TRA

NP/12 -3.2
CCG/75/28

The Node Standard Interface

Third Edition

This document replaces the document, 'The Node Standard Interface', (NP/12-2 and CCG/74/19, dated May 1974) and a number of subsequent updating documents. It represents the complete standard for the interface at the present date.

John I Davies
December 1975

This is the first revision of NP/12-3 and represents the interface as implemented on all Nodes.

John I Davies
Noel S Millar
November 1976

1. Introduction

The Node Standard Interface (abbreviated NSI) is an internal interface within the comput communications network set up by the Regional Computing Organisation (RCO). The overall structure of this network is described in a number of documents, notably 'A proposal for the development of a Node Processor '(NP/1), 'The Node Processor' (NP/7) 'The RCO Network' (NP/39), and 'Node Processor Software Structure' (NP/11). These are produced by, and available from, the RCO Communications Software Group. External versions of the NSI are made available by certain terminal support subsystems (TSS) of the network. These are described in 'Specification of TSS-NSI, Issue 2' (NP/27-2) and by 'Specification of TSS-LPL' (not yet published).

This document consists of an elementary narrative description of the NSI (Section 2), a specification of the NSI functions and responses (Section 3), and a specification of the valid sequences of functions and responses (Section 4). A number of appendices are attached to this specification in order to describe particular representations of th NSI. The first of these, for example, describes that used in the Modular One Node Processor using the Miser executive.

2. Basic Concepts

The NSI provides access to a general purpose data transport facility. It defines means by which data may be transported either in the form of 'streams' or as individual messages. A set of standard facilities, the NSI functions and responses, completely define the NSI.

Each NSI user has access to an address space within which all NSI users, including himself, appeari This space is seen identically by all users. The NSI function ATTACH establishes the calling user as the sole occupier of a contiguous area within that address space. The user may then communicate with any ATTACHed user by specifying two addresses as the originator and responder addresses for the communication. Both addresses must have been previously ATTACHed by some user and the originator address must be within the range ATTACHed by the calling user. Each address ATTACHed to the network may be conceived as a port into and out of the network.

Individual messages may be sent from any address ATTACHed by their originating user. Such messages must be delivered to the responder, and their acceptance confirmed, before any further messages may be sent from the originating address. Message transmissi is requested using the SENDMESSAGE function from the user to the network. Delivery occurs by application of the same function from the network to the user.

Data may be transferred in 'streams', broken into blocks of convenient size, by means of a CONNECTion between two ATTACHed addresses. A call upon the NSI function CONNECT establishes such a CONNECTion between an address within the ATTACHed range of the originating user and any other ATTACHed address. Once such a CONNECTion is established, blocks of data may be sent along it in either direction. The transmission of these blocks is requested by means of calls upon the SENDBLOCK function of the network. The network delivers the blocks by means of SENDBLOCK calls upon the destination user. A number of such calls may be made before any indication of acceptance at the destinatio end of the CONNECTion is received. Thus the capacity of the CONNECTion is not inherentl limited by the transit times in the network.

The extent to which such buffering within the network is provided is a matter for negotiation at the time the CONNECTion is made. Supervision of the CONNECTion, independant of buffering considerations, may take place by means of the STATUS function which delivers information from one end of the CONNECTion to the other.

Only one STATUS call may be outstanding in either direction on a CONNECTion before a STATUS response is received.

A CONNECTion may be erased by either the CONNECT originating user or the CONNECT responding user. A flag contained within a SENDBLOCK or STATUS call signals such a disconnection. The passage of a disconnecting call through the network signals the end of the CONNECTion and its receipt assures delivery of all previous data on the CONNECTion.

A NSI user may cease to occupy an ATTACHed address space by calling the NSI function REMOVE specifying a range of addresses previously ATTACHed by the user. The functions ATTACH and REMOVE imply transactions between a single user and the network. All other NSI functions described above imply transactions between users with the network as intermediary.

A Network Information Function (NIF) is provided to allow the network to inform users of abnormal conditions which may necessitate special user action. For example, a breach of NSI conventions by one CONNECTed user will result in a NIF being delivered to the other CONNECTed user.

