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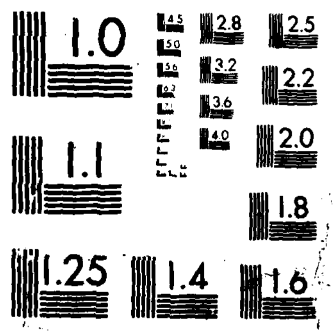

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AFCC TECHNICAL REPORT

INTERFACING COMPUTER NETWORKS THAT EMPLOY POLL/SELECT LINE CONTROL TO THE AUTODIN II NETWORK

DATA COMMUNICATIONS SYSTEMS BRANCH
1842 ELECTRONICS ENGINEERING GROUP (AFCC)
SCOTT AIR FORCE BASE, ILLINOIS

31 JANUARY 1980

1842 ELECTRONICS ENGINEERING GROUP

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Host computer networks which employ the poll/select line control discipline will be major subscribers of the AUTODIN II network. This paper provides a general overview of poll/select and contention disciplines, and discusses the advantages and disadvantages of each. Several approaches to reducing or eliminating polling overhead traffic on the AUTODIN II network are outlined.

APPROVAL PAGE

This report has been reviewed and is approved for publication and distribution.

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SUMMARY

This report presents a general overview of poll/select and contention line control discipline as used in computer networks. Besides describing the various network configurations where poll/select is used, the report also outlines tentative alternatives for interfacing the poll/select subsystem to the AUTODIN II network.

1.0. INTRODUCTION. The Air Force computer networks which currently employ the poll/select line control discipline will be major subscribers of the AUTODIN II packet switching network. A study group headed by the Air Force Computer Communications Programming Center (AFCCPC) has been established to explore a range of alternatives for interfacing these poll/select systems to the AUTODIN II network. This technical report was written to support the problem definition phase of the overall poll/select study.

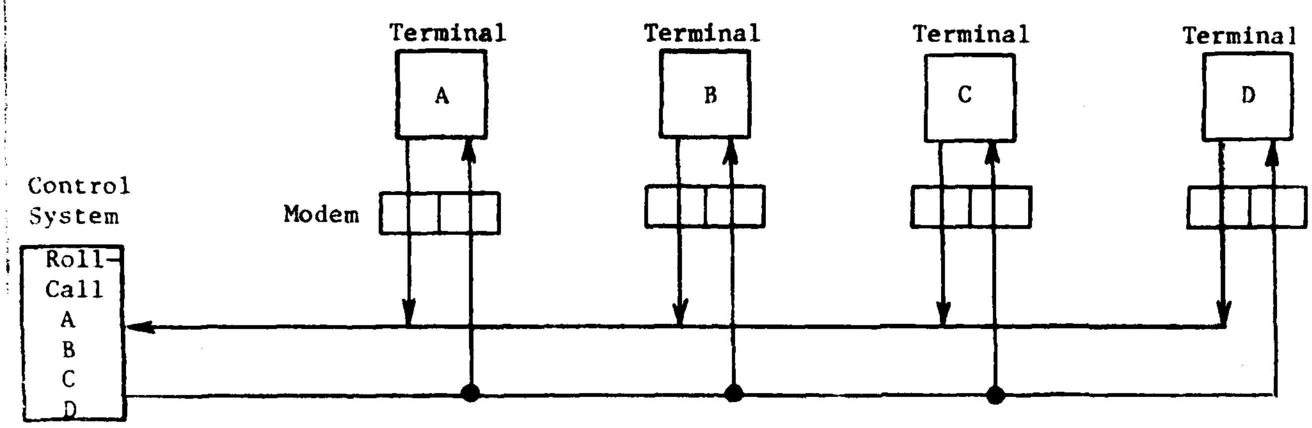
2.0 POLL/SELECT LINE CONTROL.

2.1 Poll/Select is a technique used in data communication to allow individual terminals or computers to be controlled from a host computer or message processor switch center. Roll-call and hub control polling (see Figures 1 and 2) are the two general types of polling disciplines currently used in line control.

