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INTERFACE MESSAGE PROCESSORS FOR THE ARPA COMPUTER NETWORK

QUARTERLY TECHNICAL REPORT NO. 3
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Submitted to:

IMP Program Manager
Range Measurements Lab.
Building 981
Patrick Air Force Base
Cocoa Beach, Florida 32925

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1. OVERVIEW

This Quarterly Technical Report, Number 3, describes aspects of our work on the ARPA Computer Network under Contract No. F08606-73-C-0027 during the third quarter of 1973. (Work performed from 1969 through 1972 under Contract No. DAHC-15-69-C-0179 has been reported in another series of Quarterly Technical Reports numbered 1-16.)

During the quarter we shipped three new machines and moved three others from one site to another as part of a plan to upgrade the capabilities at certain sites. The 316 IMP which was once located at Tinker AFB was upgraded to a TIP and installed during the quarter at the University of Utah. The 516 IMP which had previously been at Utah was moved to Aberdeen, and the 316 IMP from Aberdeen was returned to BBN to be upgraded to a TIP for eventual re-installation elsewhere. The TIP which was delivered to the University of London during the second quarter was connected to the network during this quarter via a 4.8 kilobits/second circuit to Norway. The three new machines shipped include a TIP to Tymshare Data Services (Cupertino, California), and IMPs to Lawrence Livermore Laboratories (California) and MIT's Information Processing Center. The Tymshare and Lawrence machines were installed in the network during the third quarter; the MIT machine will be installed during the fourth quarter when the communication circuits are delivered.

In addition to installation of three TIP's during the quarter, bringing the total number installed to 18, TIP work has included publication of a revision to BBN Report No. 2183, *TIP User's Guide*. Software development of TIP code has also occurred during the third quarter. Among the most important improvements are:

- The TIP now sends a "bell" code to the user's terminal each time an input character must be discarded due to lack of buffer space.
- Implementation of the new TELNET Protocol has begun. The TIP program can now discard output pending for a terminal upon command from a Host and can participate in option-negotiation in a rudimentary way.
- The TIP's procedures for handling dial-up modems has been improved. A complete "hang-up" procedure has been implemented (the TIP previously relied on hang-up procedure originating in the carrier's central office, but not all central offices originate this procedure). In addition, the "hunt" bit for a port can no longer be altered by a dial-in user.
- Output to terminals at rates of 480, 960, and 1,920 (10-bit) characters per second is now supported if clock signals for the circuit are supplied by the TIP. The TIP has always supported bit rates of 4.8, 9.6, and 19.2 Kbs, but prior to the third quarter the output software left gaps on the line between successive characters at bit rates above 3.3 Kbs.

A complete status report on the Terminal IMP is given in Section 2.

Our work on the High Speed Modular IMP during the third quarter has revolved primarily around debugging the IMP code on a single processor system, and around enlarging the size of the test machine. The four-bus test system described in our Quarterly Technical Report No. 2 was expanded to two processors per processor bus. The software successfully communicated with a 516 IMP while running on the single-bus hardware configuration, and by the end of the quarter debugging was beginning on a multi-bus system.

Work continued on the RJE mini-Host during the third quarter. On the hardware side progress was somewhat delayed by problems with some of the SUE components and by malfunctions of both Bell modems. However, by the end of the quarter fabrication and check-out of the synchronous line interface was nearly completed. Software development has progressed well, with almost four kilowords of code written. This code includes primarily the control structure and the IBM 2780 binary synchronous protocol modules. Check-out is expected to begin near the middle of the fourth quarter after the hardware components have been assembled and tested together.

In our Quarterly Technical Report No. 2 we discussed the beginning of a program to store Network Control Center traffic statistics on the BBN TENEX machine. The method of data transfer is being changed from once-a-day magnetic tape manual transfer to on-line transfer via the network. Soon, the previous hour's Host and line throughput as well as the previous quarter-hour's IMP and line status will be available to BBN TENEX users.

In addition to the documentation of the NCC data files, there is machine language code to access the data. The code is compatible with PDP-10 Fortran subroutine conventions. We have also written some simple higher-level language programs to examine the Host and line throughput data.

We have begun implementation of some rudimentary Host-Host protocol in the NCC machine. This will facilitate supporting the NCC machine itself, by allowing more debugging tools such as core verification by another Host. In addition, it will permit dumping of any NCC tables to any Host, thus bypassing the PDP-1.