NIFs fall into three broad categories - those indicating a network malfunction or local user malfunction, those indicating some remote user malfunction or local user misbehaviour, and those indicating possibly recoverable difficulties within the network. Clearly the first category are catastrophic for the local user, the second will usually be recoverable for the local user, and the third may or may not be recoverable for the local user.

A user may not generate NIF's to the network.

3. Specification of the NSI functions and responses

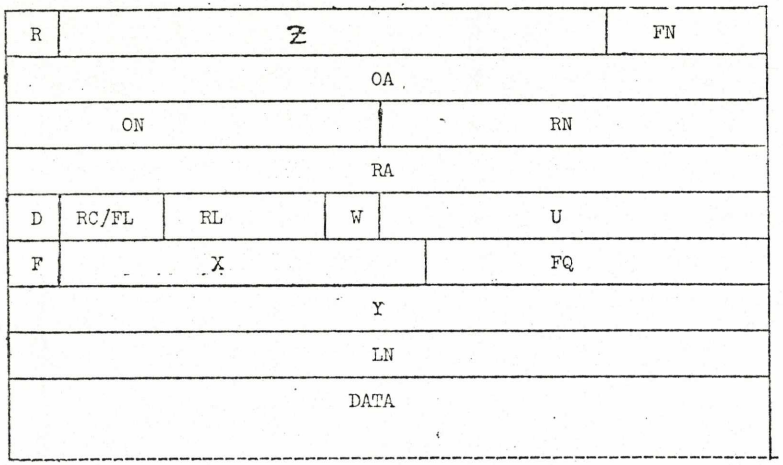
3.1 Common Features

Each NSI function or response is completely specified by a single block of parameters. The representation of these parameters is not defined beyond the requirement that it be digital. The general form shown below (Figure One) implies a binary representation in sixteen bit words but this is merely a matter of convenience for current implementations. The fields are to be read from left to right and from top to bottom with most significant digits first where applicable.

Calls upon NSI functions may evoke responses at the originating end and function calls upon the user by the network at the responding end. Responses are distinguished by the setting of the Response flag (R field). Responses may be further qualified by the setting of Fail flag (F field) and some suitable failure qualifier (FQ field).

The NSI user sees the network only in terms of his calls upon NSI functions and response and calls upon NSI functions and responses from the network to him. He is concerned with communication with other users by such actions and requires no further knowledge of the network. The functions and responses, in both user to network and network to user forms, are described below and in Table One.

By convention, any communication in which the node address (ON or RN fields) is significant may imply addressing to the local node by setting a node address of zero.



Field Name	Field Contents	Size in Units	
R	Response flag	1	bit
Z	Unused	11	bits
FN	Function number	4	bits
OA	Originating Address	16	bits
ON	Originating Node	8	bits
RN	Responding Node	8	bits
RA	Responding Address	16	bits
D	Disconnect flag	1	bit
RC/FL	Response Count or Forward buffer Limit	3	bits
RL	Reverse buffer Limit	3	bits
W	Unused	1	bit
U	flags for User	8	bits
F	Fail flag	1	bit
X	Unused	8	bits
FQ	Failure Qualifier	7	bits
Y	Unused	16	bits
LN	Length of data field	16	bits
DATA	Optional data field	0-240	bytes

