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Meeting at the Desktop: An Empirical Study of Virtually Collocated Teams

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Abstract: Corporate mergers, global markets, reduced willingness to relocate, and the increased need to reorganize and respond dynamically – we are entering an era of distributed organizations and groups. New technologies are needed that enable distributed teams to work as though virtually collocated. This case study examines how one such technology, desktop conferencing with application sharing, is used routinely by four groups within a major company. We discuss differing and evolving patterns of use. A range of difficulties arising from impoverished communication are documented. Success factors are identified, focusing on the use of technology facilitation and meeting facilitation. We conclude by describing benefits possible with this merger of communication and application sharing, as well as the challenges of organizational change that may be needed to achieve the benefits.

D to main site: Does anyone in this room understand what he's saying?
Remote site: I do
D: You're not in this room
Remote site: I'm in the global room

1. Introduction

Two categories of group-support technology are merging: communication technologies and information sharing technologies. Communication technologies such as telephones and email are conduits through which human discourse passes, often ephemerally, the lasting trace being the impression on the receiver. Information sharing technologies represent, structure and store information, such as documents and databases. These technologies have been used relatively

independently and studied in isolation.

The distinction between communicating and sharing information is not perfect, but it is important. While most communication is unstructured and ephemeral, email has some structure and may be archived. While limited computational analysis of email content is possible, email is usually treated as ephemeral because communication is the intent. (Similarly, a telephone conversation can be recorded, but few are.)

Communication technologies often support group members working at the same time, synchronous activity. In contrast, persistent information sharing technologies usually support asynchronous activity. Again, the division is imperfect: electronic and voice mail operate somewhat asynchronously; a projection system supports sharing persistent information in real time. But the distinction is significant – most email is used once; persistent objects are reused.

Of course, work requires both communication and information sharing. When one is absent, frustration is common. The inability to share data often hinders people limited to communication technology. We accepted it out of necessity with the telephone for decades, but fax spread quickly: a communication device serving an information-sharing need. Similarly, videoconference participants may hold documents up to the camera in vain efforts to have them viewed by remote participants. Email was used solely for communication, but once email attachments (supporting information sharing) came into wide use, they quickly became indispensable. The Boeing Company recently shifted 100,000+ employees to a standard email platform: the need to share attachments was a key motive for this massive effort.

Robinson (1991) noted that computer systems had not adequately merged information sharing and communication channels to support discussing shared information. Fax and attachments are useful but relatively crude enhancements. Two more powerful syntheses have emerged, first in research laboratories and now in workplaces:

i) Semi-structured documents, such as Lotus Notes, add communication features to asynchronous information sharing capabilities.

ii) Desktop conferencing, such as NetMeeting, adds data or application sharing to real-time communication systems.

Studies of semi-structured documents in work settings have been reported (e.g., Orlikowski, 1992). We present an early ethnographic study of sustained use of the second of these powerful new group support tools, desktop conferencing.

1.1 Virtually collocated teams

Desktop conferencing can act as a key enabler of geographically distributed teams, allowing team members to communicate and share information as though they are collocated. Economic globalization and competition drive the formation of geographically distributed teams that span different sites within the same

company and sometimes cross corporate boundaries. Researchers have investigated virtually collocated teams from the perspectives of identity formation (Wiesenfeld et al., 1998), effects of cultural diversity (DeSanctis and Poole, 1997) and trust (see Jarvenpaa and Leidner, 1998, for a review). The teams studied previously were generally supported by a mix of email, telephone, and document exchange (e.g. Sproull and Kiesler, 1991; Zack, 1993). Ackerman et al. (1997) investigated the effects of a continuous audio-only media space.

Studies of desktop conferencing have focused primarily on how it affects the task performance of small ad hoc groups. For example, Whittaker et al. (1993) found a shared workspace beneficial for tasks with graphical information and demanding text-based tasks. Other studies report similar positive results (e.g. Minneman and Bly, 1991). These studies suggest benefits from desktop conferencing technology, but we cannot safely generalize from ad hoc groups to teams with long-term agendas (McGrath, 1984).

The key issues when studying technology use in business settings are adoption patterns, impacts on performance and process, problems created by the technology, and innovative solutions. We sought to understand how teams adopt and use desktop conferencing in their work setting. Do teams with different histories and long-term agendas experience different patterns? What problems do teams experience while collaborating through desktop conferencing, and how do they circumvent them? How can systems be better designed and used?

1.2 Background and setting

We studied four geographically distributed teams in The Boeing Company. All four teams had existed for six months or longer when the study began, and they all had recently begun using desktop conferencing technology combined with telephone conference calls to support their meetings.

Boeing has a history of using communication technologies to support geographically distributed teamwork. Video conferencing suites in different cities have supported distributed project team meetings since the 1970s. Mergers with Rockwell North American and McDonnell Douglas in 1996 have led to rapid growth of distributed collaborations. These mergers approximately doubled the number of employees and radically changed their geographic distribution. Previously, about 80% were distributed around the greater Seattle area. Most employees could attend meetings at any other site by driving less than 90 minutes. After the merger, only about 40% of the approximately 235,000 employees worked and lived in the greater Seattle area; others are distributed across the United States, with large concentrations in southern California, St. Louis, Missouri, and Wichita, Kansas.

The merger minimally affected many projects and programs, which continued working with existing staff, suppliers, and partners. Some teams and organizations, however, quickly needed to find ways of working with people at

other locations, in some cases with people they had never met. For example, prior to the merger, executive meetings were held face-to-face at corporate headquarters, but following the merger the travel and time costs of collocated meetings were prohibitive. Many distributed teams were created to define how the newly merged company would operate and how enterprise services would integrate. Existing enterprise-wide teams were expanded to include members from other locations. Distributed design teams worked on the same section of an airplane. Effective virtual collocation has become a necessity.