During the third quarter we continued our involvement with the rest of the technical community. We published a final draft of the proposed new File Transfer Protocol and slightly revised the official new TELNET Protocol. We presented two lectures at the NATO Advanced Study Institute held at the University of Sussex in Brighton, England and also participated in the deliberations of the International Network Working Group which met informally during and after that Institute.

1.1 Changes to the Routing Algorithms

In our Quarterly Technical Report No. 2 we announced the conclusion of the first phase of our study of network routing algorithms and our intention to begin the implementation of the new algorithms which resulted from this study as a series of small, backward compatible changes. During the past quarter four such software changes were installed in the network and the fifth was coded for installation early in the fourth quarter. The paragraphs below describe the major features of each of these five phases.

Phase 1: The routing computation is performed on an incremental basis as routing messages are received. This results in more up-to-date routing and fewer tables. The routing program continues to use the best line to a destination for 2-3 seconds after it deteriorates. After propagating its new, worse value for this time, the program will accept other lines as the now best route if they are still better than the old route. This hold-down mechanism speeds the propagation of routing.

Phase 2: The IMP measures the bandwidth of the circuits to which it is connected by counting how long it takes to send routing messages. This value is kept as a smoothed average, and any large changes are reported to the NCC. It also classifies the circuit approximately as one of the following: 5Kbs, 10Kbs, 50Kbs, or 250Kbs. The IMP also measures the excess capacity on each circuit by counting the time during which the circuit is busy. This reading will be used to send routing more often on less busy lines. The measurements are accurate to within 10% and are always in error on the safe side.

Phase 3: Routing messages are transmitted at variable frequency according to the bandwidth and loading of each circuit. The following 4 standard line speeds are used for frequency determination:

Line Speed= Line Load=	5Kbs	10Kbs	50Kbs	250Kbs
full to .2 idle	6.4 sec	3.2 sec	640 ms	125 ms
.2-.4 idle	3.2 sec	1.6 sec	320 ms	62 ms
.4-.6 idle	2.13 sec	1.07 sec	213 ms	42 ms
.6-.8 idle	1.6 sec	800 ms	160 ms	31 ms
.8-totally idle	1.28 sec	640 ms	125 ms	25 ms

The frequency of routing used for a full line (first row of table above) is the frequency always used by the line "alive/dead" logic regardless of the frequency with which routing is actually being transmitted.

Phase 4: The first part of input-driven routing is implemented. Routing messages carry serial numbers and the last input and output number are saved for each line. A pool of routing buffers is introduced, and all references to the routing tables are indirect.

Phase 5: The computation of new routing messages is input driven. Immediately upon receipt of a new routing message from an adjacent IMP, the program does all that is necessary to produce a new routing message for output, containing updated information where appropriate. A triple buffer of routing messages is kept, one for current output, one for the new message to be computed, and an idle buffer. When new routing is computed, and no lines are using the idle buffer for output, there is a cyclic permutation of the input, output, and idle buffers.

We expect to provide an analysis of the effects of these changes on the network in a subsequent report.

1.2 The Satellite IMP

Our involvement in the development of ideas related to the broadcast use of an earth satellite channel has continued. During the past quarter, we have studied methods for randomizing transmissions in a satellite channel following a collision between packets in the channel. We have determined that a simple Geometric method is adequate, and convenient to implement. This study is reported in ARPA Satellite System Note 51 (NIC 18744).

Our programming efforts during this period have included the completion of a satellite channel simulator, and the continuing work on the actual broadcast SIMP program. The satellite channel simulator, which runs on a H-316 computer in the normal IMP configuration, is expected to be a useful tool for debugging the SIMP program. It will permit the interconnection of up to four SIMPs using standard terrestrial line modems. It receives from all lines and, keeping track of collisions, repeats successfully transmitted packets to all the SIMPs. At this time, we have a rudimentary broadcast SIMP program operating.

It copies packets into the upper portion of memory for transmission over the satellite channel.

We have been working with COMSAT to resolve the interface between the satellite channel unit and the SIMP modem interface in preparation for an anticipated ARPA experimental connection of a broadcast channel between the ground stations at Etam, Virginia and Goonhilly, England early next year.