Figure One
Representation of NSI Function/Response

	Function Response	User>N Network>U	R	FN	OA	ON	RN	RA	D	RC FL	RL	U	F	FQ	LN	DATA
ATTACH	FU	UN	0	1	Lower bound	Upper bound		Undefined	0	Undefined	Undefined	User Defined	0	0	0	Not Present
	RS	NU	1	1	"	"		"	0	"	"	"	0-1	See table 2	0	"
REMOVE	FU	UN	0	7	"	"		"	0	"	"	"	0	0	0	"
	RS	NU	1	7	"	"		"	0	"	"	"	0-1	See table 3	0	"
SENDMESSAGE	FU	UN	0	2	Originating Address	0	Responding Address	"	0	"	"	"	0	0	length of data	LN bytes of data
	RS	NU	1	2	"	Undefined	"	"	0	"	"	"	0-1	See table 4	"	"
	FU	NU	0	2	Originating Address		Undefined	Responding Address	0	"	"	"	0	0	"	"
	RS	UN	1	2	"		0	"	0	"	"	"	0-1	See table 4	"	"
CONNECT	FU	UN	0	3	Originating Address	0	Responding	Address	0	Forward Buffer Limit See note 2	Reverse Buffer Limit See note 2	"	0	0	length of data	LN bytes of data
	RS	NU	1	3	"	Undefined	Responding Node	See Note 1	0			"	0-1	See table 5	length of data	LN bytes of data
	FU	NU	0	3	Originating Address		Undefined	Responding Address	0	Forward Buffer Limit See Note 2	Reverse Buffer Limit See Note 2	"	0	0	length of data	LN bytes of data
	RS	UN	1	3	"	0	0	See Note 1	0			"	0-1	See table 5	length of data	LN bytes of data
SENDBLOCK	FU	UN	0	4	Originating Address		0		0-1	Acknowledgement Count	Undefined	"	0	0	length of data	LN bytes of data
	RS	NU	1	4	"	Undefined	Undefined		0-1	"	"	"	0	0	0	Not Present
	FU	NU	0	4	Undefined		Undefined	Responding Address	0-1	"	"	"	0	0	length of data	LN bytes of data
	RS	UN	1	4	"	0	0	Responding Address	0-1	"	"	"	0	0	0	Not Present
STATUS	FU	UN	0	5	Originating Address	0	0		0-1	Undefined		"	0	0	length of data	LN bytes of data
	RS	NU	1	5	"	Undefined	Undefined	Responding Address	0-1	"	"	"	0	0	"	"
	FU	NU	0	5	Undefined				0-1	"	"	"	0	0	"	"
NIP	RS	UN	1	5	"	0	0	"	0-1	"	"	"	0	0	"	"
	FU	NU	0	6									0	0		

Note 1 - This may be mapped to any address in the users ATTACHed area.

Note 2 - These may be revised downwards by the responder.

Table 1

3.2 Function Descriptions

3.2.1 ATTACH

Function - user to network
Response - network to user

This command assigns a contiguous area of the network address space to the user. The space is always within the network range occupied by the users node and no part of it may be already ATTACHed by any user. Any fail response will be qualified according to the values in Table Two.

3.2.2 REMOVE

Function - user to network
Response - network to user

This command deletes a previous assignment of address space to the calling user (obtained by an ATTACH). Any activity associated with the space deleted will be terminated without further user communication before a successful REMOVE response is returned. Any failure will be qualified according to the values in table three.

The REMOVE command may be used as a last resort cleardown with the assurance that the REMOVEd space will have no outstanding activities associated with it when the REMOVE response is received. The user may then re-ATTACH the space without any danger of effects associated with the previous ATTACH.

3.2.3 SENDMESSAGE

Function - user to network

This function requests the delivery of the associated data (DATA field) from some address within the users ATTACHed range to any other ATTACHed address in the network. The user should set the Originating Address (OA field) to some value within his ATTACHed space and the Responding Node (RN field) and Responding Address (RA field) to the required destination address for the message

Response - network to user

This response indicates to the user that his SENDMESSAGE function has been completed. Where the fail flag (F field) is set, then either the message was not delivered by the Network or the message was not acceptable to the responder. A special failure qualifier distinguishes the latter case and the DATA field may contain further information. Failure qualifier values are defined in Table Four.

Where the fail flag is clear, the message has been successfully delivered by the network and accepted by the responder. The DATA field may contain a returned message from the responding user.

Function - network to user

This function passed to a user from the network specifies a responding address (RA field) within his ATTACHed range, an originating node (ON) field, and an originating address (OA field).

Response - user to network

This response indicates acknowledgement of receipt of a message. The message may be accepted (F field clear) or rejected (F field set and FQ field indicating a high level reject, see Table Four), in the latter case some additional information about the failure may be placed in the DATA field. Otherwise the DATA field may contain a returned message.

3.2.4 CONNECT

Function - user to network

This function sets up a logical 'stream' in either direction between an address within the users ATTACHed range and any ATTACHed address within the network address space. The Originating Address (OA field) should be set to some address within the users ATTACHed range which is not CONNECTed by the user. The Responding address (RN field and RA field should be set to the required remote address for the CONNECTion.

The number of data blocks which each end may require to send ahead of acknowledgements should be indicated in the Forward buffer limit (FL field) for the originator to responder direction and in the Reverse buffer limit (RL field) for the responder to originator direction.

