among group members (Winograd and Flores, 1986). Only recently has there been a first attempt at designing information technology to support the interweaving of individual and group decision making processes (Sengupta and Te'eni, forthcoming). Early work suggestive of the kind of system we are proposing (Bush, 1945) has largely been ignored.

From a hermeneutic perspective, a system to support distributed cognition should recognize the tradition bound nature of individual understanding. The system should not try to remove bias, but should have facilities that help people push to the horizon of their understanding by making their assumptions visible. The standard of success for such a system should not be achieving the most accurate and true picture of a situation, as in a model building approach to knowing the organization, but in achieving an understanding that is useful to the individual in making interpretations and taking action. The point is not to simulate a world, but to bring a world and a self into being differently through reflexivity and a dialogue of self discovery. Traditional decision support systems are built to operate a decision model, with facilities for changing the model as the need arises. For a hermeneutic support system, in contrast, the interest is to allow for easy ways to configure and dynamically reconfigure understandings of a situation, in dialogue with others.

To support the hermeneutic circle, the system should allow for several levels of representation (from most global comprehension to most minute detail) to be at work

simultaneously. The premises and assumptions of a user should be easily added layer upon layer as a dialogue of discovery proceeds, and the user should be able to move freely back and forth among these layers of context.

A hermeneutic support system for distributed cognition should not have a termination, as a meeting support system does. In a hermeneutic system, action and decision interrupts the discourse but it does not close the conversation. The conversation supported by such a system should be open as to its starting point and data inputs, and should have no set termination, except as the participants themselves change the conversation.

Finally, such a system must be truly dialogical. All participants should be equally enabled to make independent representations. It is when the separate horizons of those in dialogue are opened to each other that a hermeneutic understanding can develop. A hermeneutic support system does not try to support a "group mind" and sees "shared understanding" as an especially elusive condition to achieve. In distributed cognition, it is recognized that only the individual participants have understandings of a situation. A hermeneutic system should help them to represent and exchange their individual understandings in as rich and flexible a way as possible, but it does not intend to provide a shared understanding, as many shared editor systems would.

Shared editor systems, such as Cognoter (Tatar, Foster and Bobrow, 1991) or ShrEdit (Olson and Olson, 1991) allow for flexible participation by many individuals in creating a single representation, and this type of group process is important to support. But because they are a shared writing space in which a single document is produced in common, the individual is not supported in representing, pushing to the horizon of, and exchanging their own complex understanding of the situation with others. Instead, each is supported in making modifications to an evolving, group representation. The same is true of the SODA cognitive mapping tool as described by Eden (1988). This type of group work, based on an image of a group mind being represented, is quite distinct from the

needs of distributed cognition.

Inquiring Systems

Hermeneutics provides us with a description of the process of interpretation and with guidelines for some features of distributed cognition systems that would tend to support that process. But our discussion of hermeneutics leaves open the epistemological question of how we judge the validity and limits of our interpretations (Mitroff and Pondy, 1974). For this we look to Churchman's (1971) review of foundational concepts of epistemology as they apply to designing an inquiring system. Inquiry is the act of producing knowledge, not as a mere collection of facts, but as a potential for acting purposively: seeking goals in light of an understanding of a situation, with the ability to adjust behavior as circumstances change. Churchman determines how to design an inquiring system by reviewing the ideas of Locke, Liebniz, Kant, Hegel and Singer, among others, as if they were answering that question. We will first review the way he progressively builds the requirements for an inquiring system by playing these writers one against the other. We will then summarize the implications for designing an information system to support distributed cognition.

Churchman begins with Liebniz, and reads him as saying that an inquiring system should be able to produce fact nets that represent contingent truths. The Liebnizian inquirer is always testing new statements for internal consistency within an existing fact net but the source of new statements that feed the growing fact net is internal and innate to the inquiring system (Churchman, 1971, p.95).

In contrast, Churchman argues, the Lockean inquirer denies the existence of innate ideas, and insists that all factors or entities of interest to an inquirer must be received as an input to the system. Thus, the Lockean inquirer identifies as a significant problem the question of how factors are labeled and what those labels mean. Churchman argues that the Lockean inquirer solves this labeling and meaning problem by recognizing the importance

of a community of inquirers and the role of consensus within the community in guaranteeing its knowledge.

Churchman then uses Kant to argue that any Lockean inquirer capable of receiving and classifying input presupposes a formal, internal structure for doing so. In a sense, what order we find in the world we have placed there ourselves. Churchman interprets the Kantian inquirer as one that moves beyond consensus to involve a dialogue among inquirers who view the same situation with several different sets of presuppositions.

A Hegelian inquirer is then introduced to dramatize and radicalize the multi-perspective Kantian inquiring system. The Hegelian inquiring system recognizes no data as meaningful except as it is seen through the inquirer's unique Weltanschauung, which in addition to Kantian perceptual primatives includes an individual's values, beliefs and emotional commitments. Also, inquiry proceeds not through the convergence of multiple perspectives, but through the dialectic confrontation of thesis and anti thesis in strong debate.

Churchman, however, does not accept Hegel's optimistic view that a synthesis with better understanding inevitably results from a dialectic process. Churchman uses Singer, his own mentor, to problematize Hegel's uni-directional image. A Singerian inquiring system emphasizes that the direction and style of inquiry change frequently and dramatically. Convergence of measurements and opinions that might signal progress to the Liebnizian, Lockean or Kantian inquirers are a signal to the Singerian inquirer that the interpretive scheme giving rise to the consensus must be somehow challenged or disturbed. Finding an answer to the current question becomes less important than finding a better question. A principle technique Singer suggests for doing so is to "sweep in" concepts and elements from outside the currently accepted ways of understanding a situation.

