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INTERFACE MESSAGE PROCESSORS FOR THE ARPA COMPUTER NETWORK

QUARTERLY TECHNICAL REPORT NO. 11
1 July 1971 to 30 September 1971

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13. ABSTRACT

The basic function of the ARPA computer network is to allow large existing computers (Hosts), with different system configurations, to communicate with each other. Each Host is connected to an Interface Message Processor (IMP), which transmits messages from its Host(s) to other Hosts and accepts messages for its Host(s) from other Hosts. There is frequently no direct communication circuit between two Hosts that wish to communicate; in these cases intermediate IMPs act as message switchers. The message switching is performed as a store and forward operation. The IMPs regularly exchange information which: allows each IMP to adapt its message routing to the conditions of its local section of the network; reports network performance and malfunctions to a Network Control Center; permits message tracing so that network operation can be studied comprehensively; allows network reconfiguration without reprogramming each IMP. The Terminal IMP (TIP), which consists of an IMP and a Multi-Line Controller (MLC), extends the network concepts by permitting the direct attachment (without an intervening Host) of up to 64 dissimilar terminal devices to the network. The Terminal IMP program provides many aspects of the Host protocols in order to allow effective communication between a terminal user and a Host process.

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MLC						
Network Control Center						
Host Protocol						

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1. OVERVIEW

This Quarterly Technical Report, Number 11, describes aspects of our work on the ARPA Computer Network during the third quarter of 1971.

Our efforts during this quarter were again primarily devoted to the Terminal IMP. The first two TIP field installations were made during the quarter, the TIP program was refined, additional terminals tested, and a preliminary TIP User's Guide was published. Section 2 describes Terminal IMP developments in greater detail.

Major changes were made to the Network Control Center computer program during the quarter, particularly in the mechanisms available for reporting Host traffic. Traffic is now separated into the eight categories defined by each possible combination of three parameters:

- input or output
- internode or intranode traffic
- packets or messages

These traffic statistics, as well as other data provided by the NCC program, are currently printed on a Teletype connected to the NCC computer, and any desired data reduction is performed by hand. Some consideration has been given to methods of storing the data in machine-readable form but there are, as yet, no firm implementation plans.

A significant effort was made during the past quarter to revise existing IMP system reports and to generate new reports required for the Terminal IMPs. Most of these documents are

expected to be completed and distributed by the middle of the fourth quarter of 1971. They include

- BBN Report No. 1822, *Specifications for the Interconnection of a Host and an IMP;* one minor revision distributed and a major revision in progress.
- BBN Report No. 1877, *IMP Operating Manual;* a major revision in progress.
- BBN Report No. 2161, *A Study of the ARPA Network Design and Performance;* already distributed.
- Terminal IMP Users' Guide; a preliminary version has already been distributed as BBN Report No. 2183, revisions will be made as we receive feedback on desirable program changes from TIP users.
- A hardware maintenance and test manual for the BBN Multi-Line Controller; in progress.
- A manual providing specifications for connection of terminals to the Terminal IMP's Multi-Line Controller; in progress.

Late in the third quarter we began to provide a biweekly report on Host status to the network community. Status information is obtained from a daily "login" survey made from the prototype TIP at BBN. This status reporting is provided partially in response to requests from the Network Working Group, and partially as a spur to the Host organizations to improve their network availability. (During the single two-week period in the third quarter for which data was obtained, only five Hosts responded to "login" attempts more than 50% of the time; further, the usual response of one of these Hosts was to refuse the login.)

As documented in BBN Report No. 1822 and elsewhere, the hardware interface between a Host and an IMP is subdivided into two separate units, a *standard* interface which is provided with the IMP and a *special* interface which is normally provided by the Host organization. However, due to some unusual circumstances involved in the experimental use of the network by two US Air Force sites, BBN agreed to design and fabricate the special Host interface required for each of these sites. The design was performed during the past quarter.

The intended Host computer at each of the two sites is a Univac 418 III; thus only one interface design was required. Early in the design study we decided (based on our interfacing experience and on some knowledge of the experiments planned) that the special interface should provide full-duplex communication. We then undertook a careful investigation of the possible methods of connecting the interface to the Univac hardware; this investigation, which involved both study of available 418 III documentation and discussions with Univac engineers, disclosed two alternatives:

1) Connection to a standard Communication Terminal Module Control (CTMC) via a Univac (custom designed) Communication Terminal Module (CTM). This method would allow data to be passed over two nine-bit half-duplex connections.

