The user's role in connecting to a value added network

Technology

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Once a user opts to buy services from a value added network, it's necessary for him to do some initial work, mostly some reprograming

Early next year data will start flowing at 56,000 bits a second over the circuits of a unique nationwide common carrier service called a value added network. This new approach to data communications combines old and new transmission facilities and adds to them a form of intelligence to improve the performance.

The value added network (VAN) is different from present data transmission services and from private data networks in both the enhanced and extensive offerings to users and the sophisticated technology it employs. The technology, called packet switching, makes it possible for the value added carrier—the implementer and operator of the VAN—to provide any user, large or small, with the kind of fast-response, error-free, low-cost-per-transaction data transmissions now available only to companies that have invested in their own large private networks.

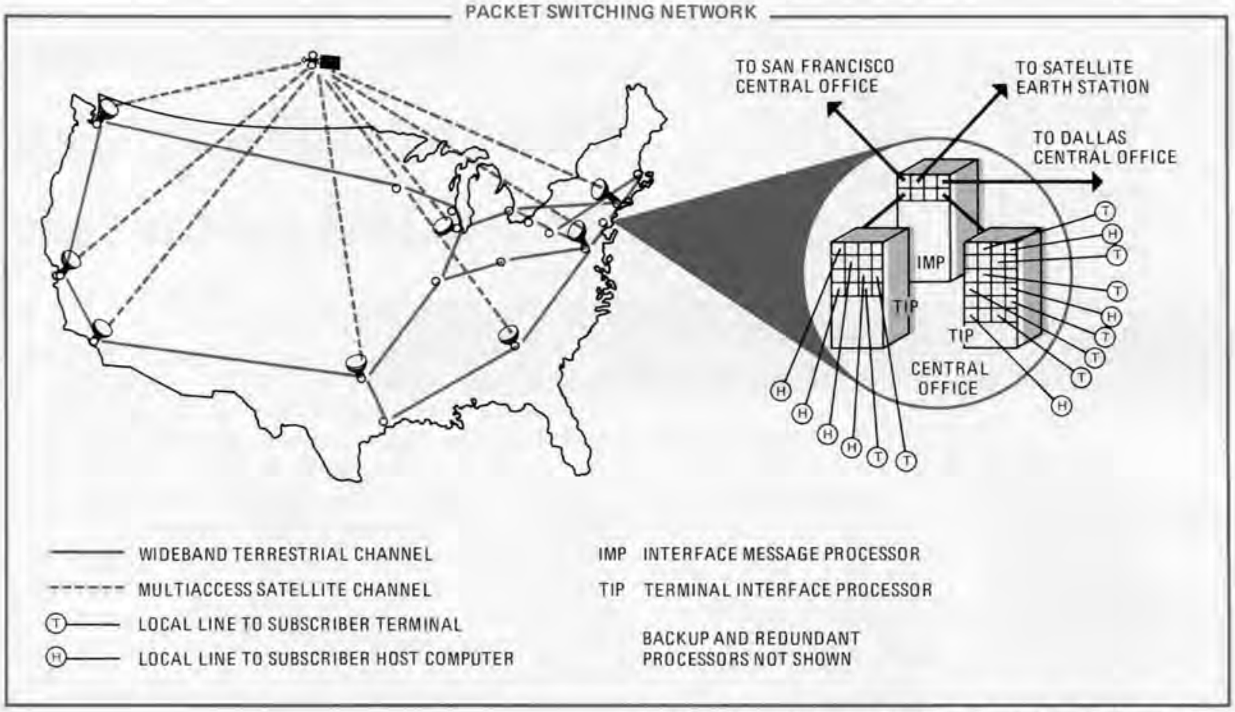
In essence, the value added carrier (VAC) takes advantage of the substantial economies of scale resulting from one very large network— fully utilizing such expensive resources as transmission lines and concentration equipment by sharing the network among the VAN's subscribers. The VAC passes on a portion of the consequent savings to the individual user-subscribers through a tariff charge based mainly on traffic volume.

Beyond the simple economics, leasing existing communications facilities allows the carrier to obtain just as much transmission capacity for each location as is required by the traffic load. This provides the flexibility to adapt quickly to subscriber traffic and geographical demands, and permits the incorporation of new transmission offerings—such as satellites and AT&T's Dataphone Digital Service—as they become available.

Conceptually and technologically, VAN's have their origin in the Arpanet, a nationwide consortium of computers at numerous research centers tied together over a packet swtching network. However, the Arpanet is operated in behalf of the government to support research activities of various Federal agencies, not as a common carrier facility.

This lack of availability of VANs to individual user-companies in commerce and industry was remedied in 1973 when the Federal Communications Commission approved the concept of value added networks, determined that VACs should be

PACKET SWITCHING NETWORK



1. Wideband terrestrial and satellite links permit different packets of bits in a subscriber's message to take alternative paths from source central office to destination central office.

regulated as common carriers, and declared an open entry (non-monopoly) policy permitting potential public network operators to propose a value added network so long as they applied for FCC approval. Thus, VACs will be regulated, but will operate in a somewhat entrepreneurial and competitive environment. Telenet Communications Corp. received FCC authorization as a VAC on April 16, 1974. Telenet's start up is slated for next January, with the network eventually having central switching offices in over 60 cities.

In addition to FCC's advocacy, the viability of the VAC concept was enhanced when AT&T amended its FCC tariff 260, for private voice-grade and wideband lines, to permit VAC's to "resell" the transmission channels they leased from AT&T to VAN user-subscribers. More recently, AT&T specifically included provision for lease of dedicated lines to VACs for resale in its new FCC tariff 267 for Dataphone Digital Service. Furthermore, specialized and satellite carriers have agreed to provide wideband transmission facilities to VAC's.

The FCC has authorized a VAC to provide the data communications network required to connect a user's terminals and computers. Specifically, connections can be made from terminal to computer, computer to terminal, and computer to computer. Transmission will be available to users at all common speeds, ranging from that for the slowest teleprinters up to 56,000 bits per second (b/s) for high-speed data transfer between two computers.

A value added carrier such as Telenet, however, will not supply data processing services nor will it provide hybrid data processing involving both data processing and data communications services. What a VAC will do is simply permit data transfer between any two or more dynamically selected user stations, where a station is defined as a data terminal or host computer. To accomplish this, the VAC leases long-haul wideband lines and invests in computerized interface and switching equipment, high-speed modems, diagnostic facilities, and the like to construct a network. The VAC programs the computerized interfaces to provide such services for customers as code conversion, speed conversion, and error detection and control. In addition, the computers at the VAC's monitoring centers gather data for user traffic statistics and billings and provide other network related services.

Typical tariffs

In return, the user pays a tariffed charge. Telenet, for example, is proposing a basic \$1.25 charge for a kilopacket, 1,000 packets of up to 1,024 bits each. This charge is independent of mileage between stations. In addition, there is a monthly charge for connecting the access line from the user's station to a port at the VAC's nearest central office. As an example, Telenet's port charge for a dedicated access line is \$50 a month for up to 9,600 b/s service. And the charge for a dial-up port is, for example, \$1.00 an hour for asynchronous service and \$2.00

an hour for 2,400 b/s synchronous service, with such charges decreasing proportionately for shorter calls. In general, lower speed service is less and higher speed service more. The toll charge, if any, for dial-up calls is borne by the user-subscriber.

The access lines and modems, leased by Telenet but paid for by the user, are under operational control of Telenet personnel to permit continuous network diagnostics and to relieve the customer of having to deal with more than one vendor in case of difficulty.

A prospective user of a VAN service must consider two areas: the technical and operational tasks and responsibilities which are the factors discussed here; and the possible impact of new communications services on the user's operating and organization structure. For although immediate cost savings may be achieved, of greater long-run significance is the new flexibility users will have for accommodating growth in existing systems and for implementing new remote and multi-computing applications based on overall communications needs and not on present technical and economic constraints.

As mentioned, the user must make a certain technical and operational effort to be able to match up with a VAN. The amount of effort is quite small if the user just wants to connect a popular terminal; more effort, mainly some reprograming, may be required to connect a host computer. That is, while the VAC operates the network, for the subscriber to employ the network properly is, at least during startup, a joint project involving both the VAC and the user. These points will be detailed following this description of how the packet-switched VAN itself goes about providing data communications transmission services to a multitude of diverse users.