As in a hermeneutic circle, Singer proposes a kind of tacking back and forth from images that simplify the view of a situation to ones that complicate; from greater scrutiny of details, instrumentation and measurements to a rethinking of basic categories, concepts and

theories. Churchman characterizes this endless process as a type of heroic journey, and enriches the image of inquiry by "sweeping in" considerations of love, ethics, culture and religion. Thus, an individual's desires, preferences, moral norms and aesthetic judgment are as important to "sweep into" the inquiring system as are assumptions about key economic indicators or competitor activities.

Inquiring System Implications for Designing Distributed Cognition Support

This sketch of inquiring systems gives us insights into a slightly more detailed set of requirements for supporting distributed cognition than the general overview provided by hermeneutics. First, the Liebnizian inquiring system points out the need for individuals to construct networks of contingent truths. We will take this to mean constructing displays of the relations among a set of factors or entities including causal relations, along with the normally unstated assumptions and presuppositions that support an individual's belief in these contingent truths. This gives us a clearer image of the hermeneutic requirement to allow for building up layers of context and moving back and forth between layers of assumptions.

Commercially available systems, such as Teamfocus from IBM, Hypercard from Macintosh or Lotus Notes, allow for the design of applications that manage the construction of such networks and the movement within them. We see great potential for using these and other similar software environments for realizing the possibilities of hermeneutic inquiry in a wide variety of ways. But what design requirements does an inquiring system perspective add to this basic image of contingently linked elements in a "fact net".

The idea of a Lockean inquiry system adds the requirement that there should be an identifiable community of inquirers, or a recognized group in distributed cognition, for whom the evolving image of contingent truths is significant. This community of inquirers are engaged in a process of structuration (Giddens, 1979) in which they instantiate in action the organization that they are trying to understand.

The Kantian inquiring system highlights the need for multiple ways to depict understandings of the organization, based on different underlying approaches to representing, or imposing order upon, a situation. We will take this requirement to mean that spatial, visual and graphic modes of representation (Meyer, 1991) should be supported equally to numerical, procedural and analytic modes of representation. The effort to develop spreadsheets and word processing tools should be balanced with equivalent efforts to develop tools for representing understandings with pictorial, spatial formats such as cognitive maps (Huff, 1990).

The Hegelian inquiring system highlights the importance of openness to strong disagreement among the inquirers, going so far as to invite "deadly enemy" confrontations. This requires that members of the community be able to make representations of the organizational situation with complete control over the premises, assumptions and context used to portray their version of what the situation is and what its implications are.

Finally, the Singerian inquiring system gives us a more refined understanding of how the hermeneutic circle might be realized in a system to support distributed cognition. First and foremost, is the importance of being able to "sweep in" the widest range of context. Inquirers should be able to represent not only traditional economic, environmental and strategic data and assumptions, but also less traditional types of data, such as subjective preferences, ethical positions and aesthetic judgments.

In keeping with a hermeneutic sensibility, we take the Singerian inquiring system to emphasize that each representation made by an inquirer is partial and inherently incomplete. The situation is never understood by an inquirer from a total, world-encompassing view, but, in a series of partial and limited ways, the inquirer is trying to sweep in new ways of seeing the situation including different levels of abstraction, different breadths of view, and different contexts of concern.

The Singerian inquiring system also enriches our understanding of the hermeneutic circle by emphasizing that it is not just a movement back and forth through layers of context

between theory and detail, but is also importantly a process of alternately simplifying and complicating. When the Singerian inquirer is satisfied with the level of theoretic generality being used, its focus is on refining the precision of measurements, the distinctions among entities and factors, and the elaboration of causal interdependencies. However, when refining of detail has been pushed to new limits, the Singerian inquirer increasingly focuses on creating new groupings of entities and measures, looking for more general patterns of relationships and a greater simplicity of theoretical frameworks. Thus, a support system for distributed cognition designed as an inquiring system, should have facilities for elaborating new levels of detail by taking any existing element or factor and "exploding" it into more refined descriptors and measures and also for collapsing several existing factors and interrelations into a new, more abstract and general constructs.

Most importantly, an inquiring system to support distributed cognition must facilitate a dialogue among the organization's community of inquirers. Each individual should have the capacity to create and modify their own representations. They should be able to exchange representations with others in the community, sending and receiving reactions, challenges and comments about each others' representations. A method to manage these representations and the messages exchanged about them is important in making such a system truly conversational and useful in inquiry.

Designing Systems for Distributed Cognition

Overview

A hermeneutic process of inquiry involves actors who make interpretations of their situation and reflect upon their action and their interpretations in order to push to the horizons of their understanding. They open themselves to their horizon of understanding and to those of others through an ongoing process of surfacing and discussing the multiple levels of assumptions and preferences that are the tradition within which they make their interpretations. Actors, interpretations and action are the core elements of a distributed

cognition system. Interpretations, in turn, are composed of multiple levels of assumptions and preferences.

In order to create a physical system with these elements that has a quality of hermeneutic inquiry, six design principles are proposed. These design principles are intended to guide the application of information technologies so that they support the creation and exchange of the rich forms of representation that are central to distributed cognition systems as depicted in figure 1. Individuals should have ownership of an interpretation so that their horizon of context may be opened to that of other actors in dialogue. This requires a multiplicity of interpretations, at least one per individual. The hermeneutic circle requires easy travel between theory and detail, foreground and background assumption. This easy travel for tacking back and forth between developing greater precision of measures and rethinking of the concepts being measured is also required for a Singerian inquiry component. As in a Singerian system, the representations will be partial, tentative and have a quality of indeterminacy. Because of the dynamic, evolving quality of the hermeneutic circle and Singerian inquiry, the system should support the emergence of new categories, constructs, and levels of abstraction. Finally, to allow for a hermeneutic openness to new modes of representation and a Kantian recognition of more than one valid way of structuring an interpretation, a distributed cognition system should support mixed forms of representation.

