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                Novell IPX Over Various WAN Media (IPXWAN)

Status of this Memo

   This memo provides information for the Internet community. It does
   not specify an Internet standard. Distribution of this memo is
   unlimited.

Abstract

   This document describes how Novell IPX operates over various WAN
   media. Specifically, it describes the common "IPX WAN" protocol
   Novell uses to exchange necessary router to router information prior
   to exchanging standard IPX routing information and traffic over WAN
   datalinks.

Table of Contents

1. Introduction

   This document describes how Novell IPX operates over various WAN
   media. It is strongly motivated by a desire for IPX to treat ALL wide
   area links in the same manner. Sections 3 and 4 describe this common
   "IPX WAN" protocol.

IPX WAN protocol operation begins immediately after link
establishment. While IPX is a connectionless datagram protocol, WANs
are often connection-oriented. Different WANs have different methods
of link establishment. The subsections of section 1 of this document
describe what link establishment means to IPX for different media.
They also describe other WAN-media-dependent aspects of IPX
operation, such as protocol identification, frame encapsulation, and
link tear down.

1.1 Operation Over PPP

IPX uses PPP [1] when operating over point-to-point synchronous and
asynchronous networks.

With PPP, link establishment means the IPX NCP [4] reaches the Open
state. NetWare IPX will reject all NCP options, and uses normal frame
encapsulation as defined by PPP. The IPXWAN protocol MUST NOT occur
until the IPX NCP reaches the Open state.

PPP allows either side of a connection to stop forwarding IPX if one
end sends an IPXCP or an LCP Terminate-Request. When a router detects
this, it will immediately reflect the lost connectivity in its
routing information database instead of naturally aging it out.

1.2 Operation over X.25 Switched Virtual Circuits

With X.25, link establishment means successfully opening an X.25
virtual circuit. As specified in RFC-1356, "Multiprotocol
Interconnect on X.25 and ISDN in the Packet Mode" [2], the protocol
identifier 0x800000008137 is used in the X.25 Call User Data field of
the Call Request frame, and indicates that the virtual circuit will
be devoted to IPX.

Furthermore, each IPX packet is encapsulated directly in X.25 data
frame sequences without additional framing.

Either side of the virtual circuit may close it, thereby tearing down
the IPX link. When a router detects this, it will immediately reflect
the lost connectivity in its routing information database instead of
naturally aging it out.

1.3 Operation over X.25 Permanent Virtual Circuits

The nature of X.25 PVC's is that no call request is made. When the
router is informed that X.25 Layer 2 is up, the router should assume
that link establishment is complete.

Each IPX packet is encapsulated in an X.25 data frame sequence
without additional framing. Novell IPX assumes a particular X.25
permanent circuit is devoted to the use of IPX.

If a router receives a layer 2 error condition (e.g., X.25 Restart),
it should reflect lost connectivity for the permanent circuits in its
routing information database and re-perform the necessary steps to
obtain a full IPX connection.

1.4 Operation over Frame Relay

Novell conforms to RFC-1294, "Multiprotocol Interconnect over Frame
Relay" [3] for frame relay service and packet encapsulation.
Currently, Novell has not stabilized the method for treating frame
relay connections - whether they treat the connections as LANs or
WANs.

1.5 Operation over other WAN media

Additional WAN media will be added here as specifications are
developed.

2. Glossary Of Terms

Primary Network Number:

   Every IPX WAN router has a "primary network number". This is an
   IPX network number unique to the entire internet. This number
   will be a permanently assigned network number for the router.
   Those readers familiar with NetWare 3.x servers should realize
   that this is the "Internal" network number.

Router Name:

   Every IPX WAN router must have a "Router Name". This is a symbolic
   name given to the router. Its purpose is to allow routers to know
   who they are connected to after link establishment - particularly
   for network management purposes. A symbolic name conveys more
   information to an operator than a set of numbers. The symbolic
   name should be between 1 and 47 characters in length containing
   the characters 'A' through 'Z', underscore (_), hyphen (-) and
   "at" sign (@). The string of characters should be followed by a
   null character (byte of zero) and padded to 48 characters using
   the null character. Those readers familiar with NetWare 3.x
   servers should realize that the file server name is the Router
   Name.

3. IPX WAN Protocol Description

   IPX WAN links have the concept of a LINK MASTER and a LINK SLAVE.
   This relationship is decided upon based on information contained
   within the first IPX packets transferred across the WAN link.