In time, several VANs may be in operation, so users will have some choices in selecting competitive and alternative services. It appears likely that all VANs will use packet-switching technology and all will be configured in substantially the same way—but each, certainly, with some technical and tariff differences. The Telenet network should serve, then, as representative of what will be available in the next few years (Fig. 1). An 18-city network is expected to be on-line by the end of 1975 although a 7-city subnetwork will be operational early in the year. Telenet has leased-medium- and high-speed lines from transmission carriers to carry data traffic among host computers and terminals. In addition, transmission capacity will be leased from domestic satellite carriers to serve both as primary wideband channels and secondary back-up circuits to the terrestrial lines.

One or more central offices are to be located in each of the cities functioning as nodes in the network. Note that each node city has two or more (full duplex) lines connected to it.

This redundant access to a central office serves several useful purposes. For one thing, multiple lines permit traffic to be simultaneously routed over parallel channels between source and destination central offices. For another, multiple access lines permit traffic to immediately reach its destination via an alternate route in the network should one of the lines become degraded with excessive noise or go out altogether.

Packet switching nodes

But most intriguing from a technical and operational viewpoint is that different packets comprising one message may be delivered along different routes. For example, suppose a user-subscriber located in a suburb of Seattle wants to transmit an 8,000-bit message to Houston. The message is delivered to the VAC's central office in Seattle over a dial-up or leased-line, and is formatted into eight 1,000-bit packets in high-speed core memory by a special processor there.

The first packet is released from buffer and, for example, travels to and through the central offices in San Francisco, Los Angeles, Dallas, and on to Houston—being error-checked over each hop of the journey and buffered at Houston to await the arrival of the other seven packets.

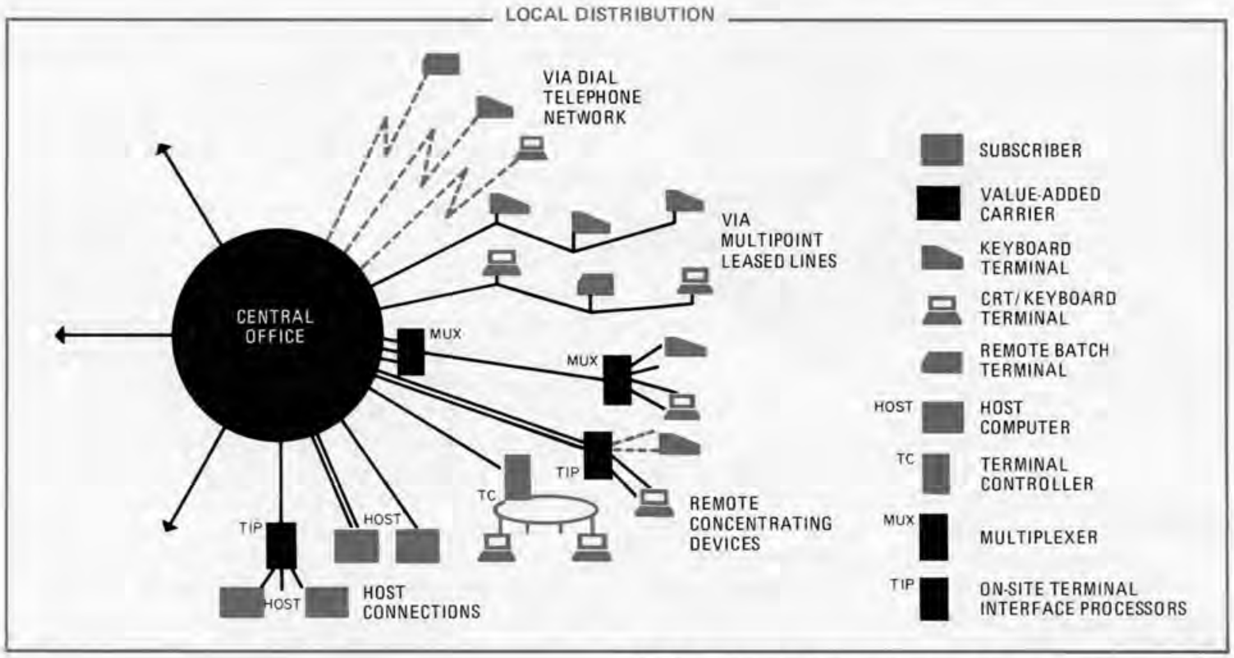
The second packet, however, might have to take a different route if the line to San Francisco is busy at that moment. In such a case, the packet could take the route from Seattle to Houston, via Minneapolis, Milwaukee, Chicago, St. Louis, and Dallas. And so on for the other packets in the message.

Once a message is accepted by the network, the VAC assumes responsibility for error-free transmission. Therefore, at the sending office the buffer for a packet is not released until the next receiving office acknowledges correct receipt. If received in error, the buffered packet can be retransmitted. When all packets have arrived without error at the buffer in Dallas, the message is released from the central office to the recipient terminal or computer. The recipient gets the packets in the same order they were sent.

Although the original message may have started out, say, at a 4,800 b/s message rate, once it enters the network it is transmitted at 50,000 or 56,000 b/s. Even including electrical propagation, queuing, and acknowledgement delays, a packet will proceed from any source office to any destination office in, on average, one-third of a second.

Central office interfaces

The inset in Figure 1 shows the two major pieces of equipment in a Telenet central office, the terminal interface processor (TIP) and the interface message processor (IMP). Each TIP has hardware/software ports to accept data from a user's terminal or host computer. Terminal data can be a character, a block of characters, or some segment of a long, con-



2. Any kind of terminal and concentration device can have access to a value added network's central office over dial-up lines and point-to-point and multipoint private lines.

tinuous message. Even though data from the several terminals may be in different lengths, codes, and speeds, the TIP formats the output data stream into the standard packets used for internal network transmission.

At the user's option, all data entered from a character-oriented terminal attached to the Telenet network can be translated into a single, well-defined 'virtual terminal' format by the TIP. Conversely, data sent from the host computer in 'virtual terminal' format is translated back into a form compatible with the terminal. This mechanism can remove much of the burden of code conversion and terminal support from the host computer, which supervises the single 'virtual terminal' type to communicate with the diverse terminal models connected to the network.

The number of TIPs actually located in each central office depends on the expected number of terminals and host computers being serviced. However, each central office will have at least two TIPs, each handling a share of subscribers even though neither one may be fully loaded under normal flow conditions. If a TIP should go out of service, either on a planned or emergency basis, all its connections to users can be instantly switched to back-up interface equipment.

The terminal interface processor are multiply connected to IMPs which route the standardized packets of data over the optimal long-haul links. The technique of dynamically routing packets individually along one of several alternate paths is used to minimize end-to-end transmission delay, spread traffic evenly throughout the network, and increase reliability. At each TIP and IMP along a route, packets are checked for errors and, if necessary, retransmitted. Flow-control techniques within the network (invisible to users, as are the packets themselves) ensure that the fast-access core memories of the processors do not become overloaded while maintaining high channel utilization. Therefore a packet cannot get lost for lack of buffer capacity at any node.

Each interface message processor and terminal interface processor periodically reports observations about itself and its environment to network monitoring center processors. These computers watch the instantaneous state of the network—warning of network components whose capacity may need to be increased and initiating remote diagnostics and repair activity when necessary. The system is designed such that the failure of an individual component can be immediately detected and its tasks simultaneously absorbed by one of its functionally redundant counterparts without interrupting service.

Interface message processors and terminal interface processors are stored program processors. Because they employ software, not hardwired logic, new programs can be readily added to permit the processors to interface with new types of terminals and host computers and provide new terminal support functions. In fact, new or modified programs can be sent over the network itself from a central location to all, or selected, IMPs and TIPs to make a new service immediately available to all subscribers without having to halt the network.

User terminals can reach the central office in a number of ways, including dial-up lines, multipoint, and point-to-point leased-lines, and using such concentrating devices as multiplexers, remote data concentrators, and terminal controllers. In some instances, VAC-owned TIPs may be installed at the user site (Fig. 2). The lines and devices in color represent items supplied by the subscriber and those in black designate those supplied and/or under control of the VAC.

Terminal access

The criteria for choosing either a dial-up line or a dedicated line to access the central office are substantially the same as those employed in configuring private data communications networks. In short, such factors as transmission speed, acceptable busy-signal incidence, response time, volume of traffic, length of individual transmissions or transactions, and whether line use is substantially continuous or mostly occasional, must be considered. Because these lines extend only to a local central office, cost is less of a determining factor than in an extensive private network.

In addition to establishing a physical connection over a line to the VAN's nearest central office, the terminal must also establish a logical connection through the network to some destination computer. For data terminals, the logical connection can be established in either of two ways depending whether the terminal has a dedicated or dialed connection to the central office.