Response - network to user

This response indicates to the user that a CONNECT function has been completed. Where the fail flag (F field) is set then either the CONNECT was denied by the network or the CONNECT was rejected by the responder. The latter case being indicated by the Failure Qualifier (FQ field) being set to High-level reject. Failure Qualifiers are defined in Table Five.

Where the fail flag is clear the CONNECTion has been accepted by the responder and set up by the network. The responding address will be that generated by the responding user (see below)
A CONNECT response may include a DATA field, and the RL and FL fields may be revised downwards from the values specified in the original function.

Function - network to user

This function, passed from network to user, indicates that the originating user wishes to establish a CONNECTion between the quoted originating address and the quoted responding address, where the latter will be within the users ATTACHed range. A degree of network buffering, that is the extent to which each user may send data blocks before they are acknowledged, is requested in the Forward buffer Limit (FL field) and Reverse buffer limit (RL field). These referring to the originator to responder direction and responder to originator direction respectively. The user may reduce these values where local considerations indicate that they are excessive.

Response - user to network

This response indicates that the responding user has recognised a CONNECT request. The connection may be accepted (F field clear) or rejected (F field set and FQ field indicating a high-level rejection). In either case a DATA field may be present.

Where the CONNECTion is accepted the user may modify the CONNECTion by reducing buffer limits (as described above). He may also map the CONNECTion to some other address within his ATTACHed range by altering the responding address (RA field). This mapping must be to some address which he has not CONNECTed.

3.2.5 SENDBLOCK

Function - user to network

This function provides the means by which data may be sent in either direction along a previously established CONNECTion. The Originating Address (OA field) completely specifies the CONNECTion required. All other addressing fields are ignored. Where the user was the originator of the CONNECTion the Originating Address for the SENDBLOCK will be the Originating Address specified in the CONNECT function. Where the user

was the responder to the CONNECTion the Originating Address for the SENDBLOCK will be the responding Address specified in the users response to the CONNECT function.

The data to be sent occupies the DATA field of the SENDBLOCK function. The user may call the SENDBLOCK function repeatedly without response up to the limit set for the CONNECTion by the Forward buffer Limit (where the user was the originator of the CONNECTion) or the Reverse buffer Limit (where the user was the responder to the CONNECTion). Responses may be included with each SENDBLOCK by returning a count in the SENDBLOCK Response Count (RC field).

A CONNECTion may be deleted by setting the Disconnect flag (D field) within a SENDBLOCK. The network guarantees to deliver all previous SENDBLOCKs called by the Disconnecting user, providing that the responding user is still able to receive them.*

A SENDBLOCK function may not be rejected by either network or user. Any failure to deliver a SENDBLOCK will result in the Network generating a Network Information Function (NIF) to the originating user.

*See 3.2.7 Network Information Function

Response - network to user

This response acknowledges the receipt of one or more SENDBLOCK functions by means of the Response Count (RC field). No data field is present. The CONNECTion is identified solely by the Originating Address (OA field) which may be either the CONNECTion originating address (at the CONNECT originating end) or the CONNECTion responding address (at the CONNECT responding end).

Function - network to user

This function, passed to a user, is the means by which data is delivered from a CONNECTion. The responding address (RA field) will contain the CONNECTed address within the users ATTACHed address space. All other address fields are undefined.

Where the user was the responder to the CONNECTion, the CONNECTed address will be that returned with the CONNECT response, which need not necessarily be that received with the CONNECT function (see 'CONNECT - Response - user to network' above).

The user will not receive more such functions than he has acknowledged plus the Forward buffer Limit (where he has the responder to the original CONNECTion) or the Reverse buffer Limit (where he was the originator of the original CONNECTion).

The Response Count (RC field) may include acknowledgements to blocks transferred in the opposite direction.

Response - user to network

This response provides a means by which acknowledgements may be sent without attached data. The required CONNECTion is identified solely by the Responding Address (RA field).

SENDBLOCK Disconnection

Where a SENDBLOCK function has the Disconnect flag (D field) set, it acts as a CONNECTion cleardown in the direction in which it travels. All SENDBLOCK and STATUS functions and responses preceding it are guaranteed to be delivered before cleardown takes place in that direction. If the disconnection is requested from both ends then the arrival of the Disconnecting function at each end signals the clearing of the CONNECTion in that direction. Otherwise a SENDBLOCK response with Disconnect may be generated by the receiver of the Disconnect function to accomplish the same effect.

