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EXTENDING ELECTRONIC MAIL WITH CONCEPTUAL MODELING TO PROVIDE GROUP DECISION SUPPORT

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Abstract: This paper reports an attempt to move computer-based techniques for supporting the analysis of group cognitive processes and decision-making from being specialist applications to becoming a routine organizational tool used as readily as electronic mail. The objective is to support the discourse processes of functional groups within an organization by enabling them to investigate, analyze and compare the conceptual frameworks of those playing roles within the group. In particular, the system developed shows when individuals are in conflict through using the same term for different concepts, or in tacit correspondence through using different terms for the same concept. It provides support for group knowledge and decision processes as an integrated extension to electronic mail requiring no particular expertise in use or supervision. The work reported is part of a larger study of knowledge support systems merging artificial intelligence and computer communication techniques.

INTRODUCTION

There has been an interesting historical evolution in the organizational application of conceptual model tools based on personal construct psychology. These tools were developed by Kelly (1955) for clinical applications in the 1950s, became widely used in social, educational and organizational psychology in the 1960s, were incorporated in interactive computer programs in the 1970s (Shaw, 1980), and adopted as knowledge acquisition tools for knowledge-based system development in the 1980s (Shaw & Gaines, 1983; Boose, 1984). The knowledge acquisition research community has led to major advances in the interactive elicitation and on-line analysis of conceptual models, but the focus has been on the elicitation of expertise and its transfer to knowledge-based systems (Boose & Gaines, 1988, 1990; Gaines & Boose, 1988; Boose, 1989). Many of the significant early applications of personal construct psychology to organizational modeling have been neglected, even though the advances in the technology have opened up new opportunities for effective application.

In particular, in knowledge acquisition research, a significant growth area has been the support of group processes through sharing and comparison of personal knowledge in group decision support contexts. Generic toolboxes encompassing and integrating a range of methodologies such as KSS0 (Shaw & Gaines, 1987; Gaines, 1988) and AQUINAS (Boose & Bradshaw, 1987), what have come to be called second-generation knowledge acquisition tools (Gaines & Linster, 1990), already make provision for users with widely varying roles, requirements and capabilities. Liou, Weber and Nunamaker (1990) have reported research on a methodology for knowledge acquisition in a group decision support system environment. Methodologies have also been developed that manage the elicitation of knowledge from groups of experts and are supported by tools that can analyze relations between the conceptual frameworks, and conflicts in the use of terminologies, for groups comprising multiple experts and clients (Gaines & Shaw, 1989; Shaw & Gaines, 1989).

However, all the research and applications to date have focused on the use of conceptual modeling tools in specific, planned studies, rather than as continuously available organizational tools such as email and conferencing facilities. This seems to reflect both the past state of the art in information technology and the resultant attitudes to realistic system development. We have moved from an era of batch processing to one of highly interactive computing through timesharing and personal computing, but our applications software is still targeted on supporting individual rather than group processes. As local and global electronic networks have come into everyday use within organizations interest has increased in research on systems developed to specifically support collaborative activities. It is important to remember that much significant technology already exists, and to examine its re-development within a group decision support environment.

The studies reported in this paper are part of an attempt to move computer-based techniques for supporting the analysis of group cognitive processes and decision-making from being specialist applications, typically used once in studying or supporting a group, to becoming a routine organizational tool used as readily as electronic mail. We have taken electronic mail as our starting point for a number of reasons. First, it is already widely used within organizations on a routine basis (Kerr & Hiltz, 1982; Quartermain, 1990). A logical, and psychologically harmonious, extension to email is far more likely to be accepted and used routinely than a new application where a major decision has to be made about use. Second, we see human discourse as an essential process in the formation of functional groups within society that is supported at a very basic level by email. Our objective is to extend the support of discourse through tools that make conceptual models more overt as an aid to mutual understanding—what Habermas (1981) has termed "communicative action."

This paper reports some preliminary experiments on the integration of personal construct psychology elicitation and analysis tools with an electronic mail system to support functional groups within an organization, and the structured development and exchange of knowledge within such groups.

UNDERLYING COGNITIVE AND SOCIAL THEORY

With the power of current technology it is easy to create impressive systems that are not psychologically and socially functional because they do not mesh with human socio-cognitive processes. On the other hand, there is no widely agreed model of the underlying dynamics of such processes—cognitive and organizational psychology research is an area of explosive growth undergoing as rapid a change as computing technology (Gaines, 1991), particularly as our understanding of the modern era is enhanced by post-modern perspectives (Heller, 1990). This section outlines the theoretical perspectives underlying the system development reported in this paper.

There are three basic premises underlying our work: that knowledge processes in society can be understood as the modeling procedures of a distributed anticipatory system; that these modeling procedures can themselves be modeled in terms of the distinctions made; and that the cognitive processes of individuals and organizations can be understood within this framework (Gaines, 1989). Simmel made this inter-relation of wholes and parts the center piece of his sociology:

> "Society strives to be a whole, an organic unit of which the individuals must be mere members. Society asks of the individual that he employ all his strength in the service of the special functions which he has to exercise as a member of it; that he so modify himself as to become the most suitable vehicle for this function.…man has the capacity to decompose himself into parts and to feel any one of these as his proper self." (Simmel, 1950, pp.58-59)

Simmel's insight that the group member is always a fragment of a person, a role created precisely to enable the person to enter the group has been developed extensively by Wolff with his notions of *surrender* and *catch*:

> "From the standpoint of the world of everyday life, the mathematician, as we often put it, lives in the 'world of mathematics', dealing with 'nonreal' elements, notably numbers, whose relation to 'real' things, to 'reality', is not part of his concern. Analogously for the logician. What makes our subject-object approach to this attitude misleading is the fact that the subject, the student of mathematics or logic—his or her individuality, including motives and attitudes—is irrelevant for our understanding; the only thing that counts is the pursuit, with its results and questions." (Wolff 1976 pp.162-163)

He makes the key point that not only does the real world**,** the object**,** disappear to be replaced by the world of mathematics**,** but also that in entering into this world the person doing mathematics, the subject**,** also disappears to be replaced by a new entity, the mathematician.

Wolff was not alone in these insights and there are two further models which develop and complement his. In terms of his "subject" Pask's (1975) concept of "P-individuals" as coherent psychological processes capable of engaging in conversations is a useful representation of the results of Wolff's "surrender", particularly when we note that several P-individuals may execute within a single processor. Thus 'the mathematician' may engage in conversation with 'the physicist' or 'the statesman' all of whom happen to use the same brain for their processing. In terms of Wolff's "object", corresponding to our notions of "knowledge", Popper's (1968) concept of a "third world" of "statements in themselves" is a useful representation of that which we "catch", particularly when we note its distinct ontological status:

> "I regard the third world as being essentially the product of the human mind. It is we who create third-world objects. That these objects have their own inherent or autonomous laws which create unintended and unforeseeable consequences is only one instance (although a very interesting one) of a more general rule, the rule that all our actions have such consequences." (Popper, 1974 p.148)

Pask goes beyond Simmel in conceiving that a P-Individual is not just what we conventionally term a 'role' within a person (which he terms an M-Individual, or mechanically characterized individual) but may itself be composed of a number of roles coming together to form a unity that we conventionally term a group or organization:

> "a P-Individual...has many of the properties ascribed by anthropologists to a role, in society or industry, for example. A P-Individual is also a procedure and, as such, is run or executed in some M-Individual, qua processor. However, it is quite exceptional to discover the (usually assumed) one to one correspondence between M-Individuals and P-Individuals." Pask (1975 p.302)

Shaw (1985) has developed Pask's notions within the framework of personal construct psychology to show how Kelly's cognitive psychology may be used to account for the psychological processes not only of individual people but also for that of functional groups such as a nuclear family or a product executive. Figure 1 illustrates these ideas. Anne is shown as having three roles, wife, mathematician and technical vice president. John is also shown as having three roles, husband, golfer and sales vice president. The wife role in Anne together with the husband role in John together constitute a cognitive entity, a nuclear family. This has behavior, language, legal rights, and a model of the world, that are distinct from those of Anne and John in their other roles, and goes beyond those of the participating roles in Anne or John alone. Similarly, the technical VP role in Anne, the sales VP role in John, the finance VP role in Mark and the production VP role in Sue constitute another cognitive entity with again behavior, language, rights and models that are distinct from its participants and other cognitive entities in which they participate in other roles.