We have also recently attempted to make rough calculations of the bandwidth to be expected from a 316 SIMP. These calculations are not final, since they are based on software which is still under development; they should, however, provide a reasonable upper bound on the SIMP's bandwidth. First we counted the number of cycles used in various tasks involved in the store-and-forward process, arriving at the following packet-processing costs:

Task	Cycles
land in/land out	600+6/word
land in/satellite out (and the reverse)	950+16/word
satellite in/ satellite out	1400+26/word

Since we are interested in an upper bound for the 316 SIMP we assume a cycle time of 1.6μsecond and 63-word (i.e., maximum length) packets. We then convert from cycles to throughput and find that the 316 SIMP is constrained by the inequality

$$L+3S \leq 600 \text{ Kbs}$$

where L is the rate of full duplex traffic over land circuits and S is the rate of full duplex traffic over satellite circuits.

A primary interest in the use of the SIMP is to connect to a broadcast satellite channel. Therefore, we have made the simplistic assumption that each SIMP will, on the average, supply 1/n of the traffic in the satellite channel where n is the number of SIMPs sharing the channel. Thus, each SIMP may supply eC/n Kbs where C is the satellite channel capacity and e is a fraction representing the channel efficiency. If each SIMP is assumed to get all the traffic it puts into the satellite channel from its land lines and vice versa then

$$L=S=eC/n$$

However, each SIMP must actually look at and discard all traffic on the satellite channel which is not actually destined for it. Our examination of the algorithms indicates that one-third of the time required to process "useful" traffic is a reasonable upper bound for this discard process; further, only incoming (but not outgoing) traffic must be discarded. Thus we obtain the inequality:

$$\frac{eC}{n} + 3 \times \frac{eC}{n} + \frac{1}{2} \times \frac{n-1}{n} \times eC \leq 600$$

or

$$\frac{7eC}{n} + eC \leq 1200$$

If we assume, for example, that e=1, then C obviously approaches 1200Kbs as n approaches infinity. Alternatively, we can see that a 50Kbs satellite channel could be fully loaded by .3 SIMPs. Thus, if a 50Kbs channel were shared by three SIMPs each would be working at about 10% of its capacity. Finally, if we desire a model in which the SIMPs are to be used at 100% of capacity, one such model has 4 SIMPs, each with three 50Kbs land lines, all connected to a satellite channel operating at approximately 436Kbs (if e=1).

2. STATUS REPORT ON THE TERMINAL IMP

The first Terminal IMP (TIP) was delivered to the field in the third quarter of 1971. At the end of the third quarter of 1973, eighteen TIPs were operational within the network at the following sites:

NASA, Ames Research Center, Moffett Field, California
University of Hawaii, Honolulu, Hawaii
University of Southern California, Los Angeles
Fleet Numerical Weather Central, Monterey, California
Tymshare Data Services, Cupertino, California
Range Measurements Laboratory, Cocoa Beach, Florida
University of Utah, Salt Lake City, Utah
Air Force Global Weather Central, Lincoln, Nebraska
U.S. Department of Commerce, Boulder, Colorado
University of London, London, England
Norwegian Seismic Array, Kjellar, Norway
Seismic Data Analysis Center, Washington, D.C.
MITRE Corporation, Washington, D.C.
Advanced Research Projects Agency, Washington, D.C.
U.S. Air Force Environmental Technical Applications Center Washington, D.C.
National Bureau of Standards, Washington, D.C.
Computer Corporation of America, Cambridge, Massachusetts
Rome Air Development Center, New York

Further, TIPs are imminently scheduled for delivery to Wright-Patterson Air Force Base, Rutgers University, and Kirtland Air Force base, and a TIP is to be installed at Bolt Beranek and Newman for service to the user community in the Boston area. Given the proliferation of TIPs over the past two years, the fact that TIPs account for a large portion of the network's traffic, and the fact that the TIP software development effort is reaching a plateau, it seems appropriate to give a complete status report on the TIP effort.

2.1 Fabrication, Installation and Maintenance

The TIP is fabricated by BBN by combining a Multi-Line Controller with a 316 IMP. The former is constructed by BBN, the latter by Honeywell. Completed systems are extensively tested both off and on the network before shipment to the field. TIPs are installed by a BBN field engineer with the help of a Honeywell field engineer. The BBN field engineer also aids site personnel in connecting Hosts and data sets to the TIP. Once installed, the TIP is under a Honeywell maintenance contract although BBN engineers are regularly sent to the field to help with difficult problems. In practice the basic Multi-line Controller has proven to be almost 100% free from failure although there have been failures of Line Interface Units, the modules to which terminals or data sets are connected.

All TIPs in the network are configured with at least 28 kilowords of core memory of which 16 kilowords is dedicated to the IMP and the remainder is dedicated to the TIP. Two TIPs have been delivered with a magnetic tape option and these have an additional 4 kilowords of memory (or 32 kilowords total). Future TIPs will have 32 kilowords of core as Honeywell now manufactures only 8-kiloword banks of memory.