2) Connection directly to the Input-Output Module (IOM) which is an 18-bit parallel full-duplex I/O channel.

Because of stringent restrictions on the ability to pass "status" and control information inherent in the CTMC design, compared with the simplicity and flexibility of the IOM, the latter approach was chosen.

Design of the special interface is based on standard TTL logic. Diagnostic features include status lights, the ability to loop the IMP side, and provisions for simulating both the IMP and the IOM sides. Both interfaces were well into the fabrication phase by the end of the quarter.

2. TERMINAL IMP

During this quarter the first two Terminal IMPs were delivered and installed at NASA/AMES and at MITRE. The first of these was installed on schedule early in August. The second installation was delayed due to severe damage to the Terminal IMP during shipping from BBN to MITRE. Damaged components were replaced in the field and the machine was in use about one week behind schedule. Once the machines were in actual operation some bugs were uncovered; these were corrected, and several additions and improvements were made, by two updates to the terminal-handling program. By the end of the quarter Version 3 of the TIP program was in field use.

In addition to the two TIP field installations, the prototype Terminal IMP at BBN is frequently incorporated into the network. The prototype TIP is used both for checkout of new terminal types and for test interaction with the network at large. For example, our bi-weekly report to the Network Working Group on Host status is based primarily on information gathered via the prototype TIP.

Version 3 of the TIP program has been operated with seven different terminals and with the type 103A modem in the BBN test cell. In addition, users have reported successful operation with four other terminals. The terminals tested are:

- Model 33 Teletype (ASCII code) - tested at BBN.
- Model 37 Teletype (ASCII code) - tested at BBN.
- Infoton Vista 1-H Alphanumeric CRT (ASCII code) - tested at BBN at speeds of 110, 150, 300, 600, 1200, 1800, and 2400 bits per second.

- IMLAC PDS-1 Graphics Terminal used as an alphanumeric display (ASCII code) - tested at BBN at speeds of 110, 1200, and 1800 bits per second.
- Execuport (ASCII code) - tested at BBN at speeds of 110, 150, and 300 bits per second. This terminal differs from the other ASCII terminals in that delays must be introduced into the computer-to-terminal data stream following carriage-return.
- IBM 2741 Terminal (PTTC code) - tested at BBN. There are at least six possible keyboard code (and matching type element) versions of this terminal. We have tested one version and provided code conversions for three other versions.
- IBM 2741 Terminal (Correspondence code) - tested at BBN. There are at least four possible keyboard code versions of this terminal. We have tested one version and provided code conversions for three other versions.
- Hazeltine alphanumeric CRT - tested by a user.
- Telterm 2 - tested by a user.
- Tectran cassette - tested by a user.
- Datapoint 3300 alphanumeric CRT - tested by a user.

In addition to these terminals, we continued program development necessary to interface the ODEC Line Printer (which requires timed delay after paper advance commands), the type 202C modem, and the Honeywell magnetic tape controller and drive. We have also conducted a preliminary survey of "remote batch" terminals, but have not, as yet, been able to resolve the technical difficulties which prevent effective use of these devices with the Terminal IMP.

Unlike the other IMP software, the TIP program interacts both with human terminal users and with portions of the Host protocol. Thus we have always expected at least three sources of pressure for changes in the TIP program.

1) User requests for the connection of new terminal types, which may have requirements for new code conversions, special timing after certain characters (e.g., carriage-return or line-feed), or special "control" routines (e.g., 202C modem or magnetic tape).

2) Changes or additions to the Host protocols defined by the Network Working Group (e.g., definition of a remote job service protocol).

3) User dissatisfaction with the TIP "control language" which provides the interface between the terminal user and the network (e.g., desire for "better" abbreviations for commonly used commands).

Subsequent to the installation of the first TIP (about halfway through the third quarter) some changes were made to the field version of the TIP program in response to pressures in each of these categories, and work was started on other changes which are not yet ready for release. We expect that this tailoring of the basic TIP program will continue for some time, as users gain more experience in using the network via a TIP terminal and as the Network Working Group gains more experience with the protocols it is developing.