

Update On National Science Foundation Funding Of The "Collaboratory"

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NSF-funded collaboratories are experimental and empirical research environments in which domain scientists work with computer, communications, behavioral and social scientists to design systems, participate in collaborative science, and conduct experiments to evaluate and improve the systems. These research projects are concerned with distributed and collaborative research that requires intense reliance on wide-area networks and the Internet, to bring together instruments, laboratories and researchers.

Three NSF programs in the Computer and Information Science and Engineering Directorate support the design of collaboratories and coordination experiments:

1. *Coordination Theory and Collaboration Technology Special Initiative (CT2)*. This initiative supports the fundamental research of relevance to the design of collaboratories. The research covers a broad spectrum of coordination problems, from formal theory to software design and collaboratory development. For the past two years, the Information Technology and Organizations (ITO) Program has coordinated this initiative. A total of 17 awards have been made. Funding for existing as well as new CT2 awards is expected to be about \$3 million this year. Also starting in FY 1991 the initiative has been institutionalized by making it an integral part of the ITO program, with an enhanced base to its budget.

2. *Research on scientific databases*. A new call seeks proposals for work on problems that are fundamental to the design of scientific databases, written by interdisciplinary groups that include relevant domain scientists. The success of the overall collaboratory design enterprise requires

the ability to store and easily access the data and knowledge in extremely large, heterogeneous and distributed databases. The Database and Expert Systems Program coordinates this effort. Funding for proposals under this announcement will total more than \$1 million.

3. *The Gigabit Network project*. NSF and DARPA have awarded over \$15 million to the Corporation for National Research Initiative (CNRI) to create testbeds to perform research on the design and development of networks that operate with data rates of about one GB per second. The availability of GB networks may enable a major paradigm shift from text-based to image-based communication. Five contracts awarded by CNRI address network architectures and potential applications for GB networks. This testbed research includes distributed computing

using multiple supercomputers and workstations, and real-time processing of composite high-speed data streams. The experiments explore the feasibility of group collaboration over the network and the use of GB networks to develop simulated environments. ■

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Cooperation, Coordination and Control in Computer-Supported Work

Rob Kling

The Technologies for Computer-Supported Cooperative Work

Researchers disagree about the definition of computer-supported cooperative work [CSCW], but the current definitions focus on the technology. CSCW may be seen as a conjunction of certain kinds of *technologies* (described elsewhere in this issue), certain *kinds of users* (usually small self-directed professional teams), and a *worldview* that

emphasizes convivial work relations. These three elements, taken together, differentiate CSCW from other related forms of computerization, such as information systems and office automation. They differ as much in their typical users and the worldview describing the role of technology in work, as on the technology itself. CSCW is the product of a particular computer-based social movement rather than simply a family of technologies [13]. Descriptions of these technologies in the CSCW



literature are saturated with rich social meanings in addition to descriptions of their technological features.

Certain distinctive slogans help to distinguish CSCW from other computer-based social movements: "cooperative work," "shared minds," "seamless systems," "collaborative systems," "intellectual teamwork" resonate with relentless positive social imagery [9, 13]. CSCW developers often focus on the fine-grained organization of features, the design of interfaces, and the way people actually use their systems (see for example, [4, 14]). There is an intimate quality to these concerns, with a focus on the pragmatics of interpersonal communication and the practical activity of groups. For example, in this issue, Kyng [14] coins the term "mutual learning" to denote a relationship of professional parity between system designers and system users. One of the striking features of the CSCW literature is the way many designers try to respect the ways people actually organize and use information. Significant attention is paid to the pragmatics of communication and information handling—such as determining whether people prefer to point by hand or with a mouse. These concerns are by-products of CSCW developers' interests—developing systems which are very usable. Their models of work, interfaces and features are aligned with the fine-grained elements of social interaction.

In the past five years, participants in the CSCW movement have produced numerous prototypes and a few commercial systems. The prototypes have served as platforms for interesting technological experiments as well as for systematic behavioral studies of how people work while using these new systems [16]. Many groupware applications, however, have not taken off commercially. Much depends on how one characterizes groupware applications and assesses successful adoptions: electronic mail and computer-confer-

encing with usenet-style boards have arguably been the most successful application. On the other hand, group calendaring systems, which are part of several widely adopted commercial office automation systems, are rarely used [1]. And few organizations have yet purchased specialized computer conferencing systems or services.

The ambitions of many CSCW researchers, however, reach far beyond the boundaries of communication with discrete messages. CSCW system advocates often suggest ways to transform the way people work. After all, why invest time and money in new technologies, if they do not produce magnificent effects?

