Network Models

Organizations have developed standard sets of protocols

Some of these organizations are:

- The International Standards Organization (ISO)
- The Institute of Electrical and Electronic Engineers (IEEE)
- The American National Standards Institute (ANSI)
- The Electronic Industries Association (EIA)
- The International Telecommunications Union-Telecommunication Standards Sector (ITU-T). This group was formerly known as the Consultative Committee on International Telephone and Telegraph (CCITT

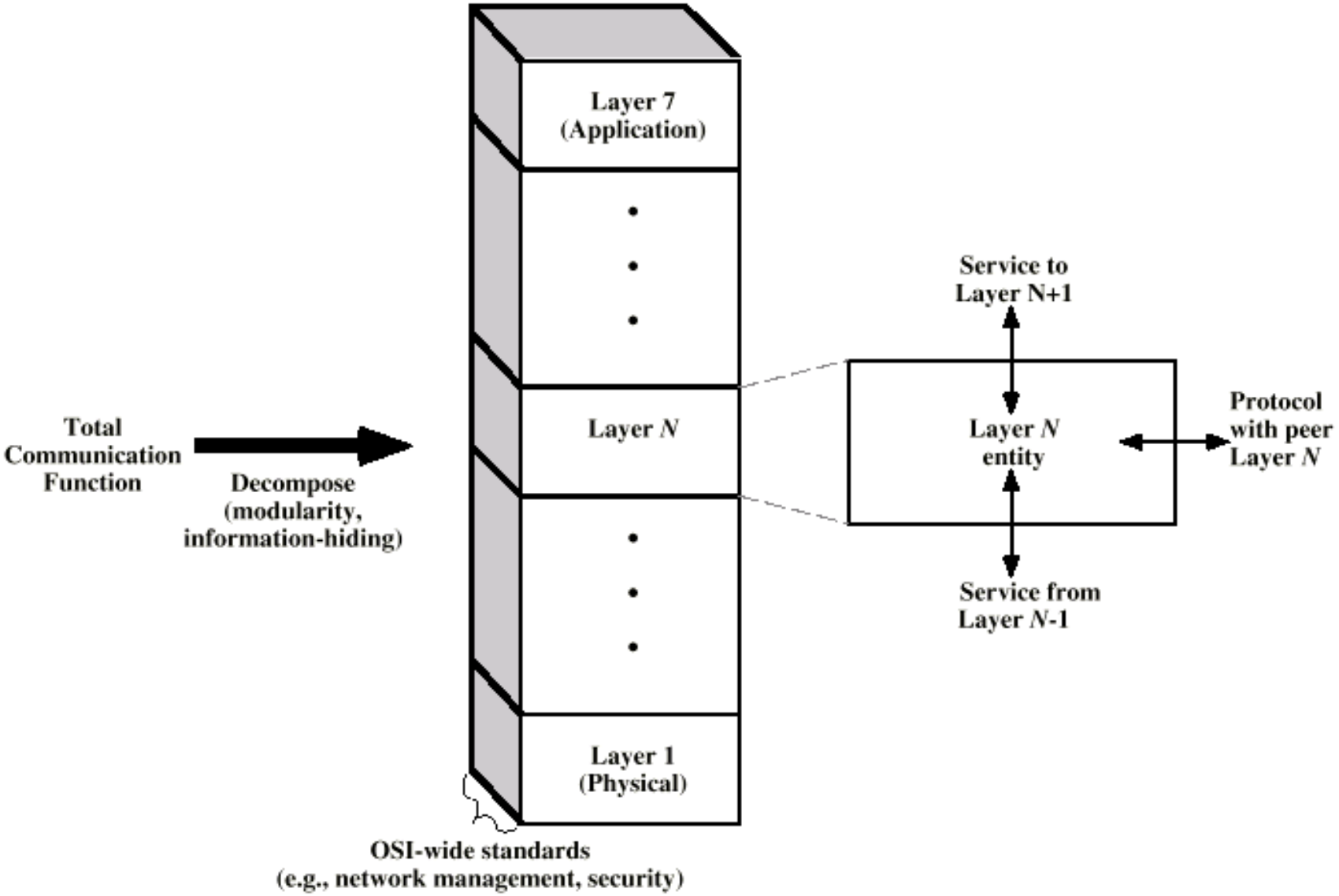
Elements of Standardization

- Protocol specification
  - Operates between the same layer on two systems
  - May involve different operating system
  - Protocol specification must be precise
    - Format of data units
    - Semantics of all fields
    - allowable sequence of PCUs
- Service definition
  - Functional description of what is provided
- Addressing
  - Referenced by SAPs

Key Elements of a Protocol

- Syntax
  - Data formats
  - Signal levels
- Semantics
  - Control information
  - Error handling
- Timing
  - Speed matching
  - Sequencing

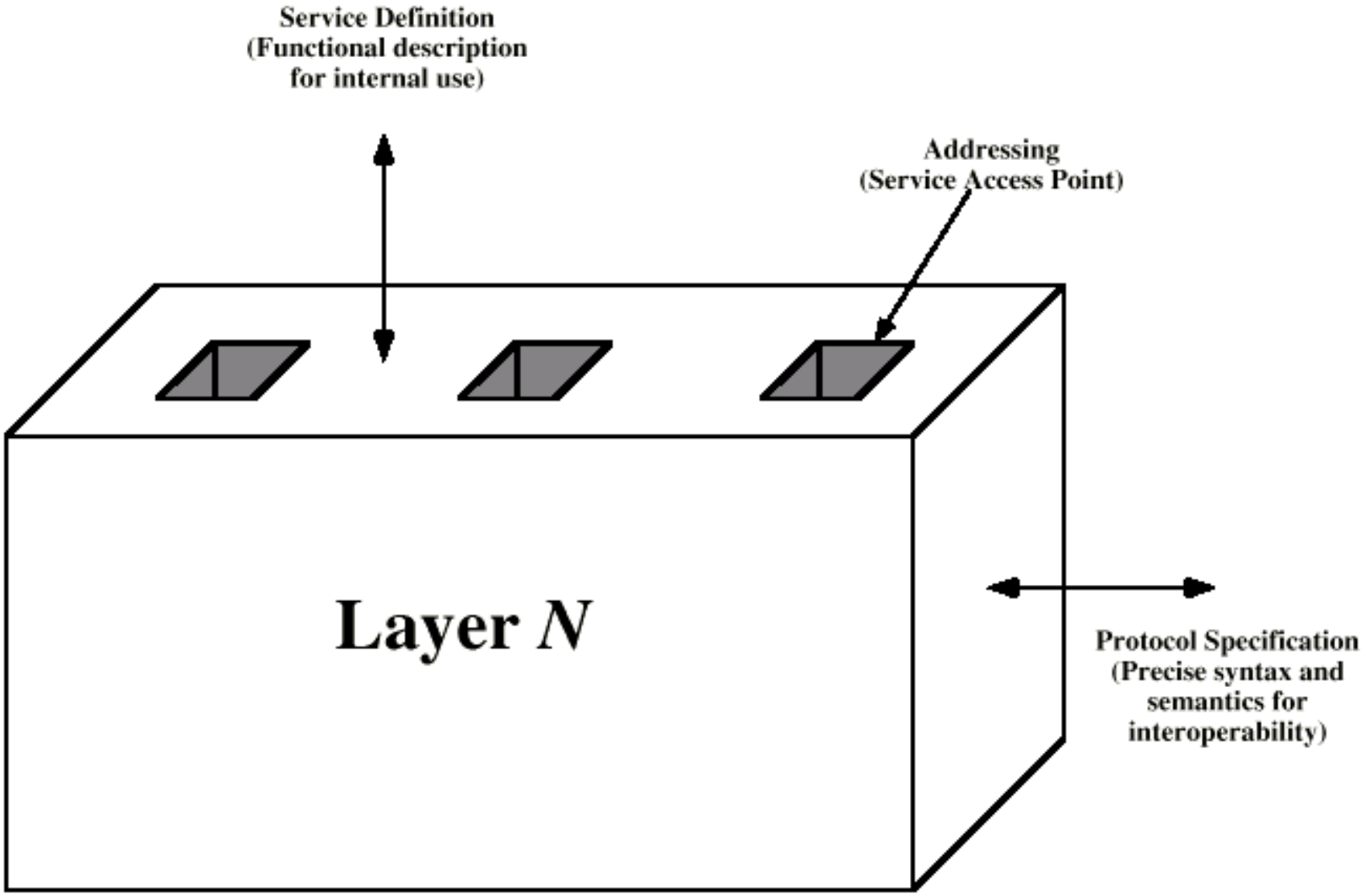
OSI as Framework for Standardization



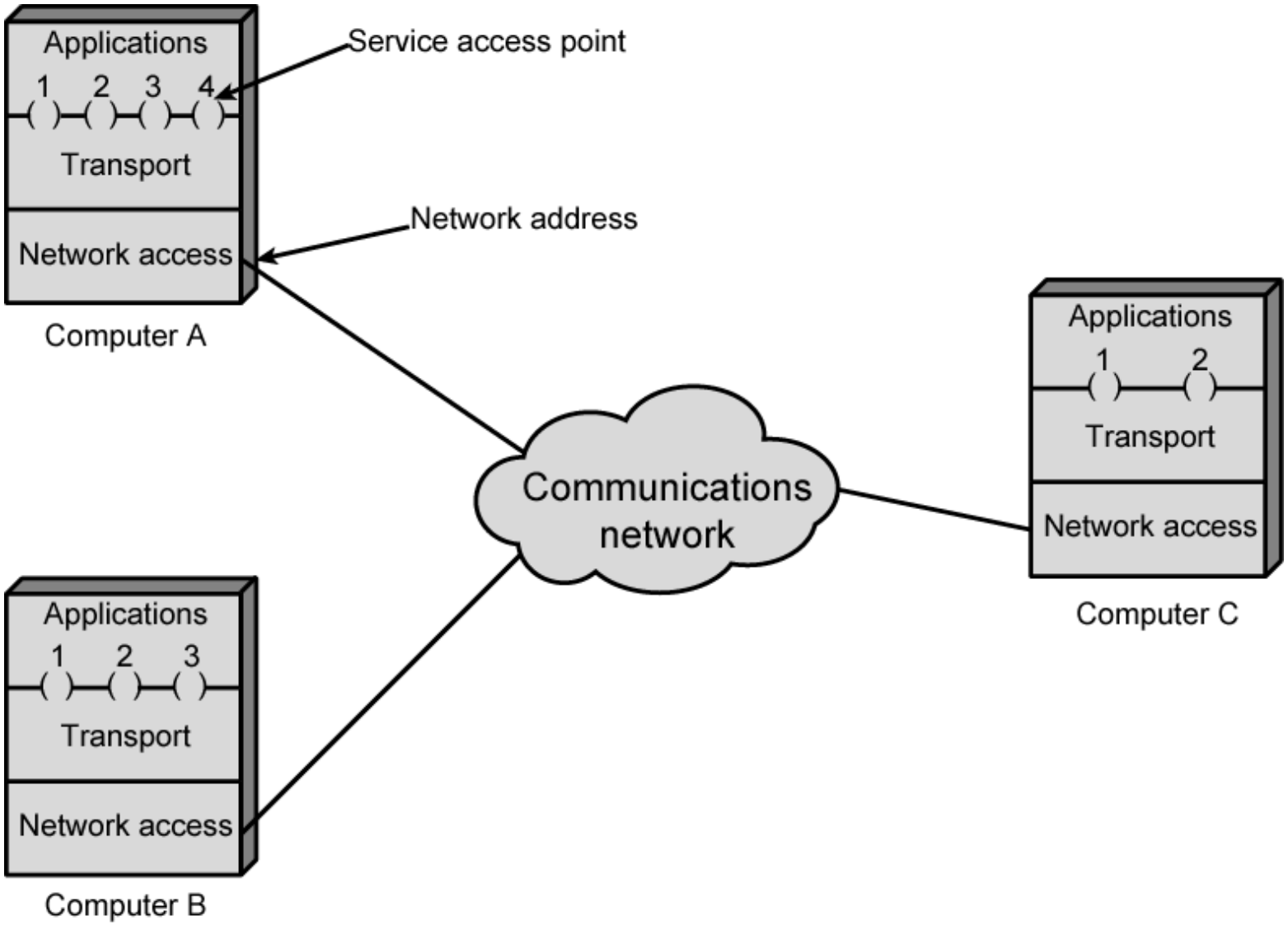
Protocol Architecture

- Task of communication broken up into modules
- For example file transfer could use three modules
  - File transfer application
  - Communication service module
  - Network access module