2. The case studies

2.1 The technology used

All four teams used Microsoft NetMeeting[1] (henceforth **NM**) client software that manages desktop conferencing sessions of up to 32 participants. NM enables any participant to share any PC application object (e.g., PowerPoint slides) with all the other participants simultaneously. A participant can also allow others to interact with the application, such as editing portions of a document. NM includes a multi-user whiteboard, chat, and a file-transfer feature. A desktop conferencing service includes a directory of NM users, a server for scheduling and hosting meetings, and instructions on effective use of these technologies.

Although NM has audio and video features, these were not used. Instead, all the teams communicated in meetings via telephone conference calls by connecting to a teleconference bridge. Speakerphones were used in the conference rooms, and in cubicles, handsets or headsets were generally used.

Although NM is designed for desktop use, some participants gathered in a conference room, where a shared PC or a laptop connected to a projector enabled everyone to see. Some conference rooms had large interactive displays (SMART Boards[2]) with touch screens.

2.2 Research Methodology

Four teams were chosen that met the following criteria: they were willing to be observed, were geographically distributed, had long-term objectives, and used desktop conferencing technology. The investigation was ethnographic: the behavior of team members was observed in their work context. One author attended meetings “silently”[3] and took notes. Recording was not permitted. Groups were observed for 3 months, and meetings took place weekly (for one

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[1] NetMeeting ™ 1998, The Microsoft Corporation

[2] SMART Board™, SMART Technologies Inc.

[3] At the beginning of each meeting the observer always announced her presence to the group.

group, bi-monthly). Some members of two teams met face-to-face in a conference room while others participated from remote sites; for these meetings the observer sat in the conference room. The other two teams met from their offices; like all other participants, the observer remained at her desk and connected to the meeting through the telephone and NM channels (Figures 1a and 1b).

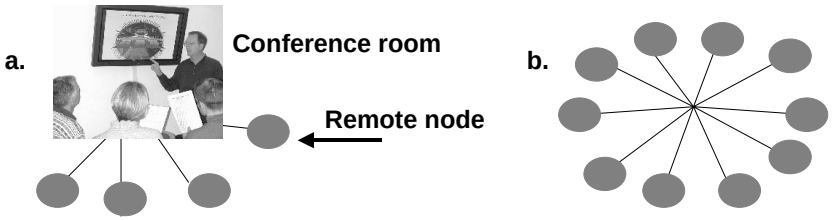

Fig. 1. Two meeting configurations: a) conference room with remote sites, b) all remote sites

After each meeting a questionnaire was distributed by email to all participants, asking questions related to ease of using the technology, social aspects of participation, and satisfaction with the meeting. Supplementary materials were collected, such as meeting agendas, minutes, and chat windows used during the sessions. In-depth interviews were also conducted with 19 selected members of the groups, lasting around 45-60 minutes each. Using content analysis, classes of problems and solutions could be identified.

2.3 The Cases

The four teams had commonalties but different goals. All teams had long-term agendas influenced by their funding, mandate, or organization, and spanned geographical and organizational boundaries within Boeing. The teams met regularly using NM and audioconferencing. Between meetings, communication was by email supplemented with occasional telephone calls. Most participants had met some key members in face-to-face meetings. Three teams were formed eight to nine months before the study began. A fourth, the Scientific team, had existed for five years, evolving, and expanding its membership.

2.3.1 The Scientific Team: Volunteers teaming for innovative solutions

The Scientific Team began as a small face-to-face staff meeting in Bellevue[4] for a project concerned with monitoring drilling processes. As participation expanded to include members from other sites, the team shifted the meetings to open discussion and information exchange in their technical domain. The team's success at applying science to solve real manufacturing problems became widely recognized in the company. Attendance increased, with people commuting as much as an hour each way to attend. Following the merger, people from several distant locations asked to participate by audioconference (telephone conference

[4] A location in the greater Seattle area

call), with presentation materials delivered prior to each meeting. The significant challenges of supporting remote participation led the team leaders to consider ending or curtailing the meetings. The adoption of NM reversed this: among the first teams in Boeing to use NM, its members were enthusiastic about its value.

From 8 to 16 members met face-to-face weekly in a conference room in Bellevue and one to three members attended from sites in Wichita, St. Louis, California, and Philadelphia (figure 1a). Members from other Seattle area sites drove to the meeting or connected remotely from their offices. Team membership was interdisciplinary: physicists and mathematicians at the main site met with machinists, engineers, and shop-floor people at the remote sites. The entire group had met only once face-to-face, in a workshop. Their three-hour meetings consisted of presentations, often showing scientific data, followed by up to two hours of open discussion where drilling problems were discussed.

The Scientific team was unusually successful in its operation, developing solutions for many problems faced by the other three teams. Their success may be partly due to the prior experience that most members had working together as they progressed from face-to-face to audioconferencing to NM use.

2.3.2 The Technical Working Group: Open participation throughout the company

The meetings of the Technical Working Group were open to anyone in the company. This unusual format was well suited to their goal of establishing best practices in their technical domain: the team could benefit from expertise at any geographic site, and employees throughout the company could benefit through participation, sharing their practices and asking questions to improve them. This increased efficiency; formerly, members had to acquire expertise themselves on a topic in order to present it. The group met through audioconferences (telephone conference calls) for several months before they began using NM.

Many members were highly specialized database management professionals. About 12-15 people attended the bi-monthly meetings, usually including the leader and nine core group members. The leader was in California; core members were located in different places, including St. Louis, Philadelphia, Huntsville, and greater Seattle, one person per site (figure 1b). Although the team leader received frequent requests to meet face-to-face, the core group members of the Technical Working Group had only met face-to-face twice. The 90-minute meetings usually consisted of a presentation of about 45 minutes followed by open discussion.