The design principles do not define any specific technology or feature, but are rather an expression of the ideals to be achieved by the selection of specific technologies and the development of particular features in distributed cognition systems. We discuss the implications and the basis for each element and design principle below, and in the next section describe one attempt to realize them in an actual system.

Elements of Distributed Cognition Systems

The three elements of a distributed cognition system are described below. Their

interactions constitute a process of hermeneutic inquiry.

Actors: The system is oriented toward an individual person, and not toward a group or a role because only individual persons have hermeneutic understanding and meaning to represent. It is the individual in dialogue with others that is the locus of inquiring systems.

Interpretations: The system is oriented toward an actor's interpretation of their situation taken as an integral, whole unit of understanding; not toward a data base of facts or decision models. An actor's interpretation includes an understanding of the factors at work in a situation and their relationships. Relationships among factors may often, but not always, be understood as causal influences, and we will be using cognitive maps extensively to represent this kind of understanding (Axelrod, 1976; Bougon, Weick, and Binkhorst, 1977; Stagner, 1977; Weick and Bougon, 1986; Eden, Jones and Sims 1979; Eden, 1988; Schwartz, 1992, Eden, 1992). Although an individual may incorporate a simulation or analytic model as part of an interpretation, such models are not the primary focus of a distributed cognition system. It is the interpretation and its levels of context that is the primary focus.

Hermeneutic inquiry involves surfacing the assumption for each aspect of an interpretation. The context or background assumption is part of the tradition of prejudgments through which we make an interpretation, and of the horizon of our own understanding in a hermeneutic sense. No data is meaningful to a Kantian or Hegelian inquiring system except as seen through an image of the world that must itself be questioned as a basis for Singerian learning.

Hermeneutic inquiry is a process of continuously elaborating levels of text and context, foreground and background, statement and assumptions. Any part of an interpretation that is in focal awareness is attended to from a set of background assumptions and preferences, or tacit understandings (Polanyi, 1967). When focal awareness shifts to one of those assumptions or preferences, another set of background

assumptions and preferences are drawn upon in understanding it. These multiple levels of context are the essential basis for a hermeneutic circle. Moving through levels of context brings the actor closer to her horizon of understanding and being able to discuss that horizon with others. Multiple levels of context are also required for a Singerian inquiry system to alternate between a successive refinement of details and a reexamination of basic questions being asked.

A Singerian inquiry system tries to "sweep in" as preferences the non-rational, non-causal, more emotive aspects of an individual's understanding. The horizon of a person's hermeneutic understanding includes not only presumptions of the way the world is, but also desires, hopes, and fears for the way it may be.

Action: The system is oriented toward the actions which punctuate the ongoing process of distributed cognition. Action taken by actors who have interdependencies defines the set of managers that will participate in a distributed cognition system, and defines the domain they will make interpretations of. From both a hermeneutic and inquiring systems perspective, it is action that lends a cyclical character to the individuals' interpretations, providing an opportunity for them to review, modify and further exchange the multiple levels of assumptions and preferences in their interpretations.

Design Principles for Distributed Cognition

The six principles of design for a hermeneutic inquiry system are described below. We do not claim to be the originator for all these principles. Each individually has been mentioned or used in some proposed or real system in the past. Our contribution here is twofold. We derive these principles from theory in the context of distributed cognition, and, in the next section, we show how these principles can be applied comprehensively in one application.

Ownership: An interpretation is always owned by an actor who is responsible for creating and maintaining it. This includes the responsibility of sharing any part of the

representation with others through a mail system at the owner's discretion. Similarly, when those others respond with ideas, critiques or alternatives, it is up to the owner to decide if they will be incorporated in her understanding of the situation. From a hermeneutic perspective, an interpretation must belong to an individual if it is to give access to her context of tradition and horizon of understanding. As an inquiring system, the dialog or dialectic among different underlying images of the world requires an owner who truly believes in them.

Let us introduce an example that will demonstrate this and future design principles. Say an organization has two major actors, one in Engineering and one in Production. Each actor has to make decisions about volume planning of specific products. Looking, top down, at the left portion of Figure 2, we see Engineering's preference for building novel technology, which applies to the factor 'functionality' in Engineering's interpretation of the problem situation. An example of an assumption (a lower level of context) is the anticipated trend for purchases of home computers. The action that follows from this combination of interpretation and context is a forecast of the types and quantity of products to be developed. Note that some assumptions may be adopted from other owners without transfer of ownership. For example, the assumption that consumer confidence lags behind GNP, is owned and will continue to be maintained by the organization's economist, but it is an open reference for others to use. (In Figure 2, this is denoted by multiple copies of the box denoting Economic Assumption.)

-----Insert figure 2 about here-----

Easy travel: An individual's interpretation should display a hypertext like structure in which any element can be linked to any other, and the links can be followed quickly and easily. Easy travel between text and context, is required by the hermeneutic circle and the Singerian inquirer. There are two types of travel: one is within an

interpretation across levels of reference and the other is across interpretations. Looking back at the left hand side of Figure 2, we notice directed relationships between Engineering's preference, cognitive maps, assumptions, and actions. Directionality is all important. For example, the arrow from a factor within the cognitive map to an assumption means that the assumption explains the factor. Similarly, a preference evaluates factors pointing at it. The directed paths between entities within a representation constitute layers of context. Ease of travel is the quality of a system which most directly supports the hermeneutic circle, allowing actors to tack back and forth from overviews to underlying assumptions, from theories to details (Te'eni, 1992).

The Hypertext model (Conklin, 1987) demonstrates well what we mean by easy travel through associations. It also shows some of its potential problems. For example, as the collection of representations grows, it becomes increasingly difficult to navigate through the collection and appropriate help is needed. (This is a price one will need to pay for richer communication.) The second type of travel is across interpretations. Users may wish to travel along time paths or along content paths across different contexts.

