Faculty of Applied Sciences
B.Sc. in Computing

Academic Year 2022/2023 2nd Semester

COMP123 – 121/122

Data Communications

Architectures and Protocols

The Need For Protocol Architecture

To transfer data several tasks must be performed:

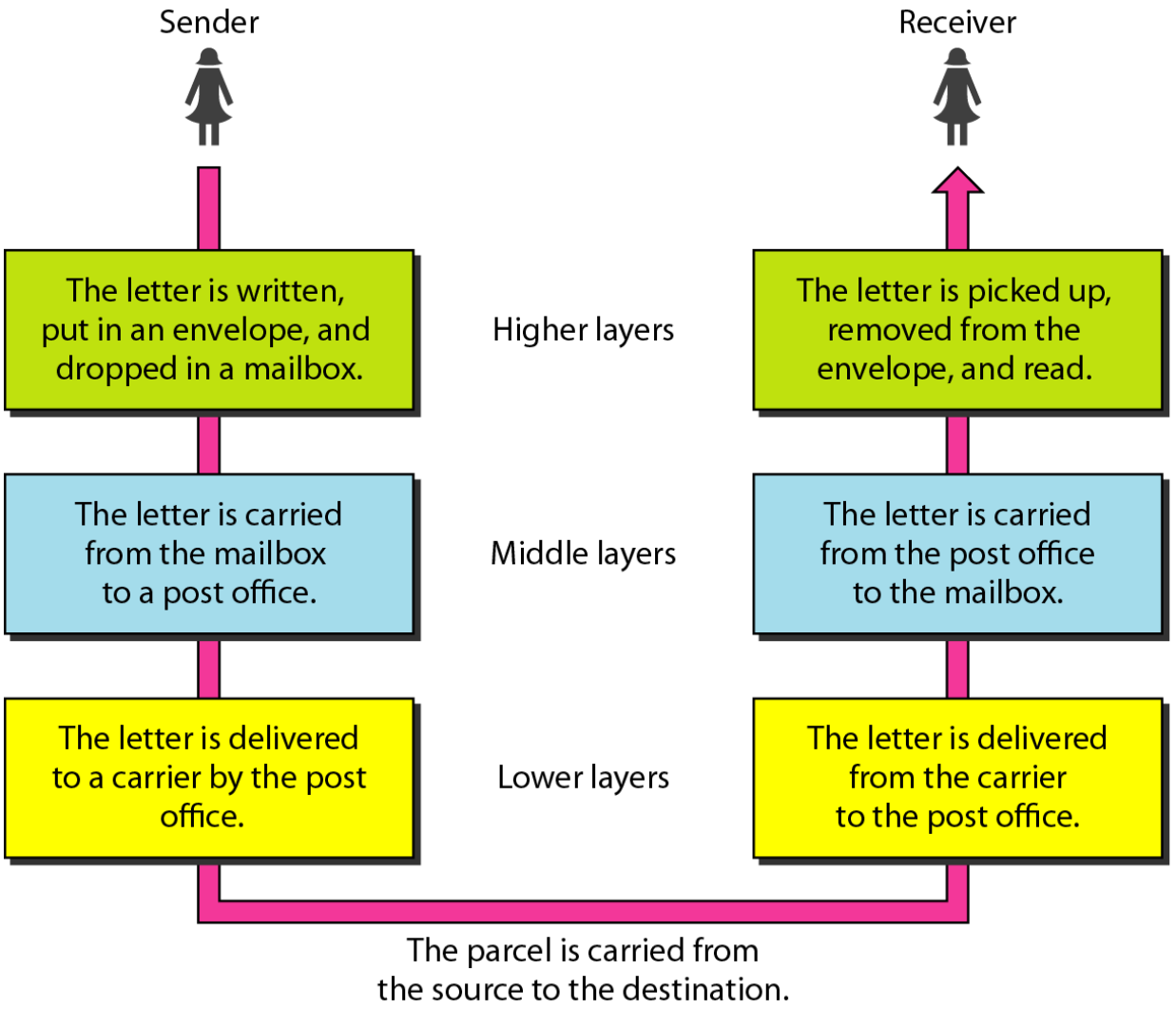
1.) the source must activate communications path or inform network of destination

2.) the source must make sure that destination is prepared to receive data

3.) the file transfer application on source must confirm file management program at destination is prepared to accept and store file

4.) a format translation function may need to be performed if the formats on systems are different

