Network Models

A Network is ..

- A combination of hardware (HW) and software (SW) that send *data* from one location to another.
  - HW: physical equipment that carries ***signals*** from one point of the network to another
  - SW: instruction sets that make possible the services that we expect from a network.

Data transformed into the form of electromagnetic signals when sent along a transmission medium (link).

Why Network Protocol Models?

- Network communication is an extremely complex task
- Need cooperative efforts from all nodes involved
- A standard model helps to describe the task of a networking product or service
- Also help in troubleshooting by providing a frame of reference
- OSI Reference Model,TCP/IP Model

Who defines Network Model?

- Need non-profit making organizations
  - ISO - International Standards Organization

    e.g. OSI, MPEG-1, 2, 4, etc.
  - IEEE - Institute of Electrical & Electronic Engineers

    e.g IEEE 802, IEEE 754, etc.
  - ITU - International Telecommunication Union

    e.g. V.34, H.323, H.324, etc

The OSI Model

- An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model.
- An **open system** is a set of protocol that allows any two different systems to communicate regardless of their underlying architecture (H/W and S/W).

ISO is the organization.
OSI is the model.

Concept of Layers

- Each layer provides a specific set of services.
- Services are provided through the definition of *protocols*.
- Each layer uses the services provided by the lower/above layers.
- Layers use protocols to communicate with each others.
- Creates standards for equipment manufacturer

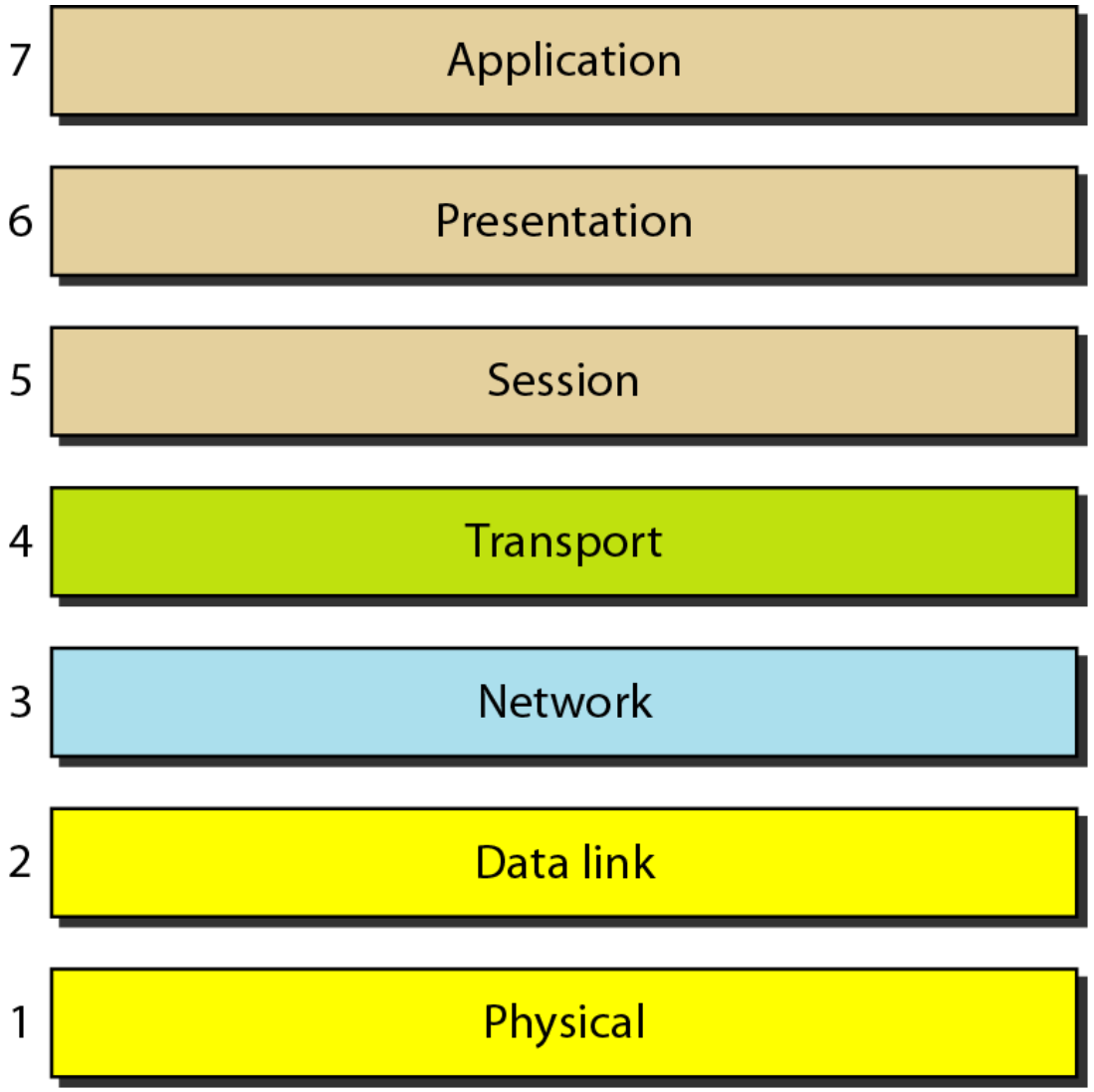
Concept of Layers

- Each layer provides a specific set of services.
- Layering provides two nice features:
  - Decomposes the problem of building a network into more manageable components.
  - Provides a more modular design, modifying the functionality of the different layers without affecting the whole system!

The OSI Model

- The OSI model is a **layered framework** for the design of network systems that allows for 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.
- Within a single machine, each layer calls upon the services of the layer just below it.
  - *e.g. layer 3 uses the services provided by layer 2 and provides services for layer 4.*

Seven layers of the OSI model



Peer-to-Peer Process

- At the physical layer, communication is direct where device A sends a stream of bits to device B. The bits must be converted to a form that can be transmitted to the receiving device.
- 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.

Peer-to-Peer Process

- ***Interfaces Between Layers***
  - The passing of the data and network information down/up through the layers in sending/ receiving require an **interface** between each pair of adjacent layers.
  - Well-defined interfaces and layer functions provide modularity to a network.

Organization of the Layers

- The seven layers can be thought of as belonging to three subgroups:
  1) **Layers 1,2, and 3** – physical, data link, and network – are the network support layers.
  2) **Layers 5,6, and 7** – session, presenation, and application – are user support layers; they allow interoperability among unrelated software systems.

