CHAPTER 34

Chapter Goals

- Introduce the NetWare protocol IPX/SPX, used primarily in Novell-based networks.
- Discuss the structures and functioning of this protocol, from its introduction in the early 1980s to its current form.

NetWare Protocols

Background

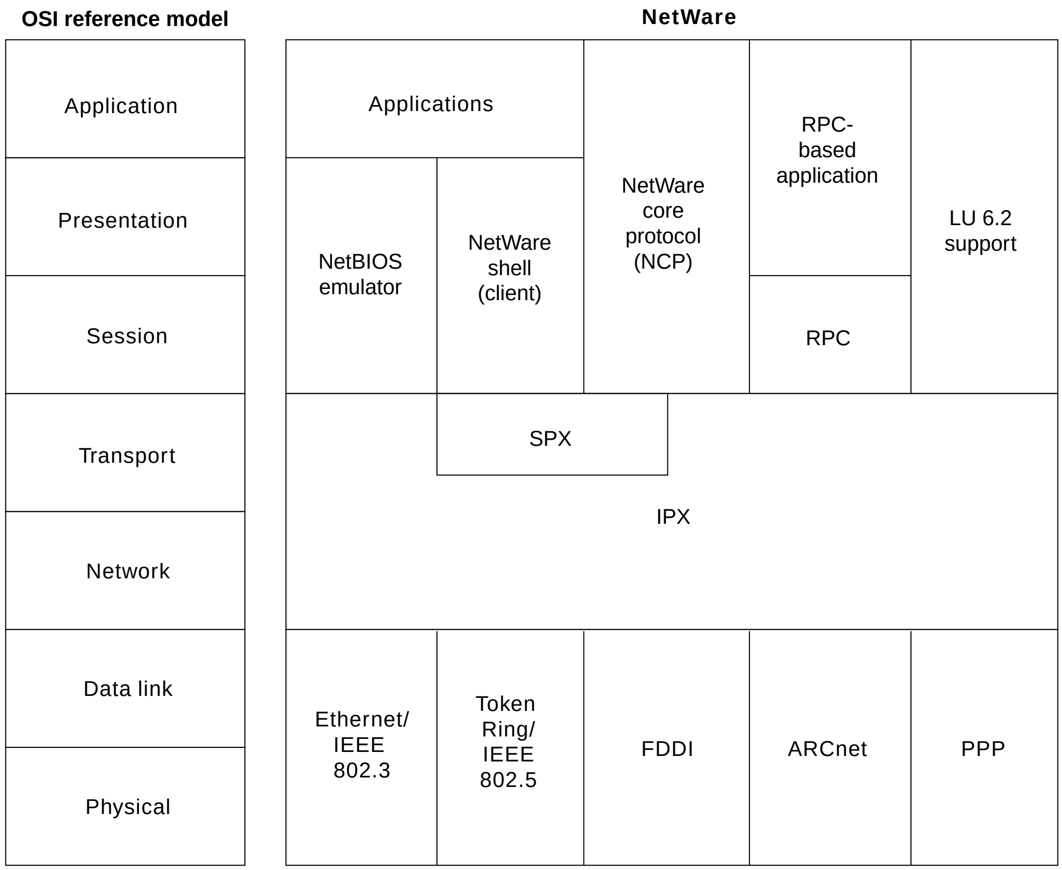
NetWare is a network operating system (NOS) that provides transparent remote file access and numerous other distributed network services, including printer sharing and support for various applications such as electronic mail transfer and database access. NetWare specifies the upper five layers of the OSI reference model and, as such, runs on any media-access protocol (Layer 2). Additionally, NetWare runs on virtually any kind of computer system, from PCs to mainframes. This chapter summarizes the principal communications protocols that support NetWare.

NetWare was developed by Novell, Inc., and was introduced in the early 1980s. It was derived from Xerox Network Systems (XNS), which was created by Xerox Corporation in the late 1970s, and is based on a client-server architecture. Clients (sometimes called workstations) request services, such as file and printer access, from servers.