A Communications Architecture Example

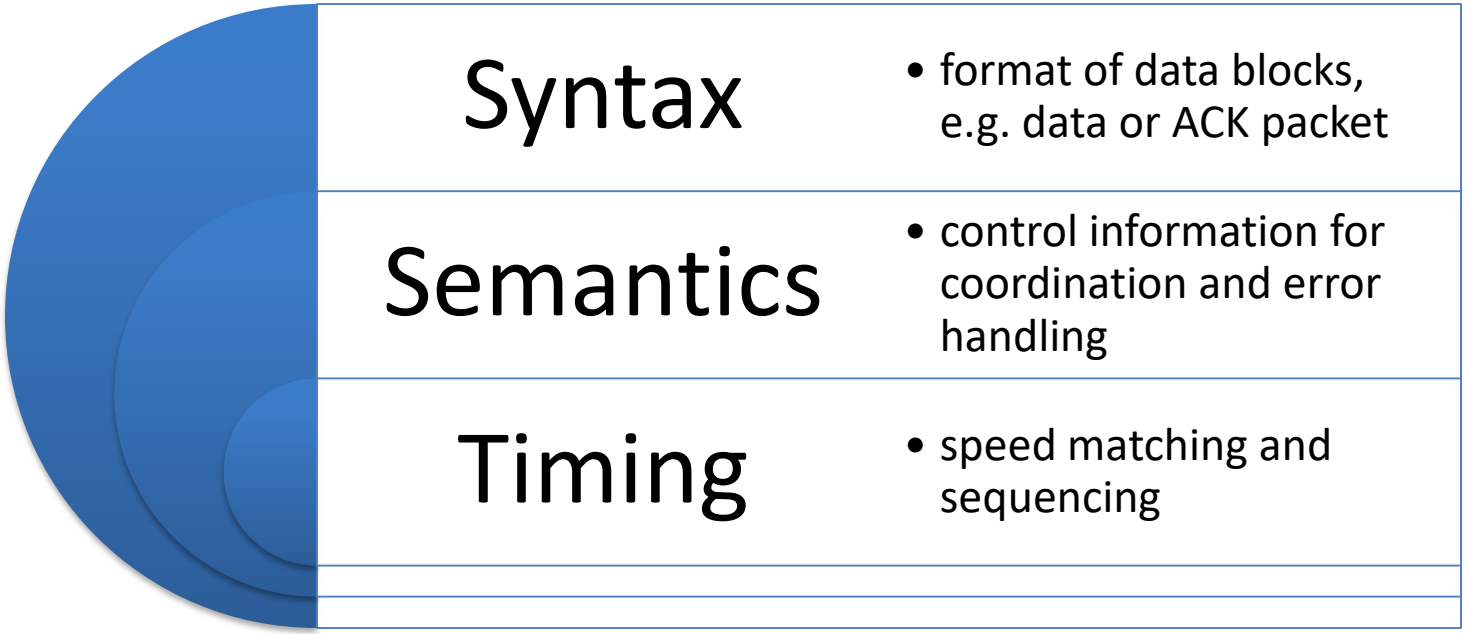


Functions of Protocol Architecture

- breaks logic into subtask modules which are implemented separately
- modules are arranged in a vertical stack
  - each layer in the stack performs a subset of functions
  - relies on next lower layer for primitive functions
  - changes in one layer should not require changes in other layers

Key Features of a Protocol

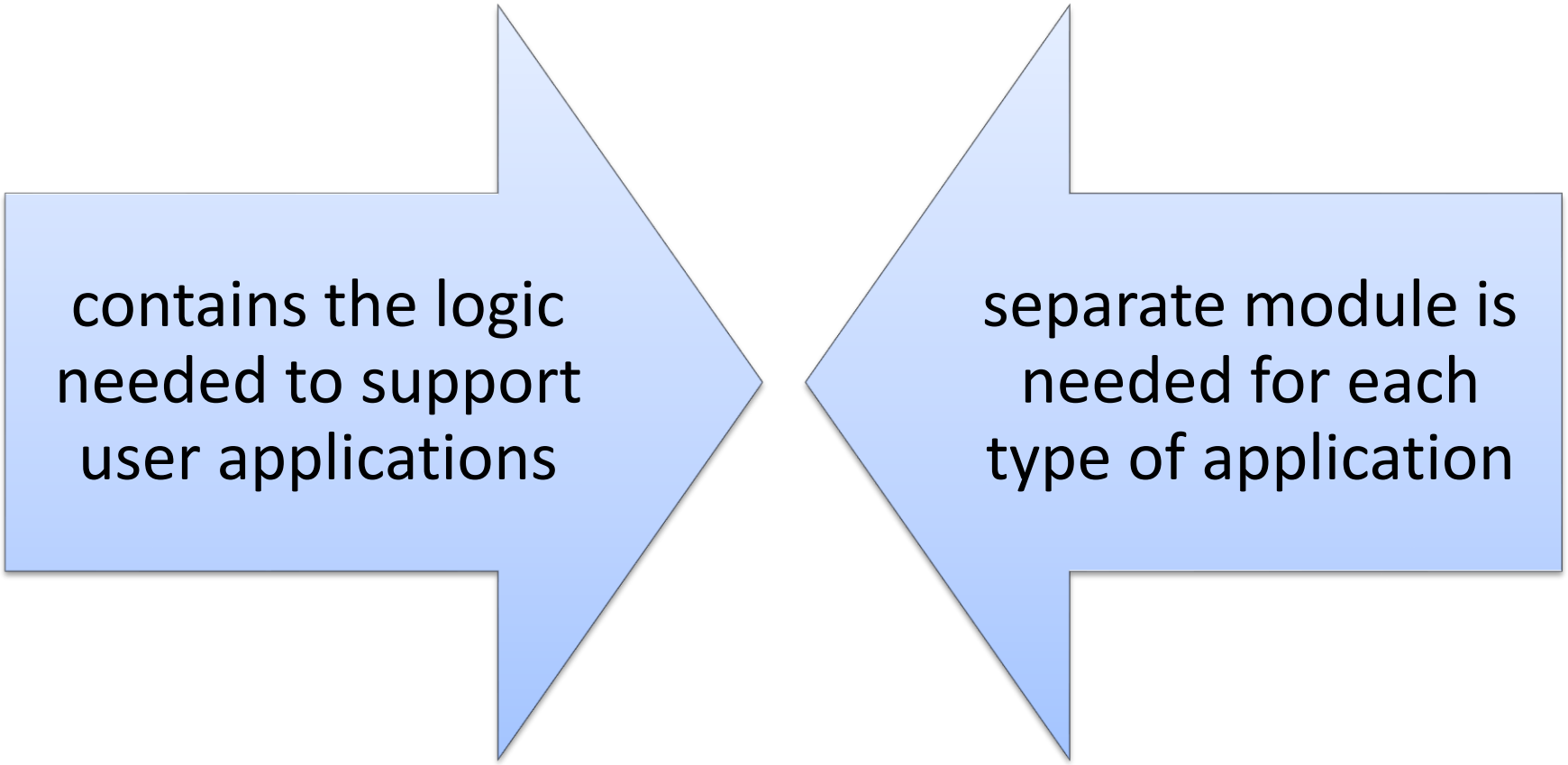
- A protocol is a set of rules or conventions that allow peer layers to communicate.
- The key features of a protocol are:



Communication Layers

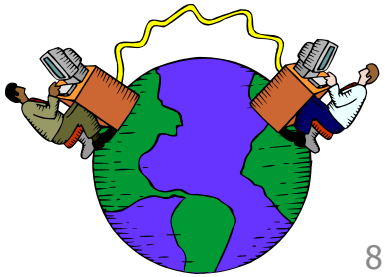
- Within a network, communication tasks are organized into three relatively independent layers:
  - Application layer
    - Contains logic to support applications
  - Transport layer
    - provides reliable data transfer
  - Network access (or Data Link) layer
    - concerned with the exchange of data