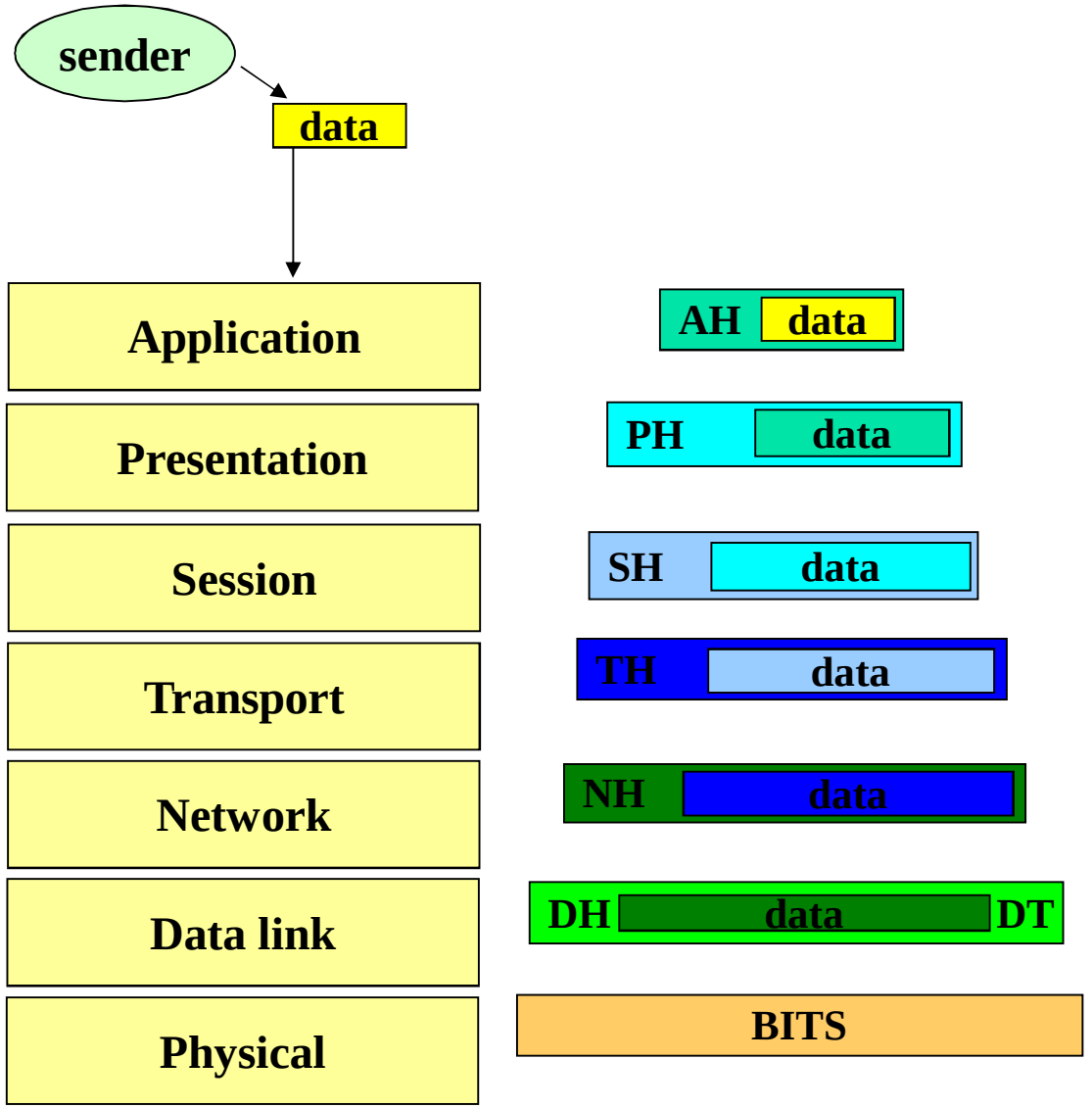
Organization of the Layers

- The seven layers can be thought of as belonging to three subgroups:
  3) Layer 4, the transport layer, links the two groups and ensures that what the lower layers have transmitted is in a form that the upper layers can use.
- The upper OSI layers almost implemented in S/W; lowers layers are combination of S/W and H/W except for the physical layer which is mostly H/W.

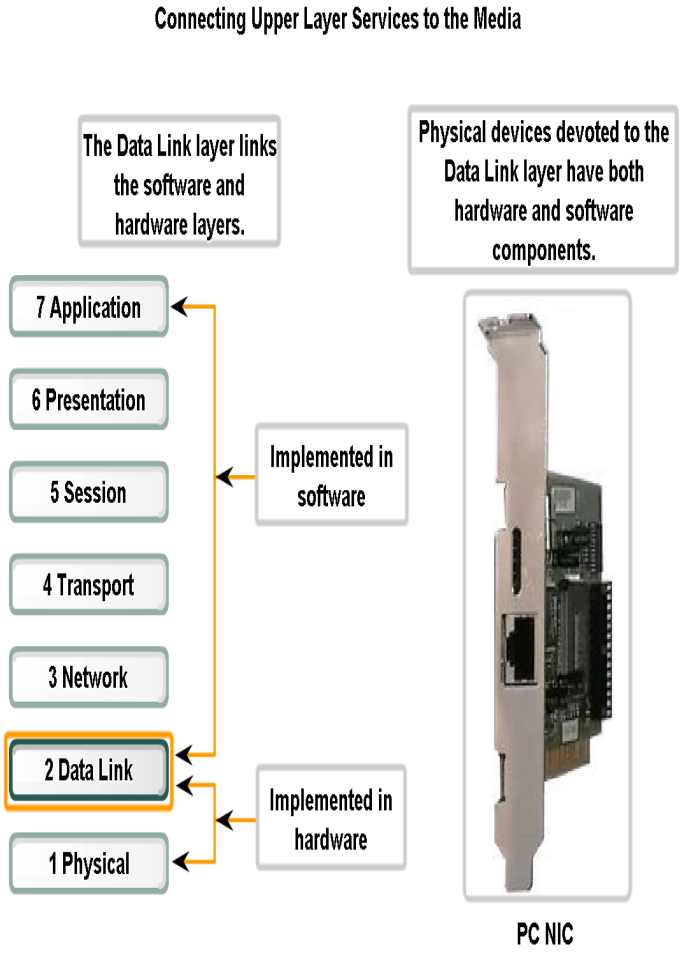
Encapsulation

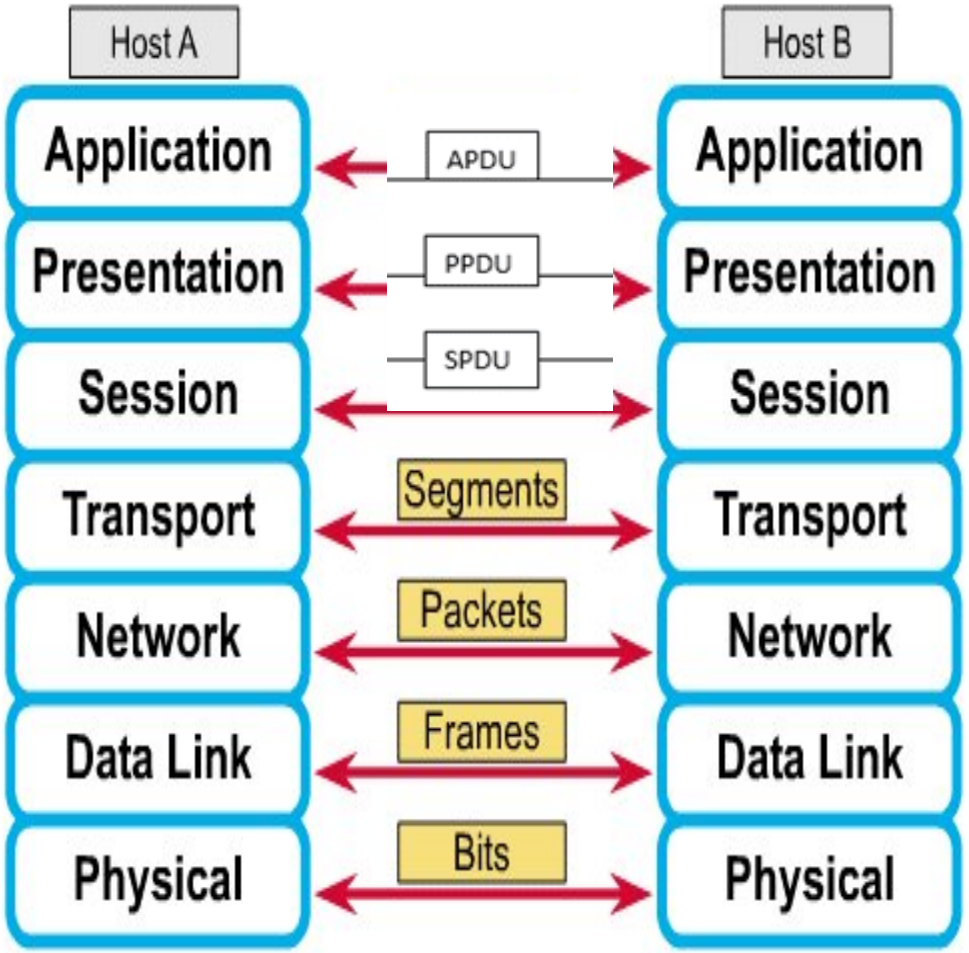
- Another aspect of data communications in the OSI model is ***encapsulation***.
  - The data protion of a packet at level ***N-1*** carries the whole packet (data and header and maybe trailer) from level ***N***.
  - Level ***N-1*** is not aware of which part of the encapsulated packet is data and which part is the header or trailer.
  - For level N-1, the whole packet coming from level N is treated as one logical unit.