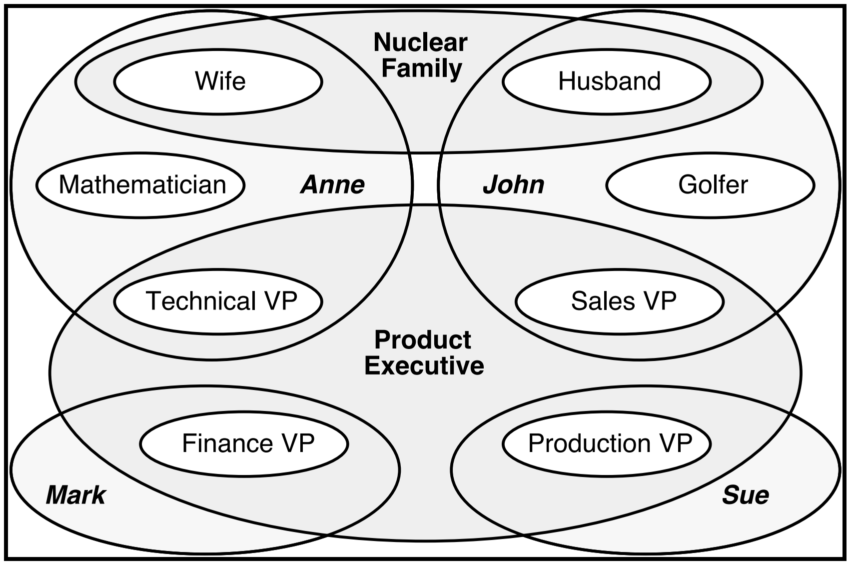

Fig. 1 Roles and groups as psychological individuals

Switching from socio-cognitive theory to computer technology, we can see email as providing a communication channel for discourse between the individuals involved. However, it provides no structures other than linguistic communication for supporting the cognitive processes underlying that discourse. For example, how do the concepts and terms used by the technical VP in discussing the rationale for a new product relate to those of the Sales VP? They may be using the same term for different concepts. They may use different terms for the same concept. They may have terms and concepts in their particular roles that are part of what that role peculiarly contributes to the group cognitive entity, and are not understood by the others involved. In an offline context, there are interactive computer-based tools specifically designed to elicit, analyze and present such conflicts, correspondences and contrasts in a group decision support framework (Shaw & Gaines, 1989). However, as noted above, they are used for specific 'studies', not as a routine part of the discourse and decision process. It is interesting to investigate what will happen if such tools are removed from their specialist isolation and integrated into routine organizational communication.

The theoretical foundations for developing eliciting, analyzing and comparing the conceptual frameworks of the cognitive entities in Figure 1 is derived from the notion that concepts correspond to terms applied to *distinctions* that we make in modeling a world:

> "a universe comes into being when a space is severed or taken apart...By tracing the way we represent such a severance, we can begin to reconstruct, with an accuracy and coverage that appear almost uncanny, the basic forms underlying linguistic, mathematical, physical and biological science, and can begin to see how the familiar laws of our own experience follow inexorably from the original act of severance." (Brown 1969)

Personal construct psychology notes that distinctions used by people often occur as a disjoint pair of concepts termed a *construct,* and that Brown's program of reconstruction is carried out using a technique termed the *repertory grid* to investigate the constructs used by an individual in a role (Shaw, 1980).

ELICITING AND COMPARING CONCEPTUAL MODELS

Repertory grid elicitation is an effective method for eliciting conceptual models in a domain (Shaw, 1980; Gaines & Shaw, 1980), and has been widely used in management, education, clinical psychology and the development of knowledge-based systems (Shaw & Gaines, 1983, 1987; Boose, 1984, 1986). It is an extensional approach in which individuals are asked to specify a set of entities in a domain, then make distinctions among them, naming the distinctions and classifying all the specified entities in terms of them. The distinction determined in this way is an approximation to the underlying concept since critical entities may be missing. However, computer-based elicitation techniques attempt to prompt the individual for additional entities to discriminate between extensionally related distinctions (that is, making the same, or similar, classifications). Group comparisons, as discussed in this paper, have similar dynamics—an extensionally apparent correspondence may be accepted or rejected, and the rejection may be based on the specification of additional entities as counter-examples.

The set of distinctions made by a person in a role, and the relations between them, characterizes the conceptual models used by the person in that role. In comparing conceptual models between different roles and different people, there are two significant dimensions of comparison: one of the distinctions themselves, do they use equivalent distinctions?; and one of terminology, how are the distinctions named? Figure 2 shows how these dimensions combine to give four different relations between concepts: *consensus* arises if the conceptual systems assign the same term to the same distinction; *conflict* arises if the conceptual systems assign the same term to different distinctions; *correspondence* arises if the conceptual systems assign different terms to the same distinction; *contrast* arises if the conceptual systems assign different terms to different distinctions.

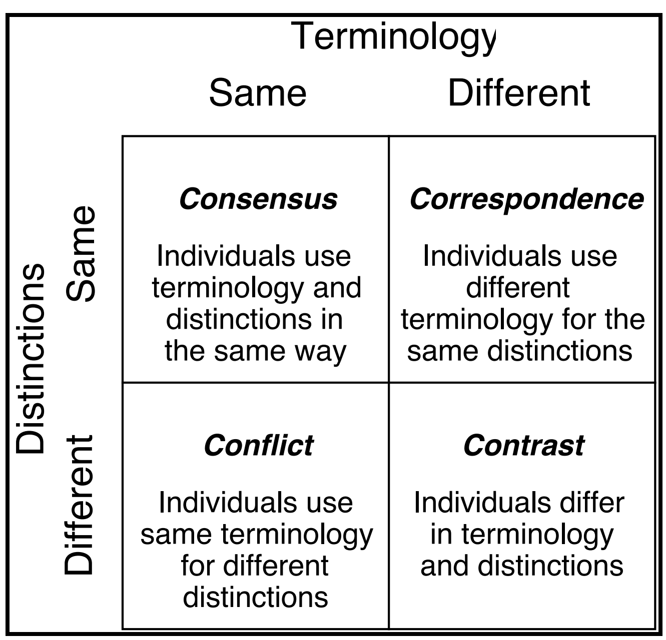

Fig. 2 Consensus, correspondence, conflict and contrast

The recognition of consensual concepts is important because it establishes a basis for communication using shared concepts and terminologies. The recognition of conflicting concepts is important because it establishes a basis for avoiding confusion over the labeling of differing concepts with same term. The recognition of corresponding concepts is important because it establishes a basis for mutual understanding of differing terms through the availability of common concepts. The recognition of contrasting concepts is important because it establishes that there are aspects of the differing expertise about which communication and understanding may be very difficult, even though this should not lead to confusion. Such contrasts are more common than is generally realized. For example, it is possible to derive the same theorem in mathematics either by using an algebraic perspective, or a geometric one. There is nothing in common in these two approaches except the final result. It may still be possible to discuss the same domain using consensual and corresponding concepts that were not fundamental to the problem solving activities.

We have previously developed computer-based interactive tools for the elicitation, analysis and comparison of conceptual structures using repertory grid techniques (Shaw, 1980; Gaines & Shaw, 1989; Shaw & Gaines, 1989). *RepGrid* is a knowledge support system providing an integrated set of tools for elicitation and analysis of elements and constructs in a given domain. It combines a number of different techniques, including element and construct elicitation and clustering, and is linked to an inductive rule generation program. It runs on the Apple Macintosh family of computers to provide a highly interactive and graphic knowledge acquisition environment. At the heart of RepGrid is an object-oriented knowledge base in which knowledge is formally represented as a multiple-inheritance digraph of classes, objects and properties.

The main tools in RepGrid are shown in Figure 3:

- *Elicit* accepts specifications of elements within a domain and provides an interactive graphical elicitation environment within which a person can distinguish elements to derive his or her constructs within the domain. The resultant conceptual system is continuously analyzed to provide feedback prompting the person to enter further elements and constructs.
- *Exchange* extends this to share elements and constructs between people and allows the terms in the conceptual system derived from one person to be used by another in order to determine whether the two conceptual systems are different in any way. It can also be used by the same person looking at changes in their own conceptual structures over time, for example, after reading a specific book, or exploring a particular domain.
- *Process* gives access to clustering tools for the analysis and display of the conceptual systems elicited: FOCUS shows the system as a hierarchical structure; and PrinCom as a spatial map.
- *Socio* processes results from several people to reveal the similarities and differences in their conceptual systems, or the same person at different times, construing a domain defined through common elements or constructs. It can be used to focus discussion between people on those differences between them which require resolution, enabling

them to classify them in terms of differing terminologies, levels of abstraction, disagreements, misunderstandings, and so on.

