E-Collaboration Support Systems: Issues to be addressed

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INTRODUCTION

Removal of communication impediments and provision for techniques that systematically direct the pattern, timing, and content of cooperative processes are two key prerequisites in the contemporary organization. Their establishment has been proven to facilitate the solution of ill-structured problems by a set of individuals working together as a team, through the interactive sharing of information between them. E-collaboration involves a variety of both communication and cooperation issues, in that it leverages the connective powers of a computer network to co-ordinate the efforts of a group of people. By using e-collaborative capabilities in an organization, people can operate as a single business entity, thus making joint decisions of added value.

Issues to be addressed in the establishment of an e-collaboration environment should have a strong organizational focus. These include work structuring in order to improve coordination, use of communication technology to make collaboration more efficient and effective, enforcing of rules and procedures for achieving consistency, and automating data processing in data intensive situations. One should further consider the conceptual, methodological and application-oriented aspects of the problem. *Conceptual focus* is associated with the consideration of the nature of individual and organizational processes, *methodological focus* with the integration of existing computer-based tools, techniques and systems into the human decision making context, and *application-oriented focus* with the consideration of the real organizational needs by extending decision support to business teams (Angehrn and Jelassi, 1994).

BACKGROUND

The environment in which a collaborative process takes place sets different communication requirements. Issues to be taken into account in the design and implementation of an e-collaboration system include:

- The *spatial distance* between team members. This refers to whether full face-to-face communication among them is possible. Depending on the group size and the proximity of members during a decision making procedure, the following settings have been identified (DeSanctis and Gallupe, 1987): (i) the *decision room*, where an electronic version of a traditional meeting situation is established; (ii) the *legislative session*; (iii) the *local area decision network*, where group participants can communicate with each other and with a central processor through a local-area network, and (iv) the *computer-mediated conference*, where communication is provided between two or more remote groups by linking decision rooms together through audio and video facilities.
- The *temporal distance* among the activities performed by the individual group members. This refers to whether collaboration is taking place through meetings at a particular time, such as in conventional meeting or teleconferencing environments, or whether participants submit their input at different points in time, based on electronic mail, bulletin boards, newsgroups and computerized conferencing concepts.
- The *type of participants' goals* distinguishes between an environment in which a group wants to solve its common problem cooperatively, and another, in which bargaining

takes place. Issues arisen in the first case concern knowledge sharing, preference aggregation, and negotiation support. Depending on the degree of cooperativeness among the decision makers, three modes of reaching a decision have been reported (Jelassi and Foroughi, 1989): (i) the *pooled mode*, where there is so much cooperation that the individuals act almost as a single decision maker; (ii) the *cooperative mode*, where decision makers may have difficulties in understanding and accepting each other's positions, and (iii) the *non-cooperative mode*, where a series of negotiations must integrate the diverse, often conflicting and incompatible, individual problem representations into a common solution.

- The type of *control* over the collaborative process: there may be cases where the participants follow a democratic process in order to reach a solution, and cases where the system is supported by a human group leader or mediator. In the former ones, communication and coordination are achieved by the users or directly by the system. The latter ones can be further distinguished in those where the human mediator cannot impose decisions on the participants, and those where there is compulsory arbitration from a group leader. Refering to a Group Decision Support System, for instance, three levels of control have been identified, namely, *democratic participative decision making, semi-hierarchical decision making,* and *third-party arbitration* (Jelassi and Foroughi, 1989).
- *Separating people from the problem:* The system designer has to evaluate the individual and group characteristics of the participants, as well as their motivations, disagreements and conflicts, in order to reduce (if not avoid) the negative impact that misunderstandings, emotions and bad communication may have. Different approaches to conflict resolution include: (i) *contending or positional bargaining*, where a party is trying to convince the opponent(s) to accept its favorite position; (ii) *accommodating*, involving a party's effort to help another party meet its objectives; (iii) *compromising*, meaning a splitting of the differences between interested parties, that is satisfying but not optimizing; (iv) *collaborating*, involving parties working together to optimize their joint outcome, like in group problem solving settings, and (v) *avoiding* the negotiation process for various reasons such as fear of conflict, not worth bargaining issues, or intention of negotiations' postponement (Lewicki and Litterer, 1985).
- The *type of communication* between the participants: collaborative environments can be based either on *point-to-point communications*, or on *broadcasting* of messages.