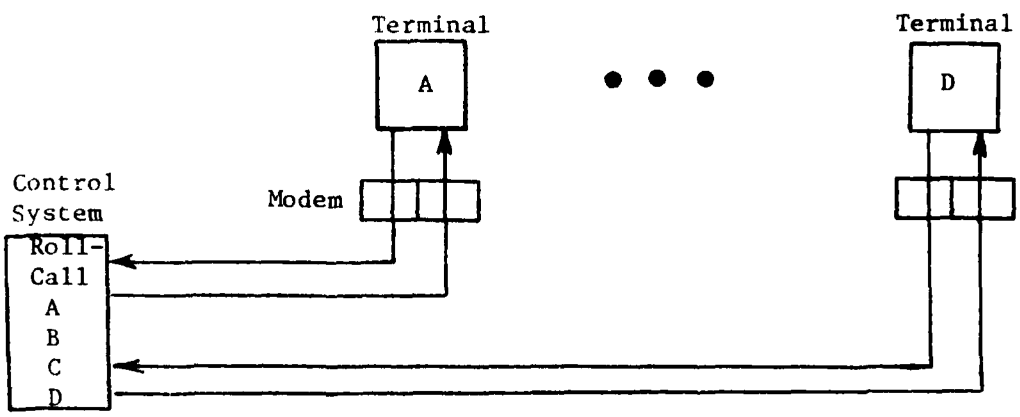
2.2 The roll-call polling select method is used when the control device sends an inquiry to each terminal to see if that terminal is ready to transmit. The roll call sequence is pre-determined via firmware or software. The control device (computer) sequence of events is shown in Figure 3 for a terminal that has a message to transmit when it is roll-called. If the polled terminal has nothing to send, it acknowledges this by a control character so that the polling device may move to the next terminal on the roll-call list. (Ref. 3)

2.3 The hub control polling select method is a technique in which the control device polls one of the terminals (usually the farthest from the control) to see if it is ready to transmit. The polled message path for this method is shown in Figure 2. If that terminal has nothing to transmit to the control, it will issue a poll message to the next terminal. If that terminal has a message, it will transmit that message followed by a further polling sequence; thus allowing the next terminal in the loop to have access to the control device in a continuing polling process. (Ref. 4)

2.4 Both the hub and roll-calling polling techniques are used in this country. The network topology and the time delay-cost trade-offs are major tools used in the analysis factors on which polling techniques are based. The roll-call polling technique is generally used instead of the hub polling technique, since the majority of long distance telephone line leases in the United States are normally of a 4-wire configuration, which would require a special bridge on the lines to allow the terminals in a hub network to "hear" one another. The cost of this special bridge at each terminal may be the deciding factor on which polling technique to use. On the other hand, hub polling in some instances is easier to implement on closely spaced terminals where 2-wire lines are readily available. (Ref. 7) Also, the time-delay factor of the roll-calling technique, where the control device has to poll each