Application Layer

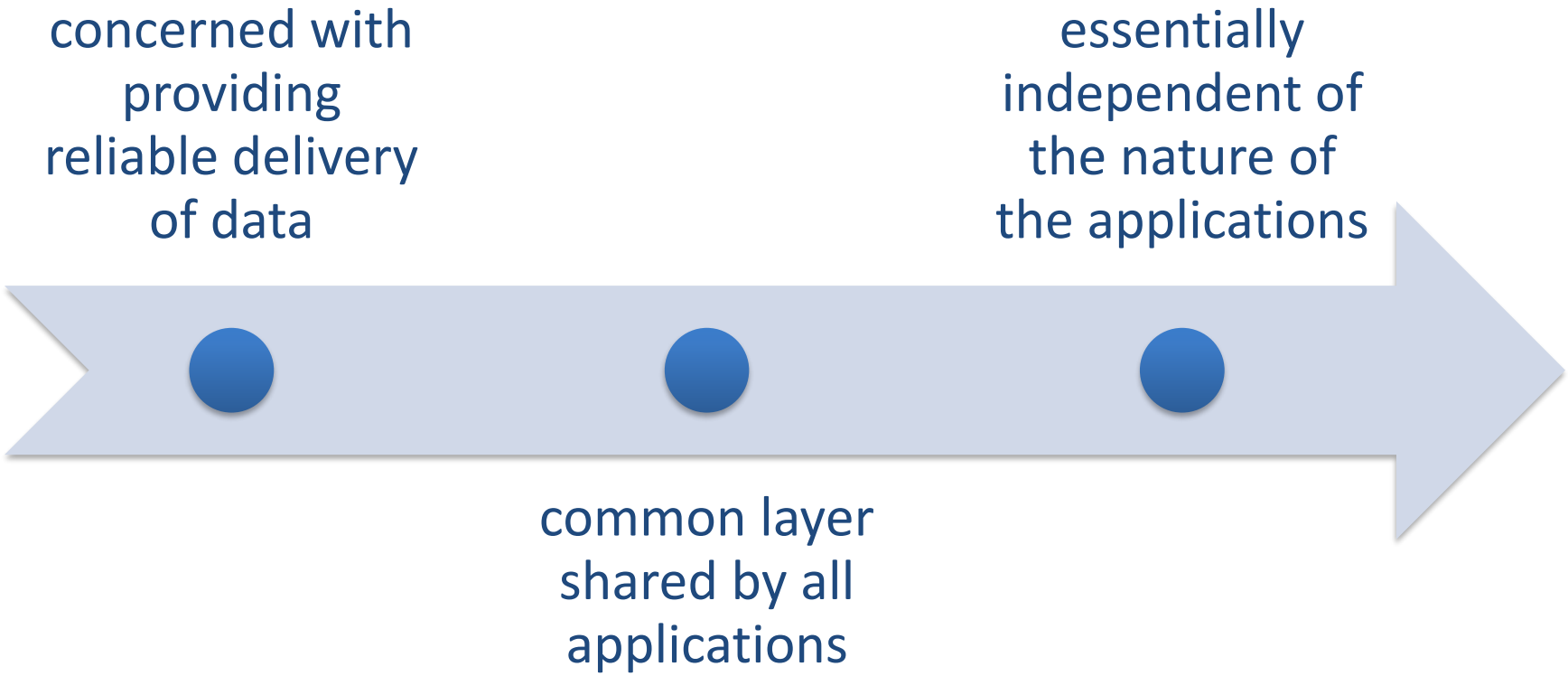


Network Access (Data Link) Layer

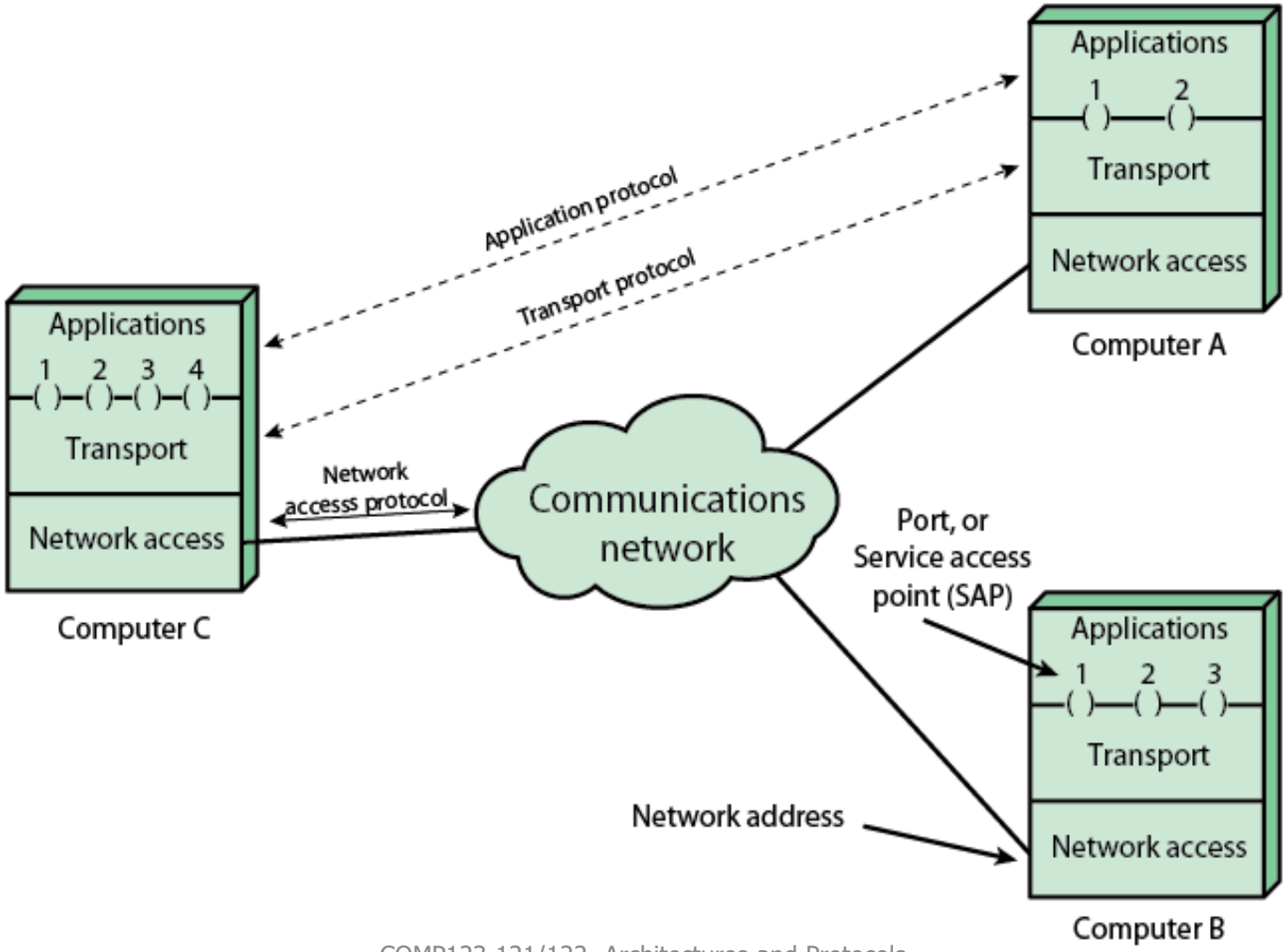
- covers the exchange of data between an end system and the network that it is attached to
- concerned with issues like :
  - destination address provision
  - invoking specific services like priority
  - access to & routing data across a network for two end systems attached to the same network