Layer Specific Standards



Protocol Architectures and Networks



Protocol Data Units (PDU)

- At each layer, protocols are used to communicate
- Control information is added to user data at each layer
- Transport layer may fragment user data
- Each fragment has a transport header added
  - Destination SAP
  - Sequence number
  - Error detection code
- This gives a transport protocol data unit

Standardized Protocol Architectures

- Required for devices to communicate
- Vendors have more marketable products
- Customers can insist on standards based equipment
- Two standards:
  - OSI Reference model
    - Never lived up to early promises
  - TCP/IP protocol suite
    - Most widely used
- Also: IBM Systems Network Architecture (SNA)

Communications Tasks

Transmission system utilization	Addressing
Interfacing	Routing
Signal generation	Recovery
Synchronization	Message formatting
Exchange management	Security
Error detection and correction	Network management
Flow control	

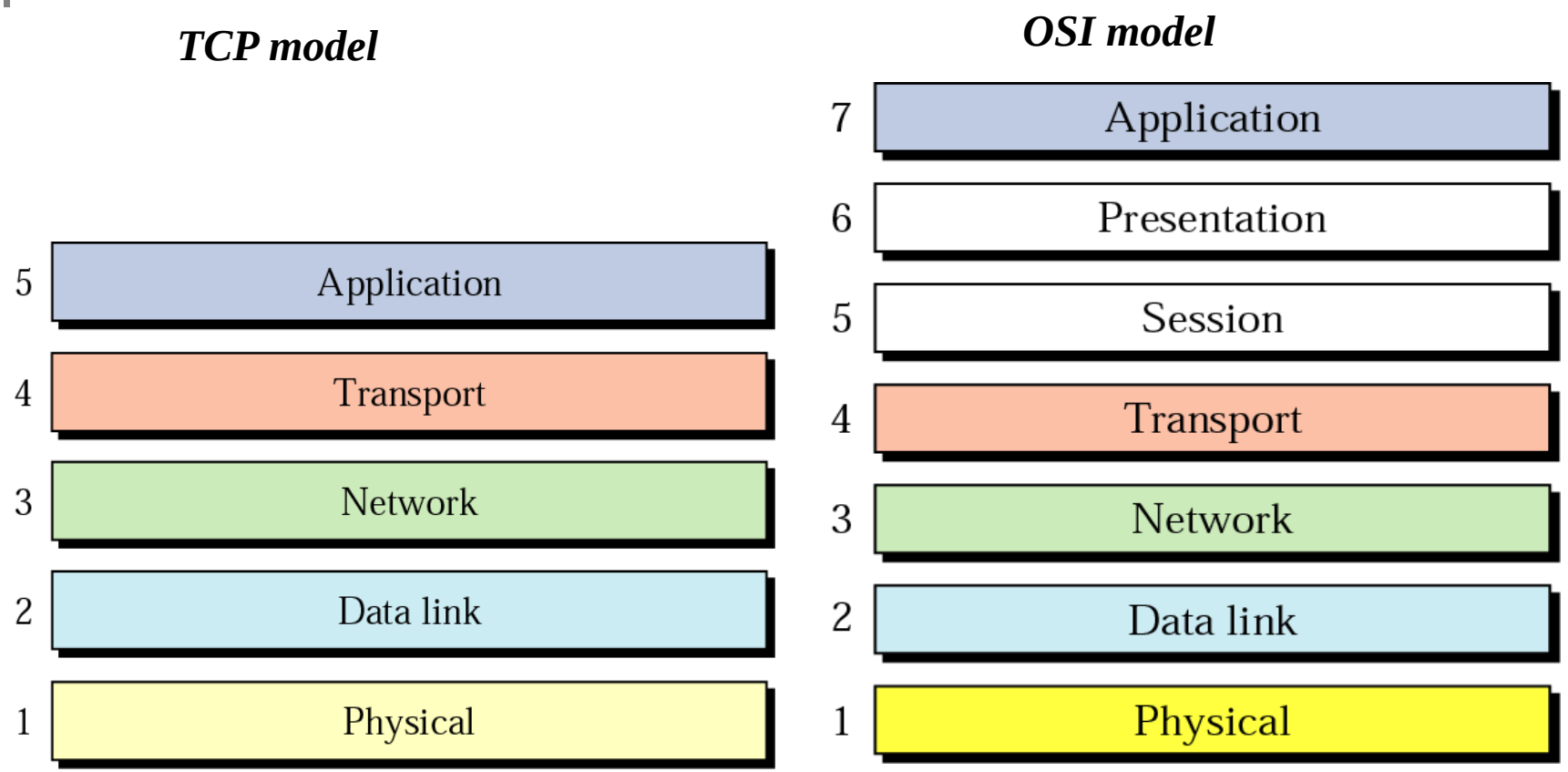
OSI

- Open Systems Interconnection
- Developed by the International Organization for Standardization (ISO)
- Seven layers
- A theoretical system delivered too late!
- TCP/IP is the de facto standard

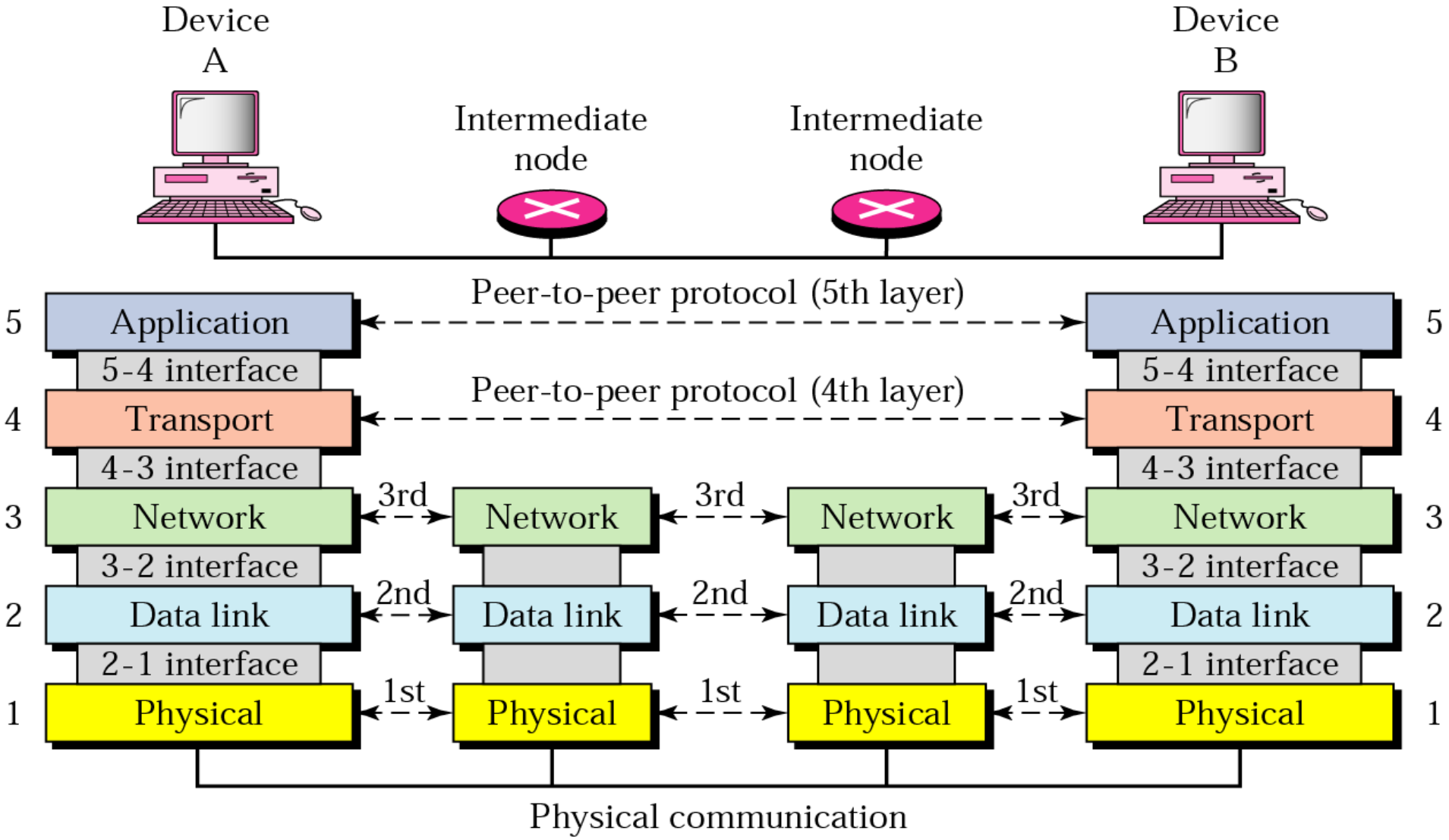
OSI - The Model

- A layer model
- Each layer performs a subset of the required communication functions
- Each layer relies on the next lower layer to perform more primitive functions
- Each layer provides services to the next higher layer
- Changes in one layer should not require changes in other layers

