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GROUPWARE AND COMPUTER-SUPPORTED COOPERATIVE WORK

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The networking of information technology devices has enabled a broad new class of tools that go under the generic name of groupware.[1] The broad study of the development and use of groupware is known quite widely as Computer-Supported Cooperative Work (CSCW).[2] These tools have emerged as new social and organizational challenges have arisen. Television and radio long ago broadened our awareness of and interest in activities all over the world. The telegraph and telephone enabled new forms of organizing to emerge. Groupware is allowing greater geographical and temporal flexibility in conducting a wide range of intellectual work.

Groupware is software designed to run over a network in support of the activities of a group or organization. These activities can occupy any of several combinations of same/different place and same/different time. Groupware has been designed for all of these combinations. Early groupware applications each tended to focus on only one of these cells, but more recently groupware that supports several cells and the transitions among them has emerged.

Whereas CSCW emerged as a formal field of study in the mid-1980s, there were a number of important antecedents. The earliest efforts to create groupware used time-shared systems, but were closely linked to the development of key ideas that propelled the personal computer revolution. Vannever Bush described a vision of something similar to today's World Wide Web in an influential essay published shortly at the end of World War II (Bush, 1945). Doug Engelbart's famous demonstration at the 1968 International Federation for Information Processing (IFIP) meeting in San Francisco included a number of key groupware components (see the report by Engelbart & English, 1968). These components included support for real-time, face-to-face meetings, audio and video conferencing, discussion databases, information repositories, and workflow support. Group decision support systems and computer-supported meeting rooms were explored in a number of business schools (see reviews by Kraemer & Pinsonneault, 1990; McLeod, 1992). Work on office automation included many groupware elements, such as group workflow management, calendaring, e-mail, and document sharing (Ellis & Nutt, 1980). A good summary of early historical trends, as well as reprints of key early articles, appear in Grief's (1988) important anthology of readings.

Today support for collaboration at a distance is included in many commercial products. There are a large number of specific groupware-based commercial products, like a host of e-mail applications, Lotus Notes, and NetMeeting. In addition, groupware functions are increasingly appearing as options in operating systems or specific applications. These trends suggest that groupware functionality will become widespread and familiar. However, there are still many research issues about how to design such systems and what effects they have on the individuals, groups, and organizations that use them.

ADOPTING GROUPWARE IN CONTEXT

Groupware systems are intended to support groups, who are usually embedded in an organization. As a result, there are a number of issues that bear on groupware success. In a justly famous set of papers, Grudin (1988, 1994) pointed out a number of problems that groupware systems have (see also Markus & Connolly, 1990). In brief, he pointed out that developers of groupware systems need to be concerned about the following issues (Grudin, 1994, p. 97):

1. *Disparity in work and benefit:* Groupware applications often require additional work from individuals who do not perceive a direct benefit from the use of the application.
2. *Critical mass and Prisoner's dilemma problems:* Groupware may not enlist the critical mass of users required to be useful, or can fail because it is never in any one individual's advantage to use it.
3. *Disruption of social processes:* Groupware can lead to activity that violates social taboos, threatens existing political structures, or otherwise demotivates users crucial to its success.
4. *Exception handling:* Groupware may not accommodate the wide range of exception handling and improvisation that characterizes much group activity.
5. *Unobtrusive accessibility:* Features that support group processes are used relatively infrequently, requiring unobtrusive accessibility and integration with more heavily used features.
6. *Difficulty of evaluation:* The almost insurmountable obstacles to meaningful, generalizable analysis and evaluation of groupware prevent us from learning from experience.
7. *Failure of intuition:* Intuitions in product development environments are especially poor for multiuser applications, resulting in bad management decisions and error-prone design processes.
8. *The adoption process:* Groupware requires more careful implementation (introduction) in the workplace than product developers have confronted.

However, there are reasons for optimism. In a recent survey of the successful adoption of group calendaring in several organizations, Palen and Grudin (in press) observed that organizational conditions in the 1990s were favorable for the adoption of group tools than they were in the 1980s. Furthermore, the tools themselves had improved in reliability, functionality, and usability. There is increased collaboration readiness and collaboration technology readiness. But there are still significant challenges in supporting group work at a distance (Olson & Olson, 2000).

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[1] Barry Wellman (2001) laments the fact that such tools are not called "netware," a name that is now a trademarked company name.

[2] Groupware and CSCW have a variety of denotations, some of them quite narrow. We choose to use these terms quite broadly, as do many others.

TECHNICAL INFRASTRUCTURE

Groupware requires networks, and network infrastructure is a key enabler as well as a constraint on groupware. The technical possibilities are very different for advanced networks like Abilene (www.internet2.edu/abilene/) when contrasted with the commodity Internet with slow links to the desktop. Heterogeneity in network conditions across both space and time still remains a major technical challenge.

The World Wide Web and its associated tools and standards have had a major impact on the possibilities for groupware (Berners-Lee, 1999; Schatz & Hardin, 1994). Early groupware mostly consisted of stand-alone applications that had to be downloaded and run on each client machine. Increasingly, group tools are being written for the web, requiring only a web browser and perhaps some plug-ins. This makes it much easier for the user, and also helps with matters such as version control. It also allows for better interoperability across hardware and operating systems.