2.3.3 A Virtual Staff: Distributed colleagues with a mobile manager

A vice president responsible for information systems offered Bill a position as chief architect. For personal reasons Bill was “willing to do everything in his power” to remain in St. Louis. The vice president agreed to let Bill pioneer new technology for long distance collaboration; Bill and his staff became NM “guinea pigs.” Eight were collocated in Bellevue. Bill, his administrative assistant, and a support company liaison were in St. Louis, and one staff member, Aaron, was in

California (figure 1a).

The team met weekly for 90 minutes. The main goal was information exchange and team building. NM was mainly used to display the agenda; a few meetings included short presentations by Bellevue or St. Louis members. The last half-hour of each meeting was open discussion in a round-robin format. About every two months Bill traveled to Bellevue to meet those members face-to-face; Aaron traveled about once every three months. As part of the agreement, Bill offered to pay for travel of anyone on the staff if they wanted to meet with him. The office assistant in St. Louis had never met the staff members in Bellevue.

2.3.4 The Best-Practice Team: Combining forces country-wide

The Best-Practice Team was charged to define the best practice for designing aerospace products. It was initiated by a vice president after several technical workshops and began weekly project activities using NM three months before this study began. The team consisted of 20 managers representing all geographical areas of the company. Although one member called the meeting "semi-mandatory," only about eight attended each meeting, all from their offices (figure 1b). The team had met face-to-face about six times at various locations.

The Best-Practice Team was the least interactive in meetings, of the four teams observed in this study. The team leader presented a list of action items and only permitted reports on their status. The little open discussion that occurred was limited to the last part of meetings in round-robin style.

2.4 Technology adoption

In three of the four cases, team leaders introduced NM. The Scientific and Best-Practice team leaders learned about NM from Boeing researchers and Bill, the Staff leader, discovered NM while searching on his own for a technology to suit his needs. The Technical Working Group had sought a better solution than audioconferencing. Soon after one member suggested NM, it was adopted by about half of the core team members, including the team leader.

Remote members of the Scientific and Staff teams were much slower to follow the main site in adopting NM. Some Scientific Team sites and several members of the Technical Working Group and Best-Practice Team participated only by audioconference during this study. Delays in adopting NM were due to:

1. Participation on some teams was voluntary and part-time; managers were reluctant to approve purchasing computers to run NM. Different sites often had different types of computers, operating systems, and support organizations.
2. Many members reported that because team participation was a part-time activity, they acted slowly to get the equipment, download the software, or in one case, obtain a special firewall-spanning account.
3. One member reported that others at his site discouraged him from using NM by saying that a lot of time would be wasted getting it synchronized.

4. Members at some sites reported having no one to consult about the technology.
5. M, the leader of Best Practice, believed that his team members were resistant to NM as they had been to other unfamiliar applications in the past. M felt that peer pressure was needed to influence adoption. In a virtually collocated team, peer pressure and other influence must work from a distance.

3 Results and Discussion

In addition to the 3 months of observation, note-taking, and materials collection, 158 questionnaires were received from team members following meetings: 73 from the Scientific Team, 38 from the Technical Working Group, 19 from the Staff, and 26 from the Best Practice Team. Members reported medium high satisfaction with the quality of documents, quality of meeting, use of time, and their participation, with no group differences (4.8 averaged across satisfaction questions, on a scale of 1 to 6, strongly disagree to strongly agree). The use of NM was felt to be worthwhile.

The meetings did not flow without problems, which particularly affected the three younger groups. The next sections describe these, categorized into problems with technology, with coordinating interaction, and with maintaining engagement. The subsequent sections describe technology facilitation and meeting facilitation methods that the Scientific Team developed to overcome such problems, and how a parallel communication channel (NM chat) was employed by members of the Technical Working Group to reduce interaction difficulty. The results conclude with advantages provided by application sharing.

3.1 Problems with technology: The role of a driver

In most meetings one person, a “technology driver,” established the NM session, helped others join, and used NM to share an application (such as a presentation or agenda) that was passively viewed by other meeting participants. The technology driver was crucial to the smooth flow of a meeting; inexperience with the technology impeded the entire group. The three younger groups did not carefully consider the role of a technology driver, and they consistently wasted time setting up the technology and repeatedly encountered problems using it.

For example, the Staff meeting often required 15 minutes to begin, a substantial loss of time for the 10 members present. The role of technology driver was assigned to two administrative assistants, but they were not suited for this role and it was several months before they felt comfortable with the technology.

The Technical Working Group often seemed confused setting up NM, usually getting underway about 10 minutes late. Once it took them 30 minutes:

User 1: (after 30 minutes) we start over too many times. this can hinder getting anything done. I hope this one sticks.

User 2: Are we in control? Who's in control? I seem to have lost some degree of control.

This team negotiated the technology driver role in an ad-hoc fashion. In the following private chat discussion conducted during a meeting (and later shared with us), two users discuss the poor use of the technology and resolve that one of them will assume control in the next meeting:

User 3 (to User 1): Yours [driving the technology] was better…
User 1 (to User 3): Understand, but [User 4] offered to drive so until there are major problems, let [User 4] drive. Can you drive next meeting?

The Best-Practice Team used the technology more smoothly, but its use was limited. One member described how NM could be used to write collaboratively or to help the group arrive at a consensus on the action items or group mission. Another member said that the group would benefit more if it used the technology to create a product (e.g., a document). But the leader imposed a restrictive meeting format (only item status was to be reported), so there was little occasion for the group to explore the use of the whiteboard or other functionality.

The Staff and Technical Working Group also made limited use of the technology. The Staff wrote a document collaboratively, but only one person typed. In one meeting a remote participant put an important email message on the screen. This confused Aaron, another remote participant, proving that not all users understood the application sharing capability. (In another meeting Aaron shared his calendar, although this seemed unintentional.) On one occasion the Technical Working Group used a shared Notepad to list proposals, but did not again share any application except PowerPoint in the period of observation.