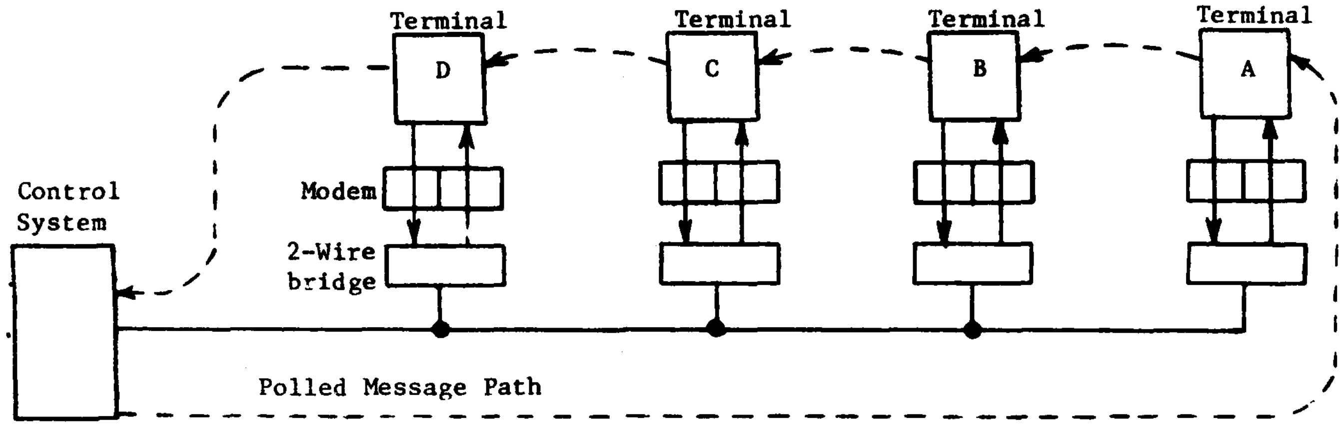


(a) Multidrop network

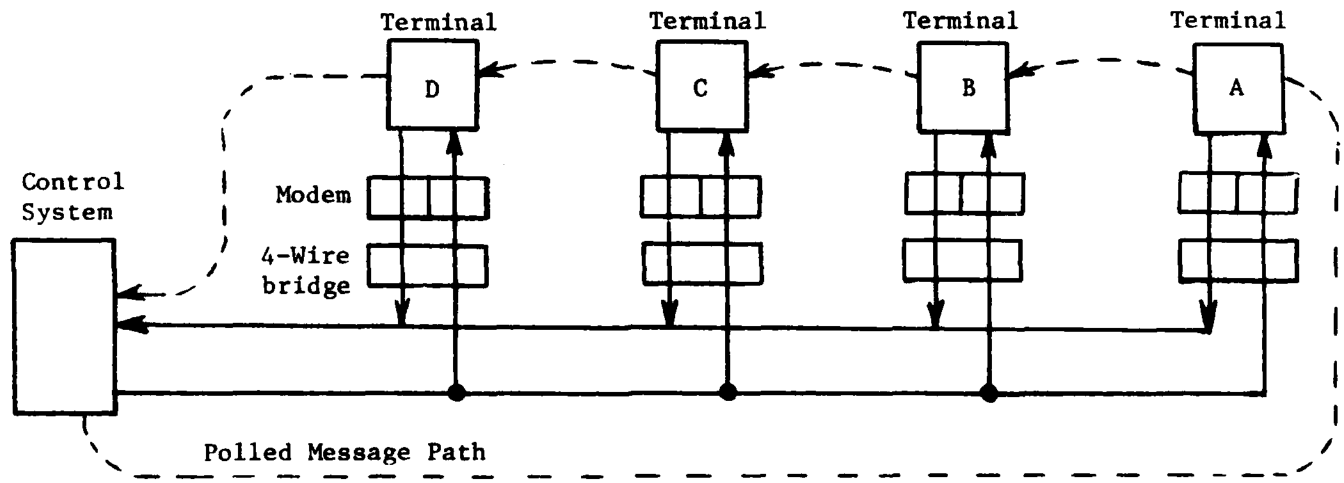


(b) Point-to-point network

Figure 1. Roll-Call Polling System



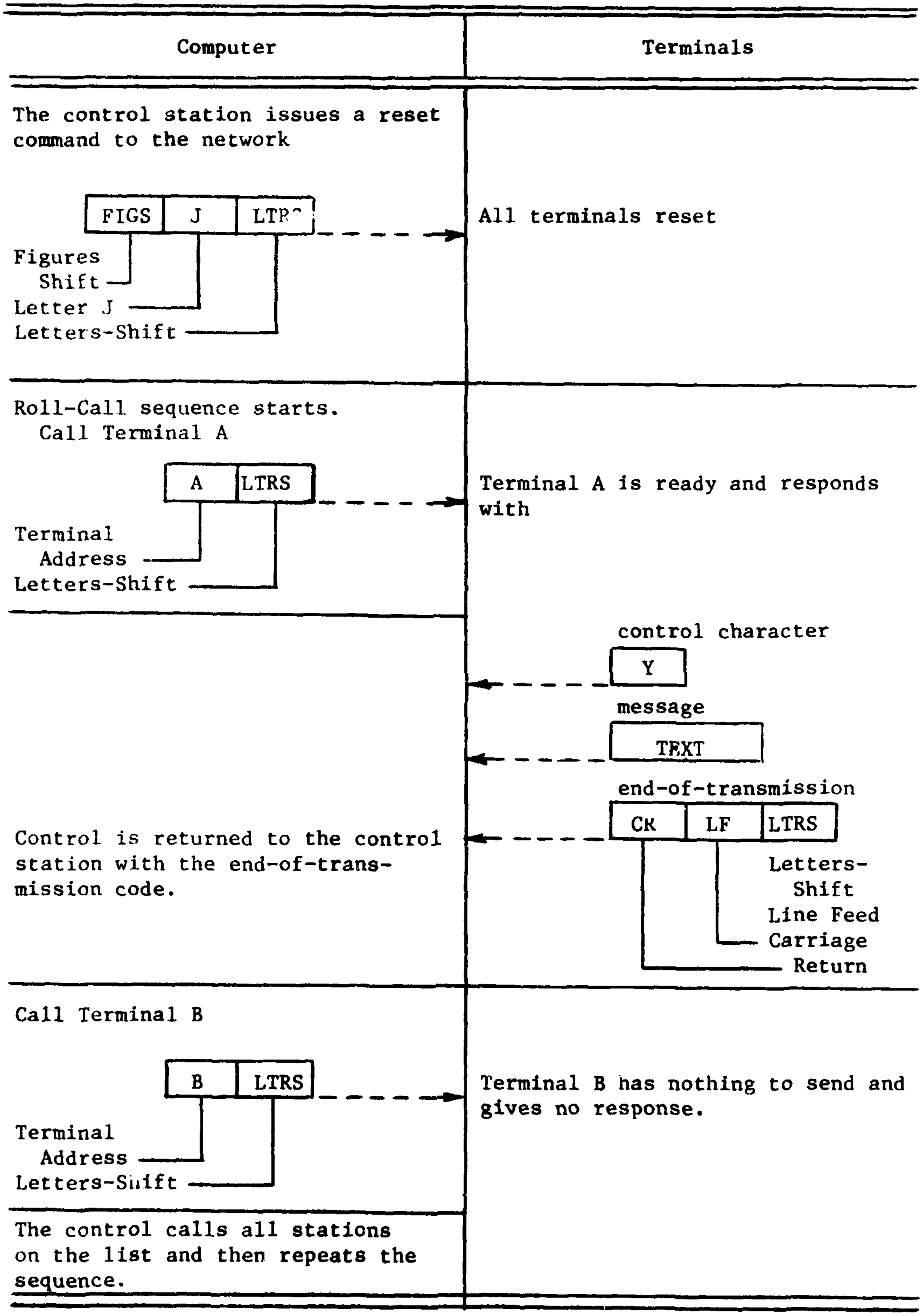
a) 2-wire network



b) 4-wire network

Figure 2. Hub Polling System

Figure 3. Roll-Call Polling



terminal in the network, may be a factor in deciding to use the hub polling technique. The hub polling control device polls only one terminal in the network with each terminal then passing the polling message to the next terminal. Thus, there are several weighting factors to be considered before the design of the polling technique, to be selected for the network under consideration, can be specified.

2.5 Thus far we have seen that the terminals in a network can have access to the control device by a polling technique which allows the terminals to transmit to the control device when their sequence comes up. A method called select calling (see Figure 4) is used when the control device has access to a terminal directly on a multidrop line, rather than waiting for the polling sequence to cycle to that terminal. In the polling techniques, each terminal has its own address and control characters this allows that terminal to have access to the line when called or selected. The control characters thus cause the control device and the selected terminal to become, in effect, a point-to-point connection during the transmitting time by locking out the unselected terminals. When the control device completes the message, it releases the called terminal and resets the other terminals for the next select call with a control character.