Cooperation, Coordination, and Control with CSCW at Work

Why have the adoption and usage rates of CSCW applications been slow despite the dramatic improvements and the level of collaboration and cooperation they would provide in workplaces? The easiest answer identifies the newness of CSCW technologies, and the limitations and clumsiness of the early applications. Any technology enthusiast can explain slow adoptions with these *reasons* for the first few years. There is often a huge discrepancy between the promises embodied in a technological movement's image and any set of early prototypes and products. Artificial intelligence researchers, for example, suggested huge potential benefits long before workable technologies could be commercially exploited [13].

Fundamental and sometimes subtle social processes in work strongly influence the ways in which CSCW applications are adopted, used, and influence subsequent work. An important, but small stream of research, examines the adoption and use of CSCW applications in-vivo—in non-laboratory workplaces. Grudin [8] for example, examined the use of computerized calendaring systems and argued that they best fit the

needs and work patterns of managers, who were most likely to call meetings. In contrast, the professionals who were the most likely participants in these meetings often did not have comparable secretarial support to keep their calendars up to date. The political economy of effort favored managers, who were also likely to approve the purchase of systems with group calendars. Grudin's analysis is important because he moved from the *possible* use of group calendars to the *actual incentive structures* for using group calendars in typical organizations. Kyng [14] provides numerous illustrations of the ways that technically interesting systems fit and misfit practical work relationships.

Many CSCW articles impede our understanding of the likely use and impact of CSCW since they rely on concepts with strong positive connotations such as "cooperation," "collaboration," and images of convivial possibilities to characterize workplace relationships, while understating the levels of conflict, control, and coercion—also common in professional workplaces. Virtually all work has a cooperative element. To take an extreme case, even prisoners in chain gangs often cooperate in some simple ways with their guards in their conduct of daily life. Otherwise, they would have to be dragged from place to place, even if they did not rebel violently. If, however, their relationships were primarily cooperative, the prisoners would not be chained.

Workplaces are much less coercive than chain gangs. The primary alternatives, however, are not simply limitless cooperation, as if these are all-or-nothing characteristics of group relations. As Grudin [8] points out in the case of group calendars, most professionals are not so eager to cater to their managers' preferences that they will continually inconvenience themselves and lower their productivity in order to help their manager's secretary schedule meetings. They work in a somewhat cooperative manner, but also are somewhat autonomous.

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Further, some group conflict is critical for identifying alternative lines of action and avoiding counter productive conformity (groupthink), as long as conflicts are resolved constructively and with dignity. *In practice, many working relationships can be multivalent with and mix elements of cooperation, conflict, conviviality, competition, collaboration, commitment, caution, control, coercion, coordination and combat* (the “c-words”). They also involve attention to substantive tasks, managing the organization of work, genuine sociability, and even recreation [5].

Some computer scientists, such as Morton Kyng [14], develop CSCW applications with a deep appreciation of the complex nuances of social relations at work that lead to unexpected patterns of computer use. Unfortunately, most articles about CSCW in scientific journals and conferences downplay the likely uses when social relationships are less euphoric than the happy terms, “cooperation and collaboration,” connote. Social life, however, is rarely so convivially univalent.

Professionals and managers are often concerned with enhancing their control, avoiding control, and countering control. It is common for professionals to be mildly competitive, even when they have long-standing collaborations and coordinate routinely. Many CSCW designers wish to enhance the cooperative elements of worklife. When they avoid discussions of control and conflict, they imply they are fundamentally illegitimate, and recognition of their importance could amplify their power. Some CSCW applications have interesting features which enhance

teamwork in new ways for cooperating groups that want more. Unfortunately, the common practice of understating the importance of conflict and control at work make the implicit theories in many CSCW papers too limited to provide an understanding of the actual uses of groupware. Coordination, for example, often requires significant control; but there are accounts of coordination in the CSCW community which virtually ignore control as a central element.

The problems of relying on resolutely convivial concepts to characterize work relations are most visible when there are overt contradictions between concepts and examples. These misfits also give us some clues about the limits of the language of possibility. For example, in this issue of *Communications*, Ishii and Miyake [10] characterize groupware as systems that “support dynamic collaboration in a work group . . .” The activity on which they demonstrate their “Team Workstation” is an instructional task in which one skilled person teaches another how to perform a specific task. They note, without any reflexive interpretation, that one of their two instructors simply “limited himself to issuing procedures.” Their key example reminds us of the possibilities for authoritarian control as well as “dynamic collaboration.”