   After link establishment, both sides of the link send "Timer Request"
   packets and start a timer waiting for a "Timer Response". These
   "Timer Request" packets are sent every 20 seconds until a response is
   received or a time-out occurs trying to initialize a connection (the
   timer is restarted each time a new "Timer Request" is sent). The
   time-out should be configurable, and is normally about one minute.
   This is directly dependent on the call setup time for the connection.
   If a time-out occurs, the router issues a disconnect on the offending
   connection and optionally attempts to retry the connection.

   When a "Timer Request" is received, the router with the lowest
   primary network number MUST respond with a "Timer Response" packet -
   and become the "Slave" of the link. If the "Slave" determines that it
   cannot support any of the Routing Types included in the "Timer
   Request" packet, the "Slave" should issue a disconnect on the
   connection being established. The "Master" of the link (determined
   when a "Timer Response" packet is received) is responsible for
   defining the network number that is to be used as a common network
   number for the new WAN link, and for calculating the RIP transport
   time that will be advertized to other RIP routers for the new link.
   This is calculated by stopping the timer which was started when a
   "Timer Request" was initiated and applying the algorithm in section
   4.2.

   To allow this, both sides of the link MUST have an adequate pool of
   WAN network numbers (unique within the internetwork) available to be
   assigned to the link when the call is fully completed. The "Master"
   of the link MUST then select a network number and construct an
   "Information Request" packet containing the calculated link delay,
   the common network number, and its own router name. On receiving this
   packet, the "Slave" MUST turn the packet around, overwrite the router
   name and node identifier and send an "Information Response".

   After the "Master" has received the "Information Response" and the
   "Slave" has received the "Information Request", standard IPX RIP and
   SAP packets are transferred across the WAN link, as currently defined
   for LAN links. The "IPX Router Specification" [5] contains
   information describing the Novell RIP/SAP protocol for third party
   developers.

   Note that the "Information Request" and "Information Response"
   packets are specific to the "Routing Type"=0 information exchanges.

With this routing type, no retransmission is made of any of the
Information packets. If a response has not been received within the
predefined time-out period, a disconnect is issued on the link, and
the link can optionally be attempted later.

If a router detects an error for which no suitable protocol response
exists (e.g., unable to allocate a network number), the link should
be terminated according to the relevant media specification.

Under certain circumstances, particularly on X.25 permanent circuits,
it is only possible to detect the remote router went away when it
comes back up again. In this case, one side of the link receives a
Timer Request packet when IPX is in a fully connected state. The
side receiving the Timer Request MUST realize that a problem
occurred, and revert to the IPX link establishment phase.
Furthermore, the routing information learned from this connection
should be immediately discarded.

4. Information Exchange Packet Formats

All IPX WAN information exchange packets conform to the standard
Novell IPX packet format. The packets use the IPX defined packet type
04 defining a Packet Exchange Packet. The socket number 0x9004 is a
Novell reserved socket number for exclusive use with IPX WAN
information exchange. IPX defines that a network number of 0 is
interpreted as being a local network of unknown number that requires
no routing. This feature is of use to us in transferring these
packets before the common network number is exchanged. Some routers
need to know a "Node Number" (or MAC address) for each node on a
link. Node numbers will be formed from the "WNode ID" field. The
node number will be the 4 bytes of WNode ID followed by 2 bytes of
zero.

Router Type number assignment. Other vendors IPX routing protocols
can make use of the IPXWAN protocol definition by obtaining Router
Types from Novell. This document will then include the new Router
Types (with the references to vendor protocol description documents).

WOption Number assignment. These numbers only need to be assigned
from Novell for the "Timer Request" and "Timer Response" packets.
Other packet types (e.g., the "Information Request" packets, are
dependent on the "Router Type" negotiated and can contain any (vendor
defined) packet type other than 0 or 1. WOption numbers in these
packets are then defined by the vendor defining the Routing Type. The
same packet format should still be maintained.

