CHAPTER 38

Chapter Goals

- Describe the development history of the DECnet protocol, used primarily in Digital Equipment Corporation minicomputers.
- Describe the architecture of DECnet networks.
- Discuss the addressing methods of DECnet.
- Describe implementation and access methods of DECnet.
- Describe additional protocols implemented in DECnet networks, including protocols used in the upper layers of the OSI reference model.

DECnet

Introduction

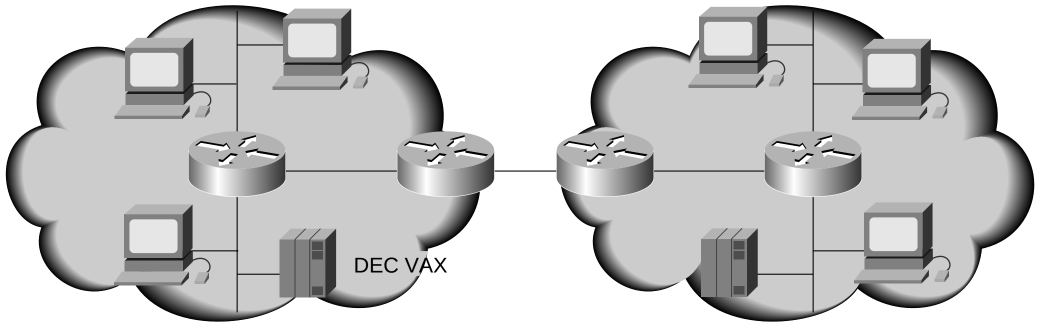
DECnet is a group of data communications products, including a protocol suite, developed and supported by Digital Equipment Corporation (Digital). The first version of DECnet, released in 1975, allowed two directly attached PDP-11 minicomputers to communicate.
In recent years, Digital has included support for nonproprietary protocols, but DECnet remains the most important of Digital's network product offerings. This chapter provides a summary of the DECnet protocol suite, Digital's networking architectures, and the overall operation of DECnet traffic management.

Figure 38-1 illustrates a DECnet internetwork, with routers interconnecting two LANs that contain workstations and VAXs.

Several versions of DECnet have been released. The first allowed two directly attached minicomputers to communicate.

Subsequent releases expanded the DECnet functionality by adding support for additional proprietary and standard protocols, while remaining compatible with the immediately preceding release. This means that the protocols are backward compatible. Currently, two versions of DECnet are in wide use: DECnet Phase IV and DECnet/OSI.

Figure 38-1 In a DECnet-Based Internetwork, Routers Interconnect Workstations and VAXs



DECnet Phase IV is the most widely implemented version of DECnet. However, DECnet/OSI is the most recent release. DECnet Phase IV is based on the Phase IV Digital Network Architecture (DNA), and it supports proprietary Digital protocols and other proprietary and standard protocols. DECnet Phase IV is backward compatible with DECnet Phase III, the version that preceded it.

DECnet/OSI (also called DECnet Phase V) is backward compatible with DECnet Phase IV and is the most recent version of DECnet. This version is based on the DECnet/OSI DNA. DECnet/OSI supports a subset of the OSI protocols, multiple proprietary DECnet protocols, and other proprietary and standard protocols.

DECnet Phase IV Digital Network Architecture

The *Digital Network Architecture (DNA)* is a comprehensive layered network architecture that supports a large set of proprietary and standard protocols. The Phase IV DNA is similar to the architecture outlined by the OSI reference model. As with the OSI reference model, the Phase IV DNA utilizes a layered approach, whereby specific layer functions provide services to protocol layers above it and depend on protocol layers below it. Unlike the OSI model, however, the Phase IV DNA is comprised of eight layers. Figure 38-2 illustrates how the eight layers of the Phase IV DNA relate to the OSI reference model.

