43.1 Introduction

Computer-supported cooperative work (CSCW) is a field of research addressing the intersection of collaborative behaviors and technology. CSCW includes collaboration among a few individuals, within teams, within and between organizations, and within online communities that may span the globe. CSCW addresses how technologies facilitate, impair, or simply change collaborative activities. It is a broader field than the four words comprising its name suggest. Although its primary focus is on computer-supported activities, it encompasses collaborative activities that have not yet been but could be computer supported. Its focus is on collaboration, but not necessarily achieved through intentional cooperation. Collaborators may compete with one another or may not even be aware of each other. The field’s initial focus was on work-related activities, and this remains a topic of interest, but the scope includes collaboration in any area of human endeavor including games and social media.

43.2 Underlying Principles

Collaboration is the central issue in all CSCW research. The key challenge for both researchers and developers is to understand collaboration, how it is accomplished, and its impediments. Sometimes, these impediments include aspects of technologies intended to support it, potentially providing requirements for enhancements or suggesting new technologies.
43.2.1 Classes of Collaboration Context

How people collaborate depends on many aspects of their context. Classification models of collaboration context capture some of the features of this relationship. For example, people collaborate in real time and asynchronously, in the same location or different locations, and in small groups, organizations, or communities, as shown in Figure 43.1. Consider the collaborative activities likely to occur in each cell. A team or small group (typically less than seven people) may work together in a team room, collaborating in the same location at the same time by speaking to one another and by creating and sharing artifacts retained in the room. They are supported by technologies that facilitate small group, face-to-face interactions, such as digital projectors and meeting facilitation tools. Small groups may collaborate from different locations using collaboration technologies to communicate and share information with one another. A small group may work together at different times in a team room (same location, different times) by accessing or updating information posted in the room. A medical team providing patient care around the clock offers another example of collaboration in the same location at different times. A small group working together on a multiauthored paper produced by passing revisions back and forth is a familiar example of collaborating at different times and locations.

Larger groups form organizations to facilitate coordinated action across all members. Organizations typically contain many small groups that may collaborate in the ways described previously, but we should also consider how these groups collaborate with one another to achieve their common objectives. The collaborative activities of large organizations fall largely into two cells of the model in Figure 43.1. Organizational activities are rarely performed in a single location, because their size and missions demand geographic dispersion. Organizations are likely to engage in complex activities that require that groups work together in different locations at the same time and at different times, and coordinating these activities is the organizational challenge and their reason for adopting collaboration technologies. In a manufacturing organization, for example, collaboration focuses on the product, and group contributions to the product are coordinated by its development or construction plan and supporting technologies.

Communities are collections of people with common interests. Neighborhood communities are defined by their common location, but most communities are geographically distributed. Communities have no organizational structures, although they are often served by organizations that view the community as their marketplace. Collaboration within a community focuses on their common interest and requires little or no coordination. Consider, for example, the community of people interested in photography. Members of this community may seek or share photographs or information about photographic techniques at the same time (via presentations) or at different times. Organizations develop technologies that support sharing photographs while offering products and services to the photography community.

FIGURE 43.1 Classification model of three dimensions (time, place, and social unit) of collaboration context.
Each cell of Figure 43.1 constitutes a substantially different collaboration context, involving different collaborative activities and demanding different supporting technologies. This classification model describes three broad attributes of context (who, when, and where) that are relatively easily categorized. Other attributes of context such as the objectives of the collaboration are more difficult to categorize but no less important.

43.2.2 Categories of Collaboration Activities

The human activities involved in collaboration can be roughly described as communicating (e.g., speaking, writing, reading, listening), sharing information with one another (e.g., displaying a presentation, a map, a document, or other data), and coordinating (e.g., taking turns, sharing a resource, or performing different subtasks). Of course, these categories overlap and are tightly integrated; people may coordinate through speech and share information through both speech and written artifacts. People collaborating engage in all three categories of activity, shifting with little effort from one to another or combining them. Nonetheless, these categories are useful when thinking about technologies that support collaboration. Table 43.1 lists some well-known technologies or technology features that support each category of activities in both same-time and different-time contexts.

The temporal dimension shown in Table 43.1 is, of course, not the only aspect of context that influences use of these technologies. Communication is critically important within small groups, and most of the communication technologies listed in Table 43.1 are principally used by small groups, often just two people. Blogs and social networking sites are exceptions and are frequently used to communicate to a larger audience, perhaps a community of people with similar interests.

When small groups meet face-to-face, they may share information using meeting facilitation tools, a simple whiteboard, or a digital projector. When geographically distributed, small groups may share information using application-sharing technologies that allow everyone in the group to see and interact with the same information. Between meetings, they may store and access information managed by a document management system, shared folders, or a web-based team or project repository. Small groups may also use wikis to share information, but wikis are more widely known for their support of communities based on shared interests. Wikipedia is a prominent example of technological support for communities, not for small groups or organizations.

Small groups generally have little need for technologies that support coordination; they coordinate their activities by communicating and sharing information with one another. When geographically distributed, however, small groups may benefit from features of conferencing technologies that manage participation in a virtual meeting (session management) and limit participants’ interactions.

