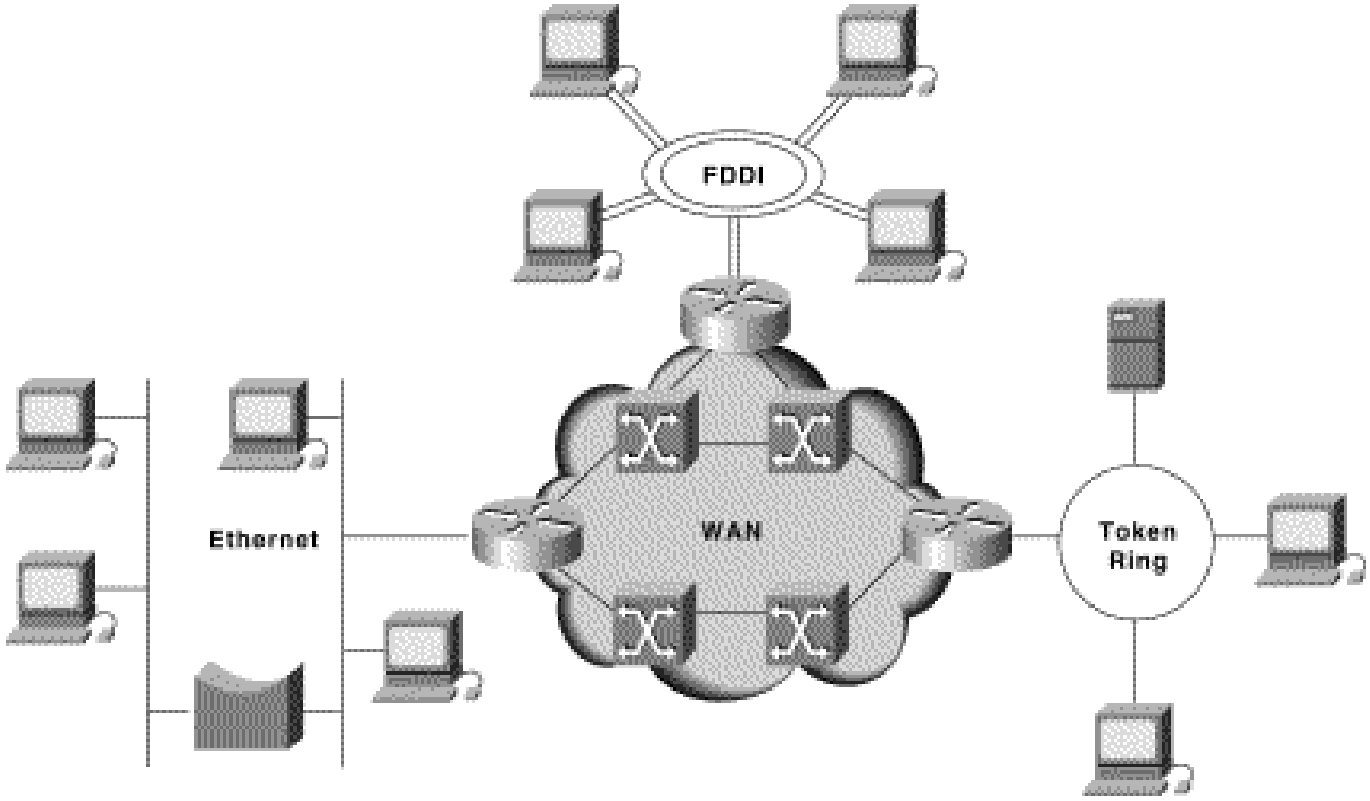
Internetwork



- An *internetwork* is a collection of individual networks, connected by intermediate networking devices, that functions as a single large network.

Local-area networks (LANs) evolved around the PC revolution. LANs enabled multiple users in a relatively small geographical area to exchange files and messages, as well as access shared resources such as file servers and printers.

Wide-area networks (WANs) interconnect LANs with geographically dispersed users to create connectivity. Some of the technologies used for connecting LANs include T1, T3, ATM, ISDN, ADSL, Frame Relay, radio links, and others. New methods of connecting dispersed LANs are appearing everyday.