Another problem was that participants did not consider the configuration of other sites. One member noted that people are accustomed to viewing material on high-resolution screens at a distance of 45 centimeters, but details may not be visible for those in conference rooms viewing a projected image from five meters.

To avoid delaying meetings, the technology driver must be proficient in using NM, the hardware, the operating system, and all applications used in the meeting. Additionally, the driver must consider how to match the applications to the group's purpose. The role is quite public; one Staff member complained that the use of the technology reveals a lot about you to the team if you are not competent with it – if you make spelling errors, cannot type, or cannot locate a file.

3.2 Problems coordinating interaction

Remote member: I hear the voice, but there is a vacancy for the whole human being.

Interacting through NM adversely affected performance by making it difficult to coordinate participation, identify remote speakers, and know who was present.

As suggested in previous studies of audio communication (e.g. Short et al. 1976), uncertainty about turn-taking often disrupted the communication flow, especially during presentations and open discussions in the Technical Working Group and Staff meetings. Interaction was hardest for remote site members; they

often reported not knowing when to interject. One described the awkwardness of the give and take: "*are they pausing for a comma, or for a period?*"

Coordinating interaction poses a different problem for these distributed teams than for ad-hoc groups previously studied. The interviews indicated a profound problem in understanding the expressions of others. Members felt they lacked enough knowledge of others' intent to make sense of their on-line behavior. Their difficulty was reflected in a response near the scale midpoint to the following questionnaire item (no difference across groups):

I could always tell how other people were reacting to the things I or others said	**3.6**

Teams are struggling to develop group processes, such as impression management (Schein 1990) and team identity (Wiesenfeld et al. 1998), and the limited social cues in audio channels make these difficult. Face-to-face meetings, when they occurred, helped the team members later make sense of on-line behavior. Face-to-face Staff and Best-Practice Team meetings were observed to be characterized by considerable side discussion, story-telling, and interjections, which rarely occurred in their NM meetings. Members reported:

> Face-to-face is much better. You can see expression and feel more of a team. Especially when people don't speak...With NM it is an abstract group, for example when do you interrupt?
>
> I get extra feedback of the body language of a person. Having met that person, I have that in the back of my mind [during NM use]. Without it, something is missing.
>
> Reflective looks means they are thinking. Silence on the line doesn't. People may say things sarcastically, but the expression on-line is confused. Many signals that you have face-to-face are lost.
>
> You have to interact with this person. Your stereotype of the person doesn't work on the program, the person works on the program.
>
> [A Scientific Team member]: It's really important to meet face-to-face to be comfortable. To know if this is an open or formal person. It does change the interaction, and the comfort level is high in this group.

The desire for a visual image of remote participants was shown in amusing ways. The Staff leader placed Dilbert cartoons on his monitor with their names.

A major problem with mediated interaction is not knowing who is present at remote sites. In NM, a window that lists participants in the session is generally soon covered and indicates only one person per office or conference room. And those who are listed may be multi-tasking (discussed later) or may have left their offices. Uncertainty is revealed by frequent inquiries into the presence of others:

Cathy: I'm Cathy, I work at ----, my area is data exchange.
[long pause]
Cathy: Is everyone still there?
[a few say yes]
Cathy : Because I didn't hear the background noises and didn't know if everyone is still there.

Similar events occurred in the Best-Practice Team, where it was often unclear who was speaking and whence they spoke. Members often tried to clarify this, or the leader identified the person. In Staff meetings, after a period of silence from a

remote site, someone sometimes checked attendance:

St. Louis, still there?
We're still there. [Note the irony.]

These observations were also consistent with the low response to the question:

It was clear who was present and who left remote sites	
Scientific Team	3.3
Technical Working Group	3.7
Staff	4.3
Best Practice Team	3.3

The higher Staff response could be due to the occasional attendance-checking. Also, with only two remote sites, remote members' behaviors were evident.

Not knowing who was present was also a problem identified in Ackerman et al. (1997). The group in their study developed norms to make public who was present. Whereas their group included fewer participants interacting continually, the meetings in this study had more members (some who had never met face-to-face), were of a formal nature, and were discontinuous. Thus, it appears that in this study, a nonuniform set of conditions inhibited the development of clear identities, for norms to be established.

To a lesser extent, people complained they could not identify who was speaking, or the speaker's organizational home. Even though written guidelines advised announcing one's name prior to speaking, this was seldom observed. This was mainly a problem in the Technical Working Group since the meeting was open and non-core members participated. A typical interchange was:

Leader: Did everyone have a chance to review the charter?
R: no
Leader: Who is this?

Fortunately, the same people usually spoke at the meetings, typically the leader and a few core group members, and their voices became familiar. Participants did not consider speaker identity a major problem (no group differences):

It was easy to identify who was speaking	**4.4**

3.3 Problems of low involvement due to multi-tasking

Many people reported performing other tasks during meetings. Multi-tasking has both costs and benefits. Most considered this a big advantage – one can attend more meetings and accomplish other work. Remote members of the Technical Working Group and Best-Practice Teams reported the most multi-tasking. This is not surprising: their 8-20 remote site participants were much less salient than the handful in the other two teams.

Some members described multi-tasking as a distraction and detriment. One Best-Practice Team member reported often reading email or talking with other people in his room, but he acknowledged that it reduced his commitment to the

group. Usually members muted their telephones while multi-tasking but often forgot to turn off the mute function before speaking, which disrupted meetings:

Leader:	Sue, anything else? [long pause]
Dick:	Sue left us awhile back. [further pause]
Sue:	No, I haven't. My mute button was on. [Sue then explains that she put 2 URLs in the chat window. The leader replies that he does not have NM in front of him so he cannot see the chat window].