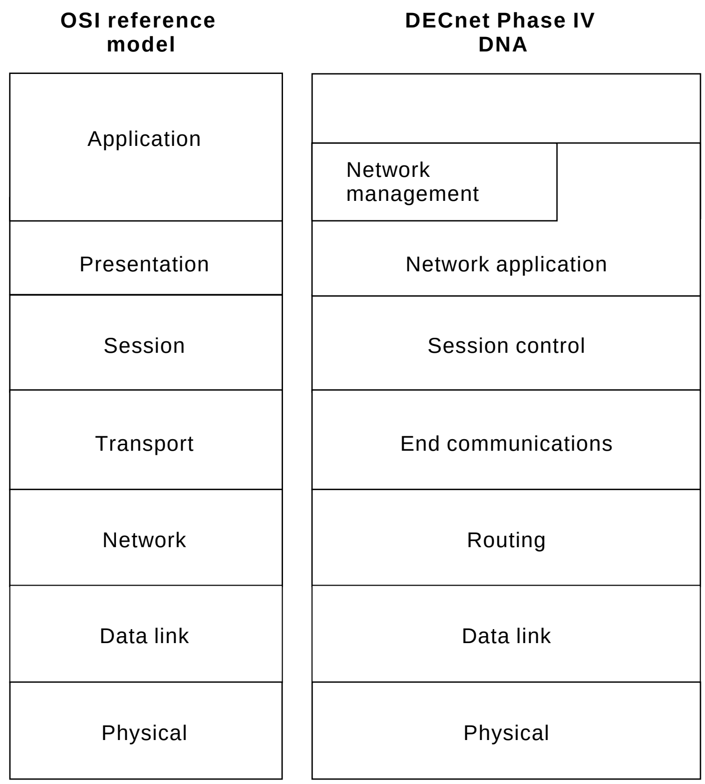
The following section details the functionality and role of each of these layers and identifies the similarities between the Phase IV DNA architecture and the OSI reference model.

Phase IV DNA Layers

The DECnet Phase IV DNA defines an eight-layer model, as illustrated in Figure 38-2. The user layer represents the User-Network Interface, supporting user services and programs with a communicating component. The user layer corresponds roughly to the OSI application layer. The network management layer represents the user interface to network-management information. This layer interacts with all the lower layers of the DNA and corresponds roughly with the OSI application layer. The network application layer provides various network applications, such as remote file access and virtual terminal access. This layer corresponds roughly to the OSI presentation and application layers.

The session control layer manages logical link connections between end nodes and corresponds roughly to the OSI session layer. The end communications layer handles flow control, segmentation, and reassembly functions and corresponds roughly to the OSI transport layer. The routing layer performs routing and other functions, and corresponds roughly to the OSI network layer. The data link layer manages physical network channels and corresponds to the OSI data link layer. The physical layer manages hardware interfaces and determines the electrical and mechanical functions of the physical media; this layer corresponds to the OSI physical layer.

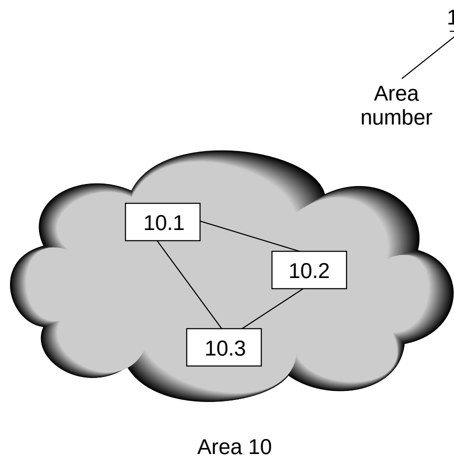
Figure 38-2 Phase IV Consists of Eight Layers That Map to the OSI Layers



Phase IV DECnet Addressing

DECnet addresses are not associated with the physical networks to which the nodes are connected. Instead, DECnet locates hosts using area/node address pairs. An area's value ranges from 1 to 63, inclusive. Likewise, a node address can be between 1 and 1023, inclusive. Therefore, each area can have 1023 nodes, and approximately 65,000 nodes can be addressed in a DECnet network. Areas can span many routers, and a single cable can support many areas. Therefore, if a node has several network interfaces, it uses the same area/node address for each interface. Figure 38-3 illustrates a sample DECnet network with several addressable entities.

Figure 38-3 DECnet Locates Hosts Using Area/Node Address Pairs



DECnet hosts do not use manufacturer-assigned Media Access Control (MAC)-layer addresses. Instead, network level addresses are embedded in the MAC-layer address according to an algorithm that multiplies the area number by 1024 and adds the node number to the product. The resulting 16-bit decimal address is converted to a hexadecimal number and is appended to the address AA00.0400 in byte-swapped order, with the least-significant byte first. For example, DECnet address 12.75 becomes 12363 (base 10), which equals 304B (base 16). After this byte-swapped address is appended to the standard DECnet MAC address prefix, the address is AA00.0400.4B30.