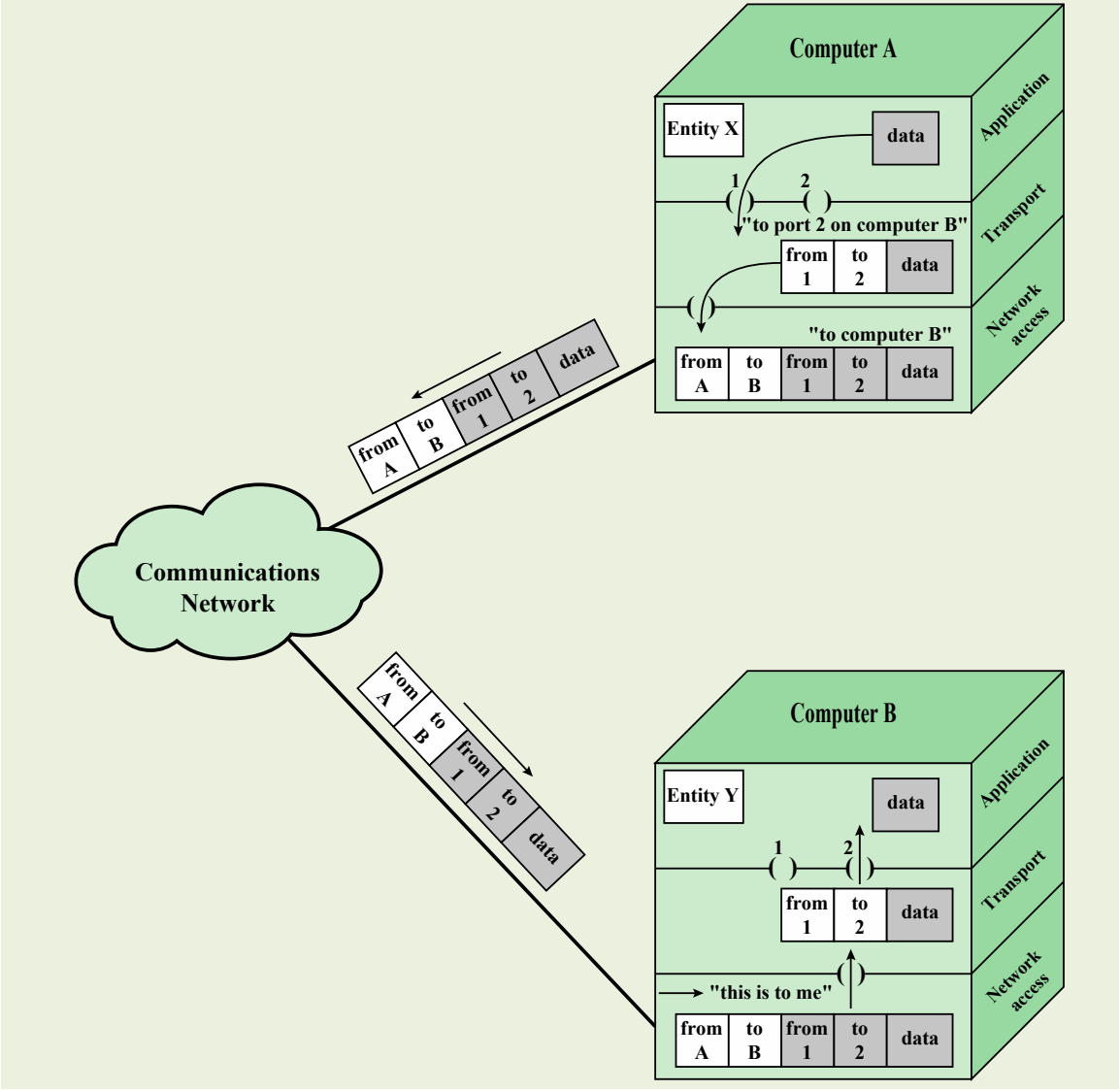
Transport Layer



Protocol Architecture and Networks



Protocols in a Simplified Architecture



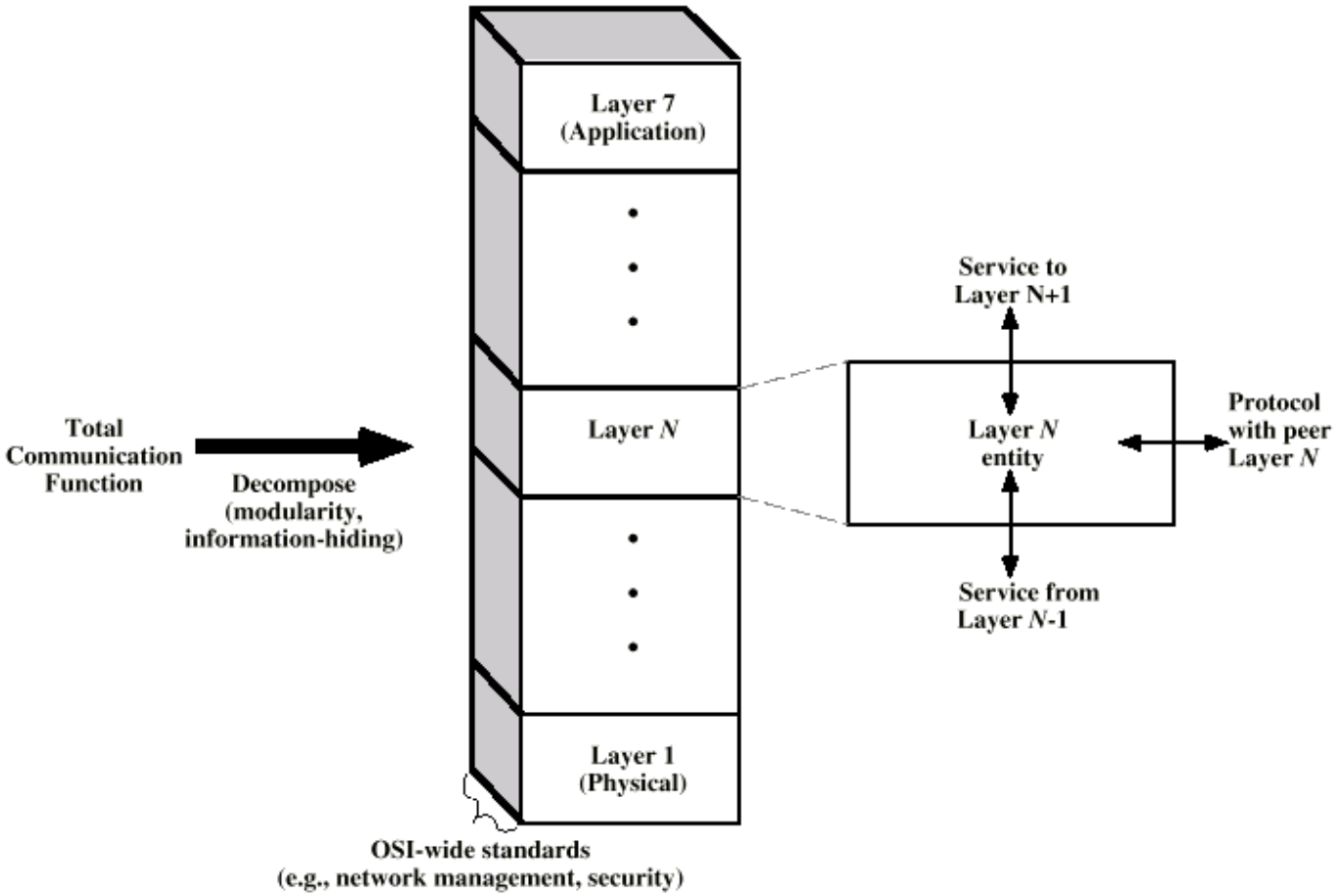
Protocol Data Unit (PDU)

- the combination of data and control information is a PDU
- typically control information is contained in a PDU header
  - control information is used by the peer transport protocol at computer B
- headers (e.g. Transport PDU header) may include:
  - source port, destination port, sequence number, and error-detection code

Network Access Protocol

- after receiving segment from transport layer, the network access protocol must request transmission over the network
  - the network access protocol creates a network access PDU (packet) with control information