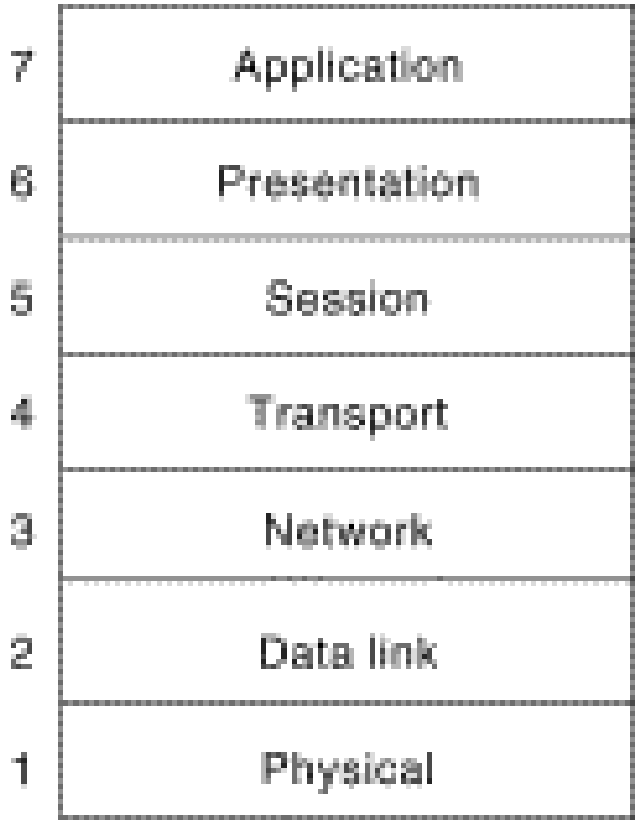
Internetworking Challenges

- Implementing a functional internetwork is no simple task. Many challenges must be faced, especially in the areas of connectivity, reliability, network management, and flexibility. Each area is key in establishing an efficient and effective internetwork.

Open System Interconnection Reference Model

- The *Open System Interconnection (OSI) reference model* describes how information from a software application in one computer moves through a network medium to a software application in another computer.
- The OSI reference model is a conceptual model composed of seven layers, each specifying particular network functions.
- The model was developed by the International Organization for Standardization (ISO) in 1984, and it is now considered the primary architectural model for intercomputer communications.