Multiplicity: Each actor involved in distributed cognition should make her own interpretation and be able to participate in the exchange and critique of representations. The possibility of a hermeneutic fusion of horizons presupposes each actor has her own understanding and horizon. Actors can also maintain multiple interpretations of the same situation. This may be the result of uncertainty, ambiguity, contingency or any other reason, and is left completely to the actor's discretion.

Multiple interpretations are needed to support individual reflective thought as well as group dialog. But allowing multiple interpretations may be counter productive if the different interpretations are hard to distinguish. The system should therefore help actors to compare and contrast interpretations. At the very least, different interpretations should be viewed in parallel to facilitate manual comparison. A higher level of support can be given with facilities for automatically detecting and highlighting similarities or differences.

Figure 2 demonstrates two representations, one of Engineering and the other of Production. The bi-directional broken lined arrows between the two models represent possible areas for comparison. Multiplicity also implies room for both redundancy and indeterminacy with regard to naming; both should be identified with the system's support but resolved by the users.

These first three principles (ownership, multiplicity, and easy travel), partially determine communication within distributed cognition. Communication must take place in order to exchange representations among individuals. In other words, Engineering cannot travel into Production's interpretations without Production's communicative actions. Communication can be either synchronous or asynchronous. Production can send a representation, or part of it, to Engineering and await her reply. An individual can communicate information to the entire world by announcing it in the public domain, e.g., the economist publishing an economic assumption. Most importantly, communication can occur not only at different levels of context but can encompass several levels of context.

Indeterminacy: Interpretations are not required to be comprehensive, complete or precise. Actors are necessarily tentative, vague, and equivocal about parts of their understanding. From a hermeneutic perspective, there is no final or stable understanding to be achieved, only a continuing interpretive process. As in a Singerian inquiring system, understanding is always taken to be partial and limited with a continuing need to "sweep in" more context. For example, cognitive maps should allow for incomplete maps, fuzzy areas and correlational rather than directed relationships. Indeterminacy as a design principle explicitly leaves room for conversation, as elements from each of the separate views in a representation do not fit precisely and tightly in a logical monolith.

Emergence: New, more abstract constructs and concepts will be developed during the process of interpretation. The hermeneutic circle involves a playful experimentation with new concepts, categories, and levels of representation. Lockean, Hegelian, and Singerian inquiring systems all emphasize induction, synthesis, and

movement beyond apparent categories. Inquiry should alternate between complicating and simplifying an interpretation. New constructs, relationships and theories should be easily added to and incorporated within a set of representations. The system should not only allow for expansion through additional links to new assumptions as a view becomes more elaborate and finely detailed, the system should also allow for new, more general or higher level entities to emerge as a synthesis of an existing set of relations. In a cognitive mapping tool, for instance, authors should not only be able to link elements in a map to documents that provide more detailed context for understanding them, they should also be able to merge several elements together into a synthetic construct that uses the previous set of factors as its context.

Mixed Form: Actors have sometimes radically different modes of expressing their understandings, ranging from text, pictures and graphs to perhaps audio or video. In order to allow a Kantian inquirer to represent an understanding fluidly, the system should be as open as possible to the actors preferred mode of expression. The actors should be able to choose how to represent an element by using a variety of visual modes as well as auditory or other sensory modes. Being able to communicate with multiple (redundant) modes concurrently is sometimes necessary for effective communication. Let us concentrate on the more traditional distinction between different forms of visual representation. Figure 2 shows a cognitive map linking to textual, graphic and tabular information. Recent psychological theories provide guidance on how to implement this principle. The theory of dual coding (Paivio, 1986) differentiates the spatial, parallel representation enabled by graphs from the linear, sequential representations enabled by numbers and text. The theory views interpretation and decision as mediated by the joint activity of spatial and textual systems, with the relative contribution of each system depending on characteristics of the task and the decision-maker's cognitive abilities and habits. Mixed form is also the basis for using technology to achieve the engaging, playful interaction (Te'eni, 1990) that should

characterize a hermeneutic process.

A Project with Business Unit Planners

In an attempt to physically realize these design principles in a working information system, we are developing SPIDER, a software environment for distributed cognition. We are working with business unit planners from a large international manufacturing company. These managers display distributed cognition because each has interdependencies with other business units which should be taken into account in their individual actions. The managers will use SPIDER to represent their understanding of the market for their products and to exchange and critique those representations among themselves in a hermeneutic process of inquiry.

Project members from the company come from engineering, marketing, sales and manufacturing departments. Each company participant is involved in making quarterly sales forecasts of the company's major products over a three-year time horizon in units and dollars. The departments are different worlds, and actors from these unique environments find that effective communication is very difficult to achieve. It requires substantial effort in representing their own context of assumptions and understandings and in exchanging those representations with others in a meaningful dialogue. In this action research, we are drawing upon the design principles discussed above, and are presenting the project here as but one way the principles could be realized. At this point, our interest is primarily an engineering one to see if a system for distributed cognition can be constructed and used .

SPIDER reflects the design criteria for distributed cognition in that it is oriented toward an individual actor (a planning manager) and is a tool for enabling the actor to build and reflect upon an interpretation of the market. Even though each actor is concerned with the subset of products which his or her planning actions affect directly, these managers have interdependencies which, if taken into account in their separate actions, would yield a more coordinated outcome. At the end of each quarterly period, when new

forecasts are made and actual results are received, a new cycle of reflection, interpretation and dialogue begins.

An interpretation is represented by creating a linked set of spreadsheets, cognitive maps, notes or graphs. These four are an initial set of document types, but one aim of the action research is to identify other possible tools for depicting understandings that can be developed and added to SPIDER. We believe that even this initial set of tools, though, is an innovative use of cognitive maps. Traditionally, a researcher has constructed a decision maker's cognitive map for the researcher's own purposes, and has taken it to be a rather static representation (Axelrod, 1976; Huff, 1990). Our use of cognitive maps is unique in that these managers are constructing their own maps, exchanging them, critiquing them, modifying them and generally making them their own representation and communication device.