However, security on the Internet is a major challenge for groupware. In some sense, the design of Internet protocols are to blame, because the Internet grew up in a culture of openness and sharing (Abbate, 1999; Longstaff et al., 1997). E-commerce and sensitive application domains like medicine have been a driver for advances in security, but there is still much progress to be made (Camp, 2000; Longstaff et al., 1997).

Personal computing was a great enabler of collaborative applications. However, we are now undergoing a liberation of computing from the desktop. Laptops, personal digital assistants, wearables, and even multifunction cell phones provide a wide range of platforms for the individuals involved in group work. More and more applications are being written to operate across these diverse environments (e.g., Tang et al., 2001). These devices vary in computational power, display size and characteristics, network bandwidth, and connection reliability, providing interesting technical challenges to make them all interoperate smoothly.

Additional flexibility is being provided by the development of infrastructure that lies between the network itself and the applications that run on client workstations, called middleware. This infrastructure makes it easier to link together diverse resources to accomplish collaborative goals. For instance, the emerging Grid technologies allow the marshalling of powerful, scattered computational resources (Foster & Kesselman, 1999). Middleware provides such services as identification, authentication, authorization, directories, and security in uniform ways that facilitate the interoperability of diverse applications (see Internet2, 2001, for pointers to a variety of projects in this area).

COMMUNICATION TOOLS

We now turn to a review of specific kinds of groupware, highlighting their various properties and uses. We have grouped this review under several broad headings. We do not aim to be exhaustive, but rather seek to illustrate the variety of kinds of tools that have emerged to support human collaborative activities over networked systems. We also highlight various research issues pertaining to these tools.

E-mail

E-mail is almost as ubiquitous as the telephone. Because messages can be exchanged across networks and different base machines and software applications, it is nearly the universal service that the telephone is (Anderson, Bikson, Law, & Mitchell, 1995). Because of this widespread use, it is often called the first and perhaps the only successful groupware application (Anderson et al., 1995; O'Hara-Devereaux & Johnson, 1994; Satzinger & Olfman, 1992; Sproull & Kiesler, 1991). More recently, with the use of MIME as the standard for attachments and Postscript and others for representation, it is easier and easier to send spreadsheets, complexly formatted text documents, graphics, etc. Because of the speed and ease of use, people use e-mail to attempt to span distance and time, and to easily disseminate information to broad communities (Garton & Wellman, 1995).

Researchers have shown that this widespread use has had a number of effects on how people behave. It has had large effects on communication in organizations: It changes the social network of who talks to whom (Sproull & Kiesler, 1991), the power of people who formerly had little voice in decisions (Finholt, Sproull, & Kiesler, 1990), and the tone of what is said and how it is interpreted (Sproull & Kiesler, 1991). For example, with e-mail, people who were shy found a voice; they could overcome their reluctance to speak to other people by composing text, not speech to another face. This invisibility, however, also has a more general effect: Without the social cues in the recipient's face being visible to the sender, people will flame, send harsh or extremely emotive (usually negative) messages. Although people adapt their styles over time, it is still a concern for the steady stream of young users new to the medium (Arrow et al., 1996; Hollingshead, McGrath, & O'Connor, 1993).

As with a number of other designed technologies, people use e-mail for things other than the original intent. People use it for managing time, reminding them of things to do, and keeping track of steps in a workflow (Carley & Wendt, 1991; Mackay, 1989; Whittaker & Sidner, 1996). But because e-mail was not designed to support these tasks, it does not do it very well; people struggle with reading signals about whether they have replied or not (and to whom it was cc'd); they manage folders poorly for reminding them to do things, etc.

In addition, because e-mail is so widespread, and it is easy and free to distribute a single message to many people, people experience information overload. Many people get hundreds of e-mail messages each day, many of them mere broadcasts of things for sale or events about to happen, much like classifieds in the newspaper. Efforts to use artificial intelligence techniques to block and/or sort incoming e-mail are of little success, mainly because it is difficult to specify exactly what people do and do not want to receive (Malone, Grant, Lai, Rao, & Rosenblitt, 1987;

Winograd, 1988). For example, it is hard to specify that all junk mail should be deleted; the system requires an enumeration of all the sources of junk mail. Those who are successful in dealing with this overload use primitive manual routines (Whittaker & Sidner, 1996).

Kraut et al. (1998) reported that greater Internet use, which in their sample was mostly e-mail, led to declines in social interactions with family members and an increase in depression and loneliness. Not surprising, these results triggered widespread discussion and debate, both over the substance of the results and the methods used to obtain them. Recently, Kraut et al. (in press) have reported new results that suggest these initial effects may not persist. Interpersonal communication is one of the principal uses of the Internet, and the possible implications of this kind of communication for social life is important to understand. Indeed, Putnam (2000) has wondered whether the Internet can be a source of social cohesiveness. These kinds of questions need to be addressed by additional large-scale studies of the kind conducted by Kraut and his colleagues.

