

Work, Friendship, and Media Use for Information Exchange in a Networked Organization

Caroline Haythornthwaite*

Graduate School of Library and Information Science, University of Illinois, Champaign, IL 61820.

E-mail: haythorn@uiuc.edu

Barry Wellman

Centre for Urban and Community Studies, University of Toronto, Toronto, Canada M5S 2G8.

E-mail: wellman@chass.utoronto.ca

We use a social network approach to examine how work and friendship ties in a university research group were associated with the kinds of media used for different kinds of information exchange. The use of electronic mail, unscheduled face-to-face encounters, and scheduled face-to-face meetings predominated for the exchange of six kinds of information: Receiving Work, Giving Work, Collaborative Writing, Computer Programming, Sociability, and Major Emotional Support. Few pairs used synchronous desktop videoconferencing or the telephone. E-mail was used in similar ways as face-to-face communication. The more frequent the contact, the more "multiplex" the tie: A larger number of media was used to exchange a greater variety of information. The closeness of work ties and of friendship ties were each independently associated with more interaction: A greater frequency of communication, the exchange of more kinds of information, and the use of more media.

Introduction

The rapid growth in the use of E-mail and other forms of computer communication media leads to questions about the circumstances under which people use these media for information exchange. Organizational and institutional decision makers want to know how computer media can aid the information exchange process, what kinds of information are best delivered through which media, and why people use one medium over another. These are more than issues of choosing media that are appropriate for the task or comfortable for the individual user. Information exchange among people is inherently a *social* phenomenon. Hence, it is important to understand how social relationships affect what is communicated, between whom, and via which media.

To examine these matters, we use information from our study of 25 members of *Cerise* (a pseudonym), a university

computer-science research group. Our social network approach focuses on the association of work and friendship relationships with the kinds of media *Cerise* members use for different kinds of information exchange, face-to-face and computer-mediated. Like many previous studies, we analyze the use of different types of media for exchanging various kinds of information at work. But we also analyze how variations in work and friendship relations are associated with the use of media in information exchange.

Tasks, Norms, and Media Use

Until now, debates about when people communicate by computer media have been dominated by discussions of how a particular medium fits specific *tasks* or how *group norms* determine the appropriateness of using different media in particular situations. Thus, with the proliferation of E-mail in the past decade, analysts have been preoccupied with the kinds of information people should exchange, and have exchanged, via this new medium. Their research has focused on understanding what technological properties of E-mail and other computer media facilitate and constrain information exchange. Analysts have noted that text-based, asynchronous E-mail provides little information about people's physical and social characteristics (e.g., dress, seating, gender, age, ethnicity) and social positions (e.g., status). They have gone on to examine whether the limited "social presence" of computer media (as compared to face-to-face contact) affects the media people choose to use, their perception of the messages they receive, and their perception of the people who send messages to them (see Kling, 1996; Short, Williams, & Christie, 1976; Sproull & Kiesler, 1991). For example, Daft and Lengel (1986) argued that people should choose rich media (e.g., face-to-face contact) over less rich media (e.g., impersonal written documents) when communicating equivocal or difficult messages (see also Kiesler & Sproull, 1992; Short et al., 1976). Some

* To whom all correspondence should be addressed.

researchers have found that users considered the lower social presence of E-mail to be less appropriate for intellectually difficult or socially sensitive communications (Fish, Kraut, Root, & Rice, 1992), and that the type of information exchanged in different organizations affected the types of media used (Markus, Bikson, El-Shinnawy & Soe, 1992; Rice, 1992).

Rather than focusing on the technological fit between communication task and type of medium, the *normative* perspective has focused on how evolving usage and norms within a group influence media choice (Rice, Grant, Schmitz, & Torobin, 1990; see also the collected papers in Fulk & Steinfield, 1990). Researchers examine the use of available media in relation to the organizational context and in relation to other media. Markus (1994) examined the use of personal contact, telephone, E-mail, and memo for different types of messages. She found that managers' use of different media more closely reflected normative pressures from the organization's leaders (who were promoting E-mail use) than it did the managers' own perceptions of which types of media were more congruent with what kinds of tasks. They had internalized these norms as guides to when it was appropriate to use E-mail. Others have found that communication media can act as a complement to face-to-face communication, extending communication possibilities and opportunities (McKenney, Zack, & Doherty, 1992; Rice, 1994b; Short et al., 1976; Sproull & Kiesler, 1991; Wellman & Tindall, 1993).

Whether focusing on tasks or norms, most media choice research has had an individualistic perspective: Focusing on the types of communication for which *each person* separately *chooses* to use computer media or face-to-face contact. The task perspective's emphasis on the technical aspect of communication is explicitly individualistic, looking at individuals using media without regard to who these individuals are, and to whom they are sending the messages. Although the normative perspective discusses the social inculcation of norms, it assumes that each individual acts independently in response to the norms with which they have been inculcated. Thus, media choice research has often treated people as if they were socially disembodied beings without positions in social systems. Reading this literature is to enter a world without matters such as power, gender, socioeconomic status, differential resources, or complex bundles of interactions and alliances (but see Garton & Wellman, 1995; Kiesler & Sproull, 1992; Saunders, Robey, & Vaverek, 1994; Weisband, Schneider, & Connolly, 1995).

The Social Network Perspective

Social network analysis

Information exchanges, whether face-to-face or computer-mediated, are more than individual human-computer interactions. They are social interactions. The nature of information exchanges is constrained by the types of relationships people have as well as the types of media avail-

able, the kinds of information to be exchanged, and the norms that are in operation. When a computer network connects people (or organizations), it is also a social network. The social nature of information exchange suggests that it is an issue of "media use" rather than an issue of individually-chosen "media choice."

Hence, we use social network analysis in this article to examine how social relationships are associated with the interplay of media use and information exchange. Social network analysis is the study of social structure and its effects. It examines patterns of ties among people, organizations, and other institutions. A social network consists of a set of these social actors (or sometimes, several sets) and the ties among them. Thus, ties are functions of pairs of actors. Network analysts also take into account information about the attributes of actors, such as their gender or work status.

The theoretical underpinning of social network analysis is the argument that behavior is affected more by the kinds of ties and networks in which people are involved than by the norms and attributes that individuals possess (Wellman, 1988). This leads to a focus in this article on how ties—and the networks in which they are embedded—affect *who exchanges information with whom, about what, by which media* (Garton, Haythornthwaite, & Wellman, 1997; Haythornthwaite, 1996b; Rice, 1994a; Wasserman & Faust, 1994; Wellman, 1997). Our objective is to compare different kinds of ties in an organization: Formally-constituted work ties, actual work relations, and friendship relations. We analyze how such ties are related to:

1. The frequency of use of different types of communication media for each kind of relationship;
2. The multiplexity of the overall ties among each pair of group members.¹

Work ties

Work statuses describe what ought to be—including legal rights and duties, while work ties describe what is—including unofficial routes for information exchange. Although many work ties are formally mandated by the organization, many others are non-mandated ties that can differ markedly from those described in organizational manuals (e.g., Blau, 1955; Han, 1996). Informal ties are prevalent and foster a wide range of information-exchange relations. Although work statuses and work ties influence each other and may overlap, they may have different patterns of information exchange (Krackhardt, 1990). For example, not all members worked directly with one another in Cerise. There were many formal ties, such as between faculty members

¹ "Multiplexity" is a social network measure of how broadly or narrowly based is a tie. In our case, we measure multiplexity by counting the number of information exchange relationships in a tie. A very narrowly based tie would have one type of relationship, such as Giving Work. By contrast, a more broadly based tie might include relationships of Giving Work, Collaborative Work, Major Emotional Support, and Sociability.

and the graduate students they were supervising, or between faculty members (or students) who were collaborating. However, there were also many work ties not captured by formal work descriptions. Thus, faculty members often informally advised students who did not formally report to them, and many pairs of students had informal work ties.