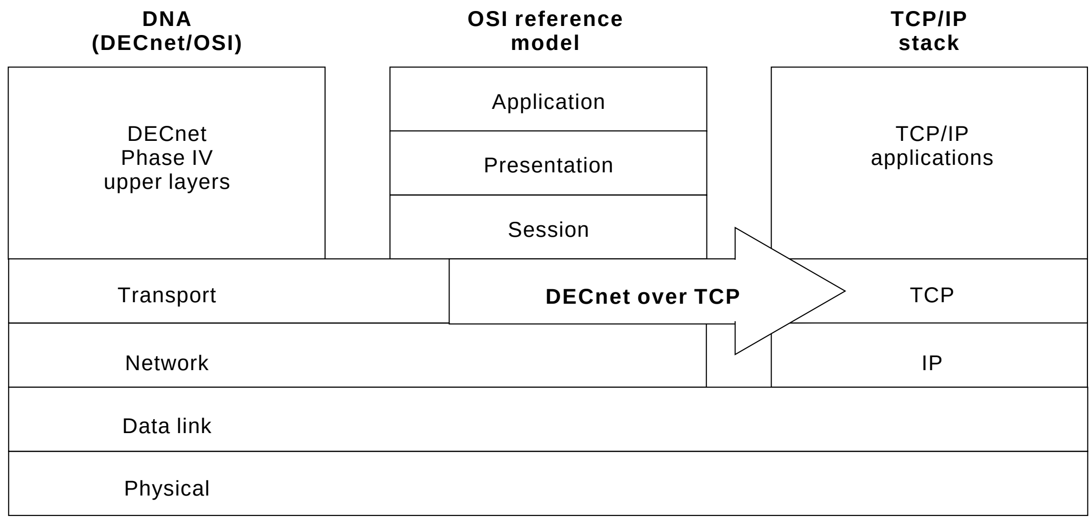
DECnet/OSI Digital Network Architecture

The DECnet/OSI (DECnet Phase V) DNA is very similar to the architecture outlined by the OSI reference model. DECnet Phase V utilizes a layered approach that achieves a high degree of flexibility in terms of support for upper-layer protocol suites. As the following section discusses, DECnet OSI actually allows for the support of multiple protocol suites.

DECnet/OSI DNA Implementations

The DECnet/OSI DNA defines a layered model that implements three protocol suites: OSI, DECnet, and Transmission Control Protocol/Internet Protocol (TCP/IP). The OSI implementation of DECnet/OSI conforms to the seven-layer OSI reference model and supports many of the standard OSI protocols. The Digital implementation of DECnet/OSI provides backward compatibility with DECnet Phase IV and supports multiple proprietary Digital protocols. The TCP/IP implementation of DECnet/OSI supports the lower-layer TCP/IP protocols and enables the transmission of DECnet traffic over TCP transport protocols. Figure 38-4 illustrates the three DECnet/OSI implementations.

Figure 38-4 The OSI, DECnet, and TCP Are All Supported by DECnet/OSI DNA



DECnet Media Access

DECnet Phase IV and DECnet/OSI support a variety of media-access implementations at the physical and data link layers. This has contributed to the relatively wide acceptance of DECnet in the computer networking industry. As explained in the following sections, both DECnet Phase IV and Phase V can support many of the common physical and data-link technologies in use today.

At the physical layer, DECnet Phase IV and DECnet/OSI support most of the popular physical implementations, including Ethernet/IEEE 802.3, Token Ring/IEEE 802.5, and Fiber Distributed Data Interface (FDDI). In addition, DECnet/OSI supports Frame Relay and X.21bis.

