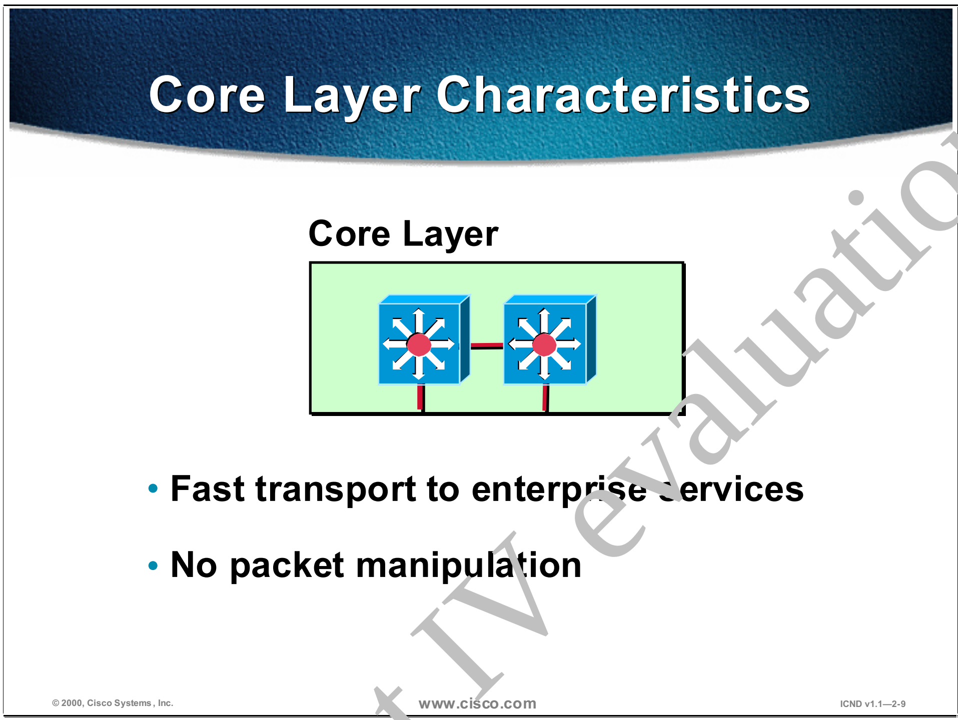

The sole purpose of the core layer of the network is to switch traffic as fast as possible. Typically, traffic is transported to and from services that are common to a majority of users. These services are referred to as enterprise services. Examples of enterprise services would be e-mail, Internet access, or videoconferencing.

When a user must have access to enterprise services, the user's request is processed at the distribution layer. The distribution layer devices then forward the user requests to the core, or backbone. The backbone simply provides quick transport to the desired enterprise service. Determining if and how a packet can get transported through the core is the role of the distribution layer.

Once you understand how an internetwork is used from a business and user-needs standpoint and can map those needs to a model, you are ready to understand how to build the internetwork.

One way to understand how to build an internetwork is to first understand its conceptual framework. The most popular conceptual framework of how internetworks are built and operate is the OSI model.

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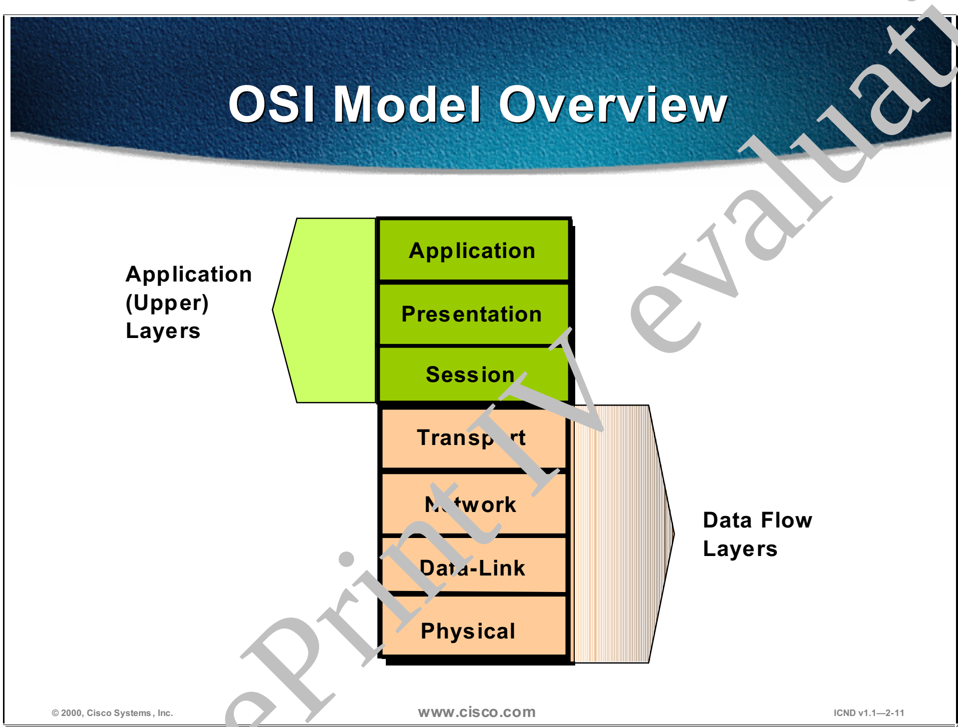
OSI Model Overview

This section provides a review of the OSI model.



