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Pluribus Satellite IMP Development
Mobile Access Terminal Network

August 1984

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This Quarterly Technical Report describes work on the development of Pluribus Satellite IMPs: and on shipboard satellite communications.

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COMBINED QUARTERLY TECHNICAL REPORT NO. 34

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PLURIBUS SATELLITE IMP DEVELOPMENT MOBILE ACCESS TERMINAL NETWORK

August 1984

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1 INTRODUCTION

This Quarterly Technical Report is the current edition in a series of reports which describe the work being performed at BBN in fulfillment of several ARPA work statements. This QTR covers work on several ARPA-sponsored projects including (1) development of the Pluribus Satellite IMP, and (2) development of the Mobile Access Terminal Network. This work is described in this single Quarterly Technical Report with the permission of the Defense Advanced Research Projects Agency. The work on the Mobile Access Terminal Network under contract 0408 has been completed. Some of this work is a continuation of efforts previously reported on under contracts DAHC15-69-C-0179, F08606-73-C-0027, F08606-75-C-0032, MDA903-76- C-0214, MDA903-76-C-0252, N00039-79-C-0386, and N00039-78-C-0405, and N0039-81-C-0408.

2 PLURIBUS SATELLITE IMP DEVELOPMENT

During the quarter, BBN's activities centered on Wideband Network systems integration, network operations, BSAT software development and testing.

2.1 WIDEBAND NETWORK SYSTEMS INTEGRATION ACTIVITIES

During May, a serious network problem was uncovered. It was found that the network could not support more than four interval 0 channel streams. BBN continued to work on this problem during May and early June. This problem was eventually traced to the improper handling by the ESI/ESI-A software of bursts which contained coding states of three words or less. These short states occur when the PSAT is forced to fragment datagram messages to fit in the available remaining space in a frame. The ESI code had been previously modified to disallow these short coding states in an effort to overcome a processing limitation which now no longer exists. Linkabit is working to correct the problem.

The Wideband Network task force convened at ISI during the week of July 22. The task force tested the ESI fix proposed by Linkabit to deal with the short coding state problem. This was found to correct the short state problem; however, further network testing uncovered another problem which would not allow the PSAT to create more than four channel streams. This problem was believed to be due to a PSAT software bug, and BBN is currently working on solving this problem. The task force tested a recent fix to the ESI made by Linkabit which allows T&M data to be enabled and generated more reliably. The task force also experimented with lowering the interburst padding required by the ESI from 1024 to 768 channel symbols. The network appeared to operate correctly with 768 channel symbols of padding.

Following the decision at the April EISN Steering Committee Meeting to locate the Cambridge, MA site at BBN instead of MIT, representatives of Western Union visited BBN during May to survey several possible candidate sites for the earth terminal equipment. Plans were drawn up for the most promising sites and were submitted to BBN for review during June. A site immediately behind the 50 Moulton Street entrance was chosen and Western Union is proceeding with the installation.

During the period July 27 - August 6, the network was down, due to the satellite changeover. The network is now operational on WESTAR IV. Network performance on the new Western Union satellite transponder appears to be significantly improved, due to cleaner signals. A full report has been provided by Lincoln on the measured performance parameters at each new site.

2.2 WIDEBAND NETWORK OPERATION AND MAINTENANCE

From an operational standpoint, May represented a very good month. An average of 5 sites were kept up on the channel throughout the month, with many days having as many as 6 sites up. The Lincoln ESI-A Interface, Codec, and Control Unit (ICCU) which had been sent to Linkabit for repair at the end of April, was returned on May 22. A cold solder connection in the clock circuit had been identified as the source of the problem. The 75 watt spare HPA in the Ft. Monmouth Earth Terminal was replaced with the repaired, original 125 watt unit on May 31. The Ft. Huachuca site was powered down during the period May 24 - June 11 to allow construction of a raised floor in the EISN lab.

