Network Working Group   M. Allen
Request For Comments: 1551   Novell, Inc.
Obsoletes: RFC 1362   December 1993
Category: Informational

                Novell IPX Over Various WAN Media (IPXWAN)

Status of this Memo

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. This document supercedes RFC 1362 and adds capability for
   Unnumbered RIP links, On-demand statically routed links and client to
   router connectivity.

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.

   The 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 negotiate down to a null set of 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.
   Options negotiated by the IPXWAN protocol MUST supercede any options
   negotiated by the IPXCP.

   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 Permanent Virtual Circuits

To determine when a permanent virtual circuit (PVC) has become active
or inactive, the router interacts periodically with either a private
Frame Relay switch or a public Frame Relay network. The method used
depends on the switch or service provider. Some support [7], section
6l others support [3], Annex D. Novell supports both methods.

When a router is restarted, IPXWAN exchanges over active Frame Relay
PVCs (that is, PVCs that have remained active before and after
restart) can begin immediately.

Each IPX packet is encapsulated in a Frame Relay frame sequence as
defined in [3] without additional framing.

When a router detects that a Frame Relay PVC has transitioned from an
inactive to an active state, link establishment is considered
complete and IPXWAN exchange over this newly activated link begins.

When an active PVC becomes inactive, the router reflects the lost
connectivity in its routing information database.

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.

        For workstation (client) connectivity, it is useful if the client
        connection software is configured with a symbolic name reflecting
        the name of the client. This allows a router management utility to
        determine which connection connects with which client/router. If
        no name is configured, it is recommended that a default string
        such as "DIAL-IN-CLIENT" is used.

3. IPX WAN Protocol Description

     After the underlying data link connection is established as described
     in the preceding media dependant description, the IPXWAN protocol is
     activated to exchange identities and determine certain operational
     charactaristics of the link.

     There are two steps in the IPXWAN operation:
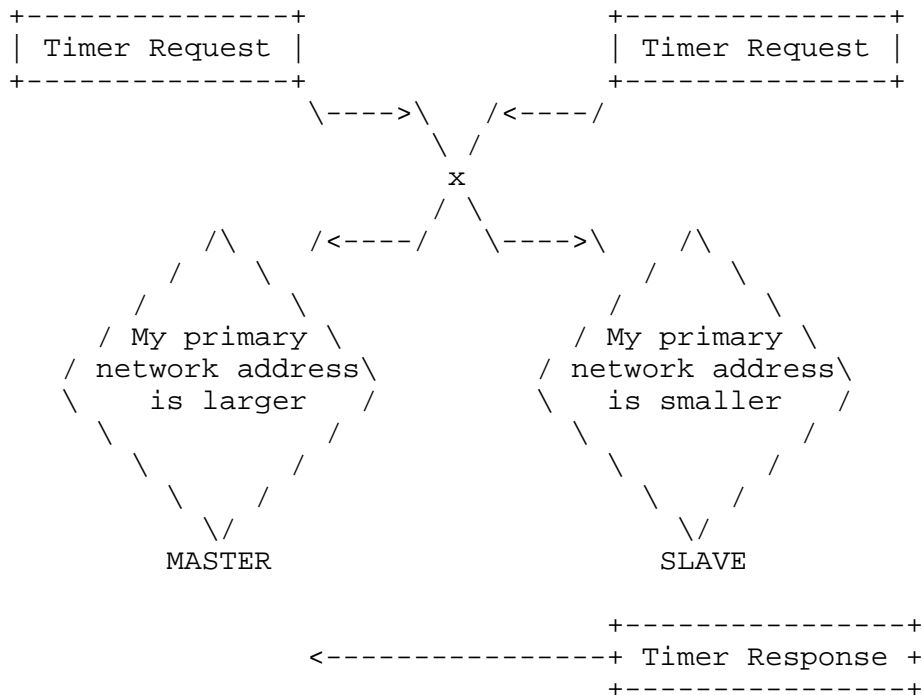
        - Negotiating master/slave role and choice of routing protocol.
          The master/slave roles persist for the IPXWAN exchanges only;

        - Information exchange of final router configuration.