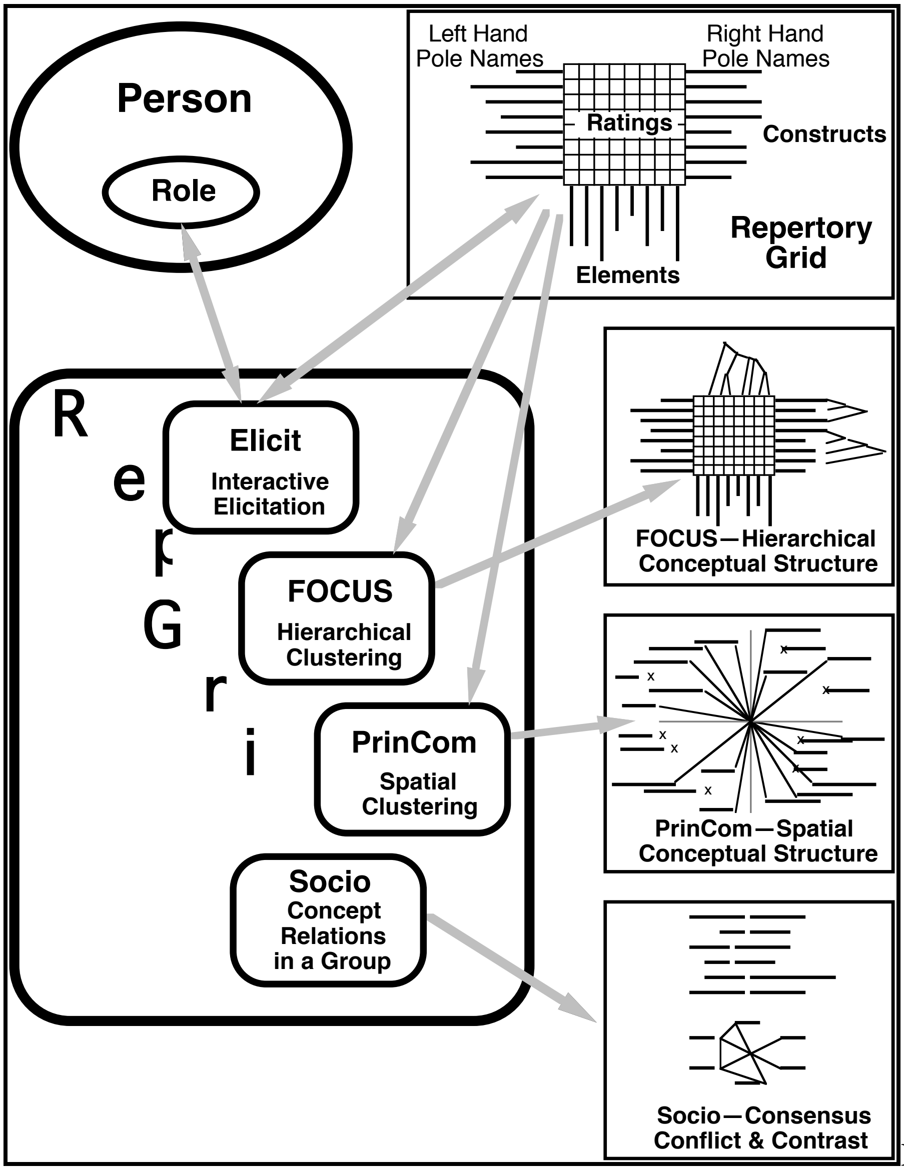

Figure 3 RepGrid Functionality

RepGrid is coupled through an inter-application protocol with Apple's HyperCard, and this has been used to integrate it with an email system to develop RepGrid-Net as described in the following section.

REPGRID-NET: A NETWORKING SUPPORT SYSTEM

RepGrid-Net is a computer-based message system that integrates conventional electronic mail and bulletin board facilities with the repertory grid elicitation and analysis facilities described above to provide both unstructured and structured communications supporting the formation and operation of special interest networks. Users see a mail system in which special-interest groups are specifically supported.

The coordinator of a special-interest group provides a basic focus for it through statements of intent, topics and issues which are handled on a bulletin board basis. He or she also provides one or more kernel grids listing specific topics and the concepts which they apply to them. These kernel grids can be developed by others interested in the groups, using the stated topics and concepts, and adding to them.

General similarities between grids are analyzed to provide a socionet of people with common viewpoints, and this may be used to access the mail system to communicate with them. Detailed comparisons of similarities and differences between viewpoints may be made, and individual concept structures can be analyzed. The elicitation and analysis facilities are all highly graphical, designed to be easy and interesting to use.

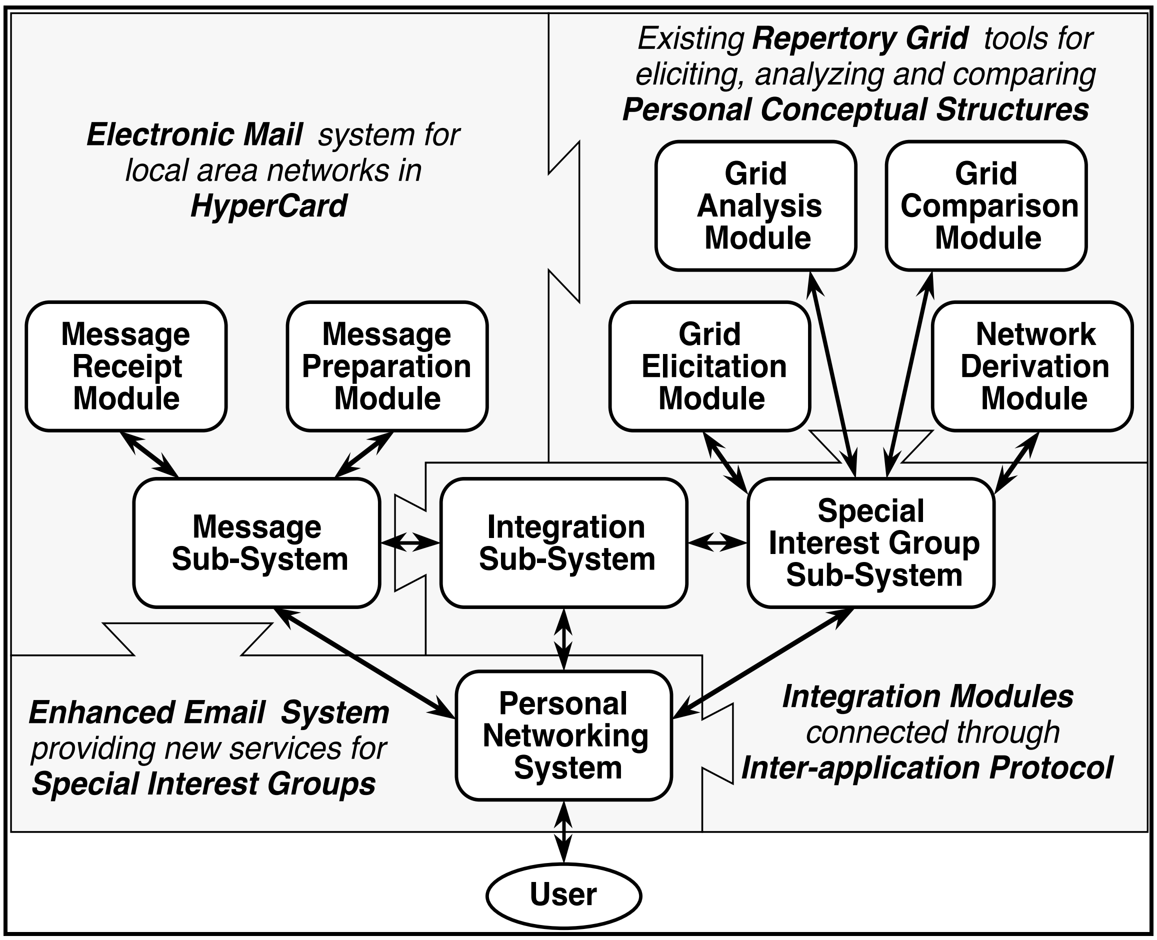

Fig.4 System architecture

Figure 4 shows the overall systems architecture. The message sub-system is written in HyperCard and is conventional in its operation. Users register with the system and may access lists of those with mailboxes registered on the system, lists of incoming mail and confirmations that outgoing mail has been accessed (see Figure 9). They may prepare and send mail, and receive and reply to mail. The special interest group sub-system is described in detail in the next section. It handles the group bulletin board and grid elicitation and analysis. The integration sub-system manages the interactions between the other two sub-systems, for example, that the graphic displays of networks of people with common interests may be used to send a message to one or more of them.

RepGrid-Net is implemented on a network of Macintosh computers coordinated through AppleTalk access to an AppleServe file server. Users see a conventional Macintosh program interface at all times and, even though two distinct programs are running, they communicate through inter-application protocols in such a way that there appears to be only a single application.

SYSTEM OPERATION

This section presents RepGrid-Net in operation for a product development group concerned with microwave ovens. An assistant to the chief executive has already entered a kernel grid on "Project67" concerned with relevant existing and competitive products, and with the major new product proposals under consideration. The participants are Anne, John, Sue and Mark in their roles as shown in Figure 1. We will go through a sequence of Anne's interaction with the system. She sees the screen of Figure 5 at login.

