Data Communication and Computer Network

Protocol Architecture & Layering

Protocol Architecture

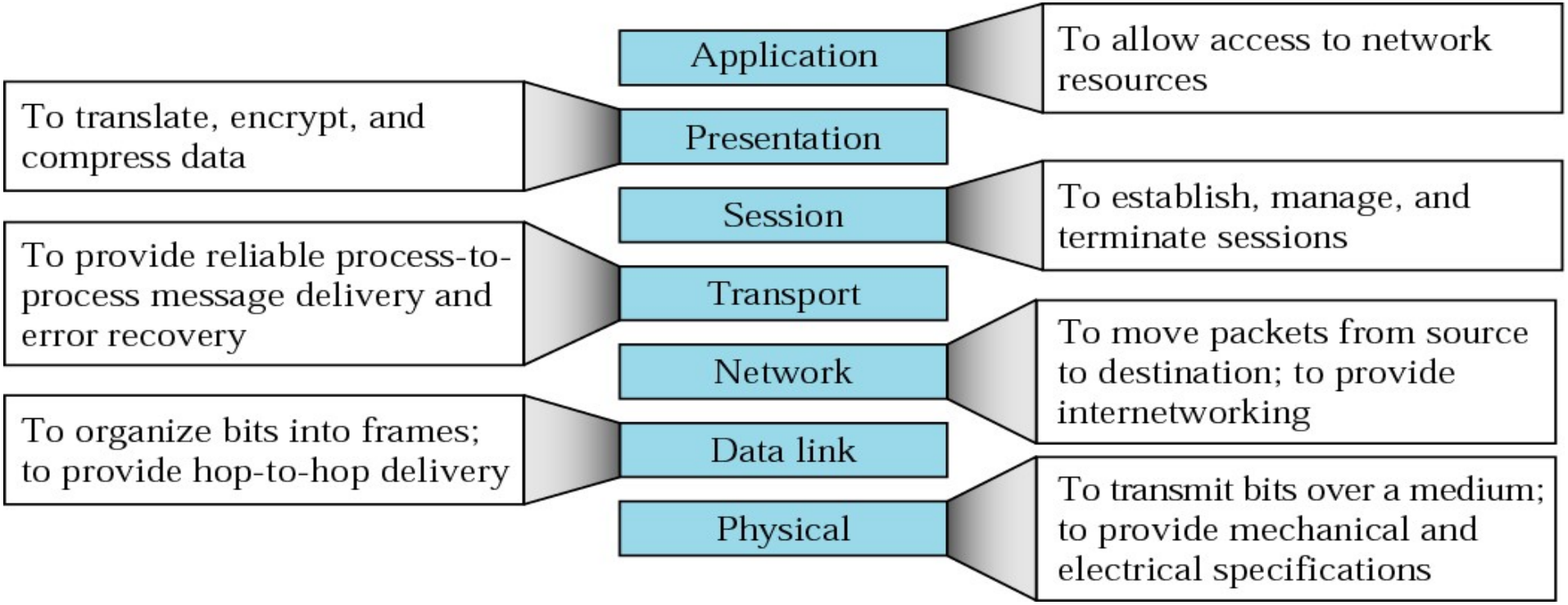
- Task of communication broken up into modules or layers
- Each layer has specific responsibilities

- Reason for layering – if one layer's implementation changed, other layers not affected if interface remains unchanged

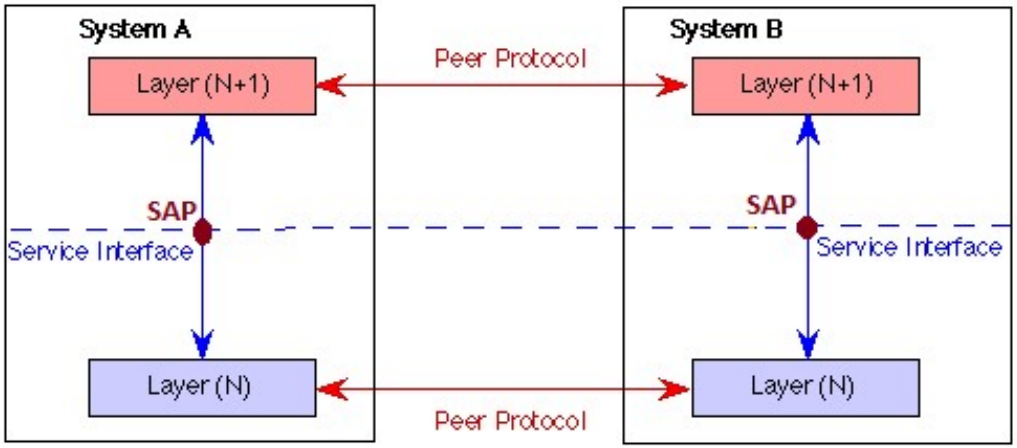
OSI Layers

- OSI Layers (Open Systems Interconnection)
- Developed by International Organization for Standardization (ISO)
- Seven Layers (depending on the complexity of the functionality each of these layers provide.)
  - ✓ Application
  - ✓ Presentation
  - ✓ Session
  - ✓ Transport
  - ✓ Network
  - ✓ Data Link
  - ✓ Physical