Encapsulation

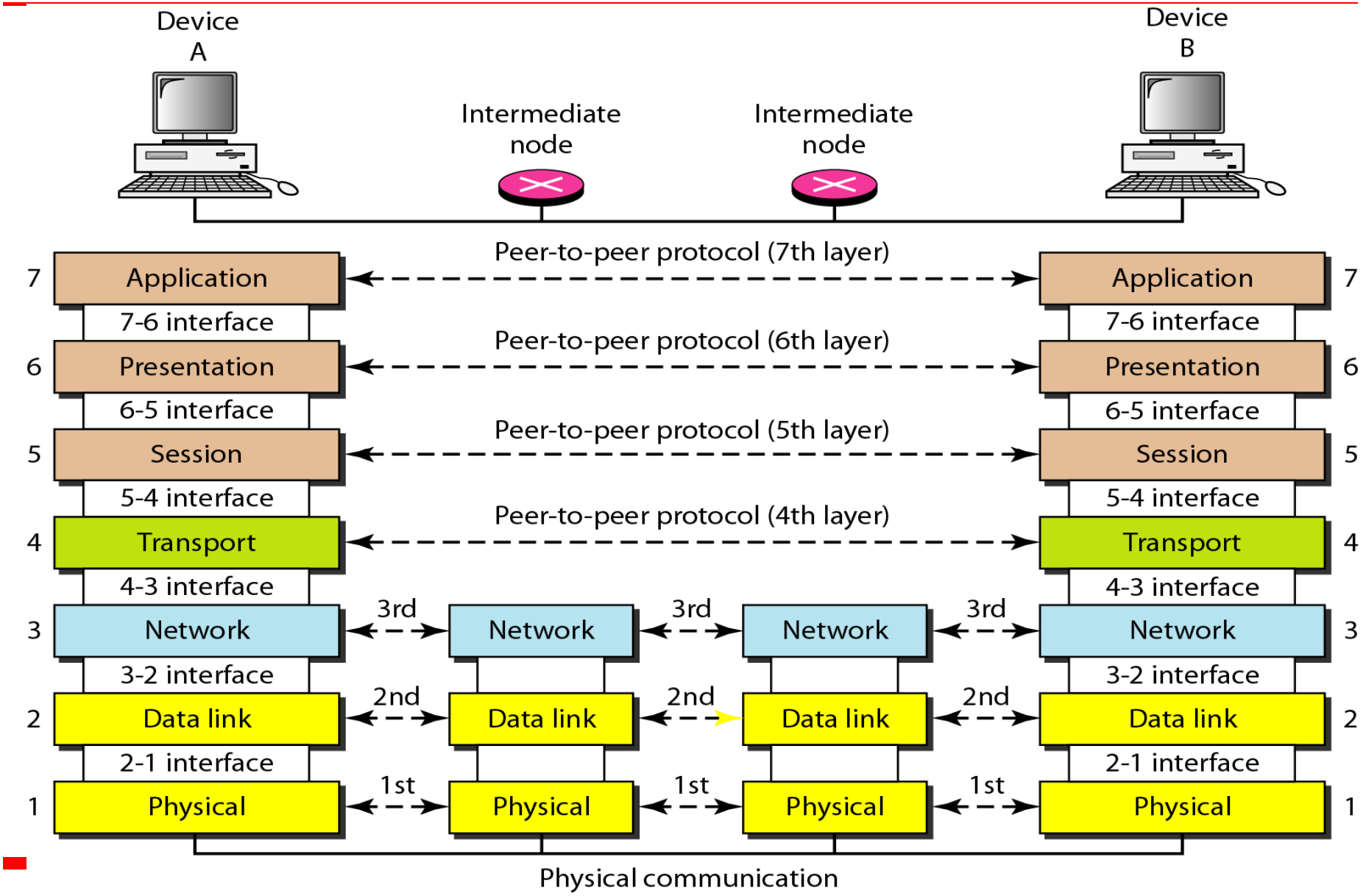


How layers are implemented?





The interaction between layers in the OSI model



LAYERS IN THE OSI MODEL

Physical Layer
Data Link Layer
Network Layer
Transport Layer
Session Layer
Presentation Layer
Application Layer