Assumptions are a central focus of the system, and when the actor declares a link from one document to another it indicates the link to an assumption or a context for that part of the interpretation. In addition to enabling links among layers of context, the system provides dialog boxes for clarifying assumptions and preferences. The system explicitly allows the actors to state preferences by distinguishing what they believe to be the case in the existing and future market place, from a separate indication of how the individual would like to see it change.

Actors can begin their interpretation with any of the document types. In this project, the central document of their representations is often a cause map showing the market factors that are important to take into account and their causal influence on each other. "The cause map contains the structure, the process, and the raw materials from which agreements and conflicts are built when people coordinate actions" (Weick and Bougon, 1986, p. 132). Each factor in a map, or the entire map, can be linked to another map, a spreadsheet, a note or a graph that serves as an assumption or a context for it. Each of those documents can in turn be linked to other document types in which their

assumptions or context can be represented. Thus, an interpretation is composed of multiple levels of context.

-----Insert figure 3 about here-----

A Brief Example

A sample top level screen in SPIDER is shown in Figure 3. This example includes several document types, including a matrix of sales forecasts and a cognitive map for a family of products. Clicking on the bubbles in the cognitive map or the rows in the spreadsheet will travel links to other windows. In these windows, underlying assumptions, general views and preferences are depicted with appropriate document types. Managers reflect upon their understanding of their situation by moving back and forth between elements in a map, calculations in a spreadsheet and other layers of assumptions. Their interpretation builds as they add elements to their map, group elements into higher level constructs, and elaborate on the web of contextual assumptions and preferences. Below we give a brief example of how SPIDER might be used in a business unit setting.

Figure 3 shows the screen of a hypothetical marketing manager (Mark) who has received a message from a manufacturing manager (Paula). She has sent him her production plans for a new product (product A) over the next two years in the form of a spreadsheet, along with a line graph showing the volume trends. Her representation also includes her cognitive map of product A in the market place, indicating her plan to introduce a new production technology. Mark has surfaced some of Paula's assumptions for product A by following a link to her more detailed map of 'new production technology'. While he was exploring her maps, he noticed that the new technology enables a more compact assembly, which is a requirement that has been voiced to him by several major clients. This triggers an idea for a new promotion initiative that will become part of his marketing effort.

From her detailed map and related notes he also discovered that the new production technology will first be introduced for product B, because Engineering believes that being first in the marketplace with that product innovation will be a important technical coup for the company. Historically, the firm has been recognized as the leader in product B innovations.

Mark disagrees with this assumption and wonders if Engineering or Manufacturing has considered the possibility that the company's speed in developing new versions of product B may actually be undermining their market. His own customers seem to just now be settling in with the last improvements to product B, and no competitor products are on the horizon. He wonders if moving up the conversion of the 'A' line, and putting off that of the 'B' line might not be more advantageous. He plans to augment his representation, showing how, from his perspective, speeding up product B may be counterproductive, whereas speeding up product A may allow them to meet some important new competitors. First he will create a new map, showing how product lifespan is positively related to a new construct he will call "customer integration", which he will define as a customer's ability to gain full advantage from integrating a product into their operations. He will link the product lifespan factor to a spreadsheet he already has showing the shortening of the life cycle for B over the last 5 years, and will link the customer integration factor to a memo he recently received from a regional sales manager discussing this integration effect at one of their customer's plants.

Then he will go back to his own representation for product A and expand the section of his map that deals with product competitiveness, showing specific new products developed by competitors and their estimated announcements. He will then send these representations to Paula and to Engineering, guiding them to these new sections in his map and urging them to rethink the priority of product B and consider new ways of shortening the production time line for product A in light of the competition.

This example illustrates the central dynamic of distributed cognition and how

information technology can support it. Rich forms of representation of the understandings of each manager are being exchanged, reinterpreted, revised and used to inform action. Assumptions are surfaced and questioned, new constructs emerge and a dialogue among different perspectives is supported. Below we discuss in more detail how SPIDER embodies each of the six design principles for distributed cognition systems.

How Spider Embodies the Design Principles

In SPIDER, ownership is defined at the point of creation and cannot be changed. Furthermore, a user can only mail an interpretation (or part of it) that he or she owns. SPIDER does not provide for a shared understanding, i.e., a general representation that is owned by the community of actors. However, to facilitate certain organizational functions, such as chief economist, an actor can make her representations available to all users by posting it on a bulletin board. Items on the bulletin board remain the responsibility of the owner to change or update.

Multiplicity in SPIDER is facilitated by a window based environment which allows users the ability to maintain and display several interpretations concurrently. The data structures contain sufficient information for comparing interpretations semi-automatically in terms of the overall structure (concepts and relationships in the cognitive maps) and labels used. We are planning several research projects using pattern recognition techniques in order to detect and highlight similarities and differences between maps automatically.

Easy travel is possible through links that are user defined. Any element within an interpretation can be linked to any document or set of documents. Users create and travel links by selecting objects and clicking with a mouse to bring up the document it is linked to. A problem representation can become large and complex, making navigation within such a space quite difficult. To support navigation a roadmap of the user's problem representation will be provided, showing an overview of the links among levels of

assumptions.

In SPIDER, emergence takes several forms. First, the system provides all the necessary facilities to incorporate elements from other problem representations (owned or received in mail) into one's own and edit them. Such editing would typically involve adding, updating and deleting parts, rearranging them, and rebuilding their links. Moreover, when a document is added to a representation, it brings along all its properties including links to its context. Second, a set of existing factors in a cognitive map can be selected and merged into a new, higher level construct. This enables the actor to better engage in the hermeneutic circle by adding not only more detail and assumptions, but also more abstract and general understandings while tacking back and forth.