Conferencing Tools—Voice and Video

Real-time meetings are among the more difficult situations to support at a distance. The most familiar technology to support remote meetings is video conferencing, where special facilities are linked by high bandwidth connections, and compatible camera/projection systems are required at all points to be connected. Although there is good new technology to support video and audio over Internet protocol (see VoIP, 2001, for details), it is still time consuming and confusing to set up a connection, and multipoint conferences require expensive multipoint conference units. For point-to-point conferencing, however, the units and connect time are inexpensive. The rise of the use of standards for conferencing, such as H323 (see OpenH323 Project, 2001, and H323 Information Site, 2001, for more details about this standard), is leading to important interoperability, much like that in e-mail and voice telephony.

Although the new systems allow less expensive connectivity, they are not all of the same quality, and some aspects of quality strongly affect the experience. High-quality audio is essential. Video is important for some cues about who is speaking and whose turn it is next (Veinott, Olson, Olson, & Fu, 1999). But, without immediate audio (less than a half second), conversational flow is severely disrupted. People with experience with these technologies will mute the audio channel that accompanies the videoconferencing (which typically has a delay of over a second) and make a second telephone call to connect the audio over more standard high-quality channels.

The other key feature of successful remote meetings is the ability to share the objects they are talking about: The agenda, the to-do list, the latest draft of a proposal, etc. More traditional videoconferencing technologies often offer an object camera, onto which the participants can put a paper agenda, Powerpoint slides, or a manufactured part. For digital objects, there are now a number of products that will allow meeting participants to share the screen or, in some cases, the operation of the actual application. NetMeeting is a current popular application for allowing remote participants to see and manipulate digital material at a remote location. Some companies are using electronic whiteboards, both in a collocated meeting and in remote meetings to mimic the choreography of people using a physical whiteboard. Furthermore, in some "collaboratories" (see later section), scientists can even operate remote physical instruments from a distance and jointly discuss the results.

A number of distributed organizations have adopted remote conferencing to coordinate their work, but not without consequences (Finn, Sellen, & Wilbur, 1997). A controlled comparison of high-quality videoconferencing with shared digital objects against collocated meetings with the good support for digital objects showed the quality of the work was the same. This is good news on the face of it. However, the remote groups are less satisfied with the process and outcome, perhaps because it requires more effort to organize the flow of work and more attention to understand the subtleties of the interactions (Olson, Olson, & Meader, 1995). Meetings with video, however, are much more preferred to those with audio only, even though the quality of the work is indistinguishable from meetings with video. In a related study, however, it was shown video was much more important (a much greater value over audio) for people who did not know each other or were from different cultures—a situation that is common in long-distance work (Veinott et al., 1999).

There is a strong tendency for video conferences to be quite formal and stilted. The easy flow of interaction that one finds in face-to-face or even telephone interactions are readily disrupted by any delays. Poor image quality makes it difficult to pick up expressions and gestures. Eye contact is especially difficult to make, because cameras are usually far from where the remote people are projected on the screen. In short, there are many details of how to configure video conferences to allow for more spontaneous, free-flowing interaction. Research is needed on which details really matter for a remote meeting's success.

Instant Messaging, Chat, and MUDs

Chat systems are like instant e-mail; people type typically short comments or questions to each other, and with the "send" button, the message is instantly shown on the other person's window. There is a trail of the conversation so far in both participants' windows so that people can keep track of the thread easily by scrolling back through recent history. A good chat system can feel like a conversation. Because most chat systems allow a number of participants, one might suspect that the conversation would get chaotic and be hard to follow. But people in chats have no more trouble following than those in a face-to-face meeting of the same number of participants, because the conversation is typically purposeful, the participants add a few more conversational cues, like naming the person or topic to which they are referring, and the recent history allows people to review the conversational threads (McDaniel, Olson, & Magee, 1996). An example of a chat session is shown later in Fig. 29.3.

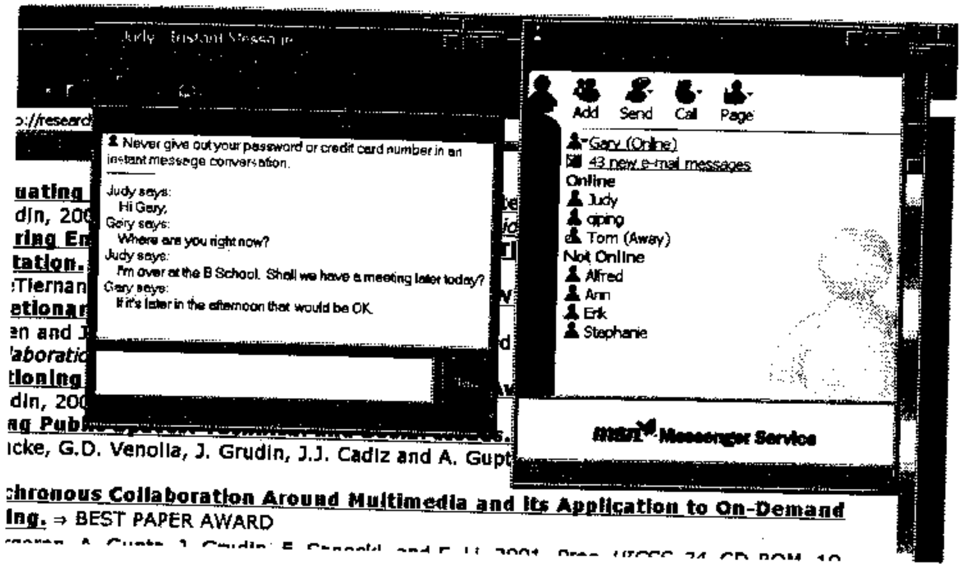

FIGURE 29.1. Example of instant messaging in action.