- header includes:
  - source computer address
  - destination computer address
  - facilities requests

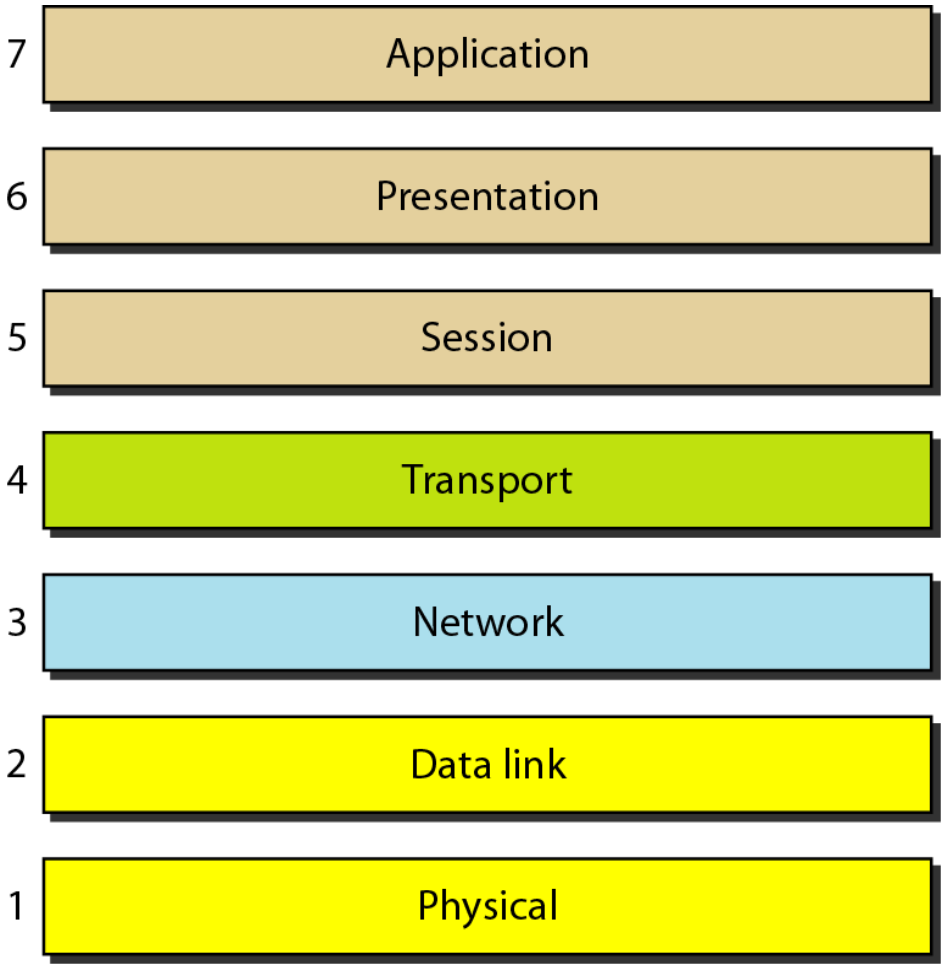
Standardized Protocol Architectures



OSI Model

- *International Standards Organization (ISO)* developed *Open Systems Interconnections (OSI)* Model.
- OSI was started to be developed at *1977* but published in *1984*.
- It breaks down the communication tasks into seven independent layers, each with its own tasks.
- Each layer represents a particular function, performed by hardware or software.
- Each layer relies on the next lower layer to perform more primitive functions.
- Each layer provides services to the next higher layer.