SPIDER is built to allow for indeterminacy: There is no requirement that cognitive maps be complete or that the elements in any one document be in a measure or on a scale that is compatible with that of other documents. The direction of causal influence among factors in a cognitive map can be indicated or omitted, and preferences can be declared or not . Similarly, confidence in beliefs about the current situation can be stated or not.

Support of mixed forms of representation are becoming common in learning and decision related software design. All modern spreadsheets provide an easy transition from tabular to graphic presentation of the same numeric data. In SPIDER we go one step further by letting users sketch graphic patterns and interpolate them into tabular form. Thus, users can choose to represent information in structured or free form, graphic or verbal forms and process this information in parallel by displaying these different forms simultaneously thorough different windows on the same screen.

We regard SPIDER as an enabling tool for richer communication, but it is also an important tool for better self-understanding by an individual actor. Most of the understanding represented in the multi-layered web of links among the cognitive maps, spreadsheets, text and graphs is usually held by an individual tacitly. It is not readily

available as a well-formulated set of 'reasons why' that are used in making a particular forecast. People "know more than they can say," (Polanyi, 1967). We have found that it takes a great deal of effort to systematically construct a cognitive map of a product line situation and to unpack the underlying factors and assumptions used in making spreadsheet entries.

The intellectual effort and careful self-examination required to interactively construct a cognitive map, its related spreadsheet, and its layers of assumptions is a source of new understanding for the managers involved. This in itself is an important learning experience. Nonetheless, the principle benefit of SPIDER as a collaborative technology should come when individuals exchange their representations, compare their own layered context descriptions with those of others, and communicate new understanding and inquiries back to their colleagues.

Summary Discussion

We have proposed a theoretical basis for understanding distributed cognition as a hermeneutic process of inquiry. Implications from that theoretical position were used to develop a set of design principles for information systems that would support distributed cognition in an organizational setting. A physical system called SPIDER that would realize these design principles was presented. Several levels of research are suggested by this type of hermeneutic inquiring system. These include understanding the conditions where we can expect distributed cognition to be genuinely open, self reflective and honest; understanding how information technologies for supporting distributed cognition will be appropriated by organization members; and understanding the consequences of such technologies on individuals and organizations.

Orlikowski and Robey (1991) propose a structurational model which emphasizes the recursive interaction between information technology use and social structures. Information technology mediates human activities, but human actors draw upon interpretive

schemes, moral norms and understandings of power from a broader institutional context in their action. When using information technology, actors produce and reproduce organizational structures, and may either sustain them or change them. As a process of structuration, the use of information technology is subject to the same level of indeterminacy as any other human action and will result in both intended and unintended consequences.

Poole and DeSanctis (1990) propose that through a process of structuration, the intended use of a technological system is read and appropriated by its users. Depending on the reading of the user, appropriation can be "faithful" or "ironic". Ironic appropriation means using the system in a manner that violates or is inconsistent with the intentions of its designer. A faithful appropriation of the intended use of a hermeneutic support system such as SPIDER, at least as conceived by the designers, presupposes values such as trust, self-disclosure, and cooperation among a community of reflective, willing users, who are interested in performing better distributed cognition (Habermas, 1981). Under conditions of faithful appropriation we expect that SPIDER will be an environment for enhancing an individual's ability to make interpretations, exchange them in dialogue with others, reflect about their implications and incorporate them in action. However, we do recognize that users develop their own unique readings, and that "ironic" appropriations of a hermeneutic support system are possible. The hermeneutic support system, like any other organizational process can become an arena for acting out strategic power games.

Possible adverse implications of this sort from a hermeneutic support system are highlighted by Orlikowski's (1991) insightful analysis on information technology and forms of organization and control. By making transparent hitherto implicit understanding and thought processes, users of a hermeneutic inquiry system may make themselves vulnerable for a deeper, more repressive and embedded means of control, through electronic surveillance of their knowledge representations. Furthermore, the rules for reflection embodied in SPIDER in the form of creating cognitive maps could become reified and

taken for granted as a fixed routine. It could lead to a situation where users cannot effectively engage in reflection without utilizing the reflection tool and hence without invoking these particular rules and routines of reflection. This fusion of rules and means of production can routinize the very act of reflection leading to an inner contradiction. This can serve to reinforce existing structures of legitimation, and actually inhibit the sense making that a hermeneutic support system is designed to encourage.

Individual and group characteristics can also influence the appropriation process. Factors such as individual cognitive styles (Hunt, Krzystofiak, Meindl, and Yousry, 1989), and information overload (Schroeder, Driver, and Streufert, 1967) can affect how the system is used, or what features are used. We began this paper with the observation that people in organizations are induced to oversimplify their cognition, and proposed that the structured layers of interpretation in a hermeneutic support system can enable richer forms of cognition and communication. But users may not be able to create cognitive maps, may get overwhelmed by the information processing burden involved in scanning multiple cognitive maps, may stop updating their cognitive maps or exchanging them, or may decide to selectively use only a few features of the system and leave its full potential unrealized.

The creation and exchange of cognitive maps in this environment of layered context opens up a wide array of research possibilities. One interesting area of exploration centers around complicating the thinking practices in organizations, and the need to overcome inertial forces of "schema perseverance". Schemas are hypothesized as cognitive structures (Bartlett, 1932; Markus, 1977; Taylor and Crocker, 1981) and cognitive maps can be viewed as a form of schema representations (Weick, 1990; Weick and Bougon, 1986). Schemata are often portrayed as relatively enduring structures, impervious to change and disproof (Ross, 1977; Scotland and Canon, 1972) that can result in dysfunctional consequences such as groupthink (Janis, 1972) and organizational decline (Barr, Stimpert and Huff, 1992). There have been repeated calls for organizations to find new structures and mechanisms to help reduce schema perseverance (Clark, 1975;

Kilmann, Pondy, and Slevin, 1976), and complicate managers' thinking practices so that they develop multiple and richer views of their environments (Weick, 1990).