A more recent outgrowth of chat systems is a set of features collectively called "instant messaging." America On Line's Instant Messenger, ICQ ("I seek you"), Microsoft's Messaging System, and Jabber are all examples of popular current system. Once a participant registers on the system, they can explicitly permit specific others ("buddies") to see if they are on the system or not (or various states like "be right back"), and receive and send messages. Figure 29.1 shows an example of an instant messaging session. Nardi, Whittaker, and Bradner (2000) provide an account of how people in one organization used instant messaging in their work.

A different constellation of features surrounding the basic chat appears in MUDs and MOOs. The word MUD comes from the initial incarnation of this type if interaction in the game world, Multi-user Dungeons and Dragons. MOOs are object-oriented MUDs. The chats in MUDs are enhanced by various descriptions of places and things, some of which can be programmed to react to various actions of another participant. For example, instead of merely saying something, the participant can state, "Judy smiles." Judy could then leave behind a magic book that when picked up could open and state its secret message. Some people have picked up the room metaphor and object actions to be used in a work setting, with automatic announcements when people enter a meeting, agenda items being ticked off, etc. One MUD, Waterfall Glen, is one such work-related example in use at the Argonne National Lab (Churchill & Bly, 1999). Babble is a MUDlike system that can be useful for discussions and awareness of others' activities, in use by some groups at IBM (Erickson et al., 1999).

Instant messaging is growing very rapidly, and as of yet there is not much research on its spread, its use, and its effects. Much of the growth is driven by informal socializing, and in light of some early reports about the isolating tendencies of some Internet usage (Kraut et al., 1998), it would be especially important to look at the role that instant messaging might be playing in establishing and sustaining social relations.

COORDINATION SUPPORT

Meeting Support

In addition to video and audio conferencing to support the conversations of meetings, technologists have also attempted to use various groupware tools to help in supporting the process and the objects used in meetings.

Some meeting-support software imposes structure on the process of the meeting, embodying various brainstorming and voting procedures. Group Decision Support Systems (GDSSs) arose from a number of business schools, focusing on large meetings of stakeholders intent on going through a set series of decisions, such as prioritizing projects for future funding (Nunamaker, Dennis, Valacich, Vogel, & George, 1991). With the help of a facilitator and some technical support, the group was led through a series of stages: brainstorming without evaluating, evaluating alternatives from a variety of positions, prioritizing alternatives, etc. These meetings were held in specialized rooms in which individual computers were embedded in the tables, networked to central services, and summary displays shown center stage. Figure 29.2 shows an example of such a computer-supported meeting room. A typical scenario involved individuals silently entering ideas into a central repository, and after a certain amount of time, they were shown ideas one at a time from others and asked to respond with a new idea triggered by that one. Later, these same ideas were presented to the individuals who were then asked to rank or rate them according to some fixed criterion, like cost. Aggregates of individuals' opinions were computed, discussed further, and presented for vote. The system applied computational power (for voting and rating mechanisms), and networking control (for parallel input) to support typically weak aspects of meetings. These systems were intended to gather more ideas from participants, because one did not have to wait for another to stop

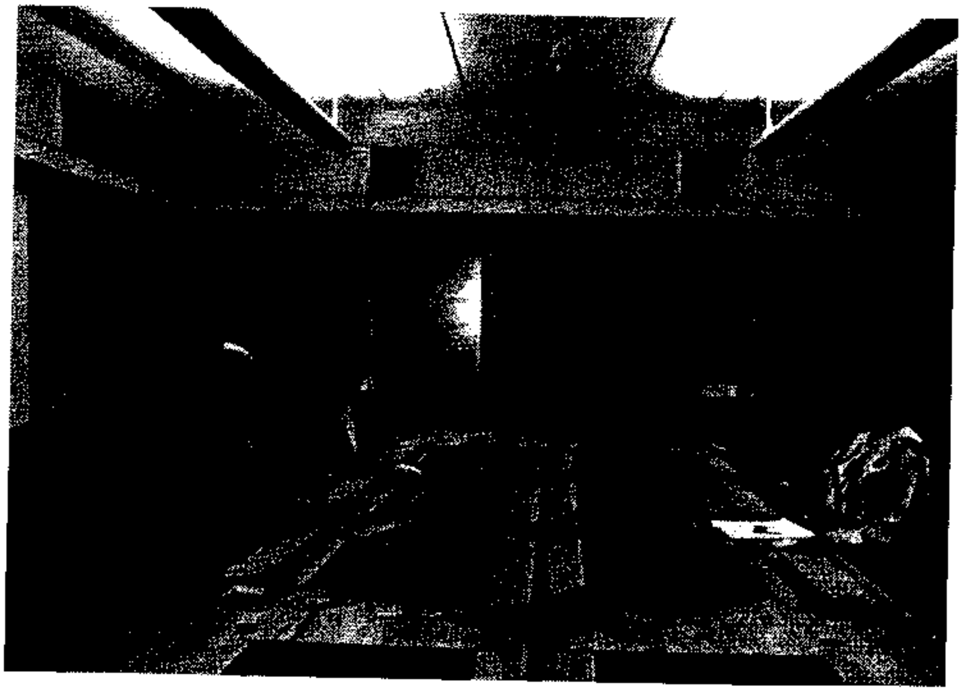

FIGURE 29.2. A computer-supported meeting room.

speaking to get a turn. Anonymous voting and rating were intended to ensure equal participation, not dominated by those in power.