A user may not initiate cleardown of a CONNECTion by means of a SENDBLOCK response.

3.2.6 STATUS

Function - user to network

This function provides a means by which communication may take place along a CONNECTion at any time, independant of the Forward and Reverse buffer Limits. The CONNECTion being used is indicated by the Originating Address (OA field) in similar fashion to the SENDBLOCK function. The Disconnect flag (D field) may be used with similar effect to a SENDBLOCK Disconnect but no acknowledgements may be sent (RC field is non-significant). Only one STATUS call may be outstanding on each CONNECTion in each direction. A STATUS function may include a data field.

Response - network to user

This response indicates to a user that a STATUS function has been completed, and that the CONNECTion is free to accept a further STATUS call. However, where the Disconnect flag (D field) was set in the original function the response marks the cleardown of the CONNECTion. A STATUS response will never indicate failure (F field is always clear). Non-delivery of a STATUS will result in the generation of a Network Information Function (NIF) to the sender. A STATUS response may include a data field.

Function - network to user

This function is the means by which a responding user receives a STATUS message. Where the Disconnect flag (D field) is set the user should regard the CONNECTION as unavailable but the connection is not deleted until he responds.

Response - user to network

This response indicates to the network that a STATUS message has been accepted. Where the original function - user to network - had the disconnect flag (D field) set, the response allows the final cleardown of the CONNECTion to take place.

STATUS Disconnection

The considerations applying here are similar to those applying to SENDBLOCK disconnection. The delivery of preceding SENDBLOCKs is similarly guaranteed.

3.2.7 Network Information Function (NIF)

The network generates NIF's when some abnormal condition occurs. NIF's may only be generated by the network and any attempt to input them to the network will be rejected as an invalid function. If a NIF has its disconnect flag (D field) set the user should generate a response to the network to acknowledge receipt of the NIF. (but see 3.2.7.1).

NIF's can be divided into two broad categories depending on whether the disconnect flag is set and a list of NIF's divided in this way is given below. The NIF number is always placed in the user flags (U field) by the network.

3.2.7.1 NIF's with Disconnect

These NIF's are issued when the remote end of a connection aborts by removing its attached space while the connection is still established. They will only be generated by the network on fully established connections eg a NIF with disconnect will not be received before the connect response (user - network) is issued. They are subject to the same disconnection considerations as those applying to sendblock and status except that delivery of preceding sendblocks to the remote end of the connect is not guaranteed. They may be viewed as a network generated status not subject to normal flow control rules.

Two NIF numbers have been allocated in this category:-

1. Remote node failure

   All connections to or through this node are aborted.

2. Remote user failure

   All connections to the attached address range of this user are aborted.

3.2.7.2 NIF's without Disconnect

These NIF's are used to report errors in sendblock and status functions or in function responses issued by the user to the network. They indicate a malfunction in the users software and it is anticipated that the normal user action would be to log the error and remove the faulty attached address range. A list of the NIF's in this category which may be issued is given below together with notes on the functions which may give rise to them. The function number and response flag of the faulty function is placed in the failure qualifier and fail flag respectively for these NIF's:-

1. Invalid parameters or function

   Any invalid function number in a response

   Buffer limits (FL and RL fields) greater than original values in a connect response. The connection is not established and a connect response with a fail qualifier 7 is forwarded to the remote user.

   Response count (RC field) greater than number of outstanding responses in a sendblock or sendblock response. The connection is not deleted.

2. Local address not attached

   The originating address (OA field) for a sendblock or status function or the responding address (RA field) for a sendmessage, connect, sendblock or status response is not attached. No connection is deleted.

3. Port busy or already connected

   The responding address (RA) already has a connection established for a connect response. The established connection is allowed to remain, the new connection is not established and a connect response with fail qualifier 7 is forwarded to the remote user.

   A status response is already outstanding at this port for a status.

   The connection is not deleted.

   Too many sendblock responses are outstanding on this port for a sendblock.

   The connection is not deleted.