At present all TIPs have at least one Host interface although this is only used at about half the TIP sites. Two Host interfaces are possible at present, and this will be expanded to three at some time in the future. A TIP can handle up to 63 modem and terminal devices.

2.2 Documentation and the TIP Users Group

In addition to numerous informal and working publications to date, five formal publications about the TIP have been written. These are:

BBN Report 2183, *User's Guide to the Terminal IMP* (kept current through updates). A guide to using a TIP from a terminal, including discussion of how to make a logical connection to a Host and how to operate the TIP magnetic tape option.

BBN Report 2184, *Hardware Manual for the BBN Terminal Interface Message Processor* (October 1972). A complete hardware logic description of the Multi-Line Controller.

BBN Report 2277, *Specifications for the Interconnection of Terminals and the Terminal IMP* (kept current through updates). The description of how to connect modems and terminals to the Line Interface Units of the TIP's Multi-Line Controller.

S. Ornstein, F. Heart, W. Crowther, H. Rising, S. Russell, and A. Michel, *The Terminal IMP for the ARPA Computer Network*, Proceedings of AFIPS 1972 Spring Joint Computer Conference, Vol. 40, pp. 243-254 (May 1972).

N. Mimno, B. Cosell, D. Walden, S. Butterfield, and J. Levin, *Terminal Access to the ARPA Network -- Experience and Improvements*, Proceedings of the Seventh Annual IEEE Computer Society International Conference (COMPCON 73), pp. 39-43 (February 1973).

The most important source of informal TIP documentation is the TIP User's Group Note series. Notes in this series are published in a timely fashion and are primarily used to warn users of impending system changes and to poll users as to their desires for future improvements. These notes, as well as TIP User's Guide updates, are distributed directly or through site representatives to all TIP Users. We estimate that there are presently between 700 and 1000 TIP users, from Hawaii to Norway.

2.3 Terminal and Modem Handling Capabilities

The TIP presently assumes all terminals use 8 bit characters except IBM 2741s; although TIP hardware exists to vary this, the TIP software does not presently allow variation. The TIP allows the following modem and terminal rates:

Clocked Internally to the TIP	
75 bps	input or output
110	input or output
134.5	input or output
150	input or output
300	input or output
600	input or output
1200	input or output
1800	input or output
2400	input or output
4800	output only
9600	output only
19200	output only

(Speeds in excess of 2400 bps were implemented during the third quarter of 1973.)

<u>Clocked Externally to the TIP</u>

any rate up to 3.3 Kbs	input or output
any rate from 3.3 to 19.2 Kbs	input only

The TIP handles a variety of terminal and modem types as listed below.

<u>Terminals*</u>

- KSR-33 Teletype compatible terminals; i.e., ASCII terminals without requirement for special timing or parity calculations.
- KSR-37 Teletype compatable terminals; i.e., ASCII terminals requiring even parity output.
- ODEC Printer; an ASCII printer requiring special timing considerations.
- MEMOREX Printer; an ASCII printer requiring special timing considerations.
- Execuport compatible terminals; i.e., Teletype compatible terminal requiring special timing for a slow carriage return and line feed.
- IBM PTTC and Correspondence 2741 compatible terminals; i.e., EBCDIC terminals with the 2741 transmit and receive interrupt options but requiring a special line turnaround protocol.

There are a large number of terminals compatible or "almost compatible" with those listed above; many of these have been used with the TIP by various groups. The TIP does not handle remote job entry terminals or other terminals requiring complex protocols.

*In addition to those listed below, at BBN we have a heavy duty Data-Products printer connected to the TIP, in a manner which requires no special software, through a special interface which provides an external clock to the TIP at maximum rate.

Modems

The TIP will work with the appropriate options of Bell 103 or 113 series modems up to 300 baud. Specifically included are the Vadic equivalents of the Bell modems.

Above 300 baud fewer options exist. For 4-wire, private line, full duplex operation, the Bell 202R, and (if properly configured) the 202D may be used up to 1800 baud. The 202C is intended for two-wire dial up use and, since it is a half duplex device, will not work with the TIP. The Supervisory-channel version provides only a 5-baud reverse path which is of no use to the TIP. With certain cross-connections, a simplex device (such as a line printer) can be run with a 202C but the complexity and the software constraints cause us not to recommend it.

