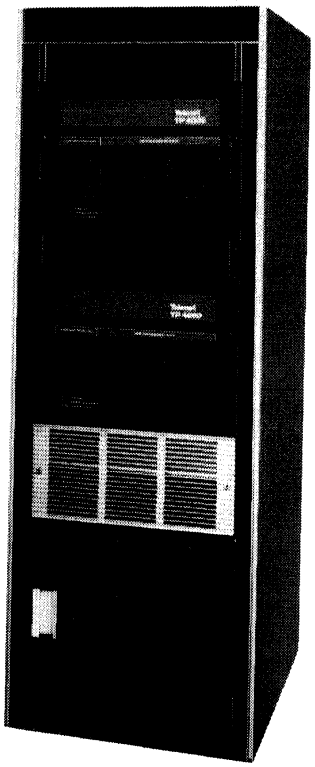
Telenet TP 4000 X.25 Interface Processor



A specialized communications processor for use either with the Telenet X.25 packet-switched network service (see Report C31-829-101), or in private X.25 networks. The TP 4000, in conjunction with the Telenet service, provides a cost-effective alternative for the user whose geographically dispersed network presently incurs high communications costs through the use of conventional transmission facilities.

The TP 4000 supports the attachment of up to 240 communications lines, which may be virtually any mix of code, speed and protocol. Async and BSC terminals are fully supported. The TP 4000 can support up to 256K bytes of main memory, and performs functions, in addition to X.25 packetizing/depacketizing, of code and protocol conversion, statistical multiplexing, virtual call establishment and routing, error detection and recovery, and numerous diagnostic statistical services.

A typical configuration including a TP 4000 processor with 128K bytes of memory, and interfaces for 32 async and 8 synchronous lines, can be purchased for $64,000, or leased under a tariff arrangement for $2,600 per month, which includes maintenance.

MANAGEMENT SUMMARY

The Telenet Processor (TP) 4000 is the latest and most versatile member of Telenet's terminal/host interface processor family. It performs all the functions of a remote concentrator and stand-alone packet-switching processor, with the additional capability to interface and access the Telenet X.25 packet-switching network service. It does not replace a front-end processor, however.

The TP 4000, and the Telenet service, can generally be utilized regardless of which type of processor is at the host site. However, some facility, in or local to the host, must be capable of X.25 packetizing and depacketizing. This can be accomplished by installing another TP 4000 or one of the smaller TP's (1000 or 2200) at the host site, or through the addition of specialized X.25 software in the host or front end. Cambridge Telecommunications of Burlington, MA, for example, markets a software package called DMEP which, when loaded in the IBM 3704/3705, provides the IBM system with an X.25 interface capability. An increasing number of large minis and mainframes are being marketed with an available X.25 capability, in which case no additional equipment or software is required.

Use of the Telenet public network service or private X.25 network system can generally be said to provide enhanced ➢

CHARACTERISTICS

VENDOR: Telenet Communications Corporation, 8330 Old Courthouse Road, Vienna, Virginia 22180. Telephone (703) 827-9200.

DATE OF ANNOUNCEMENT: July 1978.

DATE OF FIRST DELIVERY: August 1978.

NUMBER INSTALLED TO DATE: 120.

SERVICED BY: Telenet Communications Corporation.

CONFIGURATION

The TP 4000 is modular in structure and contains the arbitrator, which is the principal control device, an optional CPU, main memory, a system bus, line processing units (LPU), and line interfaces.

The arbitrator controls the flow of all internal data and the system bus as well as managing the allocation of main memory for buffering. The arbitrator controls access to memory from the bus, and allocates bandwidth on the bus based on an algorithm which allots up to 50 percent for the CPU, and assigns the rest proportionately among the Line Processing Units. If the CPU does not utilize its authorized space, the unused portion is also reallocated to the line processors. The arbitrator therefore optimizes data movement within the processor and maximizes throughput. ➢

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TABLE 1. TP 4000 LINE INTERFACES

Type Interface	Line Type	Transaction Mode	Number Lines Supported
RS-232	Non-switched	Asynchronous	4
RS-232	Non-switched	Asynchronous	8
Current Loop	Non-switched	Asynchronous	8
RS-232	Switched	Asynchronous	8
Current Loop	Switched	Asynchronous	8
RS-232 BSC	Non-switched	Synchronous	4
V.35 BSC	Non-switched	Synchronous	1
RS-232/V.35 HDLC	Non-switched	Synchronous	8
RS-232 BSC	Switched	Synchronous	4
V.35 BSC	Switched	Synchronous	1
RS-232/V.35 HDLC	Switched	Synchronous	8

error detection and recovery, better rerouting and backup support, and more efficient line usage than conventional public switched or leased telephone facilities. Because the Telenet public network rates are based mainly on the amount of data traffic transmitted, without regard to distance traversed, certain geographically dispersed data communications users could realize significant facilities cost savings. For more information on the Telenet service, see Report C31-829-101 in Volume 3.