The OSI model serves several functions:

- It provides a way to understand how an internetwork operates.
- It serves as a guideline or framework for creating and implementing network standards, devices, and internetworking schemes.

Some of the advantages of using a layered model include the following:

- It allows for dividing the interrelated aspects of network operation into less-complex elements.
- It enables engineers to specialize design and development efforts on modular functions.
- It provides the ability to define standard interfaces for "plug-and-play" compatibility and multivendor integration.

As the figure illustrates, the OSI model has seven layers. The four lower layers define ways for end stations to establish connections to each other in order to exchange data. The three upper layers define how the applications within the end stations communicate with each other and with users.

The next sections in this chapter discuss how each layer operates, with an emphasis on the lower four layers.

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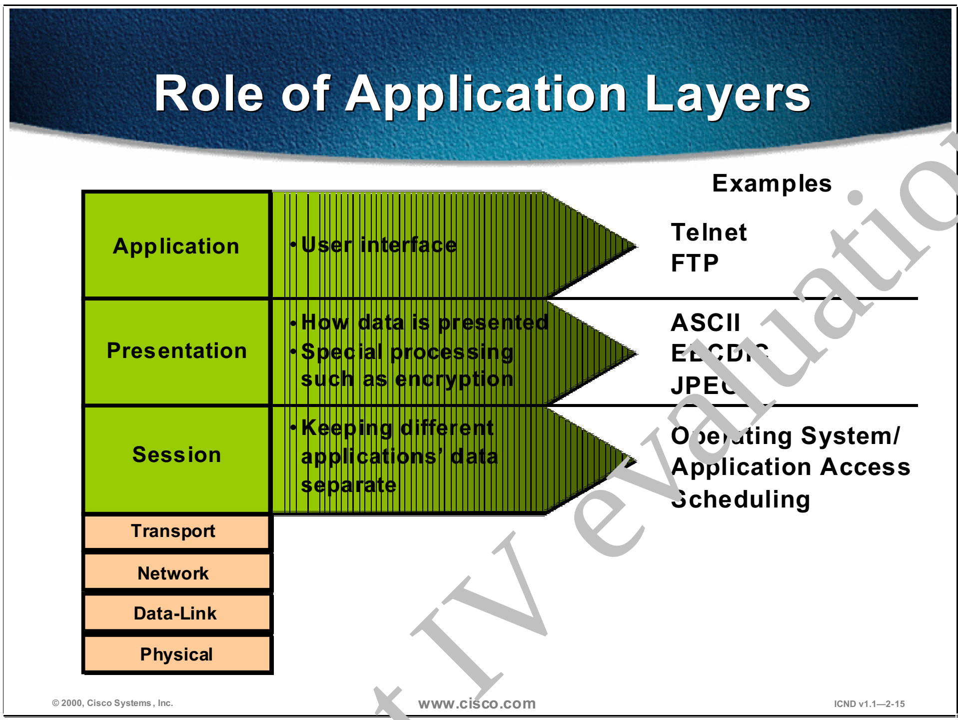

The following is a brief functional description of the upper layers:

- Application layer—This is where the user interacts with the computer. Protocols at this layer identify communication partners, determine resource availability, and synchronize communication. For example, a word processing application is serviced by file transfer services at this layer. Two key types of application layer implementations are TCP/IP and OSI.
- Presentation layer—Provides a variety of coding and conversion functions that are applied to application layer data. These functions ensure that information sent from the application layer of one system will be readable by the application layer of another system. An example of coding functions is the encrypting of data after it leaves an application in a source station and the decrypting of data by the destination device's presentation layer before it is sent to the application layer. Code formatting and conversions are done for text, figures, sound, and video.
- Session layer—Establishes, manages, and terminates communication sessions between presentation layer entities. Communication sessions consist of service requests and service responses that occur between applications located in different network devices.