When a terminal on a dedicated line is merely required to converse with one particular computer on the network, that terminal's TIP port may be pre-initialized to the desired transmission parameters and host computer address. When the terminal is switched on-line it will be automatically connected to the preselected computer in less than one second and the computer may respond by printing out its own name, such as MH COMP, on the terminal's display. Then the terminal-computer-terminal dialog can proceed just as if there were a direct physical circuit between the two station sites.

For a dial-up terminal, the process is similar, except that the operator may first have to provide a short command identifying his terminal model and a second command specifying the host computer with which it is to be connected.

Simple commands

In the majority of cases, the terminal operator will be concerned with, at most, the command that defines his terminal model and the commands required to establish and break the connections to host computers. From time-to-time, however, some users may wish to communicate other instructions directly to the TIP. This is accomplished by issuing additional commands, most of which set a transmission parameter or mode. For example, it is feasible for the operator to change the speed at which an asynchronous terminal sends and receives data, assuming, of course, that the terminal and the associated modem can support the selected transmission speed.

In addition, a VAN quite efficiently provides a number of simple functions beyond pure data transfer. For example, local editing is available for unbuffered typewriter-oriented terminals and displays. Data entered on these terminals is normally accumulated by the TIP prior to being forwarded to the destination host computer for processing. Before the buffered data leaves the TIP, it may be edited by the operator on a character or line basis, typically to correct keyboard input errors. Again, this editing facility can be preset or the user can issue short commands that define characters which when typed will delete the last preceding character from the data just entered or all the data in the current line of input.

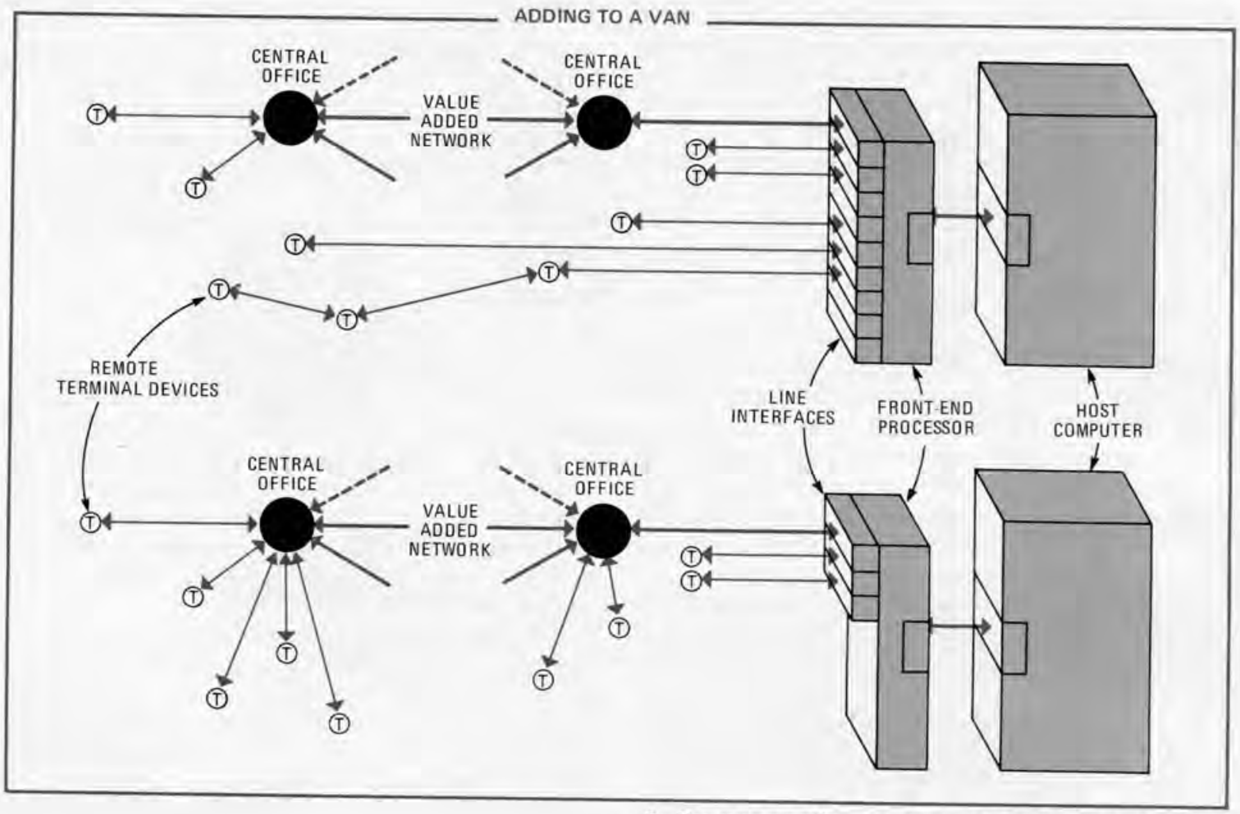
These and other functions are strictly optional; their ultimate utility may depend on the nature of the user's particular application. In short, some terminal users will want to become familiar with a limited repertory of commands and facilities. For others, the network interface can be pre-initialized to exactly those parameters and facilities required, eliminating the need for any commands during routine usage. In either case, the user can adapt the network to his needs with ease and little training.

Normally, the VAC will build a software module into each TIP's program for each class of terminal. For popular terminals this software is part of the VAN service. Therefore, at the outset about the only concern a user may have is to make sure the VAN can handle his type of terminals. But, if the terminal is very special, or brand new on the market, the user may have to help defray the cost of unique software development.

Computer access

Since a host computer converses simultaneously with many terminals or other hosts through the network the physical connection to a VAN's central office will usually be via a dedicated local point-to-point access line operating at up to 56,000 b/s. (A second access line, perhaps of a lower speed, may be installed for reliability or increased throughput capacity.) There is little a subscriber has to do to obtain a physical connection to the network. But the user must get involved in planning for logical connections of host computers as the VAN takes on more and more of a subscriber's load.

Format, signaling, and error control protocols enable a subscriber's computer to send and receive data over the carrier's system. These protocols must be incorporated in the user's system in the form of software routines. The protocol software may reside in either the host computer, when the



3. By connecting to the nearest central office, users can convert point-to-point and multipoint links into less costly local access links.

interface between the communications lines and the host computer is a hardwired transmission control unit, or in a programable processor that front-ends the host computer. To minimize the effort required to connect a host computer to a VAN, the interfaces have been designed to emulate standard communications devices on a conventional data control links—something the host "already knows about." Thus, the changes required because of the use of VAN links may involve no more than reparameterizing the communications macros in present vendor-supplied packages.

Consider the system configuration at the top of Figure 3. Here, several point-to-point lines and one multipoint line go to a hardwired transmission control unit. The top left most terminals were previously accessed via an expensive, transcontinental line. As a means of initially testing the VAN service, the user has selected to access these two terminals through the network. Therefore, the TIP, in the central office closest to the host computer, is programed to emulate a multipoint, binary synchronous line. (The terminals might actually be on a separate point-to-point line connected to their local central offices.) Accordingly, few changes in the software macros have to be made by the user in the computer's communications software.

System use of the VAN could stop with the assignment of just two terminals to the network. However, VAN utilization can grow to the stage shown at the bottom of Figure 3. Here, all terminals connected to the multipoint line and all dedicated line terminals, except the two closest to the host computer, are connected to nearest central offices. Thus, using the value added network has eliminated several point-to-point lines and one multipoint line with minor impact on user programing. The subscriber also needs fewer line terminations at his central office.

If the subscriber also opts to convert from hardwire transmission control unit to a true programable front-end processor he can remove considerable inefficiencies from the host computer, but at the initial cost of programing the front-end processor. (Such programing costs are not attributable to going on a VAN.) If this change is made at the same time the subscriber integrates his system onto a VAN, he may want to incorporate in it a software interface with more efficiency and flexibility than the emulation interface provides. If a customer wants to connect several computers to one location to the network, the carrier may determine that it is to the user's advantage to install a TIP on the subscriber's premises. With regard to software modifications, the carrier may either contract to develop the software for the user's computer or assist the subscriber in having its in-house personnel develop the software. ■

The Telenet Report

Telenet Communications Corporation, 1666 K Street, N.W., Washington, D.C. 20006, (202) 785-8444 Volume I, Number 1, Summer, 1974

Telenet "Intelligent Network" Receives FCC Approval

The Federal Communications Commission announced its approval of Telenet's "Intelligent Network" on April 18 of this year—just six months after Telenet filed its application! This action clears the way for Telenet's operation as the first U.S. carrier offering switched high-speed data communications on a coast-to-coast basis. The Commission rejected a petition by the Western Union Telegraph Company to deny the Telenet application.

