PUB 41027

PRELIMINARY

Bell System Data Communications
TECHNICAL REFERENCE

TRANSACTION NETWORK SYNCHROUS INTERFACE SPECIFICATIONS

April 1976

ENGINEERING MANAGER – DATA NETWORK SERVICES

326-113

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If further information is required, please contact:

Engineering Manager - Data Network Services
American Telephone and Telegraph Company
295 North Maple Avenue
Basking Ridge, New Jersey 07920

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1.0 Introduction

The Transaction Network Service is offered by the Transaction Network for switched communications of short, formatted data messages between Data Processing Centers (DPCs) and between low speed terminals and DPCs (Fig. 1). The low speed terminals are served by the Transaction Network Service dial-in and polled interfaces. The DPC will be served by the synchronous interface over dedicated, full duplex, synchronous data channels. This document will specify the synchronous interface to the Transaction Network Service in the form of message format, protocol, and message flow through the network. It is assumed that the reader is familiar with the contents of the Bell System Technical Reference - Transaction Network Service, PUB 41024, December 1975 which describes the Transaction Network Service.

1.1 Use

This Technical Reference is intended for system designers who want to use the Transaction Network Service in their application and is necessary for those who will program the DPC computer to operate with the synchronous interface.

1.1.1 Scope

This Technical Reference covers the Transaction Network synchronous interface specification. Characterisitics not defined are subject to change and should not be presumed. Future expansion of the system will be covered in reissued Technical References. Other Technical References on the Transaction Network Service are listed in the reference section.

1.2 Class of Service

DPCs may select service that is offered only to a population of:

a. Restricted polled terminals subscribing to the DPC service.

b. Unrestricted polled terminals served by the Transaction Network.

c. Dial-in telephones served by the Transaction Network.

d. Any combination of the above.

In addition, DPCs may elect to accept messages originated by another DPC from either (but not both) of the following DPC service classes:

e. Unaffiliated DPCs served by the Transaction Network.

f. Affiliated DPCs subscribing to the DPC service.

1.3 Channels

A customer subscribing to the Transaction Network Service using the synchronous interface will be connected via full duplex, dedicated, point to point analog or digital synchronous data channels, hereafter referred to as lines. The lines will be connected between the DPC location and the telephone company location housing the Transaction Network equipment.

1.3.1 Line Speed

The customer may specify a transmission speed of 2.4 Kilo (K), 4.8K or 9.6K bits/sec (BPS) for each analog and/or digital line subscribed to. A 201C, 208A or 209A type data set would be used for analog transmission dependent on transmission speed. For digital transmission, a Data Service Unit (DSU) or Channel Service Unit (CSU) at the 2.4K, 4.8K, or 9.6K BPS speed would be specified. The DPC electrical interface to the Transaction Network is an EIA-RS232C interface.

1.3.2 Traffic Handling Capacity

The telephone company requires the DPC to subscribe to adequate transmission facilities to meet traffic volume.

1.4 Line Group

A DPC subscribing to more than one line may specify them to appear as a line group, with traffic from the Transaction Network distributed over the lines. The entire line group would have the same assigned Transaction Network System address identification number for message routing. When only a single line is desired, the single line is considered a line group of size one and has a line group identification number assigned to it.

1.5 Alternate Delivery

A DPC on the synchronous interface may specify one alternate DPC line group (message forwarding) address to which messages from the Transaction Network will be delivered during periods of outages or overload of the primary line group. This alternate delivery may be to another line group the DPC subscribes to or to some other DPC's line group that the DPC has contracted with to handle alternate delivery traffic.

1.6 Undeliverable Messages-Message Status

Any message that encounters a difficulty which prevents delivery shall be returned to the originator with an indication in the heading information (message status) that the message was undeliverable. Any undeliverable messages that cannot be returned to the originating DPC (or specified alternate delivery address) will be dropped.

1.7 Protocol

The data link control procedures are based on American National Standards Institute protocol standards and are compatible with Binary Synchronous Communication (BSC) procedures presently utilized by the majority of computer systems. The data stream consists of 7-bit American National Standard Code for Information Interchange (ASCII) plus odd parity with the least significant bit transmitted first. A single Longitudinal Redundancy Check (LRC) character (defined as the "exclusive or" of each message character) will be accumulated for each record transmitted.

1.8 Message Formats

A message is a single entity consisting of a single heading field and a single text field. Messages to a DPC from a terminal are referred to as inquiry messages. Messages from a DPC to a terminal are referred to as response messages. The Transaction Network will handle messages independently of any previous or succeeding messages.

DPCs are required to use message heading formats specified by this document. The headings follow proposed American National Standards Institute Message Heading Formats for

Information Interchange Using ASCII. The format options must be specified in the service order at installation time.

The text format is left to the customer to specify, except for:

a) service messages (Section 4) addressed to the Transaction Network,

b) response messages to a dial-in telephone requiring Automatic Voice Answerback (AVA).

The Transaction Network is transparent to text information except for certain control characters and for predetermined one to one code conversion.

The DPC may specify the partitioning of transmitted or received messages into records which are not to exceed a DPC specified maximum length. The messages and/or records may also be grouped together into blocks for transmission to and from the DPC.

1.9 Message Flow

The Transaction Network will provide for the interactive flow of messages to and from the DPC. In general, the Transaction Network will accept any message flow from the DPC subject to an overall maximum number of characters per block, records per block and blocks per transmission. If the DPC is not capable of supporting message flow flexibility, the DPC may constrain the message flow from the Transaction Network to the DPC by specifying several message flow options in the service order.

1.10 Synchronous Interface Options

The synchronous interface is based on American National Standards Institute applicable standards. The Transaction Network will accept any data flow from a DPC that meets the framework of the following interface specifications.

To aid in adapting existing installations to this synchronous interface specification, a number of options are available (See Section 8 for a summary) to facilitate the interfacing with the DPC.

1.11 Summary of the Transaction Network Synchronous Interface

Data Link Control Procedures	Binary Synchronous Communication (BSC) Procedure - half duplex data transfers.
Mode	Contention
Code	ASCII
Parity	Odd
Rate	2.4K, 4.8K, or 9.6K bits/sec (BPS)
Facilities	Dedicated point to point, full duplex analog or digital data channels;
Transmission	Synchronous
Data Sets (Telephone Company)	Analog - 201C, 208A or 209A (speed dependent) Digital - Data Service Unit (DSU) or Channel Service Unit (CSU).

2.0 Administration

The Transaction Network provides a number of administrative functions in handling traffic on the synchronous interface. These functions include service messages, message status information, class of service, line groups, alternate delivery, and identification numbers.

2.1 Numbering Plan

The number plan of the Transaction Network for message addressing is of the form $X_1X_2X_3X_4X_5X_6X_7$- where X_n is any of the digits 0 through 9.

2.1.1 Transaction Network Identification

The digits $X_1X_2X_3$ identify and are assigned uniquely to each Transaction Network.

2.1.2 Station Identification

Digits $X_1X_2X_3$ will be those corresponding to the Transaction Network serving the station. Digits $X_4X_5X_6X_7$ shall be assigned by the telephone company to identify the station. The identification numbers are for use in the message heading information. The Transaction Network shall contain tables to translate these digits into the logical and physical location of each station on the network.

2.1.2.1 DPC Identification

Each synchronous line serving a DPC shall be assigned a unique $X_4X_5X_6X_7$ identification number per Transaction Network. The allocation of digits is in the range 0000 through 0998 yielding 999 possibilities.

Individual line numbers will generally be assigned beginning with 0998 and continue in descending order in the range of allocated DPC numbers.

Individual line numbers shall be used for service messages, maintenance and testing between the DPC and Transaction Network but not for message routing.

A line group number (Section 2.4) will be assigned to each line for message routing in addition to the unique individual line number. The line group number will be a single number for all lines in the same line group.

Line group numbers will generally be assigned beginning with 0000 and continue in ascending order in the range of allocated DPC numbers.

2.1.2.2 TRANSACTION Network Service Messages

Service messages will use the $X_4X_5X_6X_7$ identification number of 0999 in the heading information.

2.1.2.3 Polled Type Terminals

Each polled terminal shall be assigned a unique $X_4X_5X_6X_7$ identification number per Transaction Network. The allocation of digits is in the range 1000 through 7999, yielding 7000 possibilities.

2.1.2.4 Dial-In Type Telephone

The $X_4X_5X_6X_7$ digits for dial-in telephones shall refer to the access port of the Transaction Network reached by the telephone. The allocation of digits is in the range 8000 through 8999 yielding 1000 possibilities.

2.2 Class of Service, Class of Service Character (CSC)

A DPC may elect to offer service to any of three classes of terminals; restricted polled access and unrestricted polled access terminals, and dial-in telephones. Two service classes are defined for calls between DPCs: Affiliated and Unaffiliated.

The Transaction Network as part of its administration function shall contain tables identifying the service class of each polled terminal and the classes of service specified by each DPC. The class of service refers to the population of terminals and DPCs that a DPC has selected to serve.

Messages originating from DPCs shall include the class of service character (CSC) for the terminal or addressed DPC in the heading information. Messages for which the class of service does not correspond i.e., class of service of called station and DPC do not match, will be returned to the originating party with the appropriate message status indication in the heading information (Section 3.2).

2.2.1 Restricted Polled Access Terminal CSC

The CSC for a restricted access polled terminal shall be assigned by the telephone company and furnished to the DPC in the range 0110000_2 (ASCII "0") to 0111001_2 (ASCII "9").

The CSC shall correspond to the position of the DPC in the list of DPCs the restricted polled terminal is allowed to access. The list is maintained by the Transaction Network per agreement with the DPCs comprising the list.

The CSC 0110000_2 (ASCII "0") corresponds to the implied DPC address allowed a restricted polled terminal. The Transaction Network will allow implied addressing only per agreement with the DPCs in a given list. Where a DPC does not enter into agreement with other DPCs, the restricted

polled access terminal will have a list of size one and the DPC may or may not specify the implied address option.

2.2.2 Unrestricted Polled Access Terminal CSC

The CSC from an unrestricted polled access terminal is 0111111_2 (ASCII "?").

2.2.3 Dial-In Telephone CSC

Upon establishment of a connection to a dial-in telephone, the Transaction Network will assign a CSC to this connection and will insert this CSC in the message heading of all inquiry messages received while the connection is maintained.

The CSC is used not only to distinguish dial-in service, but also to distinguish successive uses of the dial-in port of the Transaction Network. The CSC is in the range 1010000_2 (ASCII "P") through 1011111_2 (ASCII "_"). The CSC used in the heading of the inquiry message delivered to the DPC must also be used in the response message originated by the DPC to assure delivery of the response message to the proper telephone.

2.2.4 Affiliated DPC

An affiliated DPC accepts messages only from other DPCs belonging to the same affiliation. A DPC may specify up to ten (10) affiliations in the service order placed with the telephone company. Each affiliation is established by the DPCs involved and may consist of any number of DPCs.

2.2.4.1 Affiliated DPC CSC

The CSC shall be assigned by the telephone company and furnished to the DPC in the range 0100010_2 (ASCII " " ") to 0101001_2 (ASCII ")").

2.2.4.2 Affiliation Identification

Each affiliation shall be assigned a unique three character identification number by the telephone company. The identification number shall consist of a two character station identifier whose contents may consist of any value

between 0110000_2 (ASCII "0") to 1111111_2 (ASCII "DEL") inclusive, followed by the CSC defined in Section 2.2.4.1.

2.2.5 Unaffiliated DPC

An unaffiliated DPC accepts messages from any other DPC that identifies itself as unaffiliated.

2.2.5.1 Unaffiliated DPC CSC

The CSC assigned is 0100001_2 (ASCII "!").

2.2.5.2 Unaffiliated Identification

The unaffiliated identification number shall consist of two ASCII "SP" characters for the station identifier followed by the CSC defined in Section 2.2.5.1.

2.3 Station Identification

Stations may send up to two characters in the heading information to the Transaction Network in a subfield immediately following the SOH character. This subfield contains station identifier or station type information. This subfield if present in the inquiry message, will be passed on in the heading information to the DPC in the station identification subfield along with the CSC. If a station identifier is not received from the station spaces, (ASCII "SP") will be inserted to fill the subfield in the heading to the DPC.

The DPC will use the CSC and station type information to identify the type of station originating the message. This information is needed so that the DPC can generate a response message with the proper format e.g., a response message to a dial-in telephone requiring AVA responses has a different text format than a response message to a dial-in telephone requiring data responses.

It is left for the DPC and station to agree on the information contained in the terminal identification subfield on inquiry messages only. The Transaction Network however, requires that for a dial-in telephone, the second digit of the station identifier be a 4, 5, 6 or 7 for an AVA response. If not, the Transaction Network will assume the telephone requires FSK response (Bell System Technical

Reference - Dial-In Interface Specification PUB 41026). The Bell System Technical Reference - Switched Network Transaction Telephone System PUB 41804, defines the options and the corresponding identifier from a Transaction Telephone.

Response messages from the DPC must have a Transaction Network specified code in the station identification subfield corresponding to the response message protocol to be used (Section 9) in delivering the response message to the terminal. These station identifier characters are not passed on to the called station.

If the response message is to a DPC, the affiliation identification (Section 2.2.4.2) or the unaffiliated identification (Section 2.2.5.2) shall be inserted in this subfield. These characters will be passed on to the called DPC.

2.4 Line Group

Each line to a DPC shall be assigned a line group identification number for message routing. If a line group has more than one line, each line shall be assigned the corresponding line group number. The DPC shall specify the arrangement of the line groups (number of lines, type and transmission rate) in accordance with the traffic handling capacity required by the telephone company.

A single line shall be considered as a line group of size one. If a DPC specifies more than one line in a line group, the Transaction Network will distribute the traffic among the specified lines in the group. A line group may have a mixture of analog and digital facilities at different speeds. Lines in the same line group must specify the same class of service.

In case of a line failure in a multiple line group the Transaction Network will distribute traffic to the remaining active lines. If the entire line group is unable to accept traffic, messages will be routed to the alternate delivery address or returned to the originator with the appropriate message status indication in the heading information.

2.5 Alternate Delivery

A DPC may elect alternate delivery to mitigate the effects of traffic overflow and scheduled or unscheduled synchronous channel outage, maintenance down time, computer outage or press of other computer tasks. The alternative delivery line group is specified in the service order. Attempts to deliver inquiry messages will always begin with the primary line group and proceed to the alternate line group as required. The alternate line group may be another line group the DPC subscribes to or another DPC's line group which has been contracted to handle the primary DPC's alternate delivery traffic. A DPC is also required to specify the line group identification number(s) for which the DPC line group is accepting alternate delivery traffic from.

An alternate delivery line group need not have the same class of service options (restricted, unrestricted dial-in, affiliated, or unaffiliated) as the primary line group(s) specified. An alternate delivery line group shall be capable of handling the additional traffic of the primary DPC line group(s) (up to a maximum of nine line groups) for which they are serving as alternate delivery locations.

The heading information (called party, calling party, terminal identification subfield) will not be changed in messages delivered to an alternate delivery line group. The alternate line group shall recognize from the heading information that the message was originally intended for a primary line group.

The Transaction Network shall make any changes in speed, message flow, format options, etc. that have been specified by the alternate line group for messages delivered on its lines.

The Transaction Network checks the heading information on messages to or from a given DPC line group, to see that the identification number corresponds to the primary line group identification or to a line group identification that tne group is serving as an alternate delivery address for, as indicated in the service order.

Response messages transmitted over an alternate delivery line group should use the primary line group's heading

information, to avoid any class of service conflict between the terminal and alternate line group which would result in an "undeliverable" message status being returned to the DPC. For example, a DPC line group which normally accepts unrestricted polled access terminal traffic, can accept restricted polled access terminal traffic as an alternate delivery location. If the response message did not use the primary line group identification number and CSC in the heading information, the Transaction Network would return the message as "undeliverable." Additionally, even where a CSC conflict did not arise, a terminal may not accept the response message if the DPC identification does not agree with the DPC identification used in the corresponding inquiry message.

2.5.1 Unscheduled Outages

In case of unscheduled outages, switching from the primary line group to the alternate line group will proceed automatically.

2.5.2 Traffic Overload

If a DPC specifies an alternate delivery line group, inquiry messages will be delivered to that alternate line group when the traffic to the primary line group has filled the allotted message queue.

2.6 Example of Administration Function Usage

Figure 2 shows a possible configuration of a Transaction Network's synchronous lines. The metropolitan area Transaction Network identification is indicated as 234 in the figure. The 2340999 number refers to the identification number used for service messages delivered to and from the Transaction Network.

DPC A has subscribed to three 2.4K BPS analog data channels as a line group. A 201C data set terminates each dedicated line at the DPC. The Transaction Network identification number of this line group has been assigned as 2340010. This identifies the address of all three lines. The Transaction Network will distribute traffic over the three lines. In the event of an outage on one or more of the lines, the Transaction Network will distribute traffic to the remaining operational lines. Alternate delivery of

traffic intended for DPC A will not occur until all lines in the line group are out of service or a traffic overload of the line group queue occurs.

The numbers 2340991, 2340992 and 2340993 identify the three lines that make up the 2340010 line group for the purpose of telephone company testing and service messages.

DPC B subscribes to two analog lines, one at 9.6K BPS terminated with a 209A data set and one at 2.4K BPS terminated with a 201C data set. These have been selected as a line group with a Transaction Network assigned identification number 2340020. The numbers 2340980 and 2340985 identify the two lines in the line group for testing and service messages.

DPC C subscribes to three lines, one at 4.8K BPS terminated with a DSU, one at 4.8 K BPS terminated with a 208A Data Set and the third at 9.6K BPS also terminated with a DSU. The DPC has specified each of these lines as a line group (of size one), with Transaction Network assigned identification numbers of 2340031, 2340032, and 2340040 respectively. DPC C may have chosen to offer restricted service to a group of restricted access polled terminals on its 2340031 line group. The 2340032 line group may be for dial-in telephone traffic, while the 2340040 line group may offer a service to the general class of unrestricted access polled terminals connected to the Transaction Network.

As an alternate delivery address, DPC C could option one of the other two line groups i.e.

alternate delivery for ... 40 could be ... 32, or ... 31,
alternate delivery for ... 32 could be ... 40, or ... 31,
alternate delivery for ... 31 could be ... 40, or ... 32.

The line identification number assigned for service messages and testing for...40 is 2340956,
...32 is 2340955,
...31 is 2340954.

Alternate delivery for DPC A's line group ... 10 could be DPC B's line group ... 20 and vice versa, if A and B contract to perform such service for each other.

The ability to subscribe to multiple lines either as single lines or as line groups with alternate delivery addressing, allows a DPC to provide adequate lines to meet peak demand, as well as average traffic flow and service reliability, even in the event of line or equipment failure. This may be important to DPCs offering services that require greater reliability then achieved using transmission facilities with typical data processing equipment.

3.0 Message Status - Undeliverable Messages

Any message which encounters telephone company or customer equipment irregularities not covered by the data link protocols, upon being transmitted through the Transaction Network, will be delivered to the called number or returned to the calling number, as is possible, and will have inserted by the Transaction Network in the message status subfield of the heading information an indication of the specific irregularity encountered. If the message is undeliverable it shall be returned to the calling number with the original called number and the calling number subfields reversed i.e., the undeliverable message will be returned as if it were a message addressed to the DPC. A single exception is a message from the DPC in which a heading cannot be found. The Transaction Network will automatically drop such messages.

The message status subfield will be present in the message heading on all messages from the Transaction Network. Messages not encountering irregularities will have a normal message status (Section 3.3) indication.