     After these steps are concluded, transmission of IPX routing packets
     begins - using the routing protocol negotiated - as well as

transmission of IPX data traffic.

3.1 The Initial Negotiation

   The first exchange of packets decides the master/slave roles and the
   routing protocol to be used on the link and gauges the link delay for
   the routing metrics. The initial negotiation is the same for all
   protocols.

```
       +---------------+                  +---------------+
       | Timer Request |                  | Timer Request |
       +---------------+                  +---------------+
               \---->\    /<----/
                      \  /
                       x
                      / \
            /\     /<----/    \---->\     /\
           /  \    /            \    /  \
          /    \  /              \  /    \
         / My primary \          / My primary \
        / network address\      / network address\
        \    is larger    /     \   is smaller    /
         \              /        \              /
          \            /          \            /
           \          /            \          /
            \/                      \/
           MASTER                  SLAVE


                            +----------------+
            <---------------+ Timer Response +
                            +----------------+
```

   After link establishment, both sides of the link send Timer Request
   packets and start a timer waiting for a Timer Response. These Timer
   Requests are sent every 20 seconds until a response is received or a
   descision is made that the remote node is not responding. This could
   be after a predefined time (min. 60 seconds) or a number of retries
   (e.g., 16).

   In composing the Timer Request, the router or workstation takes into
   consideration:

      - Which types of routing protocols it supports;

      - Whether it is prepared to assign a network address to the link;

      - For workstations, whether they require the ability to specify
        their network/NIC address on a reconnect;

   - Whether it is able to support IPX header compression [6].

For each routing protocol supported, place an option in the Timer
Request packet. The Routing Type options should be added in the
originator's order of preference with the most preferred option
first.

Some of the newer (or modified) routing protocols do not have the
requirement to allocate a network number on a WAN link. This type of
routing protocol has the advantage of potentially simpler
configuration as no network number pools are necessary for WAN links.
However, these router implementations may still wish to interoperate
with the older IPXWAN implementations which are able to allocate
network numbers to the WAN link. In this case, the following method
is used to force the older implementation to become the link master.
It should be noted that a router implementation capable of supporting
workstation dial-in MUST be able to supply AT LEAST ONE network
number on which the workstation can reside.

If the router is prepared to assign an IPX network number to the
link, it sends its primary network number in the Timer Request
WNodeID field, and omits the Extended Node ID option. On the other
hand, if the router is NOT prepared to assign an IPX network number
to the link, it sets the Timer Request WNodeID field to zero, and
includes its primary network number in an Extended Node ID option.

Workstations follow a similar, but slightly different set of rules
for setting the WNodeID field. If this is the first time the work-
station is connecting to the router, the workstation will set the
WNodeID to zero indicating the router should be the link master and
allocate a network number for the new link. In this case, the work-
station will respond to the router's Timer Request and acknowledge
only the Workstation Routing Type option. Note that a workstation
does NOT include an Extended Node ID option in it's timer request.

If the workstation is reconnecting a link after an earlier inactivity
disconnect, it is necessary for the workstation to be able to specify
its network, NIC address and "Router Name" field (so that file server
connections can be maintained after the reconnect). In this case,
the workstation will set its WNodeID field to FFFFFFFFh forcing
itself to be the link master. In this case, the router will respond
to the workstation's Timer Request with only the Workstation Router
Type acknowledged.

Further packets in the IPXWAN exchange MUST use the correct WNodeID
(workstations will always use zero).