During one Best-Practice Team meeting, frustration was strongly expressed:

Mark:	Dan, that's your action item.
Dan:	Sorry, I didn't catch that.
Mark:	Jack, what's your comment? [long pause] Jack, are you there?
Jack:	I had my mute button on.
Mark:	Next is the rotocraft area, but he is not here.
Rob:	We need communication. 80 hours is not the problem. I waste 80 hours talking on the telephone. It requires a tremendous amount of extra effort to clearly communicate. When someone says we're having a telecon, then we need to be on the telecon.... People need to be on the telecon. We need a schedule.
Joe:	We all sit here and what are we doing? Is everyone trying to be on these telecons?.....We have to decide on issues that we feel are important. Things can be done but we need to talk to each other and use these telecons.
Mark:	Thank you, Joe. [Mark moved on to the next action item]

These comments illustrate a difficulty that teams face in forming commitments: counteracting a lack of engagement, which can be exacerbated by multi-tasking.

3.4 Overcoming technology use problems: technology facilitation

Because the Scientific Team had struggled when using telephone conference calls, its leader created a new *technology facilitator* role, expanding the role of technology driver. This person was responsible for all aspects of technology use: establishing a connection, trouble-shooting, and controlling the presentation. This helped make their meetings strikingly more effective.

First, meetings almost always started promptly. Once when a server failed, the facilitator told the remote participants how to dial into another conference server, solving the problem quickly. Second, the facilitator monitored whether people at the main site were being heard, and brought in an additional clip-on microphone for someone who spoke softly. The facilitator even drove the technology when a remote member gave a presentation, by gesturing with a pointer on the display or zooming to a shared image as the speaker described it. He explained his role:

> Every node [site] needs a technical facilitator. The main goal is he must make sure how the details are implemented. The medium must be as transparent as possible. This minimizes the effect on the meeting. To be successful, everyone must be on the same page. The goal is that when the meeting starts, the same page should appear. I try to be in synch with the presenter. I try to be on the same mental page, the view that the presenter wants to give to the virtual group. For example, if the presenter wants to zoom in, I hear the word zoom, and zoom in.

In contrast to the Staff, Scientific Team speakers used the touchscreen SMART Board effectively when explaining data on the display. For example, when explaining visual images to remote sites: “machines which have a crush-grind operation” [back and forth motion] or “initially you want to push as hard as you can, then slowly.” Yet speakers at the main site also used hand gestures, as when indicating specific drilling operations, which remote people could not see.

The Scientific Team responded most favorably about technology driving:

The control of the data on the display was smoothly managed:	
Scientific Team	4.8
Technical Working Group	3.9
Staff	4.2
Best Practice Team	4.3

3.5 Overcoming interaction problems through meeting facilitation

In the early stages of the Scientific Team, the leader was also the facilitator, but he discovered that it was too stressful to facilitate the meeting, take minutes, and answer questions. He created a new role in the group, a *virtual meeting facilitator*, who acted as a “bridge” to involve the remote sites in the meeting: “*The conceptual framework is that we are the central site with nodes.*” This reflected his awareness of the need to integrate the remote sites into the meeting.

The role of this facilitator, Al, was multivariate; he addressed many of the interaction problems observed in other groups. First, he established who was present at each site. Roll call protocols were very informal in the other groups. As with face-to-face group facilitation, he kept order by introducing agenda items and by beginning and adjourning meetings. He continually confirmed that remote sites could see the display, and addressed uncertainty of attendance by continually checking with remote sites, for example:

Al: St. Louis had to leave?
Remote: No, we're still here.
Al: Who's there?
Remote: Just me.
Al: Is Canoga Park there?

He was also concerned that all speakers were identified, especially at remote sites, and made sure that everyone was heard.

Al: You have to speak up. Why don't you move over here closer to the mike?

Being a technical expert, he also clarified points for all by repeating them, or summarized or rephrased someone's explanation.

Al: Jeff this is Al. What is the Y axis?
Al: He is basically saying.....

In his nontraditional function as facilitator, Al also coordinated speaking turns by recognizing body language in the conference room (e.g. when someone sat forward or raised a hand) or by hearing an utterance on-line. For example, Nick at the main site asked a question, and then was interrupted by Jim at a remote site.

Al asked Jim to hold on, explaining that Nick just asked a question. He then asked Nick to move closer to the microphone, believing that the remote site did not hear the question. When Nick was finished, Al asked Jim to ask his question again.

Al worked hard to involve remote members in the discussion by asking specific individuals to make sure their questions were answered, referring to people when he believed that they were interested in a topic, or calling on specific people who might have the expertise to answer a question:

> Al: This is for John and Matt in St. Louis. One of our meeting goals is to find ways for our modeling efforts to be useful for you and how we might collaborate together. I'd like to hear what interests you have in this data. I need your feedback so we can be responsive to your needs.
>
> Al: Does St. Louis have a comment on that? [He explains that someone in St. Louis is working on that problem].

In addition, Al encouraged questions at certain points in the presentation, explained to remote participants what was happening at the main site, such as when silences occurred, and kept order during discussions by calling on people.

The facilitator described a difference in problem-solving perspectives. This is a very heterogeneous group, with machinists, scientists, customers, people with different priorities, knowledge, patience levels, and so forth. Al worked to draw out and consider these conflicting perspectives, to get everyone "thinking on the same page," and to balance the discussion to suit all parties' interests, important for the technical exchange. Meeting people face-to-face had value for him:

> It helps to know what they mean when they ask a question. Otherwise it's like getting a written question. For example, knowing their background: Jeff in drilling, Matt in statistics, Hal in vibrations.

The effect of the meeting facilitator appears in the questionnaire data (fig. 2). The Scientific Team and the Staff both had a main node and remote nodes (fig. 1a). But questions about remote interactions produced different responses. Remote Staff sites had far more difficulty identifying and understanding who was speaking and knowing each others' reactions, and reported that interruptions interfered with the meeting. The data must be viewed with caution, since the Staff responses are from only two remote sites. Still, this suggests the value of distributed meeting facilitation to identify who is speaking, explain comments for the benefit of remote sites, and facilitate turn-taking in speaking.

