OSI Model, TCP/IP Model and Data Encapsulation

THE OSI MODEL

- Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards.
- An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model.
- In 1977, work on a layered model of network architecture was started and the ISO began to develop its OSI framework architecture.
- OSI has two major components: an abstract model of networking, called the Basic Reference Model or seven-layer model, and a set of specific protocols.

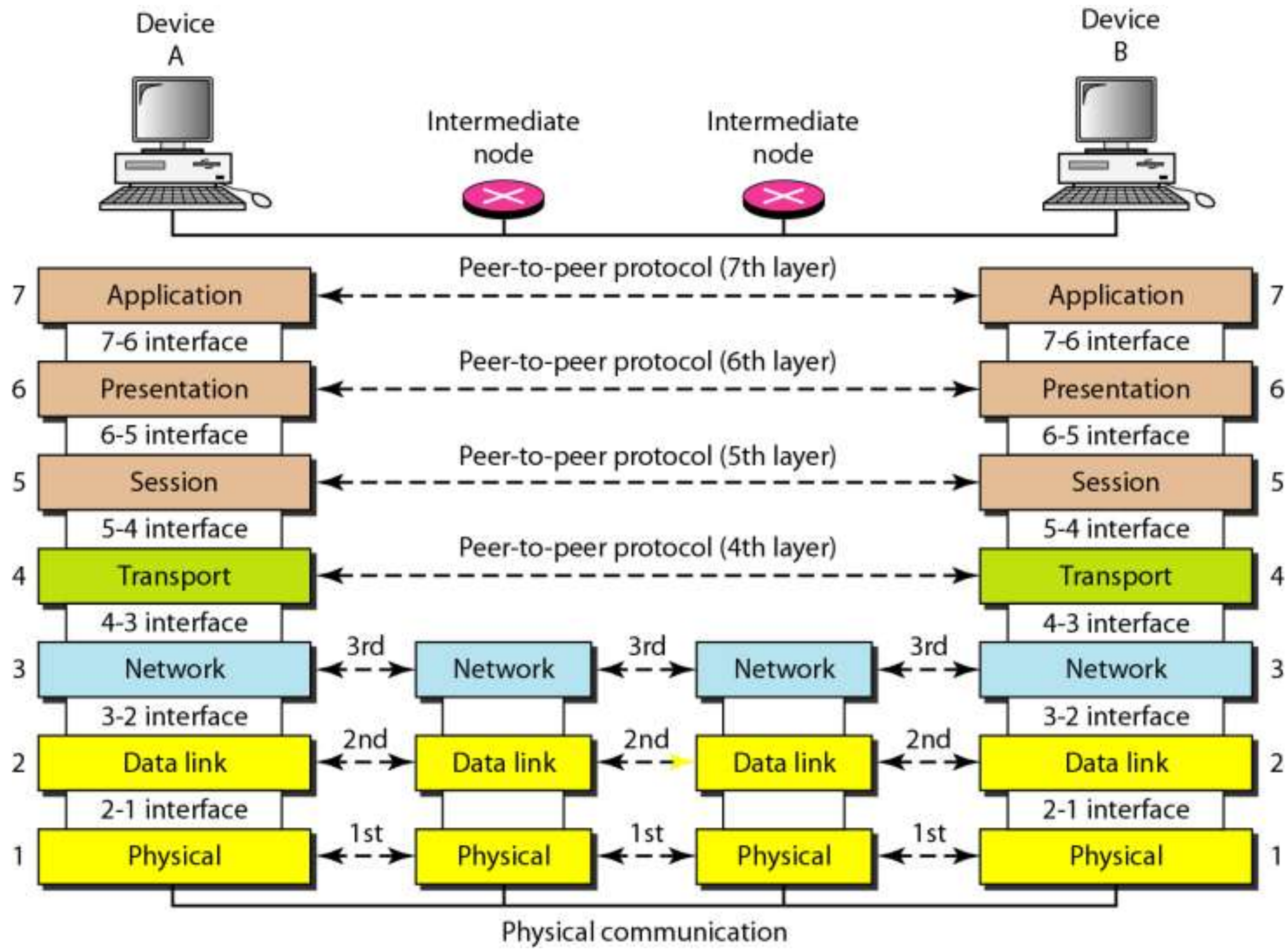
Open Systems Interconnection (OSI) model.

- The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software.
- The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust, and interoperable.
- The OSI model is a layered framework for the design of network systems that allows communication between all types of computer systems.
- It consists of seven separate but related layers, each of which defines a part of the process of moving information across a network.
- An understanding of the fundamentals of the OSI model provides a solid basis for exploring data communications.