On receiving a Timer Request packet, a router determines its role -
master or slave - for the remainder of the IPXWAN exchanges. The
master role does not denote special privileges, it merely means that
the router is the requestor in the ensuing request/response
exchanges. The descision is made as follows:

  a) If there is an Extended Node ID present (and we understand
     the option), this must be compared to our Primary Network
     Number. If we have the lower Primary Network Number, we
     MUST respond with a Timer Response and become the slave.

  b) If there is NO Extended Node ID, we must compare the WNodeID
     of the received Timer Request with our Primary Network Number
     and respond if we have a lower number.

  Note: The Primary Network Number for a workstation when
  determining master/slave roles depends on whether the
  workstation requires itself to be the master of slave. It
  should compare the received WNodeID to that sent in it's own
  Timer Request.

The numeric comparisons are done by considering each byte of the
WNodeID or Extended Node ID fields as an unsigned integer, and the
first byte as most significant.

The link slave responds to the Timer Request with a Timer Response.
To do so, each option in the received Timer Request is parsed. If an
option is not supported (or recognized), that option is rejected by
changing the WAccept field to "NO" for that option.

When selecting the router type which will be used on the link, the
first option in the Timer Request which can be supported should be
accepted. All other router types should have the WAccept field set to
"NO". A router MUST NOT accept workstation connectivity to a node
which is another router.

Note: It is permitted for a router to support a numbered routing
type, but not be able to assign the network number. In this case,
that routing type can be selected only if the other router supports
it and is able to assign the network number. This can be determined
by the value of the received WNodeID field. If the router is unable
to assign a network number to the link, it MUST support Unnumbered
RIP and include this option in the Timer Requests.

If a router wishes to provide WAN Client access without supporting
other WAN routing types, a potential problem arises since a router
and WAN client would both just be sending a single Routing Type
option indicating the use of WAN Client. The IPXWAN specification

does not allow a WAN workstation to connect to another WAN
workstation. The method for detecting this is that the sent and
received Timer Requests have a single Routing Type defined of WAN
Client. To overcome this problem, IPXWAN defines that a router MUST
NOT send a single Routing Type if that type is just WAN Client. The
router MUST additionally include one (or more) of the defined routing
types (like WAN RIP) with the WAccept option set to NO. This is so
that a workstation may detect that this is actually a router sending
the Timer Request and not just another workstation trying to call a
workstation. The extra option will serve to be a counted Routing Type
that will be ignored. If a workstation detects it is connecting to
another workstation, it should disconnect the link.

Note that a router supporting a workstation will need to be able to
supply AT LEAST one network number for workstations. All dial-in
workstations could share the same network, and be assigned unique
node numbers by the router, or each workstation could be assigned a
different network number. This is a router specific implementation
detail. Use of a single network for all clients is prefered, however,
this does involve extra work by the router when dealing with
broadcast frames. When the router is the link master and allocating
NIC addresses on a single network,it should ALWAYS use a unique value
- by incrementing the NIC address for each client connection. This
allows a workstation which is reconnecting the ability to specify his
old network and NIC address. It is unlikely with a 6 byte NIC
address, that there will be wrap-around in the numbers that would
cause a problem. Router Node Number allocation should follow a few
simple rules. The six byte NIC address SHOULD have the first byte set
to 2.

```
        Byte # +--1----2----3----4----5----6-+
               | 02 | XX | XX | XX | XX | XX |
               +----------------------------+
```

In an IEEE address space, this would represent a non-multicast,
locally defined address. Node numbers of zero or -1 are not allowed.

If a slave determines it cannot support any of the supplied routing
protocols in the received Timer Request, it MUST 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 4.3.

3.2 Information Exchange

   After exchanging Timer Request packets, the link master and slave
   have been determined, and the Routing Protocol to be used on the link
   is negotiated. The link master is now responsible for sending an
   Information Request packet to the slave specifying the network number
   to be used on the new link (zero for unnumbered RIP and On Demand),
   the calculated transport time to be used in the routing metric, the
   Router Name (for management purposes), and for a workstation
   connection, the NIC address the workstation will be adopting. The NIC
   address option is a separate option added in the Information
   Request/Response for workstation connectivity. It is NOT present for
   router to router connections.