The TP processor performs the interface between the Telenet network (public or private) and the user's hosts and terminals. The TP 4000 establishes a virtual call (logical connection path) to a specified destination terminal or host connected to the network, so that the calling terminal or host appears to be virtually connected to the called terminal or host as if on a dedicated line. Options available on the TP 4000 include asynchronous terminal, IBM 2780/3780 and HASP Multileaving protocol support. According to Telenet, 3270 protocol support will be available by year end 1979.

The TP 4000 does not, however, support mass stoage or other peripheral devices. Additional main memory for buffering is therefore required as the number and speed of its attached lines and terminals is increased. The TP 4000, according to Telenet, is capable of outputting up to 600 packets (of 128 characters each) per second. To exceed this limitation would require that another processor be installed.

Asynchronous terminals are supported by the TP 4000 at up to 9600 bps; synchronous terminals at up to 56K bps. The processor is installed and maintained by Telenet at a user's remote site, and generally requires no change to the user's existing hardware or software.

As of this publication date, General Telephone and Electronics (GT&E) is awaiting final FCC approval to acquire Telenet as a wholly-owned subsidiary.

USER REACTION

From a list of customers supplied by the vendor, *DATAPRO* contacted four current users of the TP 4000.

In addition to bus control, the arbitrator compiles statistics on detected memory errors and forwards these statistics to a failed address register, for later access by the CPU. This capability permits permanently failed memory to be bypassed, and identified automatically as requiring maintenance.

The arbitrator also handles the queuing of tasks for the CPU which are received from the line processors. These tasks are processed as interrupts by the CPU, and are queued chronologically as they are received. The arbitrator contains a stack mechanism that insures that queued tasks are properly handled and that none are lost.

A 4K-byte PROM is included in the arbitrator which is used for initial program loading and strapping. The PROM contains a 16-byte data set which uniquely identifies the TP 4000.

The CPU is composed of a high-speed microprocessor capable of executing about 2 million cycles per second. The instruction set provides for indexing, indirect, relative and immediate addressing. The CPU has a 64K-byte addressing space, 16K bytes of which is dedicated as local memory. The local memory, with a .45 microsecond cycle time, permits substantial processing to be performed by the CPU alone, with the main memory being used for data buffering and infrequently accessed error recovery routines. CPU circuitry permits automatic memory access retry when parity errors are detected. A TP 4000 performing solely as a remote concentrator will generally not require a CPU, as those functions are performed by the arbitrator and LPU's.

Main memory is available in 32K-byte increments, and can be modularly added to a system maximum of 256K bytes. Main memory is mapped into 2K-byte pages, and is accessible as such by the CPU and Line Processing Units. Memory cycle time is likewise .45 microseconds, and features full parity checking of both data and addresses.

Main memory in the TP 4000 is used primarily for data transfers and buffering. Memory buffer space is allocated by the arbitrator, a process which is key within the TP 4000 operation because there is no mass storage capability. As the network configuration increases, so must the memory buffer space. An LPU, which contains 8K bytes of memory, will generally be added for each eight lines that are attached to the processor. Use of memory for buffer space is a constantly changing and fluid situation. It is estimated, for example, that when the processor is operating at 95 percent of capacity, 19 times the memory buffer space is required than when operating at 50 percent capacity.

The Line Processing Units (LPU) are directly connected to the system bus, and support attachment of the line interfaces.

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One user had only recently implemented the processor and had insufficient experience on which to comment. The three remaining users represented a total of seven TP 4000 processors, and all were connected to the Telenet packet network. The remote hosts being accessed included IBM, Amdahl and Honeywell.

All the users stated that the TP 4000's were acquired because of their companies' commitment to switch to the Telenet service. The reasons cited for the switch were mainly to save on communications facilities cost, and for better transmission reliability through error recovery and alternate routing. All the companies interviewed were large interstate, or international, data communications users.