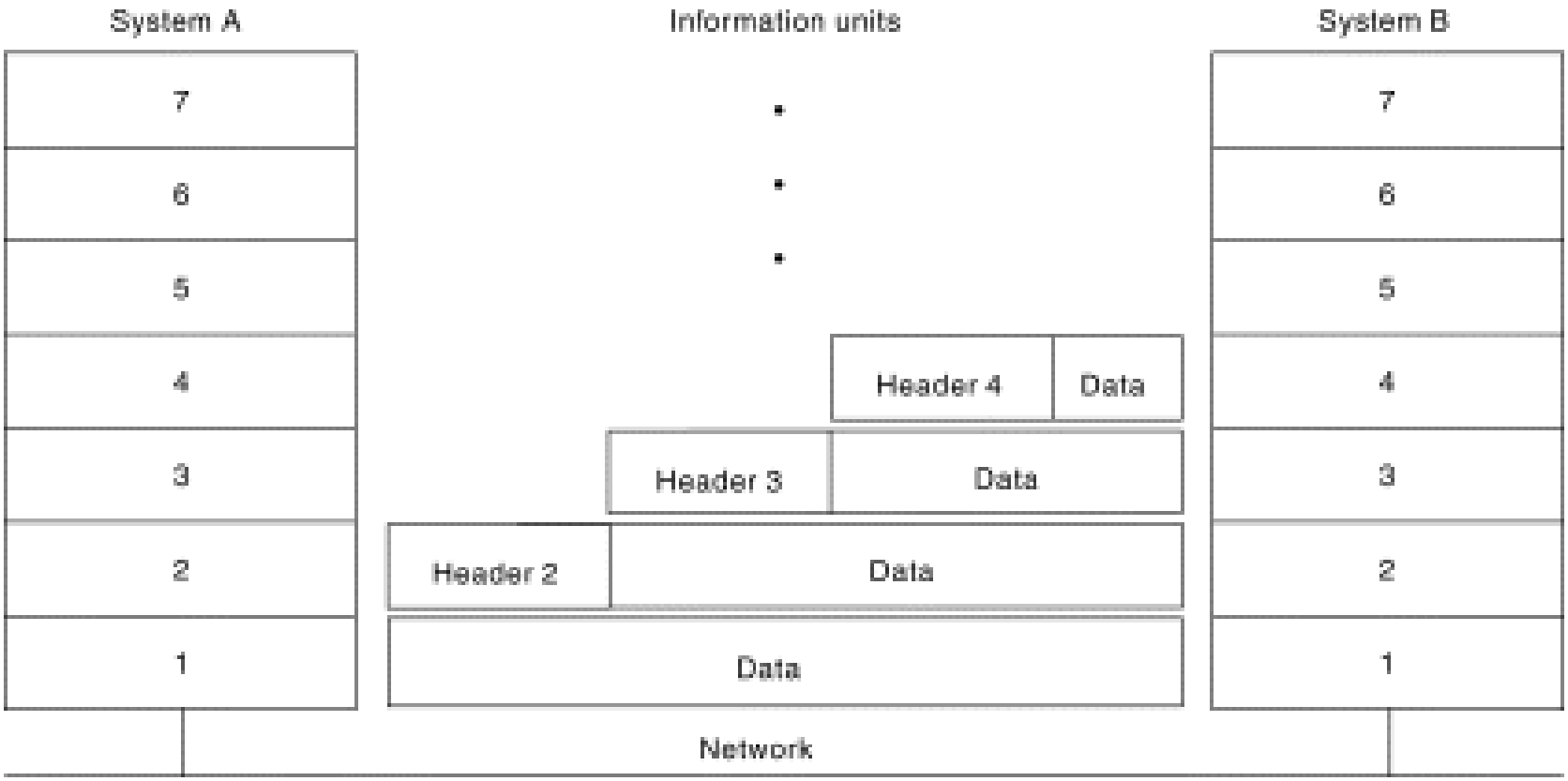
Open System Interconnection Reference Model



Open System Interconnection Reference Model

- The seven layers of the OSI reference model can be divided into two categories: upper layers and lower layers.
- The *upper layers* of the OSI model deal with application issues and generally are implemented only in software. The highest layer, the application layer, is closest to the end user.
- The *lower layer*s of the OSI model handle data transport issues. The physical layer and the data link layer are implemented in hardware and software. The lowest layer, the physical layer, is closest to the physical network medium (the network cabling, for example) and is responsible for actually placing information on the medium.

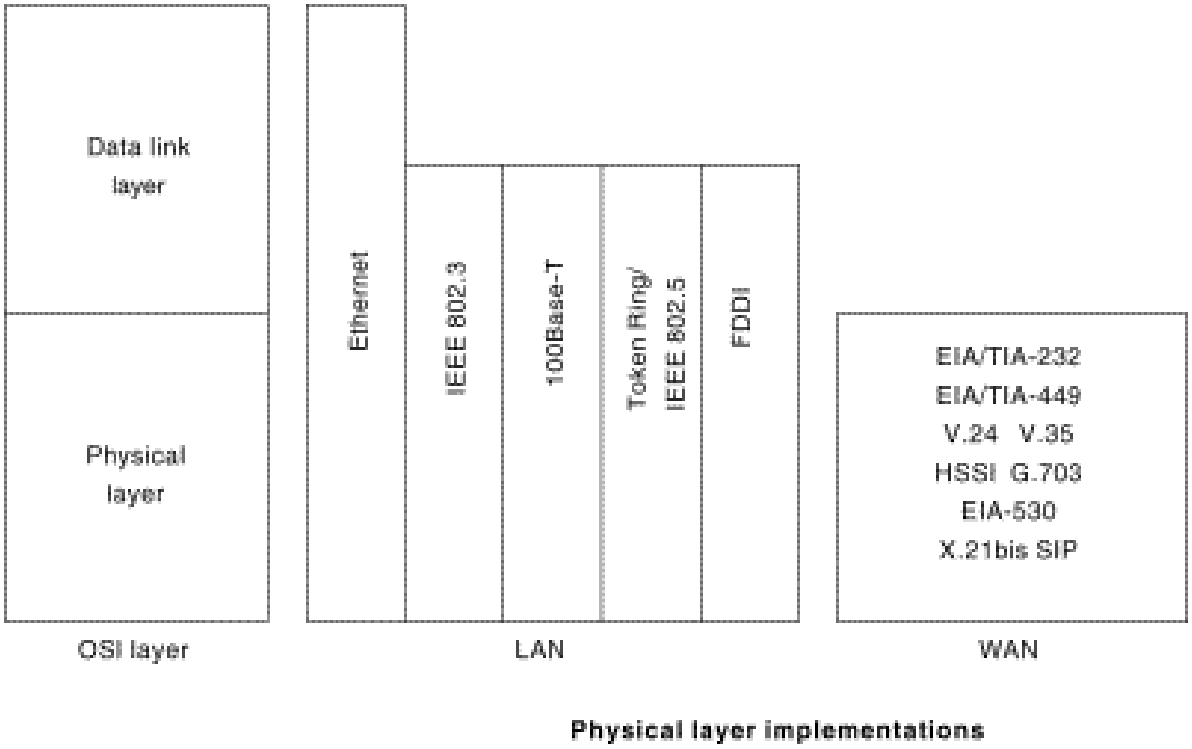
OSI Model Layers and Information Exchange