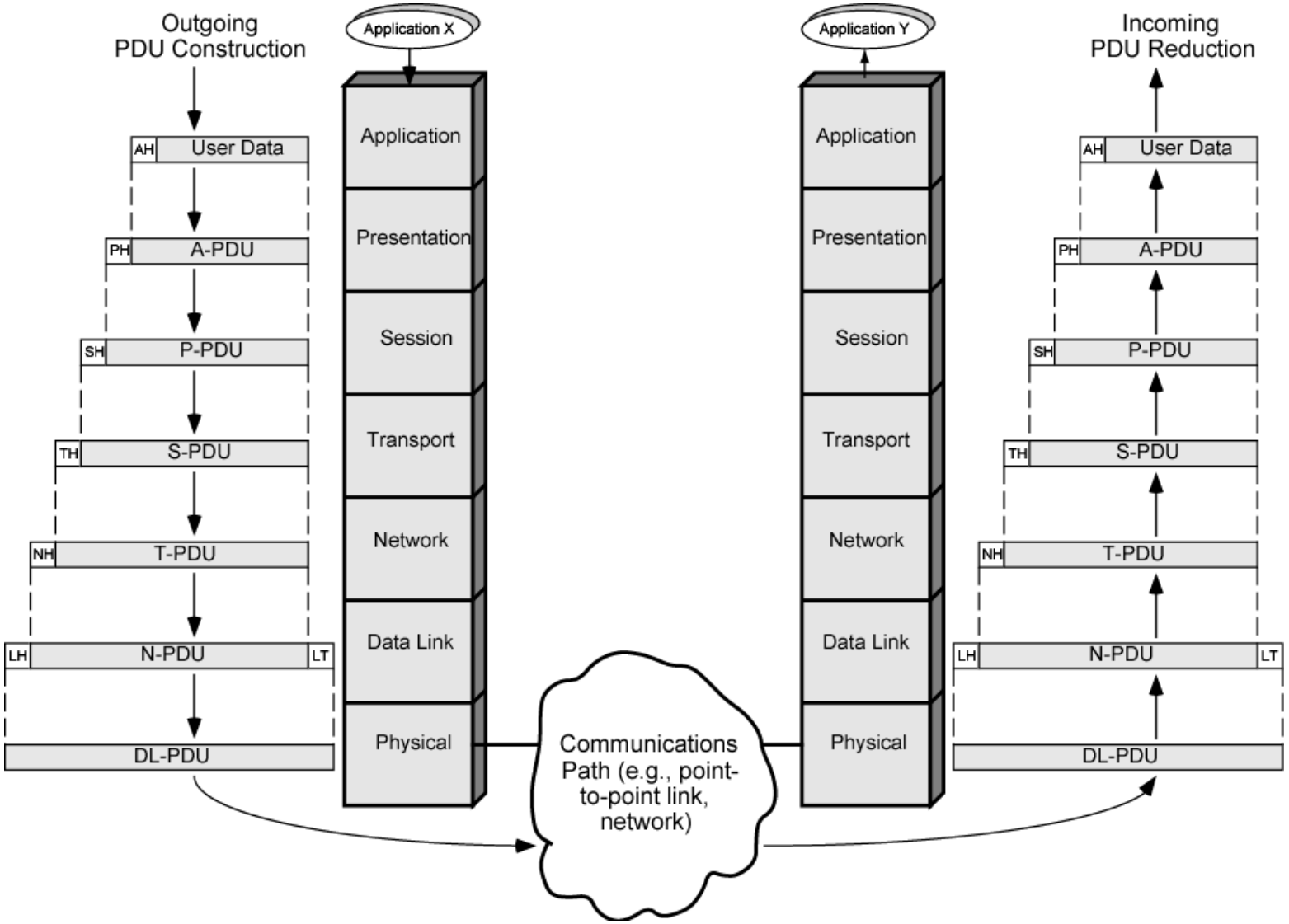
Layers of The OSI Model



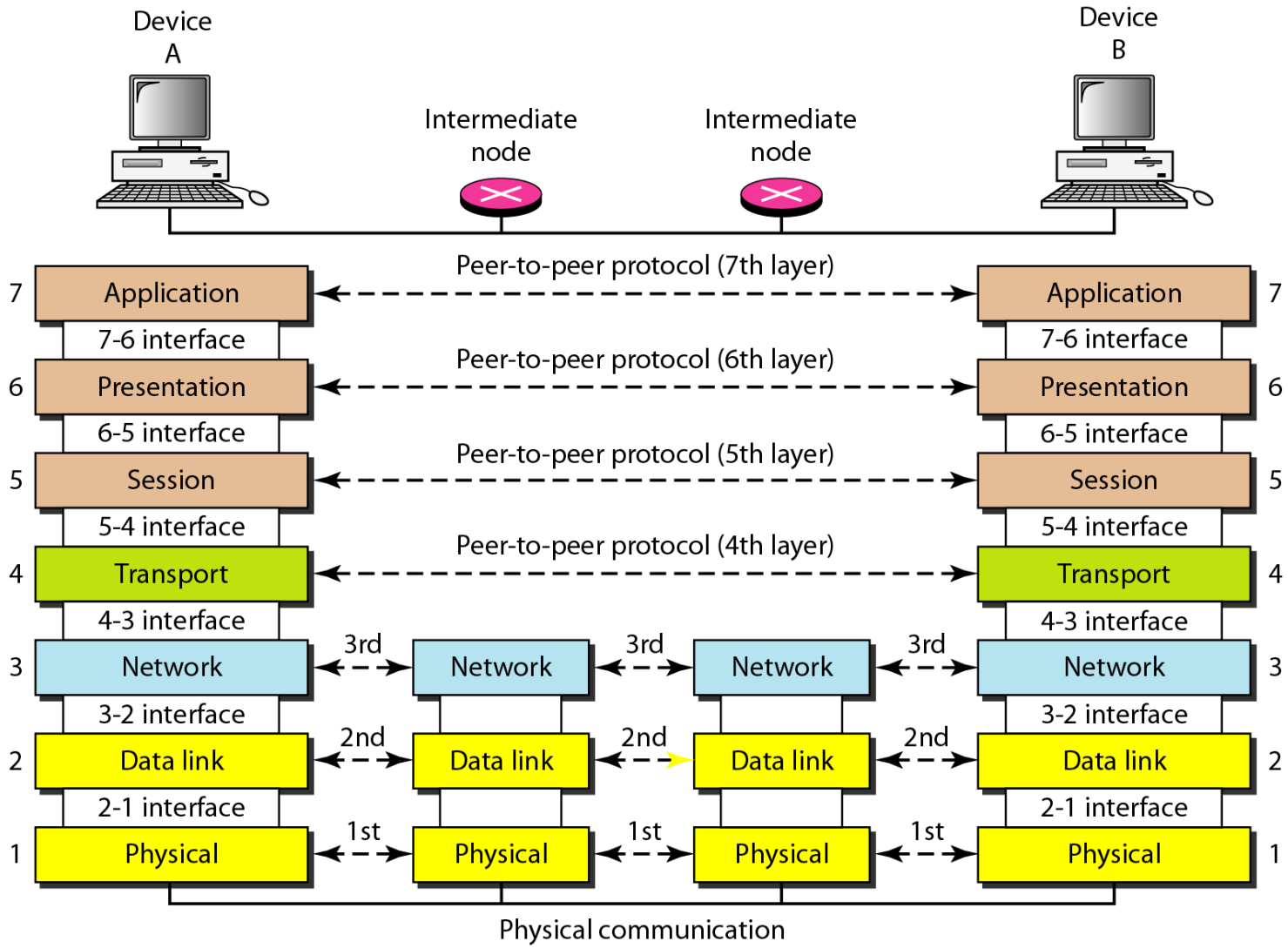
OSI as Framework for Standardization

- The functions of each layer are well defined $\Rightarrow$ standards can be developed independently and simultaneously
  - This speeds up the standards-making process
- The boundaries between layers are well defined $\Rightarrow$ changes in standards in one layer need not affect already existing software in another layer
  - This makes it easier to introduce new standards

The OSI Environment



Multiple Node Communications under OSI



The OSI Model

- Physical Layer
  - Bits physically transmitted
  - Typically defined by an interface specification
- Data link layer
  - Ensures error-free transmission
  - Requests retransmission as needed
- Network Layer
  - Determines route
  - Understands physical network topology

The OSI Model (Continued)

- Transport Layer
  - Isolates upper layers from lower layers
  - Breaks message into blocks and reassembles as needed
  - Converts addresses from local scheme to match actual network
- Session Layer
  - Establishes logical connection
  - Permission to use resources
  - Logons/passwords

The OSI Model (Continued)

- Presentation layer
  - Format conversion
  - Code conversion
- Application layer
  - User access
  - Allows applications to use the network

Lower Layers And Higher Layers

- Layers 1, 2, and 3 are *lower layers*.
  - Layer 1 is always implemented in hardware.
  - Layer 2 and layer 3 sometimes are implemented in hardware.
- Layers 4, 5, 6, and 7 are *higher layers* or *upper layers*.
  - They manipulate the data in some way, and are always implemented in software.

PDU in Different Layers

- Application layer — ***message***, record, file, envelope
- Transport layer — ***block***, ***segment***
- Network layer — ***packet***, ***datagram***
- Data link layer — ***frame***, cell, slot
- Physical layer — ***frame***, envelope