OSI model: Layered Architecture

- The OSI model is composed of seven ordered layers:
  - Physical (Layer 1)
  - Data Link (Layer 2)
  - Network (Layer 3)
  - Transport (Layer 4)
  - Session (Layer 5)
  - Presentation (Layer 6)
  - Application (Layer 7).
- Figure 2.3 shows the layers involved when a message is sent from device A to device B. As the message travels from A to B, it may pass through many intermediate nodes.
- These intermediate nodes usually involve only the first three layers of the OSI model.

Figure 2.3 *The interaction between layers in the OSI model*



Layered Architecture

- Within a single machine, each layer calls upon the services of the layer just below it. Layer 3, for example, uses the services provided by layer 2 and provides services for layer 4.
- Between machines, layer x on one machine communicates with layer x on another machine.
- This communication is governed by an agreed-upon series of rules and conventions called protocols.
- The processes on each machine that communicate at a given layer are called peer-to-peer processes.
- Communication between machines is therefore a peer-to-peer process using the protocols appropriate to a given layer.

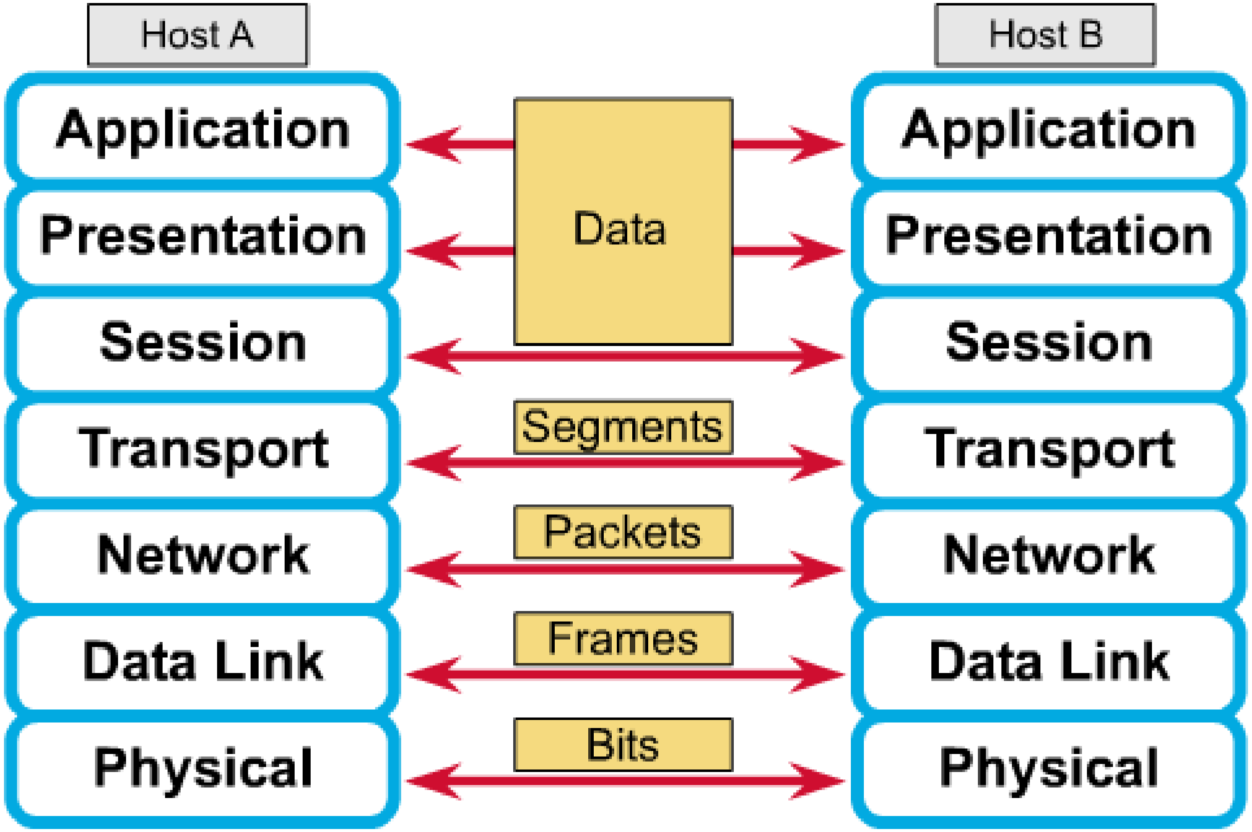
Peer-to-Peer Processes

- At the higher layers, communication must move down through the layers on device A, over to device B, and then back up through the layers.
- Each layer in the sending device adds its own information to the message it receives from the layer just above it and passes the whole package to the layer just below it.
- At layer 1 the entire package is converted to a form that can be transmitted to the receiving device.
- At the receiving machine, the message is unwrapped layer by layer, with each process receiving and removing the data meant for it.
- For example, layer 2 removes the data meant for it, then passes the rest to layer 3. Layer 3 then removes the data meant for it and passes the rest to layer 4, and so on.