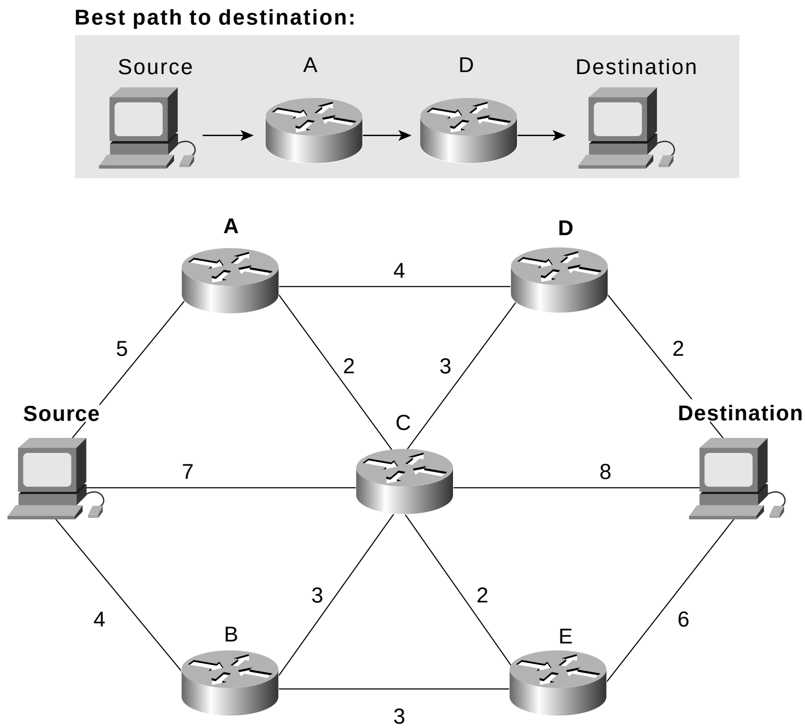
At the data link layer, DECnet Phase IV and DECnet/OSI support IEEE 802.2 Logical Link Control (LLC), Link Access Procedure, Balanced (LAPB), Frame Relay, and High-Level Data Link Control (HDLC). Both DECnet Phase IV and DECnet/OSI also support the proprietary Digital data-link protocol, Digital Data Communications Message Protocol (DDCMP), which provides point-to-point and multipoint connections; full-duplex or half-duplex communication over synchronous and asynchronous channels; and error correction, sequencing, and management.

DECnet Routing

DECnet routing occurs at the routing layer of the DNA in DECnet Phase IV and at the network layer of the OSI model in DECnet/OSI. The routing implementations in both DECnet Phase IV and DECnet/OSI, however, are similar.

DECnet Phase IV routing is implemented by the DECnet Routing Protocol (DRP), which is a relatively simple and efficient protocol whose primary function is to provide optimal path determination through a DECnet Phase IV network. Figure 38-5 provides a sample DECnet network to illustrate how the routing function is performed in a DECnet Phase IV network.

Figure 38-5 The DRP Determines the Optimal Route Through a DECnet Phase IV Network



DECnet routing decisions are based on cost, an arbitrary measure assigned by network administrators to be used in comparing various paths through an internetwork environment. Costs typically are based on hop count or media bandwidth, among other measures. The lower the cost, the better the path. When network faults occur, the DRP uses cost values to recalculate the best paths to each destination.

DECnet/OSI routing is implemented by the standard OSI routing protocols (ISO 8473, ISO 9542, and ISO 10589) and by DRP. Detailed information on the OSI routing protocols can be found in Chapter 45, "Open System Interconnection Routing Protocol."

DECnet End Communications Layer

DECnet Phase IV supports a single transport protocol at the DNA end communications layer: the Network-Services Protocol (NSP).

Network-Services Protocol

The *Network-Services Protocol (NSP)* is a proprietary, connection-oriented, end communications protocol developed by Digital that is responsible for creating and terminating connections between nodes, performing message fragmentation and reassembly, and managing error control.

NSP also manages two types of flow control: a simple start/stop mechanism in which the receiver tells the sender when to terminate and resume data transmission, and a more complex scheme in which the receiver tells the sender how many messages it can accept.

DECnet/OSI Transport Layer

DECnet/OSI supports NSP, three standard OSI transport protocols, and the Transmission Control Protocol (TCP).

DECnet/OSI supports Transport Protocol classes (TP) 0, TP2, and TP4. TP0 is the simplest OSI connection-oriented transport protocol. Of the classic transport layer functions, it performs only segmentation and reassembly. This means that TP0 will note the smallest maximum-size protocol data unit (PDU) supported by the underlying subnetworks and will break the transport packet into smaller pieces that are not too big for network transmission. TP2 can multiplex and demultiplex data streams over a single virtual circuit. This capability makes TP2 particularly useful over public data networks (PDNs), in which each virtual circuit incurs a separate charge. As with TP0 and TP1, TP2 also segments and reassembles PDUs, while TP3 combines the features of TP1 and TP2. TP4, the most popular OSI transport protocol, is similar to the Internet protocol suite's TCP and, in fact, was based on that model. In addition to performing TP3's features, TP4 provides reliable transport service and assumes a network in which problems are not detected.

Request For Comments (RFC) 1006 and RFC 1006 Extensions define an implementation of OSI transport layer protocols atop the TCP. RFC 1006 defines the implementation of OSI Transport Protocol class 0 (TP0) on top of TCP. RFC 1006 extensions define the implementation of Transport Protocol class 2 (TP2) on top of TCP.