   If a router receives an inappropriate Information Request from a
   workstation trying to set the common network number and NIC address
   the router MUST overwrite these values with preferred values. When
   the workstation receives the Information Response, it MUST note the
   new values. If the workstation is unable to adjust to the new values,
   it MUST issue a disconnect on the link. If a workstation is the link
   master (i.e., it is reconnecting), the router is additionally
   responsible for ensuring the "Router Name" field matches that of the
   original connection. If the values differ, the call should be
   disconnected.

   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.

   When Unnumbered RIP, On-demand or Workstation options are negotiated,
   Information Request packets are repeated every 20 seconds until a
   response is received. For the Numbered RIP links, the Information
   Request is NOT resent. Instead, the link is disconnected after a
   suitable delay (min. 60 seconds) - this requirement ensures
   interoperabilty with earlier versions of IPXWAN. When Information
   Requests are repeated, they should continue for a preconfigured time
   (min. 60 seconds) or a preconfigured number of retries (e.g., 16).
   Each retry uses an incremented sequence number.

3.3 NAK Packets

   The IPXWAN protocol uses a NAK packet to indicate the received IPXWAN
   packet was not acceptable. A NAK packet is an exact copy of the
   received packet with the WPacketType field set to NAK. There are two
   anticipated uses of this packet.

      - The received WPacketType is invalid or not recognized;

      - A badly formed IPXWAN packet is received.

   Returning a NAK packet allows the sender a chance to work out what
   was wrong. If the sender was unable to determine the problem, the
   call can then be disconnected.

   The value of the NAK WPacketType is FFh.

4. Information Exchange Packet Formats

   All IPX WAN protocol exchanges utilize 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 protocol exchange. IPX
   defines that a network number of zero (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. For a workstation, the
   node number will be explicitly assigned by the router and notified to
   the workstation in the Information Request packet.

   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).
   Current Routing Types are:

      00   Numbered RIP/SAP
      01   NLSP (no RIP/SAP - defined in [8])
      02   Unnumbered RIP/SAP
      03   On Demand, static routing (no RIP/SAP or NLSP)
      04   Workstation (no RIP/SAP)
      05-FF   Currently undefined

   WOption Number assignment. These numbers only need to be assigned
   from Novell for the "Timer Request" and "Timer Response" packets.

Packet Types also need to be assigned by Novell. However, the options
within these packets are dependant on the "Router Type" negotiated.
WOption numbers in these packets are then defined by the vendor
defining the Routing Type. The same packet format should still be
maintained.

Router Type 01 will not be described in this document since it
involves knowledge of the NLSP protocol to implement. Please refer to
[8] for a complete specification of these NLSP IPXWAN exchanges and
the NLSP protocol.

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      | xx                | Number of options      |
|-----------------+-------------------+------------------------|
| WOption Number    | xx                | Option Identifier      |
| WAccept Option    | xx                | 0=No,1=Yes,3=Not Applic|
| WOption Data Len  | xx xx             | Number of following    |
|                   |                   | option bytes (Hi Lo)   |
| WOption Data      | nn                | Option specific data   |
+----------------------------------------------------------------+
```

Routing Type Option:
    One or more of the following router type options should be included
    in a Timer Request packet. A router should ALWAYS include Routing
    Type zero (0) if full interoperability is required with an older
    implementation. The router types MUST be included in the senders
    order of preference. If a router receives a Timer Response with more
    than one Router Type having WAccept set to Yes, the link MUST be

disconnected.

