1 LINKS

1a Control Links

1a1 Logical link 0 will be a control link between any two HOSTs on the network

1a1a Only one control link may exist between any two HOSTs on the network. Thus, if there are n HOSTs on the network, there are n-1 control links from each HOST.

1a2 It will be primarily used for communication between HOSTs for the purposes of:

1a2a Establishing user links

1a2b Breaking user links

1a2c Passing interrupts regarding the status of links and/or programs using the links

1a2d Monitor communication

1a3 Imps in the network may automatically trace all messages sent on link 0.

1b Primary Links

1b1 A user at a given HOST may have exactly 1 primary link to each of the other HOSTs on the network.

1b1a The primary link must be the first link established between a HOST user and another HOST.

1b1b Primary links are global to a user, i.e. a user program may open a primary link, and that link remains open until it is specifically closed.
The primary link is treated like a teletype connected over a normal data-phone or direct line by the remote HOST, i.e. the remote HOST considers a primary link to be a normal teletype user.

The primary link is used for passing (user) control information to the remote HOST, e.g. it will be used for logging in to the remote host (using the remote hosts standard login procedure).

**Auxilliary Links**

A user program may establish any number of auxilliary links between itself and a user program in a connected HOST.

These links may be used for either binary or character transmission.

Auxilliary links are local to the sub-system which establishes them, and therefore are closed when that subsystem is left.

**MANIPULATION OF LINKS**

**Control links**

The control link is established at system load time.

The status of a control link may be active or inactive

The status of the control link should reflect the relationship between the HOSTs.

**Primary Links**

Primary links are established by a user or executive call to the monitor

The network identification number of the HOST to be linked to must be included in the call

An attempt to establish more than one primary link to a particular HOST will be regarded as an error, and the request will be defaulted.

**Standard Transmission Character Set**
There will be a standard character set for transmission of data over the primary links and control links.

This will be full (8 bit) ASCII.

The protocol for establishing a link to HOST B from HOST A is as follows:

A selects a currently unused link to HOST B from its allocation tables.

A transmits a link-connect message to B over link 0.

A then waits for:

A communication regarding that link from B
A certain amount of time to elapse

If a communication regarding the link is received from B, it is examined to see if it is:

A verification of the link from B.

This results in a successful return from the monitor to the requestor. The link number is returned to the requestor, and the link is established.

A request from B to establish the link. This means: that B is trying to establish the same link as A independently of A.

If the network ID number of A(Na) is greater than that of B(Nb), then A ignores the request, and continues to await confirmation of the link from B.

If, on the other hand, Na<Nb, A:

Honors the request from B to establish the link,
Sends verification as required,
Aborts its own request, and repeats the allocation process.
Some other communication from B regarding the link.

This is an error condition, meaning that either:

- A has faulted by selecting a previously allocated link for allocation,
- B is transmitting information over an unallocated link,
- Or a message regarding allocation from B to A has been garbled in transmission.

In this case, A’s action is to:

- Send a link disconnect message to B concerning the attempted connection
- Consider the state of HOST B to be in error and initiate entry to a panic routine.

If no communication regarding the link is received from B in the prescribed amount of time, HOST B is considered to be in an error state.

A link disconnect message is sent to B from A.
A panic routine is called.

Auxilliary Links

Auxilliary links are established by a call to the monitor from a user program.

- The request must specify pertinent data about the desired link to the monitor
  - The number of the primary link to B.

The request for an auxilliary link must be made by a user program in each of the HOSTs (A and B).

If Na > Nb, then HOST A proceeds to establish a link to HOST B in the manner outlined above (getlink).
2c1d If Na<Nb, then A waits:

2c1d1 For HOST B to establish the link (after looking to see if B has already established the corresponding link).

2c1d2 For a specified amount of time to elapse.

2c1d2a This means that HOST B did not respond to the request of HOST A.

2c1d2b The program in HOST A and B should be able to specify the amount of time to wait for the timeout.

3 ERROR CHECKING

3a All messages sent over the network will be error checked initially so as to help isolate software and hardware bugs.

3b A checksum will be associated with each message, which is order dependent.

3bl The following algorithm is one which might be used:

3bl1 A checksum of length 1 may be formed by adding successive fields in the string to be checked serially, and adding the carry bit into the lowest bit position of the sum.

\[\begin{array}{c}
\text{ADD} \\
\text{FIELD 1} \\
+ \text{FIELD 2} \\
\text{RESULT}
\end{array}\]

3bl1a This process is known as folding.
Several fields may be added and folded in parallel, if they are folded appropriately after the addition.

```
+---------+---------+---------+---------+
| FIELD 4 | FIELD 3 | FIELD 2 | FIELD 1 |
+---------+---------+---------+---------+
+---------+---------+---------+---------+
| FIELD 8 | FIELD 7 | FIELD 6 | FIELD 5 |
+---------+---------+---------+---------+
```