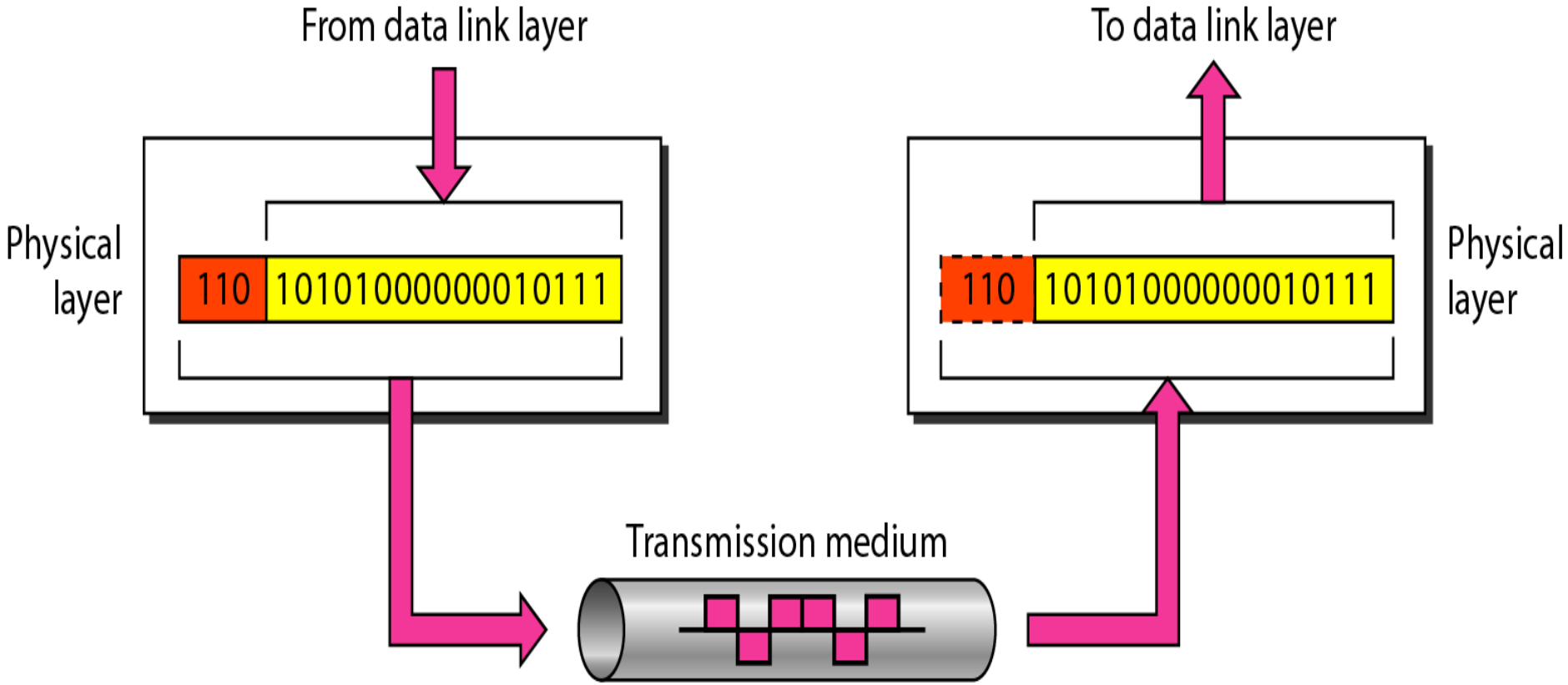
Physical layer

- The physical layer coordinate the functions required to carry a bit stream over a physical medium including:
  - Dealing with the mathematical and electrical specifications of the interfaces and transmission medium.
  - It defines the procedures and functions that physical devices and interfaces have to perform for transmission to occur.

Physical layer

- The physical layer is also concerned with:
  - Physical characteristics of interfaces and medium.
  - Representation of bits
  - Data rate
  - Synchronization of bits
  - Line configuration
  - Physical topology
  - Transmission mode

Physical layer



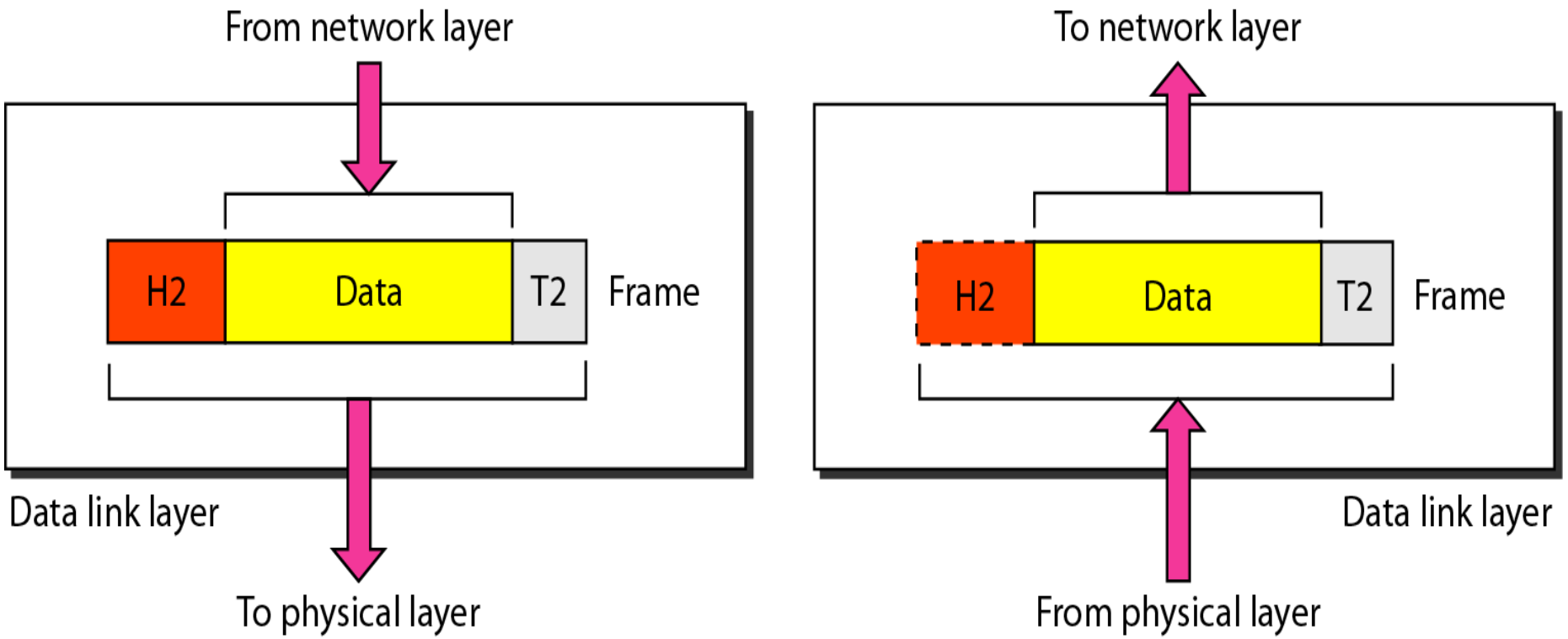
Data Link layer

- The data link layer transforms the physical layer to reliable link.
- It makes the physical layer appear error-free to the upper layer (network layer).