Friendship ties

Not only do workers have informal work ties, they also have friendships at work that may be independent of their work ties (Abbott, 1988; Kornblum, 1974). The intimacy of coworkers' friendships can range from just working together, through acquaintanceship and friendship, to close friendship. Friendship was especially fostered by the collegial work arrangements of university-based Cerise and the many interactions of members outside Cerise. Students often took courses with each other, and faculty were members of the same department.

Hypotheses

Our hypotheses draw from the social network perspective to address associations between work and friendship ties and the types of media used for information exchange.²

Overall

1. *Frequency/multiplexity: The more frequent the interaction, the more kinds of relationships and the more types of media used in that tie.* In other words, the more kinds of information exchange interactions that people have, the more frequently they will be in contact, and the more types of media they use, the more frequently they will be in contact. While this "the more, the more" hypothesis may seem obvious, it is not necessarily true. For example, Wellman and Wortley (1990) found that those community members who were socially-close intimates were not those physically-close neighbors and workmates who were in the most frequent contact.

2. *Frequency/media: Frequent E-mail communicators will be less frequent face-to-face communicators.* This hypothesis draws upon assertions that E-mail is a substitute for face-to-face interaction, both scheduled meetings and unscheduled encounters (see the review in Garton & Wellman, 1995). Hence a high rate of E-mail use should be associated with a low rate of face-to-face interaction. There are other possibilities. If E-mail and face-to-face communication are each suited for different tasks, the rate

² An earlier article examined variations in the kinds of information exchanged in different types of media, thus examining the media choice issues in the task perspectives. It found that despite the task, there was more use of face-to-face communication than E-mail or desktop videoconferencing (Haythornthwaite et al., 1995). These findings undergird our approach in this article to examine social relational correlates of information-medium exchange rather than task-media fit.

of E-mail contact might vary independently from face-to-face contact, producing no significant association. On the other hand, E-mail and face-to-face interaction may be synergistic so that a high rate of E-mail contact would be associated with a high rate of face-to-face contact (Rice, 1994b; Short, Williams & Christie, 1976).

Type of tie

In each of the following hypotheses, we examine the association between work or friendship and

- (a) the frequency of using different media;
- (b) the frequency of using different media for specific kinds of information exchange;
- (c) the multiplexity of ties.

As each hypothesis examines higher frequency and multiplexity, to reduce repetition, we refer to (a), (b), and (c) as "more interaction."

3. *Work tie: The more formal the work tie, the more interaction.* Those with formal work ties will be involved in a wider range of work activities and have a greater frequency of contact in those activities than those with informal work ties or no work tie at all. We also expect that those with formal work ties will use a higher proportion of E-mail and scheduled meetings, while those who do not have formal work ties will interact more through unscheduled face-to-face encounters. This is because formal work ties require the coordination of scheduled meetings and the immediate transmission of information that E-mail affords.

4. *Friendship tie: The closer the friendship, the more interaction.* Sociologists have documented that close friends will interact more than acquaintances or those who only have a work relationship (Homans, 1961; Wellman, 1992). Moreover, their tie is apt to be more broadly-based, including both sociable and instrumental information exchange. We also expect that those with close ties, because of their willingness and readiness to communicate, will have higher proportions of spontaneous contact, both in unscheduled face-to-face encounters and via E-mail (Wellman & Gulia, in press; Wellman et al., 1996).

5. *Work status versus work tie: Work ties will be more strongly associated than work statuses with more interaction.* Actual working relationships rather than work statuses should be associated with information exchange patterns among coworkers. If work status and work relations are substantially identical, then there should be no difference in patterns of information exchange and media use. If, on the other hand, work relations diverge from work statuses, then functioning work ties should be more closely associated with interaction patterns.

6. *Work tie versus friendship tie: Work ties will be more strongly associated than friendship ties with*

more interaction. Interaction in a work organization such as Cerise will be more activated by work than by the friendships that, despite their importance as social glue, are tangential to organizational goals and work tasks.

The Study

The Cerise Research Group

Cerise consisted of computer science students, faculty, and employees in a large North American university. Unlike many academic units, Cerise had an organizational focus—to develop a well-defined area of computer science—and it even hoped to produce a commercially-viable product. It operated much like a research and development group in the private sector: Members used a variety of communication media to deal with demanding, problem-solving tasks that required quick responses. It was organizationally flat, consisting only of faculty, graduate students, and a few staff members. The group had been together for some time when the data were collected in 1992.³

Cerise members interacted frequently, sharing work, and completing research projects and computer programs for degree completion, academic presentation, and publication. The work was generally unstructured, but members had work deadlines associated with course requirements, software demonstrations, reports, and conferences. Equipment and offices were often in use around the clock. Students were included in all aspects of the group's activities, including making decisions about equipment and office design, and writing grant proposals. Faculty and students met regularly on-site in classes and research meetings. Social activities included parties, pub nights, and an on-site food and beverage emporium organized by the students.

The Questionnaire

From a list of all Cerise members, respondents identified the 20 correspondents with whom they communicated most frequently and answered each question in relation to each of these 20 correspondents. The questions covered work and social activities that occurred regularly within Cerise. Respondents reported whom they communicated with, by which medium, and about what. For each question, respondents recorded "how often" (number of times per day, week, month, or year) they communicated with each correspondent via each of six media: Unscheduled face-to-face encounters (encounters that were not planned in advance), scheduled face-to-face meetings, E-mail, telephone, fax, and desktop videoconferencing (see Fig. 1). Unscheduled encounters were separated from scheduled face-to-face

³ Only Cerise members who worked in the same computer science building were included in the study. Those few Cerise members who belonged to other departments and did not have office space within the computer science building were not included in order to exclude those who did not have much chance of unscheduled face-to-face meetings (e.g., encounters in the hallway).

TYPE OF INTERACTION	Cerise Members				
	1	2	3	...	20
How often have you received instructions (i.e., exact directions on what work to do) from this person?					
in unscheduled face-to-face meetings					
in scheduled face-to-face meetings					
by telephone					
by fax					
by electronic mail					
by videoconferencing					

How often: D for daily W for Weekly M for Monthly Y for Yearly 0 for never
For in between amounts use e.g., 2D for twice a day, 6Y for six times a year

FIG. 1. Example of the questionnaire format.

meetings because each has different participants, social forms, and dynamics (Kraut, Fish, Root, & Chalfonte, 1990). In another part of the questionnaire, respondents also indicated their working and their friendship relations with each of the correspondents. Work ties could be "formal," "informal," or "non-working"; friendship ties could be "close friend," "friend," "acquaintance," or "work with only"; formal work statuses were "faculty," "student," or "employee."

The Sample and the Pairs

The total Cerise population included 35 members who worked in the same building (3 female and 32 male): 4 faculty, 26 students (mostly graduate students with a small number of upper-year undergraduates), and 5 employees (systems administrator, programmers, office workers). Questionnaires were completed by 25 of these members (3 female, 22 male), a 71% response rate, including 19 students (76% of the sample of 25), 2 faculty (8%), and 4 employees (16%). Although respondents were asked to report their information exchange with 20 correspondents, they actually reported on 10 to 20 correspondents. The number of respondents (25) multiplied by the number of correspondents they named gave a total of 417 respondent–correspondent pairs. We report in this article about the communication behavior of the 378 respondent–correspondent pairs who communicated at least once per year about at least one of six kinds of information exchange described below.⁴

Most ties in Cerise were working ties, formal or informal, combined with friendly relations ranging from acquaintanceship to close friendship. Twenty-one percent of the 378 pairs had a formal work tie (as described by the respondent), 64% had an informal work tie, and 16% had no

⁴ Reports on 20 correspondents captured the majority of communication between members of Cerise. Notes and letters were not included because they were rarely used by Cerise members. If all respondents had listed 20 correspondents, there would have been $25 \times 20 = 500$ pairs. If all Cerise members had completed the questionnaire, there would have been $35 \times 20 = 700$ pairs. If all respondents were actually fully connected to all others in Cerise, the number of pairs to be expected from our sample would be $25 \times (35 - 1) = 850$. Using 850 as the maximum number of pairs that could have been reported on by our respondents (if we had not limited them to 20), the network density of named pairs is 0.49 (417/850), i.e., each respondent named approximately half the members of Cerise.