Evaluations of these GDSSs have been reviewed producing some generalizations about their value (Hollingshead et al., 1993; Kraemer & Pinsoneault, 1990; McLeod, 1992). The systems indeed fulfill their intent in producing more ideas in brainstorming and having more evaluative comments because of anonymity. Decisions are rated as higher in quality, but the meetings take longer and the participants are less satisfied than those in traditional meetings.

A second class of technologies to support real-time meetings are less structured, more similar to individual workstation support. In these systems, groups are allowed access to a single document or drawing, and can enter and edit into them simultaneously at will. Different systems enforce different locking mechanisms (e.g., paragraph or selection locking) so that one person does not enter while another deletes the same thing (Ellis, Gibbs, & Rein, 1991). Some also allow parallel individual work, in which participants view and edit different parts of the same document, but can also view and discuss the same part as well. This kind of unstructured shared editor has been shown to be very effective for certain kinds of free-flowing meetings, like design or requirements meetings (Olson, Olson, Storrøsten, & Carter, 1993). The rated quality of the meeting products (e.g., a requirements document or plan) was higher when using these technologies than with traditional whiteboard or paper-and-pencil support, but like working in GDSSs, people were slightly less satisfied. The lower satisfaction here and with GDSSs may reflect the newness of the technologies; people may not have yet learned how to persuade, negotiate, or influence each other in comfortable ways—to harness the powers inherent in the new technologies.

These new technologies did indeed change the way in which people worked. They talked less and wrote more, building on each other's ideas instead of generating far-reaching others. The tool seemed to focus the groups on the core ideas, and keep them from going off on tangents. Many participants reported really liking doing work in the meetings rather than spending time only talking about the work.

A third class of meeting room support appears in electronic whiteboards. For example, the LiveBoard (Elrod et al., 1992), SoftBoard, and SmartBoard are approximately 4′× 6′ rear-projection surfaces that allow pen input, much the way a whiteboard or flipchart does. People at Xerox PARC and Boeing have evaluated the use of these boards in meetings in extended case studies. In both cases, the board was highly valued because of its computational power and the fact that all could see the changes as they were made. At both sites, successful use required a facilitator who was familiar with the applications running to support the meeting. At Xerox, suggestions made in the meeting about additional functionality were built into the system so that it eventually was finely tuned support for their particular needs (Moran et al., 1996). For example, they did a lot of list making of freehand text items. Eventually, the board software recognized the nature of a list and an outline, with simple gestures changing things sensibly. For example, if a freehand text item was moved higher in a list, the other items adjusted their positions to make room for it. The endproduct was not only a set of useful meeting tools, but also a toolkit to allow people to build new meeting widgets to support their particular tasks.

Meetings are important, although often despised, organizational activities. Laboratory research of the kind just reviewed has shown quite clearly that well-designed tools can improve both work outcomes and participant satisfaction. However, meetings in organizations seldom use such tools. Inexpensive mobile computing and projection equipment combined with many commercial products mean that such tools are within reach of most organizations. It is a puzzle for researchers to figure out why the adoption of effective tools has been so slow.

Workflow

Workflow systems lend technology support to coordinated asynchronous (usually sequential) steps of activities among team members working on a particular task. For example, a workflow system might route a travel reimbursement voucher from the traveler to the approving party to the accounts payable to the bank. The electronic form would be edited and sent to the various parties, their individual to-do lists updated as they received and/or completed the tasks, and permissions and approval granted automatically as appropriate (e.g., allowing small charges to an account if the charges had been budgeted previously or, simply if there was enough money in the account). Not only is the transaction flow supported, but also often records kept about who did what and when they did it. It is this later feature that has potentially large consequences for the people involved and will be discussed later.

These workflow systems were often the result of work re-engineering efforts, focusing on making the task take less time and to eliminate the work that could be automated. Not only do workflow systems therefore have a bad reputation in that they often are part of workforce reduction plans, but also for those left, their work is able to be monitored much more closely. The systems are often very rigid, requiring, for example, all of a form to be filled in before it can be handed off to the next in the chain. They often require a great deal of rework because of this inflexibility. It is because of the inflexibility and the potential monitoring that the systems fall into disuse (e.g., Abbott & Sarin, 1994).

The fact that workflow can be monitored is a major source of user resistance. In Europe, such monitoring is illegal, negotiated out of workflow by powerful organized workers (Prinz & Kolvenbach, 1996). In the United States, it is not illegal, but many employees complain about its inappropriate use. For example, in one software engineering team where workflow had just been introduced to track bug reports and fixes, people in the chain were sloppy about noting who they had handed a piece of work off to. When it was discovered that the manager had been monitoring the timing of the handoffs to assign praise or blame, the team members were justifiably upset (Olson & Teasley, 1996). In general, managerial monitoring is a feature that is not well received by people being monitored (Markus, 1983). If such monitoring is mandated, workers' behavior will conform to the specifics of what is being monitored (e.g., time to pass an item off to the next in the chain) rather than perhaps to what the real goal is (e.g., quality as well as timely completion of the whole process).