Organization of the Layers

- The seven layers can be categorize into three subgroups.
  - Layers 1, 2, and 3-physical, data link, and network-are the network support layers; - deal with the physical aspects of moving data from one device to another (such as electrical specifications, physical connections, physical addressing, and transport timing and reliability).
  - Layers 5, 6, and 7-session, presentation, and application-can be thought of as the user support layers; they allow interoperability among unrelated software systems.
  - Layer 4, the transport layer, links the two subgroups and ensures that what the lower layers have transmitted is in a form that the upper layers can use.
- The upper OSI layers are almost always implemented in software;
- Lower layers are a combination of hardware and software, except for the physical layer, which is mostly hardware.

Names for Data at Each Layer



Encapsulation

- Data is divided into Segments
- Add logical address, Segments become Packets.
- Add Physical address, Packets become Frames
- Lastly, Frames → Bits

LAYERS IN THE OSI MODEL

In this section we briefly describe the functions of each layer in the OSI model.

The physical layer is responsible for movements of individual bits from one hop (node) to the next.

Physical Layer

The physical layer is concerned with the following:

- Physical characteristics of interfaces and medium: defines the characteristics of the interface between the devices and the transmission medium
- Representation of bits: for data to be transmitted, bits must be encoded into signals--electrical or optical. Defines the type of encoding
- Data rate. The transmission rate-the number of bits sent each
- Synchronization of bits: The sender and receiver must use the same bit rate and must be synchronized at the bit level
- Line configuration: concerned with the connection of devices to the media
- Physical topology. The physical topology defines how devices are connected to make a network –type topology
- Transmission mode: defines the direction of transmission between two devices: simplex, half-duplex, or full-duplex

Layer 1 device – ex: hub

Note

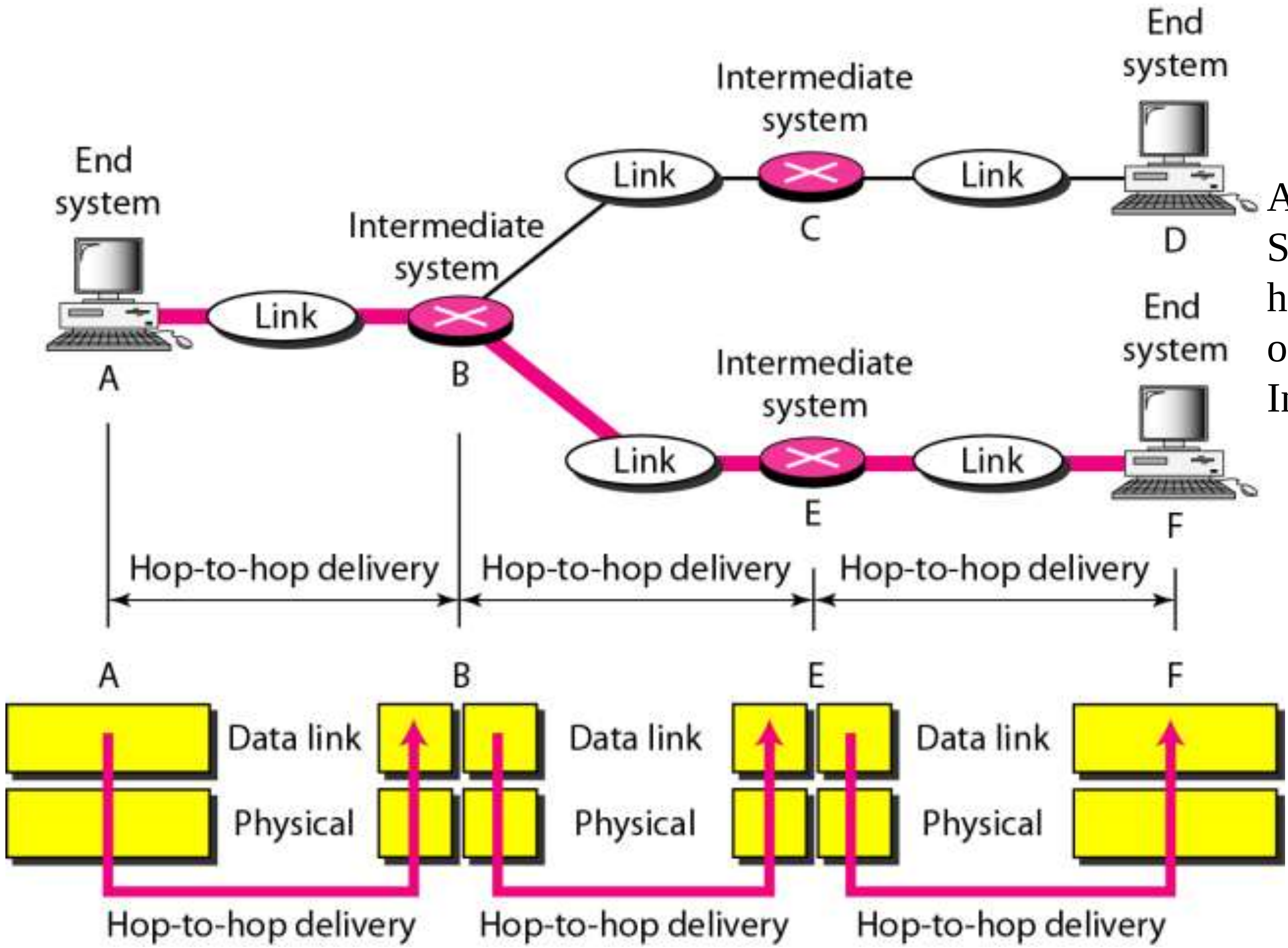
The data link layer is responsible for moving frames from one hop (node) to the next.