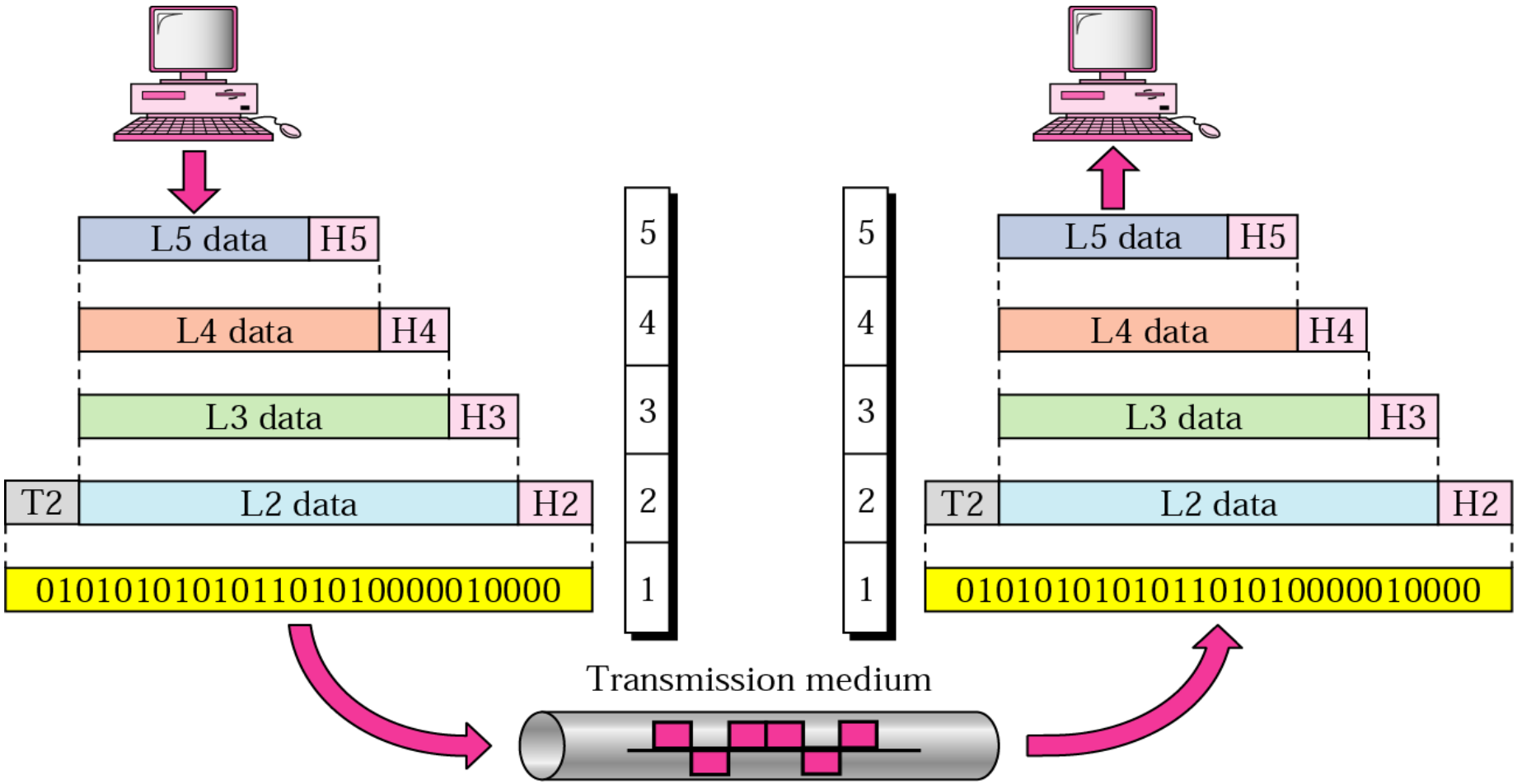
Internet layers



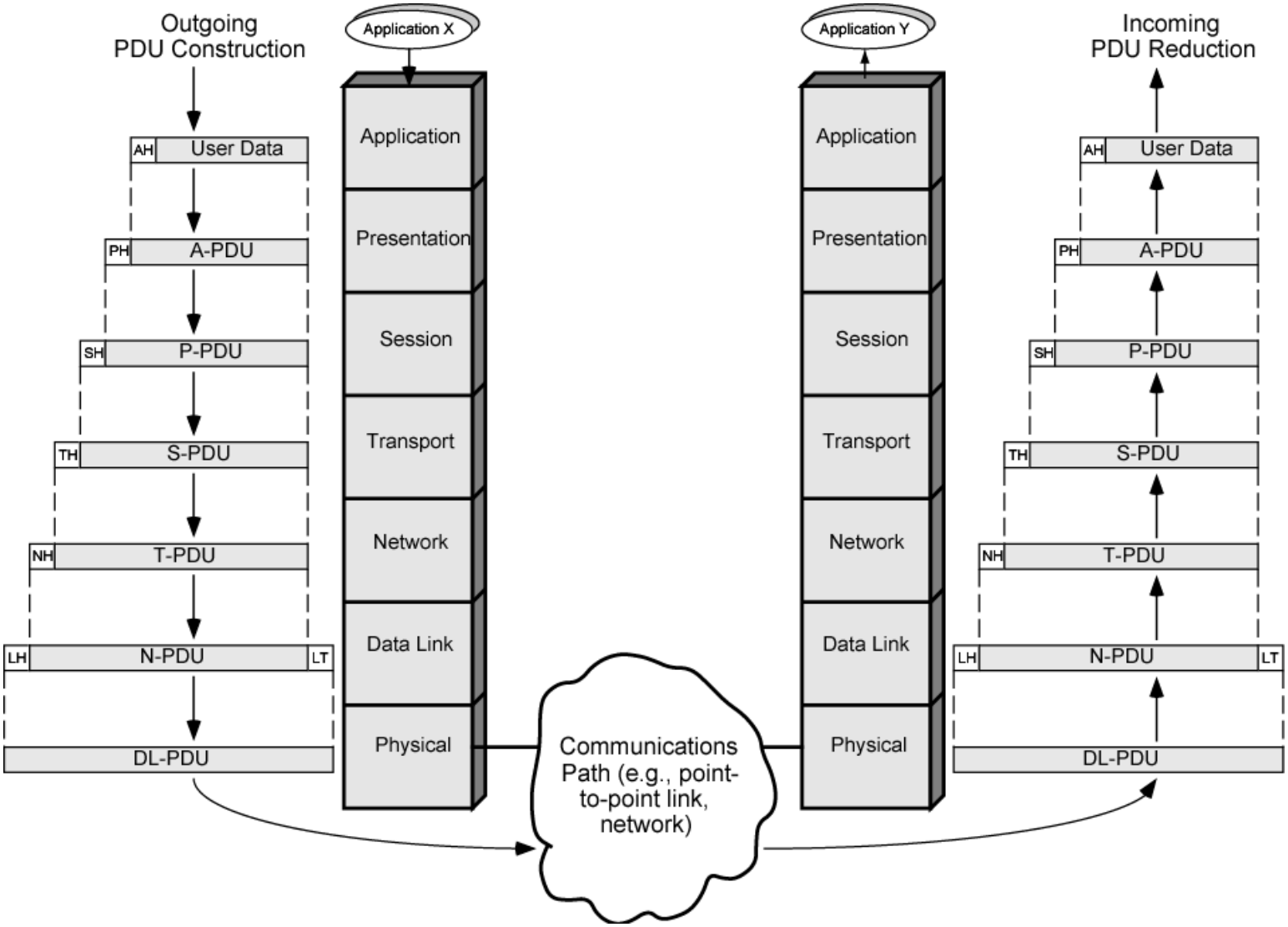
Peer-to-peer processes



An exchange using the Internet model

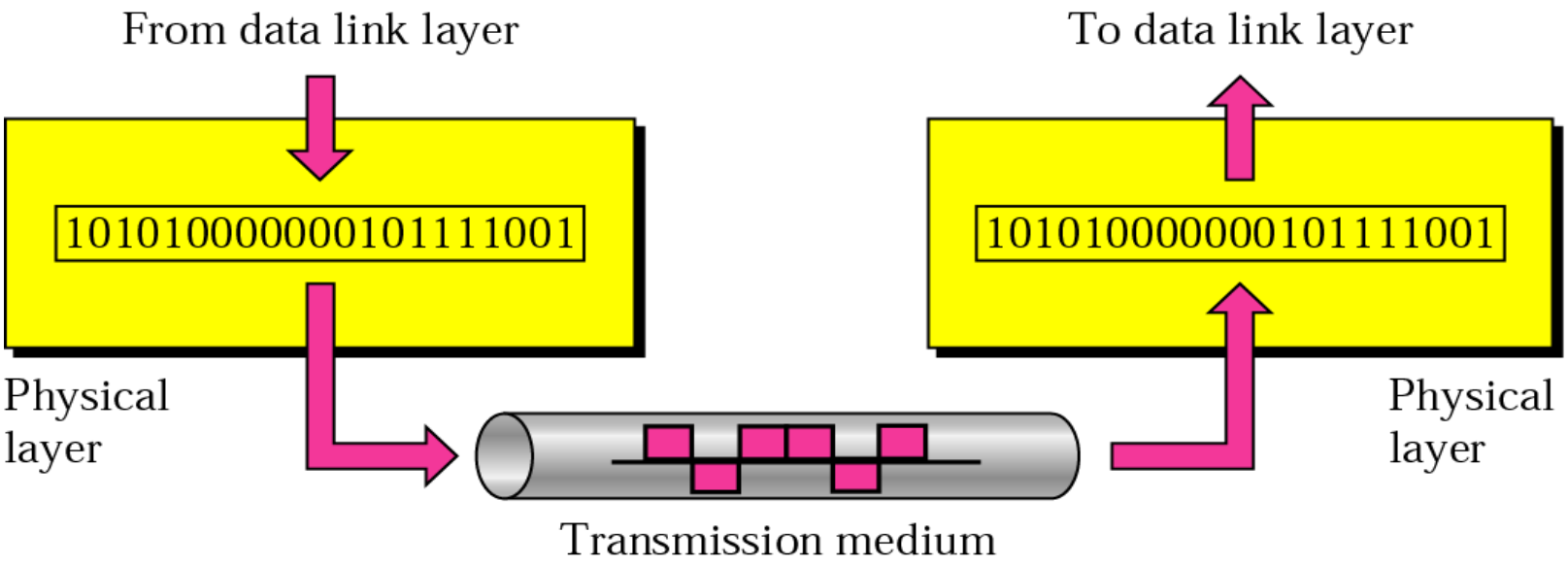


The OSI Environment



Physical interface between devices

- Mechanical
- Electrical
- Functional
- Procedural



Physical layer

The physical layer is responsible for transmitting individual bits from one node to the next.

It is concerned with transmitting an unstructured bit stream over a communication channel.

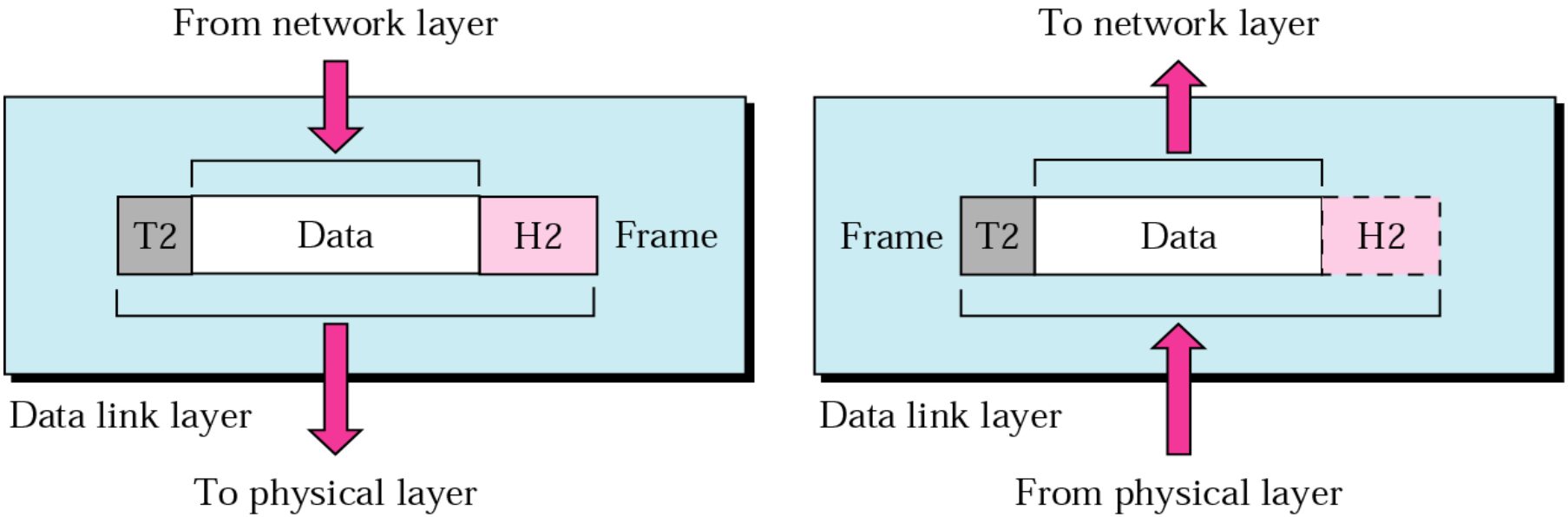
The physical layer responsibilities include:

- *mechanical connection*
- *transmition medium*
- *representing and synchronizing bits*
- *establishing the transmission rate or number of bits transmitted per second*
- *establishing line configuration*
- *establishing physical topology*
- *establishing transmission mode*

The data link layer transfers blocks of data between two nodes in a network.