3.0 CONTENTION LINE CONTROL.

3.1 The poll/select discipline allows the control device to control the transmission of the terminals; but, what if the terminals wish to initiate a transmission of data to the control device rather than wait for their polling sequence? This method is called contention; where the terminals are competing to obtain the circuit and the first to find it free gets to use it.

3.2 The contention method is less effective than the one where the control device does the polling. The contention method works best when the network has point-to-point lines to the control device from the terminals. The control device, if busy, can then build up a contention queue from the requesting terminals and then service this queue on a first-come, first-served basis, or in some other preset priority.

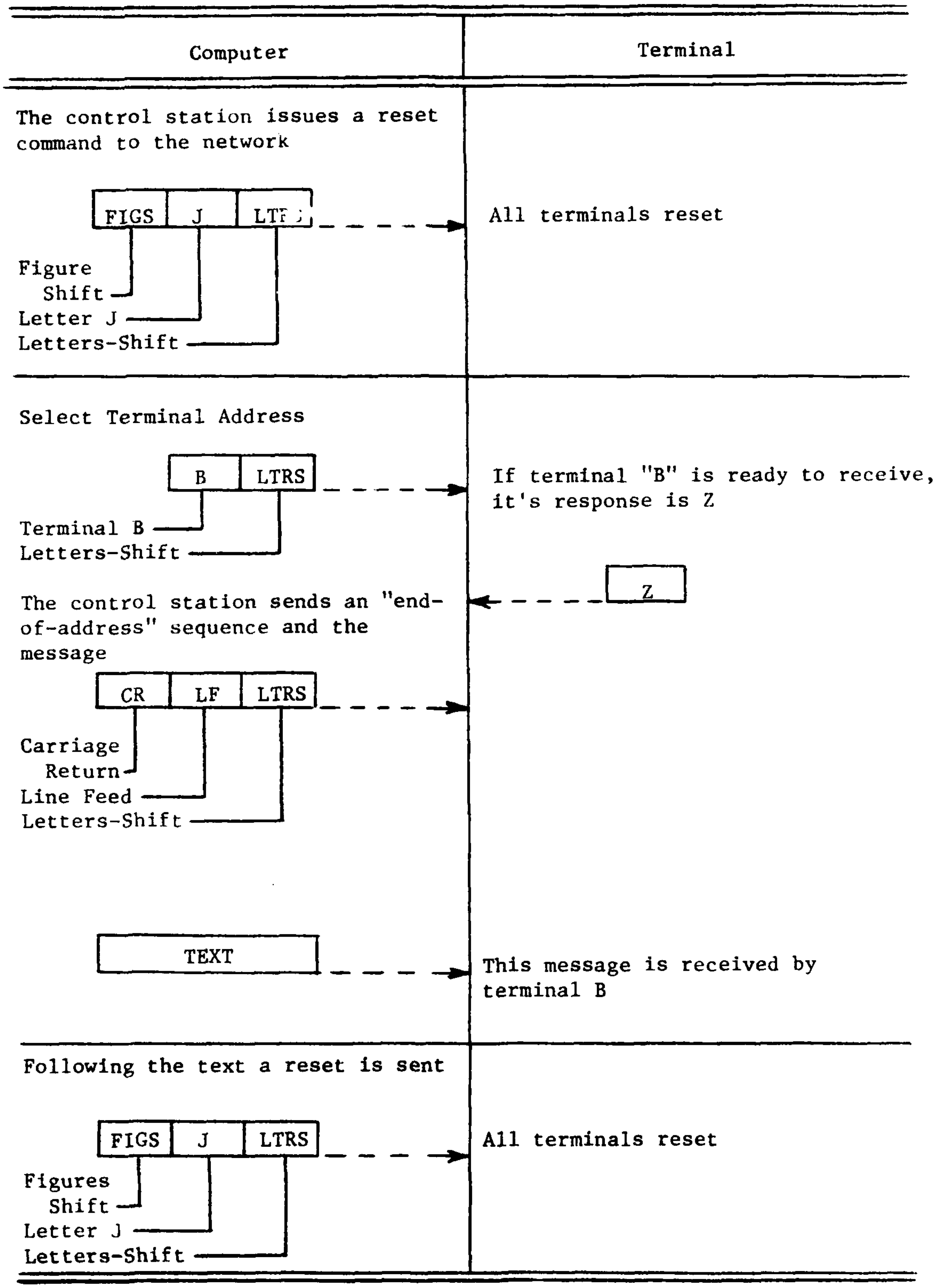
3.3 With these basic ideas on poll/select and contention in mind, a review of some ideas on how to interface poll/select networks to the AUTODIN II network is in order.

