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SYNTHESIS LECTURES ON HUMAN-CENTERED INFORMATICS

John M. Carroll, *Series Editor*

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Working Together Apart:

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Synthesis Lectures on Human-Centered Infomatics

Editor

John M. Carroll, *Penn State University*

Human-Centered Informatics (HCI) is the intersection of the cultural, the social, the cognitive, and the aesthetic with computing and information technology. It encompasses a huge range of issues, theories, technologies, designs, tools, environments and human experiences in knowledge work, recreation and leisure activity, teaching and learning, and the potpourri of everyday life. The series will publish state-of-the-art syntheses, case studies, and tutorials in key areas. It will share the focus of leading international conferences in HCI.

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ABSTRACT

Increasingly, teams are working together when they are not in the same location, even though there are many challenges to doing so successfully. Here we review the latest insights into these matters, guided by a framework that we have developed during two decades of research on this topic.

This framework organizes a series of factors that we have found to differentiate between successful and unsuccessful distributed collaborations. We then review the kinds of technology options that are available today, focusing more on types of technologies rather than specific instances. We describe a database of geographically distributed projects we have studied and introduce the Collaboration Success Wizard, an online tool for assessing past, present, or planned distributed collaborations. We close with a set of recommendations for individuals, managers, and those higher in the organizations who wish to support distance work.

KEYWORDS

distance work, virtual teams, teamwork, distributed teams, managing virtual teams, communication, coordination, technology support, infrastructure, cyberinfrastructure, team science, trust

Acknowledgments

We have been studying long-distance collaboration since the mid-1980s, when we got involved in the National Science Foundation's EXPRES Project (Olson and Atkins, 1990). The National Science Foundation has continued to be the primary source of funding for our work in this area, through a series of projects (ASC-8617699, IRI-8902930, IRI-9216848, IRI-9320543, ATM-9873025, IIS-9977923, IIS-0085951, CMS-0117853, IIS-0308009, OCI-1025769, ACI-1322304). However, we've also had support from the Army Research Institute (W74V8H-06-P-0518, W91WAW-07-C-0060), Google, U.S. West, Anderson Consulting, Apple, Intel, Ameritech, and the John D. Evans Foundation. While we have come at the issues of long-distance work primarily from the perspective of the field of Computer Supported Cooperative Work (CSCW), which we recently reviewed in (Hall et al. 2008), we have found that many other fields have looked into issues of such work. To help us with this we have had the valuable input from our multidisciplinary colleagues at the School of Information at the University of Michigan and the Department of Informatics at the University of California, Irvine. Those colleagues who have particularly influenced us include Mark Ackerman, Dan Atkins, Geof Bowker, Yan Chen, Bob Clauer, Derrick Cogburn, the late Michael Cohen, Paul Dourish, Tom Finholt, George Furnas, Joseph Hardin, Tim Killeen, Jeff Mackie-Mason, Gloria Mark, and Stephanie Teasley. One major influence on our thinking about these matters came from a challenge first presented to us by Suzi Iacono from the National Science Foundation, who asked at a conference in Vienna: Why do some long-distance collaborations work, and some not? We subsequently took up this challenge initially for scientific collaboration, in the Science of Collaboratories (SOC) Project, funded by the National Science Foundation. Later, we expanded this to include corporate settings with sponsorship from the Ford Motor Company. The early form of the SOC project was informed by an external advisory committee that included Mark Ellisman, Jim Herbsleb, Jim Myers, Diane Sonnenwald, and Nestor Zaluzec. With the advice of this group, we held a series of workshops, some in Ann Arbor and some in Washington, D.C. Summaries of these workshops, including all the people who participated in them, can be found at soc.ics.uci.edu/workshops/. Many people have worked with us over the years, many of who appear as coauthors on papers we have cited in this book. But several need to be mentioned explicitly for the major roles they had in shaping our thinking and guiding our work: Matthew Bietz, Nathan Bos, Dan Cooney, Erik Hofer, Airong Luo, Emily Navarro, Sue Schuon, Ann Verhey-Henke, Amy Voida, Jude Yew, Ann Zimmerman, and the late Steve Abrams. Several people have read parts or this entire book in draft form, including the late Steve Abrams, Matt Bietz, Jack Carroll, and Jonathan Cummings.