NetWare's client/server architecture supports remote access that is transparent to users through remote procedure calls. A remote procedure call begins when the local computer program running on the client sends a procedure call to the remote server. The server then executes the remote procedure call and returns the requested information to the local client.

Figure 34-1 illustrates the NetWare protocol suite, the media-access protocols on which NetWare runs, and the relationship between the NetWare protocols and the OSI reference model. This chapter addresses the elements and operations of these protocol components.

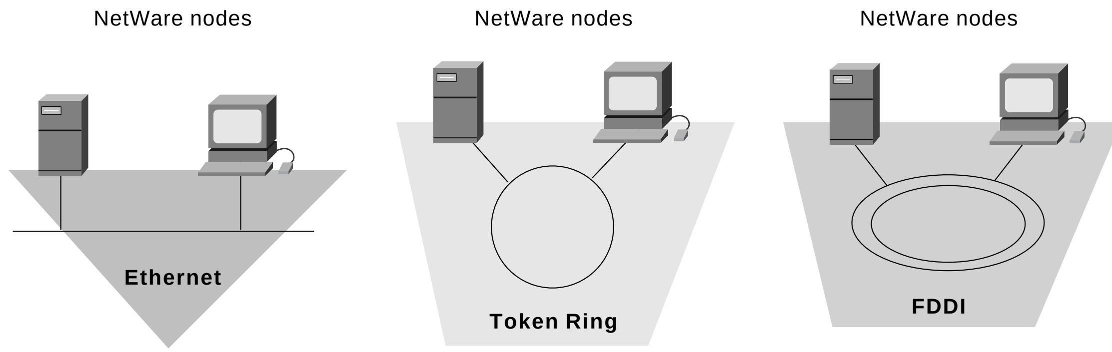
Figure 34-1 The NetWare Protocol Suite Maps to All OSI Layers



NetWare Media Access

The NetWare suite of protocols supports several media-access (Layer 2) protocols, including Ethernet/IEEE 802.3, Token Ring/IEEE 802.5, Fiber Distributed Data Interface (FDDI), and Point-to-Point Protocol (PPP). Figure 34-2 highlights NetWare's breadth of media-access support.

Figure 34-2 NetWare Supports Most Common Media-Access Protocols



Internetwork Packet Exchange Overview

Internetwork Packet Exchange (IPX) is the original NetWare network layer (Layer 3) protocol used to route packets through an internetwork. IPX is a connectionless datagram-based network protocol and, as such, is similar to the Internet Protocol found in TCP/IP networks.

IPX uses the services of a dynamic distance vector routing protocol (Routing Information Protocol [RIP]) or a link-state routing protocol (NetWare Link-State Protocol [NLSP]). IPX RIP sends routing updates every 60 seconds. To make best-path routing decisions, IPX RIP uses a *tick* as the metric, which in principle is the delay expected when using a particular length. One tick is 1/18th of a second. In the case of two paths with an equal tick count, IPX RIP uses the hop count as a tie-breaker. (A hop is the passage of a packet through a router.) IPX's RIP is not compatible with RIP implementations used in other networking environments.

As with other network addresses, Novell IPX network addresses must be unique. These addresses are represented in hexadecimal format and consist of two parts: a network number and a node number. The IPX network number, which is assigned by the network administrator, is 32 bits long. The node number, which usually is the Media Access Control (MAC) address for one of the system's network interface cards (NICs), is 48 bits long.

IPX's use of a MAC address for the node number enables the system to send nodes to predict what MAC address to use on a data link. (In contrast, because the host portion of an IP network address has no correlation to the MAC address, IP nodes must use the Address Resolution Protocol [ARP] to determine the destination MAC address.)