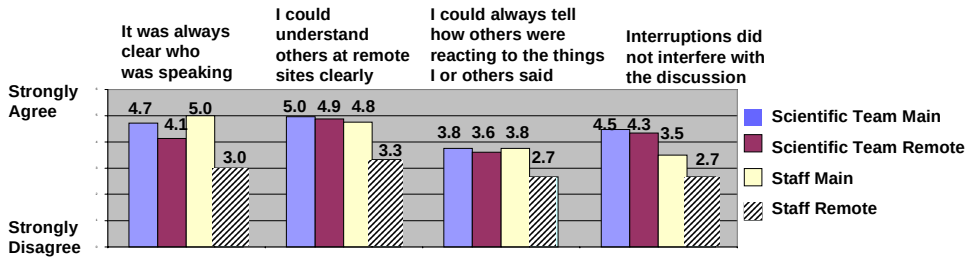

Fig. 2. Questionnaire responses about interaction: Scientific Team and Staff, main and remote sites

3.6 Easing interaction problems with an additional channel: chat

Only the Technical Working Group used NM's chat functionality. It was initiated and sustained by one member, who had used chat in other conferencing systems.

In contrast to the formal content of the meetings, the chat window was used to communicate a range of information, from private jokes to elaboration on meeting content. The principal user, who saved all public chat windows, found them very useful and entertaining, but above all claimed that it helped group members bond. In the first 5-10 minutes of a meeting, the chat was used for greetings, but also to affirm that everyone who wanted to attend this open meeting was connected properly. The chat window was also used to track attendance and any problems, especially if someone was not connected via audio:

User 6: AOK now
User 1: telecon number is 742-3000 password 6342#
User 2: Diane, are you on the telecon?
User 3: I'm on the telecon.

This checking was relatively constant; for example, in one meeting, it appeared in the chat window 16 minutes, 19 minutes and 45 minutes into a meeting. In another meeting, User 1 gave the telephone number and password three times in the chat window during the first 17 minutes.

Some found the chat window to be a useful back channel. For example, if a Web page or phone number was needed, one person sought the information as the meeting continued and placed it in the chat window. One member saved chat windows to retrieve contact names. He kept meeting minutes and supplemented them with information from the chat window. He felt that all chat should be public due to its potential contribution to the minutes. The chat window was also used to give advice on technology problems without disrupting the meeting:

User 4: I'm having trouble seeing the whole screen.
User 2: Scroll your mouse to the border and it should move your screen viewpoint.

Especially important, the chat window is used during the meeting for side discussions and private conversations (the following later shared with us):

User 3 (to User 5): This last point is what I am afraid of by the web publishing flash heads.
User 5 (to User 3): I looked away. What was the last point? (the funky sales data?)

Thus, chat can have value for distributed teams: without disrupting the meeting, it can confirm attendance and connections, be used to gather information, solve usage problems, and enable frequent side conversations.

3.7 Moving beyond audioconferencing: being on the same page

The Scientific Team leader reported that when the meeting relied on telephone conference calls, he almost disbanded it due to his frustration over the considerable preparation time. Compared to face-to-face meetings, 50% more time was needed to fax information. Last minute changes were not faxed, and

members missed up-to-date changes in experimental results, which could be critical data for materials scientists. Often the meeting stopped to fax information.

Application sharing enabled access to last minute changes, in color with high resolution, such as a microphotograph of a metal cut “just off the press.” Fax quality could not compare. The cursor could be used as a shared reference, focusing attention across sites on the same point in an image. This was especially important for detailed scientific diagrams and microphotographs.

Before NM use, the Technical Working Group had also briefly used audioconferencing only. They tried to synchronize the shared information by announcing web URLs over the telephone, but when 12-15 people tried to type a URL, everyone had to wait (a member noted) for one person’s “fumble fingers.” Sometimes the group gave up and distributed the URL via email. This group also saw the value of application sharing.

Similarly, members in the Best-Practice Team who connected only by telephone had trouble keeping up with the 35-40 action items per meeting viewed by others on the Web, and could not see other documents accessed by the group.

Teams reported that application sharing contributed more than live video, which many members had used. One reported that video “gave a picture of the group that was interesting, but it had no value” because it could not show data. The Scientific Team leader agreed; they had sometimes met in video studios, but these were expensive and hard to schedule, and they abandoned the use of video.

Thus, for distributed team meetings, application sharing provides a real advantage. It enables smooth coordination when changing document views. The shared cursor directs all members' attention to the same point, particularly useful with detailed diagrams. Advantages of shared references have been reported by Stefik et al. (1987) for face-to-face groups; we find that a shared reference also markedly improves the efficiency of virtually collocated team meetings.

3.8 The effect of application sharing: more distributed participation

Adding application sharing also changed the team’s distribution. The Scientific Team’s meticulous attendance records show that attendance increased from a median of 12 during face-to-face meetings to a median of 21 with audioconferencing. A few participants joined from greater distances and more also attended at the Bellevue main site (median of 18, see figure 4).

Adding NM with application sharing increased participation to a median of 23. However, face-to-face attendance at the main site dropped (figure 4). Median attendance dropped from 18 to 8 over the next 12 months: team members at sites in greater Seattle (up to an hour away) began attending from their offices. Figure 5 shows the number of sites during each technology phase: one for face-to-face meetings, three for audioconferences, and seven after 12 months of NM use. The data thus show that adding application sharing coincided with a marked decrease in travel by members in greater Seattle to attend the face-to-face meetings.