OSI Layers in brief



Interface, Protocol & Addressing



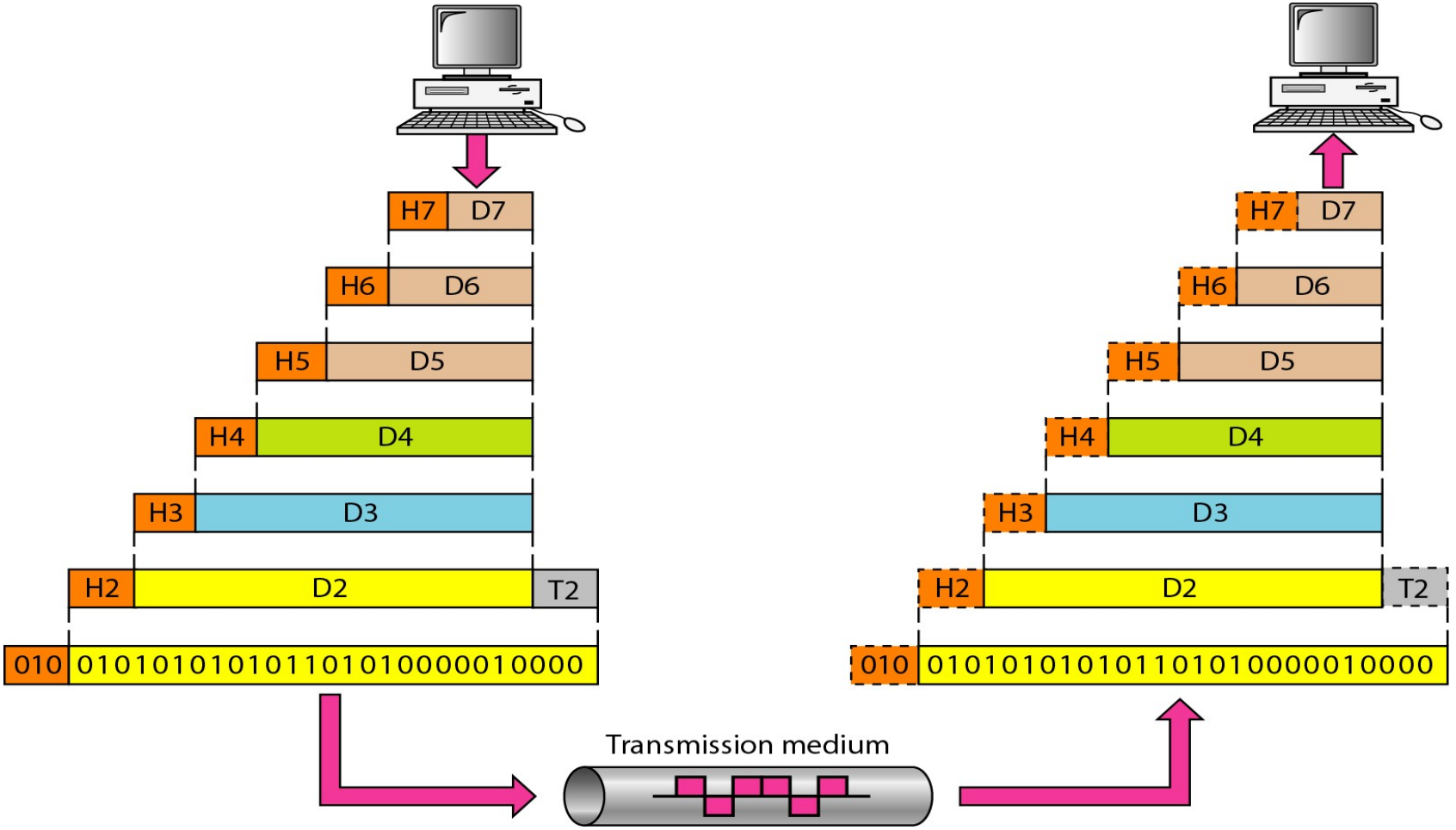
- Interface between two layers
  - A Service Access Point (SAP) is a conceptual location at which one OSI layer can request the services of another layer
  - Each layer expects some service from lower layer and provides some service to its higher layer
    - ✓ e.g. application layer expects reliable communication from transport layer (no errors in frames, no lost frames, etc)
- Protocol – set of rules followed by same layer at different nodes e.g. between the transport layer of Tx and Rx

Protocol Data Units (PDUs)

- Control information added to data at each layer (in the form of header / trailer)
  - Destination node address, sequence number, error detection code, etc
  - Control information added by layer i^{th} at transmitter is used by layer i^{th} at receiver node

- PDUs called differently at different layers
  - frame in data link layer, packet/datagram in network layer, packet/segment in transport layer, message in application layer

Operation of a Protocol Architecture



PDUs (contd.)

- Encapsulation
  - At Tx: as data goes down, each layer adds header
  - At Rx: as data goes up, each layer takes out its own header, carries out checks, hands up rest to higher layers if ok

- Number of layers to be used
  - More the no. of layers, more headers added as the data goes downwards, more wastage
  - Too few layers – defeats the purpose of layering (isolating functionalities in layers) itself

OSI Layers - brief overview

- Physical Layer
  - Physical interface between data transmission device (e.g. computer) and transmission medium or network
  - Specifies raw transmission details like connectors, medium, voltage levels, encodings used, data rate, etc.

- Data Link Layer
  - Ensures reliable communication between two directly connected nodes
  - Sends blocks of data (frames) with the necessary synchronization, error control, flow control
  - Medium Access Control (MAC)

OSI Layers - brief overview (contd. 2)

- Network Layer
  - Deals with **routing**: sending packets from source to destination nodes that are not directly connected
  - Packets may not reach in order, can get lost (does not guarantee reliable communication)
  - Congestion Control and Internetworking
  - Some other functions (like fragmentation)

- Transport layer
  - Ensures reliable, in-order delivery between any two applications ensures no frame loss, no error, no duplicate (Error Control, Flow Control)
  - Segmentation & Reassembly
  - Connection Establishment / Release

OSI Layers - brief overview (contd. 3)

- Session layer
  - It deals with the concept of Sessions
  - Controls the dialogues (connections) between computers
  - Synchronization