4. Remote node not attached

   The originating node (ON) for a sendmessage or connect response is not attached. This could only occur if the ON field was corrupted. No connection is established or deleted.

5. Remote user not attached

   The originating address (OA) is not attached in the same circumstances as NIF 4.

6. Port not connected

No connection is established for the originating address (sendblock or status) or the responding address (sendblock or status response) given. This could only occur if user tables were corrupted or if an attempt to issue a further sendblock or status after disconnect was made. No connection is deleted.

7. Response without function

A sendmessage, connect or status response is issued when none is outstanding. The connection is not deleted.

Failure Qualifiers

Table Two - Attach

1 - inconsistent parameters
2 - address range already ATTACHed

Table Three - Remove

1 - inconsistent parameters
2 - address rang does not match previous ATTACH

Table Four - Send Message

1 - invalid parameter specification
2 - originator not ATTACHed
3 - originating address already has CONNECT or SENDMESSAGE active
4 - responding Node not ATTACHed
5 - responding Address not ATTACHed
6 - insufficient buffer space available
7 - send message fails due to responder error
8 - rejected by responder (see attached text message)

Table Five - Connect

1 - invalid parameter specification
2 - originator not ATTACHed
3 - originating address already has CONNECT or SENDMESSAGE outstandi
4 - responding Node not ATTACHed
5 - responding Address not ATTACHed
6 - insufficient buffer space available
7 - connect fails due to responder error
8 - rejected by responder (see attached text message)

4. Sequencing at the NSI

This section attempts to define, with some rigour, the possible sequences of communications between the network and user across the NSI. All such communications are either functions or responses within the range already defined. The passing of functions and responses between the user and the network is assumed to take place through a noiseless duplex channel. The channel is assumed to have finite but indeterminate storage capacity and transit time. The sequencing behaviour defined is that required at the user end of such a channel.

4.1 Facilities and Ports

Each ATTACHed address in the network may be regarded by its user as being simultaneously a Facility access number available to other users on the network and the number of a Port into and out of the network. The Facility at each address is responsible for dealing with inbound CONNECT functions and inbound SENDMESSAGE functions. The Port at each address is responsible for dealing with outbound CONNECT and outbound SENDMESSAGE functions and all SENDBLOCK and STATUS traffic on a CONNECTion (established in either direction) at that address. A Port may be regarded as being in a non-existant or null state until a CONNECT or outbound SENDMESSAGE occurs. A Facility always exists wherever an address is ATTACHed.

Each Facility must ensure proper matching of responses from its address. In other words, the number of inbound CONNECT functions may never be less than the number of outbound CONNECT responses and the number of inbound SENDMESSAGE functions may never be less than the number of outbound SENDMESSAGE responses. Facilities may themselves generate responding Ports by means of CONNECT responses. The addresses associated with such Ports are not necessarily related to the addresses of the Facilities which deal with them. A single Facility may be in use by a number of users simultaneously but each NSI CONNECTION must have a unique Port number*

A Port comes into existence when a CONNECT transaction, function or response, is transmitted from the user to the network, or when a SENDMESSAGE function is transmitted to the network. The subsequent behaviour of a Port is described in the following sections and in the Port state diagrams, Figures Two, Three, and Four. The address of a Port is always that appearing in the Originating Address of a SENDMESSAGE or CONNECT function and in the Responding Address of a CONNECT response.

A Port ceases to exist, or returns to a null state, when the CONNECTion with which it is associated is deleted or when a user's SENDMESSAGE function is matched by a returned response. Only one Port may exist at a single address, therefore CONNECTions have unique addresses at either end, and each outbound SENDMESSAGE from a given address must receive a response before another is allowed.

*For example, one Facility may offer an interactive service and another a job input service. Both of these would normally support several simultaneous users. Particular Facilities may support single or multiple users at the responder's discretion. The network will make no distinction.

4.2 Main Port States (Figure Two)

4.2.1 Connecting - User to Network (State One)

This port state is entered only for an outgoing connection. It is one of the two initial states for the Main Port State diagram. It is entered only by means of a user CONNECT function input to the network and left only by the response to such a function. A failure response deletes the port and a success response moves the Main Port State to Connected (State Two) with Status and Data substates at Status Idle (Figure Three, State One) and Data Clear (Figure Four, State One), respectively.