OSI Model Physical Layer

- The physical layer defines the electrical, mechanical, procedural, and functional specifications for activating, maintaining, and deactivating the physical link between communicating network systems. Physical layer specifications define characteristics such as voltage levels, timing of voltage changes, physical data rates, maximum transmission distances, and physical connectors

OSI Model Physical Layer



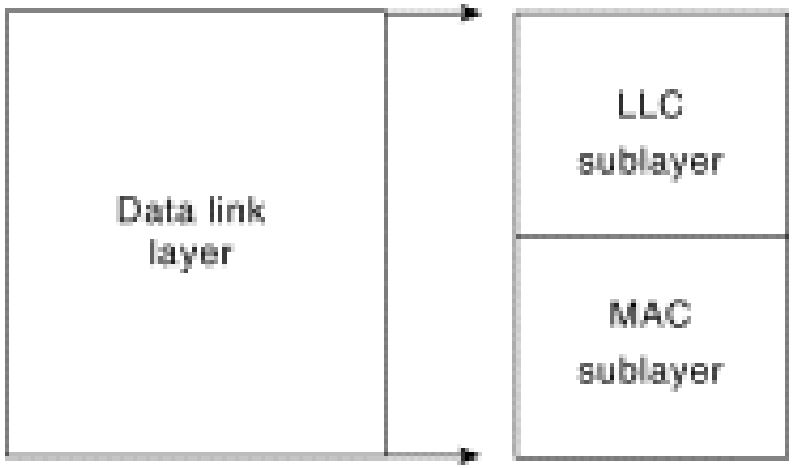
Physical Layer Implementations Can Be LAN or WAN Specifications

OSI Model Data Link Layer

- The data link layer provides reliable transit of data across a physical network link. Different data link layer specifications define different network and protocol characteristics, including physical addressing, network topology, error notification, sequencing of frames, and flow control.
- Physical addressing (as opposed to network addressing) defines how devices are addressed at the data link layer.
- Network topology consists of the data link layer specifications that often define how devices are to be physically connected, such as in a bus or a ring topology.
- Error notification alerts upper-layer protocols that a transmission error has occurred, and the sequencing of data frames reorders frames that are transmitted out of sequence.
- Finally, flow control moderates the transmission of data so that the receiving device is not overwhelmed with more traffic than it can handle at one time.

OSI Model Data Link Layer

- The Institute of Electrical and Electronics Engineers (IEEE) has subdivided the data link layer into two sublayers: Logical Link Control (LLC) and Media Access Control (MAC).