IPX Encapsulation Types

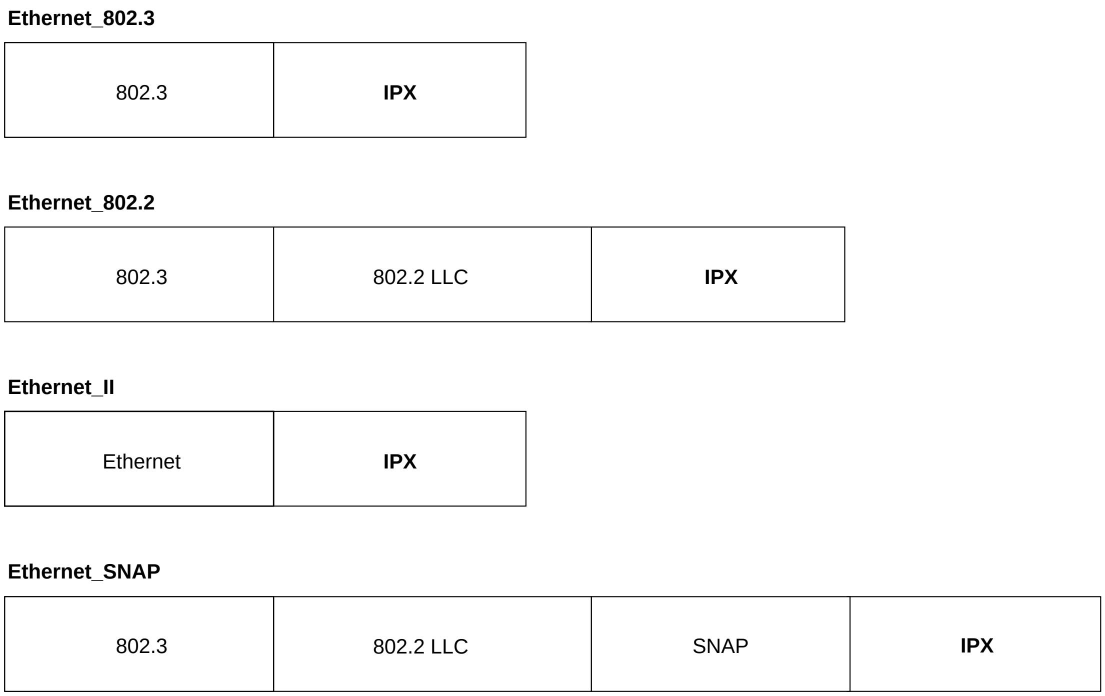
Novell NetWare IPX supports multiple encapsulation schemes on a single router interface, provided that multiple network numbers are assigned. Encapsulation is the process of packaging upper-layer protocol information and data into a frame. NetWare supports the following four encapsulation schemes:

- **Novell Proprietary**—Also called 802.3 raw or Novell Ethernet_802.3, Novell proprietary serves as the initial encapsulation scheme that Novell uses. It includes an Institute of Electrical and Electronic Engineers (IEEE) 802.3 Length field, but not an IEEE 802.2 (LLC) header. The IPX header immediately follows the 802.3 Length field.
- **802.3**—Also called Novell_802.2, 802.3 is the standard IEEE 802.3 frame format.

- **Ethernet version 2**—Also called Ethernet-II or ARPA, Ethernet version 2 includes the standard Ethernet Version 2 header, which consists of Destination and Source Address fields followed by an EtherType field.
- **SNAP**—Also called Ethernet_SNAP, SNAP extends the IEEE 802.2 header by providing a type code similar to that defined in the Ethernet version 2 specification.

Figure 34-3 illustrates these encapsulation types.

Figure 34-3 Four IPX Encapsulation Types Exist



Service Advertisement Protocol

The *Service Advertisement Protocol (SAP)* is an IPX protocol through which network resources such as file servers and print servers advertise their addresses and the services that they provide. Advertisements are sent via SAP every 60 seconds. Services are identified by a hexadecimal number, which is called a SAP identifier (for example, 4 = file server, and
7 = print server).