Such contradictions are less common than substantial oversights in an analysis. Researchers often illustrate their CSCW systems with hypothetical groups, or groups drawn from universities or industrial labs where reciprocal give and take is commonplace. Consequently, they tend not to observe (or report) how

status differences, organizational control systems, and hierarchy are reflected in the use of their groupware prototypes. It is not sufficient to simply state that social relationships and organizational arrangements are important, and then give them incidental attention. Nor should they be glossed over, as in an article about The Coordinator [6], a well-known and controversial CSCW system. This enhanced email system is designed with an assumption that reduced ambiguity in communication and the resulting tighter organizational controls are important reforms for all organizations. However, the authors characterize The Coordinator as a tool which opens possibilities for conversations to better explore alternative actions and commitments to them. They assume that patterns of “authority, obligation, and cooperation” are stable. But they argue for important changes in the way people communicate about possibilities and the actual nature of their actions. However, these kinds of conversations sometimes question and disrupt existing patterns of authority, obligation, and cooperation. Flores, et al. do not examine the interplay between actual organizational control patterns, real work, and the use of The Coordinator.

In this issue, Francik, Rudman, Cooper and Levine [7] illustrate a serious alternative for computer scientists. They initiate their discussion of Wang’s Freestyle with a typical technology-driven description, in this case expanding the capabilities of a PC to include a tablet, pen and voice handset as new I/O devices. While they are excited by the possibilities of this technological enhancement, they do not treat



organizations as systems that are free from contradictions and conflicts of interest. For example, they identify the conflicts between the way work is organized across departmental boundaries and important organizational control patterns when they discuss their pilot projects. They tacitly indicate computerization is embedded in a web of complex organizational relationships [11]. Their article opens up interesting and important questions about the design of pilot tests and adoption issues pertinent to CSCW applications that cut across organizational control lines.

CSCW developers and researchers can communicate more realistic accounts of the likely uses of these new technologies as they examine the rich multivalent social relationships in workplaces: simultaneously cooperative, conflictual, collaborative, controlling, convivial, competitive. We cannot advance our understanding of CSCW with discussions such as *The Coordinator*, which focus on specific kinds of conversations about tasks in organizations, and ignore conversations about the processes of organizing which might restructure patterns of authority, obligation, and cooperation. Consequently, they ignore fundamental and pervasive organizational processes, such as those which sustain power and organizational subcultures. Similarly, Ellis, Gibbs and Rein [4], characterize the "coordination problem" as "the integration and harmonious adjustment of individual work efforts towards the accomplishment of a larger goal." Harmonious adjustment in workplaces involves diverse strategies of social control. The authors' two key concepts, shared contexts and a group window, do not help us understand how computer systems can help restructure or reinforce different control patterns in workplaces.

When computer scientists have studied the key behavior that inhibits group performance in real workplaces, they have often found interesting phenomena. For exam-

ple, Krasner, Curtis, and Iscoe [15] studied the practices that most significantly impeded large-scale software development projects. They found a variety of communication problems. For example, developers did not understand how the customers' operating conditions influenced design trade-offs. A software environment which helps developers more readily capture, store, and retrieve documents about the alternative design choices and trade-offs might reduce some of these communication problems. The discussion of alternative design ideas are often initiated by a few people when the collaborations and communications are supported by face-to-face meetings and telephones [2]. Such CSCW applications may or may not have a favorable political economy of effort Grudin [8], depending on the level of additional effort designers would have to expend as well as benefits to them, and other system developers who work downstream.

Some designers, however, might have additional reservations about providing broad access to rich design discussions, based on the ways in which rewards, credit and blame are allocated in their organizations. If designs do not work out as planned, designers could be subjected to tough Monday morning quarterbacking. Their detailed electronic notes could provide strong evidence that they rejected choices which appear "obviously best" in retrospect or they had misvalued "obvious trade-offs." System designers may avoid using this kind of groupware to support their development team's efforts if they fear they can be blamed if their designs do not work out well. Many professionals who are attracted to buoyant images such as "intellectual teamwork" and "shared minds" may balk at using groupware, which also facilitates downstream participants sharing blame with them. Would they be foolish to avoid sharing key design notes and debates if they work in a somewhat punitive organization? As Kyng

[14] notes, "sharing information" can lead to many different kinds of consequences, depending on the social relationships between those who provide information about their work practices and those who use it.