Western Union's contention that Telenet's application failed to meet the requirements of the Communications Act and the FCC's rules was found by the Commission to be without merit. In its approval of Telenet, the Commission stated:

> . . . although the entry of packet-switching carriers into the market for communications services would have an impact on the structure of the industry, such entry should be permitted because it would introduce new and improved means of satisfying the needs of the public not otherwise available from generalized or specialized carriers.

Packet-Switching Gaining Worldwide Acceptance

Commenting on the FCC action, Dr. Lawrence G. Roberts, Telenet's President, stressed the fact that packet-switching is quickly gaining worldwide acceptance as the most effective means of providing switched data service to computer users. The approach has been adopted by many countries, including Canada, England, France and Spain, all currently implementing public packet-switching networks similar in many repects to Telenet's.

In the FCC order, Telenet was authorized to establish packet-switching centers in 18 cities, and to lease the necessary high-speed interconnecting links from other communications common carriers. Required transmission facilities include terrestrial lines operating at 50 or 56 kilobits per second and a supplemental 1.544 megabit per second multi-access satellite channel. This channel, leased from an approved domestic satellite carrier, will serve domsat earth stations located near eight major metropolitan areas.

Letters of Support Submitted to FCC

In opposition to the Western Union petition, letters of support were received by the FCC from The National Library of Medicine, The Interuniversity Communications Council, Inc., The Center for Advanced Computation at The University of Illinois as well as the Computer Corporation of America. Additionally, American Satellite Corporation submitted comments urging the FCC to act on the Telenet Application.

Telenet Will Offer Nationwide Service

By means of the initial seven switching centers which are planned to be installed and operational by early 1975, the Intelligent Network will offer coast-to-coast data communications service. These switching centers, called Central Offices, will be located in Boston, Chicago, Dallas, Los Angeles, New York, San Francisco, and Washington. (As this newsletter went to press, office space for four of the seven switching centers had been obtained, and several sites in the remaining three cities were under evaluation.) But potential subscribers need not be located in these particular cities to take advantage of Telenet's service!

Users in different cities may either lease a channel or use a dial-up line to access the nearest switching center. And, as additional cities are added to the network, the length (and cost) of system access lines will be reduced.

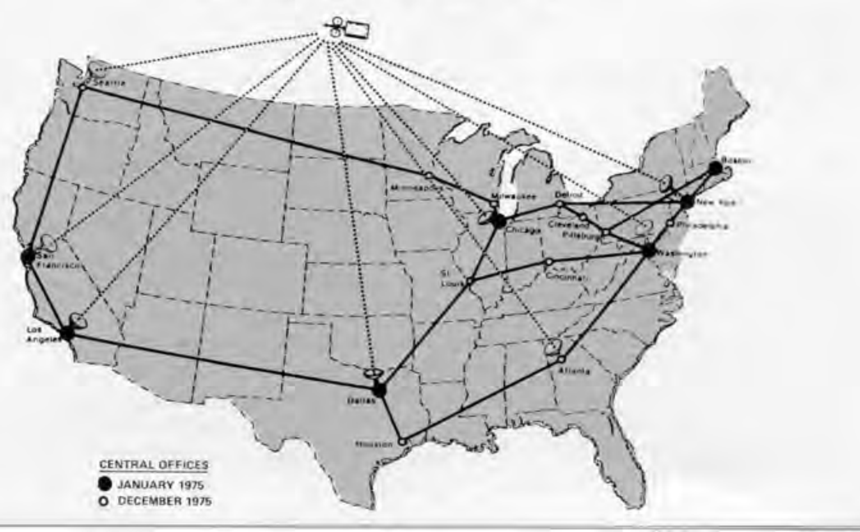
After the first seven Central Office facilities are constructed, Telenet plans to expand the Intelligent Network at a rate of one city per month—so that eighteen full-service switching centers will be operational by December, 1975. In addition to the seven cities mentioned above, the Telenet system will encompass: Atlanta, Cincinnati, Cleveland, Detroit, Houston, Milwaukee, Minneapolis, Philadelphia, Pittsburgh, St. Louis, and Seattle. And, within four years, Telenet plans to enter another 44 cities for a grand total of 62 switching centers. When all these cities are within the network, more than 50% of the U.S. population will be within 20 miles of a Telenet facility.

High End-To-End Reliability— A Prime Design Objective

Each Central Office will be equipped with standby equipment, for quick replacement of faulty facilities. And, diagnostic testing and preventive maintenance will be regularly performed by on-site Telenet personnel. Additionally, line switchover units will provide for immediate recovery from equipment

Continued on page 4

TELENET PACKET-SWITCHING NETWORK



System Implementation . . . A Progress Report

Telenet has been working on the development of the software for its IMPs and TIPs since last fall. Starting with the field-proven ARPANET software developed by its parent company, Telenet's software incorporates important extensions to the basic IMP and TIP programs. These enhanced programs, nearly complete, are running successfully in a prototype Central Office at the company's development center.

Utilizing computer equipment supplied by Prime Computer Inc., the prototype Central Office will serve as a model for the actual Central Offices, to be installed in seven cities this fall.

Shortly after receiving formal FCC authorization, Telenet ordered additional packet switching computers from Prime. The Prime Model 200 processors will be used as IMPs and TIPs, while Prime Model 300 processors will serve as the Network Control Center (NCC) machines. Software development has been done primarily on the Prime 200 computers.

Data By The Packet . . . What It's All About

The concept of packet-switching is a relatively young, but performance-proven data transmission technique specifically designed for the unique requirements of terminal-to-computer and computer-to-computer communications. Like most other switching techniques (i.e., circuit and message switching) packet-switching is designed to avoid the high cost of providing dedicated connections among all points of communication.

Circuit switching, for example, is used by the telephone company. Upon receipt of dialing signals, the switching equipment establishes a dedicated connection between sender and receiver. Throughout the duration of the call, this channel is unavailable to other users. Circuit switching makes efficient use of transmission channels when the information flow is relatively continuous, but is highly inefficient for irregular data flow patterns.

On the other hand, message switching involves routing addressed messages from sender to an intermediate switching center. Here, they are stored on disk drives—usually for a matter of minutes—until they can be forwarded to their destination or to the next store-and-forward switching center. Messages are stored so that peak demand for transmission facilities can be spread over time and so transmission facilities can be used more uniformly and efficiently throughout the day. This technique is suitable when deferred message delivery is O.K., but inappropriate for rapid computer interaction.

Packet-Switching Similar to Message-Switching

Both message and packet-switching use store-and-forward techniques and both make efficient use of transmission lines. In packet-switching, however, messages are subdivided for efficiency in transmission into short segments called "packets," which are transmitted through multiple switching centers from source to destination. But unlike message switching, packets are stored in core memory, for only a few milliseconds, and are routed along dynamically determined paths. Each node maintains a continuously updated routing table so that packets can be easily routed at each switching center, or node, along the path that most efficiently minimizes transmission delay at that moment.

At each Central Office node, small computers—called Interface Message Processors (IMPs) or Terminal Interface Processors (TIPs) . . . when terminal/host interfacing capability has been added—perform the packet-switching function. These IMPs and TIPs are interconnected by leased high-speed transmission facilities, and the TIPs provide direct access to the packet-switching network to heterogeneous, autonomously operating computers and to terminals of many types. Each participating "host" computer is connected to a nearby Central Office TIP. Each data terminal is connected to either a Central Office TIP or to a host computer . . . for indirect access. In this case the host computer is, in turn, connected to a TIP. Both terminals and hosts are connected to Telenet Central Office TIPs via local telephone company lines.

Messages Subdivided Into Packets

When a TIP receives a message, it is subdivided into packets (about 100 characters in length) and transmitted to the destination along any available network path. Each packet proceeds along its own path, from TIP to IMP and from IMP to IMP, until it reaches the destination TIP, where all packets are stored. At the destination TIP, the complete message is reassembled for delivery to the receiving host or terminal.

Data Transmission = Terrestrial Channels + Satellite Channels

A recent packet-switching innovation is the use of satellite facilities in addition

A member of Telenet's technical staff tests a new software enhancement for the IMPs and TIPs. Each switching center will contain a minimum of two IMP and two TIP computers.

to conventional land lines for data transmission. In the multi-access "broadcast" mode, satellites afford extremely efficient use of the available bandwidth by many ground stations. Each ground station occupies the channel for a brief period of time only—for the amount of time needed to transmit a single packet. Therefore, many ground stations can effectively interleave their respective transmissions. This efficient use of shared satellite channels provides high peak data rate channels (up to 1.544 Mbps) among all ground stations at the cost of a single channel.