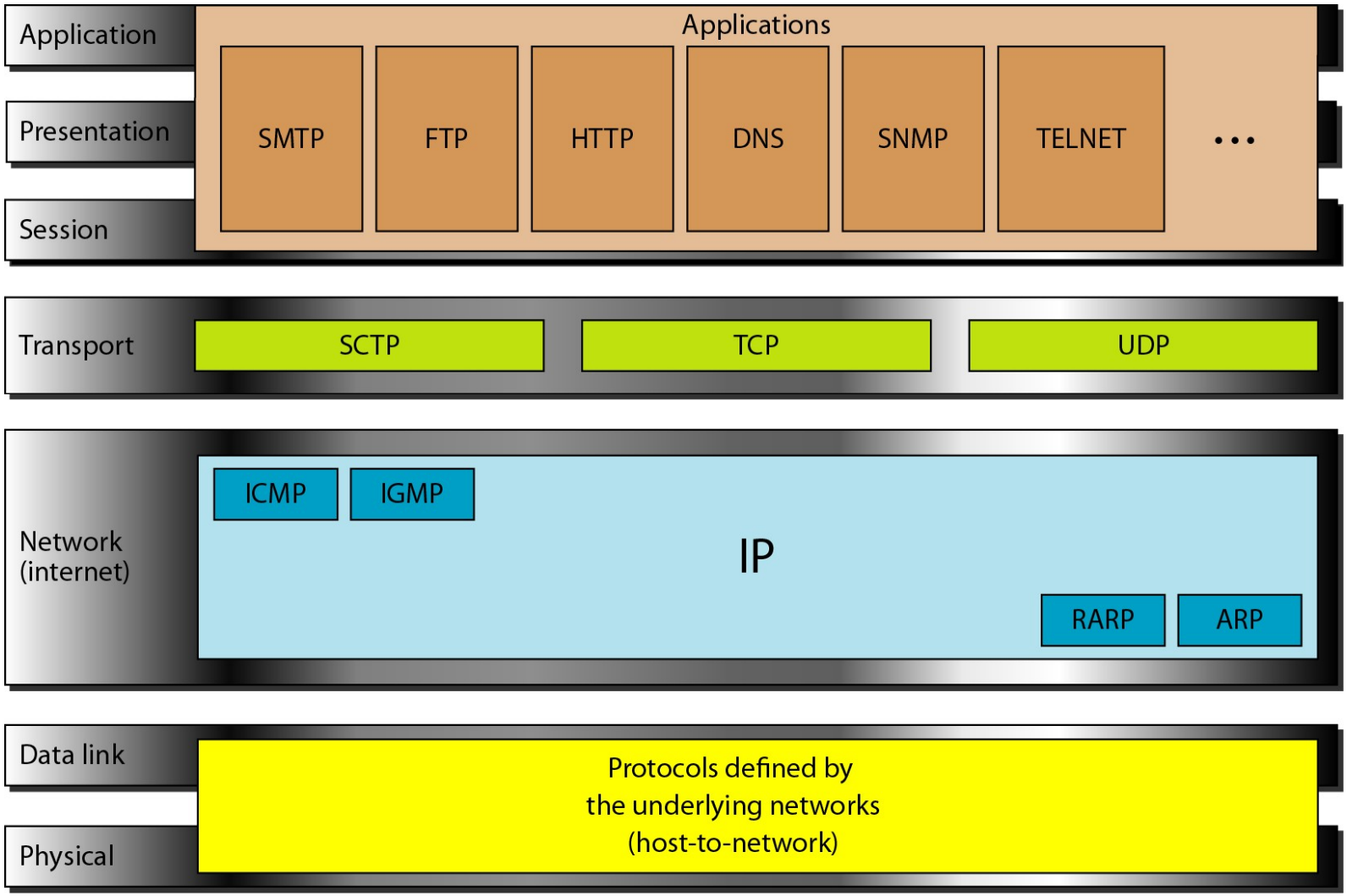
- Presentation layer
  - Compression and encryption
  - Independence from data representation (Endianness, TLV(Type-Length-Value), Basic Encoding Rules(BER) or Packed Encoding Rule (PER) of ASN.1)

- Application layer
  - Supports user applications (e.g. http, ftp)

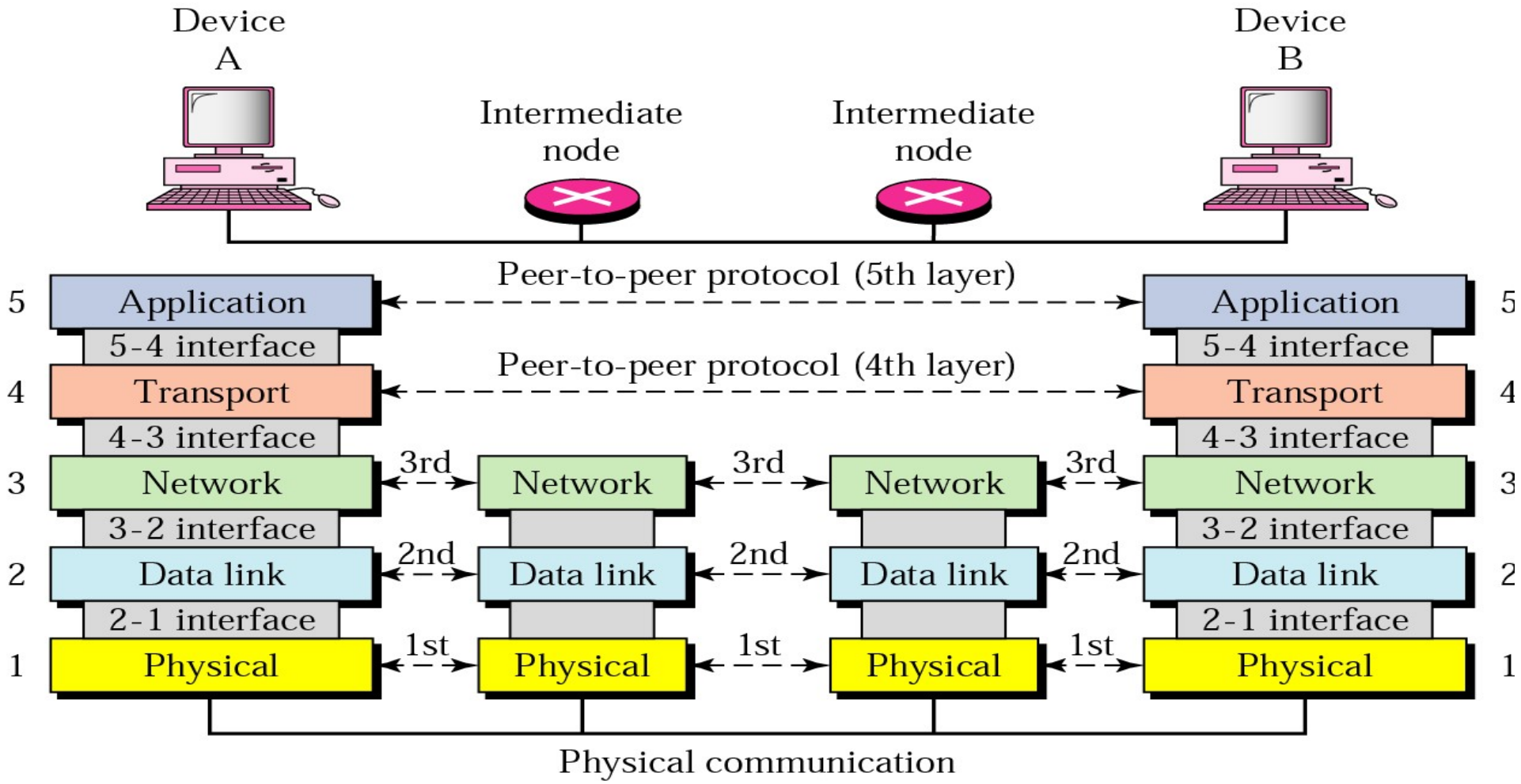
TCP/IP layers

- TCP layers – by US Defense Agency
- De-facto standard (not official, but working model)
- Used by the global Internet
- Five Layers
  - Application
  - Transport
  - Network (Internet)
  - Data Link
  - Physical