A SAP operation begins when routers listen to SAPs and build a table of all known services along with their network address. Routers then send their SAP table every 60 seconds. Novell clients can send a query requesting a particular file, printer, or gateway service. The local router responds to the query with the network address of the requested service, and the client then can contact the service directly.

SAP is pervasive in current networks based on NetWare 3.11 and earlier, but it is utilized less frequently in NetWare 4.0 networks because workstations can locate services by consulting a NetWare Directory Services (NDS) Server. SAP, however, still is required in NetWare 4.0 networks for workstations when they boot up to locate an NDS server.

SAP Filters

Using the SAP identifier, SAP advertisements can be filtered on a router's input or output port, or from a specific router. SAP filters conserve network bandwidth and are especially useful in large Novell installations where hundreds of SAP services exist.

In general, the use of SAP filters is recommended for services that are not required for a particular network. Remote sites, for example, probably do not need to receive SAP advertising print services located at a central site. A SAP output filter at the central site (preferred), or a SAP input filter that uses the SAP identifier for a print server at the remote site prevents the router from including print services in SAP updates.

NetWare Transport Layer

The *Sequenced Packet Exchange (SPX)* protocol is the most common NetWare transport protocol at Layer 4 of the OSI model. SPX resides atop IPX in the NetWare Protocol Suite. SPX is a reliable, connection-oriented protocol that supplements the datagram service provided by the IPX, NetWare's network layer (Layer 3) protocol. SPX was derived from the Xerox Networking Systems (XNS) Sequenced Packet Protocol (SPP). Novell also offers Internet Protocol support in the form of the User Datagram Protocol (UDP). IPX datagrams are encapsulated inside UDP/IP headers for transport across an IP-based internetwork.

NetWare Upper-Layer Protocols and Services

NetWare supports a wide variety of upper-layer protocols, including NetWare Shell, NetWare Remote Procedure Call, NetWare Core Protocol, and Network Basic Input/Output System.

The NetWare shell runs clients (often called workstations in the NetWare community) and intercepts application input/output (I/O) calls to determine whether they require network access for completion. If the application request requires network access, the NetWare shell packages the request and sends it to lower-layer software for processing and network transmission. If the application request does not require network access, the request is passed to the local I/O resources. Client applications are unaware of any network access required for completion of application calls.

NetWare Remote Procedure Call (NetWare RPC) is another more general redirection mechanism similar in concept to the NetWare shell supported by Novell.

NetWare Core Protocol (NCP) is a series of server routines designed to satisfy application requests coming from, for example, the NetWare shell. The services provided by NCP include file access, printer access, name management, accounting, security, and file synchronization.

NetWare also supports the Network Basic Input/Output System (NetBIOS) session layer interface specification from IBM and Microsoft. NetWare's NetBIOS emulation software allows programs written to the industry-standard NetBIOS interface to run within the NetWare system.