A principal research question would then be: can the creation and exchange of cognitive maps overcome the problem of schema perseverance and result in complexification of understanding as expressed in higher levels of integrative complexity (Schroeder, Driver and Streufert, 1967) or tolerance for ambiguity (Lorsch and Morse, 1974)? A related question would be: under what conditions will actors change their old problem representations and create, maintain, and apply more complex representations signifying a complexification of understanding (Weick, 1990)? Such conditions can be examined at the individual and/or the group level, can entail factors such as cognitive styles and cognitive modes (Hammond, 1988), or can include affective considerations in the form of trust and cooperation (Gibb, 1978; Zand, 1972).

Another major question is whether individuals can in fact create interpretations of their situation using cognitive maps. Our experience to date suggests that only about a third of the managers in our project feel fluid and comfortable in creating them from scratch as a way of representing their thoughts. Some guidance from more experienced map makers who interview managers and help them to create initial maps that the managers can start working with may be necessary.

Ultimately, the real test of success for a hermeneutic inquiring system is the ability of the actors in a distributed cognition community to coordinate their independent actions toward organizationally beneficial outcomes. In the SPIDER project, we hope to track the process of distributed cognition and assess the actors' ability to coordinate the product planing process and to improve the quality and accuracy of their forecasts. The SPIDER system is but one interpretation of the design principles we have developed. We invite others to make their interpretations so that we might open our horizons to theirs.

Information technology has for too long been used to replicate familiar features and functions of organizations. If we are to truly take advantage of the possibilities of

information technologies for supporting new forms of organizing, decision making and managing, there is a need for invention of alternatives. Business schools will need to adopt more of the laboratory orientation of engineering schools. Such a laboratory orientation would legitimize invention, using emerging information technologies to construct and experiment with new organizational forms. We see our work on distributed cognition as one example of the efforts at invention we have in mind, and look forward to a varied and increased set of other efforts in the future.

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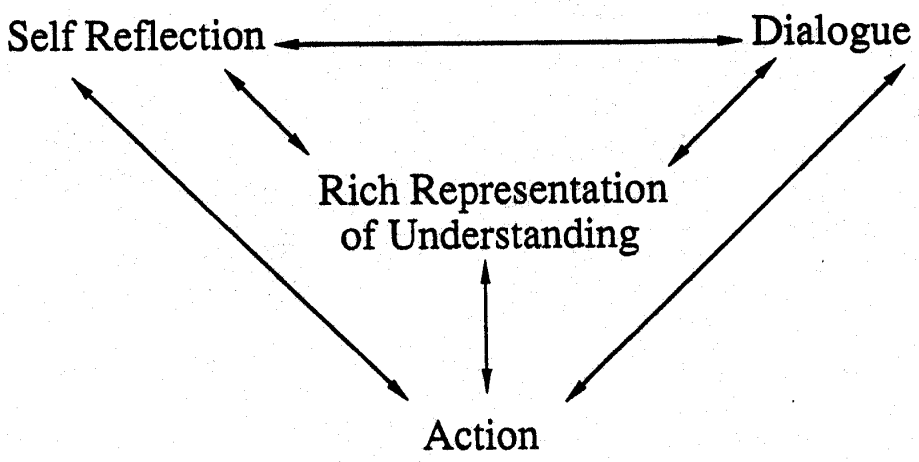

Figure 1. Role of rich representation in supporting distributed cognition.