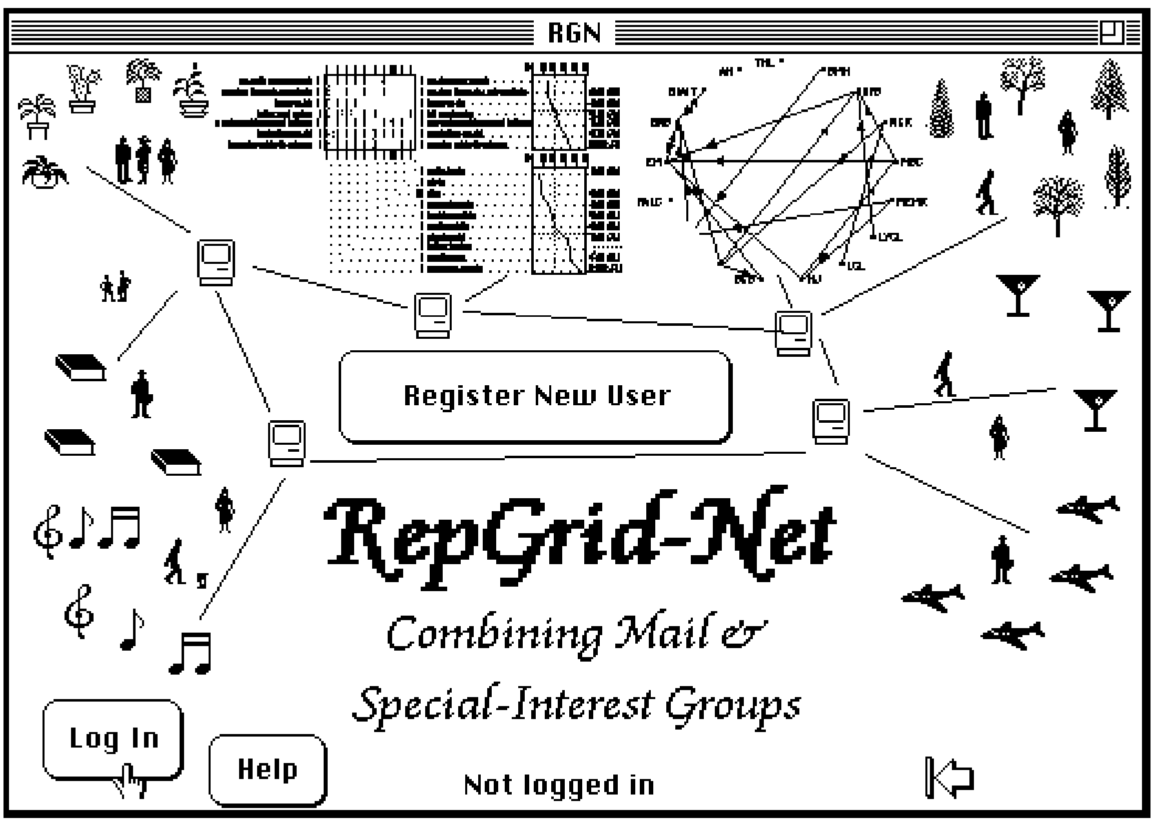

Fig.5 Initial login screen

Anne selects “Log In” and goes to the screen shown in Figure 6.

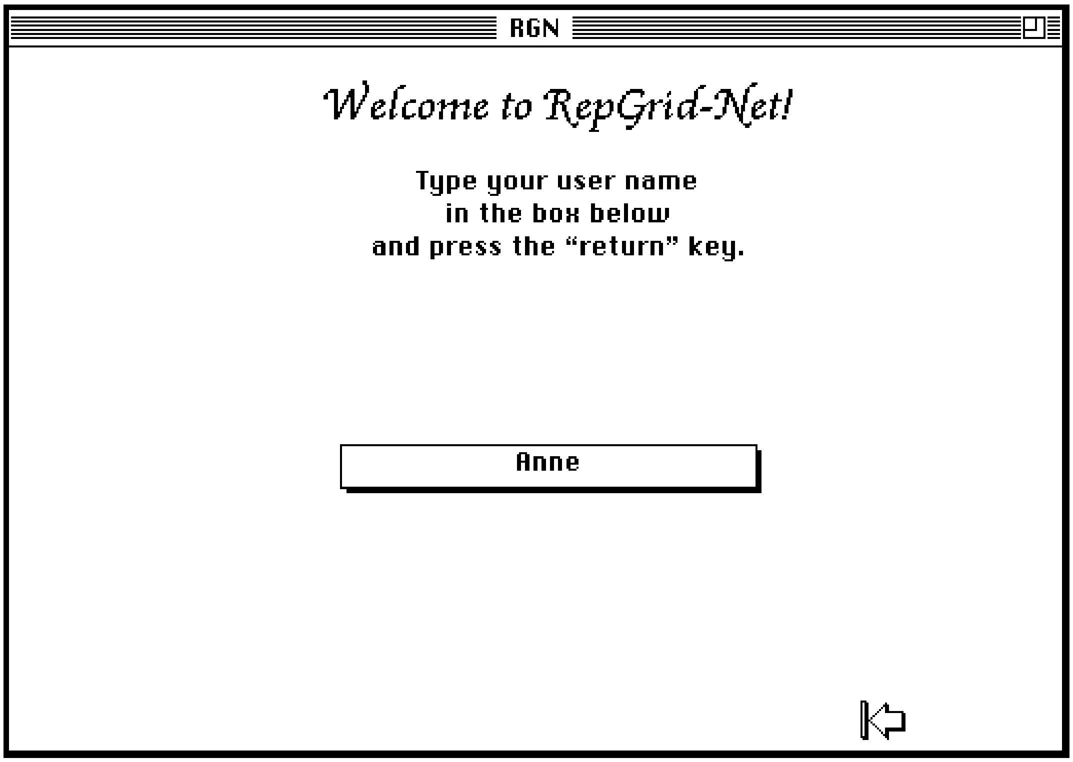

Fig.6 Log in and registration screen

She types in her name, logs in and goes to the screen shown in Figure 7.

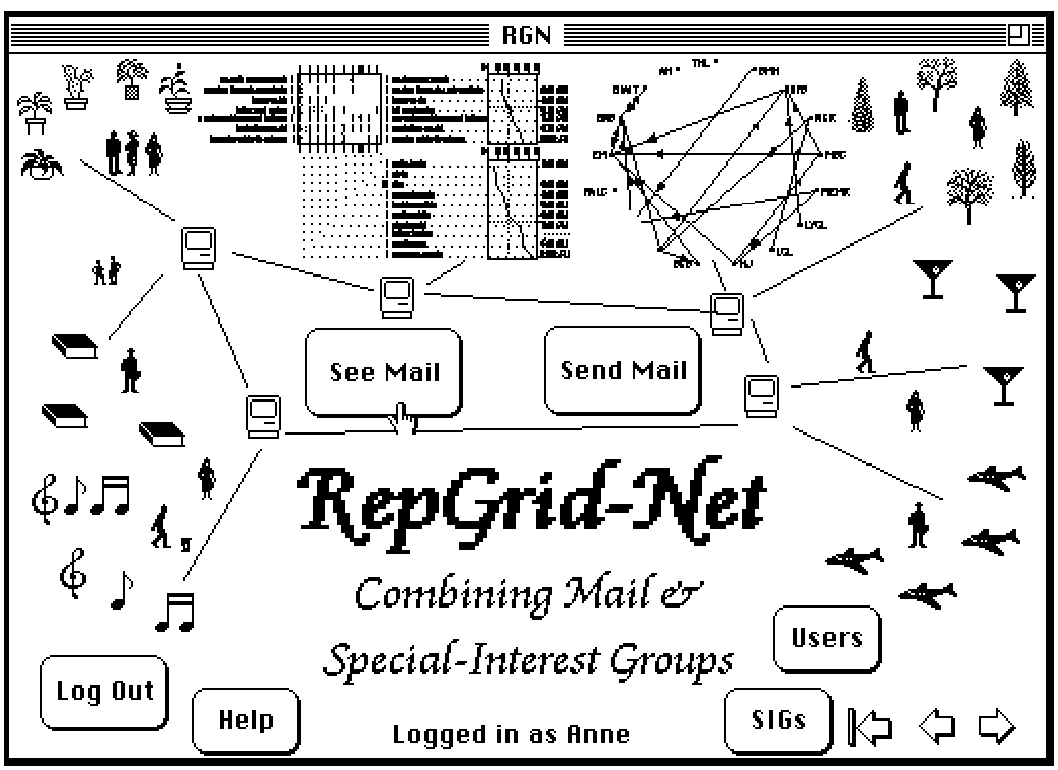

Fig.7 Main access to functionality screen

Anne selects “See Mail” and goes to the screen shown in Figure 8.