Future full development of satellite technology is certain to make low cost, small-scale, ground stations readily available to further enhance the economical interconnection of computers in isloated areas—and the economics of data transmission by packet-switching!

Telenet Stages Double-Edged Participation At Interface 74

The Telenet Intelligent Network and the benefits of packet switching to data communications users were the order of the day as Dr. Roberts led Telenet Communications Corporation in a successful dual stint at Data Communications Interface 74 in Dallas this March.

As the only national conference and exposition devoted exclusively to the needs of datacomm users, Interface 74 offered Telenet representatives three full days of valuable contact with major data communications personnel from organizations nationwide. The attention-getting Telenet booth consistently attracted large numbers of attendees throughout the exposition. And, Telenet's technical and marketing staff members responded to their questions with detailed information on immediate and future capabilities of the Telenet Network—and on how the use of sophisticated packet-switching techniques can solve many serious data transmission problems.

Dr. Roberts' Speech Highlights Conference Sessions

President Roberts provided data communications users with an informative presentation on *Public Packet-Switching Carriers* during the second day of Interface conference sessions.

Dr. Roberts reported that Telenet belongs to "a new class of communications common carriers—Value-Added Carriers—which are authorized to lease raw communication trunks from the transmission carriers, augment these facilities with computerized switching, and provide enhanced or (value-added) communication services." Telenet, he told attendees, plans to provide these value-added services by taking advantage of proven packet-switching technology.

Dr. Roberts traced the development and application of packet-switching techniques through the Defense Department's Advanced Research Projects Agency Network (ARPANET)—which was built and is currently operated by Bolt Beranek and Newman, Inc., Telenet's parent. He also pointed out that public packet-switching networks, like Telenet's, are currently being implemented in various countries in Europe and in Canada.

The user benefits of packet-switching networks, Dr. Roberts went on to say, can best be translated in terms of reduced communication and computing costs and increased flexibility.

In the area of cost-effectiveness, Telenet will help most users reduce communication line charges and better utilize both computing and terminal resources; and also decrease operating and maintenance expenses for all users by assuming complete, end-to-end responsibility. Attendees were also very interested to hear that the high reliability of the Telenet System—through such features as dynamic alternate routing and advanced error detection and correction—will provide users with further cost savings.

A final advantage to a packet net involves a distributed data base—affording more economical, direct terminal access to information stored in a centralized location or distributed among many computer sites.

Dr. Roberts also explained how the Telenet packet network can best meet computer communications wide flexibility requirements. Not only will Telenet have the capacity to absorb substantial increases and fluctuations in individual traffic loads, but also will permit the subscriber "to choose the type of terminal to be used at each location virtually independently"—without the need for additional host software. Finally, Dr. Roberts said, public packet networks will make direct interconnection of data processing computers more practical and more economical than ever before.

We Thought You'd Like To Know . . .

. . . a little something about Telenet Communications Corporation in case you happened to miss some of our recent publicity. Telenet is a majority-owned subsidiary of Bolt Beranek and Newman, Inc., a company established in 1948 for the purpose of consulting, research and development in science and technology. Since that time, BBN (a public company listed on the American Stock Exchange) has developed advanced capabilities in the computer communications field. In fact, about half of BBN's 600 employees are involved with computer science and technology.

Recent BBN Activities . . .

. . . include computer science projects from A to Z: advanced computer organization and design, computer communications networks, automatic programming, pattern recognition, computer problem-solving, natural language computer systems, information retrieval, and research on man's interaction with the machine—to name a few. Here's a quick-look at a few more specific areas of BBN involvement:

- In 1962, BBN developed one of the first time-sharing systems, which laid the groundwork for the future of this burgeoning industry.
- Today, BBN's advanced TENEX time-sharing operating system is in use in a number of research and university computer installations across the U.S.

Continued on page 4

Continued from page 3

- BBN is responsible for the design of the COMEX network—the Pacific Stock Exchange securities handling computer system.
- Recently, BBN delivered specialized packet-switching systems to the Defense Communications Agency and to the National Security Agency.

Dr. Lawrence G. Roberts and the ARPANET success story

In 1968, the Advanced Research Projects Agency (ARPA) selected BBN to design and implement the ARPA packet-switching network. Currently, BBN designs, maintains, tests, and installs ARPANET hardware and software and manages the entire packet-switching network from its Control Center. The success of ARPANET has been cited as "one of the most significant and valuable advances in computer and communications technology." Due to his contribution to this unprecedented success, Dr. Lawrence G. Roberts, current President and Chief Executive Officer of Telenet Communications, has won international acclaim as a leader in communications technology and is widely known as the "father of packet-switching."

ARPANET . . . The Telenet Model

In 1972, Telenet Communications Corporation was founded for the purposes of establishing value-added common carrier services, based on the packet-switching technique developed for ARPANET. As a BBN subsidiary, Telenet Communications has enjoyed corporate and technological support from its parent company during all phases of its efforts. Using the ARPANET as its model, and drawing upon BBN know-how and experience, Telenet began the process of establishing a nationwide packet-switching network offering high-performance data communications services to the public . . . the first coast-to-coast network of its kind. The result? Quick FCC action on the Telenet application for approval as a value-added common carrier.

Continued from page 1

failure. Even where a particular transmission channel within the network fails, network service will not be interrupted, since each Central Office will be doubly or triply connected to other Central Offices.

Two co-located Network Control Center computers will receive automatic feedback from each Central Office regarding line utilization and any malfunctions, to assure prompt corrective servicing. This data will be provided at one minute intervals, or at the occurrence of a malfunction, as in the ARPA Network. The Network Control Center (NCC) will be located at the Washington, D.C. Central Office. Aside from their performance monitoring function, billing data and centralized customer support services will both be provided by the NCC computers.

Telenet President Roberts Considered "Architect of Packet-Switching Technology"

Dr. Lawrence G. Roberts

Dr. Lawrence G. Roberts, President of Telenet Communications Corporation, has earned international recognition as a leader in computer and communications technology. Before joining Telenet in 1973, as President and Chief Executive Officer, Dr. Roberts held the post of Director for Information Processing Techniques with the Advanced Research Projects Agency of the Department of Defense.

During this time, Dr. Roberts was primarily concerned with the research, development and evaluation of new techniques for the processing of information in many areas. These included computer system design and architecture, graphics, artificial intelligence, signal processing, weather modeling, and man-machine interaction.

Additionally, the world-famous ARPA computer network—the communications network that served as the Telenet model—was developed under his direction. The network represents a new concept in interconnecting autonomous computer systems for the purposes of sharing hardware, software, and data resources among all members of the ARPA research community through the application of packet-switching technology.

Awarded Civilian Service Medal by Secretary of Defense

Dr. Roberts' outstanding achievements while acting as Director of this research and development organization with an annual budget of more than $40 million, earned him the Secretary of Defense Meritorious Civilian Service Medal. Awarded by Secretary Schlesinger on September 19, 1973, the citation commended Dr. Roberts for his . . .

> . . . industry and ceaseless drive (that) have been in large measure responsible for maintaining this Nation's commanding position in computer science.

Secretary Schlesinger also emphasized Dr. Roberts'

> . . . penetrating insight (that) has been responsible for the design, development, and implementation of the ARPA Computer Network, a revolutionary concept which has set new standards of reliability, speed and economy in the communications field . . . It appears certain that major national and worldwide communications systems of the future will be based on the technological foundation laid by Dr. Roberts.

In conclusion, the citation stated, "Rarely have the insights of a single individual had a greater impact on the progress of a profession so vital to the destiny of this country."

Prior to his Defense Department experience, Dr. Roberts headed the resource-sharing research at MIT's Lincoln Laboratory which resulted in initial packet-switching developmental efforts. Author of many articles in professional journals on a variety of computer and communications topics, Dr. Roberts has lectured throughout the continental United States and abroad. He holds Bachelor of Science, Masters of Science, and Doctoral degrees in Electrical Engineering from the Massachusetts Institute of Technology.

The Telenet Report

Telenet Communications Corporation, 1666 K Street, N.W., Washington, D.C. 20006, (202) 785-8444 Volume 2, Number 1, February, 1975

Field Installation of Telenet's "Intelligent Network" Moves Into High Gear

Field installation and testing of the nation's first public packet-switched data communications network began with Telenet's Washington Central Office in January, 1975. The establishment of similar packet-switching exchanges in New York and Boston—scheduled for March—will allow final testing of additional system elements, including the new high-speed Dataphone Digital Service (DDS) transmission facilities leased by Telenet from AT&T. Live subscriber data traffic will be used as part of the test procedures.