All DPCs must accept the message status subfield as part of the data link message format specification (Section 6.2). Subsequent usage of the information contained in the subfield is customer dependent.

A DPC response message need not contain a message status subfield. However, if included, it shall contain the "normal message" status or shall be stuffed with ASCII "SP" characters.

3.1 Message Status Format

Irregularities reported shall be identified by two ASCII characters of the form X Y (X transmitted first, followed by Y) for all messages handled by the Transaction Network. X and Y represent any of the ASCII digits zero through nine.

The first digit, X, indicates the generic class of the irregularity encountered while the second digit, Y, describes the specific irregularity. The irregularities have been classified according to the first digit, X, so that when multiple irregularities, X_1, ... X_n >0, occur for a particular message, then X = minimum (X_1, ... X_n) will be the only message status reported, it being the first encountered anomaly. For example, if irregularities (X,Y) = (1,3) and (4,1) are present, then (1,3) will be the message status reported.

If irregularities (X,Y) = (5,Y_1) and (5, Y_2) are encountered then the Y field value corresponding to the most severe error (highest priority) will be inserted into the delivered message. Priority is relative and shall be determined by the Transaction Network.

3.2 Message Status Classes

Five generic classes of message status are defined:

Class 0 - Normally handled messages (X=0).

Class 1 - Irregularities encountered during message transmission to the Transaction Network (X=1,2).

Class 2 - Irregularities encountered by the Transaction Network routing algorithms while attempting to determine the called station (X=3). (X=4 is reserved for future uses of this type.)

Class 3 - Irregularities encountered in the forward path that prevents delivery (X=5), (X=6 is reserved for future use.)

Class 4 - Irregularities encountered during delivery of message (X=7). (X=8 is reserved for future uses of this type).

X = 9 is reserved for future use.

The above classes follow sequential actions in transferring a message. An irregularity encountered in Classes 1 through 3 will prevent the next sequential step in the message transfer process and cause the message to be returned to the DPC.

Any "undeliverable" messages that cannot be returned to the originator or alternate delivery location will be erased by the Transaction Network.

3.3 Normally Handled Messages (Class 0)

Class 0 message status with (X,Y) = (0,0) indicates no irregularities were encountered during transfer of the accompaning message.

If a DPC elects to include the message status subfield in the heading information of transmitted messages, it shall contain the normal message status (X,Y) = (0,0) or else ASCII "SP" characters. No other message status is allowed in a response message from the DPC to the Transaction Network.

3.4 Reception Irregularities (Class 1)

Class 1 message status (X=1) indicates seeming data link protocol acceptance of a message, i.e., a positive acknowledgment was transmitted, with subsequent detection of an error in the received message which precludes it from any further processing for delivery through the Transaction Network.

3.4.1 Heading Format Error

Class 1 message status with (X,Y) = (1,0) indicates an error in the specified heading format. Such errors include required heading subfield missing and incorrect heading subfield length.

3.4.2 Improper Use of Characters

Class 1 message status with (X,Y) = (1,2) indicates a character, such as a control character, has been improperly inserted into the heading or text fields. The definition

and usage of permissable characters are specified in Section 4 on format.

3.4.3 Protocol Error

Class 1 message status with (X,Y) = (1,4) indicates an error in the data link protocol not covered in the BSC procedures.

3.4.4 Invalid Calling Station

Class 1 message status with (X,Y) = (1,5) indicates the identification of the calling party does not correspond to any of those expected by the Transaction Network, either as the primary identification or alternate delivery identification.

3.5 Routing Irregularities (Class 2)

Class 2 message status (X=3) indicates a message that was successfully received by the Transaction Network but cannot be routed to the called number.

3.5.1 No Such Number

Class 2 message status with (X,Y) = (3,0) indicates no such called number is presently assigned within the Transaction Network.

3.5.2 Number Changed

Class 2 message status with (X,Y) = (3,1) indicates that the called number is no longer assigned. The called number had once been assigned to a station and a new number has now been assigned to that station.

3.5.3 Improper Class of Service

Class 2 message status with (X,Y) = (3,2) indicates an improper class-of-service identification. For example, this status applies to an attempt by a DPC to communicate with a restricted access terminal where the DPC has not been specified in the Service Order, for that terminal.

3.5.4 Invalid Called Number

Class 2 message status with (X,Y) = (3,3) indicates a call not allowed by the Transaction Network Service plan.

3.5.5 Invalid Calling Station Type

Class 2 message status with (X,Y) = (3,4) indicates an incorrect heading station identification subfield. For example, in a call from a DPC to an affiliated DPC, this status indicates that the calling DPC is not a member of the affiliation called.

3.6 Nonexistence of Forward Path (Class 3)

Class 3 message status (X=5) indicates that the message was not delivered because of an anomaly encountered in the forward path.

3.6.1 Called Station Unavailable

Class 3 message status with (X,Y) = (5,0) indicates the called station is not currently accepting messages. The unavailability of a called station can be caused by hardware failures in the forward path or by that station being out of service.

3.6.2 Called Station Queue Overflow

Class 3 message status with (X,Y) = (5,1) indicates a queue overflow in the Transaction Network for the called station with no alternate delivery point available.

3.6.3 Unanticipated Response

Class 3 message status with (X,Y) = (5,2) indicates that the received response message is not permitted at this stage in the dialogue. For example, a dial-in telephone cannot receive a second response until it has entered another inquiry message.

3.6.4 Network Trouble

Class 3 message status with (X,Y) = (5,3) indicates that the message cannot be forwarded due to trouble in the Transaction Network.

3.6.5 Invalid Called Station Type

Class 3 message status with (X,Y) = (5,4) indicates that the station type of the called station is incompatible with that specified in the station identification field of the message heading. For affiliated DPC to DPC calls, this status also indicates that the called DPC is not a member of the affiliation.

3.6.6 No Such Phrase

Class 3 message status with (X,Y) = (5,5) indicates that the DPC specified, as part of a voice response message, the number of a non-existent phrase. None of the message will be delivered.

3.6.7 Service Message Cannot be Processed

Class 3 message status with (X,Y) = (5,6) indicates that the service message is undecipherable and/or cannot be processed.

3.6.8 Incomplete Transmission

Class 3 message status with (X,Y) = (5,7) indicates that the dial-in port disconnected during transmission of a response.

3.7 Forwarding Irregularities (Class 4)

Class 4 message status (X=7) indicates an irregularity encountered in delivery of the message. This irregularity does not present the message from being delivered.

3.7.1 Possible Duplicate Message

Class 4 state fields with (X,Y) = (7,0) indicates a possible duplicate message originated by the Transaction Network. This status is not reported if any other irregularity is also to be reported.

3.8 Summary of Message Status

CLASS 0 - No Irregularities Encountered (X, Y) = (0, 0)
Normal Message

CLASS 1 - Irregularities Encountered Upon Transmission To the Transaction Network

(X, Y) = (1, 0)	Heading Format Error
(X, Y) = (1, 2)	Improper Use of Characters
(X, Y) = (1, 4)	Protocol Error
(X, Y) = (1, 5)	Invalid Calling Number

CLASS 2 - Irregularities Encountered Upon Transaction Network Routing

(X, Y) = (3, 0)	No Such Number
(X, Y) = (3, 1)	Number Changed
(X, Y) = (3, 2)	Improper Class of Service
(X, Y) = (3, 3)	Invalid Called Number
(X, Y) = (3, 4)	Invalid Calling Station Type

CLASS 3 - Irregularities Which Prevent Message Forwarding From the Transaction Network.

(X, Y) = (5, 0)	Called Station Unavailable
(X, Y) = (5, 1)	Called Station Queue Overflow
(X, Y) = (5, 2)	Unanticipated Response
(X, Y) = (5, 3)	Transaction Network Trouble
(X, Y) = (5, 4)	Invalid Called Station Type
(X, Y) = (5, 5)	No Such Phrase
(X, Y) = (5, 6)	Service Message Cannot Be Processed
(X, Y) (5, 7)	Incomplete Transmission

CLASS 4 - Irregularities Encountered Upon Forwarding Message

(X, Y) = (7, 0)	Possible Duplicate Message

4.0 Service Messages

A service message is defined as a message in which the Transaction Network identification number $X_1X_2X_3$-0999 appears in the message heading information as the called or calling number (Section 6.3).

Service messages are used to coordinate the operation of the DPC and the Transaction Network. These messages are used to activate and deactivate lines and line groups, request and provide line and line group states and also

request and provide a test message loop-around (message reflection).

Service messages may not be used to change service order specifications such as format, protocol or class of service options, alternate delivery location or station number assignements. Service messages shall pertain only to the line group upon which they are transmitted. For example, a DPC may not request state changes for line groups other than the one on which the request was received, even if the line group is used as an alternate delivery location by that DPC, or is maintained by the DPC.

Service messages shall be treated like any other message on the data link. They shall follow all protocol and message format requirements and also all format options, message flow options and protocol options specified by the DPC.

The Transaction Network will accept service messages on any line in a line group serving a DPC (provided such messages are permissible for the line state as defined later in this section). The DPC shall be responsible to coordinate its service messages in such a manner to eliminate conflicting requests over different lines within the group. The DPC may choose to send service messages on a single line in the line group, whenever possible, to coordinate its requests.

All operations involving service messages consist of two parts:

1. A request service message for action by either the DPC or the Transaction Network.

2. An acknowledgment service message containing a report, affirmation or denial of the request by either the DPC or the Transaction Network.

Sequence numbers within the text of the service message are used to coordinate the acknowledgment with the request. Only one request service message may be outstanding at a given time. A single request service message may contain multiple requests, however.

There are four types of service messages;

1. Reflection

   A reflection request is a request for the reflection of the accompanying text to be sent over the same line the request was received. A reflection service message acknowledgment is the return of the text previously sent as a reflection request.

2. Set State

   A set state request is a command to change the state of a line or line group. A set state acknowledgment is the affirmation or denial of the set state request.

3. State Report

   A state report request is a request for the present line or line group state. A state report acknowledgment is the reporting of the requested line or line group state.

4. Halt/Wait

   A halt/wait request is a request for the receiving party to halt (and cancel) all service message processing and transmit an affirmative acknowledgment. It is used to restore the service message protocol whenever unanswered or unprocessable requests are detected. A halt/wait acknowledgment is the affirmation of the halt/wait request.

The Transaction Network shall return to the DPC any service message requests that cannot be processed, with the appropriate message status indication in the heading. A DPC receiving an undecipheral service message may issue a state report request, issue a halt/wait request or wait for the Transaction Network to issue a halt/wait request. The Transaction Network will issue a halt/wait request if it fails to get an appropriate acknowledgment. If the Transaction Network had issued a set state request and now receives a state report request in place of a set state acknowledgment it will issue a halt/wait request.

The Transaction Network will only issue set state requests as a result of detected equipment failures, or recovery, or as a result of a line group state change brought about by a DPC set state request. All set state requests issued by the Transaction Network will have priority over any DPC request affecting the line or line group states.

The DPC shall wait for an affirmative acknowledgment by the Transaction Network of any set state requests before putting any lines or the line group into the requested state. The Transaction Network implements all state changes before sending a set state request to the DPC. The Transaction Network set state requests received by the DPC must be affirmatively acknowledged.

4.1 Line and Line Group States

A line or line group (the term group shall be used to refer to a line group) can be in various states, each of which defines its capabilities on the Transaction Network. Group states control call process, i.e., which types of messages are deliverable to the group while in that state, while line states have primarily to do with the line's operational status, i.e., whether any type of message is deliverable. State names and number assignments (K=n) are indicated in Table 1. Data messages refer to inquiry and response messages between terminals and the DPC and to messages between DPCs. The following definitions apply.

4.1.1 Unavailable State

A group or line will be placed in the Unavailable state (K=6) only by the telephone company upon installation or removal of the group or a line within the group. No messages are to be transmitted on a line or group which is in the Unavailable state. The DPC cannot cause a change in a line or a line group in the Unavailable state. The Transaction Network shall notify the DPC with a "set state" request when the line or group is taken out of the Unavailable state.

4.1.2 Out of Service/Other (OO) State

A group or line will be in the Out of Service/Other (OO) state (K = 5) only by action of the Transaction Network upon encountering Transaction Network related equipment

failures. The Transaction Network will normally put each line subscribed to by the DPC into the OO state as the line becomes unavailable for any transmissions.

Independent of the current state (previously requested by the DPC), the following actions occur. No data transmissions will be allowed in the OO state and all transmissions from the DPC will be ignored. Upon correction of the difficulties which caused the OO state, the Transaction Network will place the line and/or group into the Active/DPC Data Only (A/DO) state (not it's state previous to the setting of the OO state) and will inform the DPC through a "set state" request. The DPC is then responsible to set a new state (such as Active) by in turn issuing "set state" requests.

Note that a group will normally enter the OO state if, and only if, every line in a group is in the OO state. Thus, if the group is OO, the group and each line in the group will be returned to the A/DO state and must be individually set by the DPC. If the group does not enter the OO state, but one or more lines in the group are OO, then when these lines return to the A/DO state, only these lines need be reset to the desired state by the DPC. See Appendix A for exception.

4.1.3 Out of Service/Far End Test (OFET) State

Lines within a group may be set to the Out of Service/Far End Test (OFET) state (K = 4) only by the DPC. The group may not be set to this state by the DPC. However, if all lines are placed in the OFET state, the group state shall be considered to be in the OFET state and the Transaction Network will issue a "set state" request to the DPC indicating the group state change. No further data transmissions will be allowed in the OFET state and the Transaction Network System will test out all related telephone company equipment. If the tests fail, the line will be placed in the OO state and the DPC will be so informed via a "set state" request (over a working line in the group if possible).

Otherwise the Transaction Network will return the line to the A/DO state and so inform the DPC with a "set state" request. If the group state was also forced into the OFET state, the group state will also return to the A/DO state

and the DPC so informed via a "set state" service message. Otherwise, the group state will not change and there will be no report of the group state.

It is then the responsibility of the DPC to set, if desired, each line and, if necessary, the group to any desired allowable state.

4.1.4 Out_of_Service/Far_End_Removed_(OFER)_State

The Out of Service/Far End Removed (OFER) state (K = 3) may be set only by the DPC to stop all data transmissions from the Transaction Network. The Transaction Network will, however, accept service message requests and will send the appropriate service message acknowledgments (all data messages will be ignored). The line(s) or group will remain in the OFER state until the DPC sends a new "set state" request. This state may be used for such purposes as scheduled down time of the line(s) by the DPC.

If the group, but not the individual lines, is set to the OFER state, the line states will not change and upon resetting the group state to a higher allowable state, each line will remain in its previous state (before the OFER state request was issued). If lines are placed in the OFER state, each line must, however, be individually reset to a new state to reactivate the line.

4.1.5 Active/DPC_Data_Only_(A/DO)_State

A line or group may be placed in the Active/DPC Data Only (A/DO) state (K = 2) by the Transaction Network, as previously discussed, or by the DPC. The A/DO state allows service messages in both directions but only data messages originated by the DPC. The DPC may use this state as an intermediate state between active and OFER. For example, to accomplish an orderly shut-down of the DPC, the DPC may wish to finish processing all received messages but accept no new messages. The DPC may also use this state for normal operations if it desires the line to be used for outputting with no contention (other than possibly for service messages) for data message transmissions from the Transaction Network on that line.

If the group was placed in the A/DO state by the DPC, the line states will not change and resetting the group to the

active state will cause each line to remain in its previous state. Any undeliverable messages that occur while the group is in the A/DO state will be returned to the alternate delivery location if possible or else dropped.

4.1.6 Active State

The Active state (K = 1) may only be set by the DPC and allows full use of the group or line for all data and service messages. The Active state is the normal state for both lines and groups.

4.2 Line and Group State Relationships

The state of a group is partially determined by the state of the line in that group having the highest functional state. The functional states of a line are ranked (hignest rank = 1) as follows.

Rank (K)	Highest Functional Line State	Corresponding Group State
1	Active	Active
2	Active/DPC Data Only (A/DO)	A/DO
3	Out of Service/Far End Removed (OFER)	OFER
4	Out of Service/Far End Test (OFET)	OFET
5	Out of Service/Other (OO)	OO
6	Unavailable	Unavailable

The line states jointly dictate the highest state that a group may assume. The DPC may set the group state to a state lower than the highest state permitted by the line states.

For example,

- if any line is Active, the group may be in the Active, A/DO or OFER state, but
- the group becomes Unavailable only if all of its lines are Unavailable (because the DPC cannot cause this state).

4.3 State Administration Facility (SAF)

The DPC may specify in the service order, the priorities on a per line basis for the line group, to indicate over which line the Transaction Network may send service messages. More than one line in the group may be specified to have the same priority, in which case the Transaction Network shall choose one of the lines at the given priority level at the time of transmission. The line (or lines) which at a given time is at the highest priority level for service message transmission is referred to as the Service Administraion Facility (SAF). The SAF will change as line states change. Reflection service messages will not follow SAF priorities (see 4.8). A line may normally be in the SAF only if the line is in the Active or A/DO states. However, if all lines in a group are in the OFER or lower states, then a line in the OFER state may be used for the SAF. In the latter case, the SAF will be used only for acknowledgment service messages since the Transaction Network will not issue request service messages over OFER state lines. Finally, if the group is in the OFET or lower state, no service messages are possible until the Transaction Network returns the group to the A/DO state.

4.4 Alternate Delivery

If the group state is not in the Active state, the alternate delivery mechanism will be automatically activated. If the alternate delivery group is not Active or the DPC did not specify one, all messages will be returned to the sender as an "undeliverable message" with the appropriate message status indication in the heading information.

4.5 Service Message End-to-End Protocol

The Transaction Network and DPC coordinate state changes through the transfer of service message. To coordinate the orderly transfer of service messages, the following end-to-end protocol must be followed. While the DPC may designate various states for a line or group to accommodate its needs, the Transaction Network will issue request service messages only upon encountering the failure, testing or repair of Transaction Network equipment, and to inform the DPC of any state changes brought about as the result of a DPC request.

To facilitate the orderly transfer of service messages, each request must receive an acknowledgment. In addition, no more than one request service message may be outstanding at any given time. However, in certain conditions, multiple requests may be contained in a single request service message. A service request will be considered to be outstanding if acknowledgments to all the requests in the original request service message have not been received by the request originating party.

In case of simultaneous requests by both Transaction Network and a DPC, the DPC request will be rejected and returned with the appropriate message status indication since Transaction Network requests will be based on higher priority requirements (e.g., failures). A DPC is required to affirmatively acknowledge a Transaction Network request. Upon processing and acknowledging the Transaction Network request, the DPC may then reissue the rejected request. Before the delayed request is transmitted, however, it should be checked to see if it still remains meaningful in light of the state changes that have since transpired.

4.5.1 Halt/Wait Requests

If the Transaction Network or DPC detects that the Transaction Network System and DPC have gone out of synchronization with respect to each other, e.g., no acknowledgments or garbled service messages, it may reset the service message protocol by issuing a "halt/wait" request service message. The Transaction Network will issue this request and acknowledgment only over the SAF.

Upon receipt of the request, the receiving party must halt (and cancel) all service message processing and transmit an acknowledgment. Furthermore, if the DPC receives this request, it may not issue another request (must "wait") over the group until it receives, processes and acknowledges at least one additional request service message from the Transaction Network. The Transaction Network will also "wait" whenever possible but, since Transaction Network requests result solely from hardware repairs or failures, the "wait" feature will not be guaranteed.

4.6 Message Priorities

When more than one service request becomes applicable by either the DPC and Transaction Network, transmission of the requests and data messages must be done in the following order:

- "halt/wait" service message
- state-related service messages
- other service messages
- data messages.