TABLE 1. The six information exchange relationships.*

Information exchange relationships	<i>n</i>	%	Work and social activities
Receiving work (RW)	215	19	Receiving work assignments, instructions about work, advice about work; giving and receiving support and disagreement in discussions; giving minor emotional support
Giving work (GW)	215	19	Giving work assignments, instructions about work, advice about work, and instructions in new hardware or software; collaborating on non-written work; collaborating on administrative work
Collaborative writing (CW)	120	11	Collaborating on written work; exchanging documents
Computer programming (CP)	212	19	Collaborating on computer programs; demonstrating own work
Sociability (Soc)	326	29	Overall socializing; receiving minor emotional support; receiving instructions in new hardware and software
Major emotional support (MES)	28	3	Giving and receiving major emotional support
		100%	
Total no. of information exchange links	1,116		Average no. of information exchange links per pair 1,116/378 pair = 3.0

* The number of information exchange links (*n*) for each relationship is the same as the number of unique pairs maintaining each relationship, e.g., 215 of the 378 pairs maintain a Receiving Work relationship. However, since a pair may maintain one to six relationships, the total of 1,116 links is greater than 378, the number of unique pairs.

work tie. Over half of the pairs had either a close friendship (10%) or a friendship tie (46%), another 30% had an acquaintanceship tie, while 13% had a "work-only" tie. Thus the average Cerise member's communication circle, or ego-centric network, consisted of 15 members of Cerise with whom they communicated at least once a year. They were formally tied to 3 people, informally tied to 10, and had a non-working tie with 2 members of their network. Their networks included 2 close friends, 7 friends, 5 acquaintances, and 2 with whom they worked without being friendly.

Cerise pairs reported communicating frequently, with some type of information being exchanged by each pair an average of once a working day (mean of 259 times a year), and a median rate of nearly once a week (43 times a year).⁵

Information Exchange Relationships

The six information exchange relationships we report about here are roughly analogous to the "tasks" studied by other researchers, but also include the emotional support and sociability relationships that were important aspects of Cerise. They are empirically derived from an orthogonal factor analytic procedure (described in Haythornthwaite, Wellman, & Mantei, 1995) showing that 23 specific kinds of work and social interaction in Cerise fit within 6 more broadly-defined information exchange relationships: Receiving Work, Giving Work, Collaborative Writing, Major

Emotional Support, Sociability, and Computer Programming (see Table 1). For example, those who "collaborated on written work" were largely the same pairs who "exchanged documents": Hence an interaction in either of these specific exchanges was treated as fitting within the broad "Collaborative Writing" information exchange relationship.

These six information exchange relationships are not necessarily exclusive. For example, the same pair could maintain both a Receiving Work relationship and a Sociability relationship. Also, the relationships may be reported from two directions, e.g., a faculty member may report on their Sociability relationship with a student, and the student may report on their Sociability relationship with that faculty member. Thus, a student-faculty combination contains two different ties: A student-to-faculty tie and a faculty-to-student tie.

In total, 1,116 information exchange relations were maintained by the 378 pairs. The average Cerise pair engaged in three of the six information exchange relationships, a mean of 3.0 kinds of information exchange per pair. Most commonly, in terms of both the frequency of communication and the percentage of pairs who engage in each type of information exchange (referred to as information exchange links), these three relationships were Sociability plus the two relationships associated with work allocation: Giving Work and Receiving Work (see Table 1 and Fig. 2). Sociability accounted for 29% of the information exchange links, maintained at a mean rate of over once per week by those pairs who engaged in this relationship. Receiving Work and Giving Work each accounted for 19% of all links with mean communication two to three times a week on average. Not only were people giving instructions on what to do and discussing what they had been doing, they were also providing the sociable companionship that lubricates work relationships.

⁵ Frequencies were converted into numeric estimates of the number of communications per year. Daily interactions were multiplied by 260 (based on 5 days a week); weekly by 52; monthly by 12; and yearly by 1. While self-reports of frequency of communication are not expected to be accurate, biases across reports are expected to be consistent. Thus, the frequency data need to be considered relative to other frequency data collected, such as from one relationship to another, rather than relative to a real-world occurrence.

Fewer information exchanges directly involved the ultimate products of this research group. Although Computer Programming links accounted for 19% of all links, these were infrequent exchanges, with pairs communicating a mean of 23 times a year and a median of only 5 times a year. This discrepancy comes from the inclusion of demonstrating one's own programming in the broad Computer Programming relationship: Such demonstrations were infrequent but reached a wide audience. Collaborative Writing of scholarly papers accounted for a moderate number of links (11%), maintained at a moderate average rate of just over once a week (mean 65, median 8 times a year). A small percentage (3%) of the links were of Major Emotional Support, although the discrepancy between the mean (45) and median (3) annual number of exchanges suggests the importance of such exchanges for a few pairs.

Media Use

A broad array of available media made Cerise a good site at which to evaluate the use of media. In addition to considerable opportunities for scheduled and unscheduled face-to-face communication, members had access to telephone, E-mail, fax, and a desktop videoconferencing system. Yet the average pair used only 2.3 of the six available media (860 separate media connections were maintained by the 378 pairs).

Cerise members predominantly used unscheduled face-to-face encounters, face-to-face scheduled meetings, and E-mail. The most frequently used communication media were unscheduled face-to-face encounters followed by E-mail and, less frequently, by scheduled face-to-face meetings (see Fig. 3). Although used less frequently, scheduled meetings were almost as widely used as unscheduled encounters to keep in contact (34 vs. 39% of all media connections), and much more widely used than E-mail (which was used for 20% of media connections). This is because large scheduled meetings provided opportunities for Cerise members not otherwise in contact to exchange information; such scheduled meetings were also the preeminent means for demonstrating computer programming.

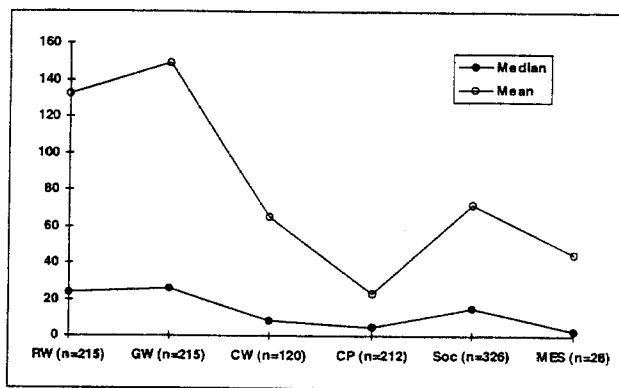


FIG. 2. Annual frequency of communication per relationship.
 RW: Receiving Work; GW: Giving Work; CW: Collaborative Writing; CP: Computer Programming; Soc: Sociability; MES: Major Emotional Support

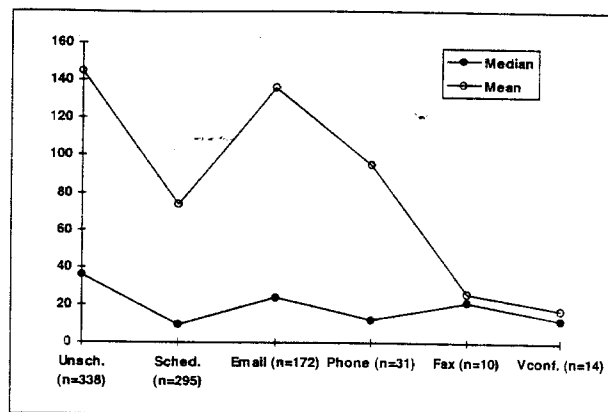


FIG. 3. Annual frequency of communication per medium.