It is concerned with creating and transmitting frames that contain these blocks of data.

- Means of activating, maintaining and deactivating a reliable link
- Error detection and control



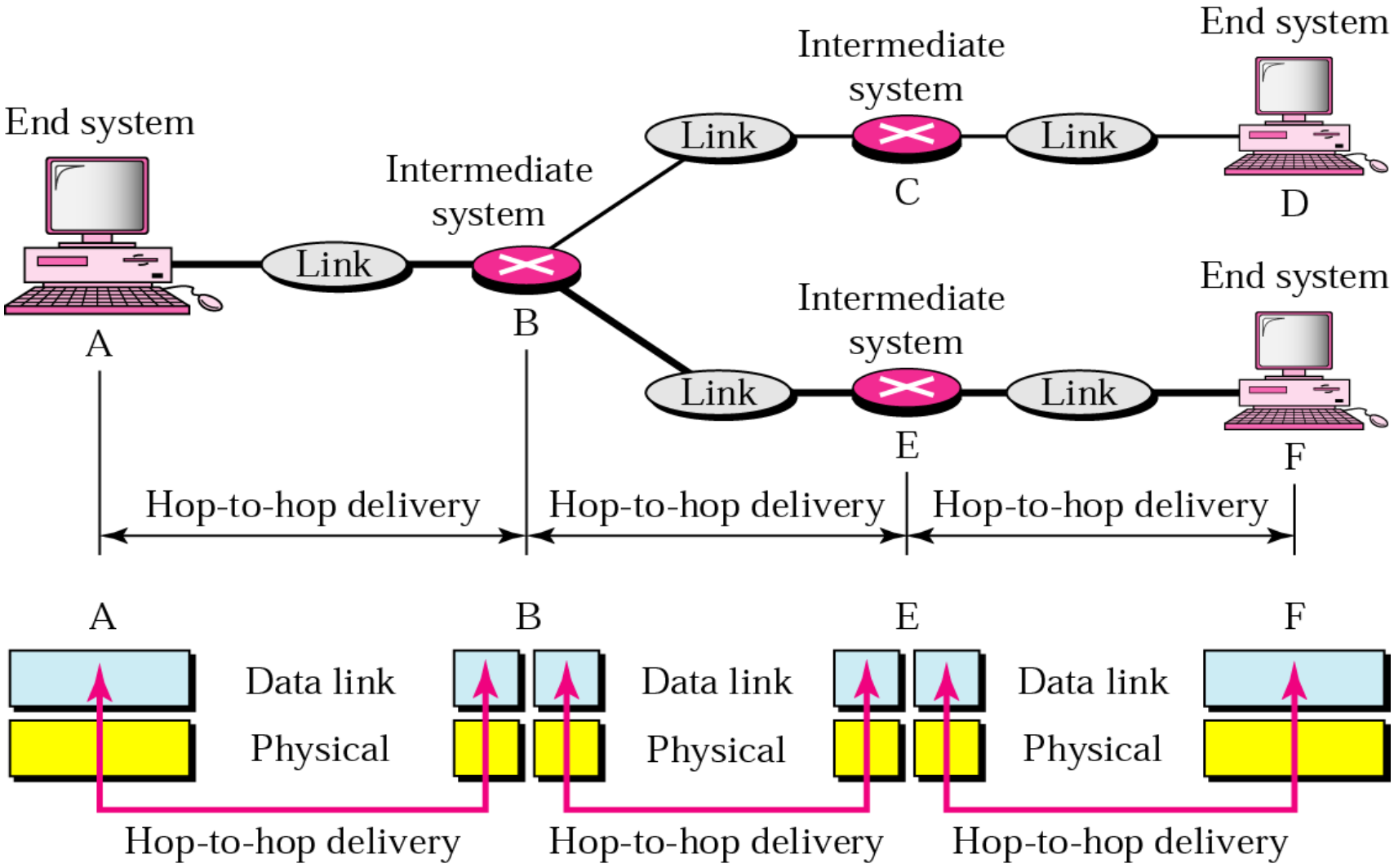
Data Link

The data link layer is responsible for transmitting frames from one node to the next.

The data link layer responsibilities include:

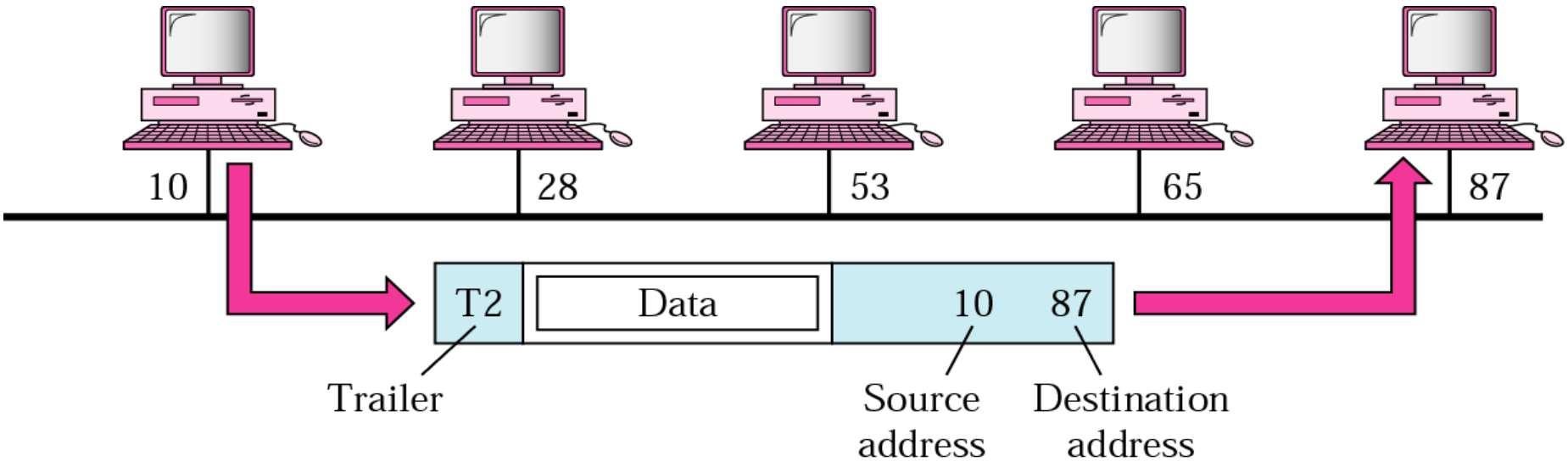
- *creating frames of data*
- *determining where a frame starts and ends*
- *physical addressing at the link level of sender and receiver*
- *providing flow control to keep one node from overwhelming the other node*
- *detecting transmission errors*
- *providing access control to determine who has control of the link at any one time*

Node-to-node delivery



Example

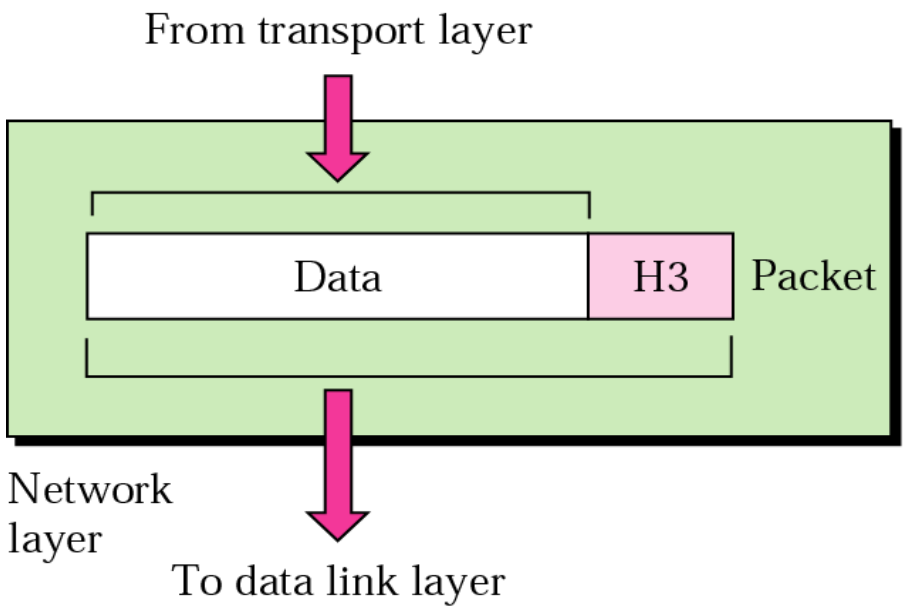
A node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link. At the data link level this frame contains physical addresses in the header. These are the only addresses needed. The rest of the header contains other information needed at this level. The trailer usually contains extra bits needed for error detection

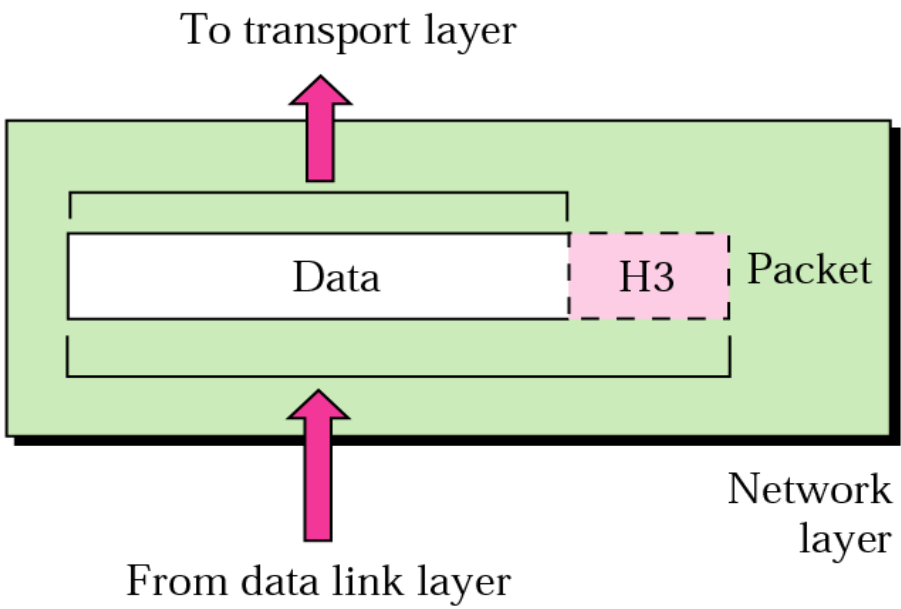


Network

The network layer is responsible for the delivery of packets from the original source to the final destination.