Both parties are responsible for adhering to this priority scheme.

4.7 Service Message Format

A service message employs the standard heading format used for data messages. Service messages are identified by the use of the appropriate $X_1X_2X_3$ 0999 identification number in the heading information. This section deals with the format of the text field. All service messages shall have a text field (immediately following STX) of the following form wnere t and s are strictly numerics.

Type	Sequence Number	Requests or Acknowledgments
t	s	# 1 + # 2 + ... + #N

In the type field,

t = 1 identifies a group of "set state" requests,
t = 2 identifies a group of "set state" acknowledgments,
t = 3 identifies a group of "state report" requests,
t = 4 identifies a group of "state report" acknowledgments,
t = 5 identifies a group of "message reflection" requests and
t = 6 identifies a group of "message reflection" acknowledgments.
t = 9 and t = 0 are used uniquely for the "halt/wait" request and acknowledgment service messages, respectively.

The sequence number shall be incremented by 2 (modulo 10) upon the issuance of each new request, $0 \leq s \leq 9$, with the even and odd digits used for requests initiated by the Transaction Network and DPC, respectively. All acknowledgments to a request service message containing multiple requests shall contain the single sequence number of the original group of requests. For example, if the original request service message contains several requests resulting, perhaps, in multiple acknowledgment service messages, each of the latter messages shall contain the same sequence number as contained within the original request service message.

Immediately following the two digits, t and s, are the individual requests or acknowledgments. Multiple requests or acknowledgments may be combined within a single service message subject to the following constraints.

1. The ASCII "+" character must separate each request or acknowledgment.

2. Requests and acknowledgments must be of one type, t. For example, requests and acknowledgments may not be combined nor may "set-state" and "message reflection" requests and/or acknowledgments be combined.

3. If requests or acknowledgments are grouped and any one or more becomes garbled, the entire service message shall be discarded. When received by the Transaction Network, the service message shall be returned as an unprocessed service message with the appropriate message status in the heading information. When received by a DPC, a state report message may be returned or the DPC can wait for the Transaction Network to initiate a "halt/wait" request or the DPC may issue its own "halt/wait" request.

4. The option of having only one request per service message from the Transaction Network may be chosen on a per group basis at installation time.

5. The Transaction Network will always send acknowledgments in the same form the request was received.

a) Single request - single adknowledgment

b) N requests/service message - N acknowledgments/service message.

6. Station identification subfield (Section 6.3.3) for service messages will always contain 3 ASCII "SP" characters.

4.8 Service Message Types

This section defines the various service message requests and acknowledgments. It should be understood that not all of the following service messages have meaning in every installation and therefore need not be implemented. Figure 3 shows the text formats required for all service messages and indicates which ones are required to be implemented by the DPC.

All requests or acknowledgments are preceded by a two-digit type code, TC, which identifies the type of request or acknowledgment.

4.8.1 State-Related Service Requests and Acknowledgments

The following state-related service requests and acknowledgments will be transmitted by the Transaction Network over the designated SAF or by the DPC over any line (in a state allowing such messages) and request either a change in line or group state or request information as to the present state of any line or group. Each line within a group shall be identified by its assigned seven-digit line number (LN) as described in Section 2.5.

4.8.1.1 Set Group State

Set group state service messages are requests to put the group into a specified state. The Transaction Network will only issue "set state" requests to set the states, K = 2 or 5, upon encountering hardware repairs or failures. Other Transaction Network "set state" request may be issued due to the result of a DPC issued "set state" request - e.g., a DPC request to put a line in the OFET that causes the group to assume a new state. The DPC may only issue

requests to set the states, K = 1, 2 or 3 (a line group of size one, allows K = 4 since group messages replace line messages) dependent on its requirements.

The request service message has the following format and may be grouped with set line state service messages,

t	s	TC	State	
1	N	00	K	+ . . .

where t, s need appear only at the beginning of each service message and K is the requested state. Only one set group state request may be outstanding at a given time. The sequence number N is a digit, $0 \leq N \leq 9$.

The effect of this request is to place the group in the requested state unless hardware problems prohibit this. The acknowledgment service message has the following format:

t	s	TC	State	
2	N	00 01	K	+ . . .

where if the request is honored, TC = 00 and the state reported is the requested new one. This is the only acknowledgment that may be sent by the DPC. If the request cannot be honored by the Transaction Network (due to hardware problems only), then TC = 01 and the state reported is the old, unchanged state.

The service message capability which sets the group to the Active state must always be implemented by the DPC and is used in lieu of the set line state service message if there is only one line in the group.

4.8.1.2 Set_Line_State

Set line state service messages are requests to put the line into a specified state. This request message may be grouped with other set group state and set line state service messages and has the following format:

t	s	TC	State	LN
1	N	02	K	$X_1 - X_7$ + - - -

where K is the requested state and LN is the number of the line to be changed. Only one such request for a given line may be outstanding at a time although several lines may be set simultaneously.

Again, the effect of this request is to place the line in a particular state unless hardware problems prohibit this. The acknowledgment service message has the following format:

t	s	TC	State	LN
2	N	02 03	K	$X_1 - X_7$ + - - -

where if the response is honored, TC = 02 and the state reported is the new state. This is the only acknowledgment that may be sent by a DPC. If the group state also changes as the result of this request, the Transaction Network will also send a "set state" request. If the request cannot be implemented by the Transaction Network (because of hardware problems only) then TC = 03 and the state reported is the old unchanged state.

This service message must always be implemented by the DPC if there is more than one line in the group. Again the Transaction Network will only issue requests to states 2 and 5. The DPC may issue requests to states 1, 2, 3 or 4.

4.8.1.3 Group_State_Report

Group state report service messages are requests for information as to the present group state. This request message may be grouped with line state report service messages and has the following format:

t	s	TC	State	
3	N	04	K	+ - - -

Where K is the group state perceived by the requesting party.

The present state of the group is reported with an acknowledgment service message of the following format:

t	s	TC	State	
4	N	04	K	+ - - -

where K is the present state of the group. The transmission of acknowledgments must always be implemented by the DPC and these service messages are used in lieu of the line state report service messages of Section 4.8.1.4 when there is only one line in the group.

4.8.1.4 Line State Report

Line state report service messages are requests for information as to the state of the specified line. This request message may be grouped with other line or group state report requests and has the following format:

t	s	TC	State	LN	
3	N	06	K	$X_1 - X_7$	+ - - -

where K is the line state perceived by the requesting party.

The present state of the line is reported with an acknowledgment service message using the following format:

t	s	TC	State	LN	
4	N	06	K	$X_1 - X_7$	+

where K is the present state of the line identified by the LN field.

The transmission of acknowledgment service messages must be implemented by the DPC unless there is only one line in the group.

4.8.2 Message Reflection Requests and Acknowledgments

The following "message reflection" requests may be transmitted over any line in the group. The associated acknowledgment, however, must be returned on the line upon which the request was transmitted. If this is not possible due to hardware problems, the request will be returned over another line in the group, if possible, and shall have an appropriate message status indication in the heading information.

"Message reflection" requests cause the accompanying character string to be returned as the acknowledgment service message. "Message reflection" requests have the following format:

t	s	TC	Character Stream
5	N	5X 6X 7X	A_1A_2 - - - - A_n

where the character stream may be any set of characters which does not violate the data link protocol and X is a digit $0 \leq X \leq 3$. Only a single request may be contained in any message. The acknowledgment shall have the following format:

t	s	TC	Character Stream
6	N	5X 6X 7X	A_1A_2 - - - - A_n

where A_1A_2 - - - A_n will be returned exactly as received.

The following subsections describe each of the possible reflection requests and their accompanying acknowledgments. The purpose of reflection requests is to provide a testing capability both upon installation of a new group and/or line and also as operational tests by both the Transaction Network and DPC. All "message reflection" requests except

TC = 50 may be sent only in the A/DO or OFER states and only by the DPC.

4.8.2.1 Single Message Reflection Request

When TC = 50, a single acknowledgment service message will be returned by the receiving station. The acknowledgment (as well as the request) will normally be transmitted according to the message flow data link options (characters per record, records per block, characters per block, blocks per transmission) along with other traffic. If the DPC, however, issues this request over a line in the A/DO or OFER state, one acknowledgment service message will be transmitted by the Transaction Network as the single block in that transmission to the DPC.

This is the only "message reflection" request which will be originated by the Transaction Network.

4.8.2.2 Multiple Message Reflection Request

When TC = 51, the Transaction Network acknowledgment to a single message reflection request will consist of a single block consisting of as many acknowledgment service messages (all identical) that are allowed by the message flow data link options selected by the DPC.

4.8.2.3 Multiple Block Message Reflection Request

When TC = 52, the Transaction Network will transmit two blocks in a separate, single transmission. Each of the two blocks will be formulated in the manner outlined in Section 4.8.2.2.

4.8.2.4 Null Message Reflection Request

Receipt of a message reflection request with TC = 53 shall cause the Transaction Network to ignore the echo request and not send back any echo acknowledgment service messages. This request may be combined with other "message reflection" requests to test the transmission of data in records and blocks from the DPC. This message, along with all other service messages, will be subject to message status indications as to irregularities encountered upon receipt of the message.

4.8.2.5 Extended Text Message Reflection Requests

The "message reflection" requests, TC = 60, 61 and 62 shall be identical in action to requests, TC = 50, 51 and 52, respectively, except that the character stream shall be extended to a full text length of 128 characters in the acknowledgment message. The expansion, as shown below, shall be accomplished by serially repeating the characters to a maximum length of 124 (128 minus t, s and TC).

t	s	TC	Character stream (124 characters)
6	N	6X	A_1A_2 - - $A_nA_1A_2$--$A_nA_1A_2$--$A_nA_1A_2A_3$

4.8.2.6 Modified Message Reflection Requests

The requests, TC = 70, 71 and 72 shall be identical in action to the requests, TC = 50, 51 and 52, respectively, except that the four character service message identification t, s and TC, will be omitted in the message reflection acknowledgment. The DPC must take care that the first four characters, $A_1A_2A_3A_4$, of the character stream do not inadvertently cause the message to look like a request or other acknowledgment from the Transaction Network. The message reflection acknowledgments may then be identified only by the presence of the Transaction Network number, $X_1X_2X_3$-0999, in the calling number field of the message heading.

4.8.2.7 Usage of Reflection Requests

The request, TC = 50, is intended for usage by either the Transaction Network or the DPC to test the operation of a given line. This request along with the remaining reflection requests are intended to aid the DPC in testing the operation of the line(s) and group prior to the production use of the line for data transfers.

4.8.3 Halt/Wait Requests and Acknowledgment

The Transaction Network will issue this request and acknowledgment only over the SAF.

The "halt/wait" requests have the following format:

t	s	TC
9	N	99

and the acknowledgments have the format:

t	s	TC
0	N	99

The "halt/wait" service request and acknowledgment may not be grouped with any other requests or acknowledgments in the same message.

4.9 State Transitions

The following sections define the causes of changes in the state of a line or a group in the Transaction Network. Most state transitions are caused by DPC initiated service messages, although some transitions are brought about through the actions of the Transaction Network.

4.9.1 State Transition Occurrences

State transitions of lines or the group when requested by a DPC shall take effect only upon receipt by the DPC of an acknowledgment, that the requests could be obeyed, from the Transaction Network. State transitions when requested by the Transaction Network shall take effect upon the issuance of the request by the Transaction Network. Thus, the Transaction Network shall be considered to have the master state table for the lines and group. The DPC may check its own table through the "state report" service messages.

4.9.2 Causes of State Transitions

For notational simplicity the following message classifications and their abbreviations are defined.

Activiation Message = (Set Active State)
(Act. Msg.)

A/DO Message = (Set A/DO State)

OFER Message = (Set OFER State)

OFET Message = (Set OFET State)

Passive Message = (Report States Request, Message
(PSV Msg) Reflection Request, Halt/wait
Request, Acknowledgments, Data)

The transition matrix is shown in Table 2. From the table, the following properties can be derived.

- Passive messages do not cause state changes.

- A group may only enter or leave the Unavailable state by action of the Transaction Network.

4.10 Service Message Examples

Figure 4 gives an example of a service message containing multiple requests. The format for the heading is discussed in Section 6. The example assumes a group of more than one line with a group number of 2010004 and line number identifications of 2010998, 2010996,.... To facilitate the orderly setting of states of the group and of a line within the group, both requests are contained in a single request service message. This is possible since both set group and set line requests have t = 1 and therefore can be grouped together.

The first two characters are t = 1 and an odd sequence number, s = 3, to indicate a request coming from a DPC. The following request puts the group into the A/DO (K=2) state to temporarily stop data messages to the DPC. Concurrently, a set line state request (separated by a "+" character) is sent to activate line 2010996 (TC = 02 and K = 1). The DPC may in another "set state" request set the group state to active (K = 1) and the line states will remain as before with line 2010996 now also active.

Figure 5 gives a typical example of service message usage. Upon establishing a good line connection, the Transaction

Network will inform the DPC by issuing a "set state" request to the A/DO. This will be sent repeatedly until the DPC also becomes active on the line and sends the acknowledgement. The DPC then sets the group to the active state to allow all normal transmissions. Some time later, the DPC detects a difficulty in reception on a line in the group and first tests the line by issuing a simple reflection request (TC = 50). After possibly detecting further difficulties, the DPC asks for a local Transaction Network test of its facilities by requesting the OFET test.

When all the tests pass, the line is again set to the A/DO state which the DPC acknowledges and resets the line or group to the active state.

Again data messages are passed until the DPC is required to go down for scheduled maintenance. At this time, the DPC sets the A/DO state to stop further inquiries but also allows it to finish processing responses to previously received inquiries. When the last response is transmitted from the DPC, the DPC sets the OFER group state to automatically initiate alternate delivery or the line state to OFER to allow use of the other lines in the group, only.

Upon conclusion of the scheduled maintenance, the DPC can then reactivate the group or line by again issuing a set active state request.

5.0 Data Link Control (DLC) Procedures

All data transfers over the synchronous interface use American National Standard Code for Information Interchange (ASCII) and DLC procedures in accordance with American National Standard, X3.28-1971, Subcategory 2.3 and Subcategory B2, with enhancements and capabilities that make them compatible with Binary Synchronous Communications (BSC) procedures as used by the majority of computer systems today.

The following descriptions of the Data Link Control (DLC) procedures for non-transparent data including connection, data transfer, and termination procedures are an outline - the ANSI standard definitions and usage given in ANSI X3.28-1971 apply.

All data transfers under the DLC procedures are half-duplex, point-to-point. To determine the direction of data transferral, either station when the line is idle, may bid for the line when it has a message(s) to send. The successful bidder then becomes the master station and may transmit data to the other station, which acknowledged the bid, which then becomes the slave station. This master/slave relationship is dynamic and is reestablished upon each successful line bid by either station.

In such a contention procedure, one station is predesignated to always be the primary station with the other station becoming the secondary station to resolve simultaneous contentions for the line. In all cases of simultaneous desire to transmit messages, the primary station shall always be the successful bidder.

Upon establishing the connection, the master station sends data blocks in a serial, synchronous, half-duplex mode of data transfer to the slave station. The slave station sends a reply to each data block consisting of a positive or negative acknowledgement to verify the validity of each block. The validity checks consists of a parity check on each character, as well as a Longitudinal Redundancy Check (LRC) of the entire data block.

All further error recovery is conducted by the master station through issuance of control sequences or retransmission of the data block up to a maximum number of retries as determined by the master station.

Upon conclusion of the transmission of data blocks, the master station relinquishes control of the line by transmitting the termination (EOT) sequence. This causes the line to again enter the idle state within which either station may again contend for the line when it has messages to transmit.

5.1 Class I and II Protocols

At service order time on a per line basis, the DPC may choose either Class I or Class II DLC procedures.

5.1.1 Class I Protocol

The Class I protocol is a basic DLC procedure. The Transaction Network will accept from the DPC most DLC procedures defined within the general ANSI or BSC procedures but will not transmit the optional "wait before transmitting- positive acknowledgement" (WACK) or the "reverse interrupt - positive acknowledgement" (RVI). In addition, the Transaction Network will always be designated the primary station for the connection procedure.

5.1.2 Class II Protocol

Under the Class II protocol, the Transaction Network will transmit, as is necessary, the WACK sequence to line bids and to data blocks but in all other respects, the DLC procedures are identical to Class I. Under the Class II protocol, the DPC may specify in the service order whether the DPC or the Transaction Network is to be the primary station for the connection procedure.

5.2 DLC Sequences

The following DLC sequences are used to implement the Class I and II protocols. The ASCII code set defines the character content used in the control sequences whose format is shown in Figure 7.

Figure 8 gives a summary of the definition and usage of each component of the DLC.

5.2.1 ACK 0 and ACK 1 (Positive Acknowledgment)

The ACK 1 (odd) and ACK 0 (even) control sequences are sent by the slave station as reply sequences to verify that a block was received without any detected errors such as parity and/or LRC error. ACK 1 is used as the positive acknowledgment for the first and all successive odd-numbered blocks while ACK 0 is used for the second and all even-numbered blocks, when more than one block is sent per transmission. ACK 0 is always used as a positive acknowledgment to a line bid which reinitializes the above counting algorithm.

The ACK 0 sequence is transmitted as DLE 0

The ACK 1 sequence is transmitted as DLE 1

5.2.2 NAK (Negative Acknowledgement)

NAK is the negative reply sent by the slave station when a message has been received with detected errors such as parity and/or LRC errors. NAK is a response to a line bid indicating the receiving party is not prepared to receive. The Transaction Network will send the negative reply to a received data block if any of the following conditions occur:

a) a detected parity error
b) a detected LRC error
c) an ENQ character in text
d) block length beyond that selected as a message flow option (Section 7)
e) an EOT character in text.

5.2.3 TTD (Temporary Text Delay)

TTD is the two character control sequence, STX ENQ, which informs the slave station that the master station is not prepared to send, temporarily, but does not wish to relinquish control of the line. The slave station replies with a NAK and waits for transmission of the next data block to resume or for the master station to relinquish the line.

5.2.4 WACK (Wait Before Transmitting - Positive Acknowledgement)

WACK is a positive acknowledgement which requests the master station to wait temporarily before sending the first or next data block. The master station replies to WACK with the ENQ sequence to request permission to continue.

The slave station will continue to transmit WACK in reply to each ENQ until it is prepared to receive a data block. Receipt of WACK shall reset the retry counters maintained by the master station. The slave station sends the correct ACK 0 or ACK 1 reply when able to continue, EOT if unable to continue or RVI after the receipt of a data block if the slave desires the master station to relinquish the line.

In the Class I protocol, the Transaction Network will recognize but will not transmit WACK. In the Class II protocol, the Transaction Network will both recognize and transmit WACK and will issue WACK, or NAK, to a line bid if unable to receive.

The WACK sequence is transmitted as DLE ;.

5.2.5 RVI (Reverse Interrupt)

RVI is a positive acknowledgment sequence (only sent by the DPC,) which requests the Transaction Network to relinquish the line. The Transaction Network will not send any additional data and will relinquish the line by sending the EOT sequence.

The RVI sequence is transmitted as DLE <.

5.2.6 ENQ (Enquiry)

Within the connection procedure, ENQ is used to bid for the line. The appropriate responses for the Class I protocol are ACK 0 or NAK and for Class II, ACK 0, WACK or NAK.

In the data transfer state, the master station transmits ENQ to obtain a retransmission of the last reply sent by the slave station to the previously transmitted data block.

ENQ transmitted as a part of a data record is used as an abort of the data block to which a NAK reply is sent by the slave station.

5.2.7 EOT (End of Transmission)

The EOT sequence is used to relinquish control of the data link. Receipt of EOT control sequence always causes both the DPC and the Transaction Network to enter the idle state. Receipt of EOT as a reply to a block shall be considered a negative acknowledgment to that block.

EOT received within a data record shall cause the slave station to transmit a NAK reply to the block.

5.2.8 PAD

All transmissions shall be preceded by a leading PAD character. The Transaction Network will send alternating ones, 01010101_2 (HEX '55') but will accept either ASCII "SYN" or HEX '55' as the leading PAD. All transmissions shall be followed by a trailing PAD character defined to be the all ones character, $1111\ 1111_2$ (HEX 'FF').

5.2.9 SYN (Synchronous Idle)

All transmissions shall begin with the leading PAD character followed by at least two "SYN" characters to establish bit and character synchronization. SYN characters inserted within the data block to maintain synchronization shall be ignored by the receiving slave station.

5.3 Retry Counters and Timing

Retry counters and time-out controls are used in the DLC procedures to establish priority and recovery procedures. Three basic time-out durations are used, and are discussed in the following section. The number of retry attempts are also discussed.

5.3.1 One-Second Timeout

In bidding for a line, the primary station allows the secondary station one second to respond to the line bid (ENQ). The primary station will retransmit the ENQ character if a reply is not received within one second.

In the Class I Protocol the Transaction Network is always the primary station.

In the Class II Protocol the DPC has the option to select the primary station.

A master station should not rebid for the line after ending a transmission for one second. This allows a slave station the opportunity to bid for the line. The Transaction Network will normally wait one second, but the DPC may specify the Transaction Network to wait three seconds as an option.

5.3.2 Two-Second Timeout

A slave station which transmits the wait sequence, WACK, shall wait two seconds before retransmission. The Transaction Network will transmit the WACK sequence in the Class II Protocol only.

5.3.3 Three-Second Timeout

A master station waits three seconds for a response to a data block before retransmitting an ENQ character.

A secondary station must wait three seconds between attempts to bid for a line (ENQ). The Transaction Network may be optionally specified as a secondary station only in the Class II Protocol.

The Transaction Network can be optionally specified to wait three seconds after being a master station before rebidding for the line.

Synchronization will assume to be lost after three seconds.

5.3.4 Retry Counters

The Transaction Network will make four attempts to gain an appropriate response to a line bid.

The Transaction Network will make three attempts to gain an appropriate response (ACK0,ACK1,NAK,WACK,RVI) to a data block.

The Transaction Network will make seven attempts to retransmit a block of data that receives a NAK reply.

After the number of retries indicated above is exceeded, the transmission will be terminated and the data link will be considered temporarily nonfunctional and the Transaction Network shall initiate appropriate diagnostic and maintenance procedures.

5.4 Connection and Termination Procedures

In the line contention mode, either the DPC or the Transaction Network System may contend (bid) for the line when that party has a message or messages to send. This

is achieved by having the bidding station send out an ENQ sequence. The slave station shall reply with ACK 0 sequence if it is ready to receive, a WACK sequence if it is temporarily unable to receive (WACK will only be transmitted by the Transaction Network in the Class II protocol), or NAK sequence if it is not. If both the Transaction Network and DPC contend for the line at the same time (send ENQ sequences), the primary station shall repeat the ENQ bid for the line in 1 second in order to resolve the simultaneous contention. The secondary station will wait 3 seconds before rebidding for the line. If an ENQ is received from the primary station before 3 seconds has expired, the station will not rebid, but will send the appropriate response (NAK, WACK or ACKO). In Class I protocol the Transaction Network is the primary station, while in the Class II protocol the DPC has the option to select the primary station.

The Transaction Network will make four attempts to get a response from the DPC (either NAK, WACK, or ACK 0), after which the data link will be considered temporarily nonfunctional and the Transaction Network shall initiate appropriate diagnostic and maintenance procedures.

After all message transfers are complete, the last message from the Transaction Network will terminate using ETX. The DPC may use ETB or ETX to end each block. Upon receipt of the appropriate acknowledgment, the transmitting party will relinquish the line by sending EOT as shown in Figure 8. This is the normal termination sequence and the transmitting station will not again contend for the line before 1 second (DPC may optionally choose 3 seconds for the Transaction Network) to allow the receiving station to gain control of the line by bidding uncontested for the line before the time interval elapses.

EOT as a control sequence may also be used to prematurely terminate the protocol in several error conditions and shall always cause both parties to return to the idle state.

The DPC may obtain early turnaround of the line by sending the RVI sequence as a positive acknowledgment. The Transaction Network will send the EOT sequence allowing the DPC to bid for the line. The Transaction Network will

guarantee buffer availability for one block upon acknowledging a bid for the line by the DPC.

5.5 Data Transfer Procedures

After contending for the line the DLC allows message transfers. Multiple messages may be sent before transmission is terminated by the EOT sequence. Multiple messages may be sent individually (one message/block).

All error control is based on retransmission of blocks and control sequences with the number of retries controlled by the master station. The Transaction Network will attempt seven retries before considering the line nonfunctional and initiate appropriate diagnostic and maintenance procedures.

All error recovery is performed by the master station. Error recovery is initiated by time-outs of 3 seconds (Figure 9) and garbled transmissions. The slave station will not initiate any DLC procedures upon the elapse of a time-out waiting for an expected transmission from the transmitting party. One exception is that after three seconds, synchronization will be assumed to be lost.

5.6 Message and Acknowledgment Sequences Examples

Figure 9 shows a number of situations and resultant message flow between transmitting and receiving parties on a data link.

6.0 Message Format

The message and control DLC sequence formats for message transfers between the Transaction Network and DPC are shown in Figure 10. The format was chosen to meet the ANSI standards and to be compatible with the terminal message formats used by the Transaction Network.

The message format of Figure 10 is designed to allow each message to be transmitted with its own LRC for individual message error checking. The full message format consists of four parts: message prefix, message heading, message text, and message suffix.

Referring to Figure 10, the leading characters, Ø, consisting of the leading PAD plus at least two SYN characters are used to establish character synchronization at the beginning of each transmission of both blocks and control sequences. Immediately following each message (or record) is a LRC character used for error detections. In addition, each transmission of both blocks and control sequences will have a trailing PAD character to prevent garbling of the last transmitted character.

6.1 Data Link Control Characters

The data link control characters for the Transaction Network Service consist of SOH, STX, ETB, ETX, ITB (represented as ASCII "US"), DLE, ACK, NAK, SYN, ENQ and EOT. The ASCII code set defines the bit patterns of the control characters.

6.2 DPC Specified Message Prefixs

A prefix field immediately following SOH of up to eight characters can be prespecified by the DPC for insertion by the Transaction Network on all messages to the DPC. The message can thus be customized by the DPC to interface appropriately with the specific DPC's hardware and software. Potential uses include characters required by the DPCs software to implement a DLC procedure as if the Transaction Network were actually a hardware device. Additional uses can be to insert DPC management system transaction codes and to insert special characters to by-pass or to begin special DPC editing routines.

A prefix field of specified length up to eight characters may be inserted by the DPC into all messages to the Transaction Network. These characters will be stripped from the message on arrival at the Transaction Network.

The prefixes for messages to and from a DPC may be specified separately and need not be of the same size or content, but once stated,must be used on each message.

6.2.1 Message Prefix (to DPC)

The prefix for messages to the DPC may be specified by the DPC in the Service Order from the set of ASCII printable graphics (greater than HEX '20') excluding ASCII "*" (HEX '2A') through ASCII "/" (HEX '2F') which are optional

heading field separators and control characters (Section 6.3.1). The field may be of zero size.

6.2.2 Message Prefix (from DPC)

The prefix for messages from the DPC may be specified by the DPC in the Service Order and may contain any ASCII characters excluding only the ASCII control characters listed in section 6.1 and ASCII "*". The field may be of zero size.

6.3 Message Heading

The message heading, as depicted in Figure 10, immediately follows any DPC specified prefix and concludes with STX.

The message heading contains supervisory information to be specified and utilized by the Transaction Network to handle the billing, routing, traffic and maintenance functions of the Transaction Network. Messages to a DPC will contain routing information in the heading necessary for correct delivery of a return message the DPC may generate to that terminal or DPC (e.g., the calling number, the terminal identification with the CSC or the affiliation identification).

The heading consists of up to five subfields of fixed length which apply solely to the text in that message. The heading subfield may not contain any data link control characters and shall not contain the ASCII characters, "GS", "FS", "RS", "*", "+", ",", "_", "." and "/".

All messages transmitted to a DPC will have the format shown in Figure 10. All subfields are present and of fixed size. The receiving DPC may identify each subfield by the heading item indicator (HII) with its associated heading subfield separators or by the absolute position of each heading subfield in the message.

For messages transmitted by a DPC, certain heading subfields are optional as indicated in Figure 10. The Transaction Network will identify each subfield by the associated heading subfield separators (RS, FS, GS or the optional heading control character set) and the HII. The DPC may transmit a fixed set of subfields up to the maximum set

allowed or dynamically choose the subfields to be sent, above the minimal set required.

On multiple record per block transmission, the DPC may select to omit SOH (or STX if optional heading control character set is selected) on all but the first record of the block transmitted (Figure 11). Conversely, the DPC may specify that the Transaction Network will always or never send SOH on the second and following records in each block as a service order option.

6.3.1 Optional Message Heading Control Characters

As a DPC option, SOH, STX, FS, GS and RS may be specified as "STX", "*", ",", "_", and "." respectively for all messages to be compatible with existing DPC software. Generic references to control characters in this document shall always be stated as given by the original specification (i.e., STX not "*"). Figure 11 shows an example of the format options.

6.3.2 Heading Item Indicator

The Heading Item Indicator (HII) immediately follows the DPC specified prefix field. HII consists of two characters which specify which heading subfields are present. The specific HEX bit patterns for HII are defined below. As an example, for the full heading, HII is HEX '7162', the sum of the addends in the following table. A minimal heading from a DPC would have an HII of HEX '7042' for the General, Station Identification, Called and Calling number subfields.

Subfield	Addend
General (no heading information)	HEX '4040'
Station Identification	HEX '2000'
Sequence Number	HEX '0100'
Called Number	HEX '1000'
Calling Number	HEX '0002'
Message Status	HEX '0020'

HII equals binary sum of each present subfield's addend to produce a two character long index to which parity will be appended.

6.3.3 Station Identification Subfield

The station identification subfield consists of three characters immediately following HII. The first two characters of this subfield identifies to the receiving DPC the DPC affiliation or the type of terminal the calling station is e.g., a Transaction II Telephone with FSK receiver and certain other options of the telephone. The characters will be the station identifier characters sent by the station in its heading information. These characters will be any ASCII character HEX '30' (ASCII "zero") to HEX '7F' (ASCII "del") and HEX '20' (ASCII "SP"), and will be sent to the DPC in the order the station originally sent them.

Dial in telephones will use identifier characters in the range HEX '30' to HEX '3F' (ASCII "?"). Polled terminals will use identifier characters in the range HEX '40' (ASCII "@") to HEX '5F' (ASCII "_"). If the terminal does not send any identifier characters, or sends only one, the Transaction Network shall insert ASCII "SP" character(s) in place of the missing character(s). The inserted "SP" will be transmitted first (is right justified). A DPC to DPC message will use affiliation identifier characters in the range HEX'30' to HEX '7F' (Section 2.2)

The contents of the station identification subfield may be used by the DPC to identify the calling station's hardware capabilities and thus its resulting text format and protocol characteristics in order to properly compose responses, e.g., Transaction Telephones will send two digits to indicate the options the set is equipped with and indicates the response format (AVA, KAT, FSK) and text content.

In response messages from a DPC, the station identification subfield will be used to identify the protocol to be used by the Transaction Network. For example the first two digits of this subfield in response messages to a dial-in telephone, ASCII "01" indicates voice only, ASCII "04" indicates FSK response to dial in telephone (see Section 9).

The third character of the subfield is the Class of Service Character (CSC) inserted by the Transaction Network into each inquiry message sent to a DPC. This character must

be returned as the last character of this subfield in each response message from the DPC. For a response message generated by a DPC to a polled terminal, (not initiated by a specific inquiry message) the assigned terminal CSC must be inserted by the DPC (Sections 2.2.1 and 2.2.2).

The station identification subfield for service messages will always contain 3 ASCII "SP" characters instead of any identifier characters and CSC.

6.3.4 Sequence Number Subfield

The sequence number subfield, preceded by GS consists of a single character, and is used to facilitate transmission in a single direction to or from the DPC. On a given line each message to the DPC will be assigned a new sequence number obtained by adding one to the previously transmitted sequence number. Sequence numbers range from HEX '40' to HEX '7F'. Adding 1 to HEX '7F' returns to HEX '40'. The sequence numbers can be used to identify possible duplicate messages.

If this optional subfield is present in messages from the DPC, the Transaction Network checks that no two successive messages begin with the same sequence number. If they are the same, the second message will be assumed a duplicate message and returned to the DPC with the appropriate message status indication in the heading information. If the field contains ASCII "SP", it will be ignored by the Transaction Network.

6.3.5 Called Number Subfield

The called number subfield, immediately preceded by the RS separator, consists of the seven digit identification number which identifies the called party.

This subfield may be used by the DPC to verify the inquiry message was delivered to the primary line group or is an alternate delivery message. The Transaction Network will not change the called number subfield when a message is delivered to an alternate location.

For messages originating from a DPC, the called number is used to route the message to the proper terminal. Service

messages to the Transaction Network will use the $X_1X_2X_3$ 0999 identification number.

The called number subfield is followed immediately by the FS separator.

6.3.6 Calling Number Subfield

The calling number subfield, immediately preceded by GS consists of the seven digit identification number which identifies the calling party.

In messages delivered to the DPC, this subfield identifies the calling station or dial-in port. Service messages from the Transaction Network will use the $X_1X_2X_3$ 0999 identification number.

In a message from a DPC, the identification number of the DPCs line group would be used as the calling number.

Response messages generated by alternate delivery locations shall use the primary location identification number in the calling number subfield. The Transaction Network verifies that the response message calling number subfield contains either the primary line group identification number or a line group identification number that the line group is serving as an alternate delivery location for (Section 2.5).

6.3.7 Message Status Subfield

The message status subfield, preceded by GS will be two digits used to indicate irregularities or absence thereof, encountered by the Transaction Network when transferring the accompanying text (Section 5.8).

If this optional subfield is present in response messages from a DPC, it must contain the normal message status indicator (X,Y = 00) or ASCII "SP" characters. The DPC may not generate any message status information other than the normal message status in response messages.

6.4 Message Text

The message text is the main body of the message. It is of variable length up to a maximum of 128 characters,

normally delimited by STX and the End of Message (EOM) character (ASCII "ETB", "ETX" or "US"). A specified suffix may be inserted by the Transaction Network before EOM. If a DPC elects to transmit data as blocks of records, and the record size is smaller than a given message text length, the text shall be continued in the next successive record. A record shall contain text from only one message. Within a block, records end with ITB (US), and the last record with ETB or ETX, if another block follows or if this is the last block in the transmission sequence respectively as shown in Figure 6. Multiple messages are allowed in a block. Messages cannot be continued to the next block.

The Transaction Network will remain transparent to the text except for data link control characters and service messages. The Transaction Network shall do a predetermined one to one translation of message text requiring Automatic Voice Answerback (AVA). If no such translation exists the message will be returned with the appropriate message status indication in the heading information.

The DPC shall be responsible for handling the text format and information supplied by any stations sending inquiry messages directed to the DPC. The DPC shall also be responsible for providing the required text format and information needed by the station it is sending response messages to. For example voice/KAT and data response telephones have a character set limited to 16 characters. Figure 12 shows the 16 possible TOUCH-TONE characters and the ASCII set the Transaction Network will translate them into. Voice response telephones however are limited to a subset of only 12 of these possible characters.

6.4.1 DPC Specified Message Suffix

A suffix field immediately following text and preceding the EOM character (ASCII "ETB", "ETX", or "US") may be optionally specified in the service order by the DPC for each EOM character. The suffix will be inserted on messages sent from the Transaction Network to the DPC (Figure 11).

A suffix may also be specified for messages from the DPC. A potential use is to provide a key to the DPCs software that an independent message has arrived and thus to allow processing to begin. The suffix, if chosen must be one

character in length, from the ASCII set excluding the data link control characters.

A unique suffix may be specified for US which is the end of a message, for US which is the end of a record which contains a message being continued in the next successive record, for ETB which is the end of a block and also ETX which is the end of a block and end of the transmission.

The DPC may close the same suffix for all EOM characters except when preceding US on a record which contains a message being continued in the next successive record. In such a case the suffix serves as a continuation character to distinguish the two uses of US as shown in Figure 11.

The Transaction Network inserts the suffix by scanning text for the EOM control character. Upon detecting EOM within a message for transmission, the Transaction Network inserts the optional suffix before sending EOM. If the message is being broken into records, the Transaction Network will insert the appropriate suffix for the US (indicating a continuation of the message in the next record or the end of record is also the end of the message).

Figure 13 shows an example of a message format using the the optional heading control character set, a prefix and a suffix.

6.4.2 BCC(LRC)

The Block Check Character using the ASCII code is a single Longitudinal Redundancy Check (LRC) character. The LRC is the "exclusive or" of each block character, initialized by the first SOH, which is not accumulated, up to and including the ETB or ETX characters. All intermediate SOH characters, within the block, are accumulated.

6.4.3 TRANSMISSION End Suffix

The DPC may desire a transmission end statement after the last message sent by the Transaction Network. If a separate segment is required for this statement, the transmission end format option of Figure 10 and Figure 11 may be selected by the DPC for transmissions from the Transaction Network only. The suffix can be up to two ASCII characters from the set greater than HEX '20' (ASCII "SP"). The Transaction

Network does not allow the DPC to specify a transmission end statement and suffix on transmissions sent from the DPC. The transmission end format option and suffix can be specified by the DPC independently of the message suffix (Section 6.4.1).

7.0 Message Flow

In handling messages the Transaction Network acts as a queue and forward device. The Transaction Network will buffer messages in a queue which functions to smooth out instantaneous traffic peaks in messages to each DPC. Efficient message flow is required to keep the finite queue from overflowing and to increase line utilization.

a) Message

A message is a single entity consisting of a single heading field and a single text field. A message may originate from any station connected to the Transaction Network and will be handled by the Transaction Network independently of any previous or succeeding messages (except service messages).

b) Record

Messages may be partitioned into records of a DPC specified maximum length. If a message exceeds the record size, it will be continued in successive records. A message or part of a continued message which does not fill a record will result in a shortened record. A record shall not contain data from more than one message. Each record shall end with the appropriate specified suffix, EOM character, and LRC. A record that is the beginning of a message will start with SOH and include the heading information delineated by STX unless the DPC chooses the option to omit SOH on intermediate records (Section 6.3). Successive records containing the same message text will normally begin with STX, which will be omitted, however, if the DPC chooses the above option to omit SOH on intermediate records.

c) Block

A block is a transmission consisting of one or more independent messages or records where each message or record has its own redundancy check (LRC) within the block. A block may be specified (by DPC) to have a maximum number of records. A single positive or negative reply will be sent by the receiving station to verify the error-free transmission of the block. The maximum size of the block can be specified by the DPC in the service order.

7.1 Message Flow Considerations

The Transaction Network will provide an interactive flow of messages to and from the DPC. If the DPC is not capable of supporting message flow flexibility, options may be specified in the service order separately for each direction of transmission which will limit the message flow to fixed boundaries which the DPC can handle. The affects of message flow on performance are discussed in Section 10.

All transmissions on the Transaction Network will adhere to the following basic requirements;

1) no characters will be inserted into the text of either a record or a block to pad out the length,

2) no messages will span more than one block, and

3) no one record will contain characters from more than one message.

7.2 Message Flow Options (to DPC)

The message flow options a DPC may specify for transmissions from the Transaction Network include:

1) maximum characters per record;
2) maximum characters per block;
3) maximum number of records per block, and
4) maximum number of blocks per transmission

In all cases, blocks and records may contain fewer then the specified maximum number.

7.2.1 Maximum Characters Per Record (to DPC)

The DPC may specify the maximum length of a record as F_1 characters within the range $40 \leq F_1 \leq 167$. This option is intended for DPCs that have record size limits (e.g. card images of a nominal 80 characters). The lower limit is chosen to allow at least a full message heading to be contained in the first record of the message and to insure line efficiency. The upper bound reflects the maximum text length of 128 character, the maximum permissible prefix, suffix and heading inclusive of SOH and EOM characters. The choice of $F_1<167$ requires the use of a message suffix character (Section 6.4.1) to be used as a continuation character.

If a DPC specifies the maximum records per block as 1, the DPC is required to specify $F_1 = 167$.

7.2.2 Maximum Characters Per Block (to DPC)

The DPC may specify the maximum length of a block as F_2 characters within the range $167 \leq F_2 \leq 512$. F_2 is calculated to be the number of characters inclusive of the first SOH character and the ETB of each record within the block but excluding any LRC characters within the block.

The lower limit is chosen to allow the required minimum of one message per block. The upper bound reflects a reasonable block size in terms of transmission error performance on the dedicated transmission facilities and also allows three maximum length messages per block to insure line efficiency.

7.2.3 Maximum Number of Records Per Block (to DPC)

The DPC may specify the maximum number of records per block as F_3 records within the range $1 \leq F_3 \leq 8$. This option allows the transmission of multiple records per block to reduce the number of line turnarounds required to transmit message acknowledgments (See Section 5 on protocol).

7.2.4 Maximum Number of Blocks Per Transmission (to DPC)

The DPC may specify the maximum number of blocks per transmission as F_4 within the range $1 \leq F_4 \leq 8$. This

determines when a transmitting party must stop in order to allow the receiving party to transmit messages.

7.3 Message Flow Options (from DPC)

The only message flow option a DPC is required to specify is the maximum characters per record. The characters/block, records/block and blocks/transmission must not exceed the maximums stated below.

7.3.1 Maximum Characters Per Record (from DPC)

The DPC may specify the maximum length of a record as F_5 characters within the range $40 \leq F_5 \leq 167$. The choice of $F_5 < 167$ requires the use of a message suffix character to be used as a continuation character.

7.3.2 Maximum Characters Per Block (from DPC)

The characters per block must not exceed 512, inclusive of the first SOH character and the ETB of each block but excluding any LRC characters within the block.

7.3.3 Maximum Number of Records Per Block (from DPC)

The number of records per block must not exceed 8.

7.3.4 Maximum Number of Blocks Per Transmission (from DPC)

The number of blocks per transmission must not exceed 8.

7.4 Queue Size Considerations

The selection of message flow options affects line utilization as well as customizes Transaction Network Service to the DPC capabilities. The following example will illustrate the dependence of queue size, number of lines and message flow on the selection of message flow options.

7.4.1 Example of Queue Size Dependence on Message Flow Options

For this example, the following conditions were assumed for the simulation of the Transaction Network.

1. A line group consisting of two 2.4K BPS lines.

2. The DPC reply time to a block of data is .2 seconds.

3. Random inquiry messages uniformly distributed between 40 and 120 characters of text.

4. Response messages uniformly distributed between 20 and 40 characters of text.

5. No transmission or internal message errors.

6. Record size maximum was specified to be 167 characters in both transmission directions.

7. Block size maximum was specified to be 512 characters.

The following message flows were examined,

A: To DPC, 3 blocks per transmission with 3 messages per block (max).
From DPC, 5 blocks per transmission with 3 messages per block (max).

B: To DPC, 1 block per transmission with 3 messages per block (max).
From DPC, 1 block per Transmission with 3 messages per block (max).

C: To DPC, 3 blocks per transmission with 3 messages per block (max).
From DPC, 3 blocks per transmission with 3 messages per block (max).

Messages Per Second Entering Queue	Maximum Number of Enqueued Messages A	B	C
.8	6	5	6
1.2	9	8	6
1.6	10	13	9
2.0	30	21	19
2.4	41	409	42

7.4.2 Maximum Queue Size

The previous example shows that the message flow options selected by a DPC for inquiry messages as well as the message flow from the DPC can directly affect the length of message queues during traffic peaks. Having message queues expand rapidly without control would affect Transaction Network Service quality to all users. To insure service quality and promote transmission efficiency a bound is placed on the allowable message queue.

The Transaction Network provides a maximum message queue of 10 for each line group. Messages addressed to a line group will be delivered to the alternate delivery address when and while the queue is at the maximum. If an alternate delivery location is unavailable or not specified, messages will be returned to the originator with the appropriate message status indication in the heading information.

8.0 Summary of DPC Options

1. Maximum characters per record from DPC
2. Maximum characters per record to DPC
3. Maximum records per block to DPC
4. Maximum characters per block to DPC
5. Maximum blocks per transmission to DPC
6. Message prefix to DPC
7. Message prefix from DPC
8. Message suffix to DPC
9. Message suffix from DPC (only as necessary with Option 1)
10. Use of optional heading control characters and separators
11. Transmission end statement and suffix to DPC
12. SOH (and STX on continuation records) deleted on intermediate records to DPC
13. Use of optional message heading subfields from DPC
14. Class of Service
15. Alternate delivery address for DPC line group
16. Line group addresses the DPC line group is serving as alternate delivery location for
17. Number of synchronous lines connecting DPC to Transaction Network
18. Line group arrangement
19. SAF designation for line group
20. Transmission rate

21. Digital or analog transmission facilities
22. Line contention wait of 1 or 3 seconds after EOT
23. Primary designation for the DLC-Transaction Network or DPC for class II protocol.
24. Single request per service message from Transaction Network

9.0 Response Message Format for AVA/KAT Responses

The Transaction Network has the capability of returning voice or tone responses to dial-in telephones only. These telephones will access the Transaction Network on a group of ports equipped with an Audio Response Unit (ARU) as shown in Figure 14. In returning a response message to such telephones the DPC must insert the proper three characters in the station identification subfield including the CSC (Section 6.3.3). The Transaction Network shall from the station identification subfield determine the proper protocol and format for the response message. The following table indicates the proper identification digits for the first two digits in this subfield, the third digit is the CSC delivered with the inquiry messages which must be returned with the response message.

Response Message-Station Identification Subfield Codes

N_1	N_2	CSC	Response Message Protocol to be used by Transaction Network
0	1	CSC	Voice only response
0	2	CSC	2025 Hz tone for 1.5 sec (no text)
0	3	CSC	2025 Hz tone for 3.0 sec followed by voice response
0	4	CSC	FSK response (dial-in telephone)
0	5	CSC	Disconnect (no text)
SP*	SP*	CSC	FSK response (polled terminal)

*ASCII "SP" Character

9.1 Voice Only Responses - (0 1 CSC)

The DPC composes an AVA message to a dial-in telephone by specifying the phrases to be used from the Transaction Network vocabulary. The phrases to be used are designated in the message text in the order they are to be spoken. Three ASCII characters are used to designate each phrase. No seperators are to be used between phrase designations. An example is given in Figure 15. A maximum text length of 128 characters must be observed (42 phrases).

The ASCII characters to be used are limited to the following list of sixteen contiguous ASCII characters;

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, :, ;, <, =, < and? (HEX'30'to HEX'3F).

The Transaction Network's Audio Response Unit (ARU) will translate the associated ASCII characters into the designated spoken message.

9.1.1 Phrase Elements

Phrases are subdivided into elements which are not necessarily or usually words. Elements are included for the natural silent intervals between words of a phrase. Additional silent periods may be DPC specified in a message between phrases or words to accentuate parts of the message (e.g. a silent interval followed by a repeat of all or part of the previous spoken message).

9.1.2 Intonation, Pace and Dialect

Neutral intonation and inflection, as well as a constant pace are used in every phrase, except as specified in specific phrases.

Regional dialects and pronunciations are not to be used. Primary emphases is to be placed on clarity and accuracy of information transfers.

9.1.3 Organization Names

The vocabulary list includes some organization names in two classes, Nationwide and Regional. A nationwide name is available in every Transaction Network, while a regional

name is of limited scope and available in only designated Transaction Network System.

9.1.4 Vocabulary List

A complete vocabulary list for the Transaction Network is available from the local telephone company representative.

9.2 KAT of 1.5 sec Responses - (0 2 CSC)

KAT responses of 1.5 sec duration are to have no text field i.e., STX is immediately followed by EOM. The Transaction Network will generate a 2025 Hz tone for 1.5 sec to the dial-in port indicated in the heading address.

The telephone is required to give an indication to the Transaction Network that the KAT was correctly received. If the proper indication is not received, the message will be returned to the DPC with the appropriate message status indication in the heading information.

9.3 KAT of 3.0 sec Followed by Voice Response - (0 3 CSC)

KAT responses of 3.0 sec duration are to have a text field associated with voice messages. The Transaction Network will generate a 2025 Hz tone for 3.0 sec to the dial-in port indicated in the heading address. The telephone is required to give an indication to the Transaction Network after receiving this tone, that it is ready to receive the voice response. Upon receiving this indication from the telephone, the Transaction Network shall deliver the spoken message indicated by the response message text.

If the proper indication is not received, the message will be returned to the DPC with the appropriate message status indication in the heading information.

9.4 FSK Response (0 4 CSC) [Dial-In Telephone]

The Transaction Network shall deliver the enclosed text to the dial-in port indicated in the heading in FSK using the protocol and format for dial-in telephones with the FSK receiver.

9.5 Disconnect (0 5 CSC)

A request for the Transaction Network to disconnect the dial-in port is to have no text field i.e., STX is immediately followed by EOM. The Transaction Network shall determine from the dial-in port number the proper format and protocol for the disconnect i.e., an FSK or voice indication of the disconnection.

9.6 FSK Response (SP SP CSC) [Polled Terminal]

The Transaction Network shall deliver the message text to the addressed polled terminal in FSK using the protocol and format for polled terminals.

10.0 Performance

The Transaction Network is designed to provide a reliable, quick, efficient service. Redundancy is provided in shared equipment to insure network operation even with some equipment failures.

Transmission error performance is covered in the Bell System Technical Reference for the synchronous facilities subscribed to by the DPC (Section 12 on references).

10.1 Inquiry/Response Time

A measure of the efficiency of the Transaction Network Service is the inquiry/response time, defined as the time between sending an inquiry message until the receipt of the corresponding response message (including message transmission time). However, the inquiry/response time is influenced by numerous parameters not all of which are under Telephone Company control. Three such DPC controlled parameters are:

1. The DPC acknowledgment time to a block of data.

2. The message flow options selected by the DPC.

3. The DPC message processing time.

This section will discuss the relationship of the Transaction Network parameters and DPC parameters and their affect on the inquiry/response time.

10.2 Dial-in Telephones Inquiry/Response Times

The inquiry/response time experienced by a dial-in telephone cannot be predicted for the following reasons:

a) Data from the telephone
   1) May not be buffered, i.e., manually keyed
   2) May be partly buffered
   3) May be buffered and transmitted up to a maximum of 10 characters/second

b) Data to a telephone
   1) May be AVA
   2) May be KAT
   3) May be KAT/AVA
   4) May be FSK at 150 BPS.

Customers using the Transaction Network with dial-in telephones will often experience inquiry/response times dominated by the type and transmission time of the messages which is customer dependent.

10.3 Polled Terminals Inquiry/Response Time

Polled terminals operate with a protocol that sets timing constraints within fixed bounds and requires all data to be buffered before transmission at 1200 BPS (Bell System Technical Reference - Transaction Network Service - Polled Interface Specification, PUB 41026). Because of these fixed timing characteristics it is possible to estimate a limit on the inquiry/response time for a polled terminal based on a simulation of the Transaction Network.

Assuming an inquiry message text length of 80 characters and a response message text length of 30 characters, it takes approximately 1.5 seconds to deliver and receive such sized messages between the Transaction Network and polled terminals. This time includes transmission delays, transmission time for the text, appropriate heading information, protocol sequences and timing but excludes the access delay (defined as the time between having a message ready for delivery by the terminal and receipt of a poll by that terminal).

The time associated with delivery of the inquiry and response message between the DPC and Transaction Network

(TDPC) is influenced by the transmission speed of the synchronous lines used.

		1.2 seconds	2.4K BPS
TDPC	=	.8 seconds	4.8K BPS
		.6 seconds	9.6K BPS

The time includes transmission delays, transmission time for text, appropriate heading information, protocol sequences and timing. The time assumes no queueing delays, a DPC acknowledgment time to a block of data of .2 second and excludes any DPC processing time.

Overall inquiry/response time for a polled terminal is the sum of the time required to receive and deliver a message; a) between the terminal and the Transaction Network and b) between the DPC and the Transaction Network (TDPC).

		2.7 seconds	2.4K BPS
Inquiry/Response Time	=	2.3 seconds	4.8K BPS
		2.1 seconds	9.6K BPS

10.4 Traffic Affects on Inquiry/Response Time

The inquiry/response time experienced by a polled terminal will be influenced by the traffic levels, message flow options the number of lines in the line group and transmission rate of the lines to the DPC. A simulation of the Transaction Network was used to determine the mean inquiry/response time for a polled terminal based on different levels of traffic, various numbers of lines and various transmission rates. The results are shown in Figures 16, 17 and 18.

The following assumptions were made in the simulation.

1. The DPC time to acknowledge a block of data is .2 seconds.

2. Random inquiry messages uniformly distributed between 40 and 120 characters of text.

3. Response messages uniformly distributed between 20 and 40 characters of text.

4. No transmission errors.

5. No internal message errors.

6. DPC processing time was a constant and subtracted from the final results.

7. Polled terminal access delay was excluded.

8. Message flow options (to and from DPC)

   a. Maximum record length = 167 characters

   b. Maximum messages per block = 3

   c. Maximum number of blocks per transmission =3.

The dashed line on each figure represents the inquiry/response time limit discussed in the previous section. The curves show the effects of increased traffic levels on the mean inquiry/response time up to the point where the line group queue of ten messages is reached 99 percent of the time. Once a line group's queue is filled, messages are delivered to the alternate delivery address or else returned to the originator.

The simulation results show that increasing the number of lines in a line group not only increases the traffic carrying capacity of the line group but also for moderate to heavy traffic levels, reduces the inquiry/response time experienced by a polled terminal accessing the line group. Additionally the affect of taking a line out of service will depend on the traffic levels for the line group. For example, a DPC operating in a region beyond the queue overflow point of a smaller line group, the removal of a line from service will result in messages routed to the alternate delivery address and or returned to the originator. However, if the DPC is operating below the queue overflow point for a smaller line group, the removal of a line will not disrupt the flow of messages to the DPC, but will increase the inquiry/response time to a polled terminal.

11.0 Maintenance

The Transaction Network maintenance plan provides for continual surveillance of all system components except terminals. This will be accomplished through routine

monitoring of test and service parameters within the Transaction Network. Some of the parameters that will be monitored include parity, character count, LRC and retransmission attempts. When the number of parity and LRC errors in a given time span exceed a telephone company specified limit, the Transaction Network will initiate maintenance procedures aimed at isolating the problem to Transaction Network equipment. The Transaction Network will periodically initiate these test procedures of its equipment as a check of the working function of the network.

11.1 Equipment Malfunction

If routine or problem initiated testing procedures finds some Transaction Network equipment is malfunctioning, steps will be taken to remove the questionable equipment from service. In most cases, equipment removal should not interrupt service, but could affect service quality, e.g., more messages delivered to the alternate delivery location or heavier traffic on specific lines of a line group. If a DPC has only one synchronous facility, with no alternate delivery provided for, an equipment failure could result in a temporary interruption.

11.2 Customer Trouble Reports

Customer trouble reports will be received by a telephone company Transaction Network Customer Service Bureau (CSB) which will initiate verification and isolation procedures. When the trouble has been isolated, the appropriate maintenance force can be notified and the trouble resolved. It is anticipated that the maintenance plan will identify and isolate network trouble conditions quickly and efficiently before a customer realizes a trouble has occurred. Some problems may be associated with individual customer equipment, eg, dedicated line facilities, which require coordination between the DPC and Transaction Network for testing.

11.3 Service Messages

Part of the Transaction Network maintenance plan involves the use of service messages between the Transaction Network and the DPCs. Synchronous facilities can be taken out of service by the Transaction Network System at the request of the DPC for testing or maintenance or repair purposes.

The Transaction Network will also inform the DPC of similar intentions.

The DPC can address an appropriate service message to the Transaction Network ($X_1X_2X_3$ - 0999 = heading called number) requesting a "reflection" of the text (Section 4.8). The Transaction Network will return the text to the DPC (over whichever interface line the request was received). This allows checking of the operation of the DPC equipment and portion of the unshared telephone company facilities.

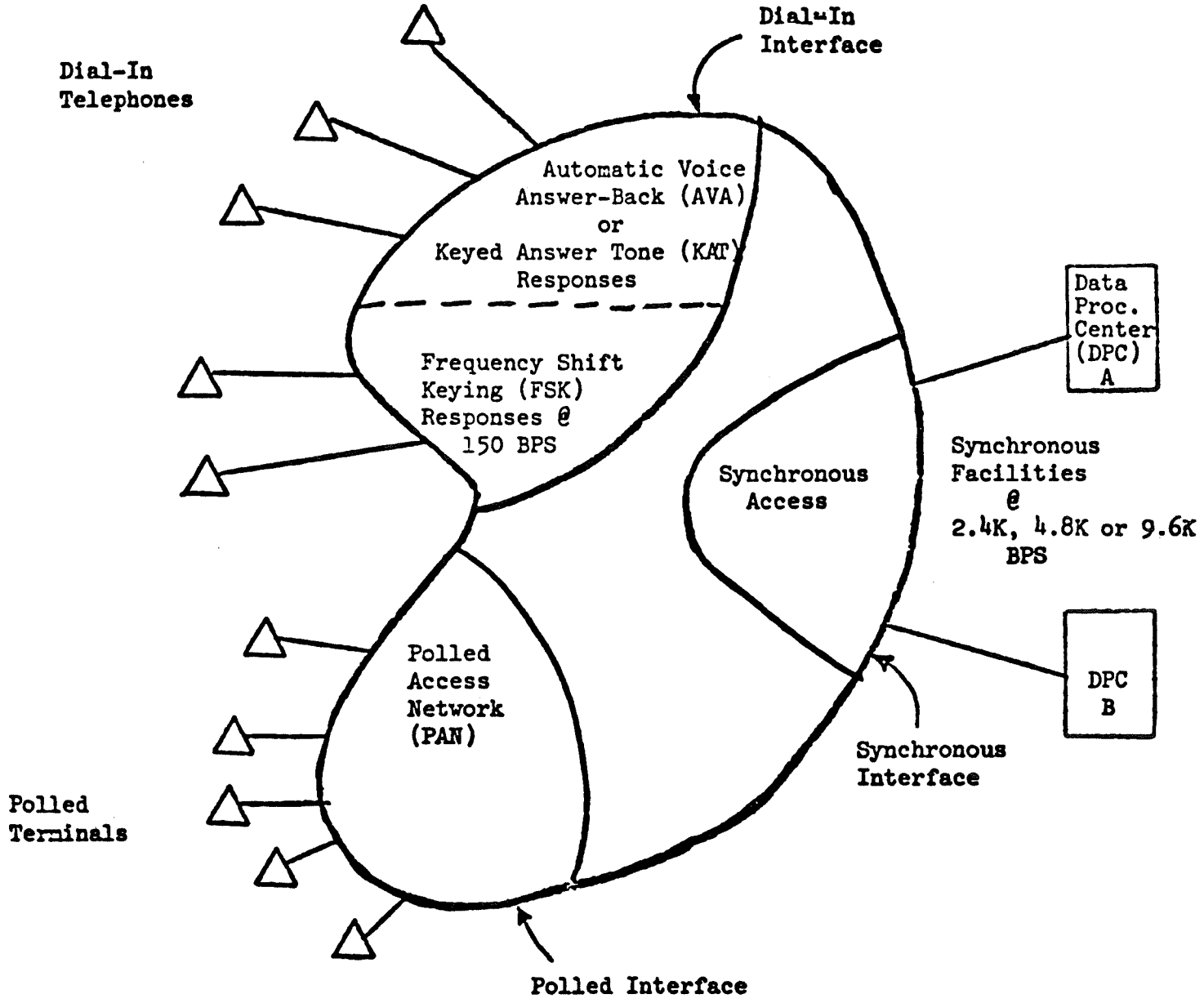
12. References

1. IBM Document General Information-Binary Synchronous Communications GA 27-3005-3.
2. American National Standard Message Heading for Information Interchange Using the ASCII for Data Communication System Control X3.57-1976.
3. Bell System Technical Reference - Data Communications Using Voice Grade Private Line Channels. PUB41004
4. Bell System Technical Reference - DATA-PHONE Digital Service Data Service Unit. PUB41XXX
5. Bell System Technical Reference - Data Set 201C Interface Specification PUB41210, April 1973.
6. Bell System Technical Reference - Data Set 208A Interface Specification. PUB41209, November 1973.
7. Bell System Technical Reference - Data SEt 209A. Interface Specification. PUB41213, May 1974.
8. Bell System Technical Reference - Transaction Network Service, PUB 41024 December 1975.
9. Bell System Technical Reference - Transaction Network Service - Polled Interface Specification. PUB41025, December 1975.
10. Bell System Technical Reference - Transaction Network Service Dial in Interface Specification PUB41026, December 1975.
11. American National Standard Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links, X3.28-1971.

13.0 Abbreviations

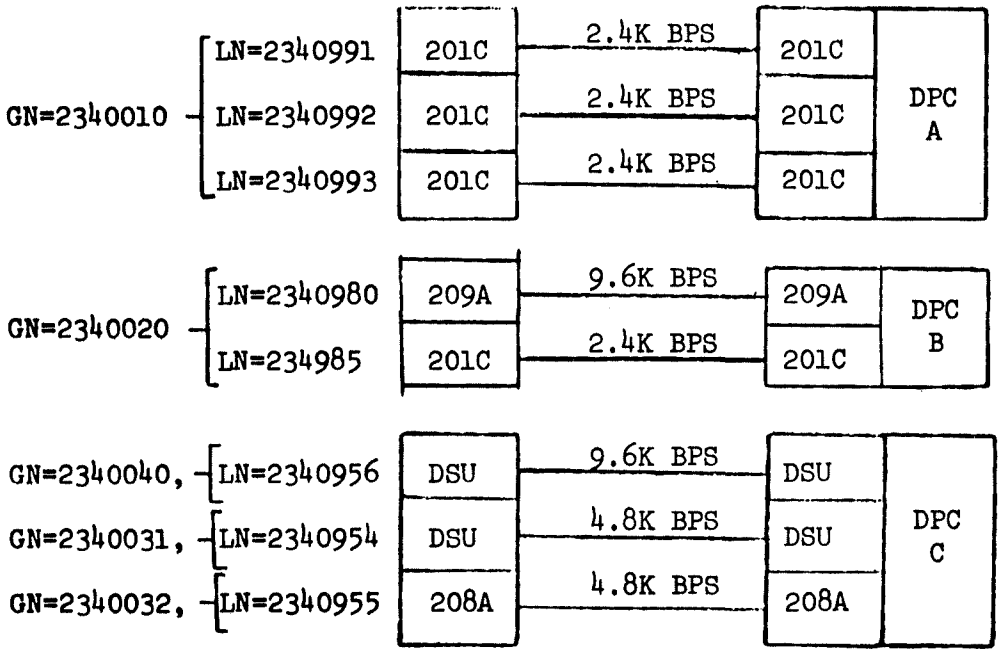
ACK	Positive Acknowledgement
ANSI	American National Standards Institute

ARU	Audio Response Unit
ASCII	American National Standard Code for Information Interchange
AVA	Automatic Voice Answerback
A/DO	Active/DPC Data Only State
BCC	Block Check Character
BSC	Binary Synchronous Communications
CSC	Class-of-Service Character
DLC	Data Link Control
DPC	Data Processing Center
ENQ	Enquiry
EOM	End-of-Message
EOT	End-of-Transmission
ETB	End-of-Block
ETX	End-of-Text
FSK	Frequency Shift Keyed
F_1	Characters per record
F_2	Characters per block
F_3	Records per block
F_4	Blocks per Transmission
HEX	Hexadecimal
HII	Heading Item Indicator
ITB	Intermediate Text Block (See US)
K	Line or Group State
KBPS	Kilobits per second
KAT	Keyed Answer Tone
LRC	Longitudinal Redundancy Check
NAK	Negative Acknowledgment
OFET	Out-of-Service/Far End Test State
OFER	Out-of-Service/Far End Removed State
OO	Out-of-Service/Other State
RVI	Reverse Interrupt/Positive Acknowledgment
S	Sequence Number (Service Message)
SAF	Service Administration Facility
SOH	Start-of-Header
SP	Space Character
STX	Start-of-Text
t	Service Message type
TC	(Service Message) type Code
TTD	Temporary Transmission Delay
US	Unit (Record) Separator
WACK	Wait Before Transmitting/Positive Acknowledgment
XY	Message Status
$X_1X_2X_3$	Transaction Network Number
$X_4X_5X_6X_7$	Station Identification Number



TRANSACTION NETWORK

FIGURE 1



Network System 234

Service message number = 2340999

GN = Group Number

LN = Line Number

TRANSACTION NETWORK

SYNCHRONOUS INTERFACE

POSSIBLE ARRANGEMENT

Figure 2

COMMAND		t	s	TC	STATE	LN
SET GROUP STATE	REQ*	1	N	00	K	
	ACK*	2	N	00 01	K K	
SET LINE STATE	REQ	1	N	02	K	$X_1X_2X_3\text{-}0X_5X_6X_7$
	ACK	2	N	02 03	K K	$X_1X_2X_3\text{-}0X_5X_6X_7$
REPORT GROUP STATE	REQ	3	N	04	K	
	ACK*	4	N	04	K	
REPORT LINE STATE	REQ	3	N	06	K	$X_1X_2X_3\text{-}0X_5X_6X_7$
	ACK	4	N	06	K	$X_1X_2X_3\text{-}0X_5X_6X_7$
HALT/WAIT	REQ	9	N	99		
	ACK*	0	N	99		

COMMAND		t	s	TC	CHARACTER STREAM
SINGLE MESSAGE REFLECTION	REQ	5	N	50	$A_1A_2 - - - A_E$
	ACK*	6	N	50	$A_1A_2 - - - A_E$
SINGLE BLOCK MULTIPLE MESSAGE REFLECTION	REQ	5	N	51	$A_1A_2 - - - A_E$
	ACK	6	N	51	$A_1A_2 - - - A_E$ & REPEAT MESSAGES
TWO BLOCKS MULTIPLE MESSAGE REFLECTION	REQ	5	N	52	$A_1A_2 - - - A_E$
	ACK	6	N	52	$A_1A_2 - - - A_E$ & REPEAT MESSAGES
NULL MESSAGE REFLECTION	REQ	5	N	53	$A_1A_2 - - - A_E$
EXPANDED MESSAGE REFLECTION	REQ	5	N	60	$A_1A_2 - - - A_E$
	ACK	6	N	60	$A_1A_2 - - - A_EA_1A_2 - -$ $A_E - - - A_1A_2A_3$
EXPANDED SINGLE BLOCK MULTIPLE MESSAGE REFLECTION	REQ	5	N	61	$A_1A_2 - - - A_E$
	ACK	6	N	61	$A_1A_2 - - - A_EA_1A_2 - -$ $A_E - - - A_1A_2A_3$ & REPEAT MESSAGES
EXPANDED TWO BLOCKS MULTIPLE MESSAGE REFLECTION	REQ	5	N	62	$A_1A_2 - - - A_E$
	ACK	6	N	62	$A_1A_2 - - - A_EA_1A_2 - -$ $A_E - - - A_1A_2A_3$ & REPEAT MESSAGES
MODIFIED MESSAGE REFLECTION	REQ	5	N	70	$A_1A_2 - - - A_E$
	ACK				$A_1A_2 - - - A_E$
MODIFIED SINGLE BLOCK MULTIPLE MESSAGE	REQ	5	N	71	$A_1A_2 - - - A_E$
	ACK				$A_1A_2 - - - A_E$ & REPEAT MESSAGES
MODIFIED TWO BLOCKS MULTIPLE MESSAGE REFLECTION	REQ	5	N	70	$A_1A_2 - - - A_E$
	ACK				$A_1A_2 - - - A_E$ & REPEAT MESSAGES

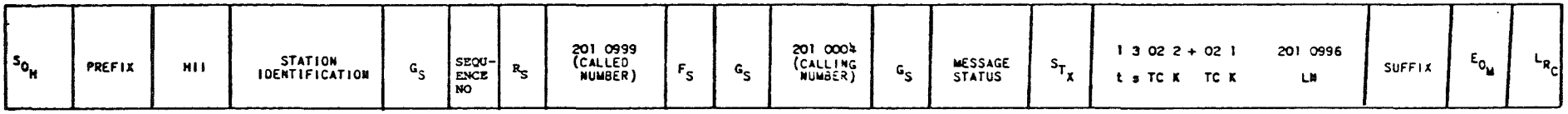
* DPC is required to implement

$1 \leq K \leq 6$ where K is the State number
$0 \leq N \leq 9$ where N is odd for DPC requests and even for Transaction Network requests.

NOTE: REQ is Request and ACK is Acknowledgment.

TRANSACTION NETWORK
SYNCHRONOUS INTERFACE
Service Message Text Formats

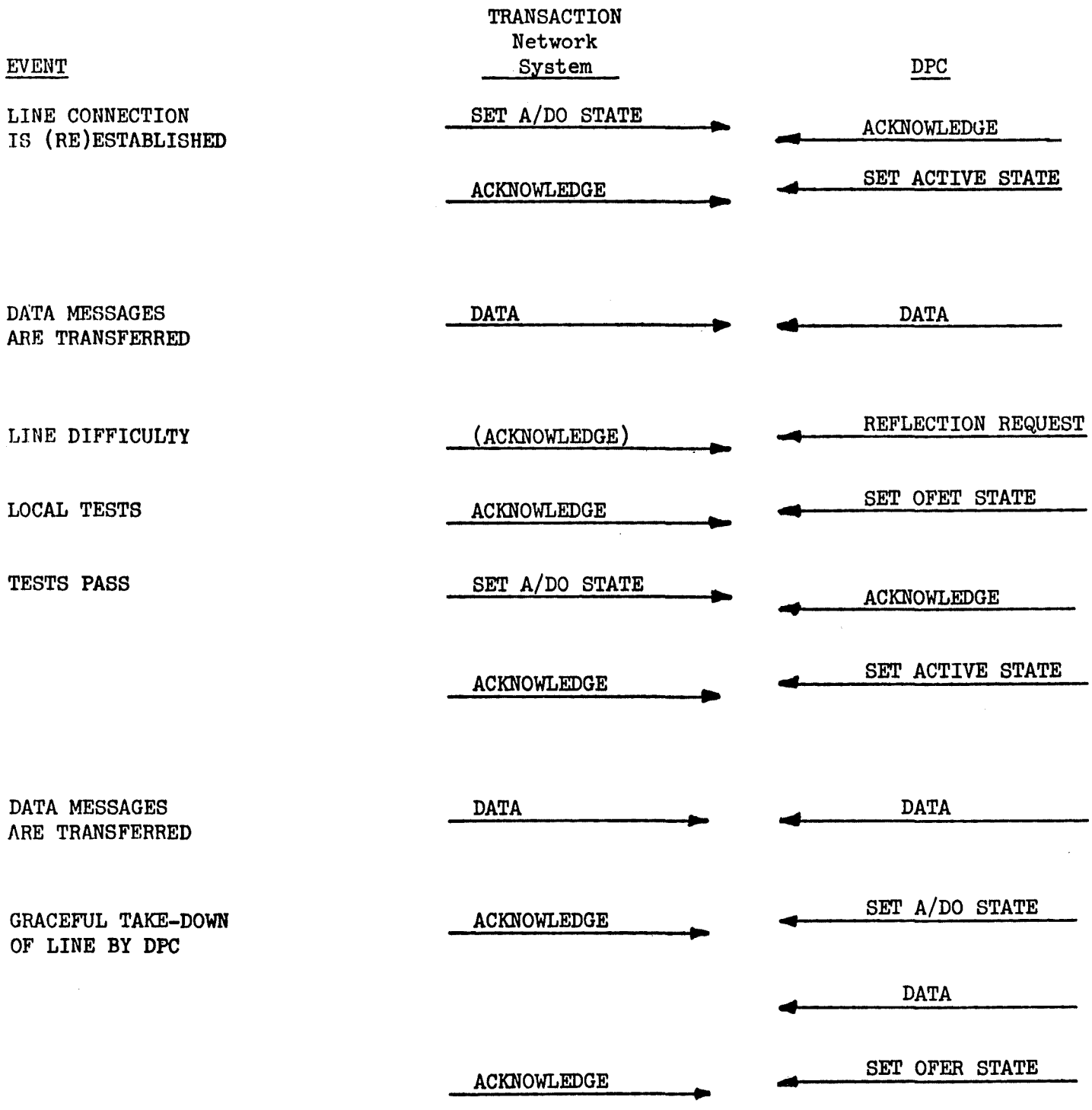
Figure 9



TRANSACTION NETWORK
SYNCHRONOUS INTERFACE
Example of a Set State Service Message

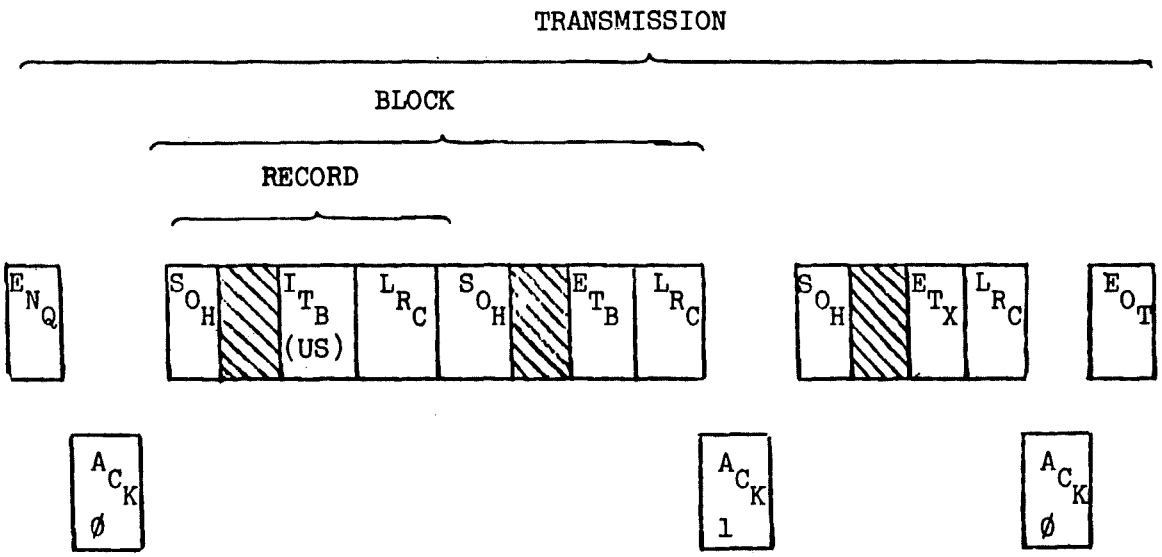
FIGURE 4

EXAMPLE: SERVICE MESSAGE USAGE



TRANSACTION NETWORK SYNCHRONOUS INTERFACE

Figure 5



End of Message (EOM)
Characters are ITB(US),
ETB or ETX

TRANSACTION NETWORK
SYNCHRONOUS INTERFACE

Basic Terminology and Use of EOM Characters

FIGURE 6

CONTROL SEQUENCE	BIT PATTERN (ASCII CHARACTERS)	USAGE CONTENTION STATE	DATA TRANSFER STATE
ACK 0 (Even Positive Acknowledgement)	$0001\ 0000_2\ 1011\ 0000_2$ (DLE 0)	Receiving Station Prepared to Receive First Data Block	Even Block Received Correctly
ACK 1 (Odd Positive Acknowledgement)	$0001\ 0000_2\ 0011\ 0001_2$ (DLE 1)	-	Odd Block Received Correctly
NAK (Negative Acknowledgement)	$0001\ 0101_2$ (NAK)	Receiving Station Unable to Receive First Data Block	Data Block Received Incorrectly, Resend Data Block
TTD (Temporary Transmission Delay)	$0000\ 0010_2\ 1000\ 0101_2$ (STX ENQ)	Transmitting Station Must Wait Temporarily Before Sending First Data Block. Send NAK and Wait	Transmitting Station Must Wait Temporarily Before Sending Next Data Block Send NAK and Wait.
WACK* (Wait Before Transmitting - Positive Acknowledgement)	$0001\ 0000_2\ 0011\ 1011_2$ (DLE ;)	Receiving Station Temporarily Unable to Receive First Data Block. Enquire Again	Receiving Station Temporarily Unable to Receive Next Data Block. Previous Block is Positively Acknowledged. Enquire Again to Resume Transmission
RVI† (Reverse Transmission Direction)	$0001\ 0000_2\ 1011\ 1100_2$ (DLE <)	-	Data Block is Positively Acknowledged. Relenquish Control of the Data Line By Sending EOT
EOT (End of Transmission	$0000\ 0100_2$ (EOT)	Return to Idle State and Drop Synchronization	A Relinquishing Control of the Line, Return to the Idle State and Drop Synchronization
SYN (Synchronous Idle)	$0001\ 0110_2$ (SYN)	Establish or Maintain Character Synchronization	Establish or Maintain Character Synchronization Erase the SYN Character
ENQ (Enquiry)	$1000\ 0101_2$ (ENQ)	Line Bid	Repeat Last Transmitted Response. Data Block is Aborted Send NAK.

* Transmitted by Transaction Network only in Class II Protocol

† Not transmitted by the Transaction Network System

TRANSACTION NETWORK
SYNCHRONOUS INTERFACE
Data Link Control Definitions
Figure 7

ACK 0 or 1	PAD SYN SYN DLE 0 (even) PAD PAD SYN SYN DLE 1 (odd) PAD	Positive acknowledgment to even or odd block, or to a line bid (ACK 0 only).
NAK	PAD SYN SYN NAK PAD	Negative acknowledgment to a block or a line bid
TTD	PAD SYN SYN STX ENQ PAD	Master station initiated transmission delay. Slave station responds NAK and waits for transmission to begin.
WACK	PAD SYN SYN DLE ; PAD	Slave station initiated transmission delay. This sequence replaces an ACK response when the slave needs time to make itself ready to receive. Master enquires again immediately and slave repeats WACK after two seconds if still not ready to receive.
RVI	SYN SYN SYN DLE < PAD	Serves as a positive acknowledgment; the Transaction Network will send EOT to relinquish the line, without further data transmission. Not sent by Transaction Network.
ENQ	PAD SYN SYN ENQ PAD	Response solicitation. OR Line bid
	(TEXT) ENQ PAD	Abort uncomplete block. Correct acknowledgment is NAK.
EOT	SYN SYN SYN EOT PAD	Data link termination. All stations that receive this sequence drop synchronism and return to the control state, waiting for a new data link to be established by a line bid and response.
SOH	PAD SYN SYN SOH MESSAGE	Message beginning. Computation of a new LRC value of both master and slave station begins.
STX	SOH (heading) STX MESSAGE	Message text beginning.
ETB	(TEXT) ETB PAD	ETB signals that the master's LRC follows, after which a response is expected.
ETX	(TEXT) ETX PAD	ETX signals that the master's computed LRC follows, after which a response is expected.

Note a/ Synchronism is dropped at each line turnaround. The PAD SYN SYN sequence establishes synchronism.

Note b/ The trailing PAD character shall be all ones, HEX 'FF'. The leading PAD character shall be alternating ones, HEX'55' from the Transaction Network. DPC may send a SYN character in place of the leading PAD character.

Note c/ SOH may optionally be selected as STX.

Note d/ STX will be replaced by * if SOH selected to be STX option is used.

Note e/ ETX and ETB can be interchanged by DPC but the Transaction Network will use ETX to signal the end of job.

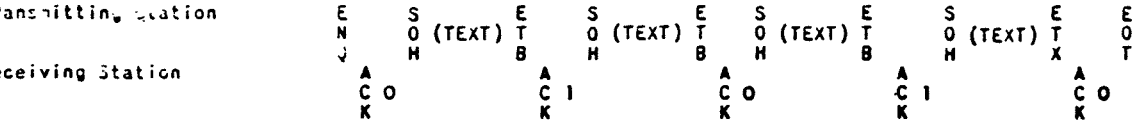
TRANSACTION NETWORK

SYNCHRONOUS INTERFACE

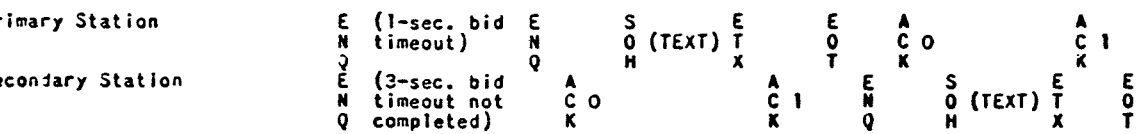
Control Sequences

FIGURE 8

Normal Message Transmission

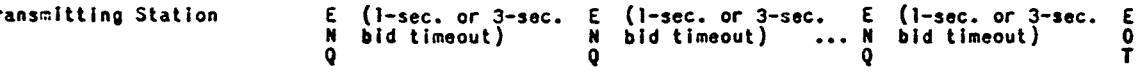


Contention for Master Status



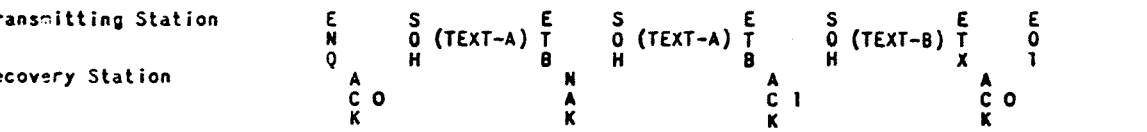
In Class I protocol Transaction Network is always primary - optional in Class II protocol.

Unanswered Line Bid

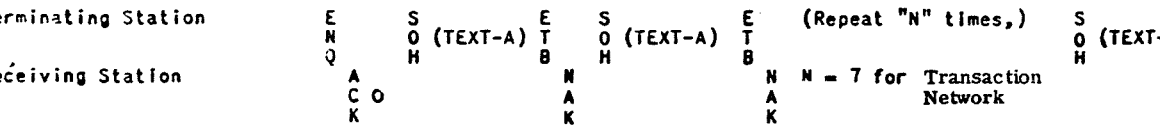


Primary stations wait one second; secondary stations wait three seconds.
Transaction Network will make 4 tries.

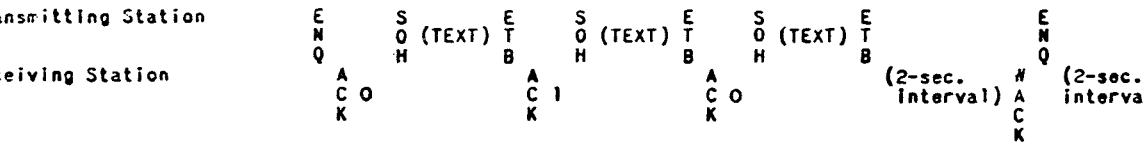
Retransmission Accepted



Retransmission Rejected



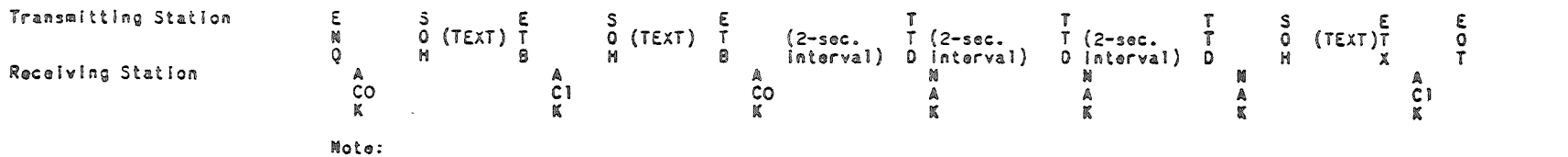
Receive-Initiated Transmission Delay



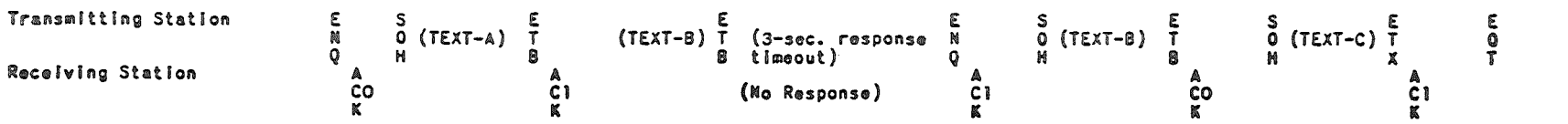
ENQ may be an immediate response to WACK.
WACK-ENQ sequences are not counted by Transaction Network.
WACK is transmitted by Transaction Network.

TRANSACTION NETWORK
SYNCHRONOUS INTERFACE
Data Transmission and Transmission Control Sequence
FIGURE 9

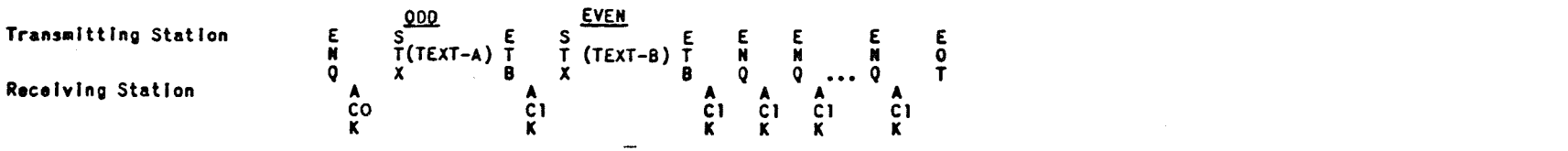
Tran. .ter-Init. d Transmission Del.



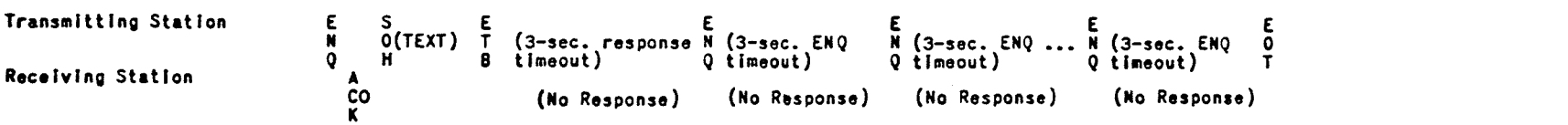
SOH Format Error, Data Ignored by Slave Station



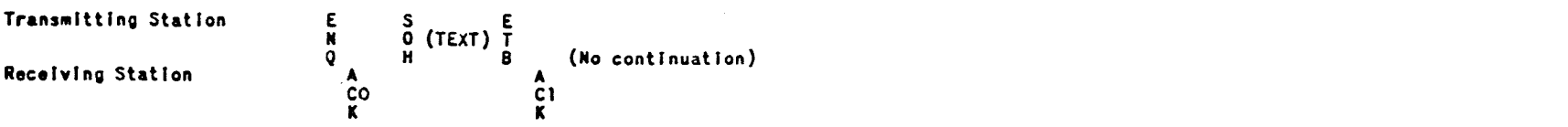
Response Not Matched to Odd-Even Block Count



Data Link Aborted on No-Response from Receiver



No-Continuation by Transmitter



TRANSACTION NETWORK
SYNCHRONOUS INTERFACE

Data Transmission and Transmission Control Sequence (Continued)

FIGURE 9

ϕ [7]	S_{O_M} [1]	DPC Specified Message Prefix (8) [2]	Heading (27)	S_{T_X} [1]	Text (128)	DPC Specified Message Suffix (1) [3]	E_{O_M} [4]	B_{C_C} [5] (1)	P_{A_D} [7]

A. Message Format

Text (128)	I_{T_B}	B_{C_C} [5]	DPC Specified Message Suffix (2) [6]	E_{T_X} [4]	B_{C_C} [5] (1)	P_{A_D} [7]

B. Optional Message End Format

ϕ [7]	Control Character	P_{A_D} [7]

C. Control Sequence Format

NII (2)	Station Identification (3)	G_S (1)	Sequence Number [8] (1)	R_S (1)	Called Number (7)	F_S (1)	G_S (1)	Calling Number (7)	G_S (1)	Message Status [8] (2)

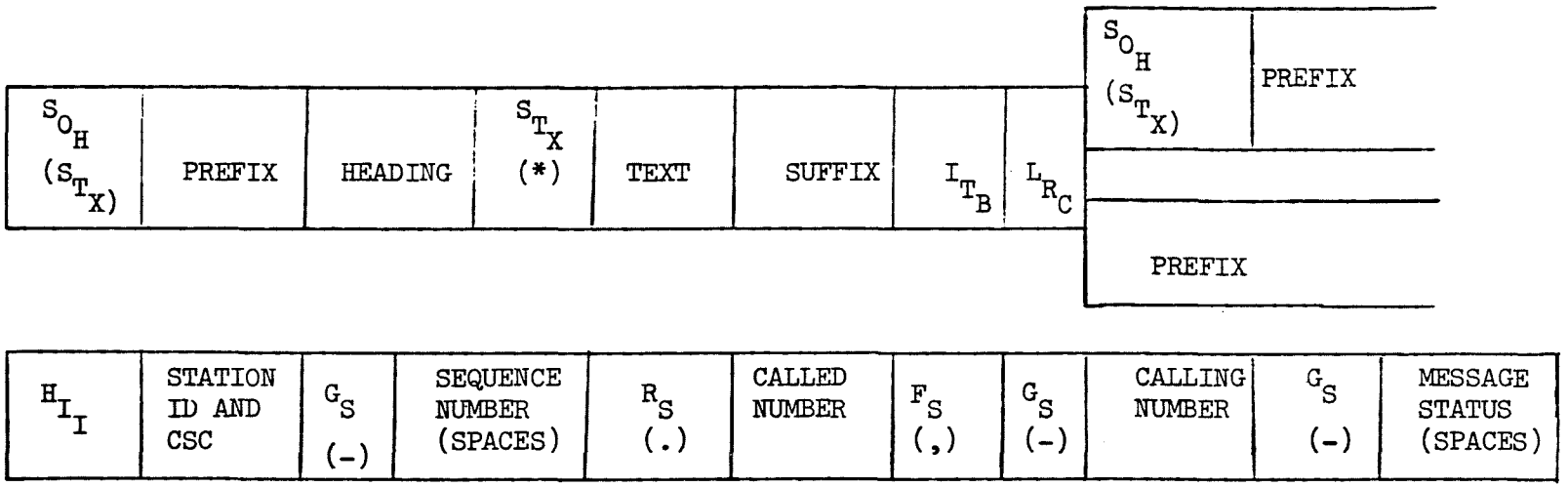
D. Full Heading to and From DPC

The numbers in parentheses ( ) under message indicate maximum field length.

Notes:
1. SOH and STX may be DPC specified as STX and *, respectively.
2. Fixed length, $P \leq 8$, and content are specified by DPC.
3. Suffix of fixed length $S \leq 1$ may be specified by DPC.
4. Dependent on the position of the message within the block, EOM is ITB(US), ETB or ETX.
5. For ASCII code, one character LRC.
6. Optional suffix for end of transmission on messages to DPC. May be specified by DPC with $S \leq 2$.
7. Appearing only at beginning and end of each block.
   ϕ is alternating 1's character (HEX '55') followed by at least two SYN characters.
   PAD is the all 1's character (HEX'FF)
8. Optional Subfield for headings from DPC.

TRANSACTION NETWORK
SYNCHRONOUS INTERFACE
Message Format

FIGURE 10



MESSAGE FORMAT OPTIONS

1. SOH, STX, FS, GS AND RS MAY BE REPLACED BY STX, "*", ",", "-" and "." RESPECTIVELY.
2. SOH WILL BE OPTIONALLY DELETED ON SECOND AND SUCCESSIVE RECORDS WITHIN EACH BLOCK.
3. HEADINGS TO TRANSACTION NETWORK SYSTEM MAY BE SIMPLIFIED IN THE OPTIONAL SEQUENCE NUMBER AND MESSAGE STATUS SUBFIELDS BY INSERTING "SPACE" CHARACTERS OR DELETING THE SUBFIELDS.
4. PREFIX MAY BE USER SPECIFIED UP TO EIGHT CHARACTERS TO INCLUDE TRANSACTION ID'S, DEVICE DEPENDENT CODES, ETC.

TRANSACTION NETWORK

SYNCHRONOUS INTERFACE

Figure 11

S_{O_H}	MSG 1	S_1	U_S	L_{R_C}	S_{O_H}	MSG 2	S_4	U_S	L_{R_C}	S_{O_H}	MSG 2 (CONT'D)	S_2	E_{T_B}	L_{R_C}

S_{O_H}	MSG N	S_3	E_{T_X}	L_{R_C}	S_{O_H}	MSG N	S_1	U_S	L_{R_C}	S_5	S_6	E_{T_X}	L_{R_C}

MESSAGE FORMAT OPTIONS

5. SUFFIX (Sn) MAY BE CHOSEN TO EXTEND THE THREE EOM CHARACTERS BY THE DPC SELECTING A SINGLE (DIFFERENT IF DESIRED) CHARACTER TO PRECEDE US, ETB AND ETX IN ORDER TO AID IN DEBLOCKING MESSAGES AND IN TURNING THE LINE AROUND.
6. MULTIPLE RECORDS PER MESSAGE (MESSAGE FLOW OPTION) MANDATES A FOURTH CONTINUATION CHARACTER SUFFIX TO BE INSERTED BEFORE US WHICH MUST BE DIFFERENT FROM THE CHARACTERS CHOSEN ABOVE ($S_4 \neq S_1, S_2, S_3$).
7. THE SUFFIX BEFORE ETX MAY BE USER CHOSEN TO CONSIST OF TWO CHARACTERS TO BE TRANSMITTED AS A SEPARATE RECORD. THIS SUFFIX ALLOWED FOR MESSAGES TO DPC ONLY.

TRANSACTION NETWORK
SYNCHRONOUS INTERFACE
Figure 11 (Continued)

TOUCHTONE CHARACTER	ASCII CHARACTER TRANSLATION (TO DATA PROCESSING CENTER)
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
#	:
a	;
*	<
b	=
c	>
d	?
#2	DEL

TRANSACTION NETWORK

DIAL-IN INTERFACE

TOUCH-TONE Character Assignment

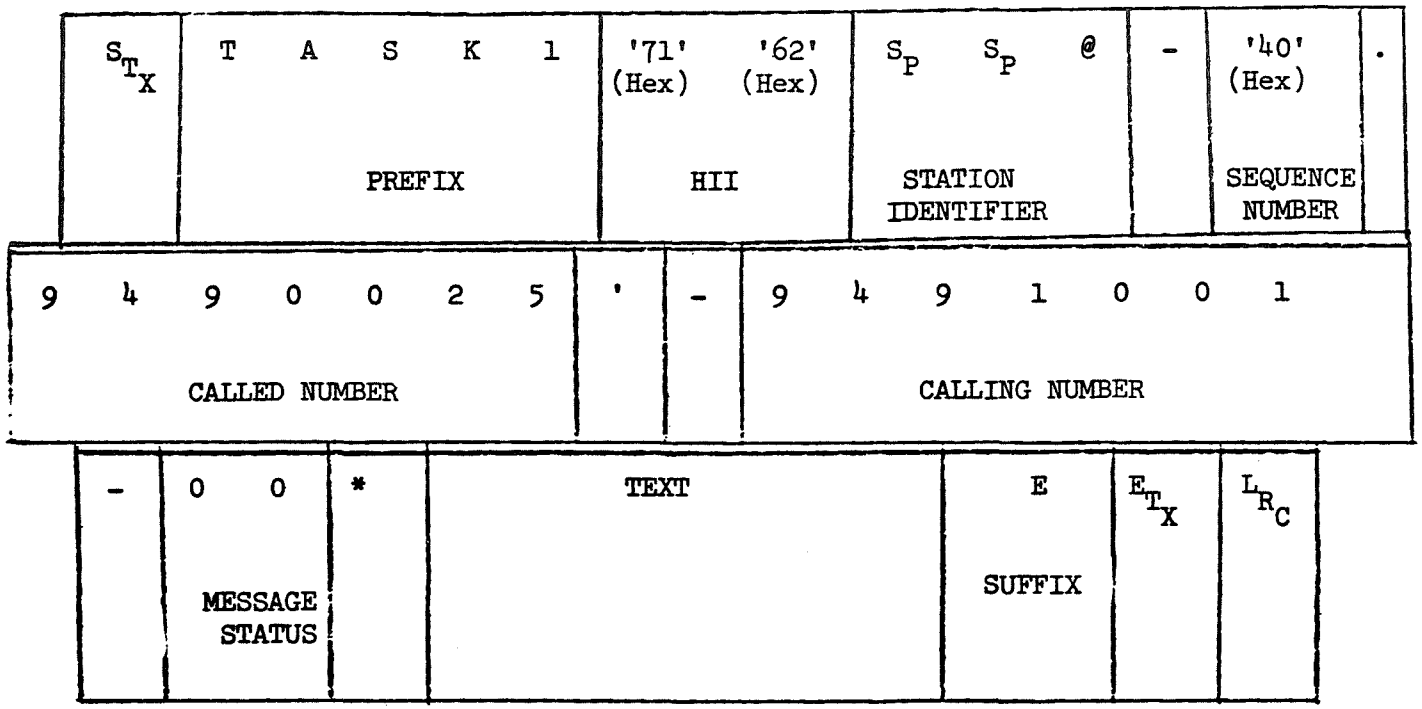
and Translation to the Data Processing Center

FIGURE 12

MESSAGE FORMAT - EXAMPLE

a/ using optional reading format;

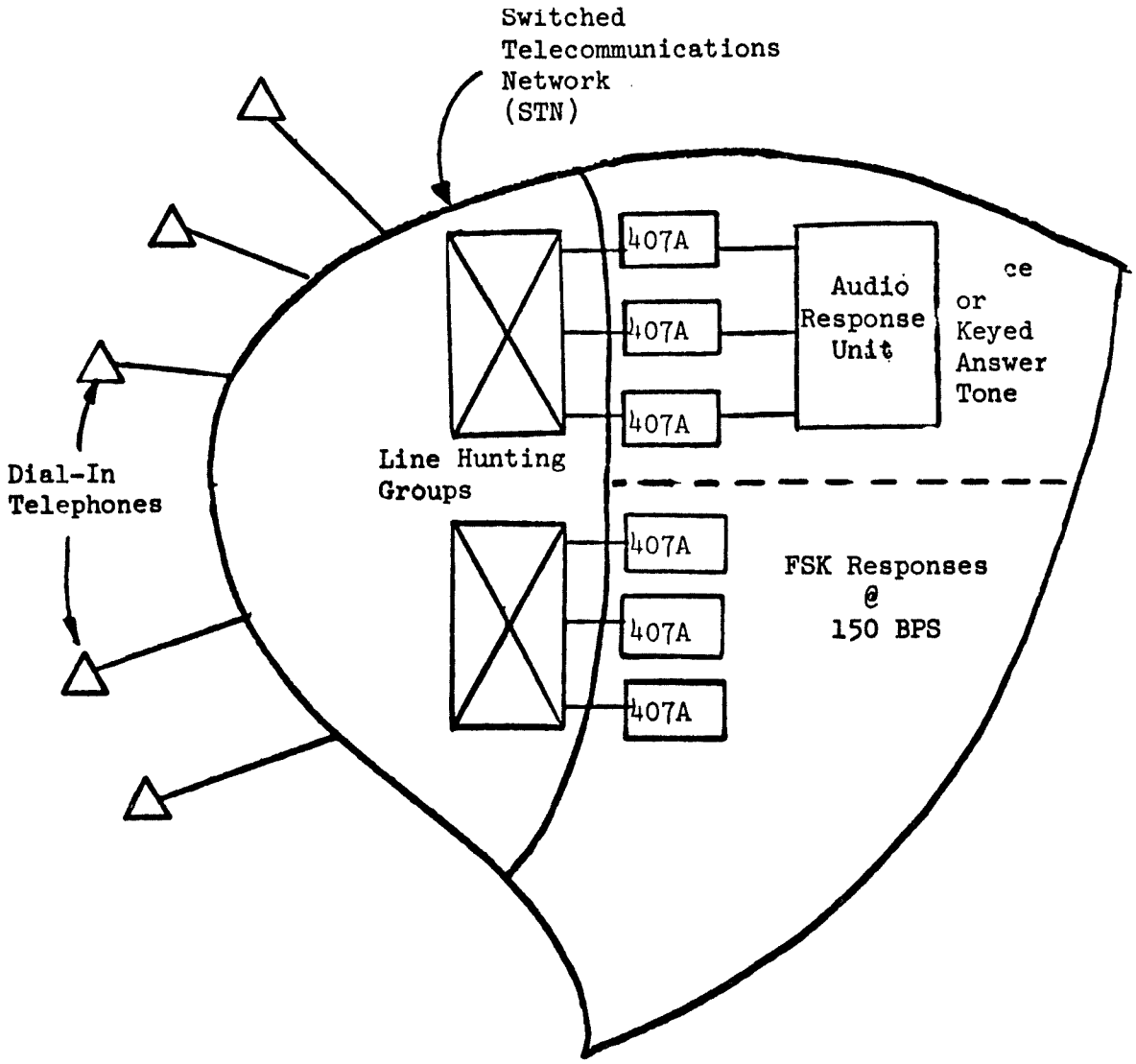
SOH, STX, FS, GS, and RS replaced by STX, *, ', ¯, ·, respectively.



TRANSACTION NETWORK

SYNCHRONOUS INTERFACE

Figure 13



TRANSACTION NETWORK

DIAL-IN INTERFACE

FIGURE 14

800	Any Bank
803	Any Store
203	Credit Card
200	Sale
300	Approved
302	Denied
335	Authorization Code
102	TWO
103	THREE
105	FIVE
:01	PAUSE (one element)

S_{O_H} [HEADING WITH AVA MESSAGE INDICATION] S_{T_X} [800203200300:01102103105] E_{T_X} L_{R_C}

Any Bank credit card sale approved. (pause) Authorization code 235.

TRANSACTION NETWORK

SYNCHRONOUS INTERFACE

Example of Transaction Network System Vocabulary List With Sample Text Format

Figure 15

INQUIRY/RESPONSE TIME (t)

VS.

POLLED TERMINAL CALLING RATE (λ)

FOR

2.4K BPS LINES

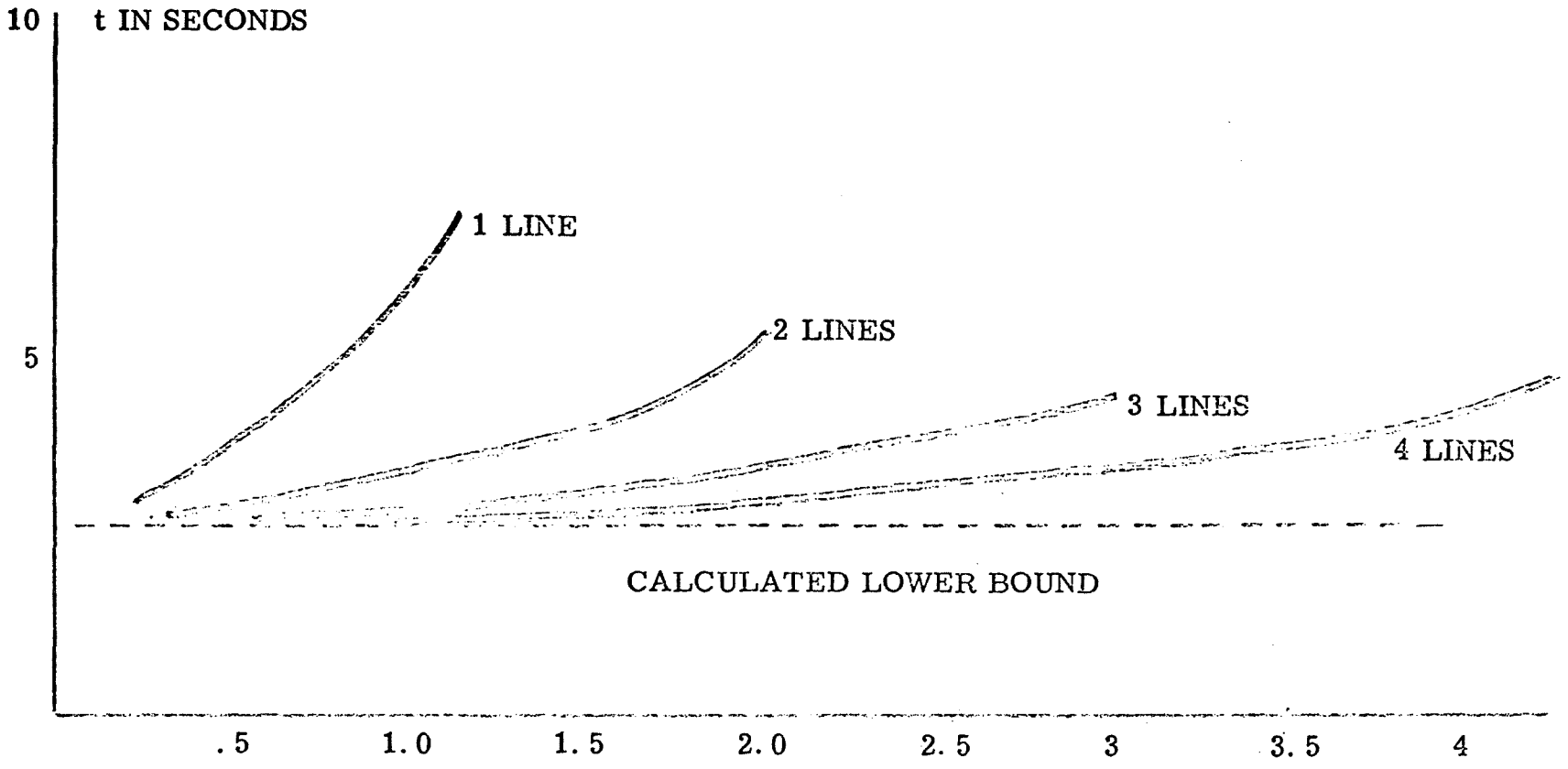


FIGURE 16

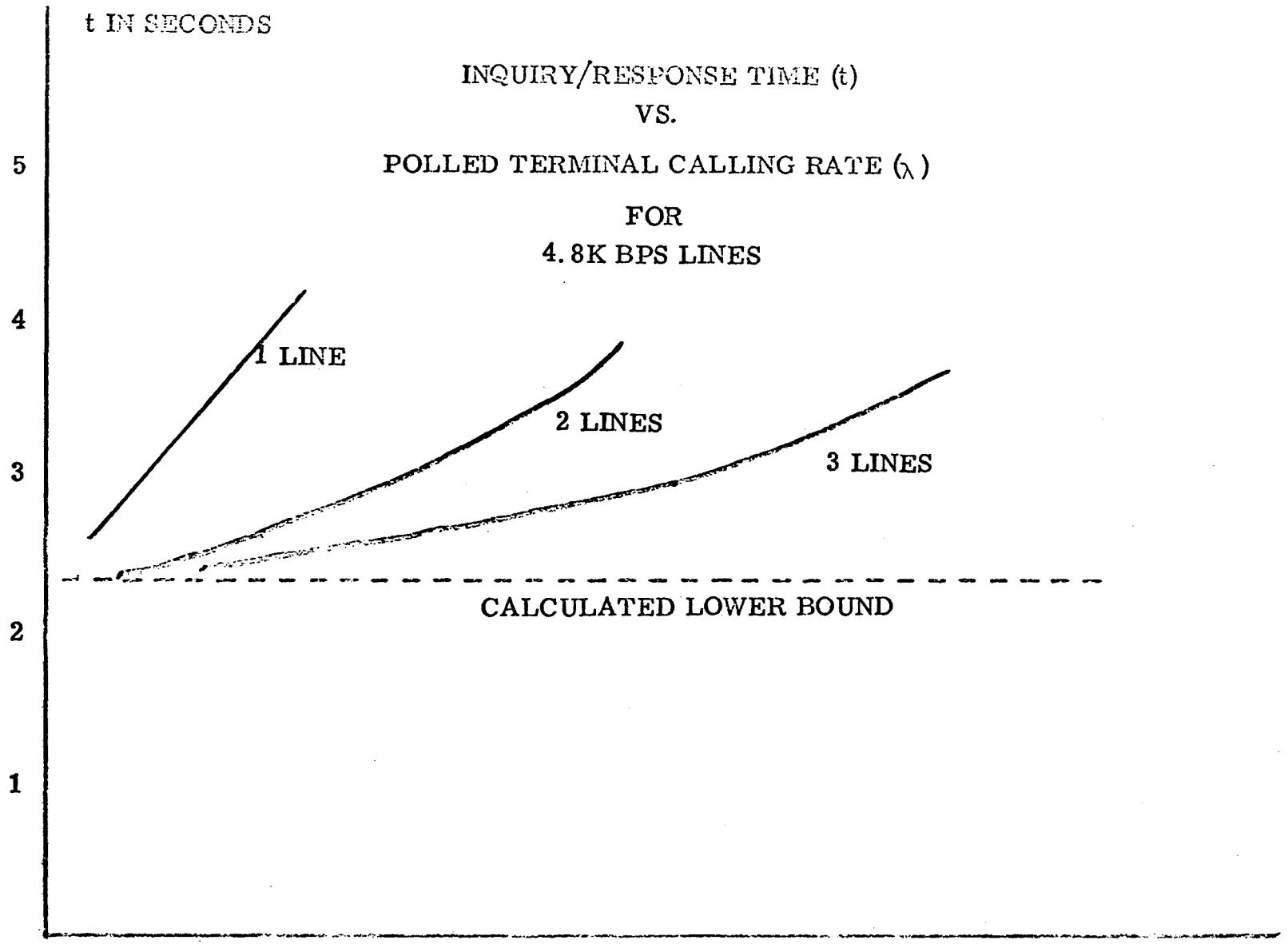

t IN SECONDS
INQUIRY/RESPONSE TIME (t)
VS.
POLLED TERMINAL CALLING RATE (λ)
FOR
4.8K BPS LINES
5
4
3
2
1
1 LINE
2 LINES
3 LINES
CALCULATED LOWER BOUND
1
2
3
4
5
6
7
λ IN MESSAGES PER SECOND

FIGURE 17

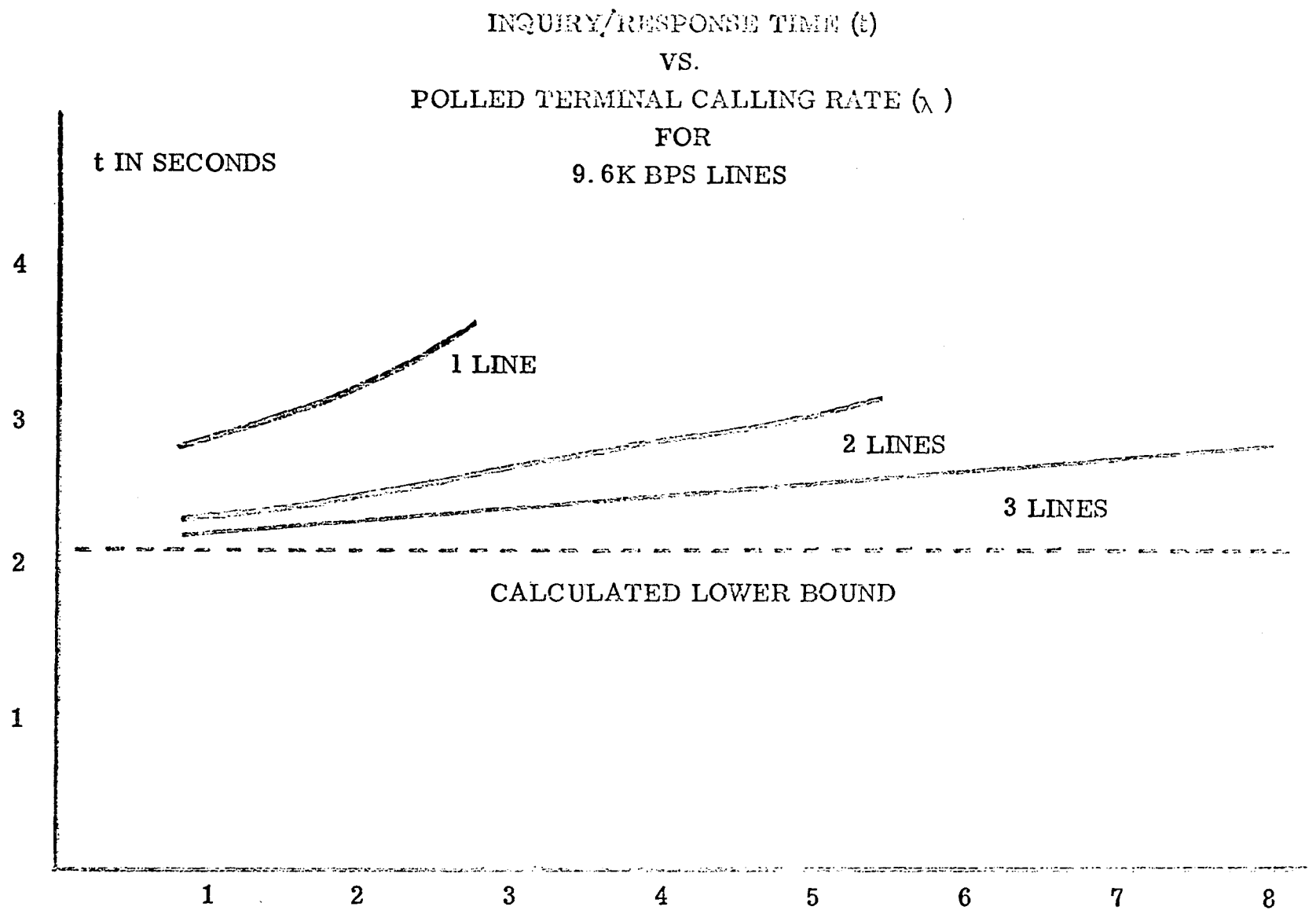

INQUIRY/RESPONSE TIME (t)
VS.
POLLED TERMINAL CALLING RATE (λ)
FOR
9.6K BPS LINES
t IN SECONDS
4
3
2
1
1 LINE
2 LINES
3 LINES
CALCULATED LOWER BOUND
1
2
3
4
5
6
7
8
λ IN MESSAGES PER SECOND

FIGURE 18

State Name Group and Line States	State No.(K)	Message Originations Permitted			Reason for Entering State				
		Data	Request Service Messages To DPC	Request Service Messages From DPC	DPC Request	Trouble Report	TRANSACTIONS Network Hardware Test Failed	TRANSACTIONS Network Hardware Test Passed	TRANSACTION Network System Action
Active	1	X	X	X	X				
Active/DPC Data Only (A/DO)	2	†	X	X	X			X	X
Out-of-Service/ Far-End Removed (OPER)	3			X	X				
Out-of-Service/ Far-End Test (OPET)	4				X				
Out-of-Service/ Other (OO)	5					X	X		X
Unavailable	6								X

All request service message other than "reflections" will be transmitted on the SAF

† Data messages allowed from DPC to Transaction Network System orly.

Line and Group State Definitior s

TABLE 1

PRESENT STATE	TO STATE Active	A/DO	OFER	OFET	OO	Unavailable
Active	Act. Msg.	A/DO Msg.	OFER Msg.	OFET Msg.	Telephone Company Action	Telephone Company Action
A/DO	Act. Msg.	A/DO Msg.	OFER Msg.	OFET Msg.	As Above	As Above
OFER	Act. MSG.	A/DO Msg.	OFER Msg.	OFET Msg.	As Above	As Above
OFET	Cannot Occur	Telephone Company Action	Cannot Occur	OFET Msg.	As Above	As Above
OO	Cannot Occur	As Above	Cannot Occur	Cannot Occur	As Above	As Above
Unavailable	Cannot Occur	As Above	Telephone Company Action	Telephone Company Action	As Above	As Above

Causes of Group and Line State Transitions in the Transaction Network

Table 2

APPENDIX A

Group 00 State

The Transaction Network will normally put each line subscribed to by the DPC into the 00 state as the line becomes unavailable for any transmissions and so inform the DPC over a working line in the group, when one is available. In certain instances, however, the Transaction Network will put the line group in the 00 state and so inform the DPC over the SAF. This will occur when data transmission over all ines is imminently in danger of shut-down. In this latter case, the DPC should not queue any more messages for transmission and, if possible, remove all message previously queued. For a brief period after issuance of the "set line group" state to 00 service message request, the DPC may expect several additional data messages from the Transaction Network as the Transaction Network empties its queues. Upon correction of the problem causing the 00 state, the Transaction Network will set the group to the A/DO state with each line state left unchanged. Thus, the DPC need only issue a "set line group state" request to the active state to resume normal transmissions.