4.0 OPTIONS FOR INTERFACING EXISTING POLL/SELECT SYSTEMS TO THE AUTODIN II NETWORK.

4.1 General. We can define two general categories of potential solutions for interfacing Poll/Select multipoint systems to the AUTODIN II Network. Category I solutions would encompass a number of options previously identified in Western Union Technical Note 78-05, which would involve minor to extensive changes in Terminal Access Controller (TAC) and Channel Control Unit (CCU) software. Category II solutions would involve the insertion of hardware "black boxes" at various points in the host network to interface multipoint poll/select systems to the AUTODIN II network.

4.2 Category I. "Interfacing Options for Polling Systems", AUTODIN II Tech Note 78-05 (Ref. 1) describes in detail three potential options for interfacing remote polled terminals through the AUTODIN II network to their associated host

Figure 4. Select Calling



computers. Although the authors' discussion is based on the Burroughs Navy Type (BNT) protocol, their basic analysis may be generally applicable to polling schemes employed by other front-end processors; i.e., IBM, Honeywell, et. al. The salient features of these three software oriented options are discussed in the following paragraphs.

4.2.1 Transparent Option. Poll and Select messages from the host (front end) are sent across the network to the TAC and then delivered to the remote terminals. Acknowledgements (ACK's), Non-Acknowledgements (NAK's) and End of Transmission (EOT's) are also sent across the network as responses to data and control messages. The principal advantages of this option are: (Ref. 1)

- o Minimal conflict with existing protocols.
- o Complete end to end accountability of control and data packets.

The major disadvantage of the transparent option is that of greatly increased overhead message traffic across the network (as a consequence of continuous polling) which in turn greatly reduces network data throughput. Technical Note 78-05 shows that the transparent mode would impose a 11:1 overhead to data ratio on the AUTODIN II network.

4.2.2 Non-Transparent Option. In this option, two distinct and independent polling loops are established at both ends of the network - between CCU and host (front end) and between TAC and remote terminals. No additional control packet overhead is transmitted across the network. Data message acknowledgment is not performed in an end-to-end basis, but rather, is accomplished by: (1) locally ACKing/NAKing data blocks from the host at the MCCU, or data blocks from the terminal at the TAC, and (2) Transmission Control Protocol (TCP) to TCP acknowledgement. Because acknowledgment is not end-to-end, we have a "pipelining" effect which enhances data throughput across the network. "Pipelining" simply means that several data packets can transit the network on the same logical connection at a given time. Data blocks are retained in TAC or CCU memory for possible retransmission until TCP to TCP acknowledgment is received. Advantages of the non-transparent mode over the transparent mode are: (Ref. 1)

- o Polling discipline imposes no additional control overhead traffic on the network.
- o Pipelining effect enhances data throughput and access line utilization.

Major disadvantages of the non-transparent option are: (Ref. 1)

- o Greater complexity is introduced into the Host Specific Interface (HSI) and Terminal Handler (TH) software modules in the TAC and CCU, respectively.
- o Terminal expansion would require major CCU HSI software changes.