Toward the latter half of June, it was found that the condition of the satellite channel and earth terminal equipment at several sites had deteriorated in its performance. Sites were found to have trouble staying up on the channel and hearing other sites when they were up. The channel bit error rate was measured several times during the month and found to be around 3x10**-3. Previous measurement had found the channel bit error rate to be approximately 5x10**-4, indicating a degradation of almost an order of magnitude. It was also found that the operating frequency of several sites deviated significantly from the specification. Western Union was alerted to these problems and began work to correct them.

However, the satellite channel and earth terminal equipment continued to exhibit degraded performance during July. Western Union deferred a major effort to get these problems resolved until after the change of satellite scheduled for the weekend of July 28.

Many sites experienced power and air conditioning failures during June. On June 5, the RADC site experienced a power failure, and the lab air conditioning failed to turn on when power was restored. The PSAT continued to operate for several hours at elevated temperature before a site person could be found to power it off. BBNCC Field Service performed a thorough check out of the machine and brought it back on on June 8. On June 19, the earth terminal was believed to have been struck by lightning. Damage was extensive and it was off the air for the rest of the month. AC Power in the PSAT lab failed again during the period from June 20-22. The Lincoln site was powered down on June 6 and June 15-17 for scheduled work on the lab AC Power. On June 14, the frequency of the Lincoln earth terminal's upconverter was adjusted. On June 18th, a power supply in the Lincoln PSAT was found to have failed, and it was replaced by BBNCC Field Service. The DCEC site was down during the period June 8-10, due to lab air conditioning problems. Earth terminal problems during the period June 21-30 caused the site to be available only on an intermittent basis. The Ft. Monmouth site was powered down on June 22 for scheduled AC power work. On June 26, the lab air conditioning failed, resulting in serious damage to the PSAT. BBNCC Field Service replaced several modules in the PSAT and the site was brought back up on July 3. The Ft. Huachuca site was powered down during the period June 1-13 while construction work was being done in the lab area.

2.3 BSAT SOFTWARE DEVELOPMENT

2.3.1 SUMMARY OF PROGRESS

In May, the BSAT / PSAT-Translator Protocol design was completed and PSAT Translator mode code was installed in the uplink, downlink, software loop, and datagram aggregation processes. Datagram aggregation was affected because using the PSAT Translator requires that the burst be sent with separate burst header and data portions for the PSAT SMI. Debugging of the PSAT Translator and the BSAT together began by the end of the month.

By June, we began testing the BSAT with the PSAT Translator at Lincoln Laboratory with the ESI-A. Testing revealed a number of minor bugs and caused us to install more consistency checking ode. There are now tests for such conditions as negative or xcessively large round trip time and for queuing bursts too late 'or transmission.

. bug in the Chrysalis macro LATER_THAN was uncovered in July. /hen comparing two times, it would sometimes indicate the later ;ime was the earlier of the two. As part of fixing the problem, ıew macros were defined and all 32-bit times in the BSAT were :onverted to unsigned numbers. This fixed a problem that had :aused the BSAT to glitch every 20 minutes when time wrapped ıround.

The code for accepting stream messages from hosts and delivering them was added in July and debugging of the stream setup and ıggregation code began. By the end of the quarter, using iebugging commands from the BSAT console terminal, the BSAT had :reated two streams and was sending messages from the Message Source to the Message Sink in both streams simultaneously. Stream Create, Delete and Change had passed preliminary testing. The tasks Remain are to write stream synchronization code, and to test the stream code on the channel.

The BSAT design was changed to split the burst rearrangement code from the channel uplink and downlink I/O processes. The new processes are called the Convolver, which performs burst rearrangement on the uplink, and the Deconvolver, which reassembles host messages on the downlink. The terms Convolver and Deconvolver were chosen for convenience and should not be confused with the convolution operation found in the signal processing field. The uplink I/O process performs the functions of the Sequencer. Details of this change are covered in the next section. At the same time, the code to handle multiple ESI ports as a single logical data path, which existed in both the uplink and downlink I/O processes, was removed.

Coding of the datagram reservation synchronization code began just before the end of the quarter. This code is necessary for multi-site network testing since it is the means whereby a site builds its knowledge of what datagram traffic is waiting to be sent over the channel.