Group Calendars

A number of organizations have now adopted online calendars, mainly to view people's schedules to arrange meetings. The calendars also allow a form of awareness, allowing people to see if a person who is not present is expected back soon. Individuals benefit only insofar as they offload scheduling meetings to others, like to an administrative assistant, who can write as well as read the calendar. In some systems, the individual can schedule private time, blocking the time but not revealing to others their whereabouts. By this description, online calendaring is a classic case of what Grudin (1988) warns against, a misalignment of costs and benefits: The individual puts in the effort to record his/her appointments so that another, in this case a manager or coworker, can benefit from ease of scheduling. However, since the early introduction of electronic calendaring systems, many organizations have found successful adoption (Grudin & Palen, 1995; Mosier & Tammaro, 1997; Palen & Grudin, in press). Apparently such success requires a culture of sharing and accessibility, something that exists in some organizations and not others (Ehrlich, 1987; Lange, 1992).

Awareness

In normal work, there are numerous occasions where people find out casually whether others are in and in some cases what they are doing. A simple walk down the hall to a printer offers numerous glances into people's offices, noting where their coat is, whether others are in talking, whether there is intense work at a computer, etc. This kind of awareness is unavailable to workers who are remote. Some researchers have offered various technology solutions: Some have allowed one to visually walk down the hall at the remote location, taking a 5 s-glance into each passing office (Bellotti & Dourish, 1997; Fish, Kraut, Root, & Rice, 1993). Another similar system, called Portholes, provides periodic snapshots instead of full-motion video (Dourish & Bly, 1992). Because of privacy implications, these systems have had mixed success. The places in which this succeeds are those in which the individuals seem to have a reciprocal need to be aware of each other's presence, and a sense of cooperation and coordination. A contrasting case is the instant messaging system, in which the user has control as to what state they wish to advertise to their partners about their availability. The video systems are much more lightweight to the user but more intrusive; the IM ones give the user more control, but require intention in action.

Another approach to signaling what one is doing occurs at the more micro level. And again, one captures what is easy to capture. When people are closely aligned in their work, there are applications that allow each to see exactly where in the shared document the other is working and what they are doing (Gutwin & Greenberg, 1999). If one is working nearby the other, this signals perhaps a need to converse about the directions each is taking. Empirical evaluations have shown that such workspace awareness can facilitate task performance (Gutwin & Greenberg, 1999).

As mentioned previously, instant messaging systems provide an awareness capability. Most systems display a list of buddies and whether they are currently on line or not (see Fig. 29.1). Nardi and her colleagues (2000) found that people liked this aspect of instant messaging. Because wireless has allowed constant connectivity of mobile devices like personal digital assistants, this use of tracking others is likely to grow. But, again, there are issues of monitoring for useful or insidious purposes, and the issues of trust and privacy loom large (see Godefroid, Herbsleb, Jagadeesan, & Li, 2000).

Studies of attempts to conduct difficult intellectual work within geographically distributed organizations show that one of the larger costs of geographical distribution is the lack of awareness of what others are doing or whether they are even around (Herbsleb, Mockus, Finholt, & Grinter, 2000). Thus, useful and usable awareness tools that mesh well with trust and privacy concerns could be of enormous organizational importance. This is a rich research area for CSCW.

INFORMATION REPOSITORIES

Repositories of Shared Knowledge

In addition to sharing information generally on the web, in both public and intranet settings, there are applications, like Lotus Notes, that are explicitly built for knowledge-sharing. The goal in most systems is to capture knowledge that can be reused by others, like instruction manuals, office procedures, training, and boilerplate or templates of commonly constructed genres, like proposals or bids. Experience shows, however, that these systems are not easy wins. Again, similar to the case of the online calendaring systems described above the person entering information into the system is not necessarily the one benefiting from it. In a large consulting firm, where consultants were quite competitive in their bid for advancement, there was indeed negative incentive for giving away one's best secrets and insights (Orlikowski & Gash, 1994). An implementation of Lotus Notes failed here. In other organizations where such a repository has been successful, the incentives were better aligned.

Sometimes subtle design features are at work in the incentive structure. In another adoption of Lotus Notes, in this case to track open issues in software engineering, the engineers slowly lost interest in the system because they assumed that their manager was not paying attention to their contributions and use of the system. The system design, unfortunately, made the manager's actual use invisible to the team. Had they known that he was reading daily what they wrote (although he never wrote anything himself), they would have continued to use the system (Olson & Teasley, 1996). A simple design change that would make the manager's reading activity visible to the team would have significantly altered their adoption. In another similar case, sales people recorded their contacts with major clients in a repository. The incentive to share in this way was aligned with their goal to not embarrass themselves in overcontacting the client. Better yet would be a shared commission in cooperative sales.

The web of course provides marvelous infrastructure for the creation and sharing of information repositories. Lotus Notes itself is now widely used in its web version, Domino. Environments for sharing like Worktools (worktools.si.umich.edu) are built on top of Lotus Notes. Document management tools like WebEx make it easy to share in a web environment. Systematic research on the use of such improved tools is needed.