Furthermore, approaches for the development of a framework for e-collaboration have to address both behavioral and technical aspects (Zigurs et al., 1988). Behavioral issues reported concern the diffusion of responsibility, pressures toward group consensus and problems of coordination. A framework that integrates behavioral and technical perspectives may reduce the negative impact and enhance the positive effects of the former ones. Issues involved in the design of such a framework are: (i) support (or not) of anonymity depending on the type of the discussion; (ii) enforcement of participants' self-awareness; (iii) display of group inputs at any stage of the discussion; (iv) structure of the decision process: the actions the participants should follow may improve the efficiency of the system in terms of accuracy and response time; (v) ability to support communication, information sharing and democratic control: provision of communication and information sharing helps participants to create a *shared workspace*, on which the discussion will be based.

COMPUTER SUPPORTED COOPERATIVE WORK

Computer-supported cooperative work (CSCW) has been defined as computer-assisted coordinated activity, such as communication and problem solving, carried out by a group of collaborating individuals (Greenberg, 1991). The multi-user software supporting CSCW is known as *groupware* (Ellis *et al.*, 1991). Sometimes this term is broadened to incorporate the styles and practices that are essential for any collaborative activity to succeed,

whether or not it is supported by computer. CSCW may also be viewed as the emerging scientific discipline that guides the thoughtful and appropriate design and development of groupware (Greenberg, 1991). Key issues of CSCW are group awareness, multi-user interfaces, concurrency control, communication and coordination within the group, shared information space and the support of a heterogeneous, open environment which integrates existing single-user applications.

The most successful CSCW technology to date is undoubtedly the *electronic mail*. Other well-developed technologies so far comprise *computer conferencing*, *teleconferencing* or *desktop videoconferencing* (the act of conferencing at a distance with the aid of audio and video links), *group authoring* (enabling cooperative writing with additions, revisions, comments and annotations), and *group decision support systems* (where problem solving is directed at the organization of the issues involved). The last category comprises mediating systems that support discussion, argumentation, negotiation and decision making in groups.

	Synchronous communications	***Asynchronous communications***
One group site	*Electronic meeting facilitation, Decision rooms*	*Media spaces, Desktop conferencing*
Multiple individual or group sites	*Teleconferencing, Desktop Videoconferencing, Broadcast Seminars*	*Electronic-Mail, Voice-Mail, Collaborative Writing, Workflow Management, Group Decision Support, Cooperative Hypertext*

***Table 1**: A taxonomy of CSCW technologies*

As illustrated in Table 1, most taxonomies of CSCW technologies distinguish them in terms of their abilities to bridge time and space (the table is a more elaborate version of the one appearing in (Baecker, 1993), page 3). As cited in (Baecker, 1993), groupware technologies of the future need to span all quadrants of this table. This is usually described as *any time - any place* groupware. During the last few years, CSCW is strongly supported and explored from both industry and academic research. Everybody speaks for the shifting role of computers, in that they do not merely handle information processing issues but they appear as tools for managing commitments and their fulfillment and as tools for producing and "listening to" the assertions and assessments that structure the organization (Winograd, 1992). Computers can make explicit the structure of human interaction in an organization, providing new operational means for generating and monitoring workflows, being a more effective observer in what is going on, determining what is needed for whom, when, and what is to be done.

A principal aim for the designer of an e-collaboration framework is to apply state-of-the-art telematics and groupware technology to provide advanced support for the users over wide area networks, in particular the Internet. Generally speaking, CSCW tools can harness the complexity of the social and knowledge processes involved, thus providing benefits in terms of speed and accuracy, and facilitating the development of business policies. Such tools can be used to support the group reasoning processes, i.e. to facilitate the evaluation of proposed solutions and their support, to structure the decision-making process through the implementation of specific methodologies, and to help group members in reaching a shared understanding of the issue by supporting knowledge elicitation, knowledge sharing and knowledge construction. Moreover, by exploiting intranet or Internet technologies, they can connect participants with similar interests, encouraging dialogue and stimulating

the exchange of knowledge.