- Transport of information
- Higher layers do not need to know about underlying technology
- Not needed on direct links

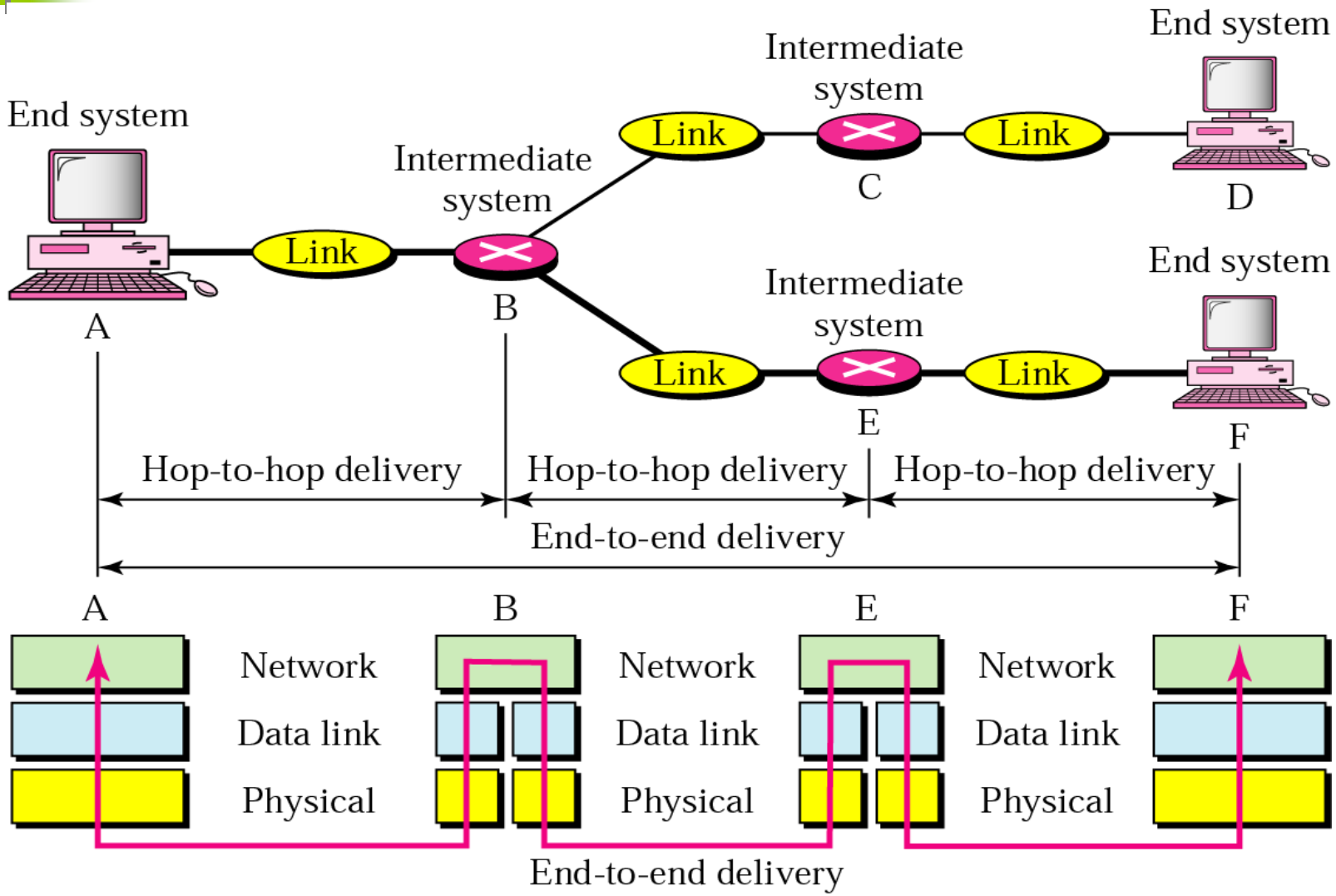




Network layer

- The network layer provides data transfer of a segment of a message from a source to a destination end-system across switched telecommunications networks, possibly involving multiple data links. The message segments in the network layer are called *packets*.
- The network layer responsibilities include:
  - *logical addressing at the network level of sender and receiver*
  - *routing packets through the network*
  - *network control (by providing node status to other nodes)*
  - *congestion control (by routing around points of congestion)*
  - *collecting accounting data for billing purposes*

Source-to-destination delivery



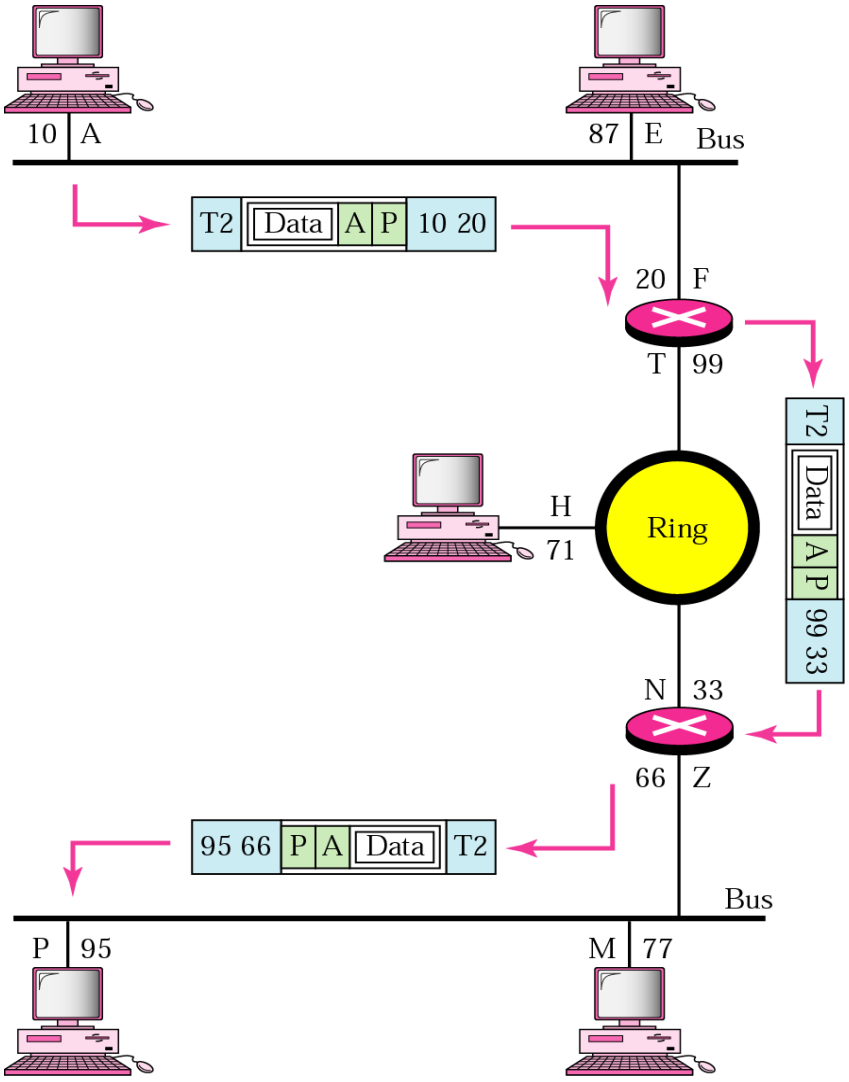
Example

We want to send data from
•a node with network address **A** and physical address 10, located on one LAN,
•to a node with a network address **P** and physical address 95, located on another LAN.

Because the two devices are located on different networks, we cannot use physical addresses only;

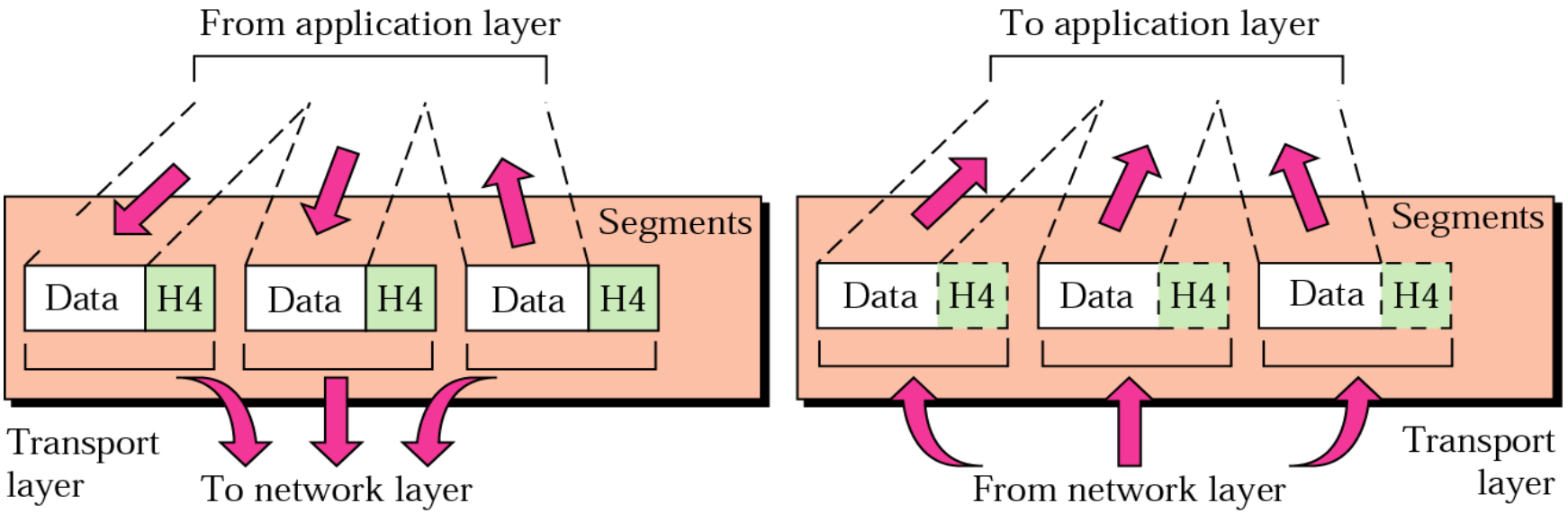
The physical addresses only have local jurisdiction.

What we need here are universal addresses that can pass through the LAN boundaries. The network (logical) addresses have this characteristic.