<table>
<thead>
<tr>
<th>TABLE 43.1 Example Technologies Used in Collaborative Activity Categories</th>
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<tbody>
<tr>
<td><strong>Communication</strong></td>
</tr>
<tr>
<td>• Telephone</td>
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<tr>
<td>• Videoconferencing</td>
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<tr>
<td>• Instant messaging</td>
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<td>• Texting</td>
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<tr>
<th>Information sharing</th>
<th><strong>Different Time</strong></th>
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<tr>
<td>• Whiteboard</td>
<td>• Document repositories</td>
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<tr>
<td>• Application sharing</td>
<td>• Websites</td>
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<tr>
<td>• Digital projector</td>
<td>• Team workspaces</td>
</tr>
<tr>
<td>• Meeting facilitation</td>
<td>• Wikis</td>
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<table>
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<tr>
<th>Coordination</th>
<th><strong>Different Time</strong></th>
</tr>
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<tbody>
<tr>
<td>• Floor control</td>
<td>• Workflow management</td>
</tr>
<tr>
<td>• Session management</td>
<td>• Computer-aided software engineering tools</td>
</tr>
<tr>
<td></td>
<td>• Project management</td>
</tr>
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<td></td>
<td>• Calendar scheduling</td>
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</table>
Using Information Systems and Technology to Support Individual and Group Tasks

(floor control). Social protocols accomplish these functions in face-to-face meetings, but in online conferences, these features prevent unwanted guests and facilitate turn taking. Small groups and communities have little need for technologies that help coordinate their different-time collaborations, but coordination is the principal challenge facing organizations. They invest in technologies that coordinate the collaborative work involved in designing, producing, and delivering their products and services such as computer-aided software engineering (CASE) tools, workflow management systems, and project management tools.

People collaborate for many purposes in different contexts and employing diverse collaborative activities. CSCW encompasses all these purposes, and collaboration technologies may be employed in any online collaborative activities. Small groups may use collaboration technologies to stay connected with distant team members, present ideas to a remote audience, generate ideas and make decisions in a group meeting, or play an online game. Organizations may use collaboration technologies to coordinate all aspects of their business, including production, delivery, and maintenance of their products. Communities may use technologies to discover others with shared interest, collect information about their interest, and provide community services.

43.2.3 Research Methods

The challenge in CSCW is to understand collaboration and how technologies can support it. Gaining this understanding is accomplished through research methods acquired from other disciplines that study human behavior such as psychology, sociology, and anthropology. Experiments in laboratories are of greatest value when designed to shed light on enduring properties of human behavior. For example, the experimental method has provided insights into the influence of visual display properties on trust and empathy during videoconferences (Nguyen and Canny, 2007, 2009) and the costs and benefits of communication between two collaborating people (Dabbish and Kraut, 2003, 2004).

The experimental method is less fruitful when studying complex collaborative activities such as software development, medical operations, or emergency responses. A researcher cannot randomly assign people to teams or treatments, and these contexts cannot easily be recreated in a laboratory setting. Instead, observational methods are employed, borrowing heavily from ethnography. Observers study and record team behavior, learning what team members do and how and why they do it in specific contexts. For example, Jackson et al. (2012) investigated maintenance and repair of the information and communication infrastructure in Nambia; Benford et al. (2012) investigated traditional Irish music making in pubs; and Pine (2012) investigated the coordination of care in the labor and delivery unit of a hospital. Observational research may identify opportunities for technological interventions, capture changes in behaviors during technology adoption, and reveal the effects (both positive and negative) of an implemented technology.

Both experimental and observational methods are inadequate for studies of large-scale online collaboration such as the construction and maintenance of Wikipedia. Participants in these collaborations are often anonymous, or at least unknown to the researcher, posing an obstacle to direct observation or controlled experimentation. These collaborations are, however, often prolific, and the products and traces of their production are accessible online. Methods for mining, analyzing, and interpreting the results of these collaborations are providing interesting insights. For example, Keegan et al. (2012) employed exponential random graph models (see Robins et al., 2007) to analyze and compare the coauthorship networks in Wikipedia of articles about breaking news and articles about contemporary and historical events. They found that the emergent organization of authors and editors of Wikipedia articles is influenced by attributes of both the editors and the article content, and editor experience is among the strongest influences. In addition to analyzing collaboration networks, mathematical methods may be employed to analyze content. For example, Al-Ani et al. (2012) employed topic modeling analysis (see Blei et al., 2003) to investigate the evolution of the content of blogs written in Egypt during the Egyptian
revolution. By using mathematical models such as these, researchers can identify relationships in large-scale collaborations similar to those that ethnographers would find in smaller scale collaborations.

43.3 Impact on Practice

Collaborating with the support of computers is widespread today in small groups, organizations, and communities, and the practice of CSCW continues to accelerate. Despite obvious progress over the past 25 years, CSCW research offers some lessons, some warnings, and some advice for collaborators and for developers of collaboration technologies.

43.3.1 Grudin’s Eight Challenges

In one of the most frequently cited articles in CSCW, Grudin (1994) listed eight challenges that continue to plague developers and users of collaboration technologies. These challenges are not technical problems; they arise from human psychology in social and organizational settings and may be avoided through thoughtful analysis of the collaborative context and careful design.

The first challenge is that users are reluctant to adopt a collaborative technology if the effort required outweighs the benefits they receive as individuals, regardless of the potential collective benefit. For example, employees have repeatedly resisted adopting time-tracking technologies despite their managers’ belief that the information will yield greater overall work efficiency. Technologies that require more effort from a person should return a benefit to that person.

The second challenge is to achieve a critical mass of users. If some people involved in a collaboration decline to adopt a technology, the advantages of the technology for all other participants may be undermined. For example, a distributed group I observed using videoconferencing to support long-distance meetings abandoned the technology because one person was uncomfortable facing a camera.

The third challenge is to avoid interfering with complex and subtle social dynamics of a group. Our actions are guided by social conventions and awareness of people and priorities, awareness that computers generally do not share. Knowledge of the usage context may be required to design an application or to guide its adoption in a way that does not disrupt existing communication channels, create uncertainty about where to find information, or challenge existing authority structures.

The fourth challenge is to allow exceptions to standardized work practices. Technologies intended to coordinate work activities often incorporate and enforce models of the work processes and cannot easily accommodate deviations from these models. An important contribution of CSCW ethnographic studies (Suchman, 1983; Sachs, 1995) is the observation that handling exceptions and unanticipated events is normal behavior in the workplace, and strict adherence to standard processes is a rare exception.