Contents

CHAPTER 1

The Changing Landscape

The rise of a widespread, reliable, and high-speed Internet has enabled groups to work together successfully when they are not in the same geographic location. Allen (1977) reported that the likelihood of interacting with another person falls off rapidly with distance and essentially asymptotes at 30 m. This means that people in the same building but in different wings or different floors or in different buildings on the same campus need to rely on these emerging distance technologies just as much as those in different cities, states, or countries. And the increase in this kind of work is incredible, no matter which domain of activity we look at.

The figures on the extent of virtual teams in contemporary corporations are staggering. The Institute for Corporate Productivity[1] stated in 2008 that 67% of the companies that were surveyed felt that "their reliance on virtual teams" would grow in the next few years.[2] For companies that had more than 10,000 employees, this figure was more than 80%. Companies are distributed in order to reach new markets, gain access to specialized resources and expertise, and/or change the costs of doing their work. As Thomas Malone (2004) notes, these new technologies not only enable distributed work but they change the very nature of how enterprises are organized and carry out their mission.

The worlds of research and scholarship have changed equally dramatically. In the 1990s in the U.S., within the National Science Foundation, a new form of collaboration in science received great attention, dubbed the Collaboratory (Wulf, 1993), a laboratory without walls. A parallel form in the United Kingdom is called variously eScience or eResearch (Jankowski, 2009). Collaboratories and eScience arose because many problems in science and engineering are large and complex. No one university houses sufficient numbers of experts in a field, requiring collaboration across distance. For instance, in the physical sciences, instrumentation is increasingly expensive and therefore must be shared. The Large Hadron Collider in high energy physics is a contemporary and classic example (Hofer et al., 2008), and follows a pattern in this field since the Manhattan Project during the 1940s. Fields as diverse as upper atmospheric physics (Olson et al., 2008), earthquake engineering (Spencer et al., 2008), and environmental molecular science (Myers, 2008), all require sharing of highly specialized, expensive equipment. In many sciences the creation of large databases is a key next step in advancing. Examples include GenBank (Pevsner, 2009), the Protein Data Bank (Bernstein et al., 1977; Berman et al., 2003), National Virtual Observatory (NVO) (Ackerman et

[1] http://www.pr.com/press-release/103409.

[2] Throughout this book we are agnostic about the actual physical location of the distributed participants. The growing trend to work from home is one example of how participants might be distributed. While there may be special issues for this particular location, we will not focus on that here.

al., 2008), the Biomedical Informatics Research Network (BIRN) (Olson et al., 2008), and the Long-Term Ecological Research (LTER) program (Michener and Waide, 2008). By coordinating their work through distance technologies or working with remote instruments, aggregated data or computing resources, academics can attack bigger questions with the promise of breakthroughs in our understanding and in solving problems. The extent of this revolution is documented in Chapter 10, where we note that our Science of Collaboratories Database has grown to more than 700 instances of such projects, even though this used a less-than-efficient opportunistic sampling strategy. Science and engineering are forever changed.

This trend to large-scale distance work is extending to domains in the social sciences and humanities, in fields that have been historically slower to pick up the strategies of collaborating on research and publishing multi-authored papers and books. People collaborate across universities to visualize social processes, do computer modeling, simulate social and political networking, and examine consequences of natural events, such as how rising water from global warming will affect low-lying London (Borning et al., 2005). In the humanities there are virtual haptic museums, and vast collections of material such as all the written material in Greek from ancient times to the fall of Constantinople, allowing researchers to find, sort, and comment on findings electronically (Inman et al., 2004) .

Many non-profits, like the Red Cross or Red Crescent, or the Girl or Boy Scouts, have been distributed for a long time, but now that there are better communication and coordination tools, they can be more effective. Distance communication has helped with the sharing of best practices, has facilitated fund raising, and, more recently, and has led to more rapid responses to disasters. For example, researchers have found that people *in* a natural disaster can help each other and their rescuers through reporting what is happening in their location through microblogging, such as Twitter (Palen and Liu, 2007; Palen et al., 2011). However, there are similar challenges in distributed non-profits as there are in academia and corporations. There are issues of focus, culture, buy-in, and trust (Lewis et al., 2010).