Transport

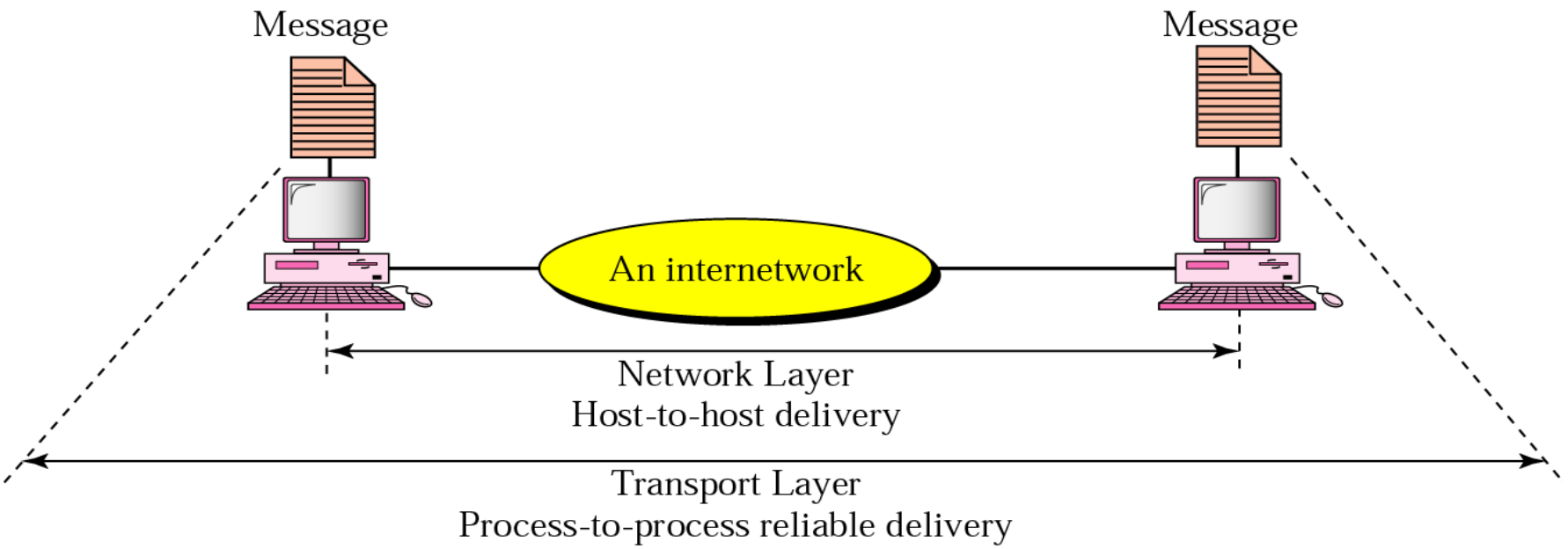
- Exchange of data between end systems
- Error free
- In sequence
- No losses
- No duplicates
- Quality of service



Transport Layer

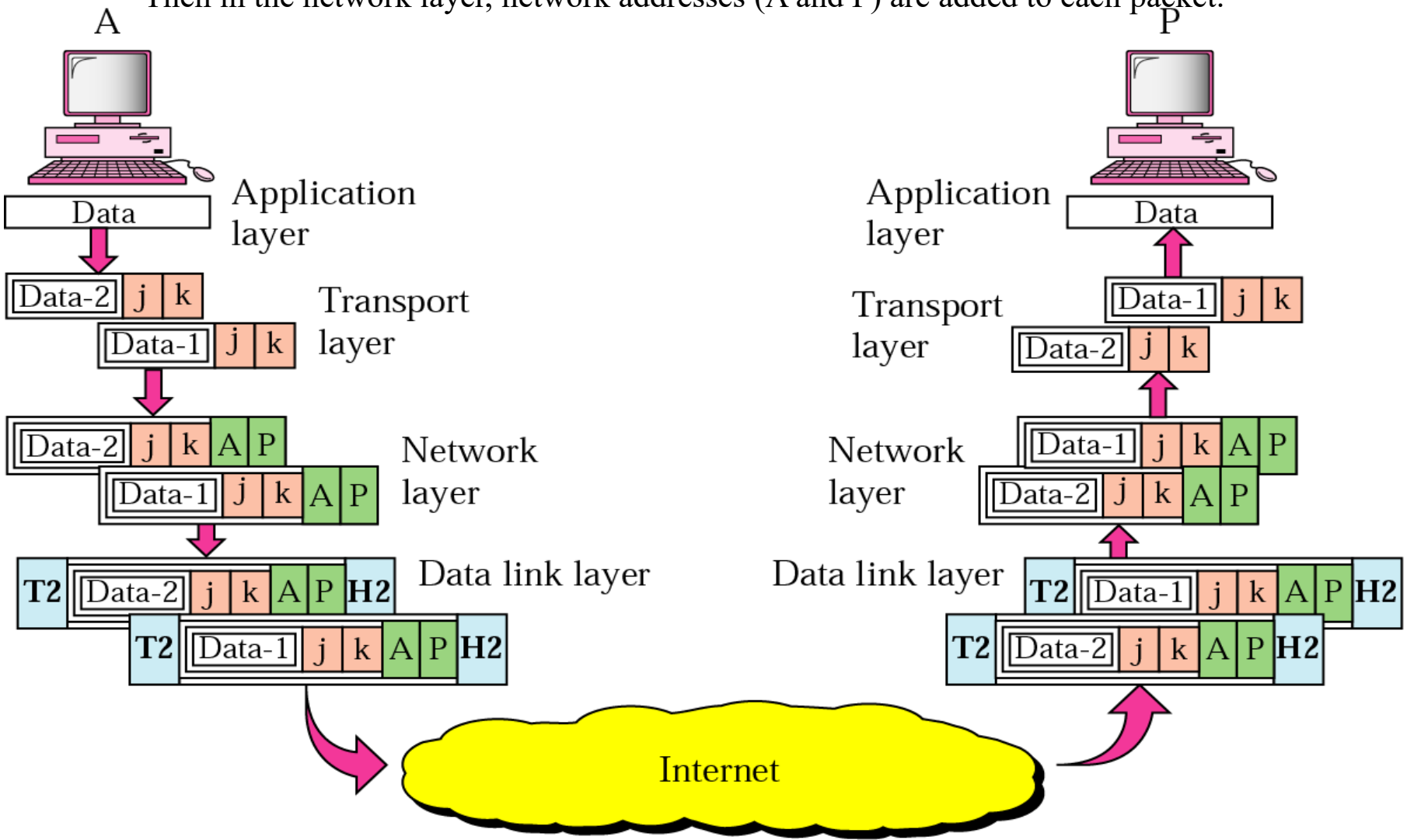
- ***The transport layer is responsible for delivery of a message from one process to another.***
- The transport layer provides reliable transmission of the entire message between the source and the destination processes.
- It is concerned with quality of service and the flow control of transactions.
- The transport layer responsibilities include:
  - *addressing of messages between processes*
  - *breaking messages into segments and reassembling the segments into messages to accommodate the size restrictions of networks*
  - *establishing and releasing connections for the flow of message segments*
  - *providing flow control to keep a sender from overwhelming a receiver*

Reliable process-to-process delivery of a message



Example : Transport layer communication

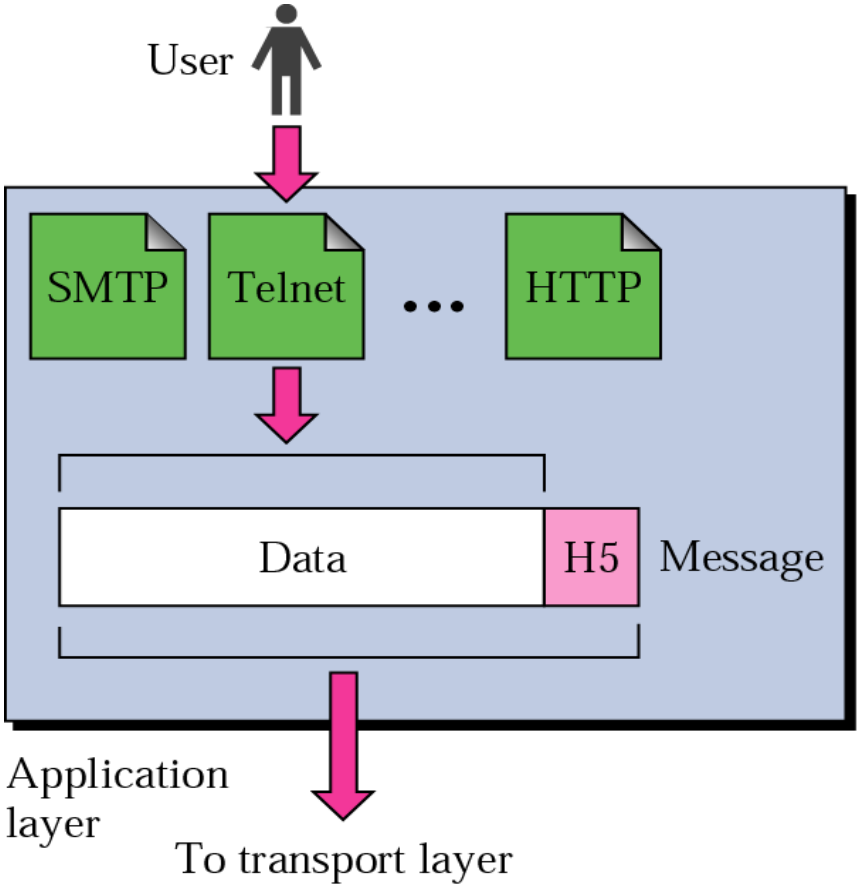
Data coming from the upper layers have port addresses j and k
(j is the address of the sending process, and k is the address of the receiving process).
Since the data size is larger than the network layer can handle, the data are split into two packets, each packet retaining the port addresses (j and k).
Then in the network layer, network addresses (A and P) are added to each packet.