All three users indicated that their TP 4000's were not yet operating at the capacity intended. All of the processors had been recently installed, and had been in operation between three and six months. One user declined to rate throughput and hardware reliability because of the minimal load that was presently being handled. He, and the other users, stated that their experience with both the TP 4000 and the Telenet service was limited, but that within a year, when their complete systems were fully implemented, more detailed comments about the product and vendor could be made. Comments were therefore solicited based on their experience to date.

The users' ratings were as follows:

	Excellent	Good	Fair	Poor	WA*
Overall satisfaction	3	0	0	0	4.0
Ease of installation	2	1	0	0	3.7
Throughput	1	1	0	0	3.5
Hardware reliability	2	0	0	0	4.0
Promptness of maintenance	1	1	1	0	3.0
Quality of maintenance	1	2	0	0	3.3
Software	1	2	0	0	3.3
Technical support	1	2	0	0	3.3

*Weighted Average on a scale of 4.0 for Excellent.

All the users favorably commented on the speed with which Telenet installed the processors and made them operational; usually within two or three days.

Two of the three stated that there were small problems during the system installation with protocol compatibility between the Telenet software and their configurations. One user noted that Telenet expeditiously corrected the problem, while the other stated that he had to write a small software change.□

Four types of LPU are available; each will support either four or eight asynchronous or synchronous lines. The TP 4000 system permits up to 36 LPU's of any type to be installed in any order, and the system may be expanded by plugging in new LPU's while the remaining units continue in operation.

Each LPU is, in fact, a small CPU. Each typically has 8K bytes of local memory (RAM), and its own microprocessor.

TABLE 2. LINE PROCESSING UNITS

Type	Ports	LPU Throughput	Interface Available
Asynchronous	4	10K bps	RS-232C
Asynchronous	8	10K bps	RS-232C/Current Loop
Synchronous-BSC	4	38.4Kbps*	RS-232C
Synchronous-BSC	1	56.0Kbps	V.35
Synchronous-HDLC	8	224Kbps	RS-232C/V.35

*If highest line speed is 9600 bps.

The CPU controls the LPU's, and can start, halt, reset or exchange interrupts with them. Extra LPU's can be configured for backup support. The CPU manages the switching of standby LPU's into operation as required. If a single port or an entire LPU fails, the CPU automatically switches the standby LPU into service.

Two sets of line interfaces are available. The first group supports switched lines; the second supports non-switched, or dedicated lines. Table 1 lists the line interfaces which are available. The line interfaces, although separate components, are included with the LPU when purchased. The user will specify facility type, speed, etc., and Telenet will provide an appropriately configured LPU and interface.

The TP 4000 can be implemented in two other configurations; multiple TP's can make up a private X.25 network, exclusive of the Telenet service, or two TP 4000's can be connected back-to-back in a single system.

Large network users can implement multiple TP processors into a private X.25 network, where each acts as a separate communications node, and all are interconnected via high-speed X.25 links. However, a private network composed of TP processors would require at least one access line to the Telenet public network in order to access the Network Control Center (NCC), which may be either a node in the Telenet network, or also privately-owned. The NCC is responsible for the IPL and software control of the processors, insomuch as the TP processors are not user programmable. An NCC purchased from Telenet consists of a Prime minicomputer loaded with the Telenet network control software, along with peripheral storage devices for collecting and storing usage and status data from the network.

The other configuration is a redundant TP 4000 system wherein all common logic and memory is duplicated. Such a system can provide complete redundancy of processor components. A dual system contains two memory banks, with a total common memory capacity of 512K bytes. The common memory is accessible to all processor components.

TRANSMISSION SPECIFICATIONS

Line Processing Units, with appropriate interfaces, provide the TP 4000's interface to communications lines. Asynchronous lines are supported, both switched and non-switched, using either RS-232C or Current Loop interfaces. Asynchronous speeds are supported from 75 to 9600 bps, with one or two stop bits. Character codes of six, seven or eight bits with odd, even or no parity are supported, including ASCII, EBCD and correspondence.

Synchronous interfaces supported, over switched or non-switched lines, include RS-232C or V.35. Synchronous terminals are supported at up to 56K bps, using BSC or HDLC (X.25) protocols. An RPQ is available, according to Telenet, for TP 4000 support of IBM SDLC terminals. The TP 4000 will support IBM 2780/3780 or 3270 emulation, as well as HASP Multileaving protocol. Terminals, both

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asynchronous and synchronous, may be directly cable-connected to the TP 4000.