4.2.2 Connected (State Two)

This port state is entered for a CONNECTion in either direction. It is the initial Main Port State for an inbound CONNECTion and is entered by means of the users response to the remote CONNECT received at some access facility address within the users ATTACHed range. The state is also entered by means of the user receiving a CONNECT response to his previous CONNECT function specifying this port address. The entry is from the Connecting - User to Network state (State One).

In either case the port address is the address appearing in the Responding Address (RA field) of the transmitted or received response.

The state is left by receipt or transmission of a STATUS or SENDBLOCK function in which the Disconnect flag (D field) is set. These functions are only valid where they satisfy the substate diagrams associated with this state. At entry to this state the substates are Status Port State - Status Idle (Figure Three, State One) and Data Port State - Data Clear (Figure Four, State One).

4.2.3 Disconnecting Sendblock Originator (State Three)

This state indicates the local user is attempting to disconnect by means of a SENDBLOCK function. The state is entered by means of a SENDBLOCK function from the user to the network having the Disconnect flag (D field) set. It is entered from Main Port State Two, Substates 1,2,3 or 4 (Status) and substates 1 or 2 (Data). The user may include any outstanding acknowledgements in the Response Count (RC field) of the Disconnecting SENDBLOCK function. The state is left by receipt of a SENDBLOCK response, STATUS, or SENDBLOCK from the network with the Disconnect flag set. The user may not generate any further functions or responses to the network but he must be prepared for receipt of STATUS and SENDBLOCK, functions and responses from the network while in this state. (These are omitted from Figure Two for the sake of clarity).

4.2.4 Disconnecting Status Originator (State Four)

This state indicates that the local user is attempting to disconnect by means of a STATUS function with the Disconnect flag (D field) set. The state is entered from Main Port State Two, Substates 1 or 3 (status) and Substates 1,2,3, or 4 (Data). The state is left by receipt of a STATUS response, STATUS, or SENDBLOCK from the network with the Disconnect flag set. The user may not generate any further functions or responses to the network but must be prepared to receive STATUS functions and SENDBLOCK functions and responses from the network while in this state (again omitted from Figure Two for the sake of clarity).

4.2.5 Disconnecting Status Responder (State Five)

This state indicates that the remote user of a connection is attempting to disconnect by means of a STATUS function with the Disconnect flag (D field) set. The state is entered from Main Port State Two, substates 1 or 2 (status) and substates 1,2,3 or 4 (Data). The state is left by the user generating a STATUS Response to the network with Disconnect set. The user should expect no further communications from the network while in this state.

4.2.6 Disconnecting Sendblock Responder (State Six)

This state indicates that the remote user of a connection is attempting to disconnect by means of a SENDBLOCK function with the Disconnect flag set. The state is entered from Main Port State Two, substates 1,2,3 or 4 (Status) and substates 1 or 3 (Data). The state is left by the user generating a SENDBLOCK Response to the network with Disconnect set. The user may include any outstanding acknowledgement in the Response Count (RC field) of the SENDBLOCK Response. The user should expect no further communications from the network while in this state.

4.3 Status Substates (Figure Three)

This set of substates is associated with Main Port State Two - Connected. The initial substate is always Status Idle (State One). The Main Port State may be exited from any substate. Certain restrictions on exit substates are given in sections 4.2.4 and 4.2.5.

4.3.1 Status Idle (State One)

This is the entry substate. It may be left by a STATUS function either to or from the user moving to substates three or two respectively. The state may be re-entered from substates three or two by a STATUS response either to or from the network, respectively. The other three substates simply enforce the STATUS 'handshake' through the CONNECTion.

4.3.2 Status Pending, User to Network (State Two)

This state simply prohibits further STATUS functions from user to network until a response is received.

4.3.3 Status Pending, Network to User (State Three)

This state simply prohibits further STATUS functions from network to user until a response is sent.

4.3.4 Status Pending, User to Network and Network to User (State Four)

This state simply prohibits further STATUS functions in either direction until a response is received or sent.