The evidence of increased collaboration is striking. For instance, Wuchty, et al. (2007) looked at publications and patents, and found in a broad range of areas larger teams were either publishing papers or acquiring patents. Such indices are found for publishing data in many fields (Porter and Rafols, 2009). Page (2007) points out similar pattern even for Nobel Prizes. The number of awardees per Nobel Prize has risen from 1.2 per prize in 1901 to 2.75 in 2004 in both Chemistry and Physics.

In addition to the challenges of being distributed, more and more teams today are multi-disciplinary. Multi-disciplinary teams are deemed necessary in order to attack complex problems. Chamberlin (1890) long ago argued for bringing multiple perspectives to bear on scientific problems. More recently, Page (2007) described, in great detail, the potential advantages of having diverse conceptual perspectives and problem-solving strategies in coming up with insights and solutions to difficult problems. Stokols et al. (2010) describe the many incentives for carrying out research in the biomedical sciences using teams that span disciplines. Research projects that focus on a real world problem, like disease, energy, the economy or the environment, tend to bring together individuals from many disciplines. For example, in studying the structure of the brain (a mouse brain, a good model of the human brain for some purposes), the Morphometry Biomedical Informatics Research Network (mBIRN) brought together researchers spanning from the molecular structure in the brain all the way up to its morphometry. Furthermore, these individuals are almost never collocated. The Atlas Project of the Large Hadron Collider at CERN in Geneva, Switzerland, involves 3000 physicists from 38 different countries, 174 universities and laboratories, and 1000 students (see Figure 1.1). A project of this scale would not be possible without contemporary computing and communication technologies.

Figure 1.1. A meeting of the ATLAS collaboration.

While the growth of such distributed projects testifies to the success that has characterized many projects, we know that both distance and the fact that the teams are multi-disciplinary create formidable challenges. Despite the availability of increasingly sophisticated cyberinfrastructure to support all of this activity, working at a distance is still difficult. Individuals from different disciplines working together suffer from lack of common vocabulary and working styles. Olson and Olson (2000) reviewed data from studies of both scientific projects and corporate teams, and documented many of the problems. The Science of Collaboratories (SOC) Project, on which much of this volume is based, began formally just as that article was published. A lot has happened in the past decade and a half. This book is our compilation of what is known today about the challenges of working remotely and with people from multiple disciplines. It additionally offers actions that can be taken to mitigate those challenges. We recently published a book on the SOC Project , *Scientific Collaboration on the Internet*, that extended our earlier work and included illustrations with many case studies (Olson et al., 2008). Cummings and Kiesler (2005; 2007; 2008) carried out a series of quantitative studies of large collaborative projects at NSF and reported many insights into the key issues involved. A particularly fruitful line of work has developed under the heading of the Science of Team Science (SciTS). An annual conference series was launched in 2010 (a brief report appeared in Falk-Krzesinski et al., 2011). A special issue of the *American Journal of Preventative Medicine* on SciTS appeared in 2008 (Stokols et al., 2008, introduced the special issue). A group at the National Institutes of Health (NIH) has produced a report entitled "Collaboration and Team Science: A Field Guide" (Bennett et al., 2010), and a website rich with resources is at teamscience.nih.gov. Falk-Krzesinski, Borner et al. (2011) conducted a concept-mapping study to attempt to give some structure to this emerging field.

Similarly, one indicator of the concern for managing virtual and multi-disciplinary teams in the corporate world is the huge number of books published on how to create and manage effective teams (some recent examples are: Hackman, 2002, 2011; Sawyer, 2007; Hansen, 2009; Rosen, 2009). Business schools, engineering colleges, and information schools have added a variety of team projects to their curricula to prepare students for a world in which teamwork is common, valued, and challenging.

Our goal in this book is to bring together many of these threads, building on our initial work in the SOC project but augmenting it with insights emerging from this wider range of investigations. In the Chapter 2 we will first explore the different types of distance collaborations, each form of which encounters some special challenges. We present examples of each type in the for-profit and non-profit worlds as well as in the science and the humanities. Next, in Chapter 3 we cover what it means to be successful in collaborations, for there can be success in different facets as well as at different levels. We follow in Chapter 4 with a brief overview of the factors that we have found to lead to success, and then, in Chapter 5–9, a chapter for each major category with details and examples of each. We close with two chapters of practical import. Chapter 10 describes an on-line resource for researchers in this area, the Science of Collaboratories database; Chapter 11 introduces an online assessment tool, the Collaboration Success Wizard, that embodies the theory presented