A perspective on communications and computing

by A. L. Scherr

Presented is an essay on the dynamics of the relationships between communications and computing. Movement of computer applications from the back office to the front office, from batch to on-line data processing, is illustrated and conclusions are drawn regarding communications protocols, network management, application and data base design, and system generality. The influence and requirements of several new technologies are presented, inlcuding those of microprocessors and teleconferencing.

Only in the past twenty-five years have computers been used in communications environments. Their first widespread commercial use was in the early 1960s, with the implementation of airlines reservations systems. During that period, the first time-sharing systems came into use in university environments. In both cases, communications capabilities were used to bring the power of the computer literally to the fingertips of the end users. Prior to that, the general mode of operation was for work to be brought to the computer.

Movement of applications into the front office. The first applications implemented in communications environments were simply extensions of existing centralized applications. With communications-based systems, however, whole new classes of applications have become possible. More specifically, the first automation in most businesses has typically been that of "back office" operations. These include such functions as accounts receivable, accounts payable, inventory control, and applications built on data generated by these applications. As communicating systems became more sophisticated and communications capabilities relatively less expensive, computing power was brought more and more into the "front office."

As an example, consider the classic data processing associated with checking accounts in a bank. For a large bank with widespread branches, the actual checks that had been accepted during the course of a business day would be collected at each branch and picked up by a fleet of vehicles that would bring them to the central data processing facility of the bank. Starting in the early evening and going into the night, these checks would then be inscribed with magnetic ink characters to denote the amount of the check. The checks would be sorted by account number and then processed sequentially against a master account file. By early morning, the account information would have been updated and printouts of the status of each account produced. These printouts would then be distributed to the branches by the same fleet of vehicles for use during the course of the current day. When a customer came into a branch to cash a check, this listing would be consulted and manual notations added to indicate changes in the balance. If a customer from one branch were to come to another branch to cash a check, a telephone call would be made to that person's home branch to verify the balance.

These applications were not simply redesigns of existing batch-oriented programs.

A centralized system with communication capabilities at each branch would eliminate a significant amount of manual processing as well as the need to return account listings to each branch by the opening of business each day. Several such systems have been justified by these savings alone. Then, as soon as a computer terminal becomes available to a teller in a bank branch, the possibilities for automation are extended far beyond the mere handling of check cashing applications.

In this way, the first communications-based applications were justified. They became the basis for installing the foundation of equipment and communication capabilities. Once in place, this foundation formed the basis for extensions into additional application areas. Thus, for example, the installation of communication links between bank branches and the central bank for the purpose of expediting check cashing made it easier to justify the additional expense of providing automated-teller and cash-issuing devices, using these same communication links. These applications were not simply redesigns of existing batch-oriented programs. Rather, they were a new class of usage made possible only by the existence of communication links between remote terminals and data processing equipment.

As more and more applications are added to communications networks and as more and more of a business's operation is automated, dependency on the computer system and its communications networks to do business becomes more critical. One can hardly imagine the air travel business being conducted today without communications-based computer systems to handle reservations, passenger service, seat assignments, etc. Thus freedom from failure in both the computer system and the communication network becomes a key requirement as the criticality of these applications to the user's business increases. The implications of this requirement are that communications programming must provide means to diagnose errors, recover from errors, reroute communications around failing links and system components, etc. To provide these services effectively in a large, complex, heterogeneous network requires strict discipline in the implementation of error protocols, i.e., signaling and record formats. (See papers by Sullivan and by Garrigues in this issue.)

Influence of communication on system generality. Another shift in emphasis brought about by the addition of communications to data processing is an increasing need for generality. Because on-line systems allow for simultaneous access to a variety of data by different phases of a business, there is a need for simultaneous availability of significant amounts of data. As a result, the approach in designing applications systems has shifted over the years from a step-by-step consideration of the processing steps of applications to one that focuses on the structure of the data. Rather than designing each data processing step and considering the output of one step as input to the next step, application analysts have been forced to consider the need for the real-time accessibility of data. Thus analysts have had to design data bases founded on the inherent structure of the data rather than the needs of any particular application.

As an example, consider the development of multiple name and address files as part of the implementation of separate batch application programs for such purposes as accounts receivable, shipping, accounts payable, etc. Under a back-office methodology name and address files would be developed for each of these subsystems and kept separately, even though in many cases the data were identical. Moreover, many common housekeeping operations and utility functions were also performed on these data. With the advent of on-line data bases, the fact that these name and address files were separate could create problems when an update was made in one side of an operation and not reflected in other instances of the same information. Another example of this problem might be that of a bank doing data processing for its credit cards separately from its other types of accounts. In so doing, an address change, for instance, might have to be processed several times. When this information is on line, the opportunity and, in many cases, the requirement exists to consolidate this information into one instance of each data item.