4.4 Data Substates (Figure Four)

This set of substates is associated with Main Port State Two - Connected. The initial state is always Data Clear (State One). The Main Port State may be exited from any substate. Certain restrictions on exit substates are given in sections 4.2.3 and 4.2.6. This state diagram is associated with a pair of counters which are set zero on entry to the Main Port State. They may be labelled the Sent Ahead (SA) and Received Ahead (RA) counters and they are associated with limit values set up during the CONNECTing sequence. Where the user was the originator of the CONNECTion, the Sent Ahead Limit (SAL) is set by the Forward buffer limit (FL field) of the CONNECT Response by which Main Port State Two was entered, and the Received Ahead Limit (RAL) is set by Reverse buffer Limit (RL field) in the same response. Where the user was the responder to the original connection the SAL is set by Reverse buffer Limit in his CONNECT Response by which Main Port State Two was entered, and the RAL is set by the Forward buffer Limit in the same response.

The following constraints always apply to the RA and SA counters:-

$$RA \leq RAL \text{ and } SA \leq SAL$$

A SENDBLOCK function into the network always adds one to SA and a SENDBLOCK received from the network always adds one to RA. Any SENDBLOCK function or SENDBLOCK response into the network always has its Response Count (RC field) subtracted from RA and any SENDBLOCK function or response received from the network always has its Response Count subtracted from SA. Movement between the Data substates is controlled by the condition of the truth values of (RA = RAL) and (SA = SAL).

4.4.1 Data Clear (State One)

This is the entry state. At initial entry RA = SA = 0, and (RAL = RL, SAL = FL) for a CONNECT originator or (RAL = FL, SAL = RL) for a CONNECT responder. The state is exited to state two when SA = SAL and to state three when RA = RAL. The other states simply control the conditions RA<RAL and SA<SAL. In this state RA <RAL and SA<SAL.

4.4.2 Data Blocked, Network to User (State Two)

This state is entered when no more data may be expected from the network but more data may be sent into the network. In this state RA = RAL and SA<SAL.

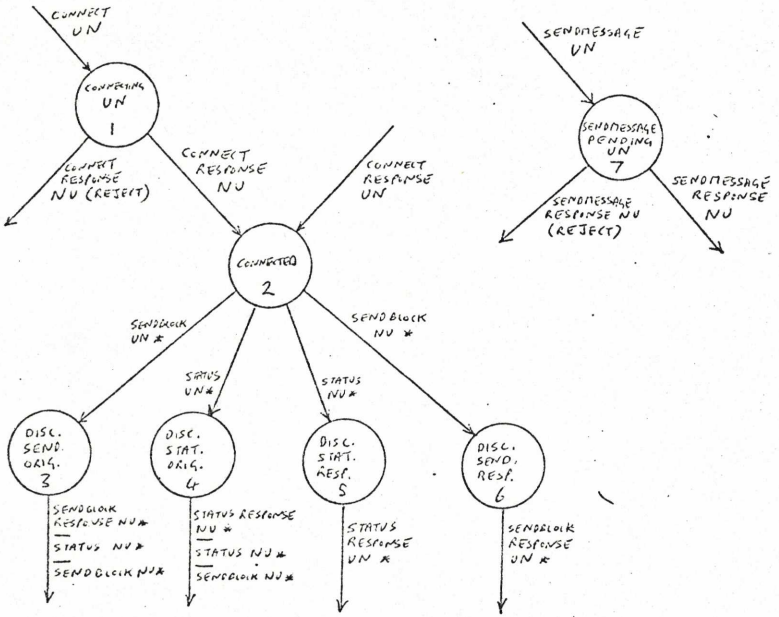
4.4.3 Data Blocked, User to Network (State Three)

This state is entered when no more data may be sent into the network but more data may be expected from the network. In this state RA<RAL and SA = SAL.

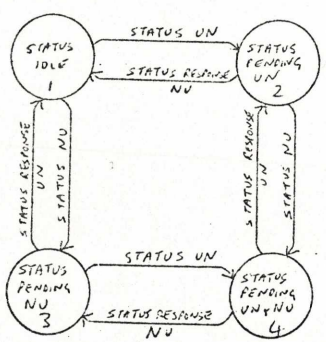
4.4.4 Data Blocked, User to Network and Network to User (State Four)

This state is entered when no more data may be sent into or expected from the network. In this state RA = RAL and SA = SAL.

Main Port State Diagram
Figure Two



Status Port State Diagram
Figure Three



Data Port State Diagram
Figure Four