DECnet Phase IV Upper Layers

The DECnet Phase IV DNA specifies four upper layers to provide user interaction services, network-management capabilities, file transfer, and session management. Specifically, these are referred to as the user layer, network management layer, network application layer, and session control layer. The upper layers of the DECnet Phase IV architecture are discussed in more detail in the following sections.

User Layer

The DNA user layer supports user services and programs that interact with user applications. The end user interacts directly with these applications, and the applications use the services and programs provided by the user layer.

Network Management Layer

The network-management protocol widely used in DECnet networks is the proprietary Digital Network Information and Control Exchange (NICE) protocol. NICE is a command-response protocol. Commands, which request an action, are issued to a managed node or process; responses, in the form of actions, are returned by those nodes or processes. NICE performs a variety of network management-related functions and can be used to transfer an operating system from a local system into a remote system, as well as enable an unattended remote system to dump its memory to the local system. Protocols using NICE can examine or change certain characteristics of the network. NICE supports an event logger that automatically tracks important network events, such as an adjacency change or a circuit-state change. NICE supports functions that accommodate hardware and node-to-node loop tests.

Certain network management functions can use the *Maintenance Operations Protocol (MOP)*, a collection of functions that can operate without the presence of the DNA layers between the network management and data link layers. This allows access to nodes that exist in a state in which only data link layer services are available or operational.

Network Application Layer

Data-Access Protocol (DAP), a proprietary Digital protocol, is used by DECnet Phase IV at the network application layer. DAP supports remote file access and remote file transfer, services that are used by applications at the network management layer and the user layer. Other proprietary Digital protocols operating at the network application layer include MAIL, which allows the exchange of mail messages, and CTERM, which allows remote interactive terminal access.

Session Control Layer

The *Session Control Protocol (SCP)* is the DECnet Phase IV session control-layer protocol that performs a number of functions. In particular, SCP requests a logical link from an end device, receives logical-link requests from end devices, accepts or rejects logical-link requests, translates names to addresses, and terminates logical links.

DECnet/OSI Upper Layers

The DECnet/OSI DNA is based on the OSI reference model. DECnet/OSI supports two protocol suites at each of the upper layers: the OSI protocols and the DECnet Phase IV protocols (for backward compatibility). DECnet/OSI supports functionality in the application, presentation, and session layers.

Application Layer

DECnet/OSI implements the standard OSI application layer implementations, as well as standard application layer processes such as Common Management-Information Protocol (CMIP) and File Transfer, Access, and Management (FTAM), among others. DECnet/OSI also supports all the protocols implemented by DECnet Phase IV at the user and network-management layers of the DNA, such as the Network Information and Control Exchange (NICE) protocol.

The OSI application layer includes actual applications, as well as application service elements (ASEs). ASEs allow easy communication from applications to lower layers. The three most important ASEs are Association Control Service Element (ACSE), Remote Operations Service Element (ROSE), and Reliable Transfer Service Element (RTSE). ACSE associates application names with one another in preparation for application-to-application communications. ROSE implements a generic request-reply mechanism that permits remote operations in a manner similar to that of remote procedure calls (RPCs). RTSE aids reliable delivery by making session layer constructs easy to use.

Presentation Layer

DECnet/OSI implements all the standard OSI presentation layer implementations. DECnet/OSI also supports all the protocols implemented by DECnet Phase IV at the network application layer of the DNA. The most important of these is the Data-Access Protocol (DAP).