No Bell modem exists for 1200 baud dial-up operation. The only such modems known to us are the Vadic 3400 series, which have been tested by BBN and seem to work as advertised. They are available with many strap options, including a set which handles the 103 protocol, allowing direct replacement in the case of devices which are now using the 103 and are limited by transmission speed.

Several manufacturers sell (or advertise) dial-up modems which provide 1200 baud transmission in one direction and 110 or 150 in the other. In concept, this is an obvious choice for CRT terminals. However, evaluation of many of these units has led us to be extremely cautious. Those that malfunctioned tended to have few problems with their modulators or demodulators, but frequently failed to establish connections due to inadequate hand-shaking protocol logic.

In December or January a report summarizing the specific problems and solutions of the various modem choices will be issued to TIP users.

During the third quarter BBN finally implemented a complete modem "hang up" protocol which is required for use of automatic-answer 103 modems connected to some central switching offices. This protocol uses two bits per device; "carrier dropped" [MOCARR] and "hanging up" [MOHANG].

The TIP has two processes watching each data set: one, which runs fairly frequently, decides whether the data set is logically connected or disconnected and a second, which runs rather lethargically (on the order of once per minute per data set), insures that a logically disconnected data set gets hung up.

The frequent process checks Carrier Detect [CD] first. If CD is high, it clears both MOCARR and MOHANG and the data set is considered connected. If CD is low, it checks Data Set Ready [DSR]. If DSR is also low, it clears MOHANG and sets MOCARR, taking note of the former value of MOCARR. If MOCARR was formerly cleared (i.e., its state just changed) it logically sets the data set as disconnected and drops Data Terminal Ready [DTR] in accordance with protocol. Otherwise, the data set was already disconnected and it is left alone.

The lethargic process checks if the data set is in the state where DSR is high but CD is low. If this is not the case it clears MOHANG and does nothing else. If this is the case, it checks MOHANG. If MOHANG is not set, it sets it and dismisses; if it is set, it clears it and drops DTR for the requisite time to get the data set hung up.

In the implementation, the lethargic process will be effected by having a clock routine set a flag once each minute; the flag's being set preempts the next execution of the frequent process for a run of the lethargic one.

In summary, the data set appears to have three stable states, two normal and one pathological: DSR low and CD low, DSR high and CD high, and DSR high and CD low. The first two are detected by the frequent process and are considered to be the disconnected and connected states of the data set. The third is the "busy but not hung up" state and is detected and cleared (back to DSR low, CD low) by the lethargic process. The lethargic process could run as often as once every 10 seconds or so; its rate was chosen in deference to Vadic "103-compatible" modems which, apparently, stay in the pathological state for the entire time a call is being originated.

2.4 Magnetic Tape Option

As discussed in our Quarterly Technical Report No. 15 (page 15) and Quarterly Technical Report No. 1 (page 17), significant modifications have been made to the magnetic tape option since it was originally developed. The major characteristics of the option are listed below:

- The TIP magnetic tape option follows a simple, efficient, robust, but ad hoc protocol.
- A tape transfer will "ride through" the destruction of a message or even a network partition for an extended period without data loss (assuming that the source and destination TIPs survive for the duration of the transfer).
- The tape option uses the network optimally with respect to throughput by allowing multiple messages to be simultaneously in transit.

- The tape option uses messages optimally by packing 2 2/3 6-bit bytes into every 16 bit word transferred.
- The maximum size record which can be handled is currently 2400 frames (7-track tape); this maximum is tailored to the users' requirements.
- The option is in routine use between GWC and ETAC for the transfer of two tapes every day.

2.5 Use of the Resource Sharing Executive (RSEXEC)

As discussed in Quarterly Technical Report No. 1 (page 5), the TIPs now make extensive use of the TENEX RSEXEC.* The TENEX RSEXEC currently is run on many network TENEX systems and a package (called TIPSER) which allows direct TIP use of the TENEX RSEXEC runs on BBN-TENEX, ISI-TENEX, and will soon run on the SRI-ARC TENEX.

TIP use of RSEXEC is presently initiated by the TIP user command @N.** This initiates a broadcast of a TIP message to all network RSEXECs running TIPSER. A connection is made between the TIP and the first RSEXEC to respond. Over this connection, the TIP user can access a number of useful services. At the present time these are:

- A "NETNEWS" service which allows the IMP and TIP system programmers and the NCC staff to communicate to users. The headline of the latest news is typed immediately on connection to TIPSER.