To connect to the X.25 packet-switching network, the TP 4000 requires one or more non-switched synchronous access lines, depending on the traffic load and redundancy requirements. Communication with the network is full-duplex synchronous, at speeds from 2400 to 56K bps. The access link from the TP 4000 to the network is statistically multiplexed and already in X.25 form. The network access link is generally a leased line to the nearest Telenet Switching (class 1) Office.

The access link, or links, utilize the X.25 protocol and offers error detection and retransmission capabilities. When two or more access lines are used, the traffic is automatically distributed among the lines to balance peak loads and minimize queuing delays.

Data received from the network by the TP 4000 is demultiplexed, and a protocol translation from X.25 to the specific terminal protocol is performed.

NETWORK INTERFACE

The TP 4000 is heavily dependent on the Network Control Center (NCC), which could be either a Telenet NCC, or a user-owned NCC. All program loading and modification, network parameterization, and diagnostics control is performed by the NCC.

Before system generation of the TP 4000, the network must be completely defined to the NCC. The NCC contains a System Builder software program which creates the operating system for the TP 4000. The builder consolidates software for the CPU, software for the LPU's, a local memory software loader, and a table processing program into one loadable operating system for the TP 4000. During IPL, the NCC downline loads the operating system into the TP 4000, followed by the parameter tables which define the TP configuration.

According to Telenet, the entire loading procedure takes from one to four minutes, depending on the speed of the access line. When loading is completed, control is finally turned over to the TP 4000.

In addition to the System Builder, there are two other control programs resident in the NCC which permit extensive control over the TP 4000. These are the Telenet Debugging Tool (TDT), and the Status Monitor.

The TDT permits the NCC operator to invoke functions in the TP which include: inspection of any memory location in any TP in the network, checking of any hardware or software component for problems, and retrieval of statistical information on network operation. Other commands which may be called under this program permit the NCC operator to reset, halt or reload any LPU, initiate switchover to backup components, or reload the entire TP 4000 system.

The Status Monitor works with diagnostic software resident in the TP, and controls transmission to the NCC of status information on any of the TP's lines or processors, or the status of any attached devices. The NCC assembles and analyzes this diagnostic information under the Status Monitor. This permits the NCC operator to remotely test and isolate faults in the TP. Should (an LPU) be determined to be faulty, for example, the NCC could take it out of operation without affecting the operation of the other lines. A single LPU replacement can be performed while the TP 4000 is powered up, and all other components are functioning normally.

HOST INTERFACE

The TP 4000 can interface host processors to the Telenet network as well as terminals, although the network will normally separate a user's terminals from the host. Communications between the TP 4000 and host is over a synchronous, full-duplex line at 56K bps. The TP 4000 is not channel-attachable to the host, nor can it replace a front end or other such host communications equipment.

The TP 4000 may be co-located with the host in order to interface the host to Telenet network. Installation of a TP 4000, or smaller TP device, as such would only be required if the host does not possess an X.25 interface capability. As previously mentioned, an increasing number of mainframe and mini manufacturers are now offering such a capability, either as an optional software package, or as an integrated firmware component. Communications between the TP 4000 and the host is by means of either one or more synchronous links operating at up to 56K bps and utilizing the X.25 full-duplex protocol, or multiple asynchronous and/or synchronous Terminal emulation links. With terminal emulation links, the TP 4000 and the Telenet network look to the host as a set of terminals.

The TP 4000, operating as a remote terminal interface, does not presently perform polling of its attached terminals. This function, if required, is performed by the host, and is completely transparent to the TP 4000 and the Telenet service. The TP 4000 merely passes polling sequences received from the host to multipointed terminals and/or cluster controllers that are attached to it.

SOFTWARE

The TP 4000 is loaded with Telenet proprietary software—the Telenet Processor Operating System (TPOS). The user cannot directly access the processor software, and any modifications to the software must be made through downline loading from the Network Control Center (NCC). The NCC, as previously mentioned, may be a Telenet facility, or a privately-owned station (if the entire network is owned by the user). The Network Control Processor (NCP) used within the NCC is a Prime minicomputer operating under the standard PRIMOS IV Operating System, loaded with Telenet network management applications software. If the NCC is a Telenet facility, the user may lease a Customer Network Control Console (CNCC), which is a key-entry display station connected via a virtual call to the NCC which services him. He may, with the CNCC, gain access to, and effect, various levels of network management functions.

The functions performed by the NCC are normally redundant within the Telenet network. If the primary NCP fails, another NCP, which contains a duplicate record of the TP 4000's system code and configuration tables, can assume control. If the TP 4000 fails, the appropriate NCP will likewise reload the TP from a stored copy of its operating system.