4.1 Timer Request Packet

```
+----------------------------------------------------------------+
| Checksum          | FF FF              | Always FFFF           |
| Packet Length     | 02 40              | Max IPX size (576 bytes|
|                   |                    | Hi Lo order)          |
| Trans Control     | 00                 | Hops traversed        |
| Packet Type       | 04                 | Packet Exchange Packet |
| Dest Net #        | 00 00 00 00        | Local Network         |
| Dest Node #       | FF FF FF FF FF FF  | Broadcast             |
| Dest Socket #     | 90 04              | Reserved WAN socket   |
| Source Net #      | 00 00 00 00        | Local Network         |
| Source Node #     | 00 00 00 00 00 00  | Set to zero           |
| Source Socket #   | 90 04              | Reserved WAN socket   |
|-----------------+------------------+-----------------------|
| WIdentifier       | 57 41 53 4D        | Confidence identifier |
| WPacket Type      | 00                 | Timer Request         |
| WNode ID          | xx xx xx xx        | Primary Net # of      |
|                   |                    | sending router        |
|                   |                    | (Hi Lo order)         |
| WSequence #       | xx                 | Sequence start at 0   |
| WNum Options      | 02                 | 2 Options follow      |
| WOption Number    | 00                 | Define Routing Type   |
| WAccept Option    | 01                 | 0=No,1=Yes,3=Not Applic|
| WOption Data Len  | 00 01              | Option length (Hi Lo) |
| WOption Data      | 00                 | IPX RIP/SAP Routing   |
| WOption Number    | FF                 | Pad option            |
| WAccept Option    | 01                 | 0=No,1=Yes,3=Not Applic|
| WOption Data Len  | 02 0E              | Pad data length (Hi Lo)|
| WOption Data      | 00->FF's           | Repeated sequence of 00|
|                   |                    | through FF's.         |
+----------------------------------------------------------------+
```

Note:
     Timer Request packets will always be 576 bytes. However,
     there should be no assumption made about the number of
     options specified in this packet.

After link establishment, Timer Request packets are sent by both
sides of the link. Each end starts their sequence number at zero.
Subsequent retries (every 20 seconds) will increment the value of
this sequence number. Only a Timer Response packet with a sequence
number matching the last sent sequence number will be acted upon.

When receiving this packet, the WNode ID should be compared to the
receiver's Primary Network #. If the WNode ID is larger than the
receiver's Primary Network #, a Timer Response packet should be sent,
and the receiver should become the link "Slave".

Packets received on the reserved socket number not having the
WIdentifier set to the hexadecimal values noted above should be
discarded.

Routing Type Option:

A routing type of zero (0) is the minimum interoperability
requirement (as defined by this document). A router ready to send a
Timer Response (and receiving a routing type of zero) MUST respond
with a routing type of zero. A router ready to send a Timer Response
(and receiving routing types not matching a supported value) SHOULD
respond with a Routing Type of zero indicating support for the
minimum common protocol.

Note that multiple Routing Type Options can be included in the Timer
Request packet if the router supports multiple routing methods for
IPX. The included Router Types MUST include and support this type
zero option.

Accept Option (for Routing Type and PAD options):

This field MUST be set to YES if the option is supported, and NO if
an option is not supported. A Timer Response MUST respond with ONLY
one Router Type set to YES.

PAD Option:

This option will normally be the last entry in the packet. Its sole
purpose is to fill the IPX packet to be 576 bytes. The pad option
data will contain a repeating sequence of zero's through 0xFF's. This
should stop compression modems from collapsing the packet and
destroying the link delay calculation.

Currently Assigned WOption Numbers (Timer Request Packet):
    Routing Type Option = 0x00;   Option Length = 0001
        Current option data values:
            0   Novell RIP/SAP routing with network
                    number assigned to the link.

    PAD Type Option   = 0xFF;   Option Length = Variable

    Compression Option = 0x80;   Option Length = Variable
                    (length dependent on compression type)
        Current option data values:
            Byte 1 Compression type
                0 = Telebit compression (length=3) [6]
                    Telebit Byte 2 - Compression options
                    Telebit Byte 3 - Number compression slots