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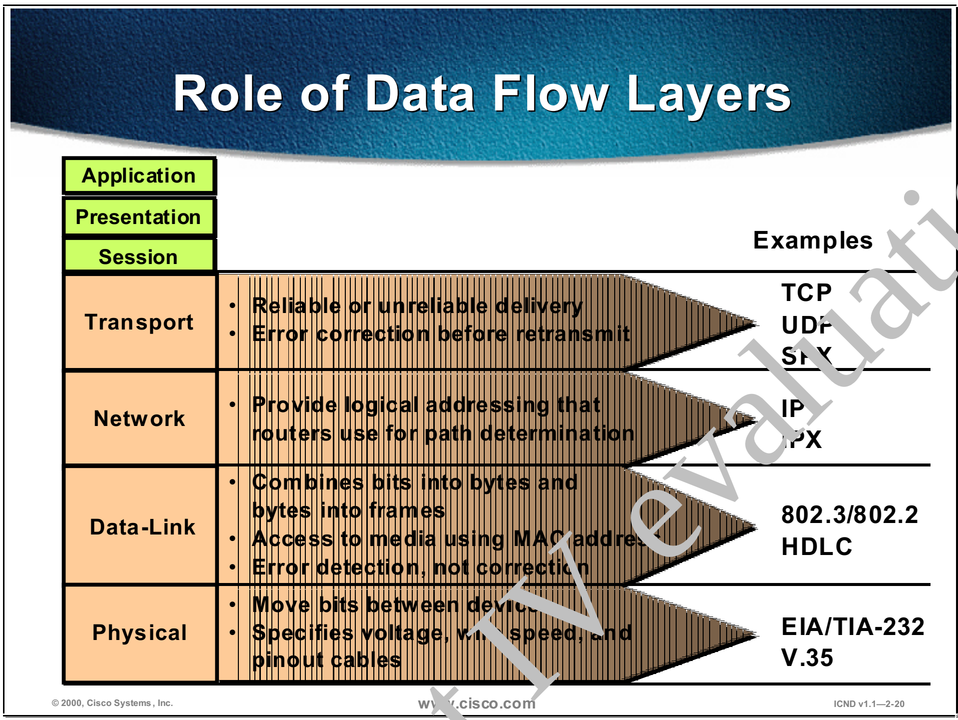

These four layers are responsible for defining how data is transferred across a physical wire through internetworking devices, to the desired end station, and finally to the application. How these layers are implemented in Cisco devices is the focus of this course.

The figure summarizes the basic function of these four layers. Later in this chapter, each of these layers is discussed in greater detail.

Note The transport layer provides reliable or unreliable delivery. Unreliable delivery is sometimes called best-effort delivery.

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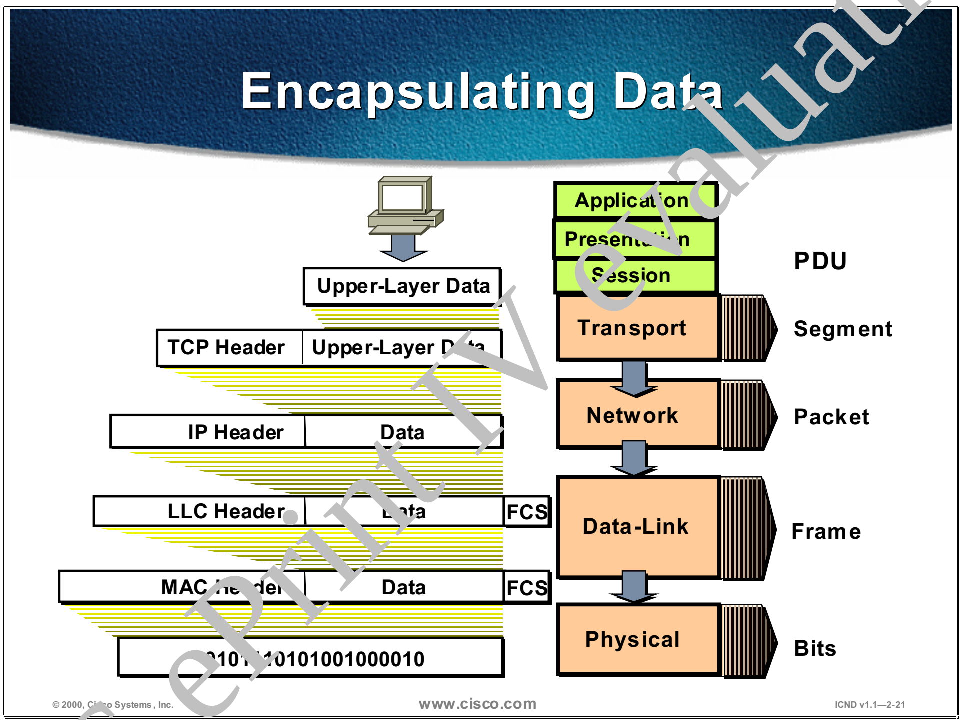
Communicating Between Layers

This section describes how data is encapsulated and de-encapsulated when communicating between layers.



Each layer of the OSI model uses its own protocol to communicate with its peer layer in the destination device. It uses the services provided over a defined interface to communicate with the layers above and below it. The figure shows a TCP/IP example.