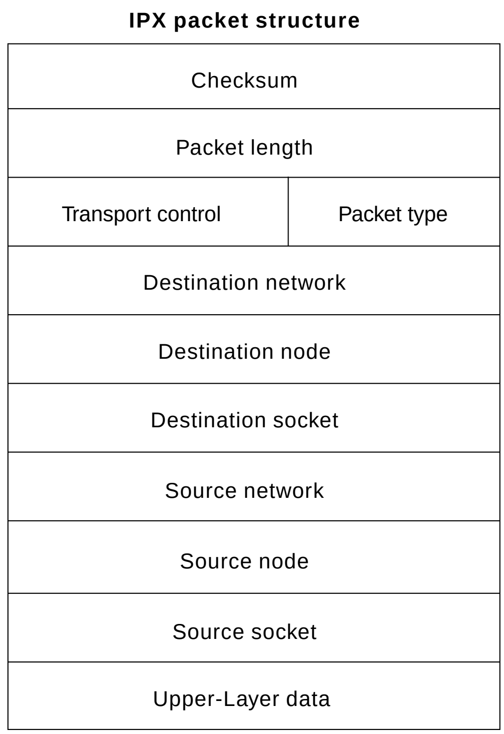
NetWare Application Layer Services

NetWare application layer services include NetWare message-handling service (NetWare MHS), Btrieve, NetWare loadable modules (NLMs), and IBM Logical Unit (LU) 6.2 network-addressable units (NAUs). NetWare MHS is a message-delivery system that provides electronic mail transport. Btrieve is Novell's implementation of the binary tree (btree) database-access mechanism. NLMs are add-on modules that attach into a NetWare system. NLMs currently available from Novell and third parties include alternate protocol stacks, communication services, and database services. In terms of IBM LU 6.2 NAU support, NetWare allows peer-to-peer connectivity and information exchange across IBM networks. NetWare packets are encapsulated within LU 6.2 packets for transit across an IBM network.

IPX Packet Format

The IPX packet is the basic unit of Novell NetWare internetworking. Figure 34-4 illustrates the format of a NetWare IPX packet.

Figure 34-4 A NetWare IPX Packet Consists of 11 Fields



The following descriptions summarize the IPX packet fields illustrated in Figure 34-4:

- **Checksum—**Indicates that the checksum is not used when this 16-bit field is set to 1s (FFFF).
- **Packet length**—Specifies the length, in bytes, of a complete IPX datagram. IPX packets can be any length, up to the media maximum transmission unit (MTU) size (no packet fragmentation allowed).
- **Transport control—**Indicates the number of routers through which the packet has passed. When this value reaches 16, the packet is discarded under the assumption that a routing loop might be occurring.
- **Packet type—**Specifies which upper-layer protocol should receive the packet’s information. It has two common values:
  - **5**—Specifies Sequenced Packet Exchange (SPX)
  - **17**—Specifies NetWare Core Protocol (NCP)

- **Destination network, Destination node, and Destination socket**—Specify destination information.
- **Source network, Source node, and Source socket**—Specify source information.
- **Upper-Layer data**—Contains information for upper-layer processes.

Summary

IPX is still installed in millions of computers in the NetWare networks. However, there has been a large change from IPX to IP within those environments, and this trend is likely to continue, with Novell supporting native IP within its networking environments.

Review Questions

Q—*What are the two types of routing protocols used by IPX?*

A—Routing Information Protocol (RIP) and NetWare Link-State Protocol (NLSP).

Q—*What information is used by IPX RIP to determine a path for network traffic?*

A—IPX RIP uses ticks to determine a network path. If a tie exists, the number of hops is used to break the tie.

Q—*What are the two parts of an IPX address?*

A—Network and node.

Q—*How do Novell stations discover services available on the network?*

A—Through the Service Advertisement Protocol (SAP).

Q—*What protocol is used at the transport layer?*

A—Sequenced Packet Exchange (SPX) protocol is the most common NetWare transport protocol.

Q—*How do IPX stations map the MAC address to an IPX address?*

A—The MAC address is used as the node address in IPX networks, so no mapping is required.

Q—*What enhancement in NetWare 4.0 reduces the need for SAPs?*

A—NetWare Directory Services (NDS).

Q—*What services are provided by NetWare Core Protocol?*

A—NetWare Core Protocol (NCP) is a series of server routines designed to satisfy application requests coming from, for example, the NetWare shell. The services provided by NCP include file access, printer access, name management, accounting, security, and file synchronization.

Q—*Describe NetWare's support of NetBIOS.*

A—NetWare also supports the Network Basic Input/Output System (NetBIOS) session layer interface specification from IBM and Microsoft. NetWare's NetBIOS emulation software allows programs written to the industry-standard NetBIOS interface to run within the NetWare system.

Q—*Would you want to filter SAPs?*

A—SAPs don't need to traverse slow WAN links, so filtering can reduce the amount of traffic that IPX generates across these types of links.