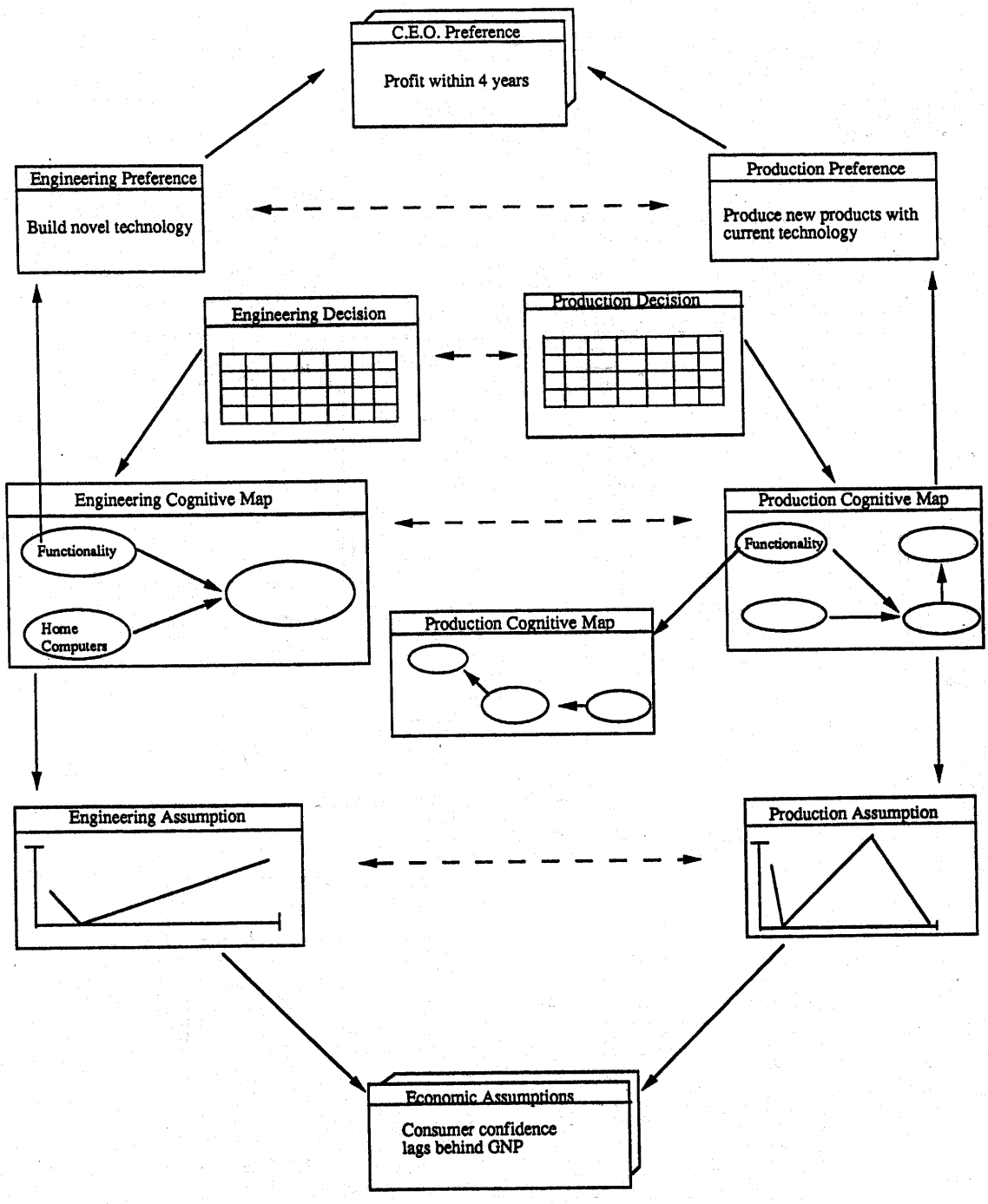

Figure 2. Two interpretations of the same situation.

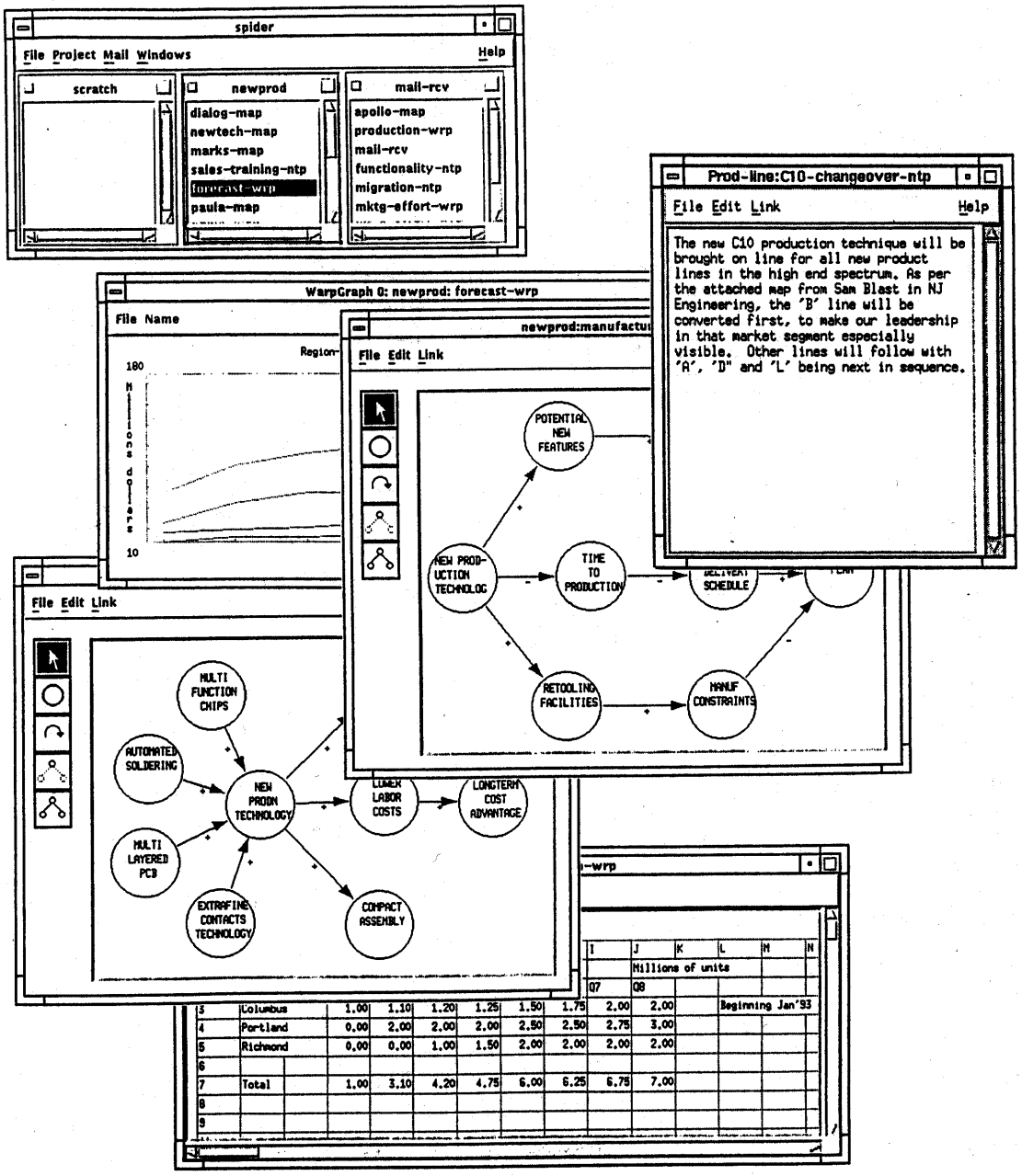

Figure 3. A sample screen from SPIDER showing multiple documents of a representation.