To exchange information, the layers use protocol data units (PDUs). PDUs include control information and user data. Control information resides in fields called headers and trailers. (In the figure, the frame check sequence (FCS) is a trailer.) Since a PDU includes different information as it goes up or down the layers, it is given a more specific name depending on the information it has. In other words, a PDU that is a packet includes network layer control information, in addition to data. Similarly, a frame is a PDU that includes data-link layer control information in addition to the upper-layer control information and data.

To attach control information to a PDU, the layers use a process called encapsulation. When a layer receives a PDU, it encapsulates the PDU with a header and trailer, and then passes the PDU down to the next layer. The control information that is added to the PDU is read by the peer layer on the remote device.

For example, the transport layer receives a PDU from the upper layers. It adds control information such as the application from which the PDU was generated. It then passes the PDU to the network layer. The network layer encapsulates the PDU with its own header information. The packet is then passed to the data-link layer. The data-link layer encapsulates the network layer information in a PDU

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called a frame. The frame header contains information required to complete the data-link functions. When the physical layer receives the frame, it encodes the frame into a pattern of ones and zeros for transmission, usually on a wire.

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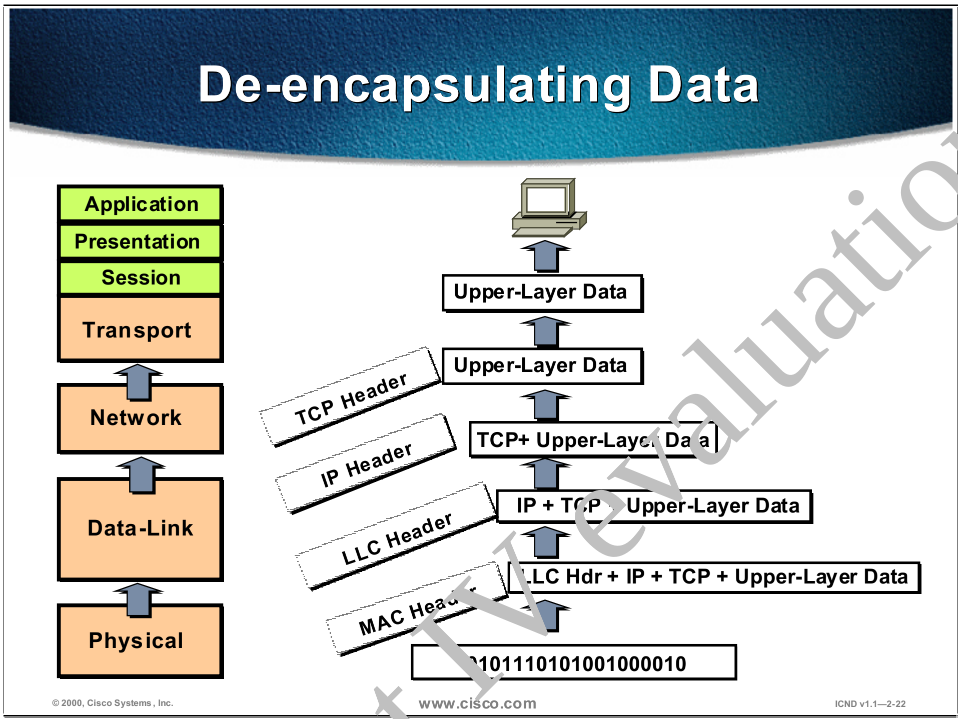

When the remote device receives a sequence of bits, it passes them to the data-link layer for frame manipulation. When the data-link layer receives the frame, it does the following:

- It reads the control information provided by the peer source device.
- It strips the control information from the frame.
- It passes the frame up to the next layer, following the instructions that appeared in the control portion of the frame.

This process is referred to as de-encapsulation.

Each subsequent layer will perform this same de-encapsulation process.

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Written Exercise 1: OSI Model Overview

Complete the following exercise to practice what you learned in this chapter.

Objectives

In this exercise you will identify the role and functions of each layer of the OSI model.

Task: Identifying the Components of the OSI Model

Given what you know about the OSI model, complete the table below by filling in the blank spaces with the correct information.

Written Exercise 1: OSI Model

OSI Model	PDU	Functional Responsibilities	Examples
Application			
Presentation			
Session			
Transport			
Network			
Data-Link			
Physical			

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Completion Criteria

You have completed the exercise when you have filled in the blank spaces in the table.