E-mail was the most used machine-mediated means of communication, used to maintain sociable as well as instrumental relationships. As the work of these computer scientists often required them to be sitting at computer terminals connected to a mini-computer, E-mail was instantly at hand to send or receive information. Most Cerise members also used E-mail from home, and many used it when traveling. They valued the ease with which E-mail allowed them to communicate with those on different schedules or with those who were not in their offices, to communicate simultaneously with more than one person, and to include computerized documents (e.g., drafts of papers, computer programs) in E-mail exchanges.

Telephones, faxes, or videoconferencing were rarely used, accounting for 4, 1, and 2% of all media connections. Although the telephone (which did not have voice mail capabilities at the time) and videoconferencing (which did not have video mail capabilities) provide more social presence than E-mail, their synchronous nature required receiving parties to make themselves available for interaction at the behest of callers. Hence, people E-mailed rather than telephoned or videoed. Videoconferencing did not catch on when it was so easy to stroll next door to enjoy the richer social presence of face-to-face communication. If the person next door was not in, then videoconferencing would not have helped, and in any event it was not useful for conveying drafts of papers or computer programs.⁶ Faxes were

⁶ Since E-mail is especially useful when correspondents do not work in the same office, floor, or building, our restriction of the sample to correspondents working in the same building probably underestimates the overall use of E-mail by Cerise members. By contrast, desktop videoconferencing was only able to reach a limited number of Cerise offices inside the building. There was more limited access to and use of the desktop videoconferencing system. At the time of our data collection in early summer 1992, there were only nine videoconferencing units in offices and laboratories. The system was being developed by some of the Cerise members as a computer-supported collaborative work tool that would allow users to communicate with from one to four other users. As a system under development, it did not have a convenient or reliable interface. Moreover, it supported only synchronous communication: Coworkers could not use videomail to leave messages for each other. Although many Cerise members had permission to use videoconferencing (and were en-

rarely used among these E-mail-experienced and co-located participants, except for some collaborative writing.

Analytic Plan

To examine information exchange and media use, we examined the *number of pairs* maintaining each information exchange relationship and the *frequency of communication* between pairs, both overall and via each medium. Frequency of communication for each information exchange relationship was derived by summing the number of communications for each pair for all of the specific activities making up the relationship. These measures were logged to normalize their frequency distributions.

Each time information was exchanged, it involved one of the six information exchange relationships and was communicated via one medium. We refer to a relation where a pair of Cerise members exchange one specific kind of information by means of one specific communication medium as an *information-medium link*. The more links a pair maintains, the more *multiplex* or many-stranded their tie. Pairs who maintain more multiplex ties are more involved with each other and maintain a closer tie (Marsden & Campbell, 1984). By counting the number of links a pair maintains, we can see how interconnected they are in terms of the kinds of information they exchange, and the types of media they use.

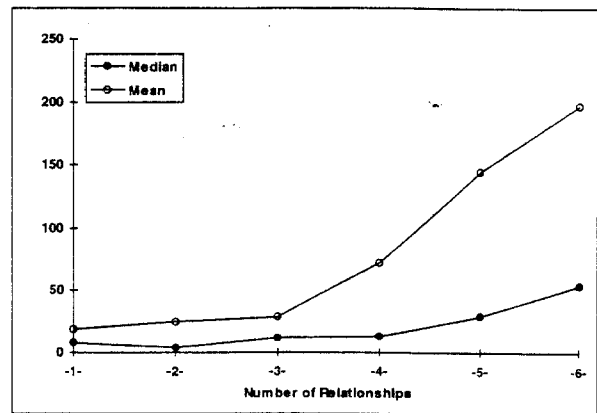
Information-medium links can be summed across all media to give the number of *information exchange links* a pair maintains. The more kinds of information exchanged via all media, the higher a pair's *relational multiplexity*. Similarly, the more types of media a pair used to exchange information, the higher the number of their *media links*, a measure of their *media multiplexity*. We first examine the number and type of information exchange links, media links, and information-medium links for *all pairs*. We then analyze ties according to the *work relation*, including *status* of the respondent and correspondent (e.g., faculty as respondent in a faculty-student pair or as correspondent in a student-faculty pair) and reported *work tie* (formal, informal, non-working), and their level of *friendship* (close friend, friend, acquaintance, work-only).

Results

Multiplexity

In Cerise, the more frequently a pair was in contact, the more kinds of information exchange relationships in which they engaged, i.e., the higher their *relational multiplexity*. The log frequency of communication by pairs was significantly correlated with the number of information exchange relationships pairs maintained ($r = 0.72, p < 0.01$) and with their communication rate per information exchange

couraged to do so), in practice it was used only by a minority: The three faculty and one employee who had units in their offices, and 10 students who used it in labs and elsewhere.



Correlation of log frequency of communication per link by number of relationships: $r = .52, p < .01$

FIG. 4. Annual frequency of communication per link by relational multiplexity.

link ($r = 0.52, p < .01$). Thus, not only did frequent communicators exchange information about a greater variety of things, they also communicated more frequently about *each* type of information they exchanged (see Fig. 4).

Media multiplexity, like relational multiplexity, was related to frequency of contact. The log frequency of communication by pairs was significantly correlated with the number of media that pairs used to communicate ($r = 0.76, p < 0.01$), and with their frequency of communication per media link ($r = 0.53, p < 0.01$). Again, not only did those who communicated more frequently use more media to communicate, they also communicated more frequently by each medium. Relational and media multiplexity were also significantly correlated ($r = 0.68, p < 0.01$), as those who had more information exchange relationships used more media to communicate. A similar relation was found by Rice (1994b) for communication by pairs in an R&D group: E-mail use was positively correlated with individual's estimates of overall frequency of communication with others in the group and with their judgments of their familiarity with others' work. Although fewer members of the R&D group used E-mail than communicated overall, those who did were more closely interconnected (higher network centrality) than non-E-mail users.

Taken together, these findings support Hypothesis 1 by showing that people who communicated frequently used multiple media in a variety of information exchange relationships. It is not that such pairs communicated frequently by only one medium, or about only one type of information. A high frequency of communication was associated with the exchange of many types of information *and* the use of many media.