OSI model and TCP/IP

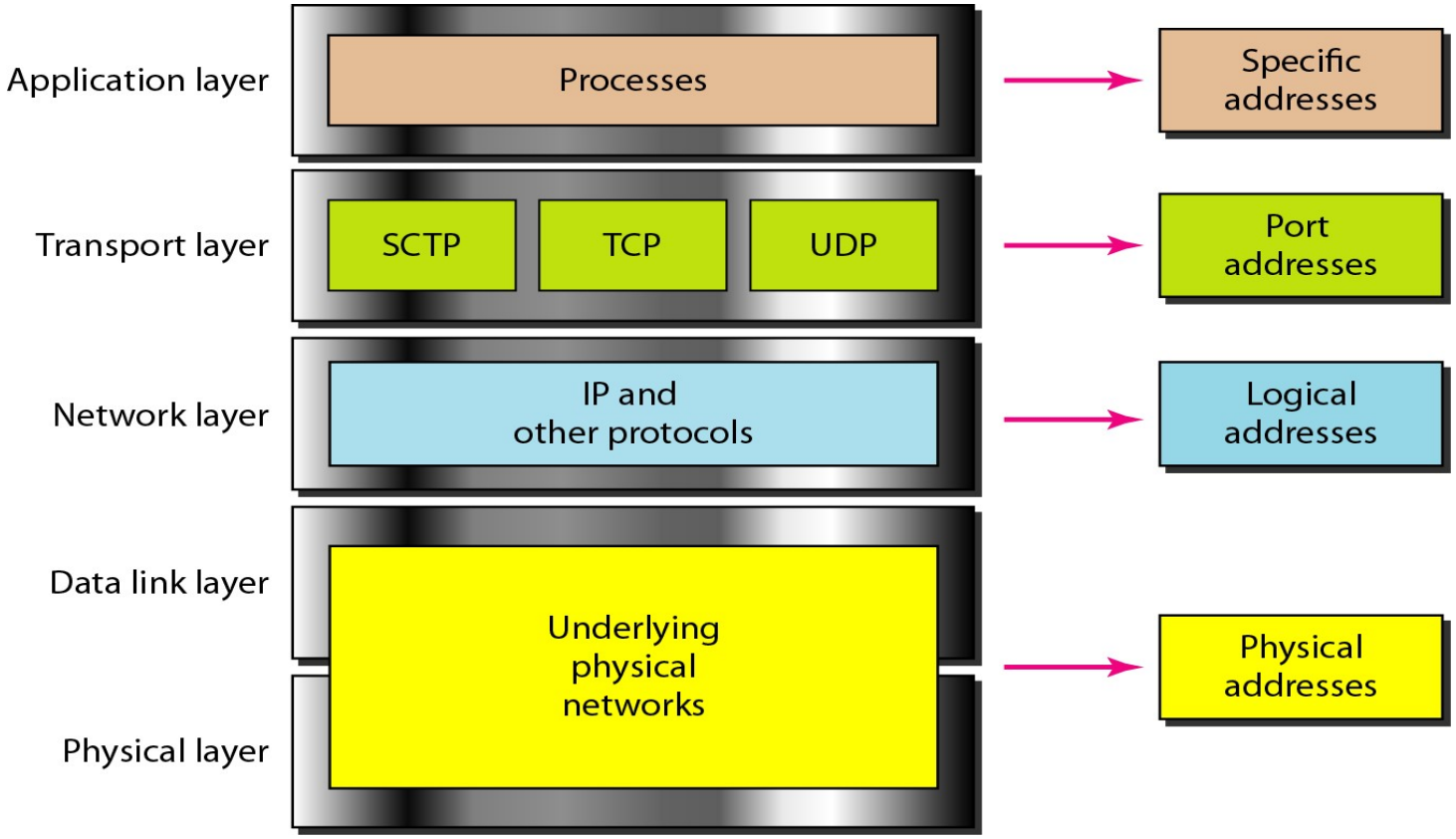


Protocols & Interfaces in TCP/IP stack



Relationship of layers and addresses in TCP/IP

Four levels of addresses are used in an internet employing the TCP/IP protocols: physical, logical, port, and specific.



Physical Address / MAC Address

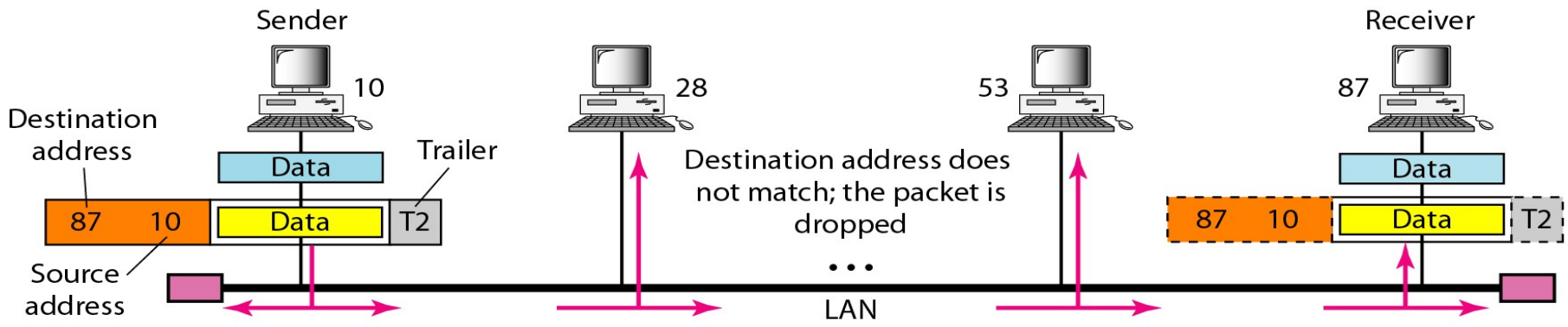
Most local-area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:

07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address.

Data communication within a LAN

A node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link (bus topology LAN). As the figure shows, the computer with physical address 10 is the sender, and the computer with physical address 87 is the receiver.