```
+------------------------------------------------------------------+
|  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   |  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     |  01                    |  NLSP                 |
+------------------------------------------------------------------+

+------------------------------------------------------------------+
|  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     |  02                    |  Unnumbered RIP/SAP   |
+------------------------------------------------------------------+

+------------------------------------------------------------------+
|  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     |  03                    |  On-demand, static Rting|
+------------------------------------------------------------------+

+------------------------------------------------------------------+
|  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     |  04                    |  Client - No RIP/SAP  |
|                   |                        |  except on request    |
+------------------------------------------------------------------+
```

Extended Node ID Option:
    The extended node ID should only be included if the WNodeID field is
    set to zero AND the node constructing the packet is a router. Note
    that an older version of IPXWAN will just reject this option and
    automatically become the link master as the WNodeID is zero.

```
+------------------------------------------------------------------+
|  WOption Number   |  04                    |  Extended Node ID    |
|  WAccept Option   |  01                    |  0=No,1=Yes,3=Not Applic|
|  WOption Data Len |  00 04                 |  Pad data length (Hi Lo)|
|  WOption Data     |  xx xx xx xx           |  Real primary network # |
|                   |                        |  of this router (Hi-Lo) |
+------------------------------------------------------------------+
```

Header Compression Option:
    Although more than one header compression option may be specified in
    a Timer Request packet, it is important that a MAXIMUM of ONE header
    compression option is accepted. If an implementation receives a
    Timer Response with more than one header compression option with the
    accept option set to Yes, the link MUST be disconnected. [Ref 6]
    defines the full Telebit Header Compression method.

```
    +-------------------------------------------------------------+
    | WOption Number    | 80                 | Header Compression |
    | WAccept Option    | 01                 | 0=No,1=Yes,3=Not Applic|
    | WOption Data Len  | 00 03              | Variable - at least 1 |
    | WOption Data      | 00                 | 0 = Telebit Hdr Compr. |
    |                   | xx                 | Compression Options |
    |                   | xx                 | Compression Slots |
    +-------------------------------------------------------------+
```

PAD Option:
    The PAD option is used to fill the Timer Request up to the 576 byte
    limit. This field will be of variable length depending on the number
    of other options in the packet. 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 should be filled with a
    selection of totally random numbers to avoid compression modems or
    PPP data compression from destroying the link delay calculation.
    Note that this is different from the original RFC 1362
    specification. This should not affect implementations.
    Implementations should not attempt to verify the contents of a PAD
    option.

```
    +-------------------------------------------------------------+
    | WOption Number    | FF                 | Pad option         |
    | WAccept Option    | 01                 | 0=No,1=Yes,3=Not Applic|
    | WOption Data Len  | xx xx              | Pad data length (Hi Lo)|
    |                   |                    | (enough to fill packet)|
    | WOption Data      | Random numbers     |                    |
    +-------------------------------------------------------------+
```

    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.

As mentioned earlier, the WNodeID field may be set to zero for a
router if it is unable to provide a network number for the link. If
a router ONLY supports the Numbered RIP/SAP option, it MUST be
capable of proving a network number for a WAN link.

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

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      | xx                   | Number of options     |
|-------------------+------------------+-------------------------- |
| WOption Number    | xx                   | Option Identifier     |
| WAccept Option    | xx                   | 0=No,1=Yes,3=Not Applic|
| WOption Data Len  | xx xx                | Number of following   |
|                   |                      | option bytes (Hi Lo)  |
| WOption Data      | nn                   | Option specific data  |
+------------------------------------------------------------------+
```

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

If the Timer Request packet contained more than one Router Type
option and the "Slave" supports all the options, the "Slave" MUST set
the WAccept Option to YES on the FIRST Router Type supported and NO
to ALL other Router Types. This is the Router Type which is to be

adopted by both ends of the link. Information exchanges will then
proceed by the link master based on the accepted Router Type.

This packet must contain the same sequence number as the received
Timer Request. This packet should ONLY be sent by the router or
workstation determining themselves to be the "Slave" of the link.
(Workstations are ALWAYS the link slave).

Routers MUST set the WNodeID to their correct value when responding
with the Timer Response. A value of zero must NOT be used.