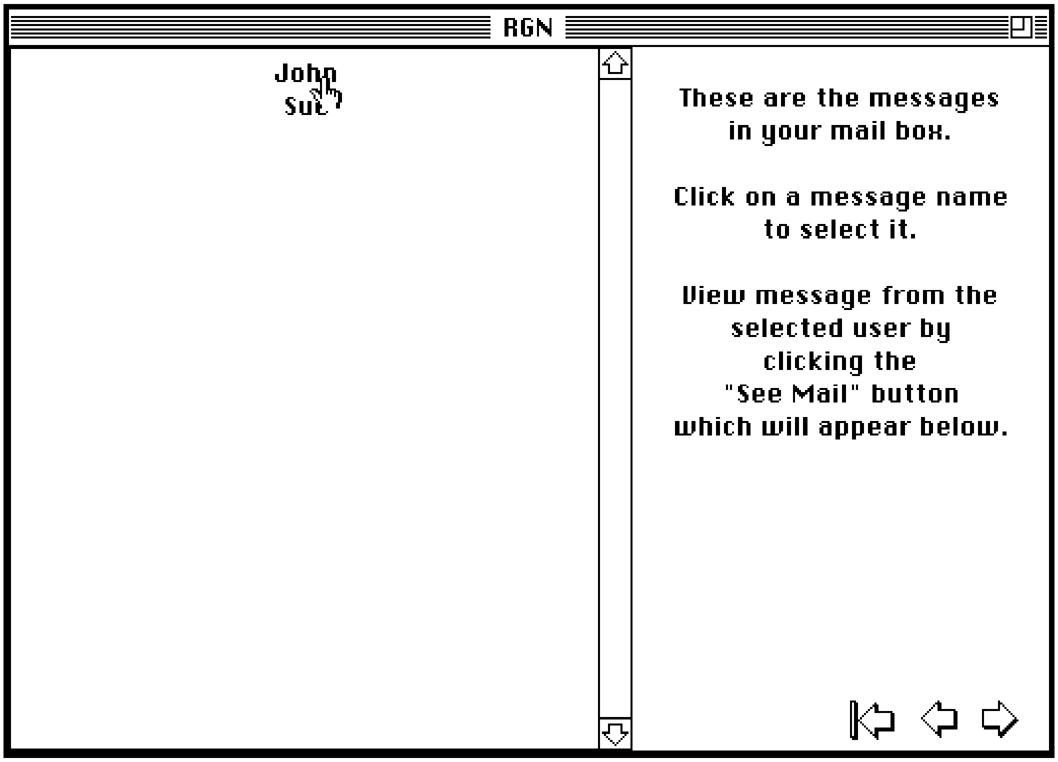

Fig.8 List of incoming mail screen

She clicks on “John” to access the mail and goes to the screen shown in Figure 9.

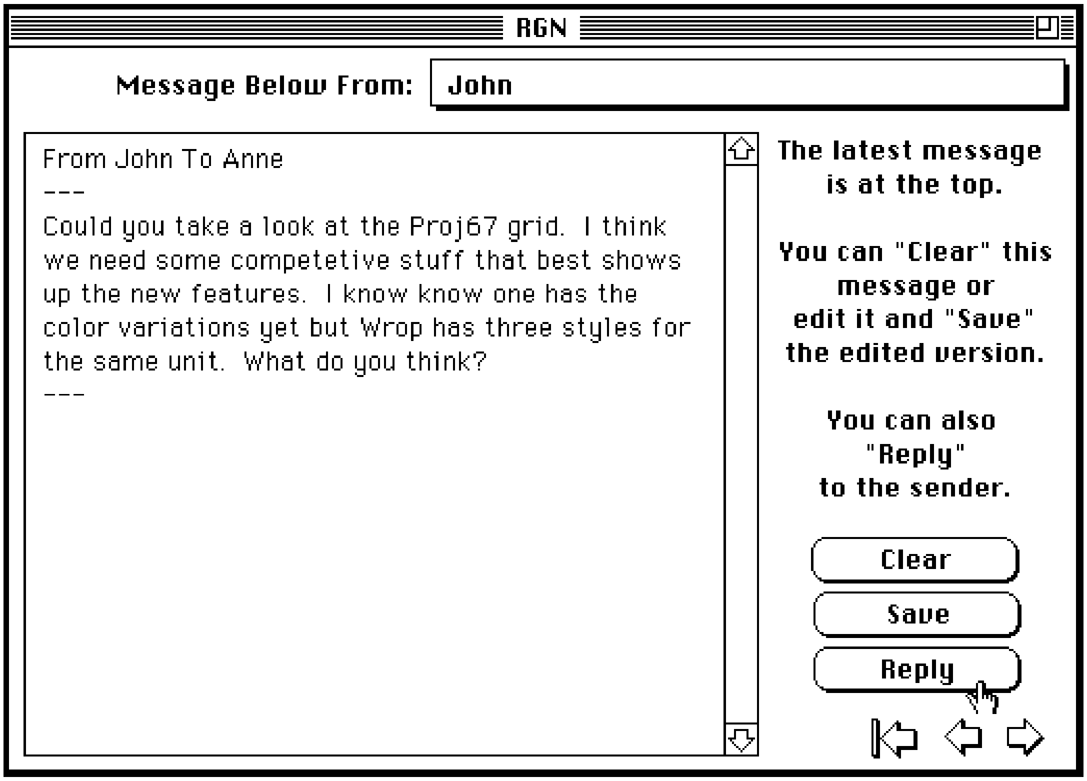

Fig.9 Incoming mail screen

Anne selects “Reply”, goes to the screen shown in Figure 10, and types a reply.

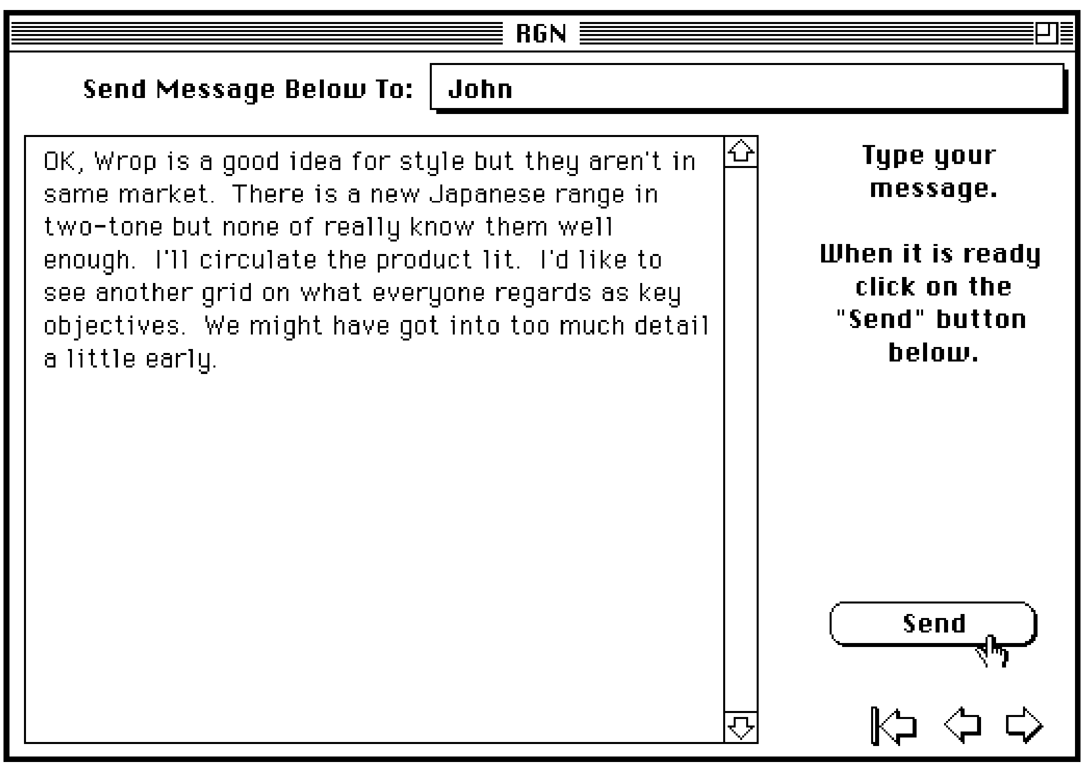

Fig.10 Outgoing mail screen

She selects “Send”, returns to the screen shown in Figure 5, selects “SIGs”, and goes to the screen shown in Figure 11.