The primary function of the TP-resident software, TPOS, is the conversion of terminal native-mode protocols into X.25, and vice versa. Conversion and access to X.25 entails three levels of communications handling. Level 1 is simply the physical interface to the X.25 network. Level 2, the Link Access Procedure, governs the formatting of data into link level, or HDLC frames, including the addition of an error checking sequence which insures data correctness between X.25 nodes. Level 3, the Packet Level Logical Interface, forms the HDLC frames into packets, with the necessary control information to insure correct routing within the X.25 network, and establishes and terminates virtual calls.

Within the TP 4000, TPOS software is distributed among the CPU and LPU's. The LPU's generally handle protocol conversion for incoming and outgoing messages to and from

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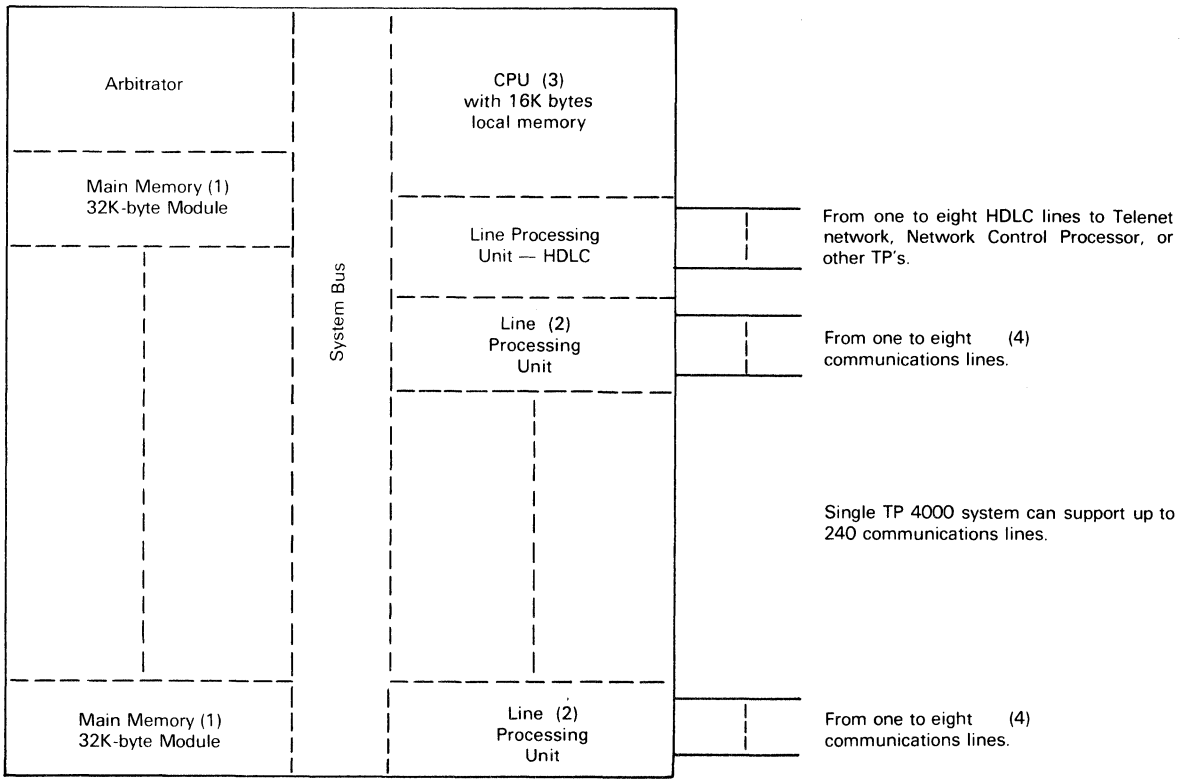
Single System Configuration



(1) Number of 32K memory modules will depend on number of lines, protocol, network topology and response time requirements. Up to eight modules for system maximum of 256K bytes main memory.

(2) Total system LPU count cannot exceed 36. Not shown are line interfaces, which are separate components, but packaged by Telenet with the LPU. See Table 1 for list of available interfaces.

(3) CPU will generally not be required when TP 4000 is implemented solely as a remote concentrator.