4.3 Information Request Packet

```
+----------------------------------------------------------------+
| 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.          |
+----------------------------------------------------------------+
```

Routers MUST set the WNodeID to their correct value when sending an
Information Request. A value of zero must NOT be used.

A workstation should replace the Router Name with the configured
name, or a constant descriptor string as described in section 2.

For a Workstation Information Request, an extra option is added which
specifies the NIC address for the workstation. In this case, the
number of options will be set to two (2).

```
+---------------------------------------------------------------+
| WOption Number    | 05                 | Define NIC Address    |
| WAccept Option    | 01                 | 0=No,1=Yes,3=Not Applic|
| WOption Data Len  | 00 06              | Option length (Hi Lo) |
| WOption Data      | 02 xx xx xx xx xx  | NIC Address for W/S   |
+---------------------------------------------------------------+
```

Routers or workstations should not refuse to use a NIC address having
a first byte with a value other than 02.

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
 if (link_delay < 1)
 {
     link_delay = 1;
 }/*IF*/
 // We are on a slow net, so add some biasing to help stop
 // multiple workstation sessions timing out on the link
 link_delay *= 6;   /* Add the biasing  for multiple sessions */
 link_delay *= 55;  /* Convert link delay to milliseconds */
```

 If a higher resolution timer is available, better results may be
 obtained using the following algorithm:

```
 conversion_factor = number of timer units in 1/18th second;
 link_delay = ((end_time - start_time) * 6) / conversion_factor;
 if (link_delay == 0)
 {
     link_delay = 1;
 }/*IF*/
 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". Link
 Delay is specified in milli seconds.

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. If the negotiated Router Type was Unnumbered RIP,
On-demand, or NLSP, the specified Common Net # will be zero.

This packet should contain a sequence number starting at zero. This
packet should ONLY be sent by the router or workstation determining
themselves to be the "Slave" of the link.

If extra options are included in this packet, they should be silently
discarded.If the information option is missing, the link MUST be
disconnected.