Some would further argue that the lack of end-to-end acknowledgment is another disadvantage of the non-transparent mode; however, this is an inherent design feature of the AUTODIN II network itself. In the AUTODIN II backbone design, packet acknowledgment is performed by the TCP to TCP virtual connection protocol as shown in Figure 5. The absence of end-to-end acknowledgment does

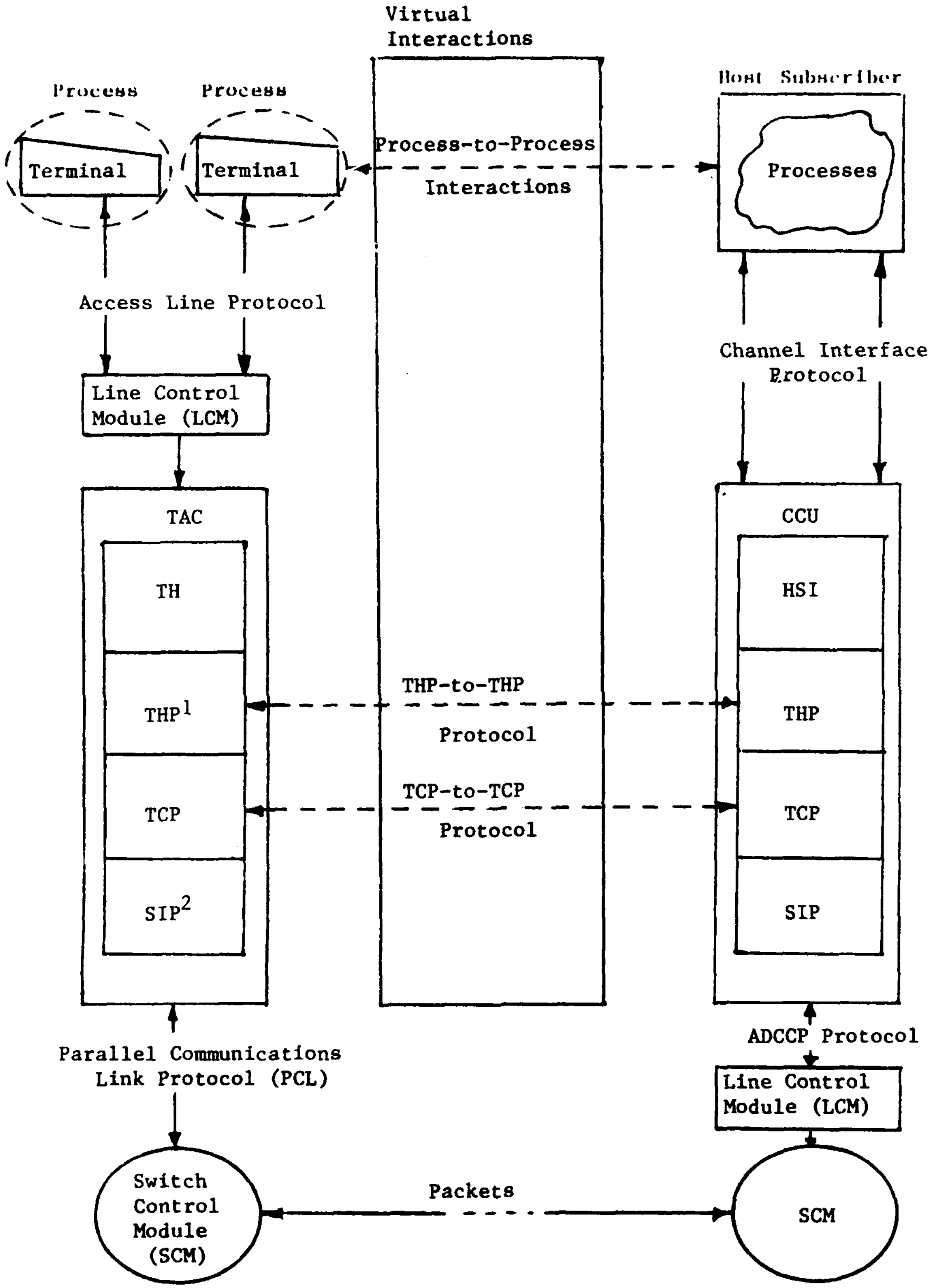


Figure 5. Levels of Protocol Interaction
Source: AUTODIN II Design Plan Vol VI, Appendix D