*R. Thomas, A Resource Sharing Executive for the ARPANET, Proceedings of the AFIPS 1973 National Computer Conference and Exposition, Vol. 42, pp. 155-163 (June 1973).
**Later this may be made automatic

- A "GRIPE" service which allows users to communicate to the IMP and TIP system programmers and to the NCC staff.
- A "HOSTAT" service which reports which Hosts in the network are up and available.
- A "LINK" service which allows a TIP user to make a two-way connection between his terminal and any user of a TENEX system running RSEXEC.
- A "SNDMSG" service which provides a general purpose "mail" distribution facility.
- A "TRMINF" service which gives the TIP user information about his terminal including the name of the TIP he is using and the TIP MLC port to which his terminal is attached.
- More than seventeen other services (commands) are presently available to the TIP user through TIPSER. Included are text editing (e.g., delete character, delete line, retype line) and terminal control (e.g., full duplex, set attention character) commands, as well as commands for finding other network users, finding an unloaded server TENEX, and commands which help in learning to use the RSEXEC.

We plan to continue expanding the facilities available to TIP users through the RSEXEC. Most immediately, we plan to add a facility which will give users news relating specifically to the TIP they are using, such as an announcement of an updated preventative maintenance period for the TIP. This will also include a facility which permits the site person responsible for the TIP to add a site specific news item and edit out old news items. Other facilities which will eventually exist via RSEXEC are:

- on-line access to the TIP User's Guide and other documents such as the Resource Notebook.
- TIP passwords, access control, and accounting
- generalization of the LINK and SNDMSG services to allow addressing of other TIP users as well as Host users.
- a READMAIL service which allows TIP users to receive mail independent of any server Host.
- an expanded TRMINF service to provide TIP status (e.g., number of users on TIP, load average).
- a distributed virtual file system for TIP users.

2.6 Software Improvements

Since the installation of the first TIP in the field, hundreds of improvements have been made in the TIP software system. Since July 1972 the changes visible to users have been documented in a series of "Letters to TIP Users" published as RFCs and TIP Users Group Notes.* Consequently, we will not describe the software development to date.** We will, however, list a few of what we think are the most important upcoming software changes:

- The TIP logger will be made re-entrant.
- The new TELNET protocol will be implemented -- this and the previous task are highest priority and should be done by early in 1974.
- The TIP's handling of terminals will be extended to the simulation of tabs and formfeeds, handling of line and page overflow (especially for CRT terminals), motor

*RFCs 365 and 386, and TIPUG Notes 5, 8, 12, 13, 14, and 19.
**Perhaps the most important change in the software is in the area of increased adaptability to specific site needs.

control, X-ON/X-OFF handling, and using a reverse channel for "Go Ahead."
- Improvement of TIP messages to the user.
- Making various TIP options yet more modular.

2.7 Bandwidth Capabilities

The TIP can physically handle 63 terminals and data sets. A recent recalculation of the TIP bandwidth indicates that there had been little decrease in the total bandwidth which may pass through the TIP to and from its 63 terminals. The maximum terminal traffic is still about 80 Kbs (e.g., eight 9600 bps CRT terminals doing only output*). The maximum total TIP throughput of Hosts, wideband lines, and terminals is still about 600 Kbs full duplex and must satisfy the inequality

$$H+L+15T \leq 600 \text{ Kbs}$$

where H, L, and T are full duplex Host, line, and terminal traffic respectively (e.g., a 50 Kbs line with full traffic in both directions counts as only 50 Kbs).

*Assuming sufficient buffer space is available and that no special software timing or parity calculations are necessary.

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13. ABSTRACT

The ARPA computer network provides a communication medium which allows dissimilar computers (Hosts) to interchange information. Each Host is connected to an Interface Message Processor (IMP), and IMPs are interconnected by leased common carrier circuits. There is frequently no direct circuit between two communicating Hosts, and the intermediate IMPs store and forward the information. IMPs regularly exchange information which is used to adapt routing to changing network conditions. IMPs also report a variety of parameters to a Network Control Center, which coordinates diagnosis and repair of malfunctions. The Terminal IMP (TIP) permits the direct attachment of 63 character-oriented terminals. The Satellite IMP (SIMP) will allow multi-station use of a single earth satellite channel. A High Speed Modular IMP (HSMIMP) is under development; one goal of this effort is to increase IMP performance by an order of magnitude. Specialized mini-Hosts under development will provide for: connection of remote batch terminals; simulation of a leased point-to-point circuit; encrypted Host communication.

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