Logical Address /IP Address

An Internet Protocol address (IP address) is a numerical label assigned to each node participating in a computer network that uses the Internet Protocol for communication

Two principal functions: host or network interface identification and location addressing

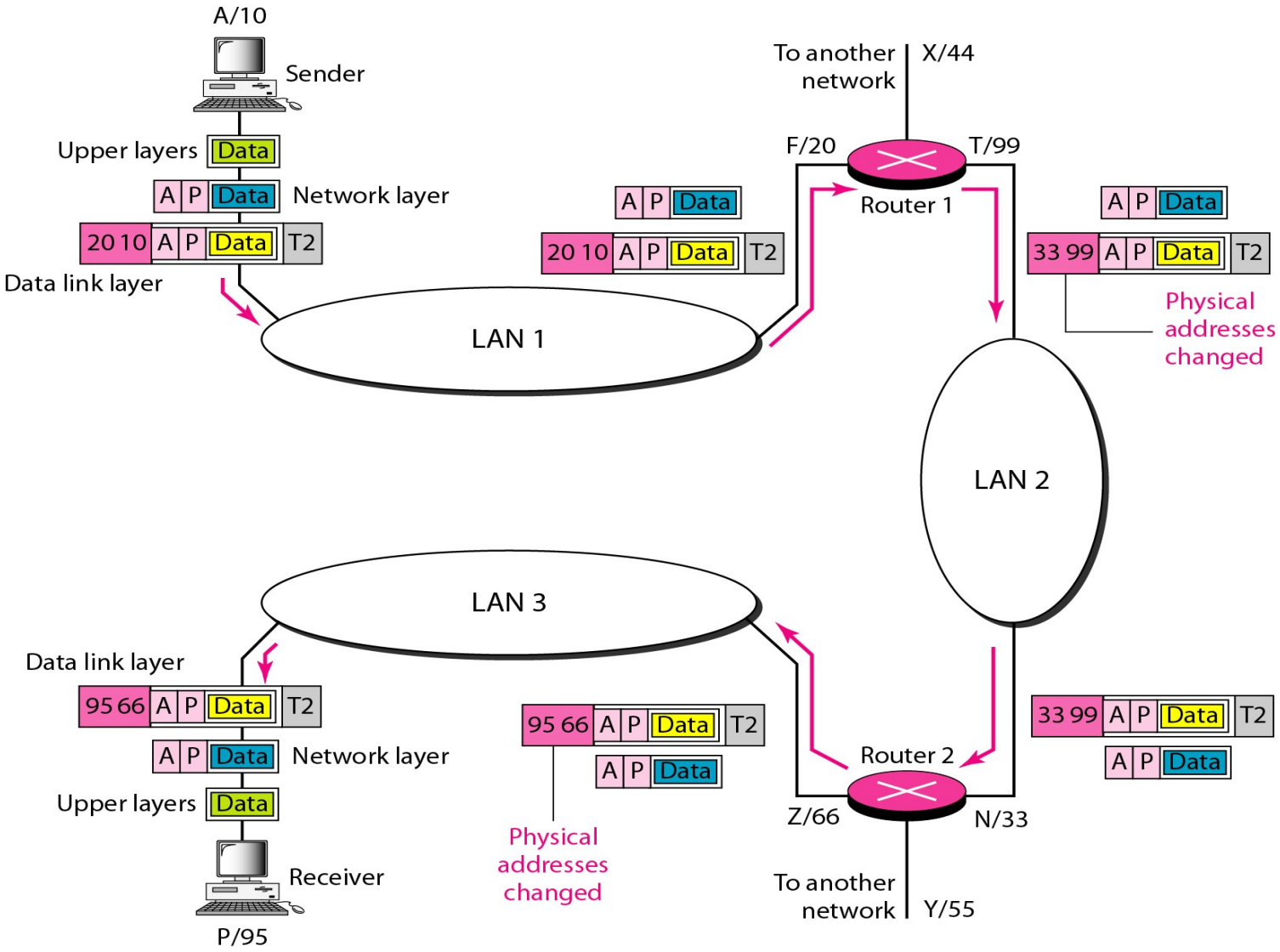
IPv4 : 10.2.1.40
A 4-byte logical address

IPv6 : 2001:db8:0:1234:0:567:8:1
A 16-byte logical address

Data communication across internet

Example shows a part of an internet with two routers connecting three LANs. Each device (computer or router) has a pair of addresses (logical and physical) for each connection. In this case, each computer is connected to only one link and therefore has only one pair of addresses. Each router, however, is connected to three networks (only two are shown in the figure). So each router has three pairs of addresses, one for each connection.

Data communication across networks



The physical addresses will change from hop to hop, but the logical addresses usually remain the same

Port addresses

753

A 16-bit port address represented
as one single number.

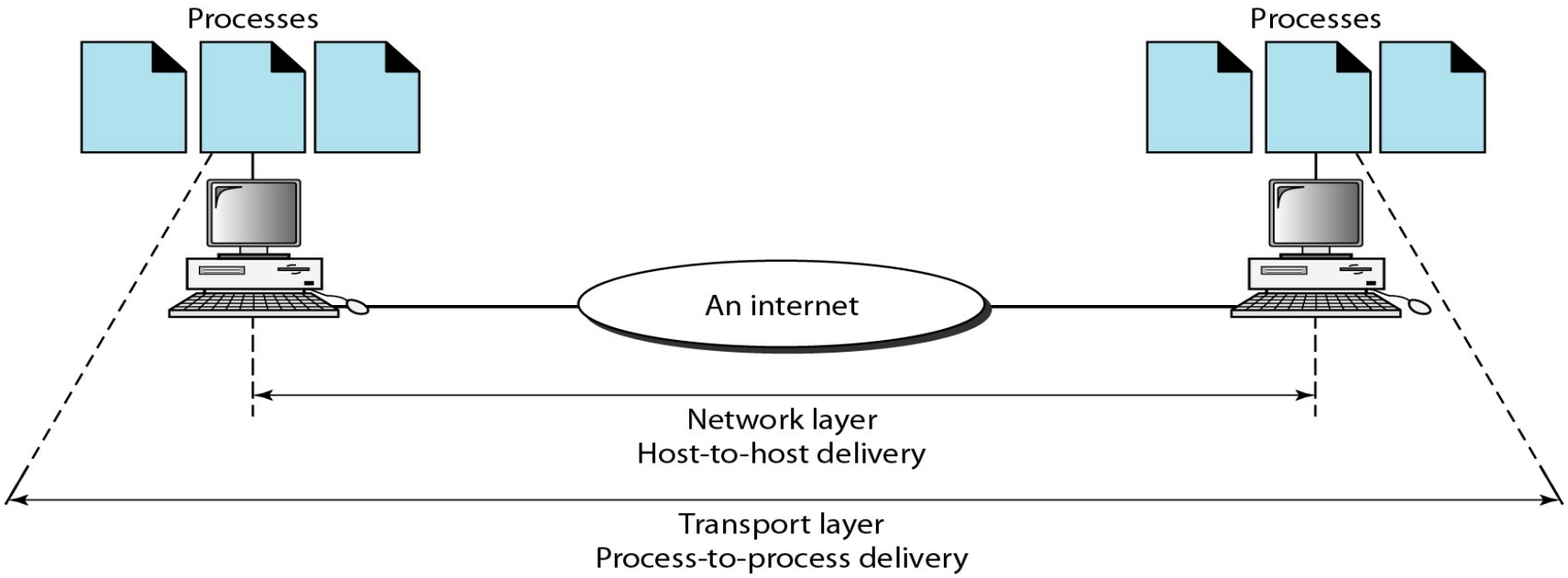
Well known port

```
ftp : 20
Ssh : 22
http : 80
```