OSI Model Data Link Layer

- The *Logical Link Control (LLC)* sublayer of the data link layer manages communications between devices over a single link of a network.
- LLC is defined in the IEEE 802.2 specification and supports both connectionless and connection-oriented services used by higher-layer protocols. IEEE 802.2 defines a number of fields in data link layer frames that enable multiple higher-layer protocols to share a single physical data link.
- The *Media Access Control (MAC)* sublayer of the data link layer manages protocol access to the physical network medium. The IEEE MAC specification defines MAC addresses, which enable multiple devices to uniquely identify one another at the data link layer

OSI Model Network Layer

- The network layer defines the network address, which differs from the MAC address. Some network layer implementations, such as the Internet Protocol (IP), define network addresses in a way that route selection can be determined systematically by comparing the source network address with the destination network address and applying the subnet mask.

OSI Model Transport Layer

- The transport layer accepts data from the session layer and segments the data for transport across the network.
- Generally, the transport layer is responsible for making sure that the data is delivered error-free and in the proper sequence. Flow control generally occurs at the transport layer.
- Flow control manages data transmission between devices so that the transmitting device does not send more data than the receiving device can process.
- The transport protocols used on the Internet are TCP and UDP.

OSI Model Session Layer

- The session layer establishes, manages, and terminates communication sessions.
- Communication sessions consist of service requests and service responses that occur between applications located in different network devices.
- These requests and responses are coordinated by protocols implemented at the session layer.
- Some examples of session-layer implementations include Zone Information Protocol (ZIP), the AppleTalk protocol that coordinates the name binding process; and Session Control Protocol (SCP), the DECnet Phase IV session layer protocol.

OSI Model Presentation Layer

- The presentation layer provides a variety of coding and conversion functions that are applied to application layer data.
- Common data representation formats, or the use of standard image, sound, and video formats, enable the interchange of application data between different types of computer systems.
- Conversion schemes are used to exchange information with systems by using different text and data representations, such as EBCDIC and ASCII.

OSI Model Presentation Layer

- Standard data compression schemes enable data that is compressed at the source device to be properly decompressed at the destination.
- Standard data encryption schemes enable data encrypted at the source device to be properly deciphered at the destination.

OSI Model Presentation Layer

- Presentation layer implementations are not typically associated with a particular protocol stack. Some well-known standards for video include QuickTime and Motion Picture Experts Group (MPEG). QuickTime is an Apple Computer specification for video and audio, and MPEG is a standard for video compression and coding.
- Among the well-known graphic image formats are Graphics Interchange Format (GIF), Joint Photographic Experts Group (JPEG), and Tagged Image File Format (TIFF). GIF is a standard for compressing and coding graphic images. JPEG is another compression and coding standard for graphic images, and TIFF is a standard coding format for graphic images.

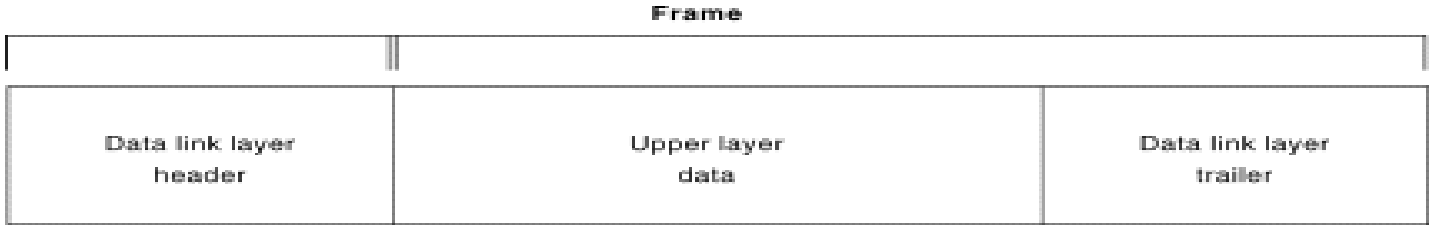
OSI Model Application Layer

- The application layer is the OSI layer closest to the end user
- This layer interacts with software applications that implement a communicating component.
- Application layer functions typically include identifying communication partners, determining resource availability, and synchronizing communication.
- Some examples of application layer implementations include Telnet, File Transfer Protocol (FTP), and Simple Mail Transfer Protocol (SMTP).