However, these data contradict Hypothesis 2 (based on the task perspective) which suggested a high rate of E-mail use would either be negatively associated with or independent of a high rate of face-to-face contact. By contrast, our findings are consistent with the social network perspective. The use of computer-mediated communication depends on the nature of the pair tie. In Cerise, E-mail did not replace

TABLE 2. Multiplexity by tie.*

	No. (%) of pairs	No. of information exchange links	Mean no. of relationships per pair	No. of media links	Mean no. of media per pair
Work tie					
Formal	78 (21)	328	4.2	230	3.0
Informal	240 (64)	681	2.8	534	2.2
Non-working	60 (16)	107	1.8	96	1.6
		$\chi^2 = 138.42, df = 2,$	$p < .01$	$\chi^2 = 44.85, df = 2,$	$p < .01$
Friendship tie					
Close friend	38 (10)	160	4.2	107	2.8
Friend	172 (46)	502	2.9	391	2.3
Acquaintance	115 (30)	259	2.3	214	1.9
Work-only	51 (13)	187	3.7	139	2.7
		$\chi^2 = 95.19, df = 3,$	$p < .01$	$\chi^2 = 29.18, df = 3,$	$p < .01$
Work status of respondent					
Faculty	29 (8)	133	4.6	102	3.5
Student	287 (76)	821	2.9	629	2.2
Employee	62 (16)	162	2.6	129	2.1
		$\chi^2 = 58.00, df = 2,$	$p < .01$	$\chi^2 = 34.75, df = 2,$	$p < .01$
All	378 (100)	1,116	3.0	860	2.3

* Chi-square tests compare the number of links maintained versus the number not maintained within each category to test for differences in multiplexity.

face-to-face communication and may have augmented it: More E-mail communication went hand-in-hand with more face-to-face communication. It is also possible that frequent communicators will use all feasible communication media to exchange all kinds of information, augmenting the use of all media regardless of type. Although few Cerise pairs used more than three means of communication (32 used four, 6 used five, and 2 used all six), those who did were the among the most frequent communicators (mean communication rates of more than twice a day; median rates of more than once a day; see Haythornthwaite, 1996a).

Relational and media multiplexity were also associated with the type of tie maintained by the pair. Pairs in more intense work relations and closer friendships exchanged more types of information, via more media, than those in less intense ties, supporting Hypotheses 3 and 4 in terms of multiplexity (see Table 2).

Work, friendship and information exchange

Work. The kinds of information exchanged in Cerise differed by work tie. Examining both the frequency of communication, and the number of pairs, Cerise pairs with formal work ties had more interaction overall than those in informal ties, who have more interaction than those in non-working ties. There is more interaction in particular about the work-oriented relationships: Receiving Work, Giving Work, Collaborative Writing, and Computer Programming (see Figs. 5 and 6). These findings support Hypotheses 3. Reflecting the hierarchical nature of faculty-student relationships, pairs that included a faculty member exchanged information more frequently in asymmetric re-

lationships that allocated work: Receiving Work and Giving Work (see Haythornthwaite, 1996a).

The differences in patterns of relationships by work tie and by work status show that the effect of these ties was not identical, providing partial support for Hypothesis 5. Further support for Hypothesis 5 is given in a regression analysis examining relational multiplexity (see Table 3). Dummy variables were used for work tie (formal, informal), friendship tie (close friend, friend, acquaintance), work status of respondent (faculty, student), and work status of the correspondent (faculty, student). Here, the type of work tie and the friendship tie (in contradiction to Hypothesis 6) are more strongly associated with relational multiplexity than the type of work status. Also, it is the presence of a faculty member in the tie, rather than who the faculty member is communicating with that is most important with respect to work status. Thus, while status tells us about the behavior of faculty, work tie tells us about the behavior of working pairs across all of Cerise. However, the two types of work relations do overlap: Faculty work status was correlated with having a formal work tie ($r = 0.39$ for formal work tie and faculty respondent; $r = 0.43$ for formal work tie and faculty correspondent). A formal work tie captures the nature of the working relationship, whereas the presence of a faculty member captures the hierarchical relationship in Cerise. (For further discussion of work tie and work status for these data, see Haythornthwaite, 1996a).

Friendship. The closer the Cerise pair's friendship tie, the more they exchanged *both* work and social information, and the more frequently they communicated about each of their relationships. Not surprisingly, close friends had espe-

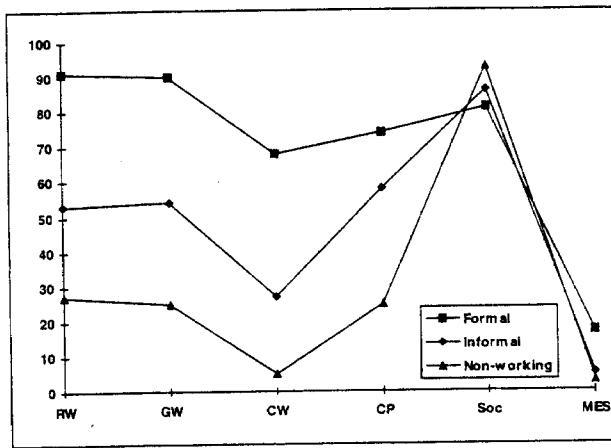


FIG. 5. Percentage of pairs by relationship and work tie.

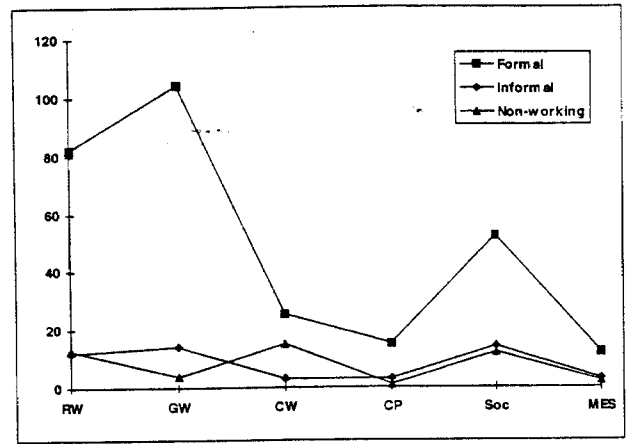


FIG. 6. Median frequency of communication by relationship and work tie.

cially frequent sociable contact (see Figs. 7 and 8). However, it is also apparent that close friends were maintaining work relationships, particularly Receiving Work, Giving Work (each with a high number of pairs, and a high frequency of communication), Collaborative Writing, and Computer Programming (each showing the highest communication rates across friendship ties). These findings support Hypothesis 4, but do not support Hypothesis 6: Close friendship ties are as strongly associated with working together as are work ties.

Work, friendship, and media use

The type of work or friendship tie maintained by Cerise members affected media multiplexity—the number of media used—more than it affected which medium was used.

This lack of differentiation by type of media is consistent with the finding reported above that all kinds of information exchange were communicated by E-mail as well as face-to-face. Within ties, the stronger the work or friendship tie, the more media used (see Table 2). Moreover, pairs in ties that used more media also communicated more often. Pairs with more formal work ties, pairs that include a faculty member as a respondent or correspondent, and pairs with a more intimate friendship tie each communicated more overall, communicated more per medium, and used more media. Informally tied pairs and friends use more media than non-working pairs and acquaintances. These findings support Hypotheses 3 and 4. Across ties, regression analysis shows each type of tie contributes moderately to media multiplexity, with faculty respondents contributing most strongly (see Table 3). Faculty in Cerise were leaders in

TABLE 3. Regressions for relational and media multiplexity.*

	Relational multiplexity			Media multiplexity		
	Parameter estimate	Standardized estimate	Squared partial correlation*	Parameter estimate	Standardized estimate	Squared partial correlation
Intercept	1.82	.00		1.68	.00	
Work tie						
Formal	1.75	.44	.11	.74	.29	.05
Informal	.91	.28	.06	.51	.24	.04
Friendship						
Close friend	1.49	.28	.10	.66	.19	.05
Friend	ns	ns		ns	ns	ns
Acquaintance	-.46	-.13	.02	-.34	-.15	.03
Work status						
Faculty respondent	1.21	.20	.05	1.14	.29	.09
Student respondent	ns	ns		ns	ns	ns
Faculty correspondent	.57	.13	.02	.47	.16	.03
Student correspondent	ns	ns		ns	ns	ns
R ² ($p < .01$)		.36			.30	

* Squared partial correlations indicate the amount of variance not accounted for by other independent variables. The correlations are independent of the order in which variables are added to the model, with each effect adjusted for the effect of all other variables.

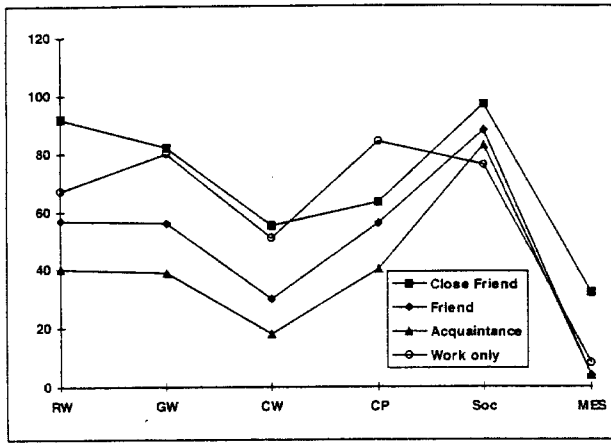


FIG. 7. Percentage of pairs by relationship and friendship tie.

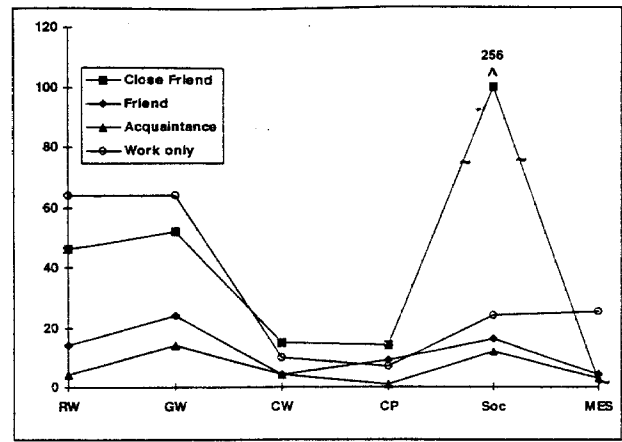


FIG. 8. Median frequency of communication by relationship and work tie.

media use, particularly in the use of the videoconferencing system.

Work, friendship, and information-medium use

Hypotheses 5 and 6 are further examined in regression analyses of information-medium multiplexity and frequency of communication by tie. The analyses shows that the work tie, friendship tie, and faculty status each had an independent effect on multiplexity, but that friendship was the single best predictor of frequency of communication (see Table 4). Thus, while work ties and work status contribute to more multiplex interaction, friendship contributes most significantly to more frequent interaction. Again, this inconsistency with Hypothesis 6 (that work ties will have stronger effects than friendship ties) points out the importance of friendship in this informal, relatively egalitarian workgroup.

Perhaps norms of collegiality are stronger in a university setting, or perhaps this finding will be replicated in other loosely-coupled, mildly-hierarchical organizations of professionals.

Patterns of Information and Media Use

Patterns of information and media use differed by the multiplexity of the tie, the type of information exchange, and the type of tie.

Multiplexity

Pairs who had only one or two information exchange relationships typically had a Sociability relationship (with infrequent contact) plus a Receiving Work or Computer

TABLE 4. Regressions for multiplexity and frequency of communication per information-medium link.*

	Multiplexity of information-medium links			Log frequency of communication per information-medium link		
	Parameter estimate	Standardized estimate	Squared partial correlation*	Parameter estimate	Standardized estimate	Squared partial correlation
Intercept	1.40	.00		2.87	.00	
Work tie						
Formal	4.10	.39	.10	.59	.18	.04
Informal	1.75	.20	.04	ns	ns	
Friendship						
Close friend	5.08	.36	.17	2.09	.49	.26
Friend	1.13	.13	.03	.44	.17	.04
Acquaintance		ns	ns		ns	ns
Work status						
Faculty respondent	4.86	.31	.11	1.18	.24	.06
Student respondent	ns	ns		-.57	-.19	.04
Faculty correspondent	2.80	.24	.07	-.53	-.15	.02
Student correspondent	ns	ns		-.62	-.22	.05
R ² (p < .01)		.43			.41	

* All variables significant at $p < .05$; for correlation coefficients, see Haythornthwaite, 1996a.

TABLE 5. Percentage of information-medium links by medium and relationship.*

	RW	GW	CW	CP	Soc	MES	All
Unscheduled	49	46	43	37	50	75	47
Scheduled	26	24	25	54	33	14	32
E-mail	19	24	23	7	15	11	17
Phone	4	3	4	1	2		3
	<			<			
Fax	1	1	3	1			1
Videoconf.	1	2	1	1			1
All	100	100	100	100	100	100	100
N	391	426	240	323	548	36	1,964

* $\chi^2 = 117.03$, $df = 10$, $p < .01$ (unscheduled meetings, scheduled meetings, and E-mail only).

Programming relationship maintained via face-to-face means. By contrast, pairs with four to six relationships typically had high, frequent contact in Sociability, Receiving Work, and Giving Work relationships, maintained by face-to-face means and by E-mail. Such pairs were more apt to engage in relationships that involved mutual trust and knowledge, such as Collaborative Writing and Major Emotional Support, to include both Giving Work and Receiving Work in their tie, and to use the telephone, fax, and video-conference.

Type of information exchange

Cerise members showed three patterns of using media to exchange information:

- (1) one pattern for three work-oriented relationships (Giving Work, Receiving Work, and Collaborative Writing);
- (2) a second pattern for Computer Programming;
- (3) a third pattern for the socially-oriented relationships (Sociability and Major Emotional Support).

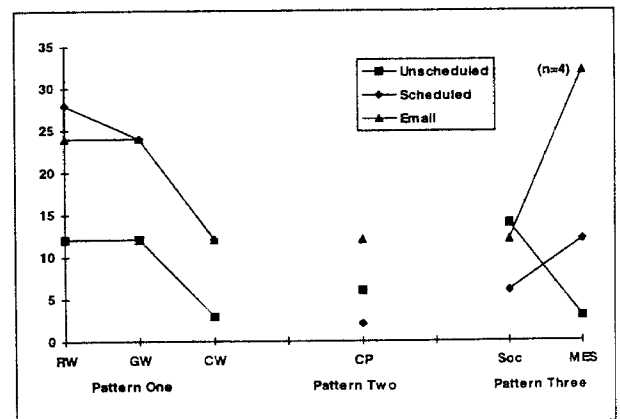
Pattern one. Work-oriented relationships. The typical pair used two types of media for each of the Pattern One relationships (1.8 for Receiving Work, 2.0 for Giving Work and Collaborative Writing⁷): Usually unscheduled encounters plus either E-mail or scheduled meetings. For these three relationships, about half of all the links were unscheduled encounters, one-quarter were scheduled meetings, and one-quarter were E-mail (Table 5). Thus, face-to-face interactions, whether scheduled or not, outnumbered E-mail links by a 3:1 ratio. To take another view of these data, unscheduled interactions in these relationships (whether face-to-face or E-mail) outnumbered scheduled meetings by a 3:1 ratio.

Although unscheduled encounters were the most widely used means of communication in these work-oriented relationships, the frequency of unscheduled encounters in work-

oriented relationships was lower than the frequency of scheduled meetings or E-mail (Fig. 9). Given the hierarchical nature of many of these interactions (even collaborative writing often entailed faculty-student pairs), frequent use of formal, controlled interactions were important for these relationships. Both scheduled meetings and E-mail support controlled interactions since the sender had control over the timing of the delivery of information in both cases.

Pattern two: Computer programming relationships.

Information exchange about Computer Programming followed a pattern of its own. While scheduled meetings (mostly attributable to the underlying "demonstrating work" relation) were widespread, tying 54% of the pairs, information was most frequently exchanged by E-mail (Fig. 9). Cerise members programmed online and routinely transmitted their work via E-mail to their collaborators. The informality of Programming exchanges is highlighted by the higher frequency of unscheduled encounters than scheduled meetings for Programming relationships. However, the high number of pairs who also had scheduled meetings shows that such meetings were important for circulating information regarding computer programs and demonstrating such work.



Note: Frequency of communication for MES via email is largely attributable to one pair; without this pair the median frequency of communication is 12.

FIG. 9. Annual median frequency of communication by relationship and medium.

⁷ These values can be derived by dividing the number of information-medium links per relationship (Table 5) by the number of pairs maintaining each relationship (Fig. 2). For example, for Receiving Work, 391 information-medium links are maintained by 215 pairs for an average of 1.8 media per pair.

Pattern three: Socially oriented relationships. Like work-oriented relationships, the typical socially oriented relationships among Cerise members were maintained via two media. Socially oriented relationships were also similar to work-oriented relationships, in that unscheduled face-to-face encounters were used extensively. For example, about one-half the Sociability links were unscheduled encounters, one-third were scheduled meetings, and one-sixth were E-mail (Table 5). Exchanging Major Emotional Support was even more likely to be maintained by an unscheduled face-to-face encounter: Such interactions comprised three-quarters of all Major Emotional Support links. While E-mail was used more frequently than scheduled meetings to maintain Sociable relationships, scheduled meetings connected more pairs. Whether they were for work or for infrequent office parties, they brought together people who ordinarily did not interact with each other. By contrast, E-mail and scheduled meetings were rarely used for exchanging Major Emotional Support (Table 5, Fig. 9). Major Emotional Support in Cerise came out of unscheduled face-to-face contact and not computer-mediated communication or scheduled therapy sessions.

Different phenomena affected the use of media in work-oriented, socially oriented, and computer-programming relationships. In work-oriented relationships, the nature of the interaction most affected which media were used, with the pattern the same regardless of whether the work task was Giving Work, Receiving Work, or Collaborative Writing. People engaged in such information exchanges principally used scheduled meetings and E-mail, media that allowed some planning and control of interactions. In such work-oriented relationships, unscheduled encounters were supplementary to scheduled meetings and E-mail. In contradiction to expectations regarding media use proposed in Hypothesis 3, this pattern held regardless of whether the work tie was formal or informal (see Fig. 10).

By contrast, it was the nature of the friendship tie that most affected which types of media were used in socially oriented relationships, providing limited support for the use of spontaneous means of communication proposed in Hypothesis 4. Close friends and friends had many unscheduled encounters, while acquaintances and work-only pairs social-

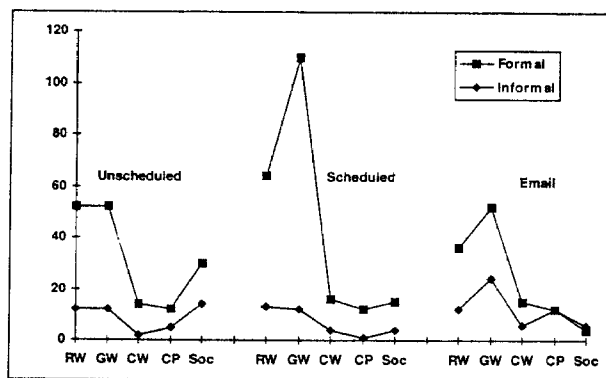


FIG. 10. Median frequency of communication by relationship, medium, and work tie.

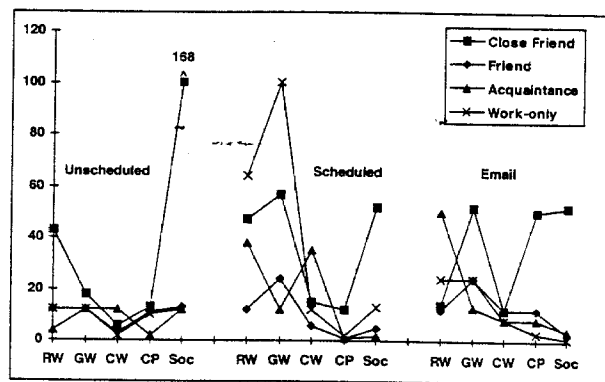


FIG. 11. Median frequency of communication by relationship, medium, and friendship tie.

ized as much through scheduled meetings and E-mail as they did through unscheduled encounters. Such social exchanges appear to "piggy-back" on media used to carry work relationships, e.g., with sociable and supportive remarks exchanged in scheduled meetings or added to a work-related E-mail communication. This was particularly so for the work-only pairs who were not friends but interacted in work relationships (see Fig. 11).

Conclusions

Summary

1. Even in a situation with extensive computer-mediated means of communication, face-to-face contact remained the medium of choice for those in weak ties who exchanged few kinds of information. In stronger ties, face-to-face means of communication were supplemented primarily by E-mail.
2. E-mail was used for affective, sociable interaction as well as for instrumental, work exchanges.
3. Videoconferencing, telephoning, and faxing (the former two without facilities to store messages) was used rarely in this co-located group whose members worked flexible hours. Members communicated face-to-face when possible and convenient, or by E-mail when necessary or convenient.
4. Those in more frequent contact exchanged a greater variety of information and communicated more frequently about each relationship they maintained.
5. The stronger the work tie, the more frequently people communicated, the more kinds of information they exchanged, and the more media they used.
6. The stronger the friendship tie, the more frequently people communicated, the more kinds of information they exchanged, and the more media they used.
7. Although the nature of the task affected the type of media used in work relationships, it was the nature of the tie that affected the types of media used in socially oriented relationships. This suggests that a combination of the task and social network per-

spectives is useful for understanding media use in work-oriented relationships, while the social network perspective is particularly useful for understanding media use in socially oriented relationships.

Implications

Despite all the attention given recently to the possibly special nature of computer-mediated communication, the major media choice in Cerise was between unscheduled and scheduled interactions, and not between face-to-face and E-mail communication. In this computer-comfortable organization, E-mail could be used spontaneously, in socially oriented relationships, or with control, in work-oriented relationships. It served as a spontaneous means of communication, perhaps as pairs added Sociability to other messages, or as pairs stayed in touch when not co-located. Yet it also supplemented controlled interactions by providing written records, continued interaction when pairs cannot meet face-to-face, control for senders on when they delivered their information, and control for receivers on when they viewed the information.

Our results suggest that the use of media in Cerise was socially determined as well as technologically and normatively determined. While previous research has suggested that a medium will be chosen because of the type of information to be conveyed or because of norms associated with group use, our results suggest the importance of social networks. In Cerise, the intensity of the work tie and the intimacy of the friendship were each independently related to a higher frequency of information exchange, maintenance of more information exchange relationships, and the use of more of the available media. Moreover, the type of tie affected what pairs communicate about: Work relationships for working pairs; social and work relationships for the combined work and friendship ties found in Cerise. Our results also suggest that the driving force for media use is not which media to use, but how many to use, with the number increasing with increasing communication frequency. We suggest further research weighing the influence on media use of social network ties and structures in the light of the arguments of the task and normative perspectives, and other research on the effects of structural position on communication and media use (e.g., Burkhardt & Brass, 1990; Burt, 1992; Rice, 1994b; Rice et al., 1990).

Thus, we find that work and friendship ties lead to factors that affect both what information is exchanged, how much is exchanged, and between whom it is exchanged. This network approach reveals the importance of the underlying pair relationships in determining communication patterns. (Future research will assess how communication and media use are related to the structure of relations in this loosely coupled organization.) To assess information exchange and media use, it is necessary to go beyond external categories of interpersonal attributes and of information categories, beyond technological categorizations of media. Our results suggest that work expands to fill the media available, but

more importantly, that the expansion is predicated on interpersonal ties, and the information exchange and frequency of communication such ties entail.

The study of computer-mediated communication has already taken into account the *technology* of computer media, with designers suggesting how computer media should be used and creating interfaces accordingly. It has also encompassed the *psychology* of computer media, with analysts worrying about the kinds of messages senders will communicate, and how recipients will perceive the sender and their message. Our research suggests it is useful to also develop a *social network analysis* of computer-mediated communication, recognizing how E-mail and other forms of computer-mediated communication can affect and interact with social relations and social organization. This is not to privilege computer-mediated communication as the current spate of information highway hype is wont to do. Although some virtual communities and virtual organizations exist principally online, it is common for E-mail and other computer media to operate as they did in Cerise—as one of a number of means of communication. The nature of E-mail—its independence of time and space, its speed of transmission, and its ability to support group as well as dyadic interactions—afforded it properties that helped sustain Cerise as a loosely-coupled, effective organization where members could interact without always needing to meet face-to-face.

Acknowledgments

Our work has benefited from the advice of Laura Garton, Joanne Gard Marshall, Marilyn Mantei, Janet Salaff, Stanley Wasserman, and anonymous referees. This research has been financially supported by grants from the Social Science and Humanities Research Council of Canada, and the Information Technology Research Centre.

References

- Abbott, A. (1988). *The system of professions*. Chicago: University of Chicago Press.
- Blau, P. (1955). *The dynamics of bureaucracy*. Chicago: University of Chicago Press.
- Burkhardt, M. E., & Brass, D. J. (1990). Changing patterns and patterns of change—The effects of a change in technology on social network structure and power. *Administrative Science Quarterly*, 35(1), 104–127.
- Burt, R. S. (1992). *Structural holes*. Cambridge, MA: Harvard University Press.
- Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science*, 32(5), 554–571.
- Fish, R. S., Kraut, R. E., Root, R. W., & Rice, R. E. (1992). Evaluating video as a technology for informal communication. In P. Bauersfeld, J. Bennet, & G. Lynch (Eds.), *Striking a balance: CHI '92 Conference Proceedings* (pp. 37–48). New York: ACM Press.
- Fulk, J., & Steinfield, C. (1990). *Organizations and communication technology*. Newbury Park, CA: Sage.
- Garton, L., Haythornthwaite, C., & Wellman, B. (1997, June). Studying online social networks. *Journal of Computer-Mediated Communication*, 3(1). <http://www.ascusc.org/jcmc/vol3/issue1/garton.html>

- Garton, L., & Wellman, B. (1995). The social implications of electronic mail in organizations: A research review. *Communications Yearbook*, 18, 434-453.
- Han, S.-K. (1996). Structuring relations in on-the-job networks. *Social Networks*, 18(1), 47-67.
- Haythornthwaite, C. (1996a). *Media use in support of communication networks in an academic research environment*. Unpublished doctoral dissertation, University of Toronto, Toronto.
- Haythornthwaite, C. (1996b). Social network analysis: An approach and technique for the study of information exchange. *Library and Information Science Research*, 18, 323-342.
- Haythornthwaite, C., Wellman, B., & Mantel, M. (1995). Work relationships and media use: A social network analysis. *Group Decisions and Negotiations*, 4(3), 193-211.
- Homans, G. (1961). *Social behavior: Its elementary forms*. New York: Harcourt Brace Jovanovich.
- Kiesler, S., & Sproull, L. (1992). Group decision making and communication technology. *Organization Behavior and Human Decision Processes*, 52, 96-123.
- Kling, R. (1996). (Ed.). *Computerization and controversy: Value conflicts and social choices*. San Diego, CA: Academic Press.
- Kornblum, W. (1974). *Blue collar community*. Chicago: University of Chicago Press.
- Krackhardt, D. (1990). Assessing the political landscape: Structure, cognition, and power in organizations. *Administrative Science Quarterly*, 35, 342-369.
- Kraut, R., Fish, R., Root, R., & Chalfonte, B. (1990). Informal communication in organizations: Form, function and technology. In S. Oskamp & S. Spacapan (Eds.), *People's reactions to technology in factories, offices and aerospace* (pp. 145-199). Newbury Park, CA: Sage.
- Markus, M. L. (1994). Electronic mail as the medium of managerial choice. *Organization Science*, 5, 502-527.
- Markus, L. M., Bikson, T. K., El-Shinnawy, M., & Soe, L. L. (1992). Fragments of your communication: Email, vmail, and fax. *The Information Society*, 8, 207-226.
- Marsden, P. V., & Campbell, K. E. (1984). Measuring tie strength. *Social Forces*, 63, 482-501.
- McKenney, J. L., Zack, M. H., & Doherty, V. S. (1992). Complementary communication media: A comparison of electronic mail and face-to-face communication in a programming team. In N. Nohria & R. G. Eccles (Eds.), *Networks and organizations: Structure, form, and action* (pp. 262-287). Boston: Harvard Business School Press.
- Rice, R. E. (1992). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. *Organization Science*, 3(4), 475-500.
- Rice, R. E. (1994a). Network analysis and computer-mediated communication systems. In S. Wasserman & J. Galaskiewicz (Eds.), *Advances in social network analysis: Research in the social and behavioral sciences* (pp. 167-203). Thousand Oaks, CA: Sage.
- Rice, R. E. (1994b). Relating electronic mail use and network structure to R&D work networks and performance. *Journal of Management Information Systems*, 11(1), 9-20.
- Rice, R. E., Grant, A. E., Schmitz, J., & Torbin, J. (1990). Individual and network influences on the adoption and perceived outcomes of electronic messaging. *Social Networks*, 12(1), 27-55.
- Saunders, C., Robey, D., & Vaverek, K. (1994). The persistence of status differentials in computer conferencing. *Human Computer Research*, 20, 443-472.
- Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications*. London: Wiley.
- Sproull, L., & Kiesler, S. (1991). *Connections*. Cambridge, MA: MIT Press.
- Wasserman, S., & Faust, K. (1994). *Social network analysis*. Cambridge, UK: Cambridge University Press.
- Weisband, S., Schneider, S., & Connolly, T. (1995). Computer-mediated communication and social information: Status salience and status differences. *Academy of Management Journal*, 38, 1124-1151.
- Wellman, B. (1988). Structural analysis: From method and metaphor to theory and substance. In B. Wellman & S. D. Berkowitz (Eds.), *Social structures: A network approach* (pp. 19-61). Cambridge, UK: Cambridge University Press.
- Wellman, B. (1992). Which types of ties and networks give what kinds of social support? *Advances in Group Processes*, 9, 207-235.
- Wellman, B. (1997). An electronic group is virtually a social network. In S. Kiesler (Ed.), *Cultures of the Internet* (pp. 179-204). Hillsdale, NJ: Erlbaum.
- Wellman, B., & Gulia, M. (1998). Net surfers don't ride alone: Virtual communities as communities. In P. Kolloek & M. Smith (Eds.), *Communities in cyberspace* (pp. 163-190). London: Routledge.
- Wellman, B., Salaff, J., Dimitrova, D., Garton, L., Gulia, M., & Haythornthwaite, C. (1996). Computer networks as social networks. *Annual Review of Sociology*, 22, 213-238.
- Wellman, B., & Tindall, D. (1993). Reach out and touch some bodies: How social networks connect telephone networks. In W. Richards, Jr., & G. Barnett (Eds.), *Progress in communication sciences*. (Vol. 12, pp. 63-93). Norwood, NJ: Ablex.
- Wellman, B., & Wortley, S. (1990). Different strokes for different folks: Community ties and social support. *American Journal of Sociology*, 96, 558-588.