Data Link Layer

- The data link layer is responsible for delivery of frames, within a local network.
- Responsibilities of the data link layer include the following:
  - Framing: divides the stream of bits received from the network layer into manageable data units called frames.
  - Physical addressing- e.g. MAC address (limited to local network)
  - Flow control : imposes a flow control mechanism to avoid overwhelming the receiver.
  - Error control: adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames ; achieved through a trailer added to the end of the frame.
  - Access control: to determine which device has control over the link at any given time.

  Layer 2 device – ex: switch

Figure 2.7 *Hop-to-hop delivery*



Assume intermediate Systems here are hubs or switches. So, only one network is Involved.

Note

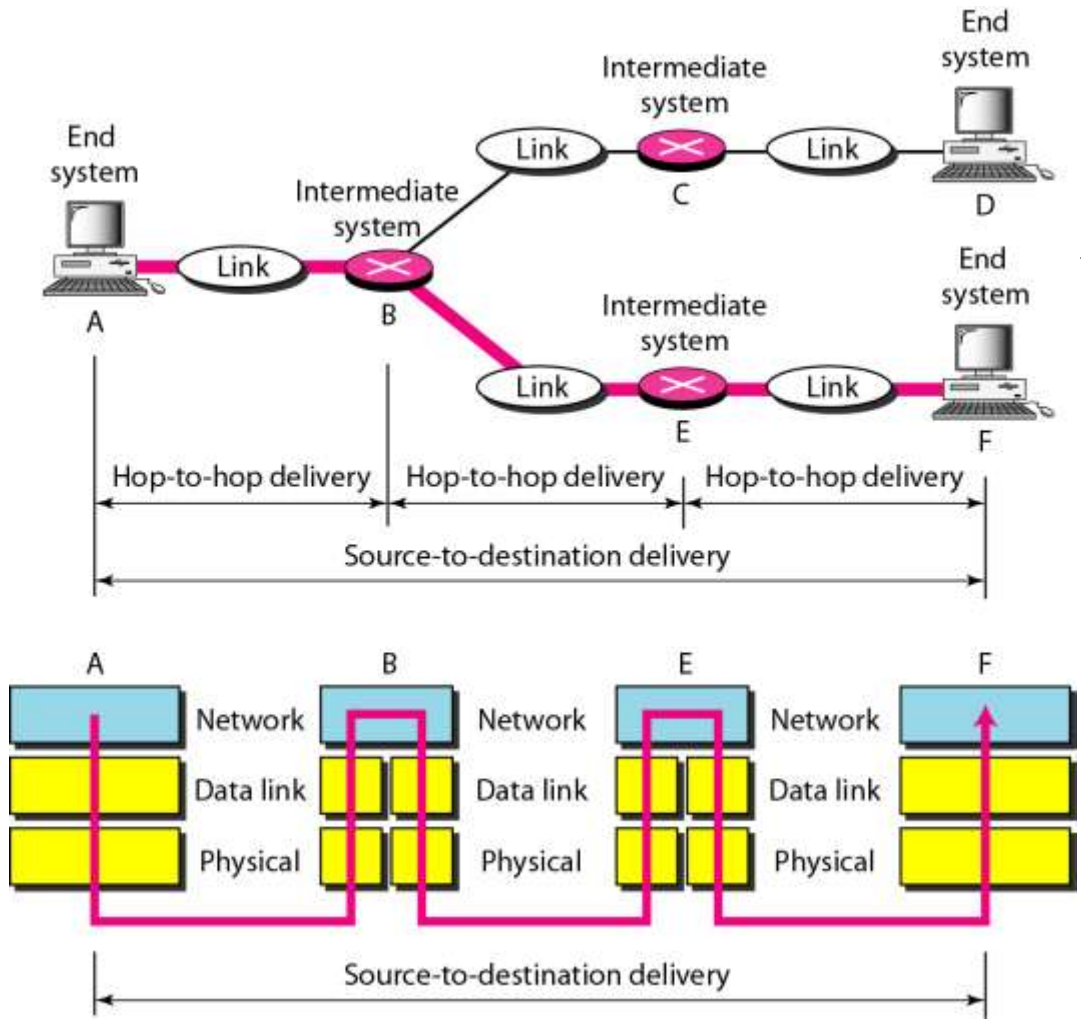
The network layer is responsible for the delivery of individual packets from the source host to the destination host.