The fifth challenge for technology designers is that the collaboration features of a technology must be readily accessible although they may be infrequently used. The challenge for the users of the technology is to understand how to use these potentially unfamiliar features while collaborating with other people. There is a risk that people may feel uncomfortable revealing to their friends or colleagues their lack of expertise with the technology.

The sixth challenge, as developer or user, is to evaluate the technology reliably. The methods developed for evaluating a single-user technology, such as walkthrough analysis or laboratory studies, are of limited value when assessing how well a team, organization, or community is supported by a technology. Users face the same challenge when choosing between technology alternatives. Evaluations of collaboration technologies generally take much longer to achieve a comparable level of reliability.

The seventh challenge is a breakdown in the intuitive decision-making process that normally guides product development and acquisition. These decisions are generally made by development or IT managers based on their informed intuitions regarding the strengths and weaknesses of alternatives.
Managers’ expertise in an application domain may be a solid foundation for intuitive decision-making, but they are unlikely to have expertise in all the aspects of group dynamics that influence the success of a collaboration technology.

The eighth and final challenge is to manage the adoption of collaboration technologies. There is substantial risk of failure when a new collaboration technology is developed or acquired because of the pitfalls posed by the preceding seven challenges. Success requires that all the participants in a collaborative activity adopt the technology together, and this is unlikely to occur without careful planning.

### 43.3.2 Adoption of Collaboration Technologies

Grudin (1994) noted the challenge of managing adoption of collaboration technologies. The scope of this challenge and methods for addressing it depend on attributes of the collaboration context. For example, technologies intended to support small group, organizational, and community collaboration face very different challenges.

#### 43.3.2.1 Adoption by Small Groups

Mark and Poltrock (2003, 2004) studied the adoption of desktop conferencing (sometimes called data conferencing) by geographically distributed teams in a large corporate setting. In this case, the technology was successfully adopted without a top–down management plan, but the diffusion process was slow and painful. Adoption was driven by users who recognized the benefits of the technology, demonstrated it to their coworkers, and helped each other learn to use it. Employees were often in one or more geographically distributed teams, and each such team constituted a social world. Information about the technology was communicated across social worlds, and people wanting to participate in a social world found that they needed the technology to be a successful contributor. The technology diffused rapidly across some parts of the company, but the managers of other parts considered this new technology to be a risk to network reliability and actively opposed its adoption. To function effectively, team members must uniformly adopt the technology, but people are members of multiple social worlds, and the active resistance of management in some social worlds created conflict and tensions. Eventually, the benefits of the technology were widely recognized, it was adopted by executive management, and resistance faded away, but the adoption process was long and painful for some individuals.

#### 43.3.2.2 Adoption by Organizations

The primary challenge of organizational collaboration is the coordination of work activities. Workflow management systems, or product-focused tools with workflow management features, are often acquired for the purpose of coordinating the contributions of many distributed groups within an organization and sometimes across organizational boundaries. Acquisition and deployment of these systems are generally a substantial investment requiring top–down planning and integration with other tools and infrastructure. Unfortunately, these implementations are often unsuccessful (Bowers et al., 1995; Kingsbury, 1997) due to social and organizational factors that lead to adoption challenges.

Workflow management systems contain explicit representations of work processes and are intended to facilitate these processes by managing the transfer of work products from one person or group to another as tasks are completed. A promised benefit of these systems is that the defined work processes must be consistently followed, but the difficulty of defining stable work processes is a fundamental problem. Suchman (1983) asked members of an accounts payable organization to describe their processes, and she received a textbook explanation. When she observed their work, however, no single instance of their work followed the processes they had described. She distinguished between their plan (their documented process) and their procedures situated in the context of a particular process instance (Suchman, 1987). People engage in considerable problem-solving to ensure that the work complies with the expected results of the overall plan, but they accommodate the circumstances that are unique to each work instance.
Ishii and Ohkubo (1990) developed a workflow modeling and automation technology for office work and encountered this same problem. They successfully built a technology capable of managing the flow of work, but found that people did not consistently perform their work in accordance with the process they had described.

I participated in the design, deployment, and evaluation of several workflow management applications intended to support an engineering design organization. The organization employed a small staff of coordinators who acted as human workflow management engines; they collected the results of each task, delivered it to the next person or group, reminded people of incomplete tasks and deadlines, and kept track of each work instance. The workflow management applications were intended to perform much of this work, reducing the number of human coordinators required to manage the work. These coordinators were experts in the work processes, but nonetheless were unable to describe them accurately and completely.

A purported advantage of workflow management systems is the ease with which process models can be revised, achieving some degree of flexibility. Instead, the workflow applications that I helped deploy were inherently and unavoidably less flexible than the human-powered systems they replaced. Suppose the organization decided to revise a work process. A process facilitated by a human coordinator using e-mail and office documents can be changed by simply updating the process documentation and informing everyone about the revisions. The human coordinator would monitor the outcome, resolve any short-term problems, and propose additional revisions if any lasting problems are identified. But a workflow application is much more than a simple description of the process flow. Developing a workflow application requires modeling the data that will be managed in the workflow, defining the process rules, and developing the user interface required to view and edit the process-related data. It requires the same software development rigor as any other application development, and in this organization, all changes to software required thorough testing and release on a schedule coordinated with all other applications. If the revised processes create unexpected problems, there are no simple ways to make short-term adjustments, and further process revisions require another cycle of development and testing.