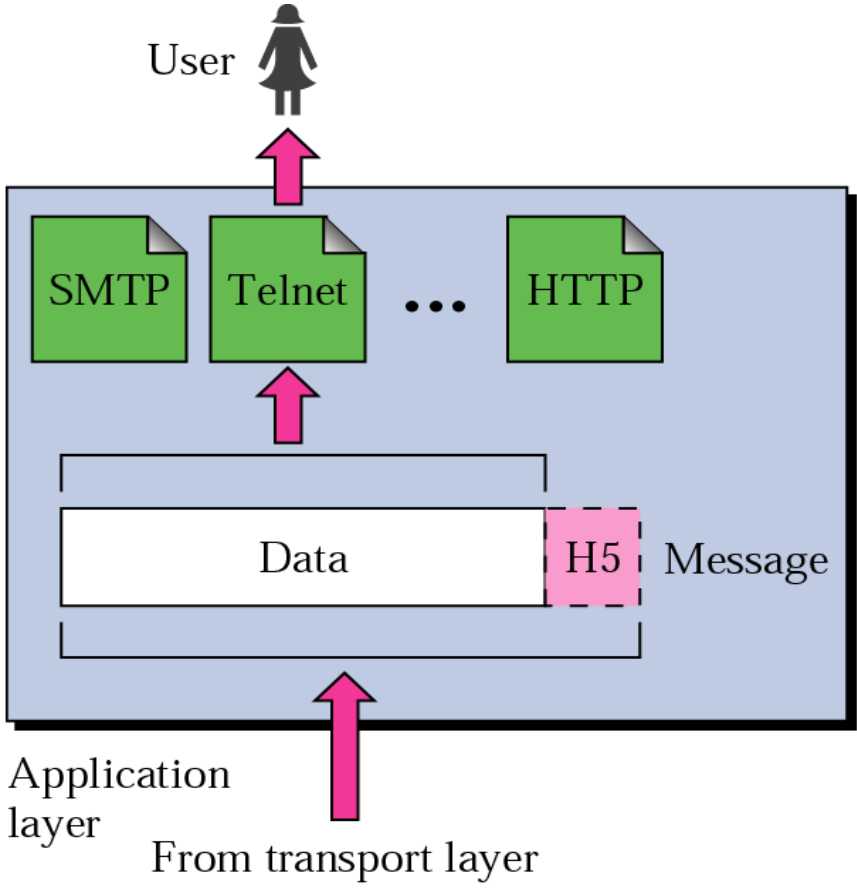


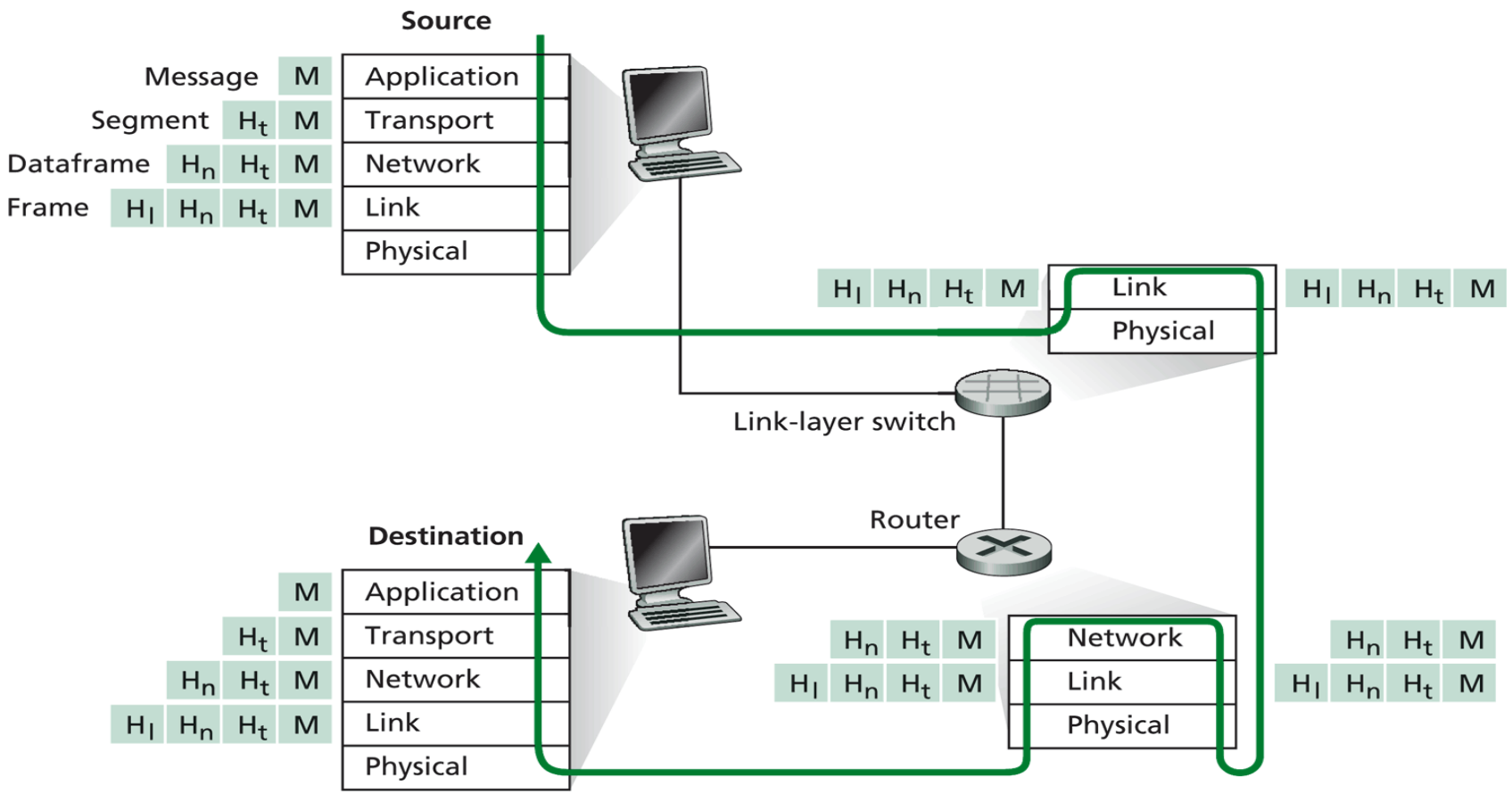
Application layer

The application layer provides information exchange and remote operations required by application processes.

This layer interacts with user software such as browsers, e-mail, chat, and FTP. .







Hosts, routers, and link-layer switches; each contains a different set of layers, reflecting their differences in functionality

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

The application layer provides information exchange and remote operations required by application processes.

The application layer responsibilities include support for:

- directory services
- e-mail services
- file transfer, access, and management (FTAM) and FTP
- virtual terminal emulation
- Internet browsers

Session layer

- *Control of dialogues between applications*
- *Dialogue discipline*
- *Grouping*
- *Recovery*

Session layer

- The session layer establishes, terminates, and structures dialogue interactions **between two applications.**
- It structures the dialogue interactions by providing both flow control and synchronization.
    - *Flow control is provided by use of data tokens that are required by applications to transmit data.*
    - *Synchronization provides a series of synchronization points that are used like bookmarks to return to a given point after a system crash*.
- The dialog interactions between applications are called *sessions*.
- The session layer responsibilities include:
    - establishing session connections
    - dialog control of communication between two processes
    - synchronizing checkpoints in the data
    - recovering and reestablishing a session in which an error or crash has occurred
    - terminating the session

Presentation layer

- Data formats and coding
- Data compression
- Encryption

Presentation Layer

- The presentation layer ensures that information exchanged between the two communicating systems is in the proper syntax and is delivered in a usable form.
- The presentation layer responsibilities include:
  - compression of data
  - encryption and decryption of messages
  - translation between different encoding systems such as ASCII and EBCDIC

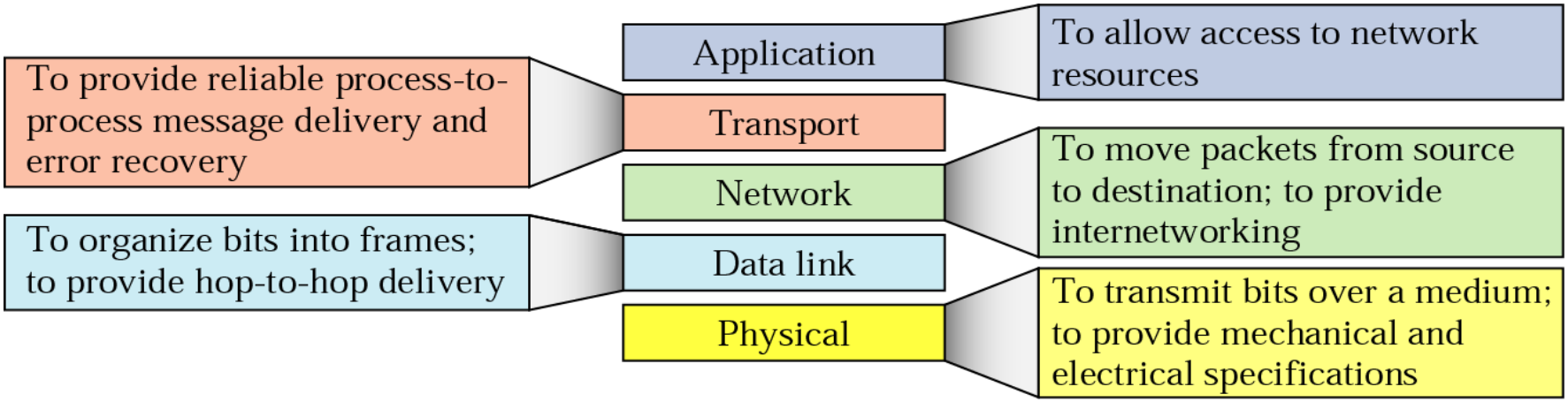
Application

– Means for applications to access OSI environment

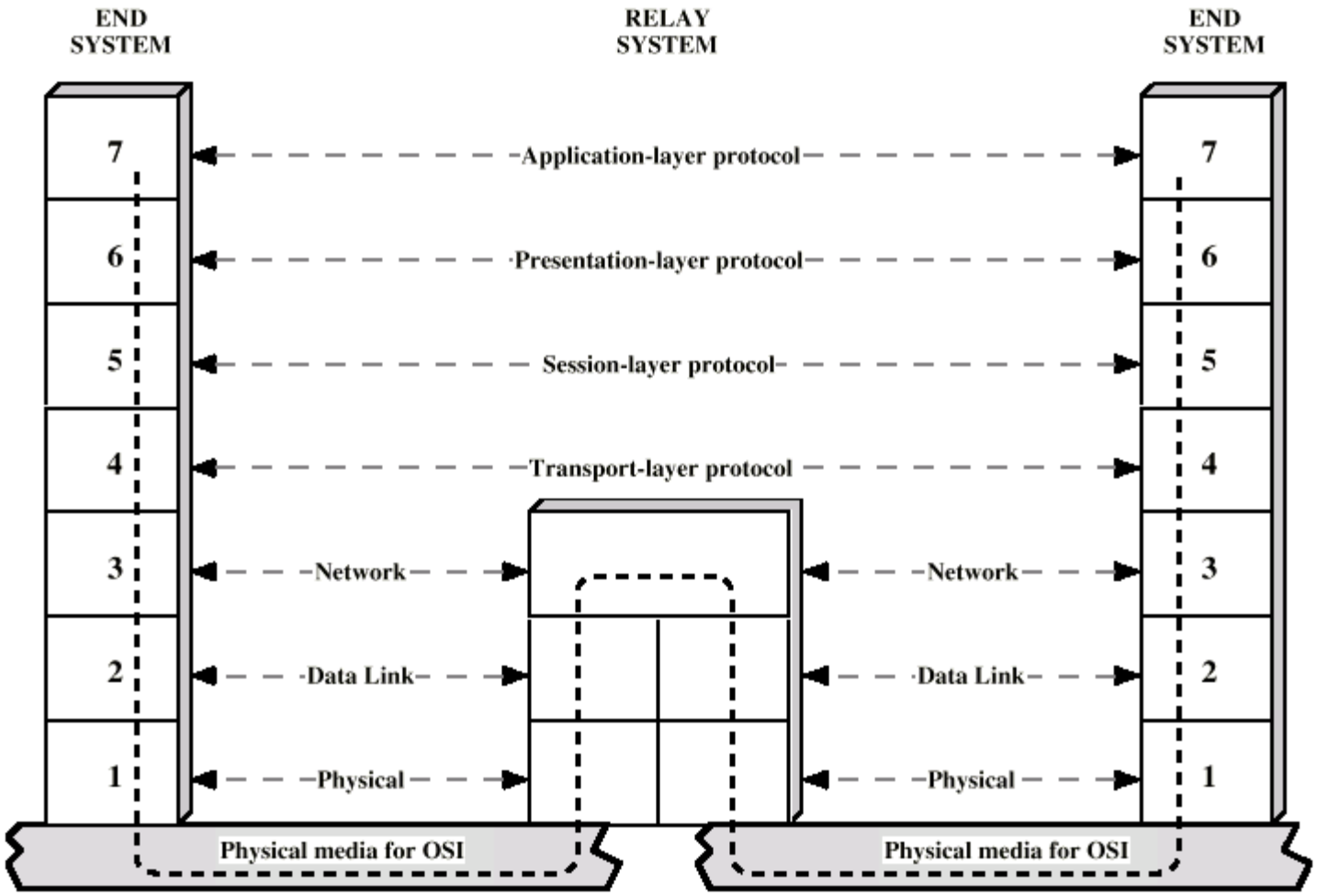
Application Layer

- The application layer provides information exchange and remote operations required by application processes.
- This layer interacts with user software such as browsers, e-mail, chat, and FTP.
- The application layer responsibilities include support for:
  - directory services
  - e-mail services
  - file transfer, access, and management (FTAM) and FTP
  - virtual terminal emulation
  - Internet browsers