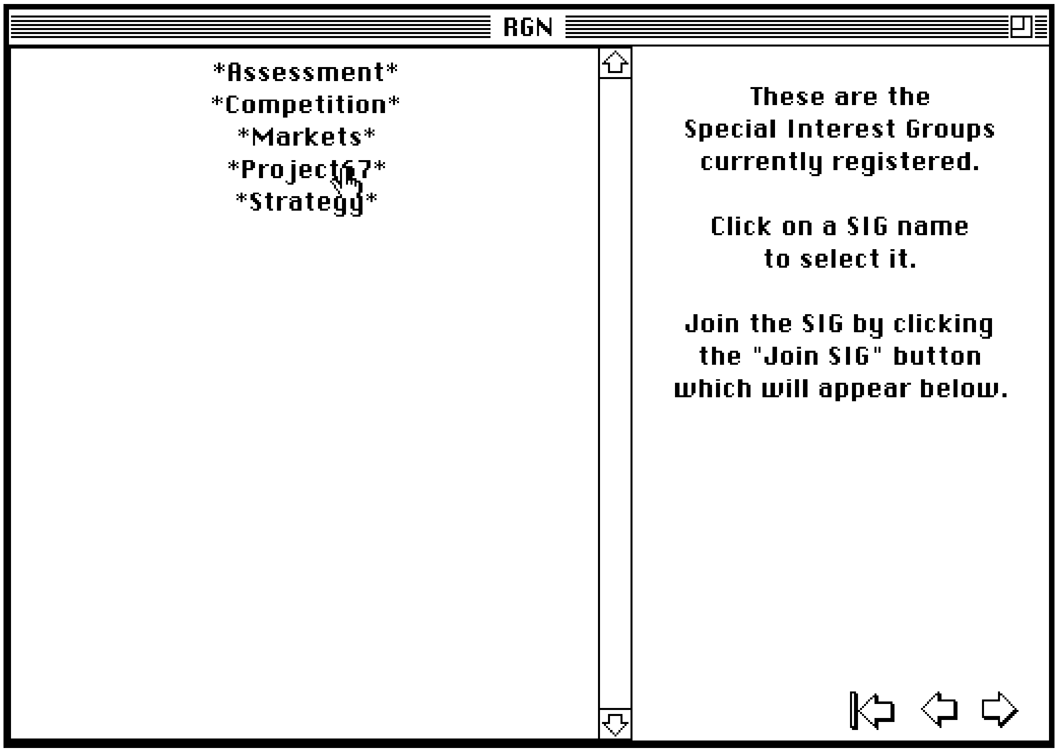

Fig.11 List of special interest groups screen

Anne clicks on “Project67” to access the specialist group concerned with product development and goes to the screen shown in Figure 12.

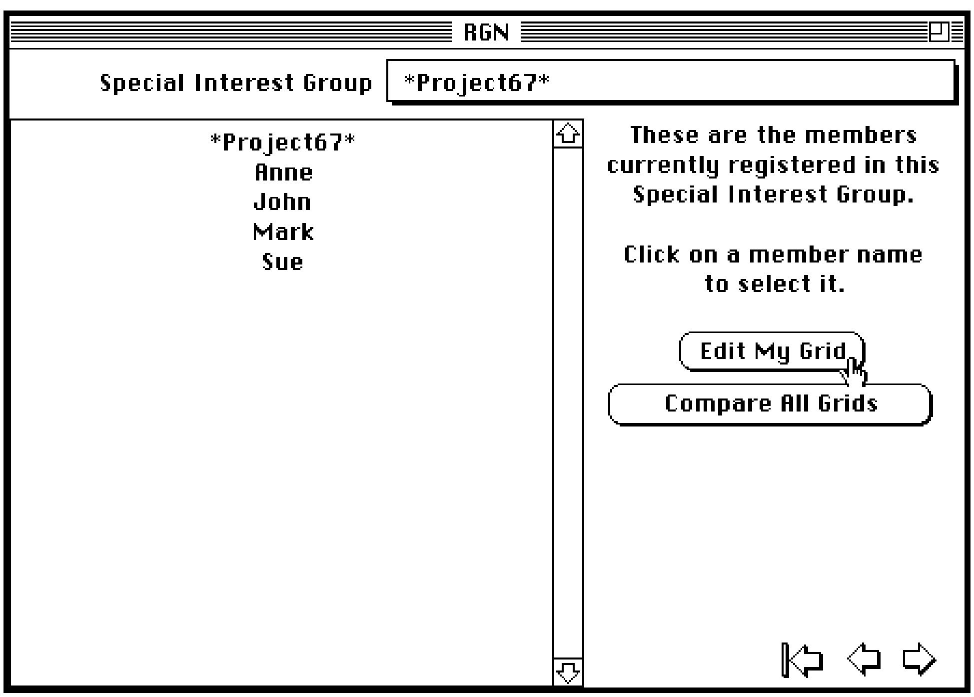

Fig.12 List of Project67 SIG members

She selects “Edit My Grid” and goes to the screen shown in Figure 13, accessing a grid she has already entered using the elements and constructs of the coordinator.

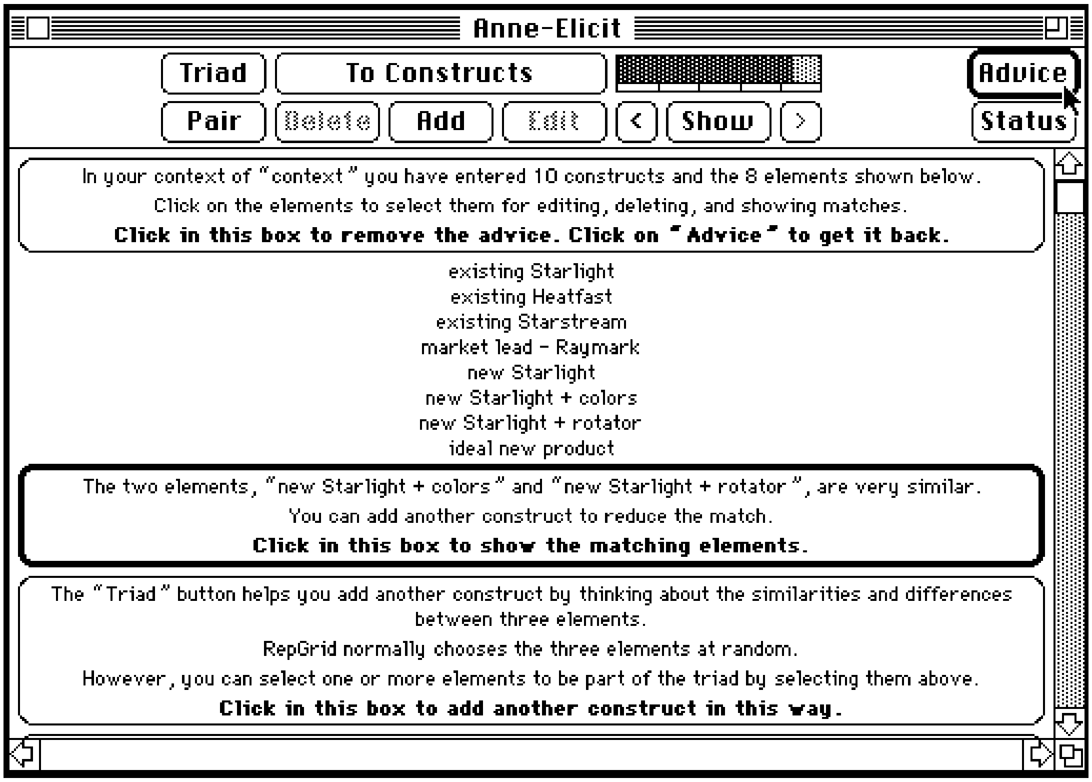

Fig.13 Repertory grid entities screen

Anne selects “Advice” and goes to the screen shown in Figure 14.