(4) Number of lines will depend on type of LPU line speeds and protocol. See Table 2 for types of, and maximum throughput capacities of available LPU's. Asynchronous lines can interface terminals or hosts. BSC line control may be operating in 2780/3780 emulation or HASP protocol. 3270 protocol support is under development.

their attached terminals. A single LPU handles Levels 1 and 2 of X.25 packetizing. Additional LPU's may be added to perform specialized functions when additional processing power is required. In a user-owned network, a single LPU may be dedicated to handling the switching of packets between TP's. Other LPU's might be added, for example, to handle the TP's terminals which are locally attached. The specialized LPU's would, in these cases, contain the TPOS modules which perform these functions. The LPU's are, in this sense, slave or supplemental processors to the CPU.

The balance of the TPOS software is concerned with interprocessor communications, buffer management, redundancy control (if applicable), and status reporting.

Commands issued from the CPU organize the information exchange between the LPU's and CPU. These commands are sent to an area of main memory which is dedicated to the target LPU, and this area is constantly scanned by the LPU. The CPU command is headed with a flag, which tells the LPU that some action is needed. The LPU accepts and processes the command as an interrupt. Since no polling of LPU's is done by the CPU, processor overhead is kept to a minimum.

Commands are similarly exchanged between the terminal-handling LPU's and the X.25 access LPU over the system bus. These commands are used to establish and clear virtual connections, call for data, interrupt or reset operations, or otherwise control protocol translations between X.25 and terminal native mode protocols.

TPOS also drives the CPU and arbitrator in the performance of two other key functions; buffer management and status reporting. The entire buffer area of main memory is divided into 144-byte blocks, each of which is further divided into quarters. The quarters are allocated as needed by the CPU to the LPU's, and unused quarters are collected and cleared so that they may be reused.

Software for data collection regarding usage and errors and status reporting is also resident in TPOS, and is responsible for continually providing the NCC with diagnostic information, for assembly and analysis by the NCC.

PRICING

Two different pricing lists are provided; one for purchased systems, and the other for tariffed systems. Because Telenet offers a tariffed carrier service, any TP 4000 processors used exclusively to access the Telenet service are furnished on a tariff basis. The user can purchase the TP 4000 only if implemented as a node in his own X.25 network.

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For tariffed TP systems, there are no additional charges for either software or hardware maintenance. The following TP tariff schedule does not include other charges which would be incurred from using the Telenet service, such as the traffic charge.

For purchased systems, Telenet charges one-half of one percent of the total system list price per month, as a hardware maintenance fee. Likewise, one-quarter of one percent of the total system list price per month is levied for software license and maintenance. Telenet has indicated that its present system of maintenance will probably soon be changed in favor of a maintenance price per system component. There is an additional charge of one-quarter of one percent per month of total system list price levied against customers who utilize Telenet's NCC facilities for this support.

TP 4000 Purchase Prices

	Purchase* Price
TP 4000; Basic System; includes arbitrator, 64K bytes main memory, chassis, cabinet, power supply, and software load for remote concentration	$19,400
Full System Redundancy; TP 4000	15,300
TP 4000X; Medium System; same as above with CPU added.	22,900
Full System Redundancy; TP 4000X	18,800
TP 4000P, Large System; same as above except with 96K bytes memory and full X.25 packet switching software and TPOS operating system**	35,200
Full System Redundancy; TP 4000P	23,100
32K-byte Memory Module	4,300
Line Processing Units; includes appropriate line interface	
4-Port Asynchronous; RS-232C interface	3,450
8-Port Asynchronous; RS-232C interface	5,200
8-Port Asynchronous; Current Loop interface	5,200
4-Port Synchronous; BSC; RS-232C interface	4,700
1-Port Synchronous; BSC; V.35 interface	4,700
8-Port Synchronous; HDLC; R-232C/V.35 interface	10,800
LPU Backup Switching Capability	350
NCC Support	***

TP 4000 Tariff Prices****

	Installation Charge	Monthly Charge
TP 4000 Basic Unit (Includes 64K bytes memory)	$300	$850
Memory Module	50	150
Processor Expansion Module	200	200
Switching Option	150	300
Common Logic Redundancy	250	700
4 Async Ports; 75-1200 bps	40	120
8 Async Ports; 75-1200 bps	60	200
4 Sync Ports; 2400-9600 bps	50	175
1 Sync Port; 56,000 bps	50	175

* Hardware maintenance is available at one-half of one percent per month of total system list price.

** Software license and maintenance are available at one-quarter of one percent per month of total system list price.

*** NCC support is available at one-quarter of one percent of total system list price per month.

****Does not reflect other Telenet charges such as access line or traffic charges. Includes both hardware and software maintenance.■