Because of increasing levels of automation in an enterprise, it is not uncommon to see two or more display terminals on the same desk to satisfy a need to access different systems at the same time. Such redundancy is costly not only in terms of the terminals themselves but also in the inherent communication capabilities that support them. Moreover, the human usability of this solution is marginal. This suggests a need for more generality in the capabilities of workstations.

Initially, a user may want to switch rapidly from one application to another. This should be possible through the use of a single set of communication capabilities. Ultimately, however, this capability should be extended down to the transaction level.

As more and more terminals require access to more and more facilities, the importance of commonality increases.

That is, it should be possible for all transactions for all applications to be available at all times to a terminal. The underlying systems facilities to accomplish this involve considerations of common protocols, common transaction switching and routing, and common user interfaces across different systems. As more and more terminals require access to more and more facilities, the importance of commonality increases.

This is emphasized by the use of more sophisticated terminal screen management systems with multiple, overlapped windows and non-keyboard- (e.g., mouse) controlled cursor movement and scrolling. These considerations influence the design of entire data processing systems, rather than just the communications subsystems. This influence is felt

Another fact of communications and computing is that the advent of economical price-performance ratios of microprocessors has made it possible to insert computing power virtually anywhere in a network that it is needed.

strongly in the design of operating systems. Operating system design changes dramatically when it is aimed at environments in which access occurs from a large number of remote workstations, as opposed to centrally controlled batch-type environments.

Influence of microprocessors. Another fact of communications and computing is that the advent of economical price-performance ratios of microprocessors has made it possible to insert computing power virtually anywhere in a network that it is needed. This means that the site at which any particular function is performed is ultimately unpredictable. The implications of the need to do this have further increased the emphasis on common protocols, data formats, and interfaces. Without this, the flexibility needed to capitalize on these new technologies is lost. (See Moore and Deaton and Hippert in this issue.)

In early communication networks, computing power was completely centralized, and the usage of bandwidth to remote sites was limited to rates that would match human capabilities. Thus, low-speed, typewriter-based terminals and the relatively low data rates associated with them dictated the bandwidth requirements. This matched well the capabilities of the voice-grade telephone lines used. It was rare to see telecommunications facilities transmitting bulk data. For the most part, the early use of telecommunications for this purpose was analogous to mailing a tape from one location to another. In virtually every case, it was often more reliable and quicker to mail the tape than it was to transmit it over telecommunications lines.

Influence of advanced technologies. With the introduction of satellites, fiber optics, and microwave links along with more sophisticated use of conventional copper wire, bandwidth capabilities have been increased and costs have decreased. As a result, new high-bandwidth applications are now feasible. Still, there is no body of existing applications that require or take advantage of bandwidth much greater than the commercially available 56-kbit-per-second terrestrial lines. Satellite bandwidth capabilities in the multi-megabit-per-second range are really used over a sustained period of time only by multiplexed communications. Moreover, the ability for a satellite to broadcast simultaneously to a large number of stations has not been completely incorporated into the range of possibilities. (See Fennel and Gobioff in this issue.)

Thus, the early years of communication networks created a virtual "Tower of Babel" of protocols and line usage techniques.

Technically, the available range of communication links presents a challenge. No longer can one design a multiplexor for copper wire lines the cost of which is based on length and which have short delays, low bandwidth, and relatively low reliability. Satellite communications have each of these characteristics in their extreme reverse state. This, in conjunction with other blurring that occurs because of reduced technology costs, has made the differences among multiplexors, concentrators, modems, line-switching devices, satellite communication controllers, and communication minicomputers begin to disappear. With the introduction of digital voice communications, it will be even more difficult to justify any real differences among these various devices. Each provides a buffering and line-concentrating function that may additionally do data processing associated with the communications. Thus the probable future in this area is a reduction in the number of specialized devices and a generalization of usage for those remaining.