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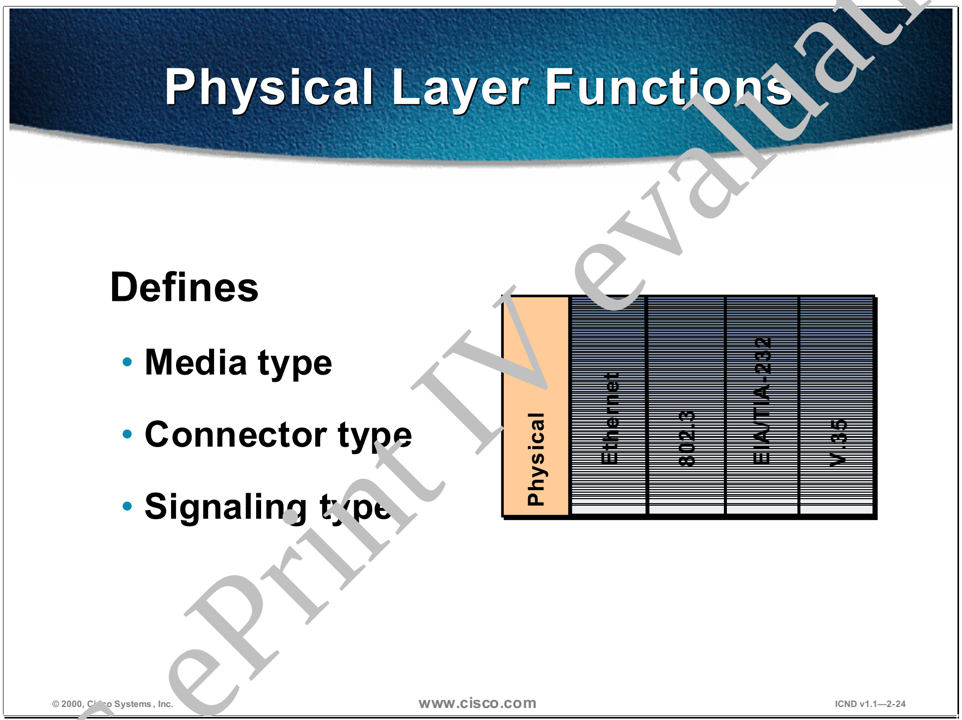
Physical Layer Functions

This section discusses details about the physical layer functions, and maps those functions to internetworking devices.



The physical layer specifies the electrical, mechanical, procedural, and functional requirements for activating, maintaining, and deactivating the physical link between end systems. The physical layer specifies characteristics such as voltage levels, data rates, maximum transmission distances, and physical connectors. An analogy for the physical layer is a downtown street, highway, or motorway. These are different types of roads that allow people to go from one location to another. The quality and specifications for these different types of roads impact the speed at which we can drive.

The physical media and connectors used to connect devices into the media are defined by standards, as are the way devices communicate at the data-link layer. In this course, the primary focus is on the standards that are associated with Ethernet implementations.

Only one station on a shared Ethernet segment can send a frame at one time, but all stations receive and look at the frame to determine if it is for them. All end stations on a segment that hear all the traffic on the wire are in the same *collision domain.* Occasionally, more than one station will try to send data at the same time. If this occurs, a collision will result. Stations that are in the same collision domain are also in the same *broadcast domain;* all stations on a segment hear all broadcasts sent on the segment.

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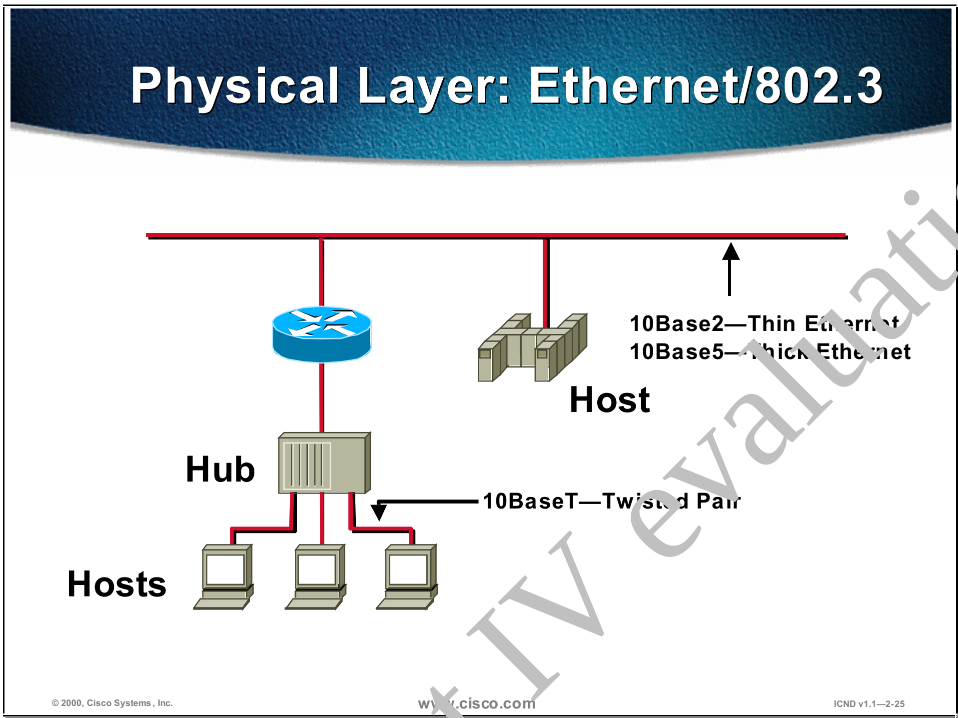

The Ethernet and IEEE 802.3 standards define a bus-topology LAN that operates at a baseband signaling rate of 10 Mbps. The graphic illustrates three defined wiring standards, as follows:

- 10Base2—Known as thin Ethernet, allows network segments up to 185 meters on coaxial cable.
- 10Base5—Known as thick Ethernet, allows network segments up to 500 meters on coaxial cable.
- 10BaseT—Carries Ethernet on inexpensive twisted-pair wiring.