One related and inescapable point is the way the use of computerized systems, including CSCW, depends on managerial policies and practices [5]. Designers who are developing generic products cannot control the managerial styles of organizations which adopt their systems. "Truth in advertising," however, requires that system developers be willing to face and write about the use of their systems with the management practices that will characterize *likely* adopters. For example, some organizations may allow their workers to mix play and work with computerized bulletin boards [5] while others will turn off systems when employees use questionable language or discuss taboo topics, such as the treatment of women in workplaces [19]. Organizations vary considerably in the tightness of managerial control and their openness to debate. In contrast with Flores, et al. [6], Perrolle [18] argues that organizations which restrict electronic discussions to technical questions distort important communications (and thus hamper their effectiveness).

The Contradictions of Technological Revolutions and Social Transformations

Like advocates of other new computerized technologies, many CSCW advocates allude to the possibilities of fundamentally transforming important social practices and relationships. CSCW researchers explore its special character, and often differentiate it from related technologies: Office Automation and Information Systems. CSCW researchers, however, are beginning to discover pertinent aspects of organizational behavior, such as the dilemmas of altering institutionalized work patterns and workplace politics, that information

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systems researchers discovered some time ago [1, 11].

Unfortunately, people who are exploring a new technological family, such as CSCW, computer integrated manufacturing (CIM), and expert systems, often write as if their new technologies can transform organizations in ways that were fundamentally impossible with precursor technologies. They often adopt a mode of analysis, technological utopianism, that amplifies the possibility of valued social change and underplays the possibilities of little change or significant problems as a byproduct of the technology [3]. These utopian assumptions, which are often implicit and relatively modest, make it hard for researchers, professionals and managers to understand the real social opportunities and limitations of the new technological family. Further, when scientists also proselytize the value of their systems, they risk exaggerating the strength of the evidence which supports the value of their favorite technologies.

Computerization alone rarely transforms organizations [12]. Many CSCW researchers often seem ambivalent about this issue. They want the excitement of "revolution" without the fear and risks social upheavals bring. In this issue Perin [17] characterizes the stable elements of organizations as "social fields." She astutely notes that organizations do not always adopt every technological capability. Her best example is the case of telecommuting. Today, millions of white-collar professionals could be more productive on their tasks that require sustained concentration by working outside their normal office, where

they are subject to frequent interruptions. Many of these people could productively work at home one or two days a week, perhaps with computer and electronic mail support. Aside from a few occupations such as college teaching, software development, and freelance journalism, however, relatively few organizations allow their professionals to work at home one or two days a week in lieu of reporting to their offices daily. Perin argues that managers' interests in controlling their workers biases them against supporting significant work-at-home programs. (Of course, people are free to work at home as much as they wish during the evenings and on weekends!).

The case of telecommuting is an important example to help us understand the opportunities and dilemmas of organizational control regarding new technologies. Perin's conceptualization of social fields is not sufficient to accommodate diverse organizations, such as universities and research labs, which allow some of their highest-status professionals to telecommute some of the time. Her theories do not acknowledge and help us understand important organizational differences. Her article helps us to clearly see the ways in which new computerized technologies are used in workplaces where both cooperation and control are fundamental social processes. Those who argue that telecommuting will become commonplace when some interesting technology is commonplace, such as ISDN or home-based video conferencing, usually ignore the incentives and mindset which encourage many managers to prefer having their subordinates on site. While

some managers could change their styles of management, the simple availability of an interesting technological alternative is rarely a sufficient incentive to drive large-scale organizational change. One cannot adequately understand the selective adoption and actual use of telecommuting, or other CSCW applications, without appreciating the rich multivalent social relationships of workplaces.

New technologies expand the limits of the possible, and CSCW systems support interesting means for reducing the complications of intellectual teamwork. The ways in which CSCW systems restructure social relationships at work, if at all, depends on preexisting patterns of authority, obligation, and cooperation, and an organization's openness to significant change, as well as the technology's information-processing capabilities. A view of work and organization as people working together in cooperative task systems is not sufficiently rich to understand the actual use and impacts of CSCW. We have to expand the range and depth of studies which examine CSCW's integration into rich, complex and nuanced worlds of work and technology. Organizations must have a more systematic basis for understanding when the exciting promises are most likely to be realized. We need a more substantial shift from technological utopianism to social realism in the CSCW literature. The articles in this special issue help to illustrate the kinds of insights social realism offers computer scientists interested in the design, use, and impacts of emerging technologies.



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Collaborative Computing: Collaboration First, Computing Second

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These articles on Collaborative Computing will seem out of place to a number of readers from the computer science community. Interesting articles perhaps, but what

do they have to do with computers? Where is the science—that is, where is the mathematics, or the code? What have these issues to do with everyday practice?

The answer is that building ap-

plications which directly impact people is very different from building computational products of the sort taught and studied in the standard courses on computer science. In traditional computer science,