[1]THP - Terminal-to-Host Protocol
[2]SIP - Segment Interface Protocol

not appear to be a major weakness of this option, because failure to deliver data packets to the access area (which have received a TCP to TCP acknowledgment) is a low probability event. (Ref 1. p. 12)

4.2.3 Independent Polling Synchronized Transfer (IPST) Option. In this option, polling messages are confined between the CCU/Host and TAC/remote terminals, as in the non-transparent option, while data message ACKs/NAKs are handled on an end-to-end basis, as in the transparent option. The major virtue of the IPST option is the elimination of polling message overhead while retaining end-to-end acknowledgment of data messages. IPST holds a slight advantage in network throughput and access line utilization over the transparent mode. Like the non-transparent mode, the IPST option would introduce more complexity into CCU and TAC software modules, and would require major HSI software changes as the number of remote terminals are expanded.

A comparison of the major features of the three software options is highlighted in Table 1 (Ref. 1)

The authors of Technical Note 78-05 reject the transparent option because of its adverse impact on network processing requirements. In the short run, IPST may be preferred to the extent that percentage of polled users remains low. When the projected long term growth of the network is taken into account, the authors indicate that the non-transparent option is preferred. (Ref. 1)

4.3 Category II. In contrast to Category I solutions, this approach calls for the installation of off-the-shelf "black boxes" at various points in the network, and would include microprocessor hardware, firmware and/or software. Because all of the unique host network/AUTODIN II network interface requirements are not currently available from the user questionaire, a more definitive analysis of the black box option will be presented in a technical report at a later date. Nevertheless, the general function of these black boxes would be to:

o Convert polling sequences to contention commands, and conversely, convert contention commands to polling sequences, or

o Locally emulate polling sequences between TAC and terminals as well as between CCU and host computers.

Thus, the black box approach is functionally equivalent to the non-transparent scheme noted previously.

The exact location and configuration of this additional hardware, firmware and/or software would be dependent on a number of parameters unique to each host system or network:

- o Host network topology.
- o Types and configurations of front end processors.
- o Types and configurations of concentrators.
- o Line protocols used.
- o Specific syntax of poll/select messages.
- o Interface capabilities of the "black box" itself.

It is probable that such black boxes, if available, are designed to be compatible with specific host front-ends (or concentrators) of specific computer vendors. At this point in time, we do not know with certainty if such black boxes are available "off the shelf" for any or all the various types of computer systems that will interface into the AUTODIN II system.

The expected advantages of this approach are summarized in Table 1. Because the black box option and the non-transparent option are functionally equivalent (theoretically), they share many of the same advantages and disadvantages. Several factors, including cost of implementation, buffer requirements, and degree of complexity cannot be assessed at this time until vendor technical data becomes available.

Summary of Options

Comparison Factors	Transparent	Non-Transparent	IPST	Black Box
Data Transmission	Block-at-a-time	Pipeline	Block-at-a-Time	Pipeline
Access Line Utilization	Low	High	Low	High
Additional Network Overhead	High	None	Medium	None
SCM Throughput	Low	High	Medium	High
Accountability/ Acknowledgement	End-to-End	TCP-to-TCP	End-to-End	TCP-to-TCP
Complexity	Low: No interaction with Line Protocol	High: HSI-THP Interact with Line Protocol	High: HSI-THP Interact with Line Protocol	*
Buffering	No BCC[1] Check in MCCU or TAC.Full Packet Buffering only	BCC[1] Check Requires Full Data Block Buffering in MCCU and TAC	BCC[1] Check Requires Full Data Block Buffering in MCCU and TAC	*
Expandability	Easily Expanded No change in CCU Software	Major Change	Major Changes	Minor Changes
Protocol Conflicts	Low	Moderate	High	Low

Source: "Interfacing Options for Polling Systems"; AUTODIN II Technical Note 78-05; Aug 78; Western Union Govt Systems Division

[1]BCC - Block Check Character -In longitudinal and cyclic redundancy checking, a character that is transmitted by the sender after each message block and compared with a block check character computed by the receiver to determine if transmission was successful (Ref 8)

* Unknown

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