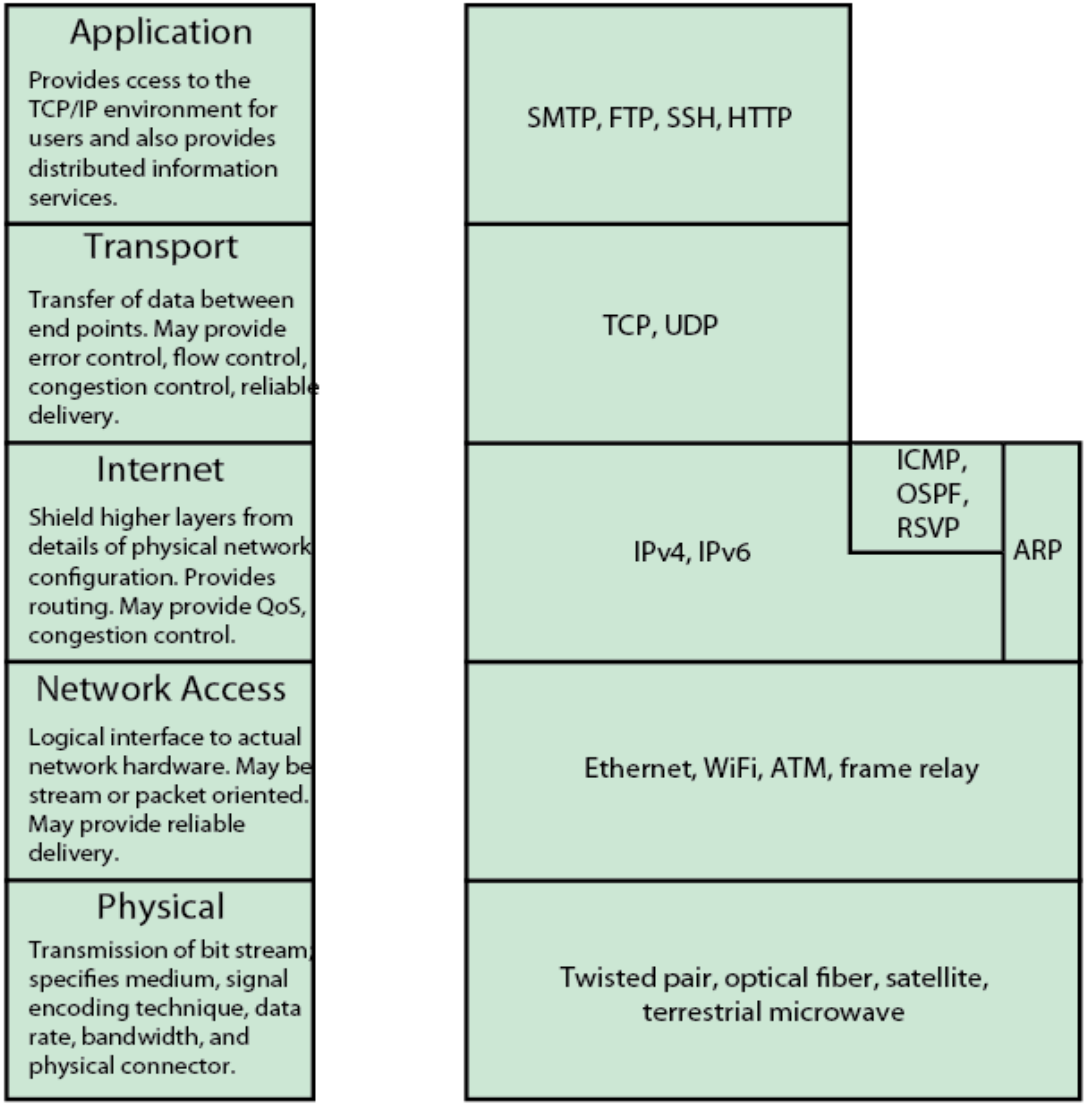
TCP/IP Protocol Architecture

Result of protocol research and development conducted on ARPANET

Referred to as TCP/IP protocol suite

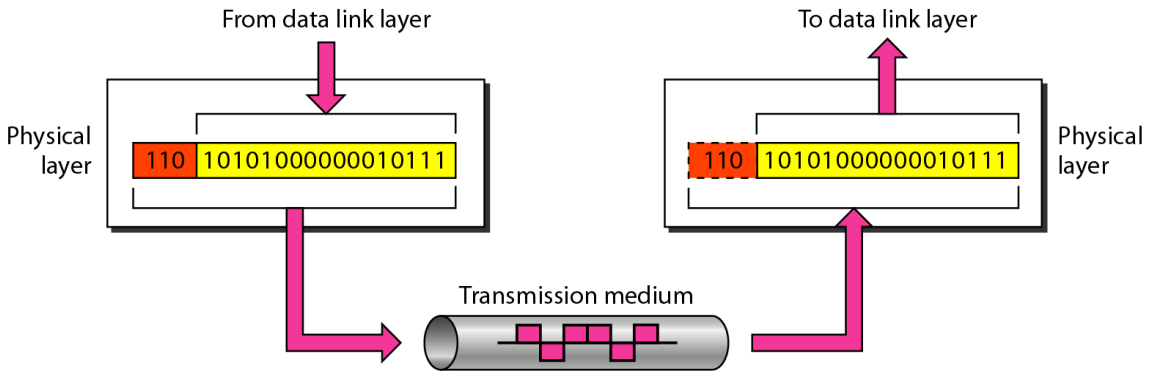
TCP/IP comprises a large collection of protocols that are Internet standards

TCP/IP Layers and Example Protocols



