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at each site who installed and managed the code. If you helped
us, we'd be delighted to hear from you; please send us your
name as you would like it to appear in the final version of the
paper. (Manasse 1990)
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Although the world of computational number theory is far removed from the daily concerns of managers, this case highlights some of the limitations in conventional thinking about organization and management when networked organizations become more common. Typically managers influence their subordinates in large measure by allocating resources to their projects and allocating credit (or blame) to their accomplishments. How will the manager's role in resource allocation change when people can reach out across the network and directly solicit resources from others to help them with their work? How will the manager's role in allocating credit or blame change when managers do not know, and perhaps cannot know, who contributed in what ways to accomplishments?

If our first message is that making and managing new connections is what is important, our second message is that technology by itself does not impel these connections. They do not happen just by installing a network and distributing electronic mailboxes. For connections such as the ones we have described to arise, decision makers and employees should be guided by a vision of a particular kind of organization or a particular way of working. A vision can help in evaluating experience (are we moving toward or away from where we want to go?). It can offer guidance in dealing with unanticipated situations (should we think of this as a problem or an opportunity?). And it can help in making choices within constraints (given limited resources, what should we do first?). Our vision of a networked organization is one in which all employees participate fully in the information life of the organization, independent of their geographic, organizational, or social location. They share information in dynamic and flexible ways that evolve with organizational issues and opportunities. Not all organizations will be comfortable with the kinds of electronic connections described in this book. New connections will be most attractive to organizations committed to employee competence and involvement and to organizational flexibility as ways to achieve and sustain success. Without such commitments, analyses of electronic communication will be dominated by first-level efficiency thinking.

Our vision is supported by four principles: (1) a view of people as people, not users; (2) open access to people and information; (3) diverse forums

through which people can work together; and (4) policies and incentives that encourage information exchange. Our vision does not include advice about particular hardware or software systems because such advice rapidly becomes obsolete. Nor does it entail separate sections of advice for "managers" and "technologists." Such separation leads to separation of responsibility; a vision should be shared by all.

The first principle of our vision is to design a networked environment for people, not users. In the early days of computing technology, the term "users" distinguished those who worked with technology from those who did not ("nonusers"). In our vision of a networked organization, everyone communicates through the network; thus the old distinction between those who do and those who do not is meaningless. Furthermore, the concept of user focuses attention on the relationship between a person and technology. Our vision focuses attention on the relationship between a person and other people. The concept of user also implies a view of technology as a discrete commodity whose attributes and functions can be specified by the designer. Synonyms are "operator" or "consumer." In our vision people want to talk to people, and they want to do so for many reasons. Technology is a facilitator.

The second principle, open access to people and information, follows from the assumption that every employee has something to offer on an electronic network, and every employee has something to gain from it. Therefore every employee should have access to the network. Furthermore, every employee should have access to the same network. If sales and engineering people use different networks, they cannot benefit from one another; they do not have open access to one another. Open access implies the same network for all employees. And it implies software and management policies that make it easy to share information over the network. Software can make it easy (or difficult) to find people and other resources on the network. It can make it easy (or difficult) to contribute information. Management policies about access to the network are just as important. Much of the value of electronic communication comes from informal, quick exchanges. If a person has to walk down the hall, share a terminal, or pay by the message, the value will be reduced. The most extensively used computer-based communication systems are ones in which communicators see no message charges; the costs are allocated as overhead. Electronic mail traffic decreases when people are charged for use. Group communication decreases substantially. As overall traffic decreases, its distribution changes.

Who uses the system begins to depend more on who can pay rather than on whose job can benefit.

While we advocate open access, we strongly distinguish between open access and invasion of privacy. Open access to people—the ability to contact them via electronic mail, is different from open access to data about people—the ability to access files containing information about them. Managers can unreservedly promote the former while offering clear guidance about the latter. This guidance must help employees distinguish between sharing information and snooping.