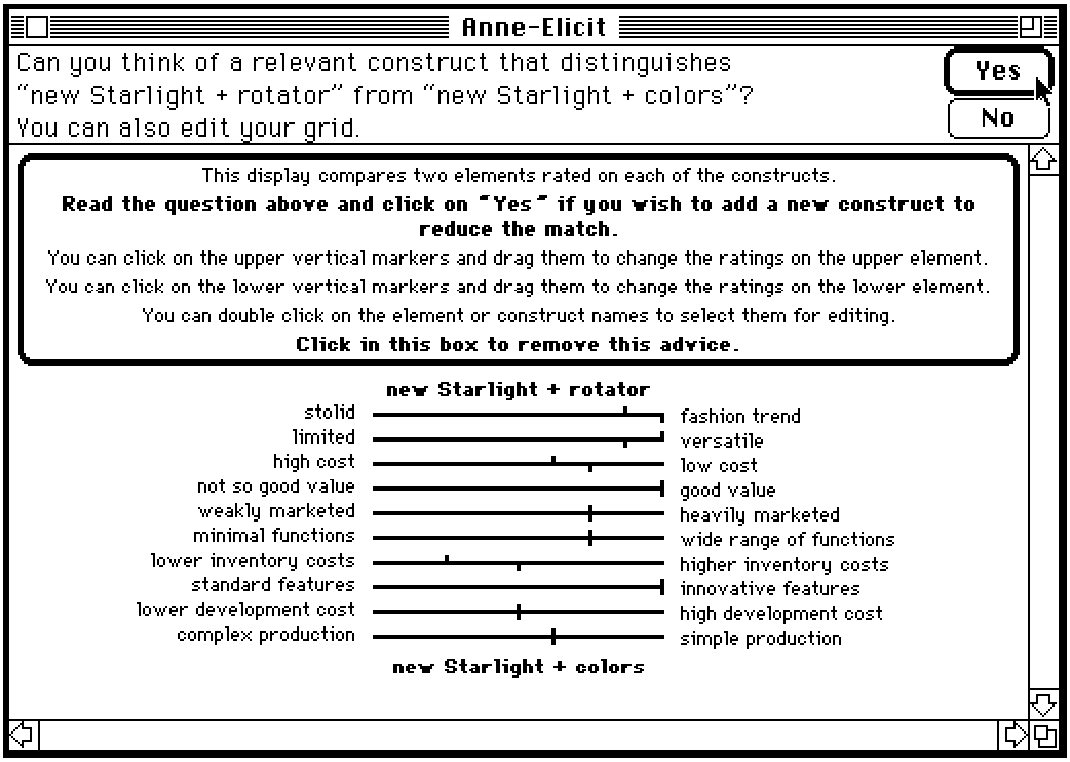

Fig.14 Element match screen

She selects "Yes" and goes to the screen shown in Figure 15.

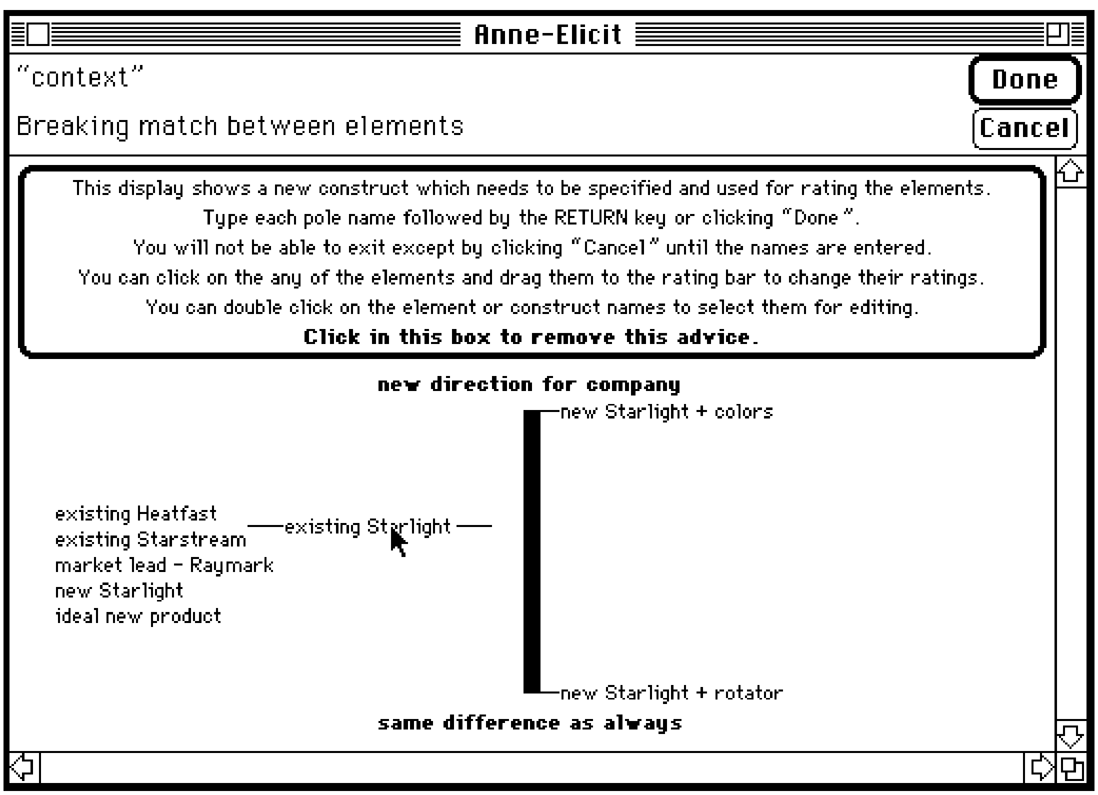

Fig.15 Element rating screen

When she has finished editing the grid, she returns to HyperCard as shown in Figure 16.

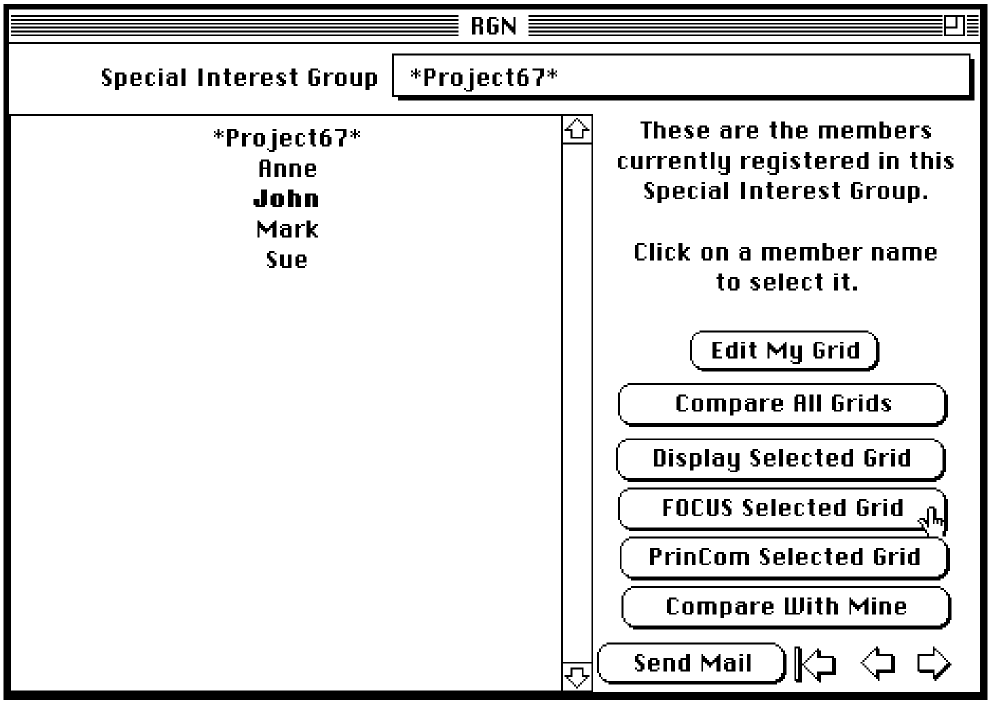

Fig.16 Grid analysis functionality screen

She clicks on "John", selects "FOCUS Selected Grid", and goes to the screen shown in Figure 17. This clusters John's grid and she can see that for him the three new models are all close and nearest to "ideal new product.'