Network Layer

- The network layer is responsible for the source-to-destination delivery of packets, possibly across multiple networks (routing).
- Responsibilities of the network layer include the following:
  - Logical addressing. (Ex: IP address)
  - Path Selection: choose the best path to forward packets to destination networks.

  Layer 3 device – ex: router

Figure 2.9 *Source-to-destination delivery*



Assume intermedia
systems are routers

Note

The transport layer is responsible for the delivery of a message from one process to another.

Transport Layer

- Responsibilities of the transport layer include the following:
    - Service-point addressing: The transport layer header must therefore include a type of address called a service-point address (or port address). The transport layer gets the entire message to the correct process on that computer.
    - Segmentation and reassembly. A message is divided into transmittable segments, with each segment containing a sequence number.
    - Connection control: can be either connectionless or connection oriented.
    - Flow control: responsible for flow control is performed end to end rather than
    - across a single link(DLL).
    - Error control: is responsible for error control is performed process-to-process rather than across a single link.
    - The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error (damage, loss, or duplication).
    - Error correction is usually achieved through retransmission.

Session Layer

The session layer is responsible for dialog control and synchronization.

- The session layer is the network dialog controller.
- It establishes, maintains, and synchronizes the interaction among communicating systems
- Responsibilities of the session layer include the following:
  - Dialog control. The session layer allows two systems to enter into a dialog.
  - Synchronization. The session layer allows a process to add checkpoints, or synchronization points, to a stream of data.

Presentation Layer

The presentation layer is responsible for translation, compression, and encryption.

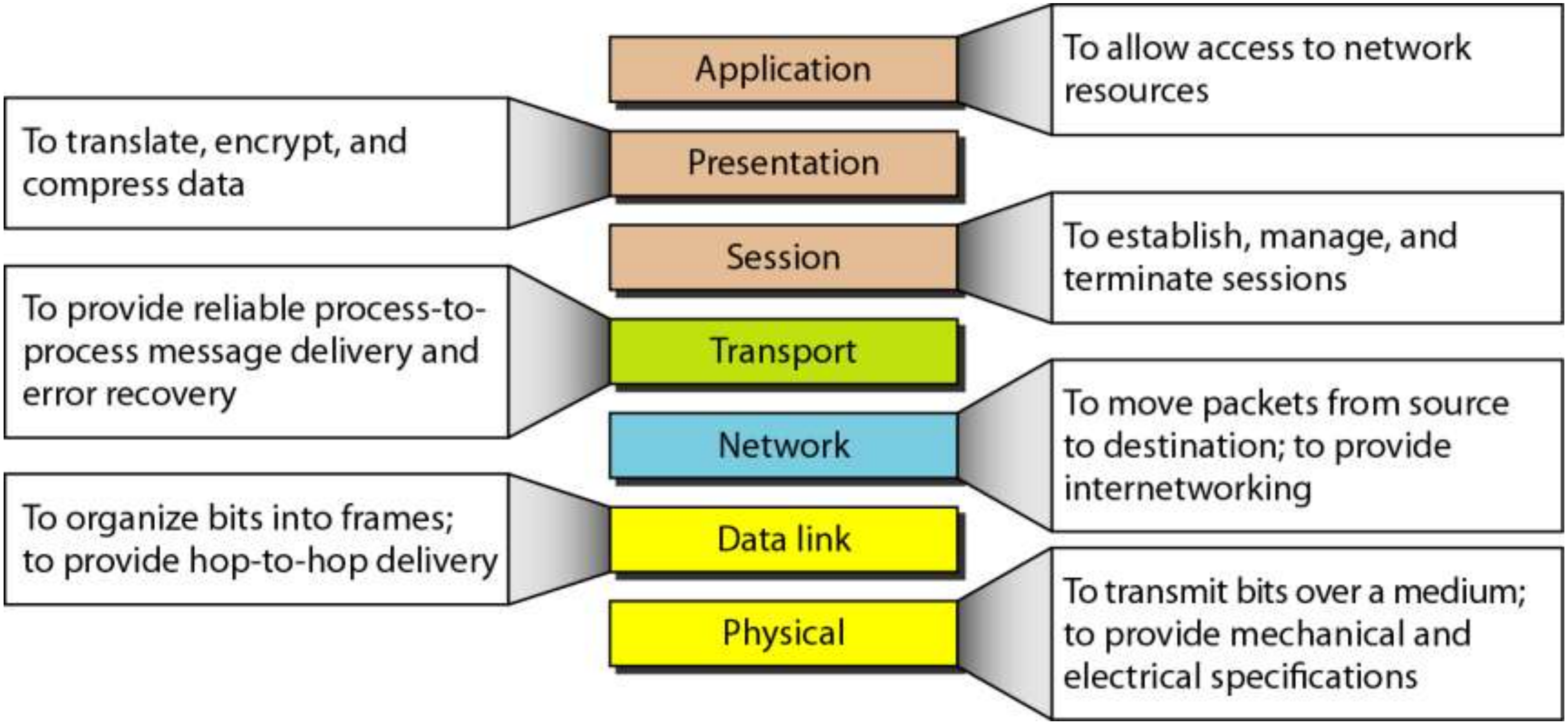
- The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.
- Responsibilities of the presentation layer include the following:
  - Translation: the presentation layer is responsible for
  - interoperability between these different encoding methods.
  - Encryption: To carry sensitive information, a system must be able to ensure privacy.
  - Compression: Data compression reduces the number of bits contained in the information -important in the transmission of multimedia such as text, audio, and video.

Application Layer

The application layer is responsible for providing services to the user.

- The application layer enables the user, whether human or software, to access the network.
- It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services
- Services provided by the application layer include the following:
    - Network virtual terminal -telnet
    - File transfer, access, and management-FTP
    - Mail services
    - Directory services: provides distributed database sources and access for global information about various objects and services

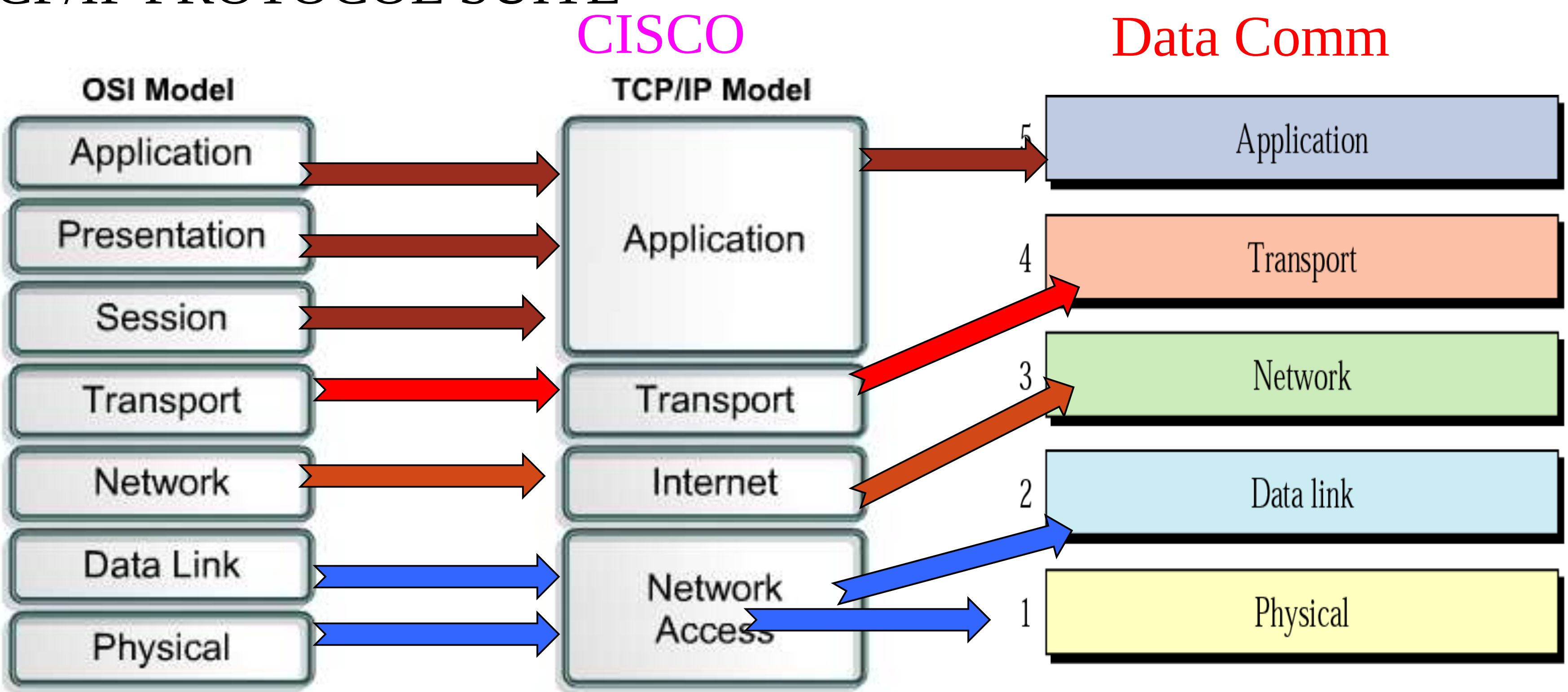
Figure 2.15 *Summary of layers*



TCP/IP PROTOCOL SUITE

- The layers in the TCP/IP protocol suite do not exactly match those in the OSI model.
- The original TCP/IP protocol suite was defined as having four layers: host-to-network, internet, transport, and application.
- However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers: physical, data link, network, transport, and application.

TCP/IP PROTOCOL SUITE



- The first four layers provide physical standards, network interfaces, internetworking, and transport functions that correspond to the first four layers of the OSI model.
- The three topmost layers in the OSI model, however, are represented in TCPIIP by a single layer called the application layer