4.2. Timer Response Packet

```
+----------------------------------------------------------------+
| Checksum           | FF FF               | Always FFFF         |
| Packet Length      | 02 40               | Max IPX size (576 bytes|
|                    |                     | Hi Lo order)        |
| Trans Control      | 00                  | Hops traversed      |
| Packet Type        | 04                  | Packet Exchange Packet |
| Dest Net #         | 00 00 00 00         | Local Network       |
| Dest Node #        | FF FF FF FF FF FF   | Broadcast           |
| Dest Socket #      | 90 04               | Reserved WAN socket |
| Source Net #       | 00 00 00 00         | Local Network       |
| Source Node #      | 00 00 00 00 00 00   | Set to zero         |
| Source Socket #    | 90 04               | Reserved WAN socket |
|-----------------+------------------+-----------------------|
| WIdentifier        | 57 41 53 4D         | Confidence identifier |
| WPacket Type       | 01                  | Timer Response      |
| WNode ID           | xx xx xx xx         | Primary Net # of    |
|                    |                     | sending router      |
|                    |                     | (Hi Lo order)       |
| WSequence #        | xx                  | Same as Timer Request |
|                    |                     | received            |
| WNum Options       | 02                  | 2 Options follow    |
| WOption Number     | 00                  | Define Routing Type |
| WAccept Option     | 01                  | 0=No,1=Yes,3=Not Applic|
| WOption Data Len   | 00 01               | Option length (Hi Lo) |
| WOption Data       | 00                  | IPX RIP/SAP Routing |
|                    |                     | (Minimum interoperating|
|                    |                     | requirement). Others |
|                    |                     | may be defined by at a |
|                    |                     | later date by Novell |
| WOption Number     | FF                  | Pad option          |
| WAccept Option     | 01                  | 0=No,1=Yes,3=Not Applic|
| WOption Data Len   | 02 0E               | Pad data length (Hi Lo)|
| WOption Data       | 00->FF's            | Repeated sequence of 00|
|                    |                     | through FF's to stop |
|                    |                     | compression modems  |
|                    |                     | doing any compression |
|                    |                     | for link delay calc. |
+----------------------------------------------------------------+
```

   The responses contained within this packet are as described in
   section 4.1. Any unknown options or not supported options from the
   Timer Request should have the WAccept Option set to NO.

   If the Timer Request packet contained more than one Router Type
   option and the "Slave" supports all the options, the "Slave" should
   set the WAccept Option to NO on all Router Types except the Routing

Type which is to be adopted. The "Master" of the link will then adopt
the routing option specified with the YES setting and complete
further information exchanges according to that routing standard.

This packet should contain the same sequence number as the received
Timer Request. This packet should ONLY be sent by the router
determining themselves to be the "Slave" of the link.

Currently Assigned WOption Numbers (Timer Response Packet):
     Routing Type Option = 0x00;   Option Length = 0001
         Current option data values:
         0   Novell RIP/SAP routing with network
                    number assigned to the link.

     PAD Type Option   = 0xFF;   Option Length = Variable

     Compression Option = 0x80;   Option Length = Variable
                     (length dependant on compression type)
         Current option data values:
         Byte 1 Compression type
             0 = Telebit compression (length=3) [6]
             Telebit Byte 2 - Compression options
             Telebit Byte 3 - Number compression slots

4.3. RIP/SAP Information Request Packet (Router Type=0 Only)

```
+---------------------------------------------------------------+
| Checksum          | FF FF             | Always FFFF           |
| Packet Length     | 00 63             | Size of header+data   |
|                   |                   | (Hi Lo order)         |
| Trans Control     | 00                | Hops traversed        |
| Packet Type       | 04                | Packet Exchange Packet|
| Dest Net #        | 00 00 00 00       | Local Network         |
| Dest Node #       | FF FF FF FF FF FF | Broadcast             |
| Dest Socket #     | 90 04             | Reserved WAN socket   |
| Source Net #      | 00 00 00 00       | Local Network         |
| Source Node #     | 00 00 00 00 00 00 | Set to zero           |
| Source Socket #   | 90 04             | Reserved WAN socket   |
|-------------------+-------------------+-----------------------|
| WIdentifier       | 57 41 53 4D       | Confidence identifier |
| WPacket Type      | 02                | Information Request   |
| WNode ID          | xx xx xx xx       | Primary Net # of      |
|                   |                   | sending router        |
|                   |                   | (Hi Lo order)         |
| WSequence #       | 00                | Sequence start at 0   |
| WNum Options      | 01                | 1 Option to follow    |
| WOption Number    | 01                | Define IPX RIP/SAP    |
|                   |                   | info exchange         |
| WAccept Option    | 01                | 0=No,1=Yes,3=Not Applic|
| WOption Data Len  | 00 36             | Option length (Hi Lo) |
| WOption Data      |                   |                       |
|  Link Delay       | xx xx             | Hi Lo link delay in   |
|                   |                   | milli seconds (see    |
|                   |                   | below for calculation)|
|  Common Net #     | xx xx xx xx       | Hi Lo Common Network #|
|  Router Name      | xx (x 48 decimal) | Router name - as defned|
|                   |                   | in section 2.         |
+---------------------------------------------------------------+
```