Capture and Replay

Tools that support collaborative activity can create traces of that activity that later can be replayed and reflected on. The Upper Atmospheric Research Collaboratory (UARC) explored the replay of earlier scientific campaign sessions (Olson et al., 2001), so that scientists could reflect on their reactions to real-time observations of earlier phenomena. Using a VCR metaphor, they could pause where needed, and fast forward past uninteresting parts. This reflective activity could also engage new players who had not been part of the original session. Abowd (1999) has explored such capture phenomena in an educational experiment called Classroom 2000. Initial experiments focused on reusing educational sessions during the term in college courses. We do not yet fully understand the impact of such promising ideas.

SOCIALITY

Social Filtering

We often find the information we want by contacting others. Social networks embody rich repositories of useful information on a variety of topics. A number of investigators have looked at whether the process of finding information through others can be automated. The kinds of recommender systems that we find on Web sites like Amazon.com are examples of the result of such research. The basic principle of such systems is that an individual will tend to like or prefer the kinds of things (e.g., movies, books) that someone who is similar to him/her likes. They find similar people by matching their previous choices. Such systems use a variety of algorithms to match preferences with those of others and then recommend new items. Resnick and Varian (1997) edited a special issue of the *Communication of the ACM* on recommender systems that included a representative set of examples. Herlocker, Konstan, and Riedl (2001) used empirical methods to explicate the factors that lead users to accept the advice of recommender systems. In short, providing access to explanations for why items were recommended seems to be the key. Recommender systems are emerging as a key element of e-commerce (Schafer, Konstan, & Riedl, 2001). Accepting the output of recommender systems is an example of how people come to trust technical systems. This is a complex topic and relates to issues like security that we briefly described earlier.

Trust of People Via the Technology

It has been said that trust needs touch, and indeed in survey studies, coworkers report that they trust those who are collocated more than those who are remote (Rocco, Finholt, Hofer, & Herbsleb, 2000). Interestingly, those who spend the most time on the phone chatting about non-work-related things with their remote coworkers show higher trust than those they communicate with using only fax and e-mail. But laboratory studies show that telephone interaction is not as good as face-to-face. People using just the telephone behave in more self-serving, less trusting ways than they do when they meet face-to-face (Drolet & Morris, 2000).

What can be done to counteract the mistrust that comes from the impoverished media? Rocco (1998) had people meet and do a team-building exercise the day before they engaged in the social dilemma game, with only e-mail to communicate with. These people, happily, showed as much cooperation and trust as those who discussed things face-to-face during the game. This is important. It suggests that, if remote teams can do some face-to-face teambuilding before launching on their project, they will act in a trusting/trustworthy manner. Zheng, Bos, Olson, Gergle, and Olson (2001) found that using chat for socializing and sharing pictures of each other also led to trustful relations. Merely sharing a resume did not.

Since it is not always possible to have everyone on a project meet face-to-face before they launch into the work, what else will work? Researchers have tried some things, but with mixed success. When the text is translated into voice, it has no effect on trust, and when it is translated into voice and presented in a moving human-like face, it is even worse than text-chat (Jensen, Farnham, Drucker, & Kollock, 2000; Kiesler, Sproull, & Waters, 1996). However, Bos, Gergle, Olson, and Olson (2001) found that interactions over video and audio led to trust, albeit of a seemingly more fragile form.

If we can find a way to establish trust without expensive travel, we are likely to see important productivity gains. Clearly, the story is not over. However, we must not be too optimistic. In other tasks, video does not produce "being there." There is an overhead to the conversation through video; it requires more effort than working face-to-face (Olson et al., 1995). Today's video over the Internet is both delayed and choppy, producing cues that people often associate with lying. One does not trust someone who appears to be lying. Trust is a delicate emotion; today's video might not just do it in a robust enough fashion.

INTEGRATED SYSTEMS

Media Spaces

As an extension of video conferencing and awareness systems, some people have experimented with open, continuous audio and video connections between remote locations. In a number of cases, these experiments have been called Media Spaces. For example, at Xerox, two labs were linked with an open video link between two commons areas (Olson & Bly, 1991), the two locations being Palo Alto, CA, and Portland, OR. Evaluation of these experiments showed that maintaining organizational cohesiveness at a distance was much more difficult than when members are collocated (Finn et al., 1997). However, some connectedness was maintained. Where many of these early systems were plagued with technical difficulties, human factors limitations, or very large communication costs, in today's situation, it might actually be possible to overcome these difficulties, making media a possibility for connecting global organizations. A new round of experimental deployments with new tools is needed.

Collaborative Virtual Environments

Collaborative virtual environments are three-dimensional embodiments of MUDs. The space in which people interact is an analog of physical space, with dimensions, directions, rooms, and objects of various kinds. People are represented as avatars, simplified, geometric, digital representations of people, who move about in the three-dimensional space (Singhal, 1999). Similar to MUDs, the users in a meeting situation might interact over some object that is digitally represented, like a mock-up of a real thing (an automobile engine, an airplane hinge, a piece of industrial equipment) or with visualizations of abstract data (e.g., a three-dimensional visualization of atmospheric data). In these spaces, one can have a sense as to where others are and what they are doing, similar to the simplified awareness systems described previously. In use, it is difficult to establish mutual awareness or orientation in such spaces (Hindmarsh, Fraser, Heath, Benford, & Greenhalgh, 1998; Park, Kapoor, & Leigh, 2000). There have even been some attempts to merge collaborative virtual environments with real ones, although with limited success so far (Benford, Greenhalgh, Reynard, Brown, & Koleva, 1998).