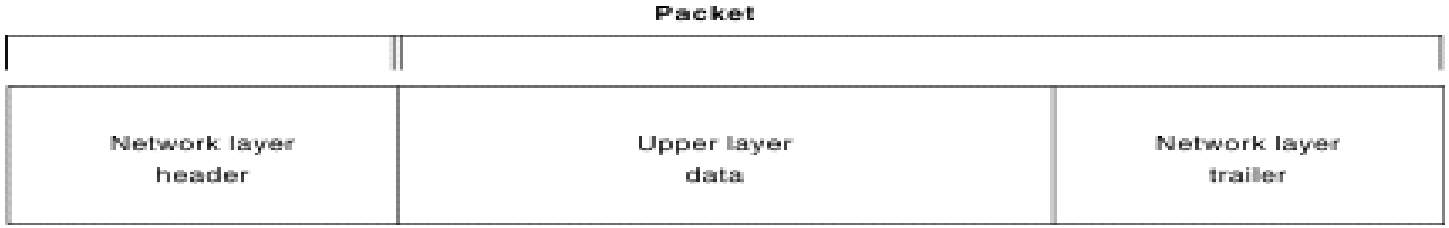
OSI Model Application Layer

- When identifying communication partners, the application layer determines the identity and availability of communication partners for an application with data to transmit.
- When determining resource availability, the application layer must decide whether sufficient network resources for the requested communication exist.
- In synchronizing communication, all communication between applications requires cooperation that is managed by the application layer.

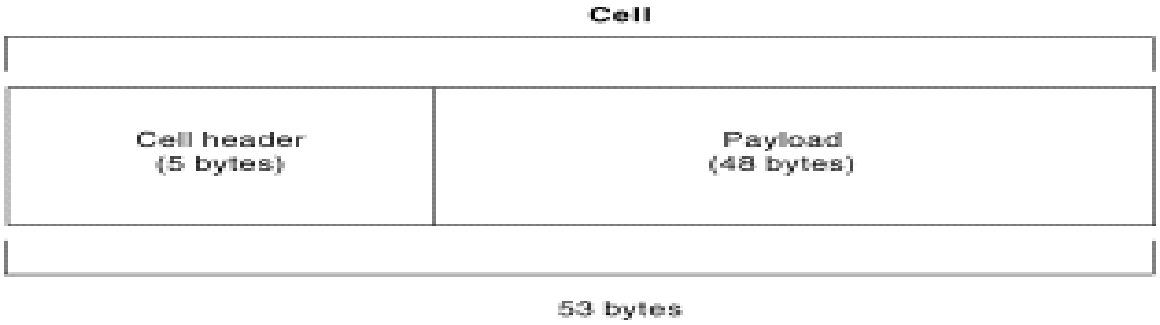
Information Formats



Data from Upper-Layer Entities Makes Up the Data Link Layer Frame



Three Basic Components Make Up a Network Layer Packet



Information Formats

- *A **frame** is an information unit whose source and destination are data link layer entities.*
- *A **packet** is an information unit whose source and destination are network layer entities.*
- *The term **datagram** usually refers to an information unit whose source and destination are network layer entities that use connectionless network service.*
- *The term **segment** usually refers to an information unit whose source and destination are transport layer entities.*
- *A **message** is an information unit whose source and destination entities exist above the network layer (often at the application layer).*
- *A **cell** is an information unit of a fixed size whose source and destination are data link layer entities.*