Even when processes remained stable, workflow management systems could not provide the flexibility offered by human coordinators. The workflow system sent e-mail messages to alert or remind people about tasks, and it provided lists of incomplete tasks. In contrast, coordinators alerted and reminded people in many ways, exploiting their knowledge of the individuals responsible for the tasks. An e-mail message was sufficient for some people, but coordinators knew who had an overflowing inbox and would be more receptive to a phone call or a personal visit. They knew when someone was on vacation and who was authorized as a substitute. To continue providing these services after the workflow management system was implemented, the coordinators continued to track all processes in spreadsheets, duplicating the information in the workflow system (Handel and Poltrock, 2011).

Achieving flexibility in workflow management applications remains an active area of research (Pesic and van der Aalst, 2006). Human coordinators could provide flexibility in many ways that exceeded the capacities of a workflow management system. Of course, human coordinators are expensive, and organizations may choose to adopt a workflow management system to avoid that cost, but these savings must be weighed against the costs of developing and maintaining a workflow management system.

43.3.2.3 Adoption by Communities

In striking contrast to the coordination demands of organizations, communities have little need for coordination technologies and primarily need tools for sharing information. An abundance of online social media services are aimed at addressing the needs of various communities. These include photograph (or other image) sharing sites, wikis devoted to topics of interest to specific communities, marketplaces where items can be bought and sold, and websites devoted to specific crafts, hobbies, or intellectual interests.

For the developer of such a technology, the first adoption challenge is to inform members of the target community about the opportunity offered by the technology. Early adopters may be found by
visiting places where community members may gather in the real world or through existing organizations that support the community. The second challenge is to persuade potential adopters that the technology offers a value greater than its cost. Many community services address the cost side of this challenge by offering their services for free. The third challenge is to attract additional members of the community and engage them in active use of the technology such that it becomes indispensable. Social media technologies often address this challenge by encouraging users to invite their friends, often using their e-mail address books or other lists of contacts. Of course, such a technology service must have some source of income, and it may solicit charitable giving from the community or advertise products of interest to that specific community. Consider, for example, the community of postage stamp collectors. This community has constructed an excellent summary of stamp collecting in Wikipedia, including links to other online sources. One of these sources (learnaboutstamps.com) is sponsored by the U.S. Postal Service and the American Philatelic Society, among other organizations. This society’s own website invites charitable contributions to support the community and includes an online marketplace where its members can buy and sell stamps.

These examples illustrate the challenges that both developers and users may encounter with technologies intended to support collaboration within small groups, organizations, or communities. Note that all the challenges have their roots in human behavior, not in the limitations of technologies. Collaboration is a social activity, and social practices can be leveraged to achieve extraordinary success or become obstacles that impede technology adoption.

### 43.4 Research Issues

CSCW research can be roughly divided into two large categories, one focused on understanding collaboration and how technology influences it, and the other focused on the computer science challenges involved in supporting collaboration. Jacovi et al. (2006) presented empirical evidence for this categorization. They analyzed the citation graph of all 465 papers presented at CSCW conferences between 1986 (the first conference) and 2004. They identified eight clusters, of which the two largest correspond roughly to social science and computer science. The social science cluster included papers about theories and models, ethnography, collocated teams, organizational memory, awareness, and user studies such as studies of adoption. The third largest cluster included meeting/decision support, shared media spaces, and conferencing. A fourth cluster included papers on instant messaging, presence, and social spaces. Smaller clusters included papers on the use of computer tools in the workplace, groupware design and workspace awareness, management of computing and information systems, and video-mediated communication and shared visual spaces.

Convertino et al. (2006) analyzed the same 465 research papers, categorizing each paper by type of institutional affiliation, author’s geographical location, its level of analysis (individual, group, or organization), type of contribution (theory, design, or evaluation), and type of collaboration function investigated (communication, coordination, or cooperation). About 80% of the papers were about small group collaboration and nearly all the rest had an organizational focus. Research on community collaboration emerged as an important theme after the years from 1986 to 2004 covered by these analyses. Most papers contributed to either design (corresponding roughly to the computer science cluster of Jacovi et al., 2006) or evaluation (corresponding to the social science cluster). Contributions to theory were frequent at the first three conferences (about 30% of papers) but then declined to fewer than 10%. Grudin and Poltrock (2012) attributed this decline to the departure of the Management Information System (MIS) community from the conference, a departure driven by decisions to archive ACM conference proceedings and establish high-quality standards and high rejection rates for conferences. In many research communities, including MIS, researchers may present their work in progress at conferences and reserve their highest quality work for publication in journals. Indeed, the MIS community continued its active research in group support systems (e.g., research in collaboration engineering such as Kolfschoten et al. 2006) and organizational collaboration in business settings (e.g., business process...
management research). This research can be found in the *Proceedings of the Hawaii International Conference on Systems Science* and published in various Information Systems Journals.

This chapter does not address the challenging computer science issues in CSCW. It focuses, instead, on research seeking to understand collaboration and how technology influences it when collaboration takes place in small groups, organizations, and communities.

### 43.4.1 Small Group Collaboration—Videoconferencing

About 80% of the research presented at CSCW conferences between 1986 and 2004 explored aspects of small group collaboration (Convertino et al., 2006). Researchers have investigated ways to support small groups in face-to-face meetings and when they are geographically distributed. They have explored meeting or decision-support technologies, communication technologies, and ways to share information. This chapter focuses on videoconferencing, a form of small group communication that has been intensively studied in many ways over many decades.

Videoconferencing supports integrated and synchronized visual and audio communication. It is an old technology that has become dramatically more usable and affordable in recent years. In 1878, du Maurier created a cartoon of a Telephonoscope that would transmit both sound and images bidirectionally. In 1927, when Herbert Hoover was US Secretary of Commerce, he used a videoconference system in Washington to communicate with AT&T President Walter Gifford in New York. This, of course, was a prototype system, but AT&T continued pursuing the idea, developed the Picturephone in the 1950s, and launched the commercial Picturephone product in 1970. The technology was a commercial failure, but telephone companies continued to research and develop videoconferencing technology, and some of their research is included in the CSCW literature. Nonetheless, adoption of videoconferencing was surprisingly slow. Throughout the twentieth century, it was little used outside research labs and in some government and industry settings that required long-distance collaboration.