A plethora of systems that support capturing of decision rationale and argumentation for different types of user groups and application areas has been already developed. For instance, *QuestMap*, which is based on *gIBIS* hypertext groupware tool (Conklin and Begeman 1987), can capture the key issues and ideas during meetings and attempts to create a shared understanding by placing all messages, documents and reference material for a project on a "whiteboard". *Euclid* (Smolensky et al. 1987) is another system of this category, which provides a graphical representation language for generic argumentation, whereas *Janus* (Fischer et al. 1989) is based on acts of critiquing existing knowledge in order to foster the understanding of design knowledge. *Sepia* (Streitz et al. 1989) is a knowledge-based authoring and idea-processing tool for creating and revising hyper-documents that views authoring as a design process, and *QOC* (Questions, Options and Criteria), based on a representation model of the rationale of reasoning in a decision making process, allows users to represent and integrate rationale of varying degrees of stability, at different stages in a design process (Shum et al. 1993). Finally, *Sibyl* (Lee 1990) is a system that provides services for the management of dependency, uncertainty, viewpoints and precedents. Generally speaking, the above systems meet the collaboration requirements concerning the type of control, conflict resolution, and behavioral issues, as discussed in the previous section, by providing a cognitive argumentation environment that stimulates reflection and discussion among participants. However, issues related to temporal and spatial distances are not fully addressed; these systems do not exploit any network infrastructure, thus users can work in an asynchronous way only through a human mediator who receives their contributions and appropriately deploys them to the system (similar criticism holds for the display of each collaboration instance to all parties involved). Most important, this category of systems do not integrate any reasoning mechanisms to (semi)automate the underlying decision making and negotiation processes.

Increasing interest has been also developed in implementing Web-based conferencing systems, such as *AltaVista Forum Center*, *Open Meeting* and *NetForum*. Such systems exploit the platform-independent communication framework of the Web, as well as its associated facilities for data representation, transmission and access. They usually provide means for discussion structuring and user administration tools, while the more sophisticated ones allow for sharing of documents, on-line calendars, embedded e-mail and chat tools, etc. Discussion is structured via a variety of links, such as simple responses or different comment types (e.g., *qualify*, *agree*, *example* in Open Meeting) to a previous message. This category of systems meets fully the requirements that are related to the spatial and temporal distances between members of a team. However, the above systems merely provide threaded discussion forums, where messages are linked passively; this usually leads to an unsorted collection of vaguely associated comments. As pointed out by the developers of Open Meeting, there is a lack of consensus seeking abilities and decision-making methods (Hurwitz and Mallery 1995). Moreover, as in the previous category of systems, issues related to the appropriate storage of knowledge in order to be exploited in future collaboration settings are not addressed.

FUTURE TRENDS

We argue that services to be provided in a contemporary e-collaboration framework can be classified in three levels (Table 2):

- The *information services* should deal with the interoperability of proprietary systems, providing efficient and cost-effective access to multimedia data in heterogeneous, distributed databases over wide-area networks. In particular, services should be included for finding relevant data and converting proprietary data to standard formats for data interchange. Additionally, these services should include ways of controlling remote servers from within compound documents and general-purpose electronic mail,

conferencing systems and hypermedia systems, such as the World Wide Web. Another major issue here concerns the provision for customized solutions, which adapt to a team member's profile according to his/her preferences, abilities, experience, collaboration mode, as well as aspects related to technical specifications of his/her platform, software available, and network connection. In order to be effective, such solutions have to remove barriers imposed by non-interoperable collaboration tools, inadequate infrastructure, undefined data sharing policies and standards, and differing priorities for presentation formats. What is often required is generation of customized content through approaches such as document transformation, dynamic documents generation, and adaptive hypermedia, and provision for personalized collaboration tools, based on adaptive learning techniques, that track a team member's activity and interactions with the system, analyze the feedback, and accordingly identify his/her needs or interests.

Category of services	***Purpose***
Information services	*Information search and retrieval, interoperability, adaptability*
Documentation services	*Information transformation, knowledge management, meta-data, ontologies, experimentation, security and privacy*
Mediation services	*Conducting of debates, argumentation, negotiations, handling of conflicts, decision making*

Table 2: *e-collaboration services.*

- The *documentation services* should provide a "shared workspace" for storing and retrieving the documents and messages of the participants, using appropriate document formats, such as XML. As argued in (Prahalad and Hamel, 1990), an organization's only advantage in today's business environment is its ability to leverage and utilize its knowledge. While a firm comprises individuals and a set of objectified resources, its most strategically important feature is its body of collective knowledge (Spender, 1996). Such knowledge resides in an evolving set of assets including the employees, structure, culture and processes of the organization. Of these, employee knowledge, and particularly tacit knowledge is identified as the dominant one, which is decisive at all mental levels and has to be fully exploited (Nonaka, 1994). Such an exploitation refers to the transformation of tacit knowledge to codified information, which is considered as a core process for economic activity and development. Security and privacy issues should be also addressed here. Moreover, controlled experimentation by simulation may augment the quality of a collaborative process by providing insight into the dynamic interactions and feedback loops formed by the problem elements (Sterman, 2000). A simulation model can map organizational knowledge onto appropriate graphs quantifying the problem under consideration, thus providing a clearer understanding of which alternative solution seems to be more prominent at the moment. Moreover, it can provide the means for an individual to conceptually define his/her position and perform experiments before asserting it to the "shared workspace". Taking into account the current state of the overall process, individuals may thoroughly contemplate on their next move to assure that it will have the best impact to the ongoing discussion. Finally, databases containing project documents may also become part of the *collective memory* of a community, facilitating the design and re-use of plans.
- The *mediation services* should regulate the group's activities and facilitate the underlying decision making processes. Commercial workflow systems can be used to support well-defined, formal administrative procedures within organizations. Decisions