The backbone of the nationwide network will be completed with the addition of Telenet Central Offices in Chicago, Dallas, San Francisco and Los Angeles during April and May—permitting Telenet to offer tariffed data communications service on a nationwide basis beginning in June.

Continued expansion of the Network from the initial seven cities is scheduled to proceed rapidly through the latter half of 1975, with facilities to be installed in all the 18 FCC-approved cities by early 1976. Further expansion to 24 cities is planned for the first half of 1976 and, by late 1977, Telenet anticipates providing local access to the "Intelligent Network" in over 60 cities across the country.

Central Office Equipment Supplied by Prime

The equipment in a typical Telenet Central Office consists of Interface Message Processors, which store and route packets, and Terminal Interface Processors, which interface subscriber computers and terminals to the network. (See photo on page 5.) These IMPs and TIPs are fabricated from computer equipment supplied by Prime Computer Inc. under an agreement which provides for the delivery of up to 125 computers during 1975.

In addition, each Central Office incorporates Telenet-designed line switching equipment which immediately transfers subscriber and network lines to standby IMPs and TIPs in the event of equipment failure. Line switching equipment is manufactured by Cooke Engineering Co.

AT&T DDS Transmission Links to be Used

To interconnect the initial seven Central Office sites, Telenet has ordered approximately 15,000 voice-equivalent miles of transmission facilities from AT&T and other transmission carriers. These links will operate at speeds ranging from 9600 to 56,000 bits per second. Where AT&T's all-digital Dataphone Digital Service (DDS) is available, Telenet is using these high-quality facilities for both interoffice connections and subscriber access links.

The FCC has approved Telenet's use of 1.544 megabit per second multi-access satellite channels to complement its terrestial lines, and Telenet plans to begin utilizing these high-capacity, low-cost channels as soon as traffic volume within the Network builds up to necessary thresholds. Telenet will lease these facilities from authorized domestic satellite carriers and will install Satellite IMP (SIMP) equipment at those carriers' earth stations.

Telenet Receives Enthusiastic Subscriber Reaction

Subscriber reaction to Telenet's new service offering has been greater than anticipated. Initial subscribers who are currently working closely with Telenet on the procedures for connecting their computers and terminals to the Network, have been assured of service dates between June and September. Commercial service begins in June.

Telenet Receives $2 Million Additional Equity Financing

In January, Telenet received $2.1 million in additional equity financing under a recently arranged financing program involving several institutional investors. The program provides Telenet with the capital necessary to finance the implementation and operation of its nationwide data communications network.

The investors participating in the private financing include Time, Inc., the diversified publishing company; Bessemer Securities Corporation and The Palmer Organization, leading venture capital firms; and Telenet's parent company, Bolt Beranek and Newman Inc. (BBN). The financing was arranged by Lehman Brothers, Inc., Telenet's investment banker, which together with BBN has made previous investments in the company.

Telenet was founded by BBN, a principal developer of packet-switching technology, in December 1972. BBN remains Telenet's largest stockholder with equity in excess of 40 percent, and will continue to provide Telenet with technical support, based upon its experience in the development and operation of the research-oriented ARPA network.

Computer Service Firms To Benefit From The Intelligent Network

Firms marketing computer-based services—including conversational time-sharing; special-purpose, application-oriented remote computing; data base inquiry services and remote batch processing—will find that Telenet's Intelligent Network represents a most attractive vehicle for providing users across the country with economical access to these services.

Today, the computer service firm may employ a variety of expensive communications channels to serve remote users, including ordinary dial telephone lines, foreign exchange lines, or WATS lines. If the firm's customers cluster in metropolitan areas, these communications expenses can be reduced through the use of multiplexers and concentrators. However, the firm then incurs capital costs for equipment and program development, to say nothing of the recurring line changes and network operating and maintenance costs.

With the introduction of Telenet's Intelligent Network, computer service firms have a new option for serving their remote users. Such a firm, by connecting its Host computers to the Network, can enable its present and potential customers to dial in to local Telenet Central Offices around the country and obtain access to the firm's remote computer services.

If the computer service firm does not presently operate a communications network, the use of the Intelligent Network permits it to immediately market its services nationally, rather than only locally—possibly even test marketing its services in several cities. No major capital investments are required. The firm will, in fact, not incur any significant communication costs until its service is actually used and generating revenues in the remote cities, since Telenet charges are based primarily upon traffic volume.

If the computer service firm presently operates an extensive communication network, a connection to Telenet may be implemented in parallel, providing access to additional cities, as well as providing backup for both peak traffic loads and outages in the computer service firm's own network. In most cases, the economic attractiveness of the Intelligent Network will cause the computer service firm to gradually phase out its existing network.

Cost Savings Emphasized

Perhaps the most significant advantage offered by Telenet to computer service firms (with or without established networks) is cost savings. Communications costs, which may range anywhere from 5 to 20 percent of a computer service firm's total revenues, represent a substantial recurring cost, for which any reduction contributes directly to profitability.

Telenet will reduce the firm's communication costs in several ways. First, Telenet's charges per terminal-hour of usage will, in general, be lower than those currently experienced by firms operating their own multiplexer/concentrator networks. For example, private multiplexer/concentrator networks typically have costs in the range of \$3 to \$7 per terminal hour for asynchronous dial-in terminals. In contrast, Telenet's charges for comparable service will be approximately \$2.

Other savings to the computer service firm, not reflected in a simple comparison of hourly communications costs, are the savings which flow from reduced network operating costs, elimination of lost revenues due to network outages, and elimination of various items of equipment. The network operation and maintenance services performed by Telenet's Network Control Center may enable the user to reduce the number of personnel which he would otherwise require to perform these functions.

The computer service firm may also obtain substantial cost savings in the communications hardware associated with its Host computer. Typically, such Host computers have hundreds of low-speed "ports" at present, each of which is a hardware interface to a communications channel. The alternative approach, offered by Telenet, involves the consolidation of the traffic from many remote points over a single (or dual) high-speed link between the Intelligent Network and the Host computer. While this approach requires "demultiplexing" software in the service firm's computer (or front end processor), the number of ports is vastly reduced, as is the amount of processing and memory required for handling terminal traffic.

Processing and memory are reduced because the service firm's computer is now handling "blocks" of data—e.g., a line of characters—rather than individual characters. Also, Telenet relieves the Host of such functions as code conversion, echoing, and simple editing.

Great Flexibility

While the cost savings offered by Telenet are substantial, many computer service firms will find the flexibility provided by Telenet to be equally attractive. For example, a computer service firm utilizing the Telenet service can install new Host computers *anywhere* in the United States; it is not constrained to install new systems in a centralized data center. All of the firm's customers will be able to access any of its Host computers, despite the fact that the Hosts may be located in different cities or within the same data center. The Network per-

continued on page 3

AT&T Tarriff Revisions Help Value-Added Carriers

AT&T has filed provisions in both its analog and digital private line tariffs which enable Telenet, as well as other Value-Added Carriers certificated by the FCC, to lease AT&T lines and to use these lines to "perform data switching for others." These tariff changes, which AT&T tried to file in mid-1974, were delayed because of ambiguities in the tariff language, but finally went into effect in October 1974.

According to the new tariff provisions, Value-Added Carriers, called "Composite Data Service Vendors" by AT&T, may utilize both conventional and AT&T's new digital private line circuits, as well as WATS lines, in their common carrier networks. Value-Added Carriers such as Telenet may also utilize the transmission facilities of other carriers; however, most of Telenet's transmission links will initially be supplied by AT&T.

Although these tariff changes were anticipated by our staff for some time (they were OKed by the FCC over a year ago), we are pleased that they have now been officially filed with the Commission.

Telenet's Director of Sales explains the advantages of packet-switched data communications service to an attendee at the 1974 Tele-Communications Association Conference in San Diego, California.

Packet Switching: A Worldwide Answer

Though commercial packet switching is new, it is by no means unique to the United States. Public packet-switching networks are currently being established in many countries around the world—including Canada, England, France, and Japan—as well as in the United States.

In October 1974, the Trans-Canada Telephone System (TCTS), which includes Bell Canada, announced its operating schedule for the first Canadian public packet-switched network, called the Datapac network. It will begin operating in mid-1976, with four network nodes—in Calgary, Toronto, Ottawa, and Montreal. During the next four years TCTS plans to expand the Datapac network to at least 14 cities. The announced charges for Datapac service are structured in the same way as Telenet charges—they are based primarily upon the volume of data transmitted.