4.4 Information Response Packet

```
+-------------------------------------------------------------------+
| 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                 | Same as Info Request    |
| 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.

A link slave will additionally respond with the received NIC address
option as a confirmation of receipt. A workstation should replace the
Router Name with the configured name, or a constant descriptor string
as described in section 2. If the Information Request contained an
inappropriate Common Net # or NIC address, the Information Response
may set new values. The receiver of the Information Response is
responsible for checking on the value and terminating the connection
if the new values cannot be used.

Routers MUST set the WNodeID to their correct value when sending an
Information Response. A value of zero must NOT be used.

5. Running Unnumbered RIP

Unnumbered RIP refers to the case where two WAN routers are
communicating using the RIP protocol across a link with NO physical
IPX network address. The premise for this ability is that there is no
need to address a packet to anything on that WAN link. RIP and SAP
run in exactly the same way as before, except the source and
destination network numbers should be set to zero.

The advantage to running unnumbered RIP links is that it is not
necessary to allocate/configure a pool of usable IPX network numbers
which can be used on the WAN links. The other advantage is that when
there is a large number of WAN links, it is not necessary to flood
the network with an unnecessary set of extra RIP information.

6. Workstation Connectivity

Workstations MUST reside on a network and have a unique NIC address
on that network to be individually addressable. However, workstations
do not need to periodically receive RIP and SAP broadcasts as they
play no part in the routing process. This allows routers to reduce
background traffic on the workstation link by not sending any
periodic RIP and SAP data. Note that it will not cause a problem if
the RIP and SAP is sent. It will just slow down the workstation
access times.

RIP and SAP information should ONLY be sent if the workstation makes
a specific request for information - like a service or route request.

It should also be noted that if multiple workstations are attached to
a single WAN workstation network (per router), broadcasts on that
network - whether originated from a workstation or the router - MUST
reach ALL other workstations. This will involve the router
duplicating the packet to all WAN workstation connections.

7. On-demand, Statically Routed Links

On-demand, Static Routing serves two purposes. The "on-demand" part
means that a router initiates communication to a destination only
when there is data to be forwarded to that destination. "Inititating
comunication" includes making a datalink call (where necessary) and
performing the IPXWAN exchange. A transient connection is closed
after a period of inactivity.

The "static routing" part means that no routing information is sent
over the link - no RIP, no SAP, and no NLSP. Instead, the router at
each end is configured with the routes and services accessible
through the link.

With on-demand, static routing, the called router must be able to
identify the calling router so that statically configured routes and
services can be attached to that connection. For example, with X.25
switched virtual circuits, the calling DTE address can be used; with
PPP, the PPP authentication can be used; after IPXWAN has completed,
the "Router Name" can be used; with a persistent datalink connection,
the physical port identifier or a permanent virtual circuit
identifier can be used. The choice of identifier is an implementation
decision. Whatever value the called router uses is called a Remote
System Identifier, or RSI. For PPP links, Novell uses PPP PAP or CHAP
authentication to determine the caller.

A router implementing on-demand, static routing must maintain a
database of RSIs, and lists describing the network numbers and
services reachable through each RSI. These lists determine the
reachability information it transmits to other routers in a routing
area. Other routers treat each on-demand, static routing link as
though it were permanently available.

The on-demand exchange has a slight variation on the IPXWAN protocol.
The differences are as follows.

In the Timer Request, the calling router offers only the "On-demand,
static routing" Routing Type. If the called router is capable of On-
demand static routing, it offers "On-demand, static routing" in the
Timer Request, along with any additional routing types it is willing
to support on the link. The Master/Slave election and choice of
routing type proceeds as described previously. If the Slave detects a
mismatch in routing types, it disconnects the link.

For a persistent datalink (like X.25 PVCs), there may be no
descerable "link establishemnt" event. For such media, arrival of a
Timer Request plays the role of detecting link establishment.

As with Unnumbered RIP, there is no network number assigned to the
link. NLSP Packets are not sent on the link. Moreover, periodic RIP
and SAP packets are not sent on the link. However, a router must
respond to RIP and SAP queries received on the link.

8. References

   [1] Simpson, W., Editor, "The Point-to-Point Protocol (PPP) for the
       Transmission of Multi-protocol Datagrams over Point-to-Point
       Links", RFC 1548, Daydreamer, December 1993.

   [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 1490, Wellfleet
       Communications, Inc., Ascom Timeplex, Inc., July 1993.

   [4] Simpson, W., "The PPP Internetwork Packet Exchange Control
       Protocol (IPXCP)", RFC 1552, Daydreamer, December 1993.

   [5] Novell IPX Router Specification.
       Novell Part Number 107-000029-001. This document may be
       retrieved via Anonymous FTP to SJF-LWP (130.57.11.140) under
       /sys/ftpguest/nw_shell/ipxdocs/ipxrout.zip.

   [6] Mathur, S., and M. Lewis, M., "Compressing IPX Headers
       Over WAN Media (CIPX)", RFC 1553, Telebit Corporation,
       December 1993.

   [7] ANSI, "Integrated Services Digital Network (ISDN) - Digital
       Subscriber Signalling System Number 1 (DSS1) - Signalling
       Specification for Frame Relay", ANSI T1.617-1991, June 1991

   [8] Novell NetWare Link Services Protocol (NLSP) Specification.
       Novell part number 100-001708-002. Information on this document
       may be obtained by sending e-mail to dsink@novell.com.

9. Security Considerations

   Security issues are not discussed in this memo.

10. Author's Address

        Michael Allen
        Novell, Inc.
        2180 Fortune Drive
        San Jose, CA 95131

        EMail: mallen@novell.com

    The working group can be contacted via the current chair:

        Fred Baker
        Advanced Computer Communications
        315 Bollay Drive
        Santa Barbara, California, 93111

        EMail: fbaker@acc.com