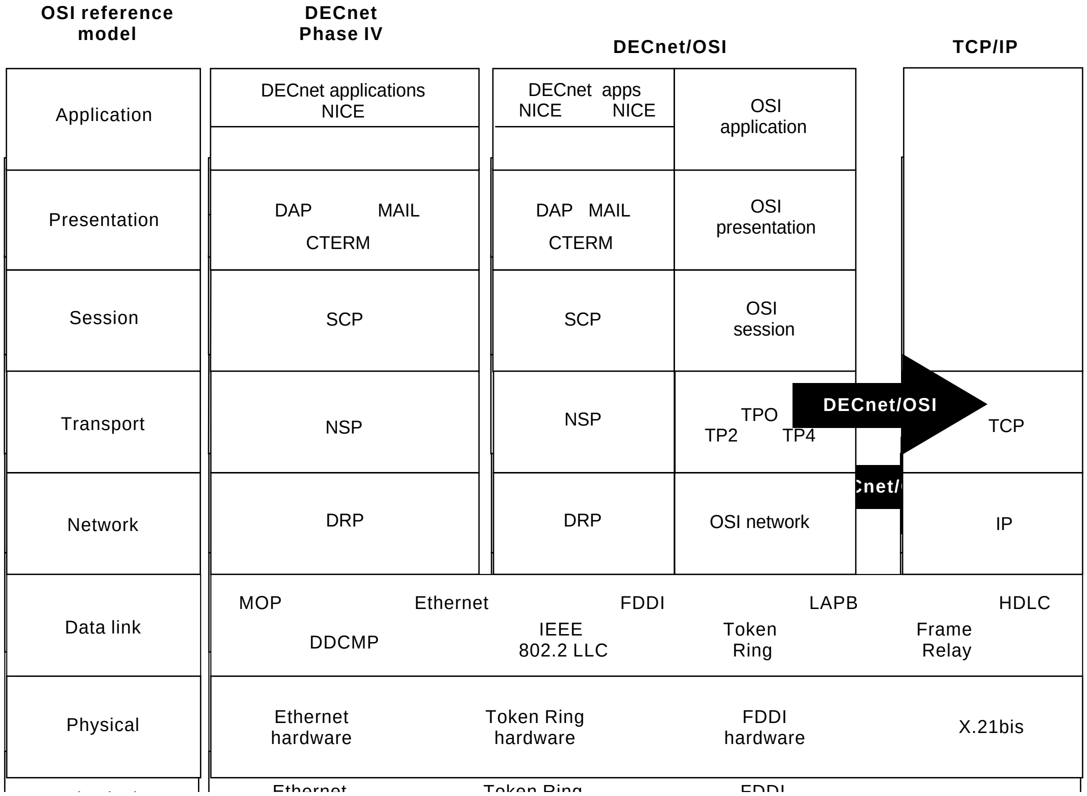
The OSI presentation layer typically is just a pass-through protocol for information from adjacent layers. Although many people believe that Abstract Syntax Notation 1 (ASN.1) is OSI's presentation layer protocol, ASN.1 is used for expressing data formats in a machine-independent format. This allows communication between applications on diverse computer systems (ESs) in a manner transparent to the applications.

Session Layer

DECnet/OSI implements all the standard OSI session layer implementations. DECnet/OSI also supports all the protocols implemented by DECnet Phase IV at the session control layer of the DNA. The primary session control layer protocol is the Session Control Protocol (SCP). The OSI session layer protocol turns the data streams provided by the lower four layers into sessions by implementing various control mechanisms. These mechanisms include accounting, conversation control, and session-parameter negotiation. Session conversation control is implemented by use of a token, the possession of which provides the right to communicate. The token can be requested, and ESs can be granted priorities that provide for unequal token use.

Figure 38-6 illustrates the complete DECnet Phase IV and DECnet/OSI protocol suites, including the implementation of DECnet/OSI over TCP.

Figure 38-6 DECnet Phase IV and DECnet/OSI Support the Same Data Link and Physical Layer Specifications



Summary

The benefits of the DECnet protocol are realized in specific networks using Digital equipment. Few networks still use DECnet, but you may encounter them in some legacy systems.

Review Questions

Q—*How do DECnet hosts use the manufacturer-assigned Media Access Control (MAC) address?*

A— They do not use the MAC address. Instead, network level addresses are embedded in the MAC-layer address according to an algorithm that multiplies the area number by 1,024 and adds the node number to the product. The resulting 16-bit decimal address is converted to a hexadecimal number and is appended to the address AA00.0400 in byte-swapped order, with the least-significant byte first.

Q—*What protocol in DECnet Phase IV is responsible for routing?*

A—DECnet Phase IV routing is implemented by the DECnet Routing Protocol (DRP), which is a relatively simple and efficient protocol whose primary function is to provide optimal path determination through a DECnet Phase IV network.

Q—*What functions does Network-Services Protocol (NSP) provide?*

A—The Network-Services Protocol (NSP) is a proprietary, connection-oriented, end communications protocol developed by Digital that is responsible for creating and terminating connections between nodes, performing message fragmentation and reassembly, and managing error control.

Q—*What functions does the Session Control Protocol (SCP) provide?*

A—The Session Control Protocol (SCP) is the DECnet Phase IV session control-layer protocol that performs a number of functions. In particular, SCP requests a logical link from an end device, receives logical-link requests from end devices, accepts or rejects logical-link requests, translates names to addresses, and terminates logical links.

Q—*The user layer provides what types of functions in DECnet?*

A—The DNA user layer supports user services and programs that interact with user applications. The end user interacts directly with these applications, and the applications use the services and programs provided by the user layer.