In the United Kingdom, the British Post Office Corporation (which provides public telephone, telegraph and data communication services) is well along in the implementation of its Experimental Public Packet Switching service (EPSS). The EPSS service will be offered initially in fall 1975, with packet-switching exchanges in London, Manchester, and Glasgow. For a period of two years the BPOC will limit the number of subscribers, and during the first year, will charge only for access links. At the present time all network access links are committed to approximately 30 organizations including British Olivetti Ltd., ICL, Barclays Bank, National Computing Centre Ltd., Data Dynamics Ltd., Civil Service Department, Scicon Computer Bureau, and the University of Oxford. At the end of the two-year experimental period, the initial three exchanges will be expanded, and additional exchanges will be installed as required.

In France, the Ministere des Postes et Telecommunications (PTT) is also establishing a public packet-switching network, initially with packet-switching exchanges in Paris, Rennes, and Lyon, and with multiplexers in Bordeaux, Marseille, and Lille. Initial provision of public service is expected in 1976.

In Japan, work is underway developing a data switching system which will provide both circuit and packet-switching services. Equipment for field trials has been built and programmed at the laboratories of Nippon Telephone and Telegraph Company, in conjunction with four Japanese manufacturers. This public switched data network is scheduled to be operational by 1977.

At the present time, Telenet is participating in discussions with these other carriers, aimed at developing standards as well as technical and operating procedures for interconnection of public packet switching networks. These discussions are continuing under the auspices of the CCITT, the international coordinating and standards-making organization for telephone, telegraph, and data communications.

continued from page 2

mits the terminal user to select the particular Host processor to use at a particular instant of time, taking into account machine availability, loading, and file availability.

Second, the computer service firm can also use the Telenet service to transfer jobs and/or large files at high speed from one Host computer to another. The Host computers may both be owned and operated by the computer service firm; or, alternatively, one of the Host computers may be owned and operated by a customer of the firm. Thus, a customer could establish, when required, very high-speed access links to the firm's Host computers, for the purpose of submitting jobs or batch data for processing and/or file update. The ability to establish such computer-to-computer links, on an as-needed basis, would enhance the range of services which the service firm could offer to its customers.

Similarly, customers of the computer service firm could submit jobs from standard remote batch terminals, as well as from Host computers or keyboard terminals.

Finally, the computer service firm will be able to offer an improved communication service to its customers by utilizing the Intelligent Network. First, it will be able to support a wide range of terminal types, and the terminal user will have many communications-related features available to him, provided by Telenet, in addition to the features provided by the computer service firm itself. These features are offered in the form of simple optional "commands" available to the terminal user.

The terminal user will see not only an increase in functional capabilities when accessing a remote Host through the Telenet system, but also a substantial improvement in overall communications service reliability and data transmission accuracy. Redundant subscriber access and switching equipment at each Telenet node, the availability of multiple paths between all destinations, the use of dynamic routing of traffic along the optimum path, the powerful network monitoring and diagnostic techniques employed combined with 24-hour maintenance, and the powerful error detection and correction codes used in the network, *all* insure that the communication service which the terminal user experiences when communicating through the Intelligent Network is *markedly superior to that experienced when using a private multiplexer/concentrator network.*

The Network Control Center . . . Serves Users

Telenet's Network Control Center (NCC) will substantially improve network performance and reliability. And, while doing this, it will serve to reduce our subscribers' need for network operations and maintenance personnel, network monitoring consoles, and line testing equipment.

The NCC performs two basic functions, both directly benefiting Telenet subscribers. First, the NCC is the command and control center where failures of any type in the Network are detected and diagnosed and where remedial action is initiated. Manned around the clock, seven days a week, constant surveillance at the NCC insures a higher level of service availability than is practical in most private data networks.

Second, the NCC is the data collection center for all Network traffic records and statistical information. It will provide accurate measurements of Network performance, will give an early indication of requirements for additional Network capacity, and will enable Telenet to prepare a wide variety of traffic analysis reports for individual subscribers, depending upon their particular desires.

Continuous Monitoring

Each IMP and TIP in the Network is programmed to examine itself, its associated lines, and the IMPs and TIPs to which it is connected, every few seconds—and to report the results of these examinations to the NCC. Specialized computers in the NCC collect these reports, determine the global state of the Network and, in case of line or equipment failure, immediately initiate repair activities. These specialized computers also alert NCC operations staff via computer printouts and audio-visual alarms as appropriate.

Remote Diagnostics

The NCC, in exercising its monitoring function for the Network, is permitted to initiate certain privileged programs in any of the IMPs and TIPs. To guarantee Network integrity, these programs, mainly diagnostic in nature, *cannot* be initiated by the operations staff at the Central Offices, but only by NCC personnel. Some of the functions which the NCC is able to initiate remotely include:

- a snapshot program to record the status of designated IMPs and TIPs;
- a trace program which can record the end-to-end path taken by a particular message or packet;
- loopback tests for checking out modems and communication lines;
- programs for initiating the dissemination of a new program release through the Network.

These diagnostic programs provide the NCC personnel with powerful and effective techniques for insuring uninterrupted service to Telenet subscribers. These techniques, too costly to implement in most private data communication networks, greatly lighten the burden of the Telenet subscriber in coping with the operational problems associated with an extensive data communications system.

Automatic Traffic Reports

Traffic data collected by the NCC forms the basis for off-line traffic analysis reports prepared for individual subscribers, as well as for Network planning purposes.

For example, at the termination of a subscriber's virtual connection, say between a terminal and a remote Host, a message is sent to the NCC identifying the connection, its start and stop time, and the number of packets sent and received. From this information, Telenet is able to prepare traffic reports for subscribers indicating traffic volume as a function of time and location.

In addition, traffic data collected by the NCC will be used to determine when Central Office facilities should be expanded, when and where additional link capacity is required, which links are experiencing high error rates and require examination, and which IMPs and TIPs have been malfunctioning and may require adjustment.

We feel the Telenet NCC is an invaluable tool for network control and maintenance. We think you, too, will agree.

Personality Highlight:

Christopher B. Newport
Vice President, Engineering

The development of the Intelligent Network is a monumental responsibility. And Dr. Christopher B. Newport, our V.P. of Engineering, is uniquely qualified to assume this responsibility. Dr. Newport and his staff are in charge of a multitude of inter-related tasks at Telenet including overall systems engineering, Central Office design, specification of hardware interfaces and communication protocols, hardware selection (including computers, modems, multiplexers and terminals), and system testing.

Dr. Newport has 18 years of experience in the design, development, and implementation of computer-based communication systems of all kinds. He has worked on packet switching systems since 1968 when, while at Honeywell Information Systems, he was responsible for the design and special engineering of the Honeywell minicomputers which were used by Bolt Beranek and Newman, Inc. as IMPs and TIPs in the ARPA network.

During his six years at Honeywell, prior to joining BBN and then Telenet in early 1973, Dr. Newport served as Director, Communications and Time Sharing Systems, and later as Chief Engineer for Honeywell's Advanced Communications Product Line. With a staff of approximately 100, he was responsible for the design and development of several Honeywell time-sharing computer systems, as well as for the system specification and world-wide integration of communication facilities for Honeywell's new line of large-scale computers.

Prior to joining Honeywell, Dr. Newport was Systems Manager for the Automation Division of the Marconi Company, and worked on the design and implementation of a wide range of real-time communications systems, for air traffic control, radar, and message switching.

Dr. Newport holds Bachelor of Science and Doctoral degrees in electrical engineering from Birmingham University (England).

Flexibility and Cost Savings for the Corporate Data Center

Data processing management in today's corporation is seeking to serve the company's evolving requirements in the most responsive and cost-effective manner possible. Telenet's Intelligent Network will help improve the cost effectiveness of corporate data processing resources by making these facilities more accessible to users and by avoiding unnecessary duplication of computer and terminal equipment, as well as computer programs and data files.

In many respects, the limited range of communication facilities which have traditionally been available has limited the effective use of data processing resources. Partially due to the inflexibility of conventional communication facilities, corporations have often been forced to establish a separate in-house network for each different data communications application. This constraint becomes increasingly serious as a corporation devotes an increasing percentage of its expenditures to data processing, as a larger portion of the company's activities become automated, as a larger fraction of its information files are stored in machine-readable form, and as the amount of data exchange among organizations grows with the growing interdependency of our society.