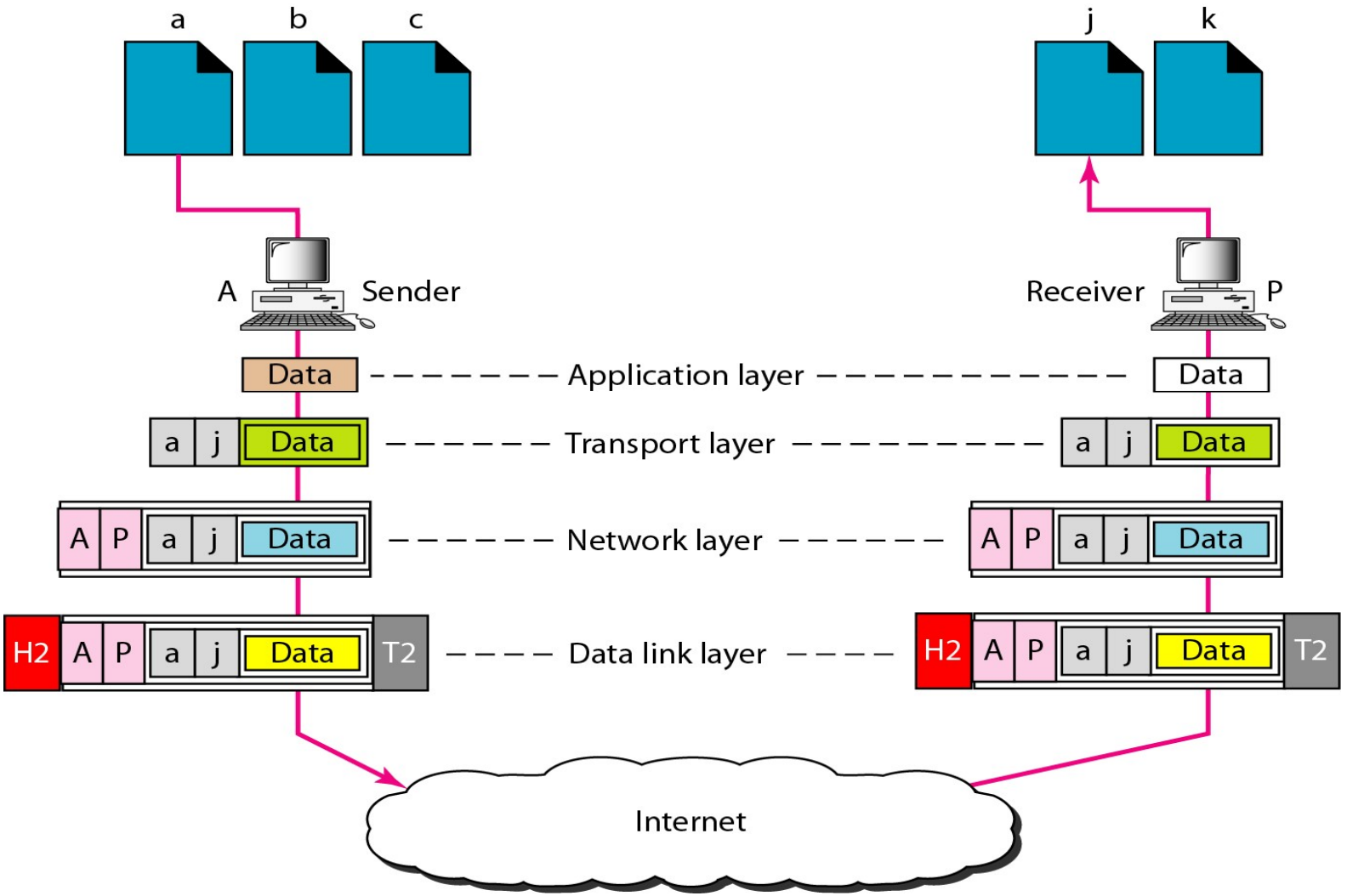
Data communicating via the Internet

Example shows two computers communicating via the Internet. The sending computer is running three processes at this time with port addresses a, b, and c. The receiving computer is running two processes at this time with port addresses j and k. Process a in the sending computer needs to communicate with process j in the receiving computer. Note that although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.