Figure 2.16 *TCP/IP and OSI model*

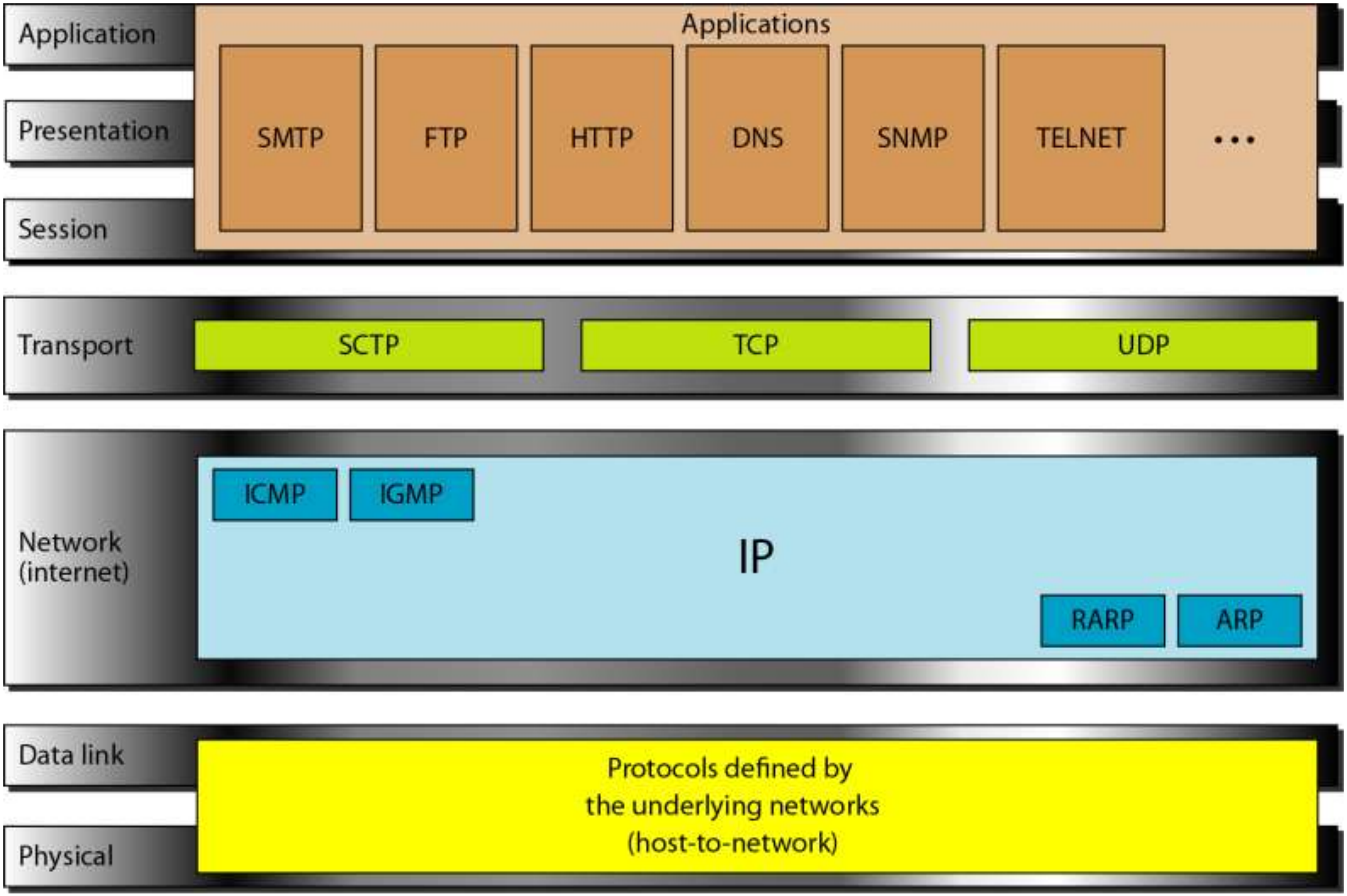
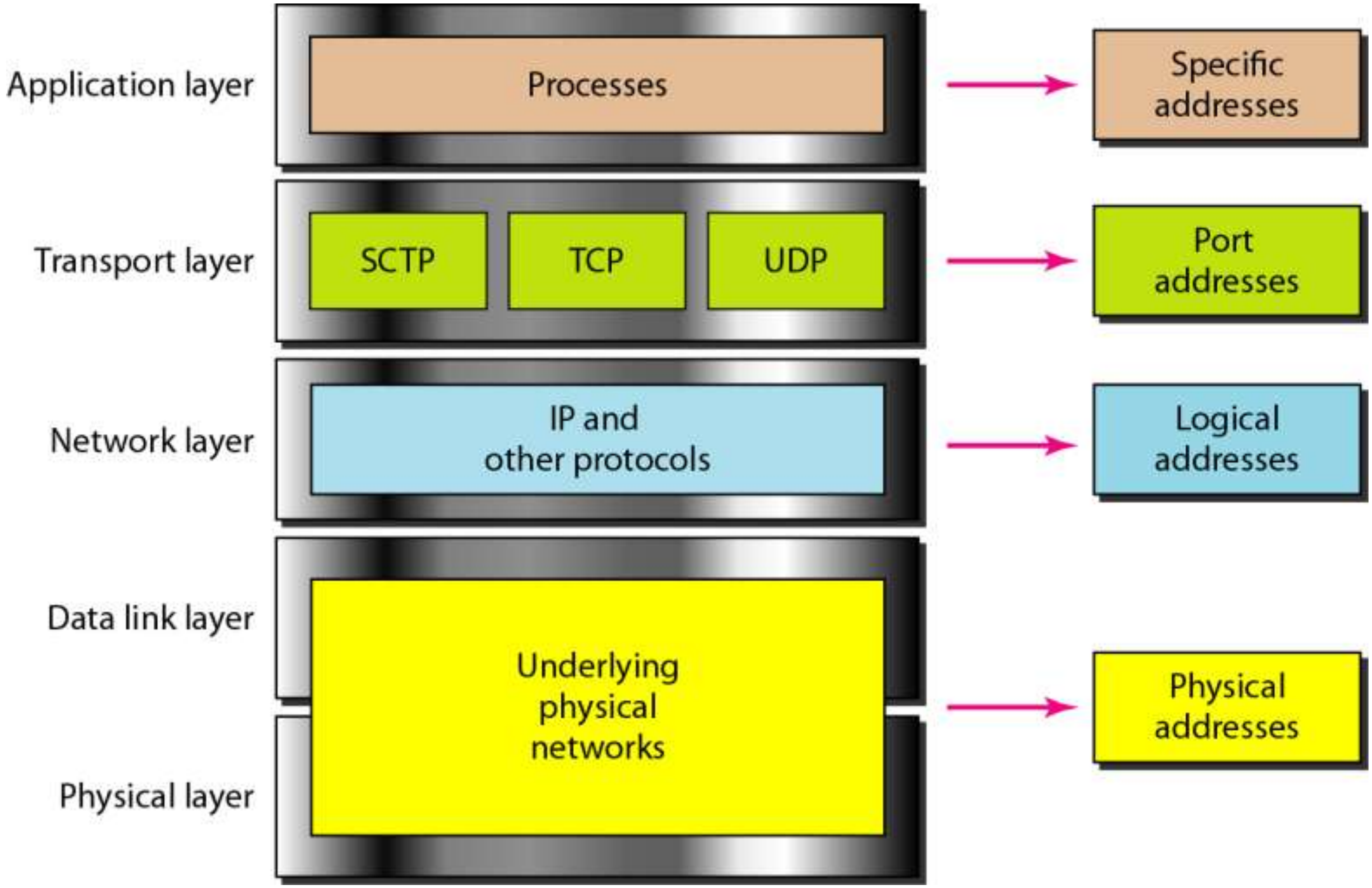


Figure 2.18 *Relationship of layers and addresses in TCP/IP*



The physical addresses change from hop to hop,
but the logical and port addresses usually remain the same.