Corporate data processing management will find that use of the Intelligent Network enables them to implement new teleprocessing applications quickly and easily. The manager who plans his own teleprocessing network (without using Telenet) must provide for the cost of network design, equipment selection, installation, and network operation and maintenance. Moreover, to allow for future traffic growth, the manager must install a network whose capacity exceeds the actual traffic load during the initial operating period. The network is typically designed for a specific application, and for specific terminal types, locations, and traffic types. The resulting design is necessarily inflexible. As the corporation's requirements change (as they often do before the network is even completed) it becomes difficult and costly to revise and reconfigure the teleprocessing network accordingly.

In contrast, Telenet provides a versatile, general-purpose data communications network which can be quickly and easily utilized to support teleprocessing applications; it affords the user great flexibility to evolve his teleprocessing system in accordance with his corporate requirements, in terms of traffic loads and terminal/Host locations and types.

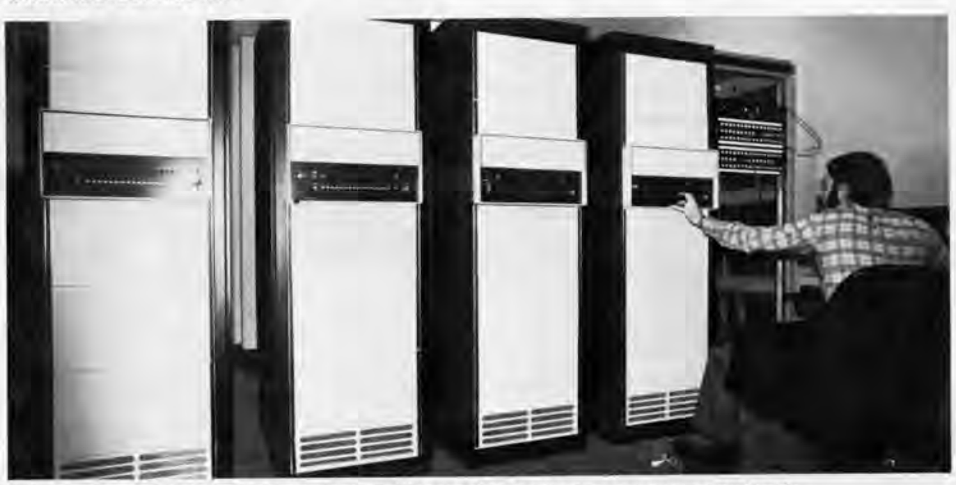
Whereas a terminal in a conventional teleprocessing network is typically dedicated to a particular application and linked to a specific remote Host computer, the Telenet service permits *any* terminal to establish a "virtual connection" with one remote computer, and to later establish a "virtual connection" to a different remote Host computer. The same terminal is then more easily utilized for multiple purposes and applications and can more easily obtain access to backup computing facilities when necessary. At the same time the terminal retains all the functional capabilities to be linked to a single remote computer and operated in the same fashion as in a conventional teleprocessing system.

In addition to improved terminal and Host utilization and capability, Telenet permits Host computers to establish virtual connections with other Host computers, and to transfer data over these links at rates up to 50 kilobits per second. (A Host computer can have many simultaneous virtual connections to various terminals and Hosts on the Network; a terminal can have only a single virtual connection at a given instant of time.) Host computers may establish high-speed virtual connections whenever required, and will be charged only for traffic sent, rather than for a dedicated long-haul line facility, or for the holding time associated with each switched connection.

The ability to transfer data at very high speeds, upon demand, to a selected Host computer presents teleprocessing system designers with many new options and possibilities. It becomes practical for data or jobs to be sent directly from one regional data center to any other, possibly for backup or load sharing purposes. It becomes very simple to transfer summary files from regional data centers to centralized data centers. Similarly, very high-speed data transfers from major data collection centers (such as a claims processing office of a property/casualty insurance company) to a central site become possible.

Once a corporation's Host computers are connected to the Intelligent Network, a broad range of terminal-to-Host and Host-to-Host data communication applications become practical and easy to implement. The user is largely isolated from the problems of network design and operation, and is able to focus upon his particular data processing requirements. While Telenet offers substantial savings in communication costs, perhaps the greater advantage in the long term will be the much larger cost savings which flow from greater flexibility and efficiency in the use of corporate data processing resources.

By utilizing the Telenet service, a corporation could, in effect, integrate several otherwise separate teleprocessing systems (terminals, lines and Hosts) into a single integrated teleprocessing network, affording both greater flexibility and improved overall utilization of corporate data processing resources.



A member of Telenet's technical staff tests the control programs running in two IMPs and two TIPs. Also shown is the automatic line switching equipment which is used to transfer subscriber access lines from a failed TIP to a standby unit.

Easy and Adaptable Terminal Access

Subscriber terminals can be physically linked to Telenet's network in a variety of ways, depending upon individual circumstances and needs. These include dial-up lines; multipoint, and point-to-point leased lines; or by using concentrating devices such as multiplexers, remote data concentrators, and terminal controllers. In some instances, Telenet-provided multiplexers or TIPs may be installed at the user site.

In addition to establishing this physical link to Telenet's nearest Central Office, the subscriber terminal will also establish a "virtual connection" through the Network to some destination computer. The virtual connection can be established in either of two ways, depending on whether the terminal has a dedicated or a dialed link to the Central Office.

When a terminal on a dedicated line converses with only one particular computer on the Network, that terminal's TIP port may be pre-initialized to the desired transmission parameters and Host computer address. When the terminal is switched on-line, a virtual connection to the preselected computer will automatically be established in less than one second; the computer may then respond by printing out its own name, or a "prompt" character, on the terminals' printer or display. Then the terminal-computer-terminal dialog can proceed just as if there were a direct physical circuit between the two station sites.

For a dial-up terminal, the process is similar, except that the terminal operator may first have to provide a short command identifying his terminal model and a second command specifying the Host computer with which it is to be connected.

In the majority of cases, the terminal operator will be concerned with, at most, the Telenet command that defines his terminal model and the commands required to establish and break the connections to Host computers. From time to time, however, some users may wish to communicate other instructions directly to the TIP. This is accomplished by issuing additional commands, most of which set a transmission parameter or mode. For example, the operator may instruct the Network to convert the data from his terminal into a standardized Network Virtual Terminal code.

Additionally, the Network offers a number of other useful communication options. For example, local editing is available for unbuffered typewriter-oriented terminals and displays. Data entered on these terminals is accumulated in a TIP buffer, on a character, line or message basis. Before this data is sent to the remote Host, the terminal operator may correct simple keyboard input errors. Again, this editing facility can be preset—or the user can issue short commands that define "edit" characters which, when typed, will delete the last preceding character from the data just entered or all the data in the current TIP buffer.

These and other functions are strictly optional; their ultimate utility depends on the nature of the user's particular application. In short, some terminal users will want to become familiar with a limited repertory of commands and facilities. For most others, the Network interface can be pre-initialized and the terminal operator need not utilize any Network commands, nor even be aware of the Network, during routine usage. In either case, the Network can be adapted to the user's needs. (A summary of the most frequently used command types is given below.)

Optional Network Communication Aids

Command Groups	*Function*
Terminal Identification	Identifies the specific make and model of terminal which the operator is using. For asychronous terminals, the Network automatically determines the transmission speed and code, and, unless otherwise instructed, assumes default options for terminal type.
Virtual Connections	Establishes a virtual connection with a designated terminal or Host. Provides indication to terminal operator if Host is not functioning, or not currently accepting traffic.
Buffering	The TIP stores characters entered by a terminal until a "transmission character" is encountered. At that point, all accumulated characters are transmitted to the Host to which a virtual connection is open. These commands allow a user to define which characters are to be considered "transmission characters." For example the user can specify as transmission characters (1) all alphanumerics (each character is sent as a separate packet); (2) carriage return characters (each line is sent as a packet); or (3) various control characters such as editing (DELete and CANcel), terminanting (End Of Message or End Of Text), forms control (TABbing, line feed), etc. The user may also specify the maximum *number* of characters that the Network should buffer before transmitting to the remote Host.
Editing	Permits the terminal operator to specify special characters to be used for editing purposes, such as deletion of incorrectly entered characters or lines of characters. A terminal operator using an unbuffered terminal will also be able to display at his terminal the entire buffer of data accumulated by the TIP.
Terminal Characteristics	Permits the terminal operator to change the use of padding characters or line feed characters, or the speed at which the Network sends to and receives from an asynchronous terminal. User may also request one of various local Network echoing conventions. For unbuffered terminals, the use of local echoing provides excellent error control over the local access line.
Code Conversion	Permits the terminal operator to transmit data as if the Network were transparent, or to have the Network convert the terminal data into a standardized Network Virtual Terminal (NVT) code.

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