Calculation of link delay is performed as follows:

```
   // Start_time is a time stamp when Timer Request sent out
   // End_time is a time stamp when a Timer Response is
   // received.
   link_delay = end_time - start_time; // 1/18th second
   // We are on a slow net, so add some biasing to help stop
   // multiple workstation sessions timing out on the link
   if (link_delay < 1)
   {
       link_delay = 1;
   }/*IF*/
   link_delay *= 6;    // Add the biasing
   link_delay *= 55;   // Convert link delay to milliseconds
```

   The "Link Delay" is used as the network transport time when
   advertized in the IPX RIP packet tuple for the network entry "Common
   Net #". For a consistent network, a common link delay is required at
   both ends of the link and is calculated by the link "Master".

   The Common Net # is supplied by the link "Master". This number must
   be unique in the connected internetwork. Each WAN call requires a
   separate number.

   Currently only a single option is defined for the "Information
   Request" packet for Routing Type=0.

4.4. RIP/SAP Information Response Packet (Router Type=0 Only)

```
    +-----------------------------------------------------------------+
    | Checksum          | FF FF               | Always FFFF           |
    | Packet Length     | 00 63               | Size of header+data   |
    |                   |                     | (Hi Lo Order)         |
    | Trans Control     | 00                  | Hops traversed        |
    | Packet Type       | 04                  | Packet Exchange Packet |
    | Dest Net #        | 00 00 00 00         | Local Network         |
    | Dest Node #       | FF FF FF FF FF FF    | Broadcast             |
    | Dest Socket #     | 90 04               | Reserved WAN socket   |
    | Source Net #      | 00 00 00 00         | Local Network         |
    | Source Node #     | 00 00 00 00 00 00   | Set to zero           |
    | Source Socket #   | 90 04               | Reserved WAN socket   |
    |-------------------+---------------------+-----------------------|
    | WIdentifier       | 57 41 53 4D         | Confidence identifier |
    | WPacket Type      | 03                  | Information Response   |
    | WNode ID          | xx xx xx xx         | Primary Net # of      |
    |                   |                     | sending router        |
    |                   |                     | (Hi Lo order)         |
    | WSequence #       | 00                  | Sequence start at 0   |
    | WNum Options      | 01                  | 1 Option to follow    |
    | WOption Number    | 01                  | Define IPX RIP/SAP    |
    |                   |                     | info exchange         |
    | WAccept Option    | 01                  | 0=No,1=Yes,3=Not Applic|
    | WOption Data Len   | 00 36               | Option length (Hi Lo) |
    | WOption Data      |                     |                       |
    |   Link Delay      | xx xx               | Hi Lo link delay (as  |
    |                   |                     | received in Info Requ) |
    |   Common Net #    | xx xx xx xx         | Hi Lo Common Network # |
    |                   |                     | (as received in Info  |
    |                   |                     | request)              |
    |   Router Name     | xx (x 48 decimal)   | Router name - as defned|
    |                   |                     | in section 2.         |
    +-----------------------------------------------------------------+
```

The responses contained within this packet are as described in
section 4.3.

5. References

   [1] Simpson, W., "The Point-to-Point Protocol (PPP) for the
       Transmission of Multi-protocol Datagrams over Point-to-Point
       Links", RFC 1331, May 1992.

   [2] Malis, A., Robinson, D., and R. Ullman, "Multiprotocol
       Interconnect on X.25 and ISDN in the Packet Mode", RFC 1356,
       August 1992.

   [3] Bradley, T., Brown, C., and A. Malis, "Multiprotocol Interconnect
       over Frame Relay", RFC 1294, January 1992.

   [4] Simpson, W., "The PPP Internetwork Packet Exchange Control
       Protocol (IPXCP) Compromise Version", Work in Progress.

   [5] Novell IPX Router Specification. Novell Part Number 107-000029-
       001. (Note: Currently, this document is only available as part
       of a Novell developers program as part of an SDK. Novell Labs,
       Provo (UT) should be able to provide more information on this
       document.)

   [6] Lewis, M., Telebit Corp. "IPX Header Compression based on Van
       Jacobson Header Compression for TCP/IP", Work in Progress,
       contact: (mlewis@telebit.com).

6. Security Considerations

       Security issues are not discussed in this memo.

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