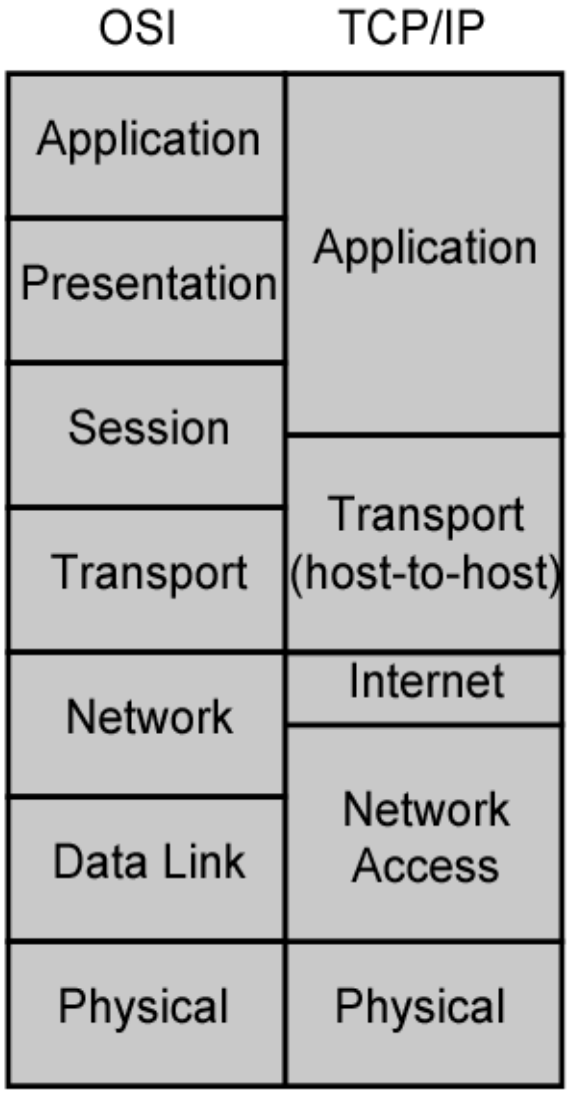
Summary of duties



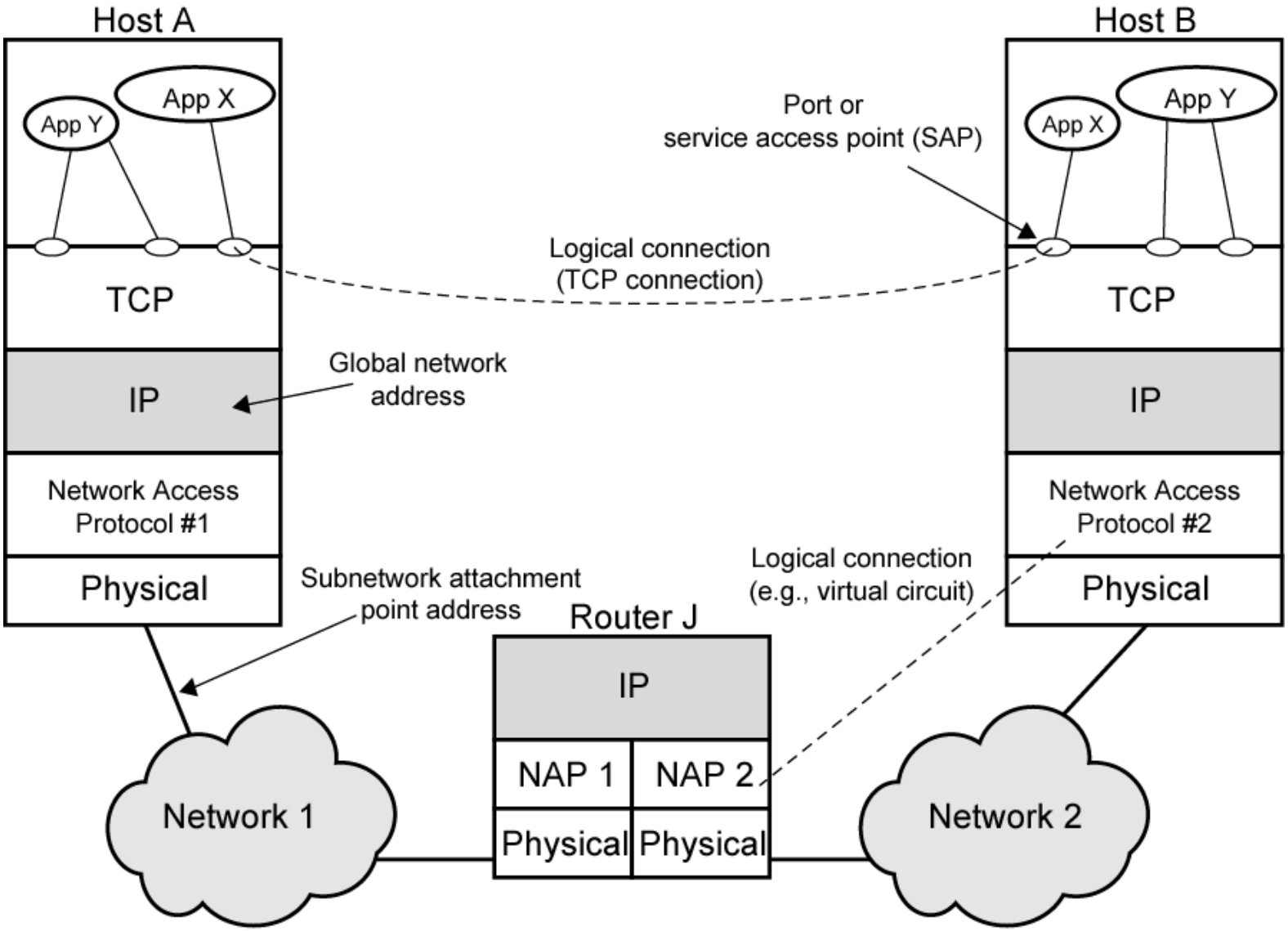
Use of a Relay



OSI v TCP/IP


OSI
TCP/IP
Application
Presentation
Session
Transport
Network
Data Link
Physical
Application
Transport (host-to-host)
Internet
Network Access
Physical

TCP/IP Concepts



TCP

- Usual transport layer is Transmission Control Protocol
  - Reliable connection
- Connection
  - Temporary logical association between entities in different systems
- TCP PDU
  - Called TCP segment
  - Includes source and destination port (c.f. SAP)
    - Identify respective users (applications)
    - Connection refers to pair of ports
- TCP tracks segments between entities on each connection

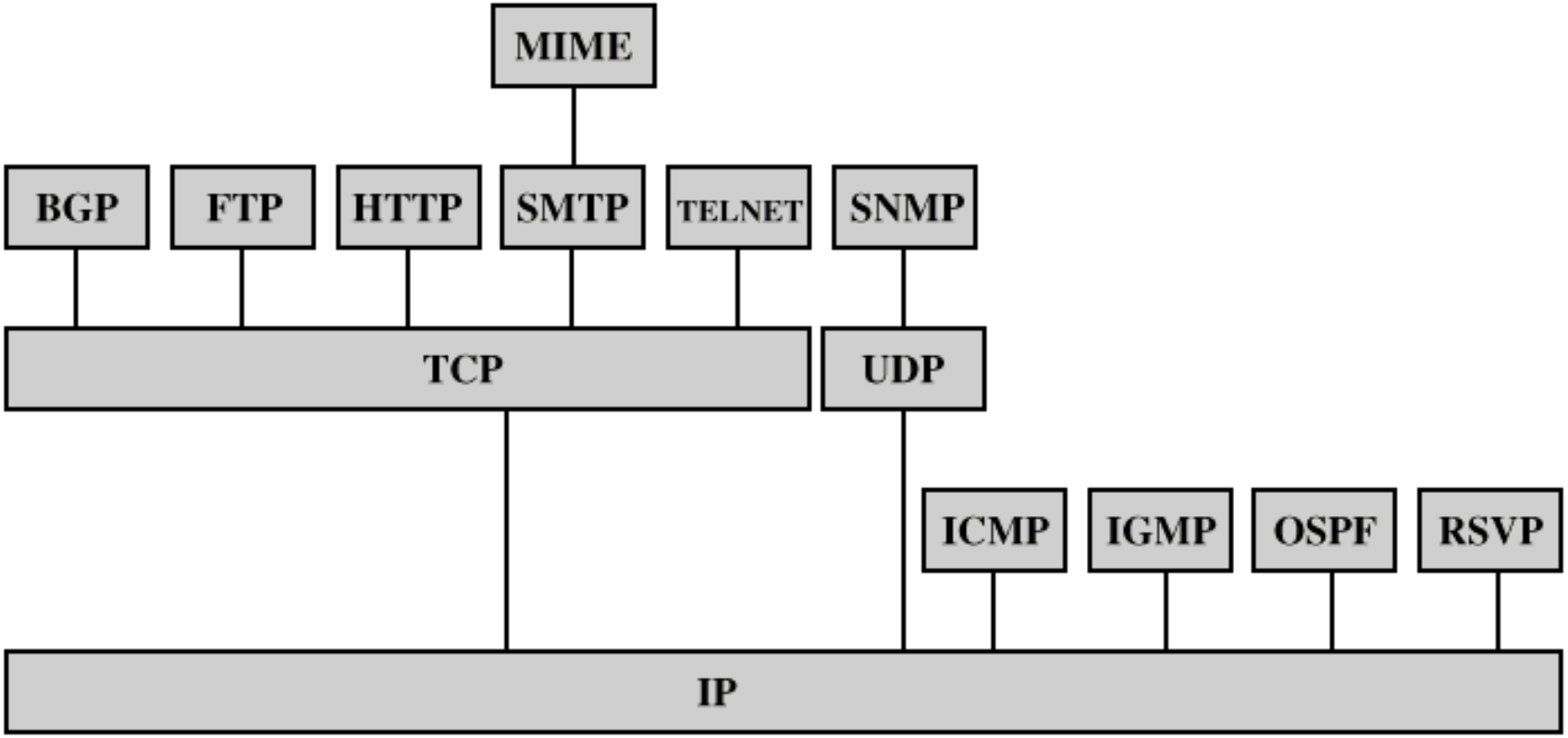
UDP- *User Datagram Protocol*

- *Alternative to TCP is User Datagram Protocol*
- *Not guaranteed delivery*
- *No preservation of sequence*
- *No protection against duplication*
- *Minimum overhead*
- *Adds port addressing to IP*

Addressing level

- Level in architecture at which entity is named
- Unique address for each end system (computer) and router
- Network level address
  - IP or internet address (TCP/IP)
  - Network service access point or NSAP (OSI)
- Process within the system
  - Port number (TCP/IP)
  - Service access point or SAP (OSI)

Some Protocols in TCP/IP Suite



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension

OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol