THE BELL SYSTEM TECHNICAL JOURNAL
Vol. 57, No. 10, December 1978
Printed in U.S.A.

***Transaction Network, Telephones, and Terminals*:**

Customer Service Center Interface

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(Manuscript received June 6, 1978)

The Customer Service Center (CSC) interface to the Transaction Network System (TNS) is designed primarily for flexibility and efficiency so as to be able to interconnect with the majority of present customer computer installations. In addition, since these host computers have a large potential capability under program control, TNS features are made available, but are not generally mandated, to provide CSC control over and thereby optimize usage of this interface. This paper describes the design philosophy and the features of this interface.

I. DESIGN CRITERIA

The Transaction Network Service (TNS) is a new Bell System data offering to handle short data messages between Customer Service Centers (CSCs), e.g., host computers, and remote stations such as telephones, terminals, and other CSCs. An accompanying paper[1] describes the overall system design as depicted in Fig. 1; in this paper, the CSC interface is covered in detail. The CSC interface consists of a synchronous data link using the binary synchronous protocol.

1.1 Anticipated customer configuration

Figure 2 shows a block diagram of a typical software and hardware configuration at the CSC. The actual configuration is dependent on the supplier of hardware or software. The basic features however, are always present and may be relocated (e.g., if a front-end processor is installed, then some access method functions take place in the front end) to other segments of hardware and/or software.

The host computer software is generally operating under an operating system with several application programs resident for processing the

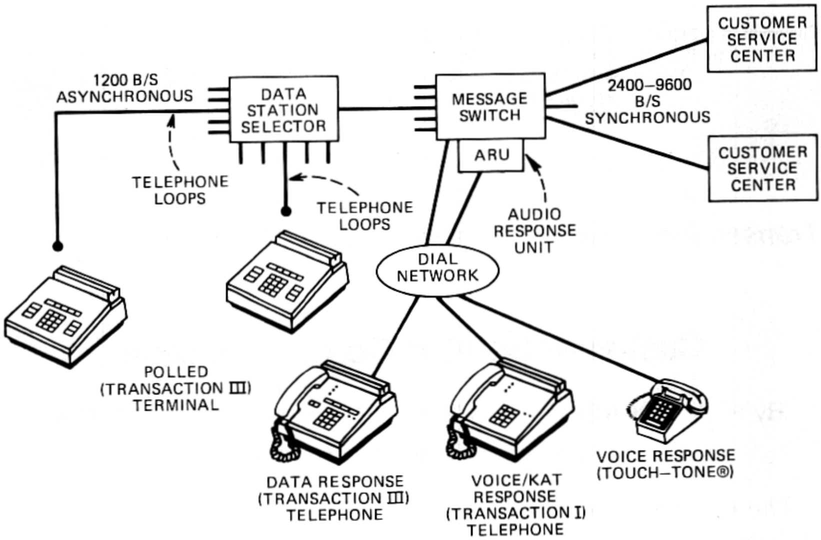


Fig. 1—Transaction Network.

messages. These programs are written by the CSC's staff. To interface between these application programs and the data links (which are connected to the remote TNS), a telecommunication monitor is often used.

Telecommunication monitors provide three basic functions:

(*i*) A data base interface.

(*ii*) Multi-threading (the capability of processing multiple messages in parallel) of application programs.

(*iii*) A data link interface (drives the telecommunications access method) and the device-dependent characteristics of the far-end station.

The first function depends solely on the processing programs, whereas the last two functions directly affect the CSC interconnection with TNS.

1.2 Design statement

The hardware for the data links has been specified according to standard industry practices to consist of four-wire, point-to-point, synchronous facilities operating at 2.4, 4.8, or 9.6 kb/s.

The system design challenge then is not the physical connection of stations but instead is the passing of intelligence between two entities, namely, the TNS message switch and the CSC's application program. To accomplish this, protocols are specified which properly pass the intelligence over the data link and through the software and hardware to the application programs.

These protocols are essentially *a priori* agreements between stations

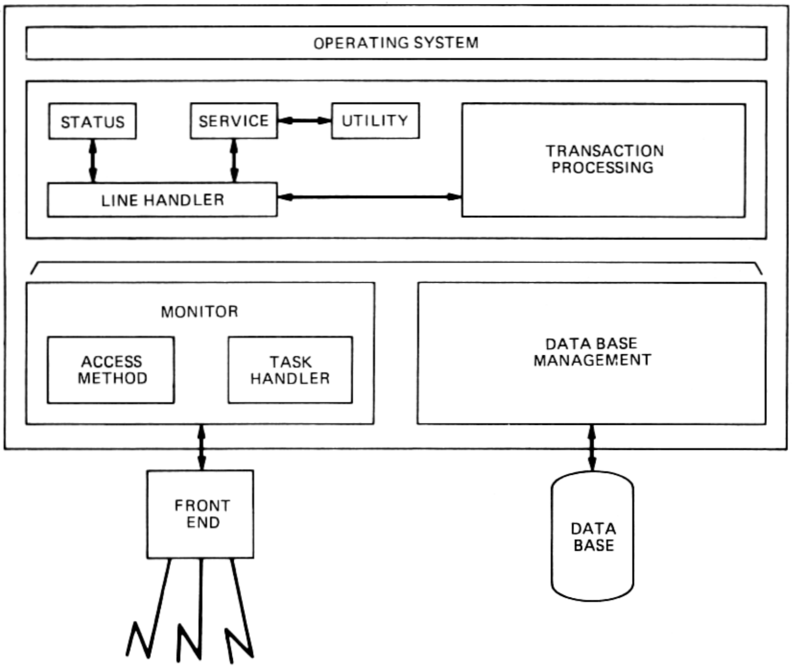


Fig. 2—Sample software configuration.

which provide for communication procedures under normal conditions and correction of any errors or anomalies that may arise.

1.3 Design criteria

In providing the TNS protocol specification for CSCs, the basic assumption is that the major hardware and software elements are available and that all the CSC should be required to do is provide interface programs (which can be written in a high-level language such as Cobol) between the CSC telecommunications monitor and the CSC's data base. Therefore, in selecting the features to be offered to CSCs, the following criteria are followed:

(*i*) A single, universal interface to be compatible with all expected types of CSC installations.
(*ii*) Minimum hardware/software impact on existing CSC installations.
(*iii*) Simplicity of installation with extension to full capabilities.
(*iv*) Efficient use of facilities and processing of messages.
(*v*) Reliable, flexible, and maintainable service.

The next sections describe briefly the features offered by TNS to achieve the above; complete descriptions are given in Refs. 2 and 3. Section II describes the overall network features; Section III, the data link protocol (DLP) and message format specification; Section IV, the options to provide flexibility; Section V, status reports and service messages; and Section VI, a description of a system implemented to test the interface.

II. NETWORK FEATURES

TNS provides a set of features so that each individual CSC can establish a network to fit its individual requirements. These features consist of a group concept which provides one single logical address for several physical links, alternate delivery which provides for automatic rerouting of messages, and screening which allows the CSC to predetermine the stations with which it desires to communicate.

2.1 Line group

Complete control of the CSC network by TNS ends at the local TNS port. To provide redundancy on the interface, one-for-N (N is the number of links utilizing identical data sets on a single message switch) sparing of message switch ports is provided. This spare port will be automatically switched in to replace any failing port by the message switch.

To further provide redundancy of both the data links and the CSC ports as well as greater traffic capacity, multiple data links may be incorporated into a line group. The line group contains multiple physical paths under a single, logical TNS directory number.

TNS will then distribute the message load that is transmitted to the CSC among all active lines in the line group and will accept messages from the CSC on any active line in the group.

In addition to the single line group directory number used for call routing, each line in the line group is assigned a unique address for service message and maintenance purposes as discussed in Section V.

2.2 Alternate delivery

The line group concept provides increased traffic capabilities as well as hardware redundancy for a single CSC entity. If the primary CSC itself becomes unavailable due to exceeding its traffic capacity or due to outage of the entire CSC, an alternate delivery feature to a secondary CSC is available. This forwarding mechanism, if optioned, is automatically triggered when either the primary line group is not active or when the message queue to the CSC overflows.

Forwarding a message consists of a single attempt to deliver to a secondary line group with the message returned to the originator if both primary and secondary line groups are not available. A line group may provide alternate delivery for up to nine other line groups.

Thus, alternate delivery provides an automatic alternate CSC for both scheduled or nonscheduled outages of an entire line group, and, as such, complements the line group concept.

2.3 Class of service

TNS provides an automatic screening function based on the originator of a message: polled terminals, dial-in telephones, or other CSCs. This allows the CSC to receive messages from any station or only from predetermined stations, e.g., the establishment of a private network within TNS.

2.3.1 Telephone and terminal classes of service

A CSC may elect to communicate with any combination of the following:

(*i*) Dial-in telephones.
(*ii*) Unrestricted polled terminals.
(*iii*) Restricted polled terminals.
(*iv*) Other CSCs (affiliated or unaffiliated).

Essentially, dial-in telephones consist of all stations originating calls over the Switched Telephone Network to the TNS dial-in interfaces.[2] If this class of service is chosen, TNS will allow the CSC to both transmit to and receive from stations such as *TOUCH-TONE*® calling stations and Transaction I and Transaction II telephones. No further screening is available for dial-in stations, since TNS does not have control over originations on the Switched Telephone Network.

For polled terminals,[2] completely dedicated TNS facilities are used to provide service and, consequently, the terminal's physical location is known: given this definite physical connectivity, it is useful that a terminal may be identified by TNS as being unrestricted and capable of communicating with any CSC specifying unrestricted class of service, or as being restricted and capable of communicating only with those CSCs (up to 10 for a shared private network) whose identity is stored in a TNS restricted service list.

For CSC-to-CSC transfers, affiliated CSCs provide the logical equivalent of a private network for members of the affiliation. TNS verifies that the calling and called CSCs are members of the affiliation identified in the message, as provided by an affiliation list stored in TNS. A CSC identified as unaffiliated can receive messages from any other CSC provided the message is identified as unaffiliated.

A Class of Service Character (CSCH) is used to accomplish these screening functions and is inserted by TNS for messages from a telephone or terminal or is provided by the CSC for messages between CSCs. Essentially, the range of the Class of Service Character identifies the station class and the value within the range identifies specific routing characteristics.

All screening for the CSC uses the service classes elected by the primary, *not* the alternate, delivery CSC, even when the message is delivered to the alternate CSC.

2.4 *Example of network features*

Figure 3 depicts a group of three lines ordered by CSC A and a group of one line ordered by CSC B. The groups have group identification numbers for message routing of 5550012 for group A and 5550018 for group B, as identified by the dotted loops. Note that, for routing purposes, the three lines in CSC A's group are indistinguishable. If any one or more of the links become inoperative, all traffic is automatically routed to the remaining active lines in the group. Of course, no such protection exists for group B since it is a group of size one.

In addition, each line within a group is assigned an identification number which for group A consists of the numbers 5550997, 5550998, and 5550986 and for group B is 5550990. These numbers are used for service messages and for line maintenance purposes.

Also shown is an alternate delivery point for automatic forwarding from CSC A to CSC B, which will be used whenever either CSC A's group is not active or its queue temporarily overflows.

III. INTERFACE SPECIFICATIONS

The basic interface specifications are based on the referenced ANSI standards:

(*i*) Data transfer its half-duplex under Binary Synchronous Communication (BCS) procedures.[4]

(*ii*) Data link hardware is full duplex, including data set operation and 4-wire facilities.

(*iii*) Seven-bit ASCII[5] is used for all data link control characters and all Bell System specified message heading entries which, with odd parity,[6] produces 8-bit (or one byte) characters.

(*iv*) The least significant bit is transmitted first.[7]

(*v*) Message heading is based on proposed ANSI standard.[8]

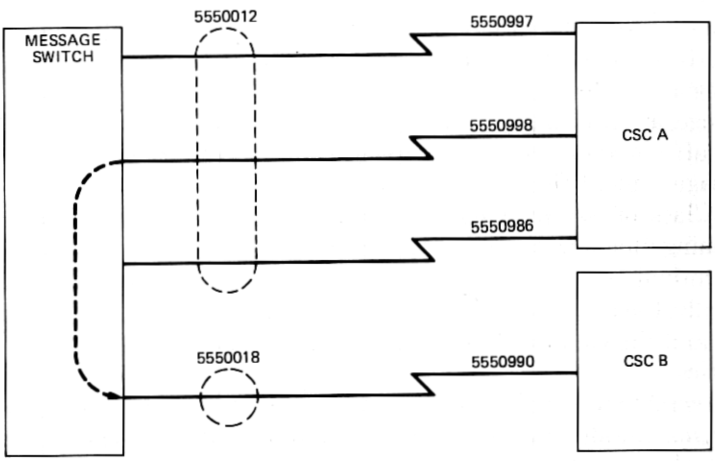


Fig. 3—Line group and alternate delivery.

3.1 Data link protocol (DLP) description

In Fig. 4, data link protocol procedures are broken into three parts: connection, data transfer with acknowledgments, and termination.

Under a contention protocol, either party may bid for the link when it has messages to send. A bid consists of issuing an enquiry (ENQ) sequence. In cases of simultaneous bids, one party is permanently designated the primary and will rebid in 1 second, while the other is the secondary and will rebid in 3 seconds. Upon successfully bidding for a line, as determined by receiving a positive acknowledgment (ACK 0), that station becomes the master station and the station which sent the positive acknowledgment becomes the slave. The master station then starts sending blocks of messages which are acknowledged by alternating acknowledgments, ACK 0 and ACK 1, from the slave station. This master/slave status designation is dynamic and is reestablished upon each successful bid for the line.

Upon completion, the master station relinquishes control of the line by sending the termination sequence (end of transmission sequence, EOT) and may not bid anew for the line for a post EOT delay of 1 or 3 seconds. Within this post-EOT delay, the former slave station may bid for the line without any contention from the former master and can thereby become the master station without contention.

After the post-EOT delay, either party may bid for the line and contention may occur.

If a block becomes garbled, the slave station sends a negative acknowledgment (NAK) and the master retransmits the block up to a predetermined maximum number of retries.

One of the features of the data link protocol consists of the optional inclusion of the transmission of the WACK and RVI sequences as replies, where both are positive acknowledgments. The WACK sequence requests the master to temporarily halt transmitting the next block until informed

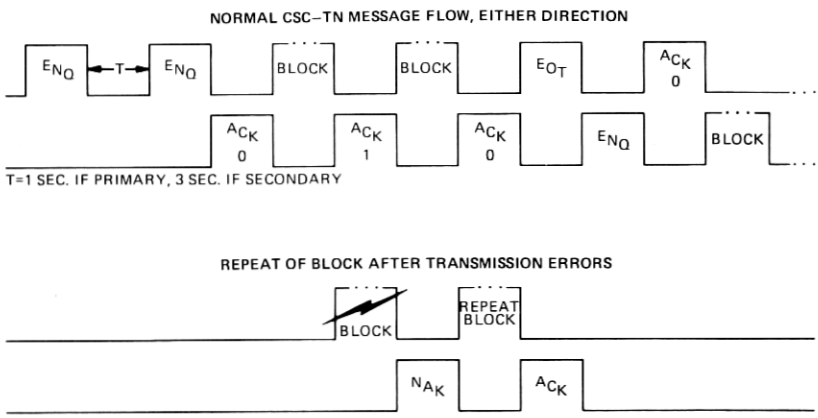


Fig. 4—Data link protocol.

to do so by receipt of the correct acknowledgment from the slave in response to an ENQ (also used to obtain retransmission of garbled replies), whereas the RVI sequence requests that the master relinquish control of the line by sending the EOT sequence so that the slave may in turn transmit.

3.2 Message, record, block, transmission definitions

A message is defined as one heading and one text as supplied by any station in the network. In general, each stream of characters that contain messages terminates with an end-of-message (EOM) character which is immediately followed by a Longitudinal Redundancy Check (LRC) character.

A record is defined as an entity ending with ITB as the EOM character or with ETB or ETX when it is the last record in the block. A message is normally one record but may span multiple records dependent on CSC-selected message-flow options.

A block is one or more records to which an acknowledgment must be sent. Each block ends in either ETB or ETX followed immediately by an LRC character. Put another way, a block is the entity to which an acknowledgment is sent and a record is a member of a block.

A transmission consists of a single connection procedure, is followed by the transmission of one or more blocks, and is then concluded by a single termination procedure. The last block, as sent by TNS, uses ETX as the EOM character, whereas all previous blocks end in the ETB character. Thus, receipt of ITB, ETB, or ETX can be used by the CSC to define the position of a record within the transmission as well as to delimit the record.

3.3 Data link protocol specification

This section gives a specification of the data link protocol procedures that were described in general in Section 3.1. These procedures are in accordance with ANSI standard, X3.28-1971,[4] subcategories 2.3 and B.2 with enhancements and capabilities that make them compatible with Binary Synchronous Communication (BSC) procedures as used by the majority of computer systems today.

The data link protocol consists of a point-to-point contention procedure for nontransparent data in a nonconversational mode. Two protocols are offered: Class I and Class II. Both recognize the WACK sequence and also the RVI sequence as positive acknowledgments, but neither transmits RVI. The RVI sequence is a request from the slave station for the master station to stop transmitting. This allows the slave station to interrupt the master station and transmit a high priority message. The WACK sequence is a request from the slave station for the master to delay transmitting a new block. This is normally used when the slave station has no more buffer space for new blocks. The WACK sequence is only transmitted by TNS in Class II.

The Class I protocol is a basic BSC procedure widely supported within the computer industry. The Class II protocol has been enhanced to support a fuller feature data link protocol procedure. The resultant choice between protocols increases the compatibility with existing teleprocessing monitors. Both protocols yield performance which is dependent on the choice of options, as described later in this paper.

3.4 Message format specification

A message is defined independently of records or blocks and is defined to consist of one of each of the following parts, as shown at the top of Fig. 5. The first part is a prefix of up to eight characters which may be included in every message from or to TNS and immediately follows the SOH character. Following the prefix, a Bell System specified heading must be provided by the originating station, as discussed below.

Immediately following the heading and preceded by STX is a text field provided entirely by the originating station and transparent to the transaction network within the following constraints:

(*i*) No data link control characters may be included.

(*ii*) The text length is 128 characters or less.

Preceding the EOM character, a suffix field consisting of one character may be combined with the EOM character in every message from and to TNS. Immediately following the EOM character, an LRC character must be included for error detection.

All blocks are preceded by a synchronization pattern (shown as Ø in Fig. 5) that consists of a leading pad character of alternating ones and zeros followed by at least two SYN characters. Also, all blocks end with a trailing pad character consisting of eight binary ones.

While the text is composed solely by the originating station, the heading is specified by TNS.

The heading format follows the proposed ANSI standard for heading formats. The two-character Heading Item Indicator[8] (HII) identifies

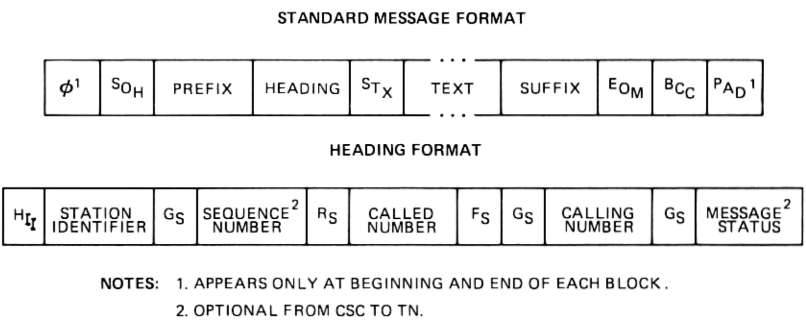


Fig. 5—Message format specification.

which of the allowable fields are present. The one-byte sequence number subfield of the heading consists of an entry which is incremented by one on each successive message transmitted per data link by TNS. For a message transmitted from the CSC to TNS, this field may be omitted with the appropriate alteration of HII or may be stuffed with a space character if the field is not to be used. If a sequence number is included in messages sent to TNS, TNS will check to make sure that, on a given line, no two successive messages begin with the same sequence number. If they do, the second one will be returned with a message status report.

The message status subfield consists of two characters and contains information *only* from TNS to the CSC, as will be seen in Section V. Thus the subfield must either be omitted on messages from the CSC, or stuffed with ASCII spaces or the normal status, all ASCII zeros.

The calling and called number subfields are seven characters in length and contain the routing information.

The station identifier subfield is used by TNS for screening as discussed in Section 2.3 and may also be used by the CSCs to identify the type of station or calling party.

IV. SPECIFICATION OPTIONS

Options are available within these specifications to accommodate the varying degrees of capabilities and requirements of each CSC to do the following:

(*i*) *Control* what TNS may send to the CSC.
(*ii*) *Specify* what the CSC will send to TNS.

The major options consists of:

(*i*) Data link protocol options to provide additional line efficiency and teleprocessing monitor compatibilities.
(*ii*) Message format options which allow the replacement of all Bell System-specified control characters in the heading by an optional set of characters which lie outside the ASCII control character set; and also prefixes and suffixes which are intended to aid in deblocking and transaction handling.
(*iii*) Message flow options to comply with teleprocessing monitor characteristics which in turn specify maximum characters per record, maximum characters per block, maximum records per block, and maximum number of blocks per transmission.

In addition to the above, the previously mentioned options determine the classes of service to be supported by the CSCs and also the network configurations such as line group specifications and alternate delivery points.

4.1 Data link protocol options

Several options are available to enhance the data link protocol (DLP). The first is a one- or three-second post-EOT delay for TNS which should not be confused with the primary/secondary designation. This post-EOT delay only applies immediately after relinquishing the line and before bidding anew. Choosing 1 second allows TNS to speed message transfers in the absence of messages from the CSC. The choice of 3 seconds gives the CSC a larger window in which to bid for the line *uncontested*, after the transmission of EOT by TNS.

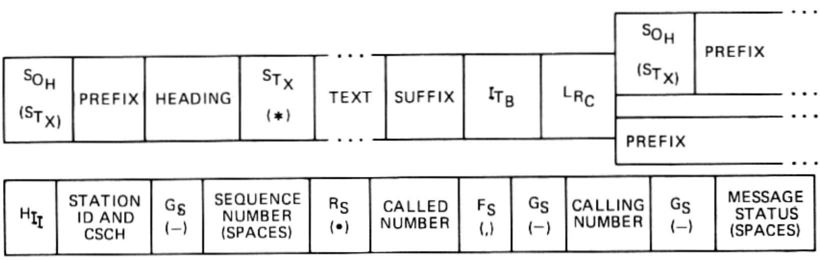
The second option is the choice of Class I or Class II protocols. The CSC chooses this option to best fit its existing software configuration.

The last data link protocol option is the primary/secondary designation in the case of simultaneous line bids. This option applies only to Class II protocols, since Class I protocols mandate that TNS be the primary.

4.2 Message format options

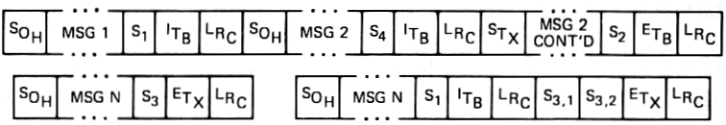
The message format options provide considerable flexibility in accommodating existing CSC procedures. Referring to Figs. 6 and 7, these include:

(*i*) Use of optional, noncontrol character heading subfield separators.
(*ii*) SOH deleted on the second and successive records in a block (a BSC option).
(*iii*) CSC use of optional sequence number and message status subfields to TNS.
(*iv*) Prefixes for transaction identification and device codes.
(*v*) Suffixes to aid in deblocking.
(*vi*) Transmission end record to provide end-of-job indication.



1. SOH, STX, FS, GS AND RS MAY BE REPLACED BY STX, "*", ",", "–", AND "•" RESPECTIVELY.
2. SOH WILL BE OPTIONALLY DELETED ON INTERMEDIATE RECORDS.
3. TO THE TN, THE OPTIONAL SEQUENCE NUMBER AND MESSAGE STATUS SUBFIELDS MAY CONTAIN "SPACE" CHARACTERS OR BE DELETED.
4. PREFIX MAY BE CSC SPECIFIED UP TO EIGHT CHARACTERS TO INCLUDE TRANSACTION IDs, DEVICE DEPENDENT CODES, ETC.

Fig. 6—Message format options.



5. CSC MAY CHOOSE A SUFFIX (S_1, S_2, S_3) TO EXTEND THE THREE EOM CHARACTERS BY SELECTING A SINGLE (DIFFERENT IF DESIRED) CHARACTER TO PRECEDE ITB, ETB, AND ETX 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 ITB WHICH MUST BE DIFFERENT FROM THE CHARACTERS CHOSEN ABOVE ($S_4 \neq S_1, S_2, S_3$).

7. IN ADDITION, THE SUFFIX BEFORE ETX MAY BE CSC CHOSEN TO CONSIST OF TWO CHARACTERS ($S_{3,1}$, $S_{3,2}$) TO BE TRANSMITTED AS A SEPARATE RECORD.

Fig. 7—Message format options (cont'd).

4.3 Message flow options

A set of options are offered to alter message flow which range from simplified message transfers to very efficient data link usage.

The basic requirements are: the messages must be confined within a single block, no record should contain characters for more than one message, and the records should be inherently of variable length up to a maximum.

The options are:

(*i*) Maximum number of characters per record (F_1) to and/or from TNS. If less than the maximum message length is selected, the message suffix must also be included to identify continuation records.

(*ii*) Maximum number of characters per block (F_2) from TNS.

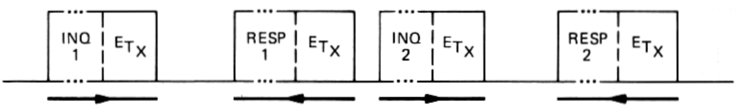
(*iii*) Maximum number of records per block (F_3) from TNS.

(*iv*) Maximum number of blocks per transmission (F_4) from TNS.

4.4 Examples of option choice

The two examples in Figs. 8 and 9 show the range of effect of the various messages flow options.

In Fig. 8, F_1 has been chosen to be the maximum and F_3 and F_4 to be

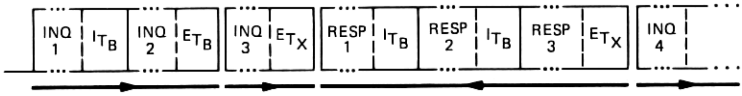


SINGLE MESSAGE PER TRANSMISSION

OPTIONS:

1. CHARACTERS PER RECORD — F_1 = MAXIMUM
2. RECORDS PER BLOCK — $F_3 = 1$
3. BLOCKS PER TRANSMISSION — $F_4 = 1$
4. NO SUFFIX REQUIRED

Fig. 8—Message flow—example 1.



MOST EFFICIENT MESSAGE FLOW

OPTIONS:

1. CHARACTERS PER RECORD — F_1 = MAXIMUM
2. CHARACTERS PER BLOCK — F_2 = MAXIMUM
3. RECORDS PER BLOCK — F_3 = MAXIMUM
4. BLOCKS PER TRANSMISSION — F_4 = MAXIMUM
5. NO SUFFIX (OR PREFIX)

Fig. 9—Message flow—example 2.

1. Note that specifying the characters per record to be the maximum and records per block to be 1 makes F_2, the characters per block, automatically redundant and equal to M, the maximum characters per message.

The effect of these choices is that TNS will send only one message at a time. Thus if the return message is ready for transmission before the post-EOT delay of 3 seconds (or 1 second) elapsed, one then gets a relatively straightforward but inefficient inquiry/response-type flow on the line.

Since there is only one block per transmission, no suffix is required. This choice may in fact be appropriate when traffic requirements are very low or when the teleprocessing monitor can handle only one inquiry and response pair at a time.

By contrast, Fig. 9 shows the most efficient line utilization where F_1 through F_4 are set to the maximum, reducing the number of acknowledgments and line turnarounds.

Notice that the prefix and suffix have also been eliminated by the CSC, reducing the character overhead on the line.

V. MESSAGE STATUS AND SERVICE FACILITIES

The remaining major features of TNS are the message status reports and the service facilities alluded to previously. These features provide the CSC with considerable control over the data links and error conditions. The implementation of these features is designed so that a CSC need do little (e.g., not take advantage of all these extra features) or, as conditions warrant, may take full advantage of these capabilities.

5.1 Message status reports

Any message that encounters telephone company or customer equipment irregularities not covered by the data link protocols will be delivered to the called station, as is possible, or returned to the originating station. A report of the irregularity encountered is always inserted in the message status subfield of the heading as previously defined. The report is of the form X and Y, where X and Y are ASCII digits from 0 to 9.

A class structure has been set up in the same order in which errors would be detected by TNS. The first class, Class I, consists of reception errors, or errors upon receipt of the message from the station not covered by the data link protocol. The second class, Class II, consists of routing errors as detected by TNS in attempting to route the message to the called party. Class III consists of forward path errors which prohibit the delivery of the message. For Classes I, II, and III, the message will always be sent back to the originator.

Class IV also consists of forwarding irregularities, where in this case the error does not prevent the message from being sent forward. And finally, in the great majority of the cases, Class 0 applies to normal message transfers.

The message status reports which will be seen in messages delivered to the CSC are shown in Fig. 10. Since most of the message status reports are self-explanatory, this paper will briefly highlight a few of the irregularities that will be reported. For example, "heading format error," or $XY = 1,0$, means that a required heading entry is missing in the heading field. One point to note, however, is that, if no heading can be found, the message will be dropped as an extraneous data stream not intended for message transfers.

CLASS I – IRREGULARITIES ENCOUNTERED UPON TRANSMISSION TO THE TN.

(X, Y)

(1, 0) HEADING FORMAT ERROR
(1, 1) MAXIMUM TEXT LENGTH EXCEEDED
(1, 2) IMPROPER USE OF CHARACTERS
(1, 4) PROTOCOL ERROR
(1, 5) INVALID CALLING STATION

CLASS II – IRREGULARITIES ENCOUNTERED UPON TN ROUTING.

(X, Y)

(3, 0) NO SUCH NUMBER
(3, 1) NUMBER CHANGED
(3, 2) IMPROPER CLASS OF SERVICE CHARACTER
(3, 3) INVALID CALLED NUMBER
(3, 4) INVALID CALLING STATION TYPE

CLASS III – IRREGULARITIES WHICH PREVENT MESSAGE FORWARDING FROM TN.

(X, Y)

(5, 0) CALLED STATION UNAVAILABLE
(5, 1) CALLED STATION QUEUE OVERFLOW
(5, 2) UNANTICIPATED RESPONSE
(5, 3) TN NETWORK TROUBLE
(5, 4) INVALID CALLED STATION TYPE
(5, 5) NO SUCH VOICE PHRASE
(5, 6) SERVICE MESSAGE CANNOT BE PROCESSED
(5, 7) INCOMPLETE TRANSMISSION

CLASS IV – IRREGULARITIES ENCOUNTERED UPON FORWARDING MESSAGE

(X, Y)

(7, 0) POSSIBLE DUPLICATE MESSAGE

Fig. 10—Synchronous message status reports.

Another example, "called station unavailable" with $XY = 5,0$, is necessarily a broad category encompassing *all* accidental or intentional failures of the called station to respond correctly to the delivery of messages.

Only one status in Class IV applies, namely, possible duplicate message. This will be appended whenever TNS is unsure whether the message was previously delivered.

5.2 Service facility—service messages

Service facilities consist of instructions passed between TNS and any user station. As contrasted to a data message passed between terminals, telephones, and CSCs, a service message is a message either originated by or addressed to TNS and therefore includes the TNS station identification number in the heading of the form NXX-0999.

There are two types of service messages. A request service message contains one or more requests for service actions and an acknowledgment service message contains one or more acknowledgments which are reports, affirmations, or denials of the requests.

Service messages may initiate actions only for the line group on which they are received and therefore, for appropriate coordination, all the lines within the line group must be handled by a single entity or CSC.

TNS will accept service messages over any line in the group, but the CSC may specify one line as the Service Administration Facility (SAF) over which TNS will send all service messages. This is done by specifying a priority scheme for each line in the line group which TNS will follow, as any line or lines in the line group become unavailable for use. This priority applies to both request and acknowledgment service messages, but not to reflection service messages, as will be seen.

5.2.1 Line and line group states

A major usage of service messages arises from the fact that a line or line group can be in any one of several states, as shown in Fig. 11, each of which defines its capability. Service messages are used to set or report these states. While TNS will change states only upon the discovery or correction of failures, CSCs may implement state changes, if desired, to accommodate their own operational procedures.

State 1, the active state, may only be set by the CSC and allows all message transfers. This is the normal state for a line or a line group.

State 2, the active/CSC data only (ADO) state, can be set by either TNS or the CSC allowing data messages only from the CSC and service messages in both directions. This may be considered as a standby state and, upon recovery from failures, TNS will always set state 2 and *never* state 1.

State 3, the out-of-service far-end removed (OFER) state, may be set

TYPE FIELD	SERVICE MESSAGE SEQUENCE NUMBER	TYPE CODE	STATE	LINE NUMBER	FIELD SEPATATOR	
t	s	TC	K	$X_1X_2X_30X_4X_5X_6$	+	...

- TYPE FIELD ($0 \leq t \leq 9$) IDENTIFIES THE BASIC TYPE OF THE SERVICE MESSAGE.
- SERVICE MESSAGE SEQUENCE NUMBER ($0 \leq t \leq 9$) COORDINATES REQUESTS AND ACKNOWLEDGEMENTS.
- INDIVIDUAL REQUESTS AND ACKNOWLEDGEMENTS MAY CONTAIN THE FOLLOWING TEXT FIELDS;
  - THE TYPE CODE ($00 \leq TC \leq 99$) IDENTIFIES THE TYPE OF REQUEST OR ACKNOWLEDGEMENT.
  - THE STATE ($1 \leq K \leq 6$) IDENTIFIES THE STATE REQUESTED OR REPORTED.
  - THE LINE NUMBER, IN LINE RELATED SERVICE MESSAGES, IDENTIFIES THE LINE, WITHIN THE LINE GROUP, ON WHICH ACTION IS TAKEN.
  - THE FIELD SEPARATOR, "+", DELIMITS INDIVIDUAL REQUESTS OR ACKNOWLEDGEMENTS.
  - ALTERNATIVELY, TEXT OF REFLECTION SERVICE MESSAGES APPEARS AFTER TC.

Fig. 11—Service message request and acknowledgment format.

only by the CSC which then prevents all message transfers except for request service messages from the CSC and their accompanying acknowledgment service messages from TNS.

State 4, the out-of-service far-end test (OFET) state, may only be set by the CSC and requests that TNS test its synchronous port hardware. No message transfers are possible and, upon successful completion of the test, TNS will set either state 2 or, upon failure, state 5.

State 5 is the out-of-service other (OO) state, which means that the TNS synchronous port hardware has failed.

State 6 is the unavailable state for a line that has not yet been put into service.

The relationship between the group state and the line states is as follows: Ordinarily, the group state will follow the highest line state within the group, where state 1 is considered to be the highest of the states. The group may *never* assume a state greater than the highest line state. For example, if there are three lines in a group and two lines are in state 1 and one line is in state 4, the group will normally be in state 1.

The CSC, however, may purposely put the group state to a lower state, thus not requiring the setting of each of the individual line states to accomplish a service objective of its own. Therefore, if a line has a state higher than the group state, the group state in effect determines the operational status of that line. For example, if there are three lines in the group and the lines have states of 1, 2, and 3 and the group has a state of 3, each line will effectively be in state 3. However, when the group state is changed back again, the lines will return to their original states.

The TNS and the CSC must both keep a state table for each line and the line group, with the TNS defined to have the master state table.

5.2.2 Service message protocol

To accomplish the transfer of service messages, a simple end-to-end service message protocol must be obeyed.

For each request put out by either station, there must be an acknowledgment. Only one request service message may be outstanding on a group at any given time from either TNS or the CSC, although, as will be seen in ertain cases, a request or acknowledgment service message may contain multiple requests or acknowledgments.