The 10Base5 and 10Base2 standards provide access for multiple stations on the same segment. Stations are attached to the segment by a cable that runs from an attachment unit interface (AUI) in the station to a transceiver that is directly attached to the Ethernet coaxial cable. In some interfaces, the AUI and the transceiver are colocated in the station itself, and no cable is required.

Because the 10BaseT standard provides access for a single station only, stations attached to an Ethernet LAN by 10BaseT are almost always connected to a switch or hub. In a hub arrangement, the hub is analogous to an Ethernet segment.

Note In this course, Ethernet LANs are usually depicted in figures as 10Base2/10Base5 LANs, even though they are likely connected using 10BaseT.

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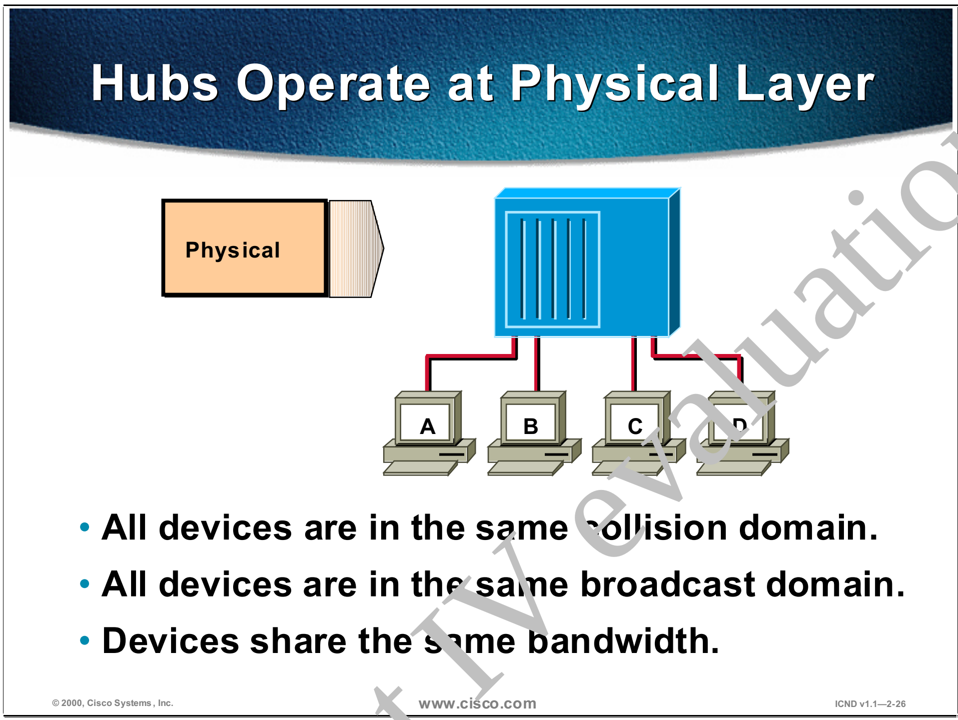

Hubs are devices used to extend an Ethernet wire to allow more end stations to communicate with each other, as if they were on the same segment. A hub does not manipulate or view the traffic that crosses it; it is used only to extend the physical media.

When you use a hub, the topology changes from a linear one, where each device plugs directly into the wire, to a star, as shown in the figure.

With hubs, end-station data arriving over any of the cables to a hub port is electrically repeated on all the other ports connected to the same Ethernet LAN, except for the port on which the data was received. Contention still occurs for the LAN media in the star. In addition, all devices still hear all traffic; thus hubs maintain single collision domains as well.