Improvements in videoconferencing and network technology have dramatically enhanced its quality and reduced its cost. This long history of improvements, including integration of videoconferencing with computers and their networks, has generated repeated resurgences of interest in videoconference systems. Engelbart and English (1968) demonstrated videoconferencing, including overlays of video and data, in their groundbreaking research exploring how computers could augment human intellect. Despite this steady stream of improvements, adoption of videoconferencing remained slow until recently. Today, many executives have personal videoconference systems on their desks, consumers use Skype’s features to communicate with friends and family, and cameras are built into computers and mobile phones. The ability to communicate both visually and auditorily seems intuitively appealing, and its slow adoption despite improved performance and declining cost posed a puzzle that attracted many researchers.

At the second CSCW conference, Egido (1988) reviewed reasons for the failures of videoconferencing. She noted that forecasts in the early 1970s predicted that 85% of all business meetings would be electronically mediated by the end of that decade. But, when her paper was written in 1987, only about 100 videoconferencing facilities existed worldwide, and many of those were located in the offices of teleconferencing vendors and telecommunication companies. Egido argued that two factors were responsible for the low rate of videoconferencing adoption. The first factor was the inadequacy of needs-assessment methodologies, which were largely based on surveys at that time, with the consequence that technologies were not designed appropriately for the contexts in which they would be used. The second and closely related factor was the portrayal of videoconferencing as a direct replacement for face-to-face meetings. It does not provide the same opportunities for interpersonal interactions that occur in business meetings, and many years of research have found no decrease in face-to-face meetings when videoconferencing is available. Egido concluded that videoconferencing may be an attractive (if expensive) communication option in many situations, and research should focus on understanding communication tasks in the office environment and how such a technology could best support it.
At the same conference, Robert Root (1988) followed Egido’s advice and proposed a system called CRUISER based on a thoughtful analysis of office communication patterns. Root observed the importance of frequent, low-cost face-to-face interactions in which both technical and personal information can be exchanged quickly and easily. He designed CRUISER to support social interaction in office environments that are geographically distributed, providing easy, convenient access to other people regardless of their physical location. Its users were able to stroll (metaphorically) down a virtual office hall, peek into virtual offices via videoconferencing, and stop to chat for a while if the office occupant was available. Note that this research involves an analysis of a social context, identification of the technology requirements to support collaboration in this context, and a proposed system intended to address these requirements. There is, of course, a big gap between a technology proposal such as this one and the development of a successful system that meets all the requirements and integrates seamlessly into the social environment.

Root and his colleagues implemented and evaluated CRUISER in a research and development laboratory (Fish et al., 1992). CRUISER was essentially a videoconferencing system with full-duplex audio, but it included three novel ways to initiate conversations: (1) cruises opened an immediate videoconference connection to a called party that timed out after 3 s unless the recipient explicitly accepted it, (2) autocruises initiated 3 s calls between selected users at random times that were extended only if both parties accepted it, and (3) glances opened a one-way video-only connection to the recipient’s office that lasted only 1 s. Observations of how people used this system were enlightening about the challenges facing videoconferencing developers. CRUISER metrics indicated that the cruise feature was used much more than a glance, and autocruises were rarely used. Videoconferences initiated by the cruise feature were short, rarely lasting more than a few minutes, and were primarily used to schedule a face-to-face meeting or for status reporting. People frequently used it to see whether someone was present and available, and then arranged to visit them. But the sudden onset of the cruise or glance connection was perceived as intrusive, disruptive, and an invasion of privacy. Its developers had hoped to recreate the opportunities for informal social interaction that occur when walking between offices, but CRUISER’s interaction methods were very different from the methods that people use when meeting one another face-to-face.

CRUISER was among the first of many systems developed to explore novel ways to establish videoconferences quickly and easily while respecting privacy (Cool et al., 1992; Tang et al., 1994). Researchers reasoned that persistent dissatisfaction with videoconferencing could, in part, be due to the clumsy process of starting and ending contact, a process that Tang (2007) termed contact negotiation. Members of a collocated team can easily see when other team members are busy or available, and they can easily negotiate contact with one another. Dourish and Bly (1992) developed Portholes to provide similar awareness of availability to distributed teams. Portholes displayed thumbnail images of team members from cameras in their offices, offering a quick and current view of who was present and available. Clicking on one of the thumbnail images in later versions of Portholes brought up a menu of communication options including videoconferencing (Lee et al., 1997). Systems such as Portholes facilitate awareness and contact negotiation but again raise concerns about privacy. Many people feel uncomfortable with the idea of being continuously visible via a camera image, even though they may be continuously visible to others in an open office environment. Tang (2007) reviewed research investigating alternative approaches to negotiating contact, concluding that the essential cognitive and social cues could be conveyed via text and icons instead of attempting to recreate sensory cues through video. His research demonstrates an approach that may successfully avoid the experience of an invasion of privacy.

While some researchers focused on simplifying contact negotiation, others questioned the benefits provided by video. The book Video-Mediated Communication (Finn et al., 1997) included 25 papers by noted researchers in the field exploring these benefits. To a great extent, these papers confirmed the findings of earlier studies that the addition of video to audio communication does not improve collaborative problem-solving. Furthermore, many people have stated informally that they do not want to see or be seen by the person with whom they are speaking while discussing business. This has been a
disappointment to the telecommunication and network companies that hoped widespread adoption of videoconferencing by US industry would drive an increase in demand for bandwidth.

