

Introduction

The global revolution in human interconnectedness goes back at least to the last century. By the turn of the century, we had telegraphy and telephony that started us on the path to a wired world, networked transportation (e.g., railroads) that fundamentally altered how we organized our communities (e.g., Stilgoe, 1985), and office technology that began altering the ways we were able to organize ourselves (Yates, 1989). Throughout the 20th century the pace of innovation and change accelerated, with each generation lauding the next apparent steps toward a better world.

However, by the latter decades of the 20th century we began to realize that the technologies of interconnectedness were not by themselves a panacea. Rather, the century was full of surprises. When new technologies of connectedness emerged the initial inclination was to think of possible gains, such as efficiency gains in speed or accuracy (Sproull & Kiesler, 1991). But repeatedly we are surprised by second-order effects that no one had predicted. For instance, electronic mail provides what seems like an effective asynchronous communication medium of considerable flexibility, making it possible for people anywhere on a relevant network to communicate easily. But new problems arise. First, making it easy to communicate makes it too easy to become flooded with information, resulting in efforts to filter the message stream to reasonable levels (e.g., Malone, Grant, Turbak, Brobst, & Cohen, 1987). Second, something about the medium itself appears to make users of email cast their messages in ways that come across as hostile or negative to recipients (Sproull & Kiesler, 1991), adding a further unpleasant

dimension to email usage. To be sure, email use is flourishing as this century comes to a close, but it is a more complex and surprising medium than first thought.

Repeated surprises of these sorts have led many to call for multidisciplinary research that would bring together experts on human cognitive, social, and organizational behavior with the technologists who are designing and deploying the new tools. Indeed, the 1980s witnessed the birth of numerous new conferences to explore the issues involved, such as CHI, CSCW, ECSCW, and INTERACT. Numerous smaller workshops and seminars further accelerated the pace of multidisciplinary discussion.

It was in this context that the National Science Foundation (NSF) announced a funding program in the area of Coordination Theory and Collaboration Technology (CTCT, or CT squared). This initiative was announced in calls for proposals issued in 1989 and 1990. It grew out of a series of workshops funded by NSF that began the process of defining this area of research and creating a community of researchers whose work might be funded.

Two workshops on Coordination Science were held at MIT (June 1987 and February 1988) under the leadership of Thomas Malone, and one on Open Systems at Xerox PARC (June 1988) that was organized by Bernardo Huberman. These workshops gave strong indication that the questions about coordination asked in many disciplines are similar and that ideas and methods from each could inform the other.

Two workshops were sponsored by NSF on issues of technology and cooperative work, one organized by Jolene Galagher at the University of Arizona (February 1988), the other at New York University (June 1988) under the leadership of Margrethe Olson. These workshops focused on the behavioral science aspects of coordination and collaboration relating to the interaction of individuals, small groups, and formal organizations and on computer-based systems and software design for collaboration. Two influential books came from these workshops (Galagher, Kraut & Egidio, 1990; M. Olson, 1989).

The 1988 announcement of the CTCT initiative captures many of the themes explored in these anticipatory workshops.

The initiative focuses on processes of coordination and cooperation among autonomous units in human systems, in computer and communication systems, and in hybrid organizations of both systems. . . . This initiative is motivated by three scientific issues which have been the focus of separate research efforts, but which may benefit from collaborative research. The first is the effort to discover the principles underlying how people collaborate and coordinate work efficiently and productively in environments characterized by a high degree of decentralized computation and decision-making. The second is to gain a better fundamental understanding of the structure and outputs of organizations, industries and markets which incorporate sophisticated,

decentralized information and communications technology as an important component of their operations. The third is to understand problems of coordination in decentralized, or open, computer systems. [NSF 88-59, p. 2]

Two rounds of CTCT competition were held, one in 1988 (with results announced in June of 1989) and a second in 1990. From these two rounds of competitions, 20 projects were funded out of 136 applications. In subsequent years, additional projects were funded out of the regular NSF unsolicited proposal competition, so that by the time the CTCT group held a series of three grantee workshops in 1991, 1992, and 1993, nearly 30 different projects participated. These annual workshops gave the investigators in this program an extended opportunity for interdisciplinary exchange.

A closely related activity took place in March 1989, several months after the submission deadline for the first CTCT Initiative. A major workshop on scientific collaboration was held at Rockefeller University under the direction of Joshua Lederberg and Keith Uncapher. This workshop focused on the feasibility of designing network dependent multi-purpose systems to support remote scientific collaborations in specific disciplines. The components of such systems would include multimedia communications, remote access to instrumentation, digital journals and libraries, and a variety of services to support science. This initial workshop led to a series of follow-on meetings that by 1993 resulted in an influential National Research Council report on "collaboratories" (cf. NAS report). Several of the original CTCT projects clearly fit into this "collaboratory" concept, and additional projects were included in the CTCT workshops described earlier. A recent review showed that collaboratories were becoming an increasingly widespread form of sociotechnical support for distributed team science (Finholt & Olson, 1997).

Laurence Rosenberg of the National Science Foundations was a key player in all of these activities. Throughout this period he was manager of the Information Technology and Organizations program, and a deputy director of the Division of Information, Robotics, and Intelligent Systems (IRIS) in the directorate for Computer and Information Science Engineering (CISE). He was primarily responsible for funding these various workshops that led to the CTCT initiatives, and was also active in the closely related collaboratory arena. In particular, he served as the NSF program manager for the nearly 30 projects funded under the CTCT initiative.

In the spring of 1994 Larry Rosenberg died of cancer after a relatively brief illness. The three editors of this volume decided that a fitting tribute to Larry's efforts at NSF would be for those of us who had been funded through his interdisciplinary CTCT initiatives to put together a book that reported on the work we had done. This effort was facilitated by the fact that those of us so funded had come to know each other quite well through the annual work-

shops of the CTCT program in the 1991–1993 period. We had become familiar with each other's work, and had explored a number of themes and cross-connections among the projects. These links are reflected in a number of ways in the individual chapters in this volume.

The multiyear projects funded by the CTCT program were all invited to submit chapters for this volume, and almost all of those invited agreed. The initial drafts of chapters were carefully reviewed by other authors, and revisions were obtained. Thus, we used the collegiality established by Larry in the program and its annual workshops to facilitate the production of this volume. We offer these chapters to honor the memory of his efforts on all of our behalf.

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—Gary M. Olson

—Thomas W. Malone

—John B. Smith

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