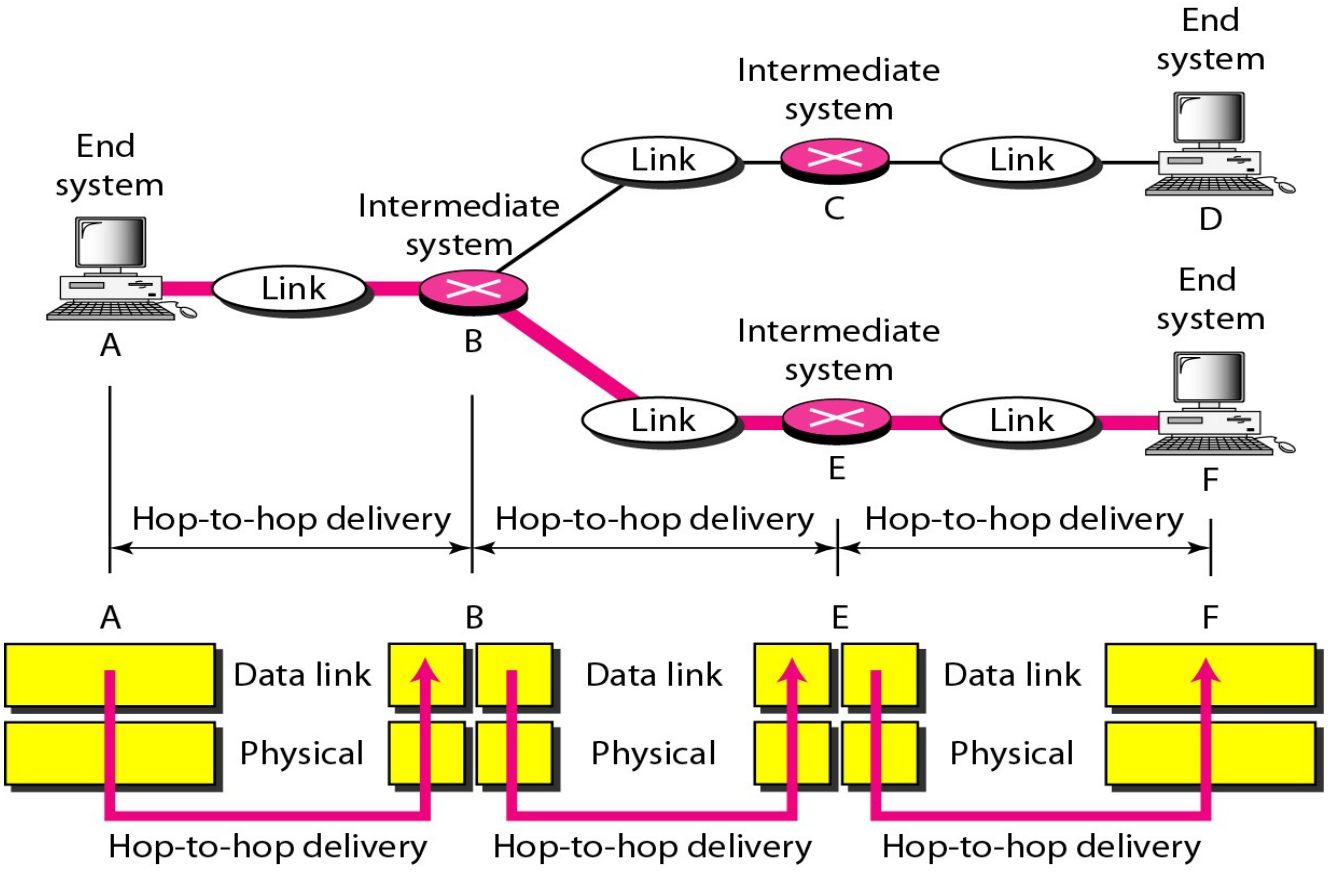
Appendix 4: Reliable process-to-process delivery of a message