should be considered as pieces of descriptive or procedural knowledge referring to an action commitment. In such a way, the decision making process is able to produce new knowledge, such as evidence justifying or challenging an alternative or practices to be followed or avoided after the evaluation of a decision, thus providing a refined understanding of the problem. On the other hand, in a decision making context the knowledge base of facts and routines alters, since it has to reflect the ever-changing external environment and internal structures of the organization (Bhatt and Zaveri, 2002). Knowledge management activities such as knowledge elicitation, representation and distribution (discussed in the previous category) influence the creation of the decision models to be adopted, thus enhancing the decision making process (Bolloju *et al.*, 2002).

The mediation services of the system are based on the specification of the underlying logic, argumentation structure and actions (that is, duties and rights) of the team members. More specifically, mediation services should consist of the following four levels:

- the *Logic Level*, where the notions of *consequence* and *contradiction* are defined. This level formally specifies the notions of theory that will be used and provides the appropriate inference relations.
- the *Argumentation Framework Level,* where the concepts of positions, supporting arguments, counterarguments and issues as well as linguistic constructs for arguing about priority relationships among competing arguments are defined. The argumentation concepts at this level result in a kind of nonmonotonic formalism, founded on argumentation principles.
- the *Speech Act Level,* where the space of possible kinds of actions a participant may perform during a discussion is defined. Participants may alter the structure of the Argumentation Framework at the second level by, for example, adding and deleting claims or arguments.
- the *Protocol Level*, where norms and rules about duties and rights of the participants to perform actions defined at the previous level are specified. Such norms or *protocols* provide a means for structuring in advance demands for possible communication actions and should promote *fairness*, *rationality* and *efficiency* by taking into account the roles of participants, the type of their goals and the type of control needed.

CONCLUSION

We have summarized a series of communication and cooperation issues to be considered in the development of systems supporting e-collaboration in the contemporary organization. Services to be provided by such systems have been classified in three levels, namely, information, documentation, and mediation services. We argue that much more research and applied work needs to be carried out on issues concerning the synergy of knowledge management and decision making, while this should be further enhanced by providing advanced argumentation and experimentation features. Much attention should be also paid to adaptability issues, by thoroughly taking into account an individual's profile during a collaborative process. Finally, we argue that more tools based on the concept of intelligent agents (Wooldridge, 2002) should be developed. Exploiting the basic characteristics of intelligent agents, such tools may perceive conditions holding in a dynamic e-collaboration environment, act with respect to these conditions, and reason to draw inferences and solve problems, thus facilitating the tasks of the individuals involved.

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TERMS AND DEFINITIONS

Computer-supported cooperative work (CSCW): A computer-assisted coordinated activity, such as communication and problem solving, carried out by a group of collaborating individuals. Key issues of CSCW are group awareness, multi-user interfaces, concurrency control, communication and coordination within the group, shared information space and the support of a heterogeneous, open environment which integrates existing single-user applications.

e-Collaboration: The process in which a set of individuals communicate through an intranet or Internet to co-ordinate their efforts towards the solution of a problem.

Group Decision Support System: An interactive, computer-based system that aids a set of decision makers working together as a group in solving ill-structured problems. It enables decision makers to analyze problem situations and perform group decision-making tasks.

Groupware: The multi-user software supporting CSCW. Sometimes this term is broadened to incorporate the styles and practices that are essential for any collaborative activity to succeed, whether or not it is supported by computer.

Intelligent Agent: A software entity that performs a set of operations on behalf of a user or another program. Such entities are embedded in computer-based information systems to make them smarter. This is usually achieved with the employment of artificial intelligence techniques.

Knowledge Management: The active management of the expertise in an organization involving collection, categorization, and dissemination of knowledge; the activity of representing and processing knowledge.