Along the way, we converted from using development tools under 4.1 BSD Unix to 4.2 BSD Unix as our development system BBN-VAX was upgraded. The Butterfly operating system Chrysalis also under went significant improvements which required some editing and recompilation of all user programs. The conversions to Chrysalis 2.0 and to using tools under 4.2 BSD Unix went smoothly.

2.3.2 BURST REARRANGEMENT PROCESSES

2.3.2.1 Summary

The uplink I/O process has been split into two parts: the basic synchronous I/O drive in one process, and the burst rearrangement and data copying code in another process. Because this latter process performs burst rearrangement, putting messages with like reliabilities together, it has been named the Convolver. Similarly, the downlink I/O process has been split into two parts: the I/O driver, with some simple checks to discard bursts obviously corrupted in one process, and the host message reassembly and burst processing code in another process. This latter process is called the Deconvolver because it reassembles the host messages from the rearranged form in the channel burst.

Placing the convolving and deconvolving functions into separate processes is an outgrowth of the overall design philosophy that the BSAT should be a very high performance system. This means splitting functions along algorithmic lines into processes to allow for duplication of the process to multiply throughput. Previously, these computations were tied to the processor node on which the I/O devices existed. This limited throughput to whatever a single processor could handle. Now these computations may be performed on one or more processor nodes. The downlink burst processing is one of the most CPU-intensive functions in the Channel Module. Now that it can be moved to its own processor node, or replicated to multiply throughput, it is no longer a principal limiting factor.

In the next sections, the changes for each of the four processes are described. The synchronous I/O device driver code in CPM_Xmit and CPM_Rcve (the uplink and downlink I/O processes) has not changed and is not described.

2.3.2.2 CONVOLVER PROCESS

The Convolver receives a burst descriptor, operates on it and any host messages that might be attached, and passes the result on to the uplink I/O process CPM_Xmit. The Convolver operations performed on one burst are completely independent of those on any other burst. This allows the Convolver process to be replicated. The Convolver performs the following tasks for each burst:

* Converts time-to-send from Satellite Time to ESI Time
* If ranging on the burst, records the ESI Time of transmission
* Moves all data from host buffers to the uplink output processor node
* Reorders the host message data for burst (burst rearrangement)
* Passes the rearranged burst to the uplink I/O driver.

For some bursts, particularly those not containing host messages, some of these are null tasks.

The first task is conversion from Satellite Time to ESI Time. Uplink processing prior to the Convolver deals only with Satellite Time. The Convolver converts the time-to-send in the burst descriptor's timestamp field from Satellite Time to ESI Time. Processes following the Convolver in the uplink deal only with ESI Time.

Next, if the burst is to be used for ranging, the ESI Time of tranmission of the burst is recorded. Later, in downlink processing, when the burst is received, the ESI Time of reception minus the saved transmission time will become the new satellite channel round trip time.

Any data that is to be transmitted over the channel must be in memory in the uplink output processor node. This is necessary because of a restriction in the Butterfly I/O system; I/O transfers can only be made to or from memory on the specific processor node to which the I/O board is connected. Burst headers are composed directly in the I/O node's memory, and do not need to be copied. Host messages that are part of a burst must be copied.

The Convolver performs both burst rearrangement and copying of the message data to the channel output processor at the same time. The rearranged burst is then passed to the uplink I/O process.

2.3.2.3 UPLINK I/O AND BURST SEQUENCING

Since there may be more than one Convolver running, there is no guarantee that bursts will arrive at the uplink I/O process in any particular order. Since bursts (packets sent over the satellite channel) must be passed to the ESI-B in transmission-time order, bursts are resequenced in the uplink I/O process, CPM_Xmit, prior to channel output.

To accomplish this transmission-time sequencing efficiently, the Datagram Scheduler, which coordinates all scheduling in a PODA frame, assigns sequence numbers to every scheduled channel burst to be transmitted from the site. The uplink I/O process will hold onto bursts arriving out-of-sequence and early, and discard out-of-sequence, late bursts.