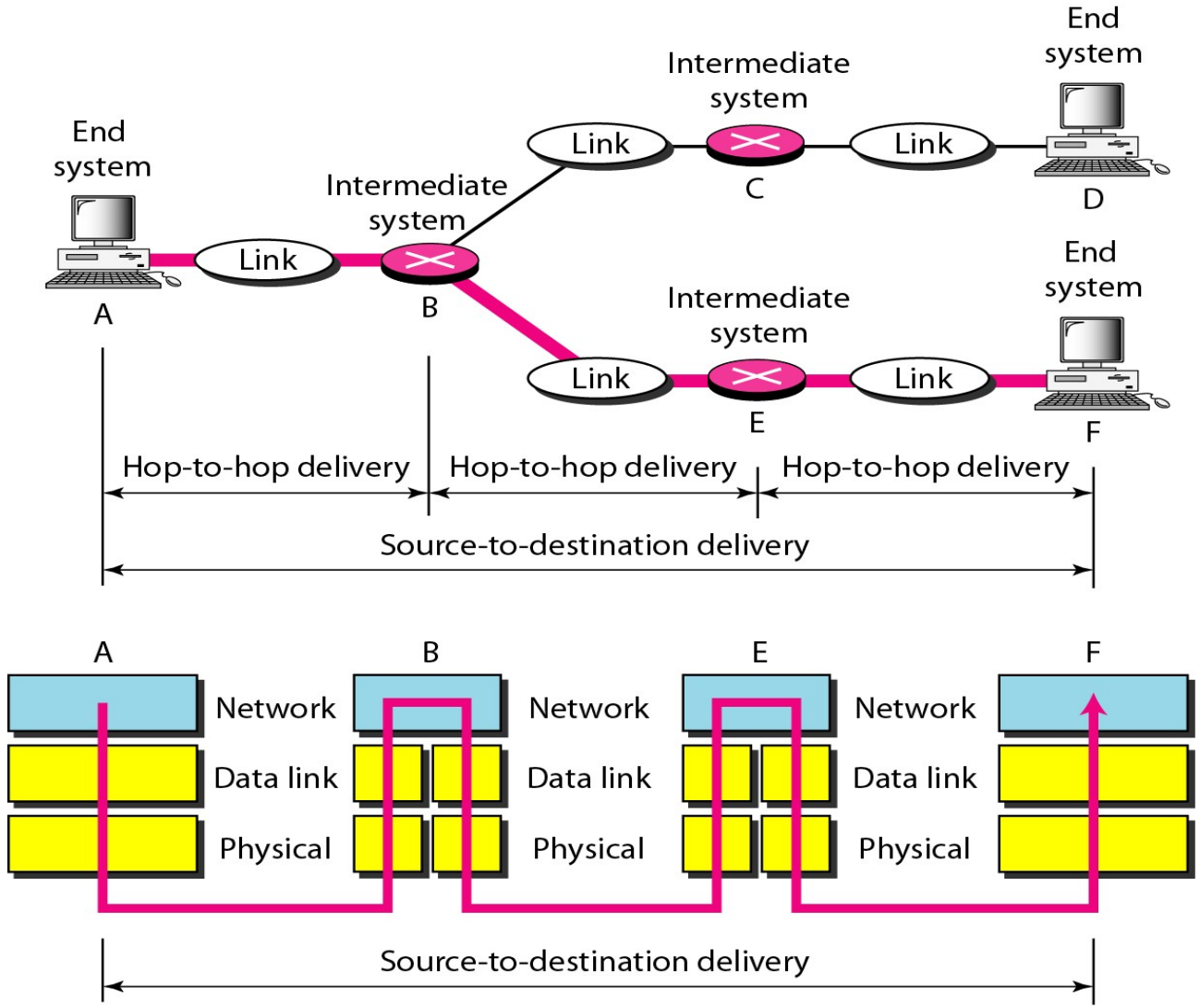
Port addresses



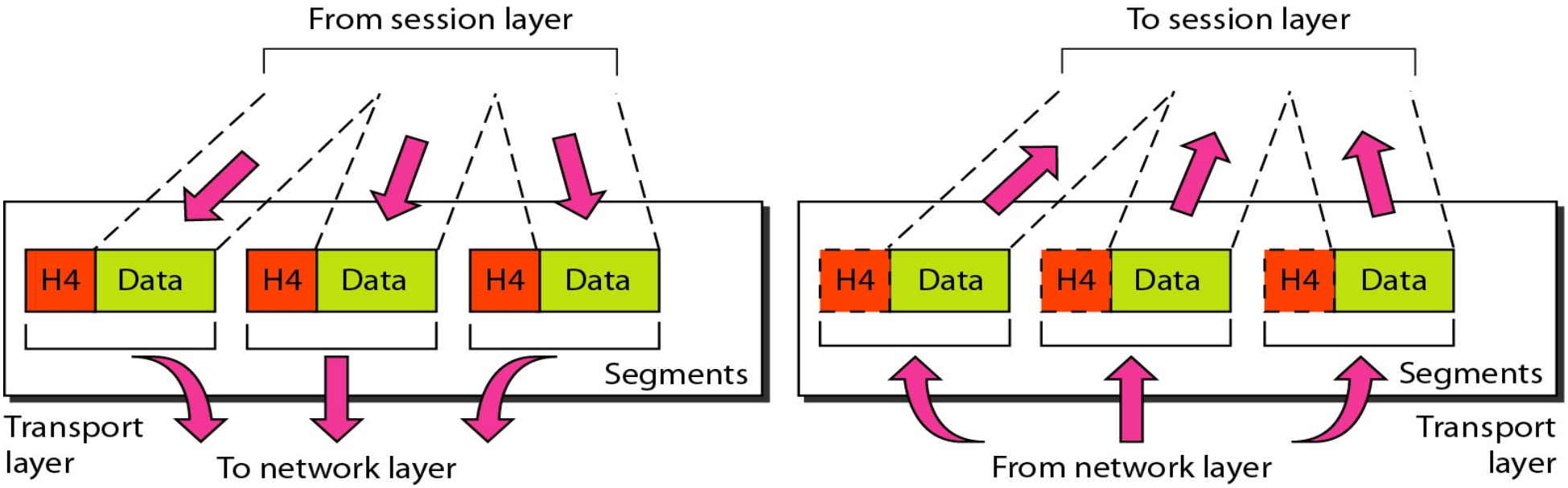
Appendix 1 : Hop-to-hop delivery (L2 switching)



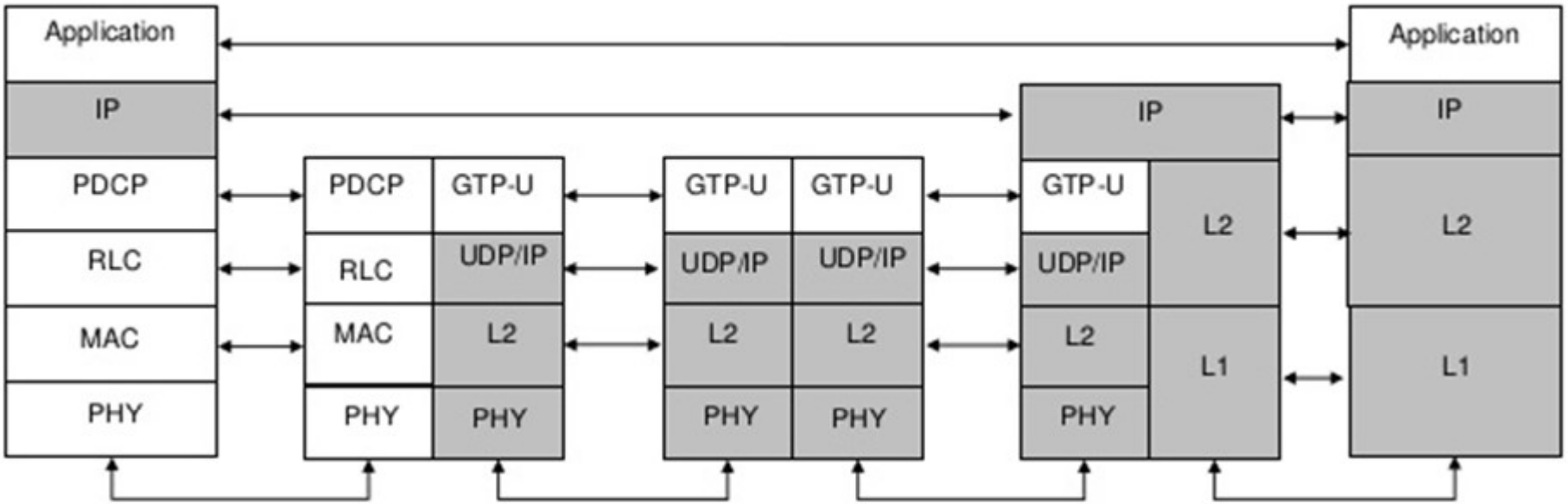
Appendix 2 : Source-to-destination delivery (L3 Switching)

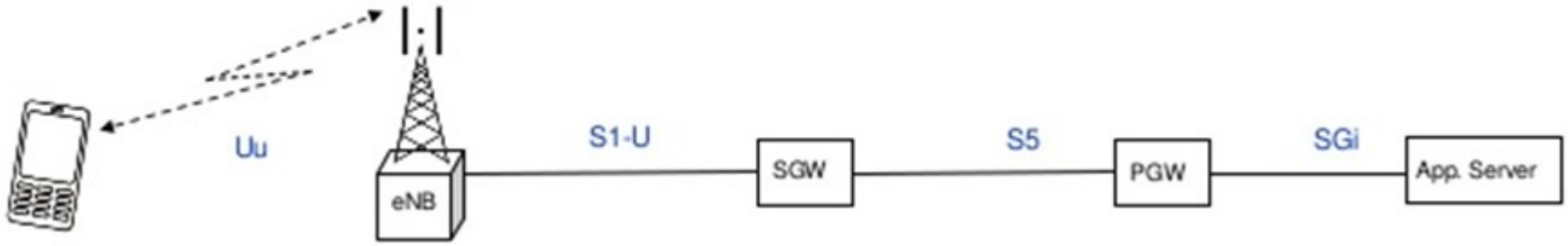


Appendix 3 : Segmentation & Reassembly



Appendix 4 : LTE data plane (User plane) protocol stack





Appendix 5 : LTE data plane (User plane) protocol stack (diff img)