Influence on communications of computing protocols. Communications architecture began with the electrical interfaces specified by the telephone companies. The determination of higher-level protocols used at the end points was left to the users. Thus, the early years of communication networks created a virtual "Tower of Babel" of protocols and line usage techniques. Very few of the possible interconnections that could be made electrically were logically possible. Moreover, lines could not be simultaneously shared. As a result, specialized devices were used. For example, a remote job entry workstation communicated on its own line to a large data processing system; a data base inquiry terminal cluster communicated on its own line to the data processing computer; the word processing workstation communicated over its communication links to its processing unit. As workstation capabilities and the need to share communication links became more and more important, there was a need to provide more flexible interconnection. Thus there is a trend toward a sharing of physical communication links among several applications and more and more general-purpose capabilities in the terminal devices. As a result, protocols have begun to be defined at higher and higher levels of function. In earlier systems, distinctions were made between logical and physical connections, so that multiple logical connections could exist on the same physical connection. Protocols were invented to support this split, to provide for the establishment of logical connections, to provide for the security that was needed when such sharing of physical resources took place, etc. Recently, it has become desirable to define protocols for exchanging data, for invoking programs remotely, and for coordinating error recovery in cases where several nodes are participating in the execution of a single transaction. The definitions of these protocols extend the domain of communications architecture to encompass the rest of the system. Thus, this is another case where communications protocols have become an important consideration in the design of data base systems, work load scheduling, security, accounting, etc.

Future trends. The trend in the use of communicating workstations in an office systems environment will lead to these devices becoming as common as the telephone. Moreover, the effect that the presence of these devices will have on business will be analogous to the effect that the telephone had when it was first introduced almost one hundred years ago. That is to say, the use of the telephone replaced a large segment of written communication and personal contact. Compared to writing, the available bandwidth was increased, whereas relative to personal contact, it was substantially decreased. In a very real sense, people had to relearn communication skills and adapt their mode of doing business to the existence of this new communication channel. In many businesses, offices were organized around the use of the telephone and, in fact, some modes of business were made possible only by its existence.

The introduction into the common office environment of the intelligent workstation with high-bandwidth telecommunication facilities will probably have even more influence than the telephone on the way business is done.

The introduction into the common office environment of the intelligent workstation with high-bandwidth telecommunication facilities will probably have even more influence than the telephone on the way business is done. Certainly, more bandwidth will be available for what in the past has been written communication. Letters will be transmitted more rapidly. Short messages will be delivered virtually instantaneously. Teleconferencing facilities will be used rather than simple conference telephone connections. On the other hand, teleconferencing and lower-bandwidth facilities will be used in the future in place of face-to-face meetings. In fact, the need for face-to-face contact with one's co-workers may all but disappear. Some specialists in the field of office systems design are predicting that offices as we know them will cease to be necessary. That is, offices may become obsolete with the availability of computer systems containing all the necessary files of correspondence and other communications and the ability to communicate with one's colleagues in a high-bandwidth mode from virtually any place on the globe.

The real limitation appears to be that we will not be capable of reproducing the bandwidth available in a face-to-face meeting—the feel of a handshake, for example—using any of the known forms of telecommunications. Thus there is a personal challenge and an opportunity to recreate the way we communicate in business meetings, if we are to reduce the bandwidth required to conduct business. As individuals, we must become skilled at focusing on the essentials of interpersonal communications: comments, requests, trust, objective facts, etc. Consequently, new protocols and new techniques will need to be developed. The fact that the medium for communications begins with computer-based, intelligent workstations offers the opportunity for computer assistance of these protocols. Thus the workstation can be the beginning means by which people are trained to communicate more effectively. This is analogous to the influence of the telephone on communication.

As the usage of telecommunications enters its second century, our society faces opportunities and potential shifts in modes of communicating that are as challenging as prospects were when we began using the telephone one hundred years ago.

Reprint Order No. G321-5179.

Allan L. Scherr *IBM Corporation, 400 Columbus Avenue, Valhalla, New York 10595.* As a member of the MIT Project MAC, Dr. Scherr did research on time-sharing system performance and user characteristics. After joining IBM in 1965, he participated in the definition of the System/370 architecture, and in 1968 he became the design manager for the TSO Project. In 1971, Dr. Scherr was given overall project responsibility for the first MVS release (OS/VS2 Release 2), and he subsequently became the systems manager for both OS/360 and OS/VS2. In 1977, he was assigned responsibility for managing the development of a new programming system for distributed processing (IBM 8100 DPPX), and in 1980 he was named Director of Communications Programming, responsible for IBM programming products for communications and network management support. Dr. Scherr is currently Director of Communications and Applications Systems on the Engineering, Programming, and Technology Corporate Staff. In 1965, Dr. Scherr received his Ph.D. degree in electrical engineering and computer science from the Massachusetts Institute of Technology.