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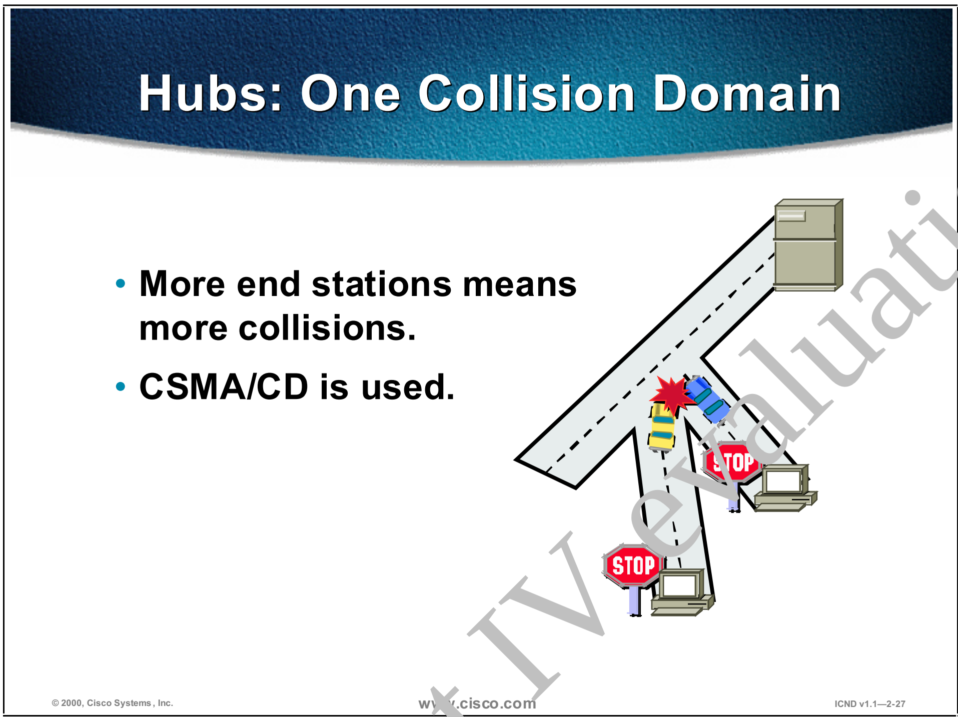

On Ethernet LANs, a hub (by itself) does not change the connection of all attached end stations to the single collision domain. As the figure illustrates, a problem can occur when there are too many end stations trying to access the same segment.

The Ethernet technology presented is carrier sense multiple access collision detect (CSMA/CD) LAN. That is, stations on a CSMA/CD LAN can access the network at any time. Before sending data, CSMA/CD stations "listen" to the network to hear if it is already in use. If it is, the station wishing to transmit waits. If the network is not in use, the station transmits. A collision occurs when two stations listen for network traffic, "hear" none, and transmit simultaneously. In this case, both transmissions are damaged, and the stations must retransmit at some later time. Backoff algorithms determine when the colliding stations retransmit. CSMA/CD stations can detect collisions, so they know when they must retransmit. The more stations are on a segment, the more chance for collisions. This is why switches or bridges are used to segment LANs that have too many collisions.

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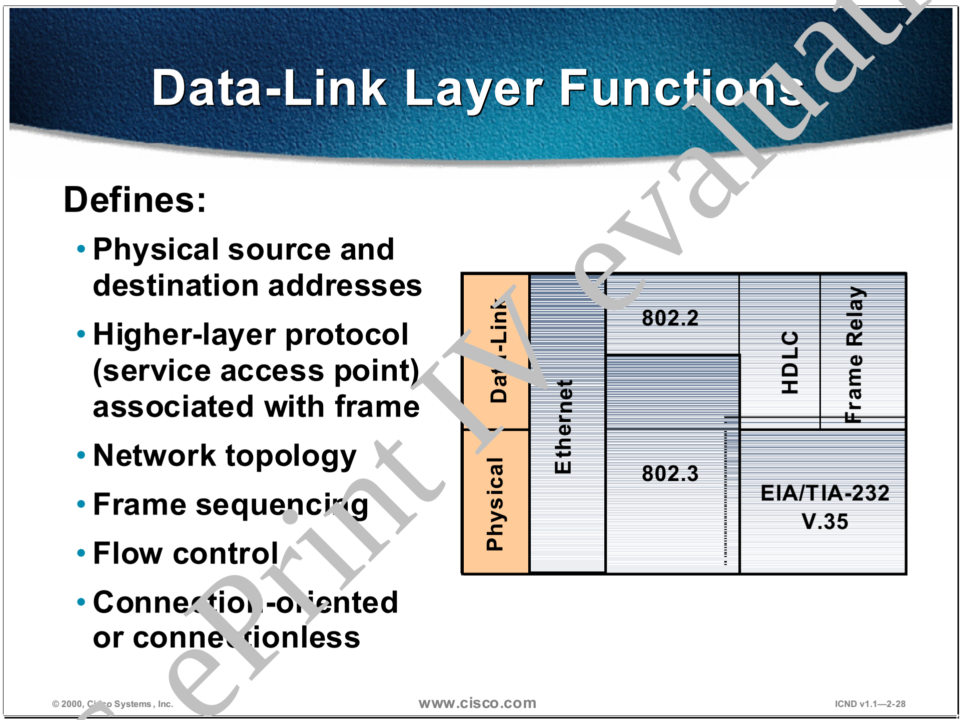
Data-Link Layer Functions

This section discusses details about how the data-link layer functions, and maps those functions to internetworking devices.