More recent research suggests that there are benefits of adding video to an audio communication channel, but the benefit is not better collaborative problem-solving. Williams (1997) found that video led to improved conflict resolution in stressful communication conditions, such as when two people with different native languages must negotiate in English. In three-way videoconferences (between three different locations), video showing both remote participants simultaneously (spatial video) helped people keep track of their three-way conversations and yielded higher quality conversations in the judgment of the participants (Inkpen et al., 2010). Video also provides a way that people can collaborate on a physical task, but in these situations the cameras are focused on the task and not the people (Kraut et al., 1996). Indeed, in some situations video can be a distraction and impair performance. Pan et al. (2009) presented English clips to Chinese students and tested their comprehension. The students achieved better comprehension with audio alone than with audio plus video.

Although the benefits of adding video to an audio conference are difficult to quantify, many people clearly enjoy the experience more. Even the studies that found no benefits (Finn et al., 1997) reported that participants liked seeing one another and believed that they had achieved a better solution, despite the objective evidence that they had not. This observation has led some researchers to explore emotional or affective consequences of videoconferencing.

One reason that people meet face to face is to establish a relationship and level of trust that will sustain their collaboration when geographically distributed. If videoconferencing is intended to replace face-to-face meetings, then its support for developing trust is important. Bos et al. (2002) studied the effects of four computer-mediated communication channels on trust development: face-to-face, audio, audio plus video, and text chat. They measured trust between three people using a game that poses a social dilemma. To cooperate, they must trust one another, and consequently their success in the game can be considered a measure of the trust within the group. Groups in the face-to-face condition began cooperating quickly; groups in the text chat condition never learned to cooperate; and both the audio groups and the audio plus video groups eventually learned to cooperate, but continued to experience defections throughout the game. These results suggest that communication mediated by technology does not support an awareness of the presence of others as effectively as face-to-face meetings.

The failure of videoconferencing to support development of trust posed a challenge to researchers in this field. Nguyen and Canny (2005, 2007) took up this challenge and investigated whether it was a social consequence of the breakdown of eye gaze awareness, which is disrupted in videoconferencing because camera lenses are not located where the eyes are displayed. They developed a group videoconferencing system that provides spatially faithful eye gaze awareness and studied the development of trust in three conditions: face-to-face meetings, their spatially faithful videoconference system, and a similar system with conventional nonfaithful displays. Like Bos et al. (2002), they indirectly measured trust via performance in a game that poses a social dilemma. They found that game performance and thus trust were essentially equal when people met face-to-face or when using the spatially faithful videoconferencing system, but was lower and more fragile when using the conventional system. These results suggest that eye gaze awareness and mutual gaze may contribute to the development of trust.

Many studies have found that face-to-face encounters are superior to videoconferences in establishing trust or feeling that a conversation is natural. Reconsidering the implications of their own research, Nguyen and Canny (2009) noted that even studies with mutual gaze awareness had found substantial and consistent differences between face-to-face interactions and videoconferencing. They hypothesized that eye gaze awareness was not the sole reason that they had found equal development of trust in face-to-face and video conditions. Instead, they proposed that video framing had played an important but unnoticed role. Videoconferencing equipment is usually configured to show only the heads or the heads and shoulders of participants, and most commercial videoconferencing systems (including laptop computers) are similarly configured. Nguyen and Canny’s system, however, was configured to display the entire upper body at life size. In typical videoconferences, the main
Using Information Systems and Technology to Support Individual and Group Tasks

nonverbal channels of communication are facial expression and gaze, but their system had added
three additional nonverbal communication channels: posture, gesture, and proxemics.

Nguyen and Canny (2009) conducted an experiment in which two participants talked for 20 min in
one of three conditions: (1) face-to-face seated across a table from one another, (2) in a videoconference
with a life size view of the other participant's upper body, or (3) in a videoconference with the same
equipment but masked so that they could see only the face of the other participant. Near the end of
the experiment, one of the two participants was asked to assist the experimenter by entering the room
with the other participant and pretend to accidentally drop some pens. Nguyen and Canny reasoned
that the other participant would be more likely to help pick up the pens if the two participants had
indeed established empathy during their 20 min conversation. The experimenter measured whether
the other participant helped pick up the pens and the time until the participant initiated that behavior.
There were no significant differences in measures of empathy or the pen-drop experiment between
the face-to-face meeting and the videoconference showing the whole upper body, but the two videocon-
ferencing conditions were strikingly different. When participants viewed only the face, their ratings of
empathy were lower; they were less likely to help pick up pens, and they were much slower to pick up
pens. These results are strong evidence that a videoconference showing the whole upper body at life size
will yield better nonverbal communication and more effectively support development of empathy than
a videoconference showing only the face.

Today, video cameras are integrated in laptop computers and mobile telephones, and videocon-
ferencing services that use these cameras are freely available. Although videoconferencing is freely
available, its adoption remains much lower than other prominent communication technologies such
as telephones, e-mail, and text messages. Researchers have identified key barriers to adoption and
pointed the way to solutions. Nguyen and Canny's results tell us that videoconferences will be com-
petitive with face-to-face meetings if they display the whole upper body and achieve good eye gaze
awareness, and high-end or immersive commercial systems have adopted this framing recommen-
dation. Contact negotiation in most commercial systems is modeled on a telephone calling interface,
but researchers have evaluated other approaches that offer promising improvements in the video-
conferencing experience.

43.4.2 Organizational Collaboration

Organizational collaboration occurs when two or more groups work together, requiring coordination
of their mutual efforts. As described earlier, workflow management technologies provide coordination
mechanisms intended to support organizational collaboration. Workflow management systems typi-
cally contain an explicit, editable model of work processes, and they pass work artifacts and assignments
from person to person (or group to group) in accordance with this model.