Sub-layers of the Data Link Layer

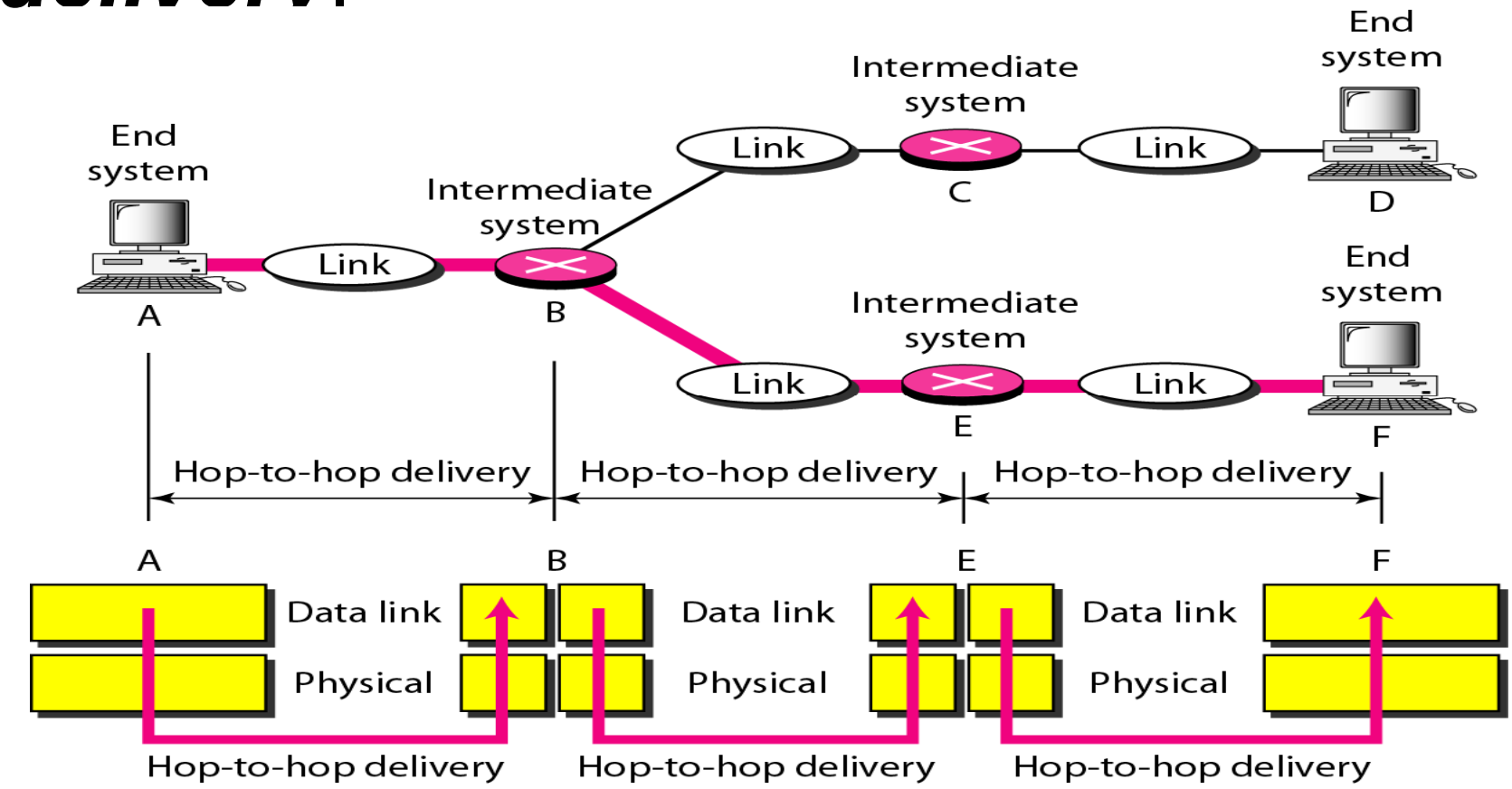
- MAC (Media Access Control)
  - Gives data to the NIC
  - Controls access to the media through:
    - CSMA/CD Carrier Sense Multiple Access/Collision Detection
    - Token passing
- LLC (Logical Link Layer)
  - Manages the data link interface (or Service Access Points (SAPs))
  - Can detect some transmission errors using a Cyclic Redundancy Check (CRC). If the packet is bad the LLC will request the sender to resend that particular packet.

Data link layer



Data Link layer

- The data link layer provides ***hop-to-hop deliverv***.



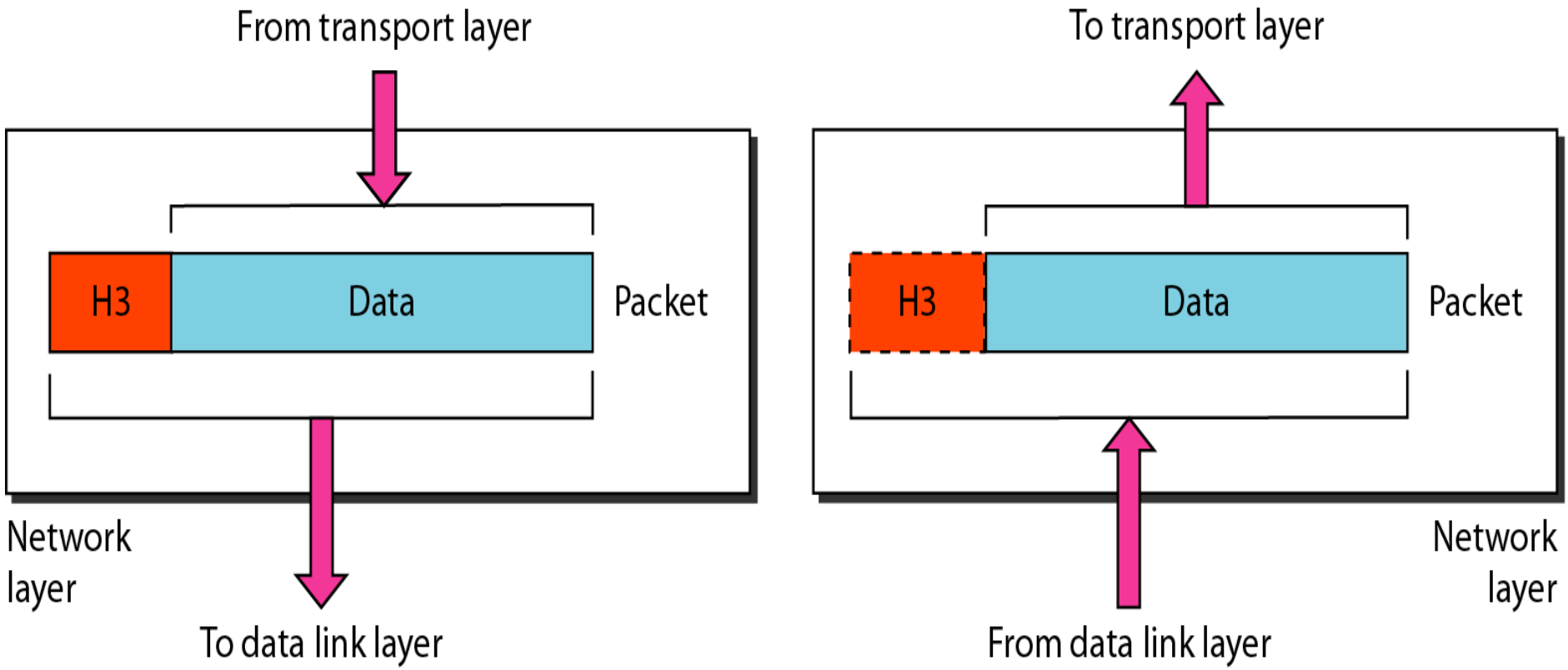
Data Link layer

- There are other responsibilities of data link layer include:
  - ***Framing***
  - ***Physical addressing***
  - ***Flow control***
  - ***Error control***
  - ***Access control***

Network layer

- The network layer is responsible for the delivery of individual packets from the source host to the destination host.
- At the sender side, data is received from the higher layer (transport) and passed down to the lower layer (data link).
- At the sender side, data is received from the lower layer (data link) and passed up to the upper layer (transport).