The data-link layer defines how data is transported over a physical medium. In addition, it defines how to encapsulate protocol-specific traffic in such a way that traffic going to different upper-layer protocols can use the same "channel" as it goes up the stack. To provide these functions, the IEEE Ethernet data-link layer has two sublayers, as follows:

- Media Access Control (MAC) (802.3)—As the name implies, the MAC layer defines how to transmit frames on the physical wire. It handles physical addressing associated with each device, network topology definition, line discipline, error notification, orderly delivery of frames, and optional flow control.
- Logical Link Control (LLC) (802.2)—As the name implies, the LLC is responsible for logically identifying different protocol types and then encapsulating them. The logical identification is done by a type code or a service access point (SAP) identifier. The type of LLC frame used by an end station depends on what identifier the upper-layer protocol expects. Additional LLC sublayer options include support for connections between applications running on the LAN, flow control to the upper layer by means of ready/not ready codes, and sequence control bits. For some protocols, the LLC is used to define reliable or unreliable services for data transfer, instead of the transport layer. (How reliable services operate is discussed in the "Transport Layer Functions" section of this chapter.)

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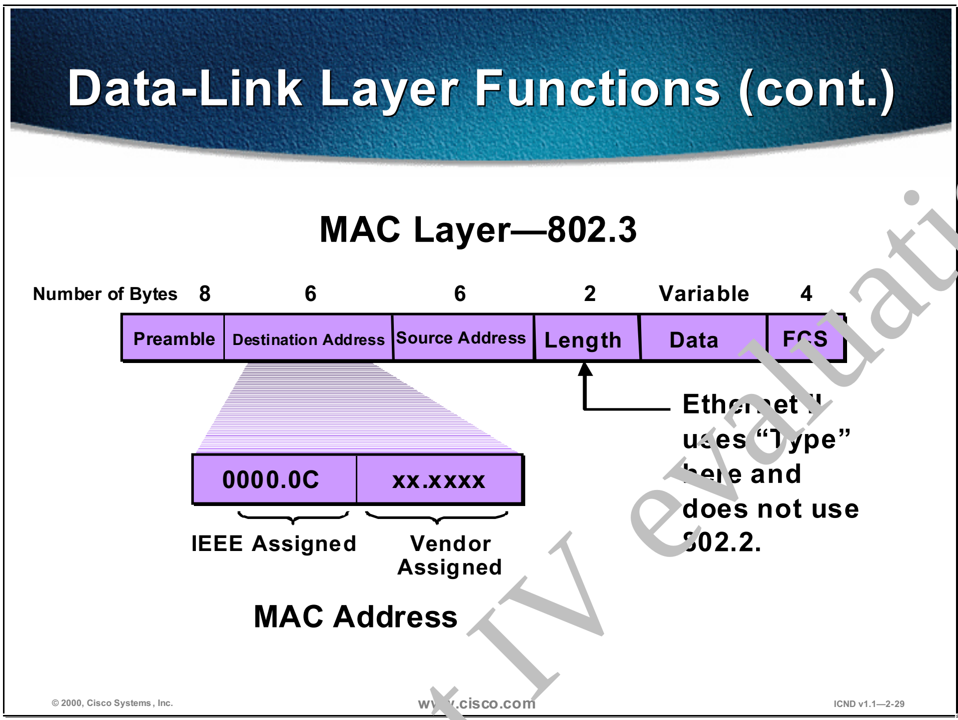

The figure illustrates the frame structure for MAC layer 802.3 frames. This standard frame structure is shown to provide an example of how control information is used to transmit information at this layer.

The definitions of the MAC sublayer fields are as follows:

- The IEEE 802.3 frames begin with an alternating pattern of ones and zeros called a preamble. The preamble tells receiving stations that a frame is coming.
- Immediately following the preamble are the destination and source physical address fields. These addresses are referred to as MAC-layer addresses. They are unique to each device in the internetwork. On most LAN interface cards, the MAC address is burned into ROM, hence the *term burned-in address* (BIA). When the network interface card initializes, this address is copied into RAM.

  The MAC address is a 48-bit address expressed as 12 hexadecimal digits. The first six hexadecimal digits of a MAC address contain a manufacturer identification (vendor code) also known as the Organizational Unique Identifier (OUI). To ensure vendor uniqueness, the IEEE administers OUIs. The last six hexadecimal digits are administered by each vendor and often represent the interface serial number.

  The source address is always a unicast (single-node) address, while the destination address may be unicast, multicast (group), or broadcast (all nodes).
- In IEEE 802.3 frames, the two-byte field following the source address is a length field, which indicates the number of bytes of data that follow this field and precede the FCS field.
- Following the length field is a data field. This field includes the LLC control information, other upper-layer control information, and the user data.

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- Following the data field is a four-byte FCS field containing a cyclic redundancy check (CRC) value. The CRC is created by the sending device and recalculated by the receiving device to check for damage that might have occurred to the frame in transit.

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