ADD
```
+-------+-------+-------+-------+
|       |       |       |       |
+-------+-------+-------+-------+
|       |       |       |       |
+-------+-------+-------+-------+
|       |       |       |       |
+-------+-------+-------+-------+
|       |       |       |       |
+-------+-------+-------+-------+
|       |       |       |       |
+-------+-------+-------+-------+
|       |       |       |       |
+-------+-------+-------+-------+
|       |       |       |       |
+-------+-------+-------+-------+
+-------+-------+-------+-------+
```

```
ADD
+-------+-------+-------+-------+
|       | CARRY  |       |       |
+-------+-------+-------+-------+
ADD
```

```
ADD
+-------+-------+-------+-------+
|       | CARRY  |       |       |
+-------+-------+-------+-------+
ADD
```

```
ADD
+-------+-------+-------+-------+
|       | RESULT |       |       |
+-------+-------+-------+-------+
```

Duvall
3b1a2a Using this scheme, it is assumed that, if there are \( n \) fields, the carries from the first \( n-1 \) fields are automatically added into the low order position of the next higher field, so that in folding, one need only add the \([n]\) result fields to the carry from the \( n\)th field, and then add in an appropriately sized carry from that addition (and repeat the desired number of times to achieve the result).

3b1a3 A checksum computed in this manner has the advantage that the word lengths of different machines may each be used optimally:

3b1a3a If a string of suitable length is chosen for computing the checksum, and a suitable checksum field length is selected, the checksum technique for each of the machines will be relatively optimal.

3b1a3a1 Field length: 288 bits (lowest common denominator of \(24,32,36\))

3b1a3a2 Checksum length: 8 bits (convenient field size for all machines)

3b1b If a message is divided into groups of fields, and each group is checksummed in this manner, an order dependent checksum may be got by shifting the checksum for each group, and adding it in (successively) to the checksum of the next group.

3c A facility will be provided where two HOSTs may enter a mode which requires positive verification of all messages. This verification is sent over the control link.

4 MONITOR FUNCTIONS

4a Network I/O drivers

4a1 Input

4a1a Input message from IMP.

4a1b Do error checking on message.

4a1b1 Verify checksum,

4a1b2 Send "message received" acknowledgment over control link if acknowledge mode is in effect.
There is a strong possibility that the character translation may be done in the IMP.

This needs to be explored further with BBN.

There are two main considerations

- Should the translation be done by table or algorithm?
  - Initially it seems as though the best way to go is table.
  - How should we decide which messages should be translated, i.e. is it desirable to not translate everything (YES!!) and by what means can we use to differentiate?

Decode header, and pass message to correct recipient as identified by source, and link.

Output

- Build header
- Character translation
  - See remarks under the section on output translation (trans).
- Create checksum
- Check status of link
  - If there has not been a RFNM since the last message transmitted out the link, wait for it.
- Transmit message to IMP
- If acknowledge mode is in effect, wait for
  - RFNM from destination IMP.
  - Response from destination HOST over control line 0.
4b Network status

4b1 Maintain status of other HOSTs on network

4b1a If an IMP is down, then his HOST is considered to be down.

4b2 Maintain status of control lines.

4b3 Answer status queries from other HOSTs.

4b4 Inform other HOSTs as to status of primary and auxilliary links on an interrupt basis.

4b5 Inform other HOSTs as to status of programs using primary and secondary links

5 EXECUTIVE PRIMITIVES

5a Primary Links

5a1 These require the HOST number as a parameter.

5a1a Establish primary link

5a1b Connect controlling teletype to primary link

5a1c INPUT/OUTPUT over primary link

5a1d Interrogate status of primary link

5a1d1 Don’t know what, exactly, this should do, but it seems as though it might be useful.

5a1e Disconnect controlling teletype from primary link

5a1f Kill primary link

5b Auxilliary Links.

5b1 Establish auxilliary link.

5b1a requires the HOST number as a parameter

5b1b It returns a logical link number which is similar to a file index. It is this number which is passed to all of the other Auxilliary routines as a parameter.

5b2 INPUT/OUTPUT over auxilliary link
5b3 Interrogate status auxiliary link.

5b3a Don’t know what, exactly, this should do, but it seems as though it might be useful.

5b4 Kill auxiliary link.

5c Special executive functions

5c1 Transparent. INPUT/OUTPUT over link

5c1a This may be used to do block I/O transfers over a link

5c1b The function of the monitor in this instance is to transfer a buffer directly to its IMP

5c1c At does not modify it in any way

5c1c1 This means that the header and other control information must be in the buffer.

5c1d The intended use of this is for network debugging.

6 INITIAL CHECKOUT

6a The network will be initially checked out using the links in a simulated data-phone mode.

6a1 All messages will be one character in length.

6a2 Links will be transparent to the monitor, and controlled by user program via a special executive primitive.

6a2a The initial test will be run from two user programs in different HOSTs, e.g. DDT to DDT.

6a2b It will be paralleled by a telephone link or similar.