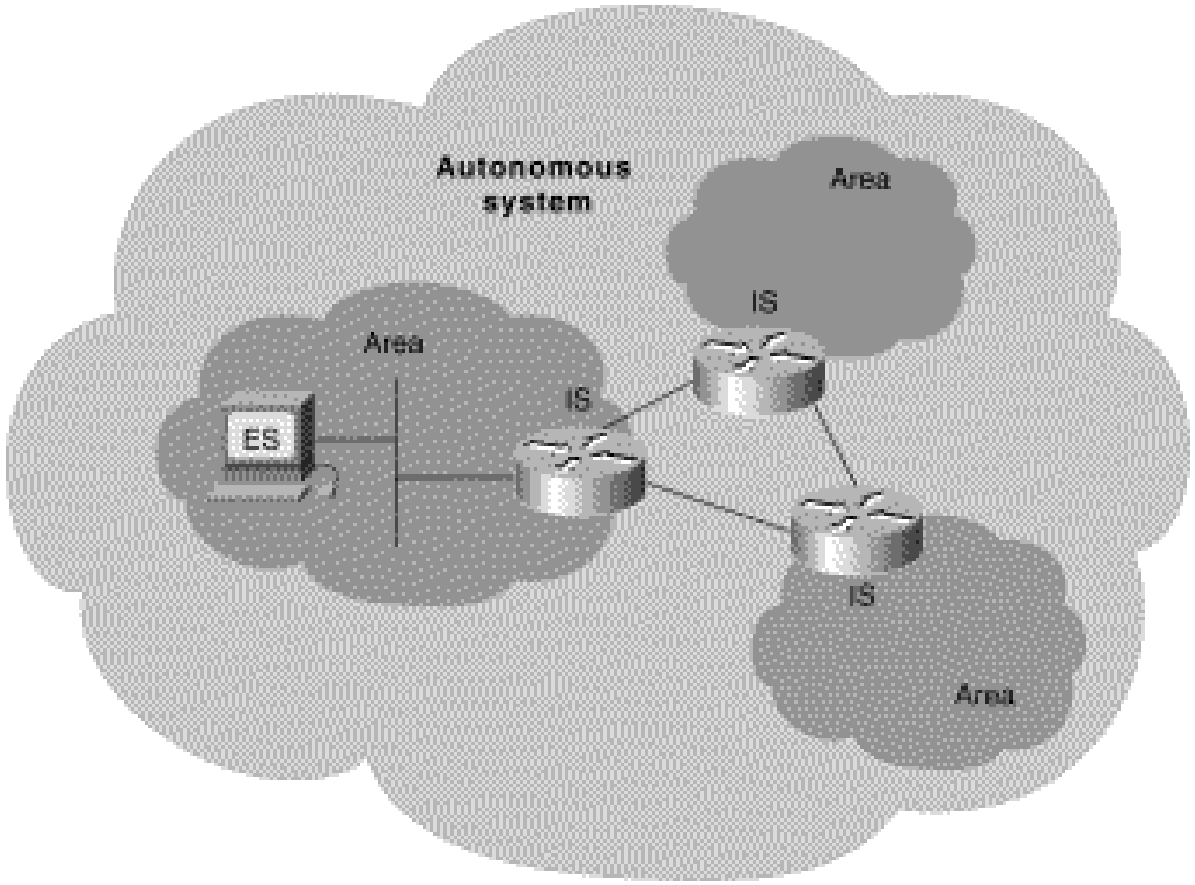
ISO Hierarchy of Networks

- Large networks typically are organized as hierarchies. A hierarchical organization provides such advantages as ease of management, flexibility, and a reduction in unnecessary traffic.
- ISO has adopted a number of terminology conventions for addressing network entities,
  - end system (ES)
  - intermediate system (IS),
  - area, and autonomous system (AS).

ISO Hierarchy of Networks

- Typical ESs include such devices as terminals, personal computers, and printers.
- An *IS* performs routing or other traffic-forwarding functions, such devices as routers, switches, and bridges. Two types of IS networks exist: intradomain IS and interdomain IS. An intradomain IS communicates within a single autonomous system, while an interdomain IS communicates within and between autonomous systems.
- An *area is a logical group of network segments and their attached devices. Areas are subdivisions of autonomous systems (AS's). An AS is a collection of networks under a common administration that share a common routing strategy. Autonomous systems are subdivided into areas, and an AS is sometimes called a domain.*

ISO Hierarchy of Networks



Connection-Oriented and Connectionless Network

- Connection-oriented services must first establish a connection with the desired service before passing any data. A connectionless service can send the data without any need to establish a connection first.
- Connection-oriented service involves three phases: connection establishment, data transfer, and connection termination
- Connection-oriented services must negotiate a connection, transfer data, and tear down the connection, whereas a connectionless transfer can simply send the data without the added overhead of creating and tearing down a connection.
- Each has its place in internetworks