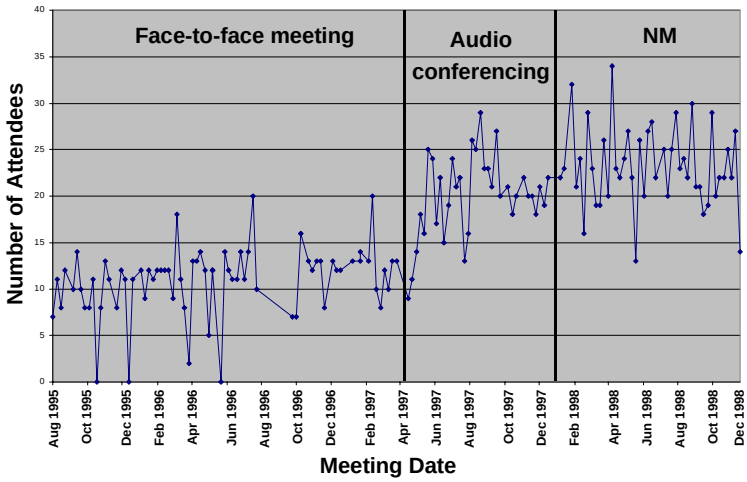

Fig. 3. Scientific Team attendance during technology phases

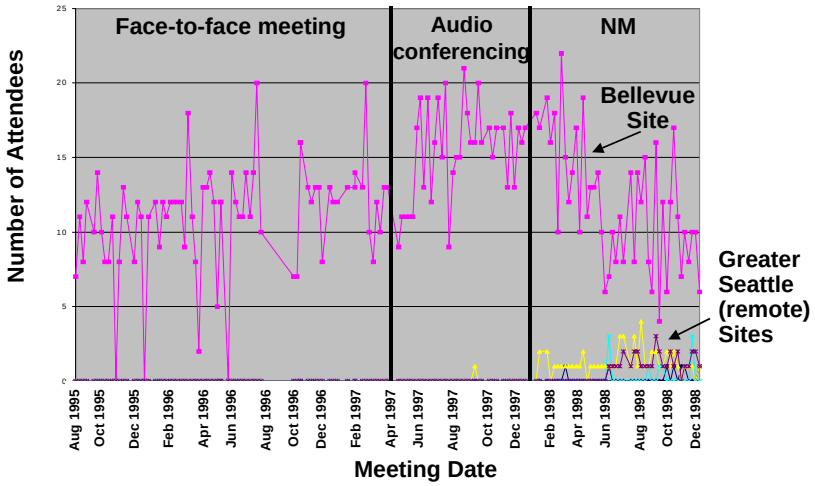

Fig. 4. Change in attendance distribution in greater Seattle by site

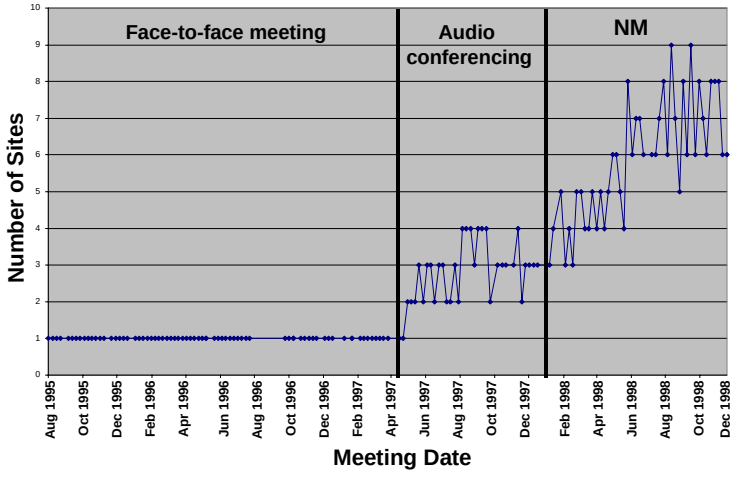

Fig. 5. Total sites for Scientific Team during technology phases

4. Conclusions

We have crossed a divide. Technology has made it feasible for many organizations to rely on geographically distributed teams, but distributed meetings are relatively inefficient. Email, fax, and telephone do not adequately support such teams: consider the successful Scientific Team that almost disbanded due to the limitations of these technologies. Desktop conferencing, which combines information-sharing with synchronous communication, holds promise for supporting virtual collocation. Yet users of such technology face challenges.

To start with, the goal of connecting remote team members is hard to achieve. Impediments to adoption and use of the technology by remote members include having no one to consult about the technology at a site, the relative lack of importance of remote teams in the eyes of managers and participants, and local discouragement. It is a Herculean task to overcome these from a distance.

In addition, as with face-to-face groups, teams with long-term agendas must consider how to develop and maintain appropriate social behaviors, such as trust and cohesion. When interviewed, members of these teams expressed concerns over how they could develop trust. Audio media are known to offer limited social cues for expression (Short et al., 1976), and we observed that it also affects team-building; team members complained "*with NM it is an abstract group"* and "*NM makes us one step removed, so it's a feeling of being on the periphery."* The challenge of team-building is further compounded by the double-edged nature of multi-tasking, which offers advantages yet can hinder engagement and reduce commitment to the group. Also contributing to the difficulty of building cohesion is that teams may have to overcome not only geographical distance, but also organizational boundaries and cultures, and even language codes, as had occurred in these groups through corporate mergers. Handy (1995) says that trust requires touch, but it is difficult to guarantee that dynamically changing teams will have adequate face-to-face interaction-and what is 'adequate' is not yet known.