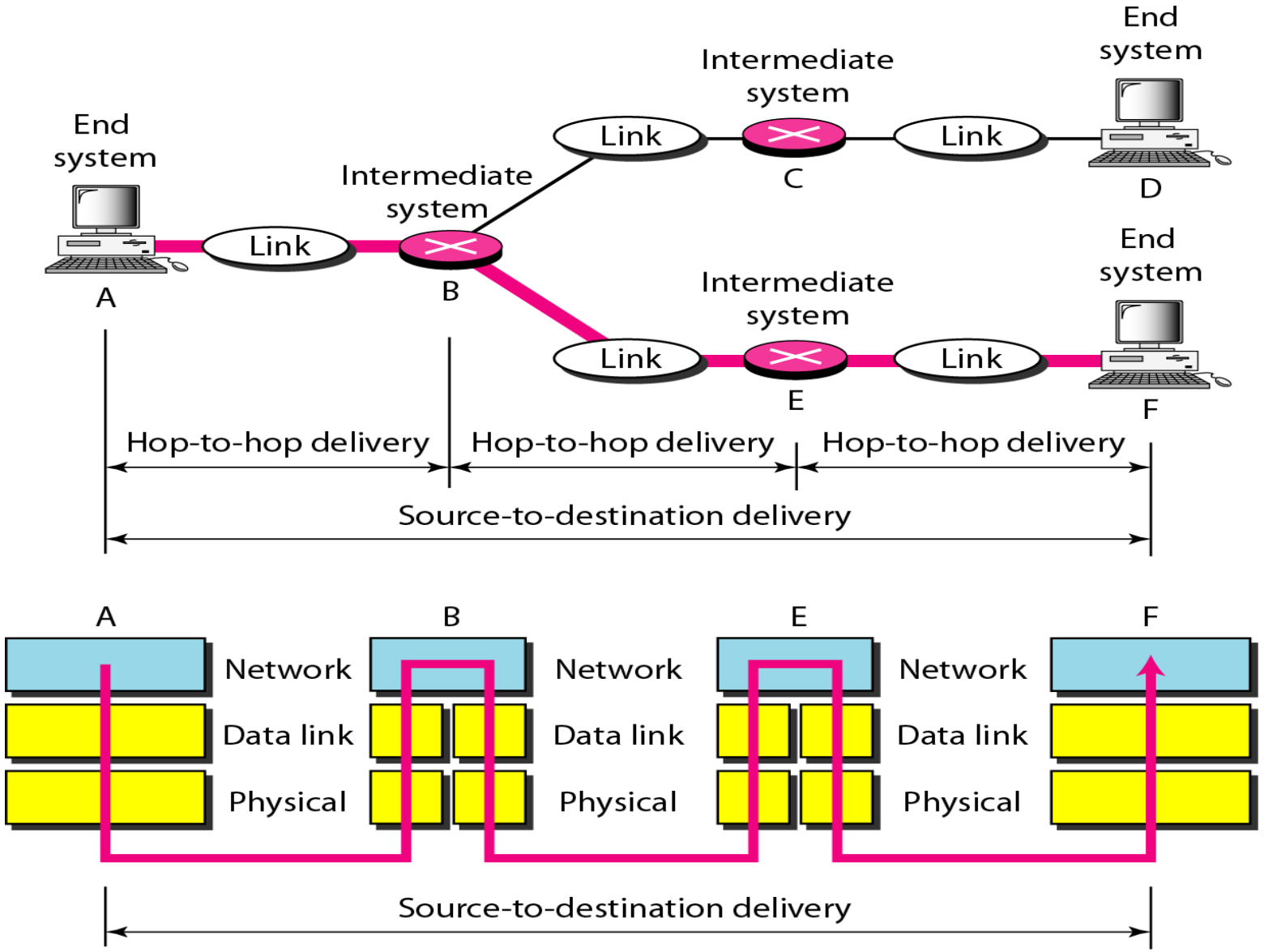
Network layer



Network layer

- Again, the network layer is responsible for the delivery of individual packets from source to destination.
- If two systems are connected to the same link, there is usually no need for a network layer.
- If the two systems are attached to different networks with connecting devices between the networks, there is often a need for the network layer to accomplish ***source-to-destination delivery***.

Source-to-destination delivery



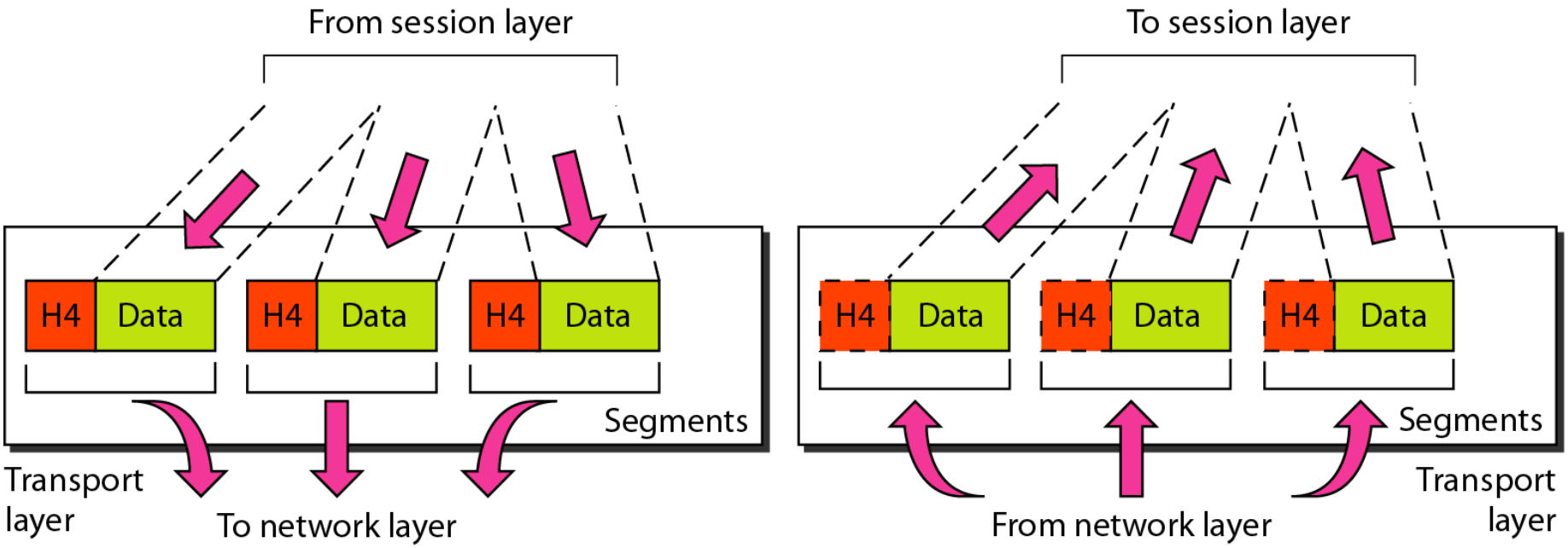
Network layer

- Other responsibilities of network layer include:
  - ***Logical addressing***
  - ***Routing***

Transport layer

- The transport layer is responsible for the delivery of a message from one **process** to another.
- At the sender side, it receives application data and passes it down to the network layer.
- At the receiver side, it receives data from the network layer and passes it up to the appropriate process.