What people seem to want is more like the Holodek in Star Trek. These environments are complicated technically, and perhaps even more complicated socially. In real life, we have developed interesting schemes that trigger behavior and interpretation of others' behavior as a function of real distance, a field called "Proxemics" (Hall, 1982). Only when these subtle behaviors are incorporated into the virtual environment will we have a chance of simulating appropriate interhuman behavior in the virtual three-dimensional world.

Collaboratories

A collaboratory is a laboratory without walls (Finholt & Olson, 1997). From a National Research Council report, a collaboratory is supposed to allow "... the nation's researchers [to] perform their research without regard to geographical location—interacting with colleagues, accessing instrumentation, sharing data and computational resources [and] accessing information in digital libraries" (National Research Council, 1993, p. 7). Starting in the early 1990s, these capabilities have been configured into support packages for a number of specific sciences (see review in Finholt, in press). Figure 29.3 shows a screen dump from the Upper Atmospheric Research Collaboratory (Olson et al., 2001), in which space scientists have access to geographically remote instruments, as well as each other through a simple chat facility.

A number of companies have also experimented with similar concepts, calling them virtual collocation. The goal there is to support geographically dispersed teams as they carry out product design, software engineering, financial reporting, and

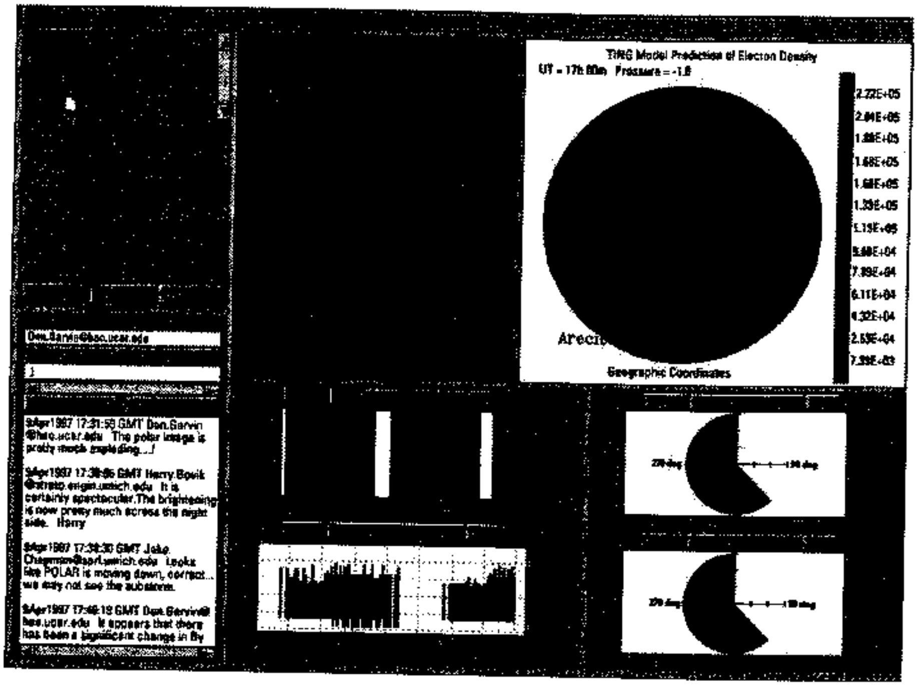

FIGURE 29.3. Screen dump from a collaboratory in upper atmospheric physics.

almost any business function. In these cases, suites of off-the-shelf groupware tools have been particularly important and have been used to support round-the-clock software development among overlapping teams of engineers in time zones around the world. (Carmel, 1999). There have been a number of such efforts, and it is still unclear as to their success or what features make their success more likely (Olson & Olson, 2000).

CONCLUSIONS

Groupware functionality is steadily becoming more routine in commercial applications. Similarly, suites of groupware functions are being written into operating systems. The prospect is that many of the functions we have described in this article will be ordinary elements of infrastructure in future-networked computing systems. There are still lots of issues for researchers to resolve.

Prognosticators looking at the emergence of groupware and the convergence of computing and communication media have forecast that distance will diminish as a factor in human interactions (e.g., Cairncross, 1997). However, to paraphrase Mark Twain, the reports of distance's death are greatly exaggerated. Even with all our emerging information and communications technologies, distance and its associated attributes of culture, time zones, geography, and language will continue to affect how humans interact with each other. Emerging distance technologies will allow greater flexibility for those whose work must be done at a distance, but we believe (see details in Olson & Olson, 2000) that distance will continue to be a factor in understanding these work relationships.

ACKNOWLEDGMENTS

Preparation of this chapter was facilitated by several grants from the National Science Foundation (Grants IIS-9320543, IIS-9977923, ATM-9873025, IIS-0085951, and cooperative agreement IRI-9216848). We are also grateful to several anonymous reviewers for helpful comments on an earlier draft.

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