Unlike scheduled bursts, ESI Commands are not transmitted over the satellite channel, but are executed soon after the ESI-B receives them. The timestamp field in ESI Commands is not significant, and execution of an ESI Command in the ESI-B is not synchrounized to scheduled burst transmission. These packets no longer go through the burst rearrangement and Satellite Time to ESI Time conversion code, but now bypass the Convolver and sequencing. They are placed directly on a separate queue to CPM_Xmit by whichever process composed the ESI Command. ESI Commands are intermixed on the output I/O queue with scheduled bursts.

2.3.2.4 DOWNLINK I/O PROCESS

The downlink I/O process, CPM_Rcve, accepts bursts from the ESI, extracts reservation information from the burst header, and passes the burst to the Deconvolver for any further processing. This process has been pared to the basic I/O routines needed to receive data from the ESI-B. For convenience and efficiency, some simple functions, such as extracting reservations from the burst header for the Datagram Scheduler, are also present.

Incoming bursts are checked for a variety of errors; bursts obviously in error are discarded. Errors include HDLC CRC errors, buffer overrun, burst header CRC errors from the BSMI when available, inconsistent burst length and expected length values, and others.

Reservations are extracted in this process rather than in a Deconvolver process, because the Datagram Scheduler needs reservations in the order in which they were received from the channel. If reservations were extracted in a Deconvolver, a duplicable process, the reservations would have to be sequenced and sorted somewhere. Since the Datagram Scheduler is not a duplicable process, it would be undesirable to add a sort routine to handle the relatively frequently arriving reservations. It was also considered an unnecessary complication to add a new process solely to sort reservations. Extracting reservations in the unique CPM_Rcve process eliminates the need for sorting.

Datagram burst arrival information is needed by the datagram reservation synchronization process, Reservation_Sync. CPM_Rcve increments a sequence number for each burst of interest to Reservation_Sync and passes that number, along with the burst, to the Deconvolver. When the Deconvolver composes the burst arrival information blocks for Reservation_Sync, it includes this sequence number. This number is used to process the information in Reservation_Sync in the order in which the bursts arrived, by ignoring out-of-sequence blocks. If there is only a single Deconvolver process, information will never be passed out of sequence.

2.3.2.5 DECONVOLVER PROCESS

The deconvolver handles all the incoming packets from the ESI that are not so corrupted that CPM_Rcve has discarded them. This is a duplicable process whose input is a single queue from

CPM_Rcve of incoming bursts.

The incoming packets may be either channel bursts or ESI Replies or, if the channel is looped, ESI Commands. The ESI Replies indicate such events as ESI Reset Complete, Gross Frequency Offset Acquisition Complete, protocol errors, alarms, and status. Channel bursts are typically broadcast (BSAT-to-BSAT) bursts such as leader, datagram, and stream bursts.

The first Deconvolver process started has the additional task of ensuring that the PNC Time / ESI Time conversion variables are updated reasonably often. If no TIME REPLY has been received by any Deconvolver for one and a half seconds, the Deconvolver will do a dead-reckoning update of the conversion variables. Processes are started one at a time, so there is no hazard in determining which Deconvolver is started first.

The principle function of the Deconvolver is to reassemble the host messages from the rearranged burst and copy the messages into buffers on the destination host's processor node. It skips over messages in the channel burst whose destination is not for a host at this site.

When the BSMI is operational, it will perform deconvolution on the majority of the incoming channel bursts, putting the burst header and the reassembled messages directly into host format buffers on the CPM_Rcve processor node. The Deconvolver will then be simplified to processing the burst header and copying the host messages into the appropriate buffer pools. The exception will be that fragmented datagram messages will still be deconvolved by a Deconvolver. This exception was made because of the complexity of reassembling fragmented datagram bursts in the presence of channel errors and intervening stream bursts that must be deconvolved.

Information about burst arrival is passed to the datagram reservation synchronization process. Since more than one Deconvolver may be running, the information, is not guaranteed to be passed to Reservation_Sync in arrival-time sequence. However, a sequence number maintained by CPM_Rcve is passed along with the burst arrival information so that the original arrival sequence can be determined. Current design allows Reservation_Sync to ignore out-of-sequence information, but sufficient information is passed to sort the incoming data into arrival-time order, if desired.

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