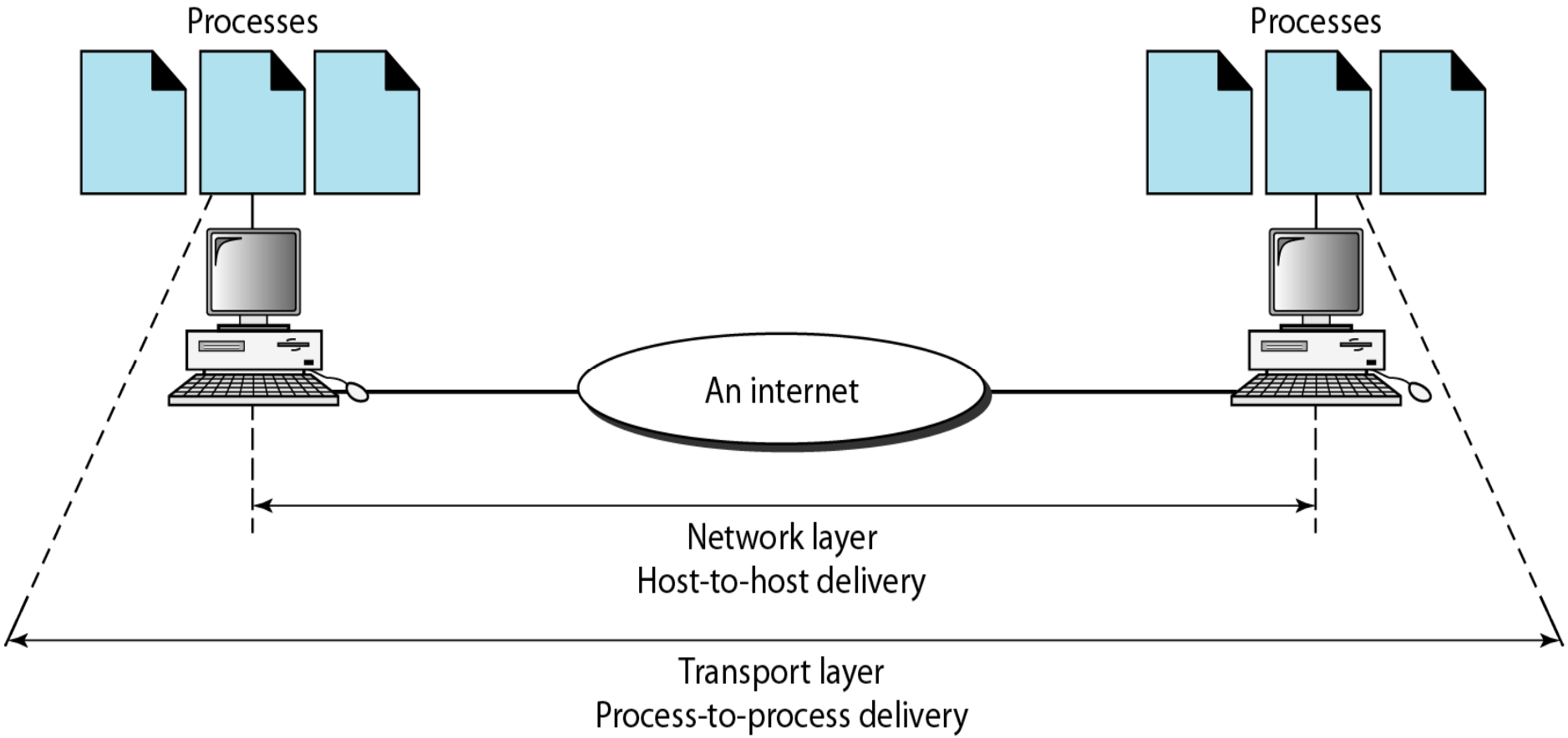
Transport layer



Transport layer

- Again, the transport layer is responsible for the delivery of a message from one **process** to another.
- Unlike the network layer which is source-to-destination delivery, the transport layer is ***process-to-process delivery*** of the entire message.

Reliable process-to-process delivery of a message

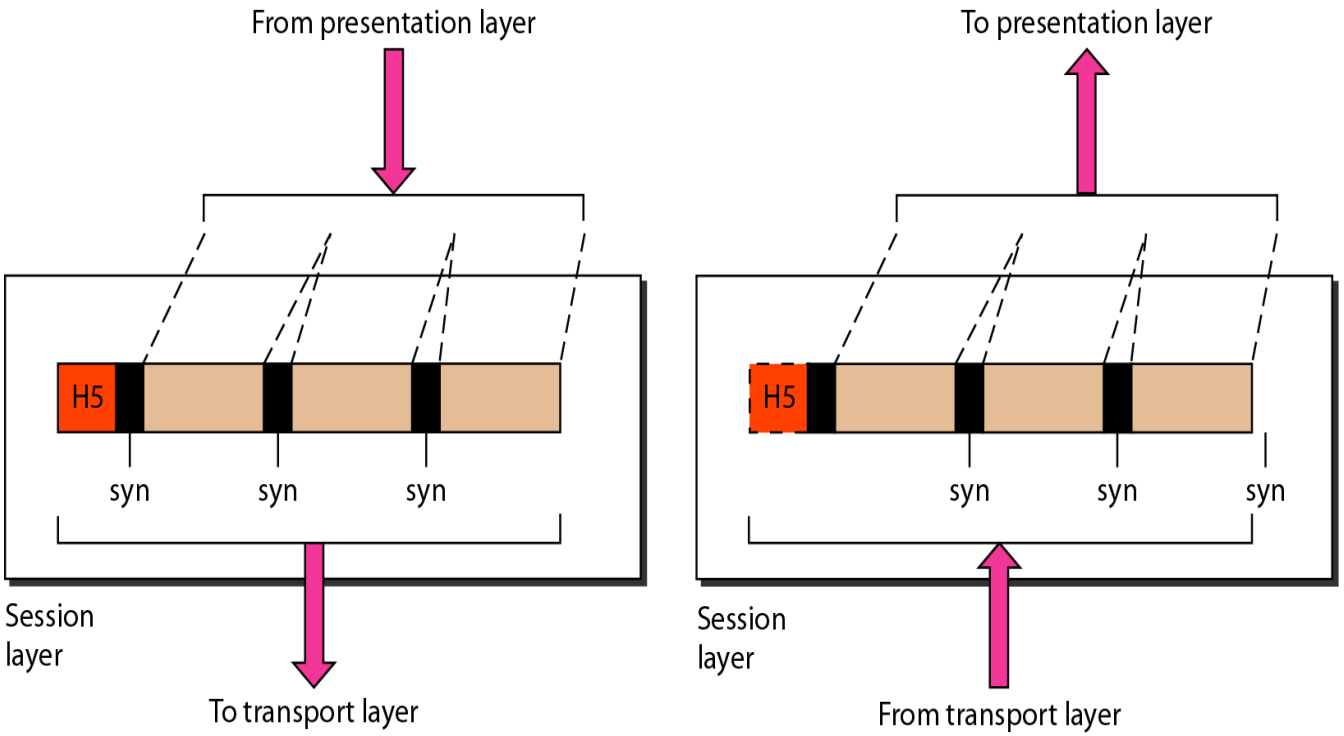


Transport layer

- Other responsibilities of transport layer:
  - ***Service-point addressing***
  - ***Segmentation and reassembly***
  - ***Connection control***
  - ***Flow control***
  - ***Error control***

Session layer

- The session layer is responsible for dialog control and synchronization.