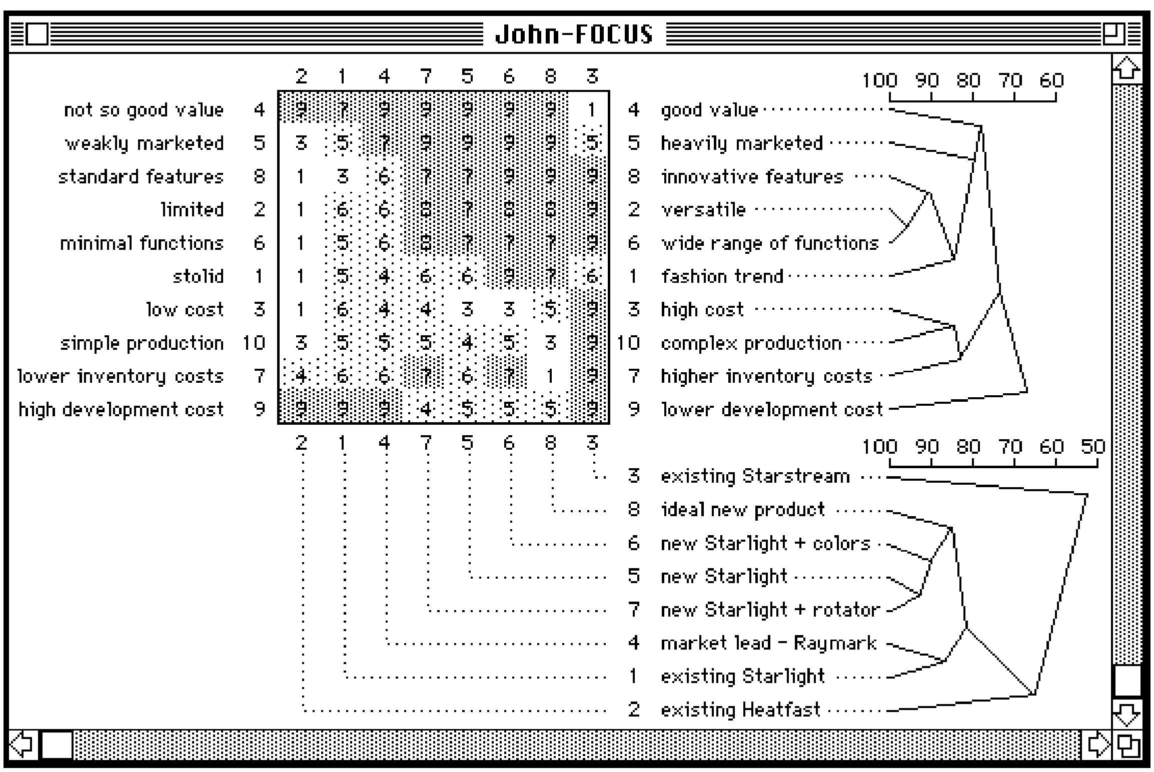

Fig.17 FOCUS cluster analysis screen

Anne returns to HyperCard, selects “Compare with Mine” and goes to the screen shown in Figure 18. It seems that she and John agree on most attributes except those involving costs at the bottom of the list, and on most products except the competition’s market lead product. This comparison illustrates how the consensus-conflict axis in the left column of Figure 2 is determined and analyzed based on the participants’ capabilities to use one another’s terminology and distinctions in the same way.

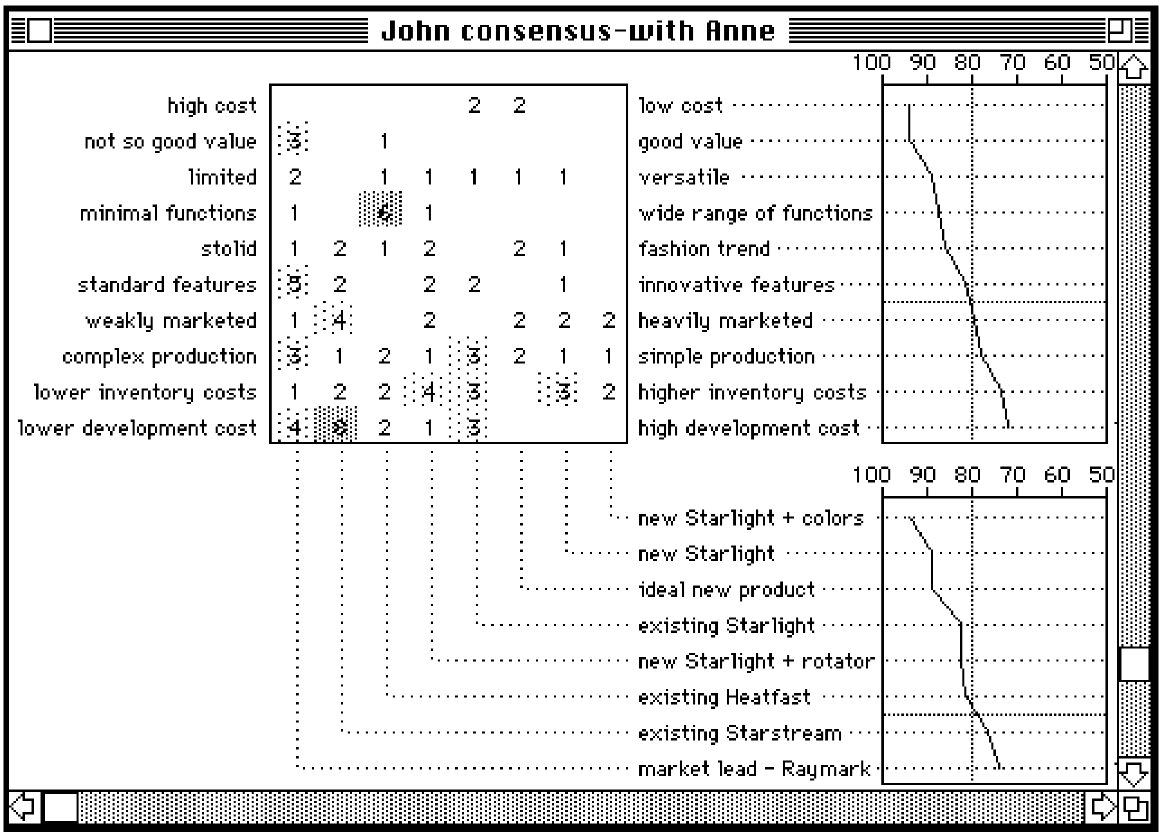

Fig.18 Grid comparison screen

She selects “Compare All Grids” and goes to the screen shown in Figure 19. An arrow from one person to another in the socionet shows that the first person can understand the constructs of the second. Thus, John is the only one with mutual understanding with everyone else. These comparisons are based on the correspondence-contrast axis of Figure 2. The capability to understand another person is assumed to depend on the availability of corresponding constructs that need not be consensual in that they may be termed differently. We have a basis for mutual understanding if we can make the same distinctions even if we have to determine a mapping between our terminologies to provide mutual translation.

Anne clicks on “Project67”, the kernel grid provided by the chief executive’s assistant, and uses a popup menu to return to HyperCard, and goes to the screen shown in Figure 16 with Project67 now selected. She can now explore why the Project67 grid is different from hers. She can send mail to the coordinator discussing the differences, querying his use of terms, and so on. The system is highly non-modal and the user can continue using the system as demonstrated, browse between cards, use the RepGrid tools to further develop grids, use the email to communicate, and so on.

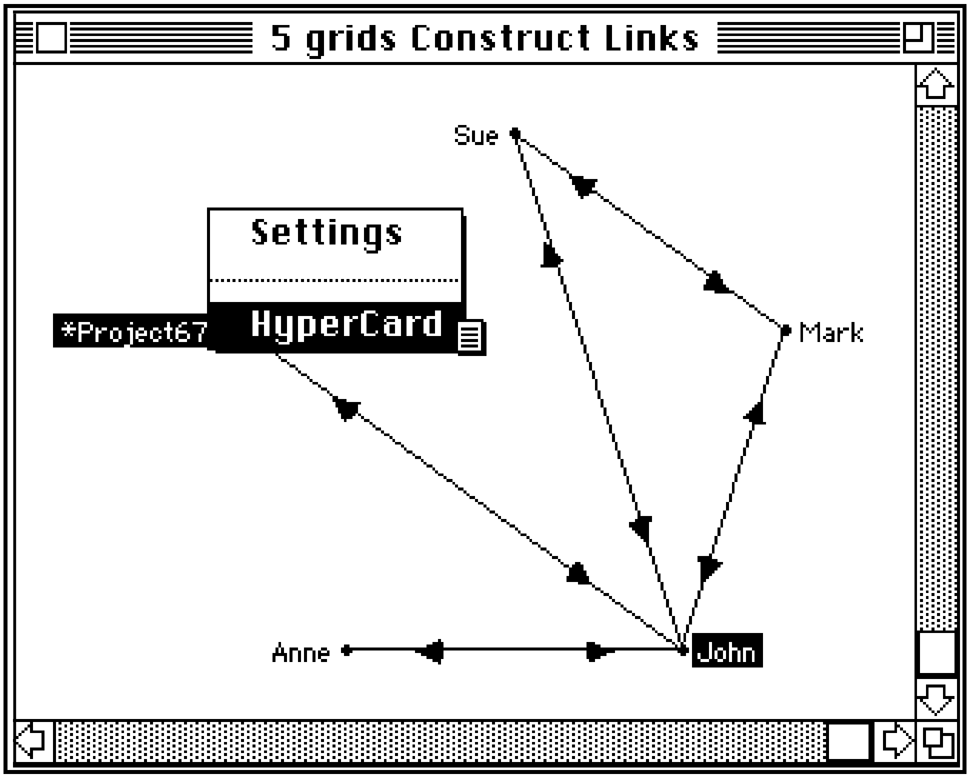

Fig.19 Socionet based on grid comparisons screen

CONCLUSIONS

Potential applications of knowledge acquisition systems already developed extend far beyond the development of expert systems; a significant area is the support of group processes through sharing and comparison of personal knowledge. RepGrid-Net is a message system supporting special interest group formation and collaborative activities at many levels. It integrates techniques and programs that have already been widely used to support the elicitation and analysis of conceptual structures. However, it makes them available in a very much more informal and open setting than previously.

The current implementation is written for the Apple Macintosh and operates only on a local server network. Transferring the code to other personal computers and workstations involves the usual problems of portability of highly interactive user interfaces. Remote operation presents no major problems since the grids are compact data structures similar in size to email messages, and work is already underway to allow the system to operate over global networks.

The system described shows the potential current applications of computer-mediated communication systems to be extended simply and naturally with a range of new features supporting human knowledge processes.

ACKNOWLEDGEMENTS

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