The third principle, building and maintaining diverse forums, follows from the assumptions that people need to work collectively and that collective work is of different kinds. Hence, group communication is necessary, but it is not generic. The forums in which groups work must match the kinds of communication needed. (Of course, they will differ across organizations. Box 9.1 gives an example of some developed in a school system. Box 9.2 gives an example of some developed in a scientific community.) Many forums cannot and should not be specified in advance but will emerge and evolve dynamically as organizational problems and opportunities change. Software can make it easy for people to know about, join, and participate in multiple groups.

Box 9.1. A vision and diverse forums at Central Kitsap

Just after northern California's 1989 earthquakes, the librarian at Cougar Valley Elementary School sent electronic mail to each of the school's eighteen teachers, telling them about a parent who had experienced several earthquakes in Guatemala. Less than five minutes later had come back the first request for the parent to give students a firsthand account of earthquakes. Cougar Valley is part of the Central Kitsap school system, which decided in 1985 to install computers in its schools. The planning . . . "involved 150 teachers, parents and other volunteers who laid out the educational principles for the two new schools. Strategy 2020's vision of these schools of the future took the form of "paradigm shifts"—new ways of doing things." Among them were the following:

- Administrative and educational decisions should be made at the lowest level, preferably by teachers and students.
- Teachers should become managers of instruction, not presenters of information.
- "My classroom is my castle" must be discarded as a guiding principle. Teachers should function as teams of professionals, sharing ideas and communicating frequently.
- Students should become more actively involved in their own learning, both individually and in groups.

•Technology should be employed to manage learning as well as diagnose, present, and evaluate it.

Central Kitsap's implementation has two key parts. One is small-group instruction. The other part is . . ."a tool of cultural transformation . . . one that turned out to be surprisingly important, has been the local area network linking all the computers in the school. Teachers and administrators use its electronic mail feature to take attendance, assemble lunch orders, schedule meetings, and exchange information on items such as assignments for particular students. 'Not only does it free teachers from busywork, but they are no longer isolated from each other' [the superintendent's administrative assistant said]. Even if they go through a whole day without seeing each other, teachers can work together. Education has become a collective enterprise."

Source: Edward B. Fiske, "Reform by High-Tech," New York Times, January 7, 1990. Sect. 4A, 48–49.

Box 9.2. Example of SCIENCEnet features for oceanographers

Examples of Electronic Services

Omnet.fax: To send a fax anywhere in the world.
Papermail: To have hard copy mailed in the United States or Canada.
OCE.review: To submit a proposal review to the National Science Foundation Ocean Division.
Sonic: Gateway to data services at Ocean Network Information Center.
ECS: Gateway to satellite data services at National Climatic Data Center.

Examples of Electronic Bulletin Boards

Enso.info: El Nino southern oscillation information.
FIC.status: Information for Fleet Improvement Committee.
Grad.students: Information of interest to oceanography graduate students.
Mizex: Marginal ice zone experiment.
Products.services: Advertisements by members of SCIENCEnet.
Ship.sched90: University National Oceanographic Laboratory System research vessel information for 1990.

Examples of Electronic Discussion Groups and Projects

Arctic environmental drifting buoy experiment.
Gulfstream experiments planning committee.
National Research Council panel on physical oceanography.
South Atlantic ventilation experiment.
Warm core rings principal investigators.

Source: SCIENCEnet Subscribers/Catalog of Services, Fall 1988. Omnet, Inc., 137 Tonawanda St., Boston MA 02124.

Management policies should encourage people to take responsibility for their electronic groups. Managers can forbid all forms of extracurricular interaction, require supervisors to approve messages before they are sent to a group, or reprimand people who circulate controversial or distasteful ideas. Elaborate rules and restrictions can save managers from some embarrassments, but they discourage people from taking responsibility for their own behavior.

Making it easy to exchange information through providing open access and diverse forums is a necessary but not sufficient condition for communication to occur. Additionally, people must want to contribute to and benefit from coworkers and other resources on the network. By way of illustrating the distinction, consider a network in which anyone can send the C.E.O. a message. Being able to send messages to the boss often typifies an open access network. If the C.E.O. actually responds to received messages, then the network also embodies incentives to communicate. Motivating people to communicate via the network can be accomplished through both technical and human means. Software can motivate beneficial information exchange through, for instance, automatically notifying a contributor when someone reads his or her contribution or through filtering and organizing messages. Incentives for beneficial exchange can be conveyed through modeling (high-status people communicate via the network), evaluation feedback (rewarding electronic contributions to others), and norms (expecting people to communicate via the network routinely).