Although workflow management is widely used in some industries, its value has been controversial
in the CSCW research community. During the early years of CSCW, some researchers were optimis-
tic about the potential for aiding collaboration through development and implementation of formal
models that both described and guided the work. Winograd and Flores' (1986) explorations of the
conversation-for-action analysis method inspired novel approaches for modeling work processes and
using these models to coordinate work (Medina-Mora et al., 1992; De Michelis and Grasso, 1994).
Suchman (1994) criticized these technologies on two grounds. First, the technologies embody a cat-
ergization scheme and impose this scheme on its user community, displacing their own preexist-
ing categories for describing their work. Second, a workflow system that mediates all work activities
amounts to an oppressive disciplinary regime and is politically repugnant. Winograd (1994) responded
to these criticisms, explaining that the categorization schemes used in workflow management are not
intended to serve as models of language but as structures that support unambiguous communica-
tion across organizational boundaries, and that workflow systems need not be oppressive. This debate
essentially ended contributions to workflow management research within the CSCW community, with
the exception of approaches intended to increase flexibility and give greater control of the work process to the user community (e.g., Dourish et al., 1996).

Research in organizational collaboration is principally found in management journals and conference proceedings, but some threads continue to find an audience within the CSCW community. Researchers have explored the flow of information within organizations, investigating properties of organizational memory (Ackerman and Halverson, 1998) and the role of social network systems in organizational acculturation, which is essential to successful organizational collaboration (Thom-Santelli et al., 2011). Balka and Wagner (2006) studied how technology is appropriated within organizations, focusing on the configurations required to make new technologies work successfully. One generally thinks about configuring the technology itself, but they noted that new technologies may require configuring organizational relations, space and technology relations, and the connectivity of people, places, and materials. Similarly, Lee et al. (2006) proposed expanding the concept of cyberinfrastructure to include the associated human infrastructure (people, organizations, and networks) as a way to bring into focus some of the factors that are critical to a successful cyberinfrastructure program.

Recent work in organizational collaboration has focused on domains or settings of special interest such as insurance, hospitals, and nonprofit enterprises. Painter (2002) studied the adoption of a new electronic claim file system in a health insurance program and its effects on collaboration. Abraham and Reddy (2008) studied coordination between clinical and nonclinical staff in the patient transfer process of a hospital, focusing on failures of information sharing and the reasons for these failures. Le Dantec and Edwards (2008) compared two nonprofit homeless outreach centers and found that differences in their organizational structures and composition were tightly coupled to differences in their use of information and communication technologies. Many workers in these settings are volunteers who do not receive much training in organizational processes or its technologies, offering both an opportunity and a challenge for coordinating technologies such as workflow management. Stoll et al. (2010) examined coordination across multiple nonprofit organizations seeking to help the victims of human trafficking. Their work highlights structural, technological, and organizational factors that challenge nonprofit organizations seeking to employ technologies that are widely used in the for-profit world.

43.4.3 Community Collaboration

In recent years, the CSCW research community has grown increasingly interested in collaborations that occur within communities, especially online communities. The participants in these collaborations are not members of the same teams or organizations. Often, they do not know one another. Nonetheless, online community collaborations have yielded impressive results, as exemplified by Wikipedia. Researchers seek to understand who participates in these communities, why they do it, how they become informed members of the communities, how their collaborations are structured or organized, and how their participation evolves over time.

Not surprisingly, the most frequently studied online community collaboration is the production and maintenance of the Wikipedia online encyclopedia. This research is important because the encyclopedia is massive and widely used. The Wikipedia system indirectly supports this research by saving all contributions by authors and editors online where researchers can readily access it.

Bryant et al. (2005) were among the first to study contributions to Wikipedia, and the first of several to focus on how people became active editors of Wikipedia. They interviewed nine people who frequently edit Wikipedia pages. They described their results using activity theory in which the building blocks are objects, subjects, community, division of labor, tools, and rules. They described the evolution from a novice editor to an expert Wikipedian as a transformation in each of these six areas. For example, editors develop a feeling of membership in a community while learning the community’s rules and tools.

Of course, most users of Wikipedia only read articles and never contribute to an article. Antin and Cheshire (2010) ask why people contribute to Wikipedia when they could gain its benefits by just reading it without the work of writing and editing it, and then suggest that readers would also like to contribute
but do not because they do not know enough about the system to feel ready to do it. They argue that reading is a form of legitimate peripheral participation, a category of behavior that provides a pathway to learn about the Wikipedia community and its environment. This is not, however, the only reason that people choose not to contribute. A survey of more than 40,000 users of Wikipedia explored reasons for not contributing, focusing on why so few women (less than 15%) are contributors (Collier and Bear, 2012). They found that women were less likely than men to feel confident in their expertise and the value of their contribution, they were more likely to feel uncomfortable with the high level of conflict involved in the editing process, and they were less likely to feel comfortable editing another person’s work.

The distribution of contributions to Wikipedia follows a power law, with most people making very few edits. Antin et al. (2012) studied the factors that distinguish between people who make many edits and those who make few edits. They found that early diversification into multiple kinds of editing activities is strongly predictive of more editing behaviors later, people continue to engage in the same kinds of activity patterns over time, and early diverse editing behaviors are associated with later organizational and administrative behaviors.

Contributors to Wikipedia interact not only with the content but also with one another. Choi et al. (2010) studied socialization of new members in WikiProjects, which are topic-centric subgroups of Wikipedia contributors that improve coverage in a particular domain. They studied the messages written to newcomers by existing project members and identified types of socialization tactics. Using correlational analyses, they found that more socialization messages were associated with more editing behavior by the newcomers. They performed trace ethnography, a method that generates a rich account of interactions by combining a fine-grained analysis of automatically recorded editing traces with an ethnographically derived understanding of the sources of these traces.