Because of this, in the case of simultaneous requests, TNS is always considered to be the master since it will only originate service requests due to detected failures (or their correction), and therefore its request must be processed. In this case, the CSC request will be rejected and returned with a message status report.

In case this service message protocol becomes violated, a halt/wait request will reset the protocol from either station by ordering all service message processing canceled; when received by the CSC, the CSC may not originate any new requests until it receives at least one additional request from TNS. This is required for the case where TNS is attempting to report a service failure and, because of a violation of this protocol, it cannot get a service request into the CSC. Therefore, it will halt all service message processing so that it will be able to send at least that *one* service request to the CSC.

Finally, since multiple requests or acknowledgments may be contained in a single service message, in order to facilitate the CSC programming, an option exists to limit TNS to the transmission of only one request per request service message.

TNS will always send acknowledgments in the form the requests were received. For example, N acknowledgments per service message will be sent back when N requests per service message were received. Therefore, if one request per service message was received, one acknowledgment per service message will be transmitted.

5.2.3 Service message format

Figure 11 shows the format of a service message excluding the heading which is identical to a data message. The first two characters in the text of a service message consist of a type field, t, and a sequence number, s, followed by the individual requests or acknowledgments.

The type field, t, identifies the basic type of the service message. When grouped together, individual requests or acknowledgments must be of the same type.

The next character is the service message sequence number (not to be confused with the heading sequence number) which coordinates the requests and acknowledgments. The sequence number, *s*, must be exactly echoed in the acknowledgment to make sure that each request and acknowledgment may be paired by the request originating party. It is in the range from ASCII 0 to 9 and is incremented by two modulo 10. It is even for TNS requests and odd for CSC requests.

Each individual request or acknowledgment is identified by a type code (TC) which uniquely identifies the function to be performed. The remaining entries may consist first of a state K (between 1 and 6 as previously defined under the state definitions) which contains the state requested or reported. The second entry that may be present is a line number identifying the line on which the function is to be performed. Alternatively, for reflection requests the text to be reflected appears after TC.

Finally, when multiple requests or acknowledgments are present within the same service message, the field separator ASCII "+" is used as a delimiter immediately following each individual request or acknowledgment.

5.2.4 Service messages

This section defines the individual service message requests and acknowledgments. The set state service messages consist of set group state or set line state requests, which are commands to put the group or line into a specified state. The accompanying acknowledgments report whether the requested action was taken and the resulting state.

Similarly, the report state service messages consist of report group or report line requests seeking information as to what state the other station perceives to be true. The requests contain the state that the inquiring station assumes to be true. Thus, the acknowledgment contains the receiving station's perception of state.

The Halt/Wait request/acknowledgment service messages carry out the actions described in Section 5.2.2.

While the above service messages follow the priority scheme of the SAF, the reflection request service messages may be transmitted over any line. The associated acknowledgments must be returned on the same line over which the request was received. The reflection service messages are requests to provide a predetermined echo of the original transmission. They are intended to provide a testing capability both for new installation testing of software and hardware by the CSC and also as an operational test by both TNS and the CSC.

The simplest reflection request is for the return of the accompanying text. Other reflection requests produce single or multiple messages in one or two blocks as the echo subject to the constraints of Sections 4.2 and 4.3. Also, reflection requests are defined to allow the testing of input/output buffer sizes and to allow the acknowledgment to appear as an inquiry from a customer station.

5.2.5 Summary of service message capabilities

The service messages provide the CSC with the capability of exercising considerable control over the interface. This includes, in addition to the normal failure recovery procedures, the capability to fully test and reconfigure the local network due to operational requirements.

5.3 Service facility—station identifier subfield

The remaining service facility feature is the station identifier subfield in the message *heading* of messages from the CSC to terminals; that is to say, response messages. Whereas service messages do not relate to a specific data message, the station identifier service facility is used to choose operational procedures to be followed by TNS for a particular message.

This service facility is generally used for dial-in telephones, for the following actions:

(*i*) Voice only response.
(*ii*) Key answer tone response for 1.5 seconds with no accompanying voice message.
(*iii*) Keyed answer tone for 3 seconds followed by a voice message.
(*iv*) FSK response for dial-in telephones.
(*v*) CSC specified disconnect of the telephone from the dial-in port.
(*vi*) Finally, if no instructions are required, as for example, if the message is destined to a polled terminal, the CSC inserts the null field entries of ASCII "space space."

VI. TEST INSTALLATION

To verify the procedures of the interface specifications, a test configuration was installed on the Bell Laboratories' IBM 370/168 at Holmdel, N.J. The software configuration is shown in Fig. 2. The task consisted of writing Cobol programs to transfer messages with the TNS message switch.

The approach taken was to write processing programs which were independent of the originating station and had a preprocessor and postprocessor to handle any station dependencies of the message text. It required less than 150 lines of Cobol code to enqueue and dequeue the inquiry and response messages.

A service message routine was written to handle normal service message processing (e.g., acknowledge TNS requests and activate lines) and consisted of some 200 Cobol statements. Message status reports were simply logged and used as a debugging tool for the test system.

VII. ACKNOWLEDGMENTS

We would like to acknowledge the work of G. S. Hoffman in writing Cobol application programs, T. Tammaru for hardware design of the synchronous interface, and K. W. Sussman for interface design contributions.

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