In one organization, half of the employees used electronic mail routinely and the other half did not, despite easy access to the technology. This meant that all communications that were intended for everyone had to be sent two ways: via electronic mail and via hard copies distributed to mailboxes. This situation changed, however, as a result of the "King Tut caper." The organization had purchased tickets for a very popular museum exhibit, "The Treasures of Tutankhamen," to be distributed on a first-come, first-serve basis to its employees. By the time employees found the hard-copy announcements in their mailboxes, the employees who read the electronic announcement had already signed up for all the tickets. Apparently when relatives heard they had missed out on King Tut because their spouse or parent didn't read electronic mail, they applied strong pressure to make sure they wouldn't be left out again in the future. Even independent of

family pressure, the left-out employees had a vivid demonstration of the utility of electronic mail for routine communication.

9.1 Getting Started

Organizations can decide to have a network, but the process of acquiring, installing, and adapting or designing forms of computer-based communications can be expensive and time-consuming. As some organizations are beginning to demonstrate, the long-term process is made less burdensome if employees know they come before technology and organizational effects are considered along with the efficiency ones (see National Research Council 1986; Bikson, Gutek, and Mankin 1987). For organizations new to networking, we advocate a "plain vanilla" system that everybody can use over a fancy system that only some people can use. Simplicity and ease help make people feel comfortable in the networked environment and spend their time doing their work. They should be able to connect to the network easily, retrieve their computer files easily, and find their electronic mail easily.[1]

In the same vein, connecting everyone early—with modems, for example—is preferable to connecting only a few through fiber optics that may take months or years to install. By this, we do not deny the value of more advanced technology. (We would not have wanted our forefathers to widen the Erie Canal instead of building railroads.) But connecting everyone with something simple from the start and more gradually introducing expensive, special equipment and asking employees to learn more difficult skills gives a correct signal. People see that what they do counts more than what technology and a few technology enthusiasts can do. Getting everyone connected early also provides valuable organizational experience. It gives employees experience with new connections and new ways of working and thinking. It gives management experience with changed behavior and responsibilities. It allows for experiments in organizational design.

Connecting everyone also provides a built-in stimulus to behavior change. As the past twenty years of experience with facsimile machines has shown, if few people can use a new form of communication, they are driven away; they do not know if others will get their messages and thus have less reason to send them. When many people can use a form of communication, they believe others will see their messages and thus have more reason to

send them. A critical mass of people communicating in the same way therefore tends to increase the per person frequency of communications (Markus 1987). That in turn increases the fraction of people's daily communications met by communicating in that way, reduces the personal cost of using the system, and encourages even further use. Nonetheless some networks, although they connect large numbers of people, are too specialized to meet many of a person's communication needs. For instance, employees using a parts order system may be connected with customers and suppliers but not with their coworkers. Here, the critical mass for parts ordering exists, but the critical mass for each person's beneficial communications does not. Such a system is unlikely to change behavior or to have broad second-level effects.

Unfortunately, introducing even a modest electronic communication network usually involves an additional cost to the start-up burden imposed by stand-alone technologies. Installation may require rewiring or construction, new telephone connections, and interaction with new and multiple vendors. Employees must adjust to disruption, unexpected patterns of use, and unforeseen problems. Problems in interconnected systems often spread to the entire organization rather than being isolated on one person's desk or in one person's machine. Management can pass through many of these costs to employees by insisting they weather these crises without help, or it can buffer employees from confusion and technical complexities by offering services to help. For instance, if there is no on-line directory of names and electronic addresses, management can give employees a paper directory. The paper directory doesn't obviate the value of developing an automated on-line directory later; meanwhile people can find most of the people and information they need.

Many organizations employ people who provide technical advice and help others get started. In some organizations, these jobs are oriented toward the technical components of nodes, pathways, and packets. They emphasize such matters as registering accounts, verifying passwords, and setting switches. In other organizations, these jobs are oriented toward the human network—people, forums, and resources. They emphasize helping people join groups, helping them create and manage groups, and helping them locate and acquire services. People especially may need expert humans to help them administer electronic groups. Piling technological start-up costs on top of group management and coordination costs can create a burden that potential groups cannot or will not assume. As a panel

of the Commission on Science, Engineering, and Public Policy reported about its own attempt to create an electronic group, there was no "access to service support (comparable to telephone system operators) . . . Panel members had to rely on their own resources to remedy any system inefficiencies . . . Analyses of a sample of messages received by Panel staff indicate that approximately 10 percent contained some complaint about delays, losses of material in transmission, or unavailability of the group mail system" (National Research Council 1989:27). If group development and support is an organizational function, then it makes sense for the organization to facilitate groups rather than expecting them to operate their own technical services.

In some cases, one organization can provide services for many organizational clients. In the sciences, for instance, OMNET™ provides electronic mail services for many disciplines. Started by an oceanographer, OMNET staff know what its subscribers actually do in their daily scientific work, so they can tailor services for their scientists. OMNET has a telephone hot line to answer questions ranging from how to hook up a printer to how to connect to other scientific networks. No one's equipment is too primitive; no one's requests are too silly. OMNET distributes electronic and hard-copy directories listing all subscribers and a newsletter telling about improvements to the network. It also encourages subscriber exchanges through electronic bulletin boards. (See box 9.2.) Encouraging subscribers to discuss resources, problems, and ideas helps to foster independence and learning. Yet a human buffer remains between the technology and the people whose job is science, not communication technology.

Costs and Predicaments

Introducing computer-based communication can entail considerable direct costs for equipment, installation, programming, routine maintenance, and upgrades. Other costs arise from choices that managers make to introduce organizational changes, and the predicaments, or dilemmas, that involve giving up one goal in pursuit of another. For example, is our goal to supervise work more closely or to decentralize authority? Reaching one goal necessarily sacrifices the other. Electronic communication is transforming the nature of some organizational predicaments, but predicaments, and the choices they require, cannot be avoided.[2]

Managers emphasizing different costs will approach a new technology differently. For a new business telephone and voice mail system, manager A concerns herself with direct costs, such as those that arise from delivery delays and usability flaws. Manager B sees new system costs as opportunities to be leveraged. She proposes to use the system to deliver new services to customers, such as a 24-hour-service help line. She wants to use system training as a testbed for a bigger program in employee education. Manager C concerns herself with predicaments. Other things equal, the new telephone system tends to emphasize the marketing function, by, for instance, allowing each customer to order a custom-made product. But this strategy is in conflict with a productivity strategy that lowers costs through standardized production. It is difficult, if not impossible, to optimize both simultaneously. The new system also has cost-reduction objectives. By routing calls to most offices directly, the system saves the expense of having telephone receptionists, but that obviates the objective of pleasantly buffering employees from unwanted interruptions. These predicaments are not unique. Home builders in the postwar period who changed from high-quality, handmade homes to lower quality, assembly-line developments had to trade cost-reduction objectives for custom service objectives. So did bankers who installed electronic banking machines rather than hire more trained tellers. In the case of manager C, she must fashion policies in which marketing dominates production, or vice versa. She must decide if direct calling will dominate receptionist-channeled calls, or vice versa.

Computer-based communication amplifies some predicaments, poses some new predicaments, and makes some obsolete. We alluded to a predicament amplified by electronic communication in chapter 6, when discussing information overload. While more connections can bring peripheral or distant employees beneficial information or influence they would have lacked otherwise, it also will bring undesirable information and influence. We noted that information overload is more of a problem for visible or top employees, when they lose control over their own communications. One solution is to ignore all distribution list messages and messages from unknown people or to use automatic filters that accept only known names and desired messages. Yet this solution poses an opportunity cost by cutting off unexpected information from unexpected sources. Another solution is to compromise by accepting a random but small set of unanticipated messages each day along with all prespecified

ones. This reduces the opportunity cost of not using the technology to get unexpected information.

Still, no matter what solution one chooses for information overload, a predicament is unavoidable. It is impossible to seek valuable information without encountering valueless information. More information also increases the complexity of people's view of the organization. While having a complex perspective makes employees "smarter," it also increases the likelihood of conflict as employees become more involved in more affairs of more parts of the organization (Robey, Farrow, and Franz 1989). Some firms restrict communication with "irrelevant" people, or they restrict communication on "irrelevant" topics, but these attempts at control do not resolve the predicament. Because organizations and their environments change continually, an ideal structure of relevant and irrelevant people and topics may look smart at one moment and stupid the next. There may be inequity as some people have more access to valuable communications and contacts than others do. And in the end, some people will get "too much" information while others get "too little." The only answer is to choose broad information access or narrow controlled access and live with the strengths and weaknesses of one's choice.

A new predicament brought about by modern communication technologies, including computer-based communication, is entailed in the increased speed and access of communication that they make possible. When people can communicate instantly, they start expecting instant communications. For example, employees who use their electronic mail system to send requests for information or publications to their library press the pace of library search, retrieval, and copying. They also push library administrators to make faster decisions about acquisitions, databases, and services. The predicament comes from the fact that when events change quickly, they can't happen slowly. Yet sometimes a slower, more deliberate pace is preferable.

Direct access contributes to direct communication. In a big company, employees in the field can connect directly with the offices at headquarters whose advice they need, and people at headquarters can connect directly with the regions where they have business. Why use the field office coordination department? But direct communication has costs. For example, without a filtering structure at headquarters, who will coordinate all the individual decisions, proposals, and activities that take place? Suppose many offices at headquarters decide at once to implement new programs,

overloading the field personnel. Suppose the field personnel bombard one office with requests. Intermediaries slow decision making and even garble communications, but they aid coordination, consistency, and control from the center. Again, the predicament entails a choice with both benefits and costs.

Electronic communication is making some organizational predicaments obsolete or changing the way people have thought about them. We have alluded to some of these changes: simultaneous linking and buffering, in-groups without out-groups, big groups that seem small, and long-distance supervision. One dilemma that may disappear in its present form is between external and internal modes of accountability. In the past, managers have had to choose either to allow supervisors to monitor and evaluate their units or to have specialized staff do evaluations. When supervisors evaluate their groups, there is little assurance that they will do so rigorously. When outsiders evaluate groups, there is little assurance they will do so sympathetically. They may not understand fully the problems the groups face, and the groups may pay little attention to the evaluations. But with databases, on-line performance statistics, electronic notebooks, and computer conference transcripts, the relationship between insiders and outsiders can change. Both can have access to some of the same information. This could make it possible for supervisors and outside staff to do evaluations in parallel or even together (McLaren 1982:83-84). Despite these changes, better technology and management policies cannot solve all predicaments. Dilemmas are built into organizational structures and processes. Technology designs and policies can affect responses to these dilemmas but not change them fundamentally.

9.3 The Future

Technology advances continue to increase the variety of electronic communication tools available. While many of the arguments we have advanced will hold true no matter what the particular technology details are, at least three changes may substantially affect some of our predictions. The first change is increasing bandwidth in computer-based communication. Soon electronic mail may include graphics, pictures, sound, and video. These advances are under development today and in early use in some settings.[3] Increasing bandwidth is likely to reintroduce some of the social context cues that current electronic communication lacks. For instance, when you

read a colleague's message, you may be able to look at his or her image or perhaps you'll prefer to see a representation of his or her facial expressions when he or she wrote the message.

Many think that if technological improvements can reintroduce such social context cues, then electronic communication will resemble face-to-face communication. But this conclusion probably is incorrect. Adding social context cues will not make electronic communication identical to face-to-face communication. Electronic communication has a qualitatively different temporal, social, and structural rhythm (McGrath and Hollingshead 1990). For instance, suppose people could use electronic mail with video at their convenience—in the office, on the road, or at home. Meeting with the boss electronically while wearing a bathrobe at home will not replicate the face-to-face business meeting in the office.

In addition to increases in bandwidth, the number of gateways connecting networks of different organizations and interorganizational networks will increase. In this book we have emphasized intraorganizational communication—connections among employees, departments, or businesses within the same organization. Interorganizational computer networks connect different organizations, such as firms within an industry, school systems, and government agencies. These networks allow for the rapid exchange of information across organizational boundaries and underlie, for instance, just-in-time inventory links between suppliers and producers and reorder links between distributors and consumers. In Sweden, interorganizational communication enables national trade union representatives to meet remotely. Interorganizational communication is important in its own right but raises a different set of issues from intraorganizational communication. For example, it is highly sensitive to legal and regulatory institutions. In the future, it will undoubtedly become more important, but because its legal, regulatory, and economic implications are likely to run counter to the principles of open access and diverse forums, we cannot make substantial predictions about its course in this book.

A third change to come is public electronic communication: commercial access networks will connect households with one another and with retail firms and community services. The United States is actually behind other industrial countries, notably France, where millions of telephones have small screens attached, and services from the telephone book to on-line news, from classified ads to pornography, are available (Kinsley 1989). Currently in the United States, newspapers, cable TV companies, and long-

distance and local telephone companies are warring over which of them will dominate commercial electronic communication. When these battles are settled, we should see a vast increase in public electronic communications, along with stronger incentives to improve services and convenience. There will also be more incentives for companies to offer portable communication technologies, such as computers you can read in bed, wall hangings that turn into movie screens, and eyeglasses that turn into computer and television displays. "Letters by telephone" may mean the demise of postal services as we know them today. Even more than bandwidth and interorganizational communication, public electronic communication opens up many new questions not addressed by our current research within organizations and closely associated groups of people.

Monitoring Change

Although no one can predict and prepare for all the changes that will occur, decision makers and citizens can systematically monitor these changes and learn from early experiences with them. This is necessary because profound technological change is accompanied by new skills, new knowledge, and new ways of thinking (Tushman and Anderson 1986; Barley and Williams 1985; Hirschhorn 1985). Such changes can destroy cherished competencies and traditions. Diesel locomotives required new skills and knowledge that steam engine manufacturers did not typically possess. Typewriters created new occupational roles and changed the organization of the office. Automatically controlled machine tools required wholesale changes in engineering, mechanical, and data processing skills. Organizations that do not understand how and why such changes are taking place can neither exploit nor adapt effectively to them.

Learning about the organizational and social components of technological change is part of the more general job of organizational learning. People often have difficulty with this task because their own organization's experience is limited, and their access to others' experiences is constrained (March, Sproull, and Tamuz in press). Suppose you wanted to compare the effectiveness of the information system you purchased with the systems you almost purchased or with a different type of system that came on the market later. Assembling good comparison information involving other technologies and organizations would not be simple.

One way people in organizations learn is by carrying out thought experiments and simulations—comparing the organization's experience

with what might have happened or could happen in slightly different circumstances. Near catastrophes sometimes stimulate this behavior. People in the airline industry monitor near-collisions of aircraft to help them understand, anticipate, and forestall real crashes (Tamuz 1987). Recently a Cornell graduate student propagated a computer virus through many computer networks, causing breakdowns in hundreds of systems. Although previously people were aware that computer security could be compromised, the incident prompted them to analyze weaknesses in their computer systems and in how employees and institutions were organized to deal with such events.

Another way to learn is by doing systematic research and planning. A predicament connected with doing research is that if it is left for employees to do on their own, their everyday, routine activities tend to drive out the special, nonroutine research tasks. As a result, many organizations establish separate research or planning units, or they employ professional research consultants or support research by outside laboratories. Yet whereas professionals may do excellent research, they may have limited access to the organization and limited credibility, with no way to ensure that their findings and recommendations will be heeded. Because of these limitations, outside researchers may be best suited to helping top-level managers or other employees understand their problems and options and compare them with those in other organizations.

Most learning about technological change in organizations takes place through people's varied experiences and contacts with others. For people to exploit new methods and ideas, they must have a prior mental scaffolding—broad knowledge and experience—that may not have much to do with current job requirements. Organizations expand the flexibility and knowledge of their employees through such vehicles as research laboratories, visits with outside experts, sabbaticals for employees, and cross-organizational forums. These internal procedures for learning in order to learn increase the absorptive capacity of the organization (Cohen and Levinthal 1990).

Organizations best realize benefits from new technology when they make complementary changes in organization and management (National Research Council 1986). Often there is no argument here; new technology is viewed as an opportunity to make other organizational changes, and the only question is what changes to make. New computer-based communication technology has prompted some managers to invoke the following

organizational objectives: a clear chain of command reinforced by routing all network messages through the hierarchy; rationalization and control of information exchange by blocking certain channels of communication; reduced inefficiency and waste by forbidding extracurricular messages or work messages outside a person's responsibilities; and improved security by surveilling message files.

The same technology has prompted other managers to initiate or intensify a different set of objectives: a flexible, internally motivated, continuously learning work force; a strong internal culture to support information sharing and participation in problem solving; delegation or shared responsibility in recognition that dispersed activity requires local action and flexibility and that employees have or can locate salient information; and creation of dynamic procedures, structures, and groupings to amplify expertise and technology. These two sets of objectives are contradictory but together make a point: computer-based communication allows people to work somewhat more efficiently, but the realized benefits depend ultimately on the policies, designs, and vision of people who want to organize work in new ways.

Appendix

A Lesson in Electronic Mail

By Robert F. Sproull

Electronic communication technology uses computer text processing and communication tools to provide a high-speed information exchange service. Anyone with a computer account can create and send information to anyone who has a mailbox on that computer or on any other computer to which it is connected through a computer network. The networked computers might be physically proximate and connected to a local area network, or they might be in different states, countries, or continents and connected via long-distance telecommunications that form a permanent network or a transient dial-up link. Depending on software sophistication, the mailed information can be a message, a document, a computer program, statistical data, or even a collection of organized messages—a computer discussion—forwarded from some other mailbox. At the recipient's convenience, he or she can read the information, edit it, save it, delete it, move it to another computer file, and/or reply to the sender.

Access

The utility of an electronic mail system depends heavily on who has access to it and how convenient the access is. If only a few people have access to the system, it won't serve an appreciable fraction of anyone's communication needs and may become an unused curiosity. Barriers to use arise if people have to share computer terminals, or walk "to the computer room" to get access, or learn a complex set of instructions to send and receive mail. Electronic mail can be as convenient and uninhibiting as picking up the telephone, or it can be one more piece of office drudgery.

For people who already have terminals on their desks, electronic mail can be offered as one of the services available on the terminal. Whether these

terminals connect to large computers or are part of personal computers, they can all deliver the mail.

An initial implementation of electronic mail often identifies clusters of users who already have computer access for another purpose and equips their computers with sufficient software and communication capabilities to send and receive mail. This user group can then be grown by offering mailboxes to new users, perhaps with incentives for joining. Deciding on a rate of growth and corresponding expense is one of the key parts of designing an organization's electronic mail system.

(2) Naming

Each electronic mail message must name precisely the mailbox to which it is destined. It would be nice to use names like "John Smith," but names are rarely unique, and the electronic mail system has insufficient information to resolve ambiguities properly. Some systems assign a unique number to each mailbox, just as a unique number is assigned to each telephone line, but this technique forces each sender to remember or look up mailbox numbers in a directory and gives people the impression they are just numbers to a computer—hardly conducive to smooth communication. A better solution is to add addresses to names, much the way addresses are placed on envelopes, so that the name and address together identify a unique mailbox. For example, "John Smith at Computer Science at Carnegie Mellon University" may suffice to identify a unique mailbox and to give the electronic mail system enough information to transport the message from the sender to the recipient. (Issues surrounding naming and addressing in electronic mail are much more complex than this discussion implies. Devising a scheme that can gracefully handle worldwide use by millions of people has taxed the committees setting electronic mail standards. Supporting "white pages" directory services for millions of users is especially challenging.)

(3) Transport

How is electronic mail delivered from a sender to one or more receivers? There are two basic methods and combinations of them.

At one extreme, all electronic mail terminals communicate with a single computer, where the electronic mail software runs. A person signs on to the

computer and uses the software to compose a message or to read messages from a disk file that serves as a mailbox. For delivery, the text of the message is simply copied into the recipient's mailbox file. Because all mailboxes are on the same computer, a message can be routed to anyone just by copying it to the proper mailbox. If the users of such a system are geographically distant, telecommunications must be used to link the terminal to the single "mail computer." Commercial electronic mail systems, such as CompuServe, operate essentially in this way.

At the other extreme, each person operates a separate computer, which runs electronic mail software and holds on its disk a single mailbox file for its user. To send a message to another person, the computer uses a computer-to-computer communications network and an associated electronic mail protocol to transport the message text from the sender's computer to the receiver's computer and thence into the receiver's mailbox. Alternatives to a network are also possible, such as dedicated communications links between computers used only for electronic mail traffic or dial-up links that are used only when mail transmission is required.

In practice, electronic mail systems usually operate between the two extremes. A local group of users will all have mailboxes on one computer and can send mail to each other by simply copying messages directly into mailboxes. Messages for distant users are transported through the computer network to the computer where the recipient's mailbox is located. Each local site has such a computer, holding mailboxes for all local users. These computers are linked via a network in order to transport mail from one local site to another. If a site's computer becomes overloaded, a new computer can be added to the network to share the load at the site.

Today electronic mail systems cannot always send mail to other electronic mail systems because software from different vendors uses different formats and conventions. Dissimilar systems can sometimes be connected by mail gateways, whereby one computer's mail system can format and deliver messages to a foreign system. For example, Digital's All-In-One mail system can send mail to a gateway that in turn sends the mail to IBM's SNADS mail system. Eventually the need for gateways will be obviated by using standard electronic mail protocols, a single set of rules for formatting messages that flow between computers, so that all computers use one format. A worldwide standard for this purpose, called X.400, *Recommendations for Message Handling Systems*, has been defined and is beginning to be implemented.

Different electronic mail systems also provide different facilities for ensuring privacy and security. The transport and storage of electronic mail messages can be as secure as sensitive military communications or as public as waving a banner at a football game. Encryption can be used to obtain security so that a message can be read only by the sender and receiver who know a secret code that scrambles and unscrambles the message. Today very few electronic mail systems will encrypt messages. A computer system's access controls, such as log-in procedures and passwords, may help ensure that a mailbox and other computer data are not accessed by other people. But many personal computers lack these controls; a night visitor can read anyone's mail. Facsimile machines also have poor security: the telephonic transmission is not secure, and the receiving machine may be accessible to many people. The rather poor state of electronic mail security is likely to improve only slowly; for now, people are concentrating on making mail easier to use for wider audiences.

(2) Group Communication

Electronic mail transmits messages to individuals by copying messages to their personal electronic mailboxes. A single message will be copied to several mailboxes if the sender lists the name of each recipient explicitly. One message may also be delivered simultaneously to many mailboxes by sending the message to a group name or distribution list (DL)—for example, PC Users, Strategy Group, or Movie Reviews. The sender does not specify, or need to know, the names and addresses of group members. The computer automatically mails a copy of the communication, which is addressed to the group as a whole, to the personal mailbox of each group member. Electronic bulletin boards (bboards) and conferences transmit messages to a single named mailbox that is accessible to more than one person. The distinction between these forms of group communication is that in DLs, messages come to recipients' own mailboxes, intermixed with personal communications, whereas in bboards and conferences, people have to take a bit more initiative to find messages. Bboards and conferences differ from one another in that bboards simply display messages in chronological order as they are received; conferences group messages by topic and display grouped messages together.