Millions of people rely on Wikipedia as a source of information, and the quality of its content has been widely discussed. Researchers have explored how this high quality is achieved and how attempts to undermine its content, such as vandalism, are thwarted. Arazy and Nov (2010) found that communication and coordination between contributors increased quality and that editors who contribute to many topics in Wikipedia yield higher quality. Geiger and Ribes (2010) described the work involved in countering acts of vandalism in Wikipedia as an instance of distributed cognition in which the task is distributed across people and software tools. Keegan and Gergle (2010) studied the emergence of a new information-control role they call one-sided gatekeeping. They found that elite editors of the In The News section of Wikipedia were able to block inappropriate news items effectively, acting as gatekeepers, but their gatekeeping was one-sided because they were not more effective at promoting a proposed news item.

This research illustrates the questions and approaches asked about participants in online communities. Studies of Wikipedia have focused on contributors to its contents more than readers of the content, viewing the contributors as the most active members of the communities. The primary questions involve who is contributing, why some contribute more than others, and how content quality is achieved. Research methods include interviews and surveys, but new methods have emerged that integrate these traditional methods with large-scale statistical analyses of online data. The understanding that emerges from this research may suggest tools and methods for improved support to large-scale collaborations.

43.5 Summary

This chapter has selectively reviewed concepts and principles in the area of CSCW, focusing on research that contributes to our understanding of how people collaborate and the effects of technology on their collaboration. Context strongly influences how people collaborate, and categorization models describe some of these influences by categorizing who collaborates (groups, organizations, and communities), where they collaborate (same place or different places), and when they collaborate (same time or different times).
Our understanding of collaboration has implications for both developers and users of collaboration technologies. Developers must avoid well-established challenges that often befall collaboration technologies, and they should adopt potentially unfamiliar methods for establishing requirements and evaluating collaboration technologies. Technology adoption is especially challenging, because it often requires that all collaborators use the same technology, but this same factor may cause adoption to be extraordinarily rapid once critical mass is achieved.

Our evolving understanding of collaboration is illustrated with reviews of research on three prominent topics pertaining to small group, organizational, and community collaboration. Videoconferencing is of special interest because of its long history, wide appeal, yet remarkably slow adoption rate. Although the cost has plummeted and quality has risen, videoconferencing has not achieved its predicted popularity. Research suggests that the user interface is the principle obstacle to adoption. Contact negotiation remains awkward, and most videoconference devices fail to display important communicative behaviors. New technologies designed to benefit from these lessons may find greater success in the marketplace.

Workflow management is a prominent example of support for organizational collaboration, but the CSCW research community has been highly critical of both the practical value and social impact of this technology. More recent research has focused on the organizational collaboration challenges faced in domains of special interest such as health care and charities.

Interest in community collaboration, especially online communities, is growing. Online communities offer an attractive laboratory for studying collaboration because interaction data are saved automatically and vast quantities of data are available. Recent studies of Wikipedia reveal who participates, why, and how in the construction and maintenance of this online encyclopedia.

The CSCW field continues to evolve in response to changes in technologies, changes in ways people collaborate using technologies, and changes in the population of users. In its infancy, CSCW was constrained to studies of the workplace because few people had access to computers outside the workplace and networks were primitive. Today, mobile phones have greater computing power than those early personal computers, computing technologies are inexpensive, networks are ubiquitous, and information services are readily available. Other technology trends such as adoption of touch screens, tablet computers, and ubiquitous computing in the home, in the workplace, and in vehicles are all likely to influence how, where, and when people collaborate. Ongoing changes in technologies, usage contexts, and usage populations will pose new research questions and opportunities. For example, will the lessons learned about collaboration in the workplace prove applicable when children are collaborating in elementary schools? How will the ability to communicate and share information affect the lives of people living in poor rural areas? Researchers have been exploring collaboration among friends and within families, and this area of research will grow as people of all ages and incomes discover that collaboration technologies are both affordable and easy to use. Continuous communication availability may strengthen bonds within extended families, but it may also stress existing social norms. Access to shared information may empower people who have few economic resources, but the impacts on existing power and social structures may be unsettling.

Glossary

**Awareness:** Perception of relevant aspects of a communication context such as another person’s availability for interaction or where another person is looking (eye gaze awareness).

**Contact negotiation:** The process of starting and ending contact in technology-mediated communication such as telephones and videoconferences.

**Desktop conferencing:** A category of technology that supports synchronous collaboration. All participants in a conferencing session see the same display with real-time updates, and some versions allow two or more people to interact with a display simultaneously.
Ethnography: A qualitative research approach for investigating what people do and how and why they do it. The data may include participant observation, field notes, interviews, surveys, and the work products of the people who are studied.

Legitimate peripheral participation: A theory describing how new members of a community are integrated into the community. Newcomers engage in simple, low-risk tasks that contribute to community goals.

Social world: A social world is a collection of people who have shared commitments to certain activities, share resources to achieve their goals, and build shared views by appropriate methods. Any type of collective unit can be a social world, including groups, organizations, and communities.

Workflow management: Coordination of sequences of work activities, assigning tasks to individuals, monitoring task progress, and, when a task is completed, forwarding relevant results to the person responsible for the next task. A workflow management system contains explicit models of the task sequences that comprise a work process and automatically manages the flow of work.

Further Information

CSCW research is presented and published in the proceedings of the annual ACM Conference on Computer Supported Cooperative Work (CSCW), the biannual ACM International Conference on Supporting Group Work (GROUP), the biannual European Conference on Computer Supported Cooperative Work (ECSWC), the International Conference on Collaboration Technologies (CollabTech), the International Conference on Collaborative Computing (CollaborateCom), and Collaborative Technologies and Systems (CTS). The principal journal in this field is Computer Supported Cooperative Work: The Journal of Collaborative Computing, published by Springer.

Influential early papers in the CSCW field can be found in Greif (1988) and Baecker (1993). Recent reviews include Olson and Olson (2011) and Grudin and Poltrock (2012).

References


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