To counteract these difficulties, the scientific team, perhaps through their maturity and experience of passing through other technology phases, developed new roles that offered solutions for virtually collocated teams. The technology facilitator enhanced display information for remote participants by gesturing with the cursor and zooming. The meeting facilitator overcame many problems in coordinating interaction experienced by the three younger teams. Aware that remote participants find it hard to interject, he governed speaking turns. He identified speakers, but more than that, he knew their individual expertise and directed questions and comments accordingly, making their knowledge and role more evident to the group. This helped to counter the complaint echoed by several that "*...anything we've learned – the job description, the work role – comes from personal face-to-face interaction. With NM we would not have gotten this information...*". The meeting facilitator continually identified who was present at remote sites, another valuable contribution. NM might be enhanced to make

members' status continually visible during the meeting in a nondisruptive way: who is present and who has left the meeting temporarily, or permanently.

The teams we observed were at relatively early phases of technology adoption. They maintained much the same meeting behaviors of face-to-face meetings, but introducing a new technology affects existing processes. Remote participants reported difficulty in contributing, not knowing when to interrupt, feeling left out. As reported by Isaacs et al. (1995), presenters can be unnerved by the lack of engagement of remote participants. Chat was used by one group to recreate social interactions absent in formal remote meetings. To gain greater advantage from new technologies, virtually collocated teams must reflect on their goals and how to restructure their activities to achieve them. Only one team had developed facilitation roles that greatly enhanced the contribution of remote members.

Distributed teams benefit from adding application sharing to audioconferencing. The value of shared reference and views cannot be understated; getting top quality materials "off the press" does not compare to faxes, even apart from the work of faxing materials (or sending email) to 15-20 participants. The use of application sharing by the scientific team coincided with a marked decline of traveling, suggesting that members felt that application sharing, but not audio conferencing alone, is sufficient for good distant participation in meetings. Competent facilitators and a history of face-to-face interaction may also have eased their transition to virtually collocated meetings.

No team in this study worked full time on a shared set of deliverables. Members of a team that communicated continuously via audio developed norms to move easily in and out of group participation (Ackerman et al., 1997). Remote team members are not part of the continuity of each others' work. We do not suggest continuous communication for all teams and tasks, but our results confirm the need for a seamless transition between remote and collocated activities for diverse distributed teams. This could be achieved through support for informal interaction (Whittaker et al., 1997) together with formal meetings. In this way, technology can become well integrated with virtually collocated teamwork.

The participant who insisted "I'm in the global room" expressed succinctly the changing nature of interaction. We see a new metaphor: a computer as a window onto a global meeting room where information can be displayed by anyone in the team and seen anywhere. This metaphor reflects new kinds of flexibility, where anyone in a company can participate in a Technical Working Group meeting, and where the team leader relocates across the country and remains leader of the group. To the mobile officeless Staff leader, the technology enables impromptu information sharing, holding a meeting "with whomever, and wherever he is."

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References

Ackerman, M. S., Hindus, D., Mainwaring, S. D., and Starr, B. (1997): “Hanging on the 'wire: A field study of an audio-only media space”, *ACM Trans. on Computer-Human Interaction*, vol. 4, no. 1, pp. 39-66.

DeSanctis, G. and Poole, M.S. (1997): “Transitions in teamwork in new organizational forms”, *Advances in Group Processes*, 14, Greenwich, CT: JAI Press, Inc, pp. 157-176.

Handy, C. (1995): “Trust and the virtual organization”, *Harvard Business Review*, vol. 73, no. 3, pp. 40-50.

Isaacs, E.A., Morris, T., Rodriguez, T.K. and Tang, J.C. (1995): “A comparison of face-to-face and distributed presentations”, *Proceedings CHI’95*, Denver, ACM Press, pp. 354-361.

Jarvenpaa, S. L. and Leidner, D. E. (1998): “Communication and trust in global virtual teams”, *Journal of Computer-Mediated Communication*, vol. 3, no. 4, http://www.ascusc.org/jcmc/.

McGrath, J. E. (1984): *Groups: Interaction and Performance*, Englewood Cliffs, N.J.: Prentice-Hall.

Minneman, S. L. and Bly, S. A. (1991): “Managing à trois: a study of a multi-user drawing tool in distributed design work”, *Proceedings CHI'91*, New Orleans, ACM Press, pp. 217-224.

Orlikowski, W. (1992): “Learning from Notes: Organizational issues in groupware implementation”, *Proceedings CSCW’92*, Toronto, ACM Press, pp. 362-369.

Robinson, M. (1991): “Double level languages and co-operative working”. *AI & Society*, vol. 5, pp. 34-60.

Schein, E. H. (1990): *Organizational Culture and Leadership*, San Francisco: Jossey-Bass.

Short, J., Williams, E. and Christie, B. (1976): *The Social Psychology of Telecommunications*, London: John Wiley & Sons.

Sproull, L. and Kiesler, S. (1991): *Connections: New Ways of Working in the Networked Organization.* Cambridge, MA: MIT Press.

Stefik, M., Foster, G., Bobrow, D., Kahn, K., Lanning, S., Suchman, L. (1987): “Beyond the Chalkboard: Computer Support for Collaboration and Problem Solving in Meetings”, *Communications of the ACM*, vol. 30, no. 1, pp. 32-47.

Whittaker, S., Swanson, J., Kucan, J., and Sidner, C. (1997): “TeleNotes: Managing lightweight interactions in the desktop”, *ACM Trans. on Computer-Human Interaction*, vol. 4, no. 2, pp. 137-168.

Whittaker, S., Geelhoed, E. and Robinson, E. (1993): “Shared workspaces: how do they work and when are they useful?”, *International Journal of Man-Machine Studies*, vol. 39, pp. 813-842.

Wiesenfeld, B. M., Raghuram, S. and Garud, R. (1998): “Communication patterns as determinants of organizational identification in a virtual organization”, *Journal of Computer-Mediated Communication*, vol. 3, no. 4, http://www.ascusc.org/jcmc/.

Zack, M. H. (1993): “Interactivity and communication mode choice in ongoing management groups”, *Information Systems Research*, vol. 4, no. 3, pp. 207-239.