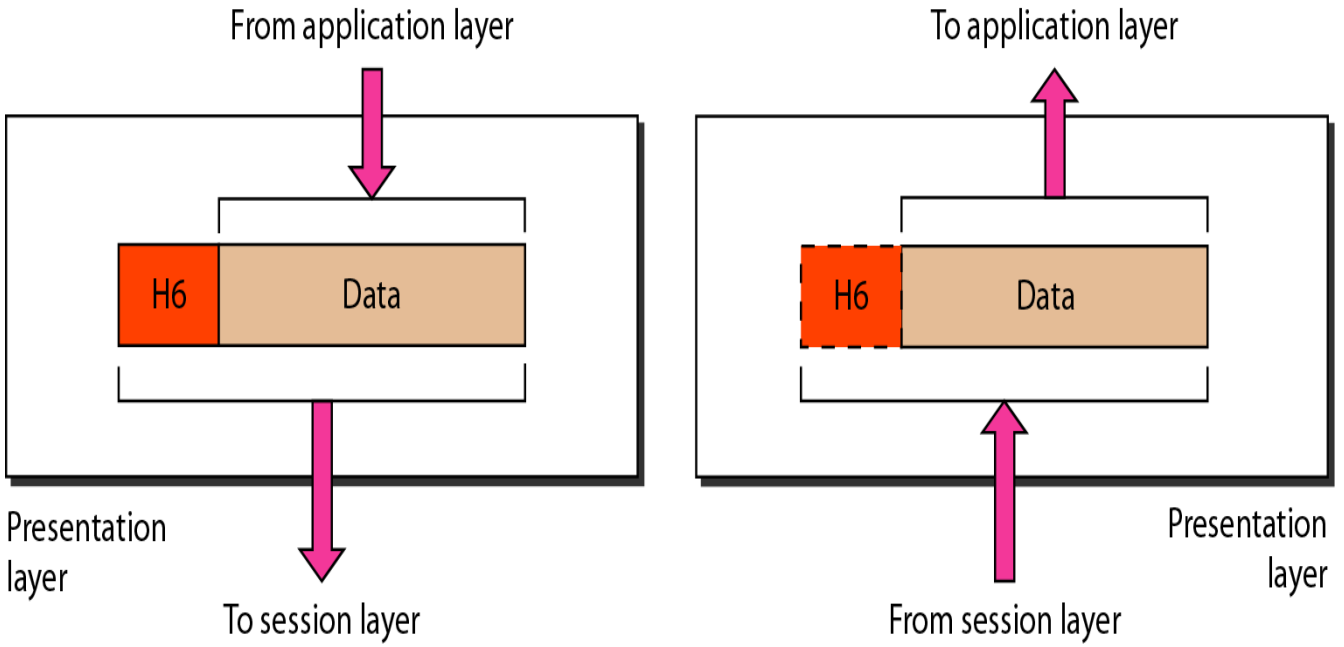


Session layer

- Specific responsibilities of the session layer include:
  - ***Dialog control***
  - ***Synchronization***
  - ***Authorization and Authentication***

Presentation layer

- The presentation layer is concerned with syntax and semantics of the information exchange between two systems.



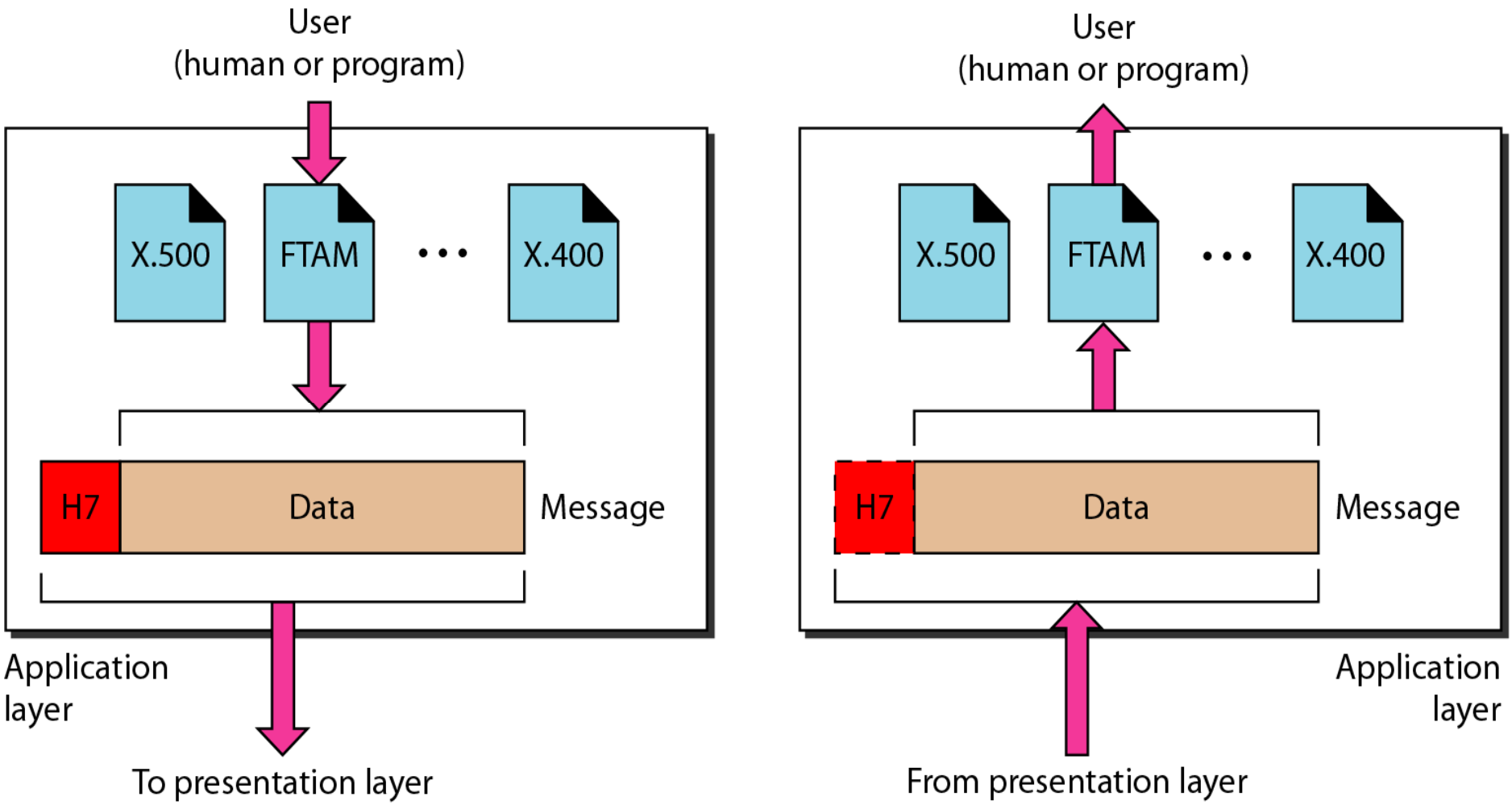
Presentation layer

- Specific responsibilities of presentation layer:
  - ***Translation***
  - ***Encryption***
  - ***Compression***

Application layer

- The application layer enables user, weather human or software, to access the network.
- It provides user interfaces and support for services such as e-mail, remote file access and transfer, shared database management, and other types of distributed information services.

Application layer



Application layer

- Specific responsibilities of presentation layer:
  - ***Network virtual terminal***
  - ***File transfer, access, and management***
  - ***Mail services***
  - ***Directory services***

Protocols for each layer

Layer	Example
7.) Application	HTTP, FTP, SMTP
6.) Presentation	ASCII, JPEG, PGP
5.) Session	BOOTP, NetBIOS, DHCP, DNS
4.) Transport	TCP, UDP, SPX
3.) Network	IP, IPX, ICMP
2.) Data Link	Ethernet, Token Ring, Frame Relay
1.) Physical	RS232, 100BaseTX, ISDN

Summary of layers