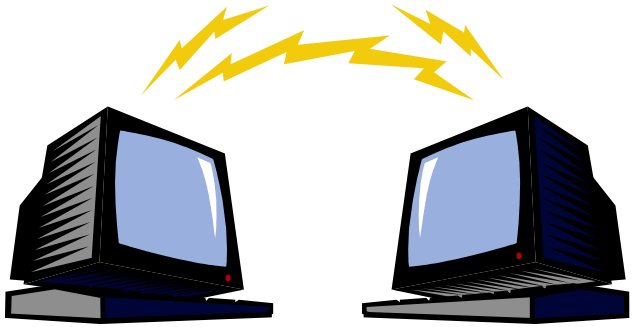
Physical Layer

- Covers the physical interface between computer and network
- Concerned with issues like:
  - Characteristics of transmission medium
  - Nature of the signals
  - Data rates

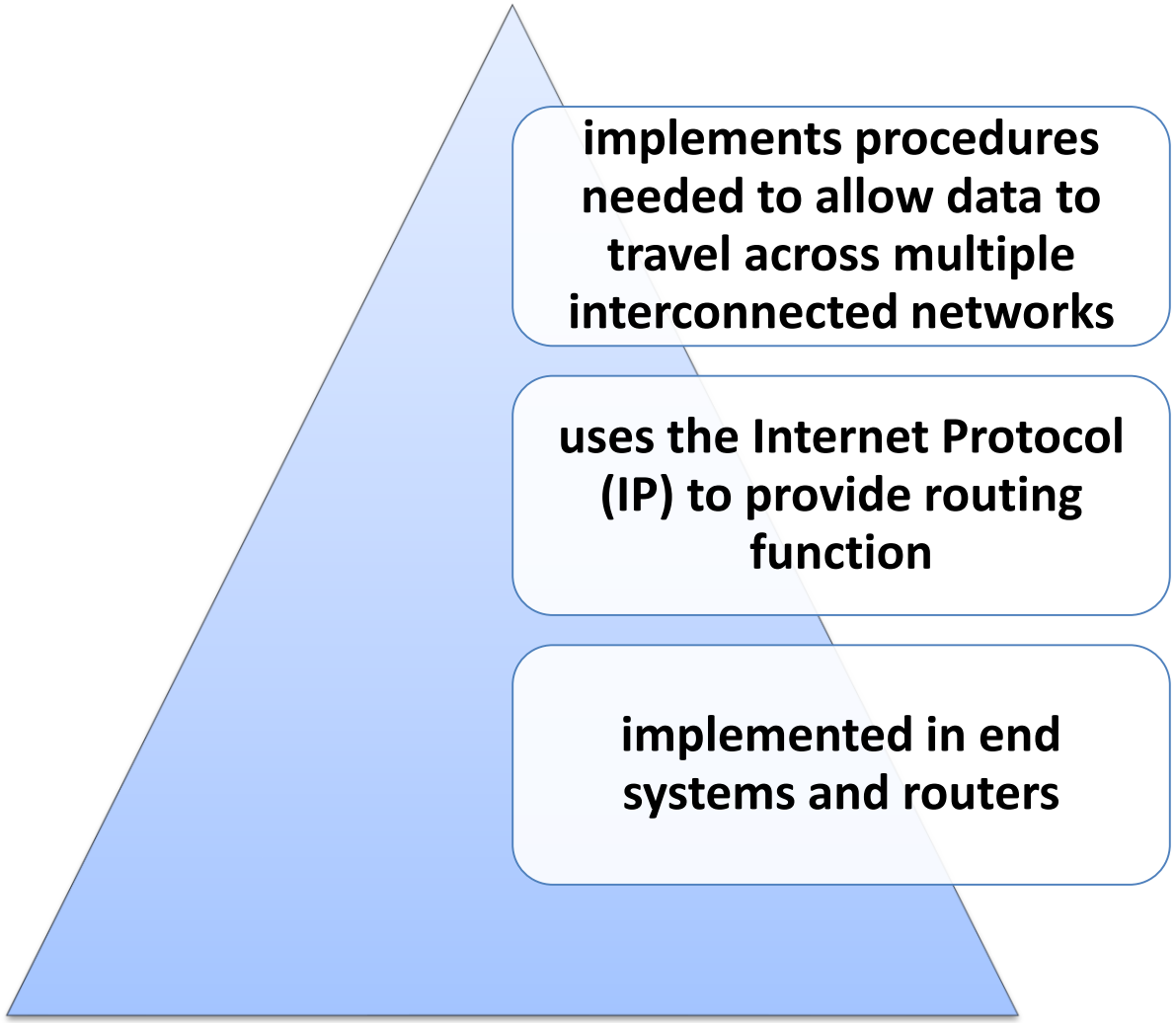


Network Access/Data Link Layer

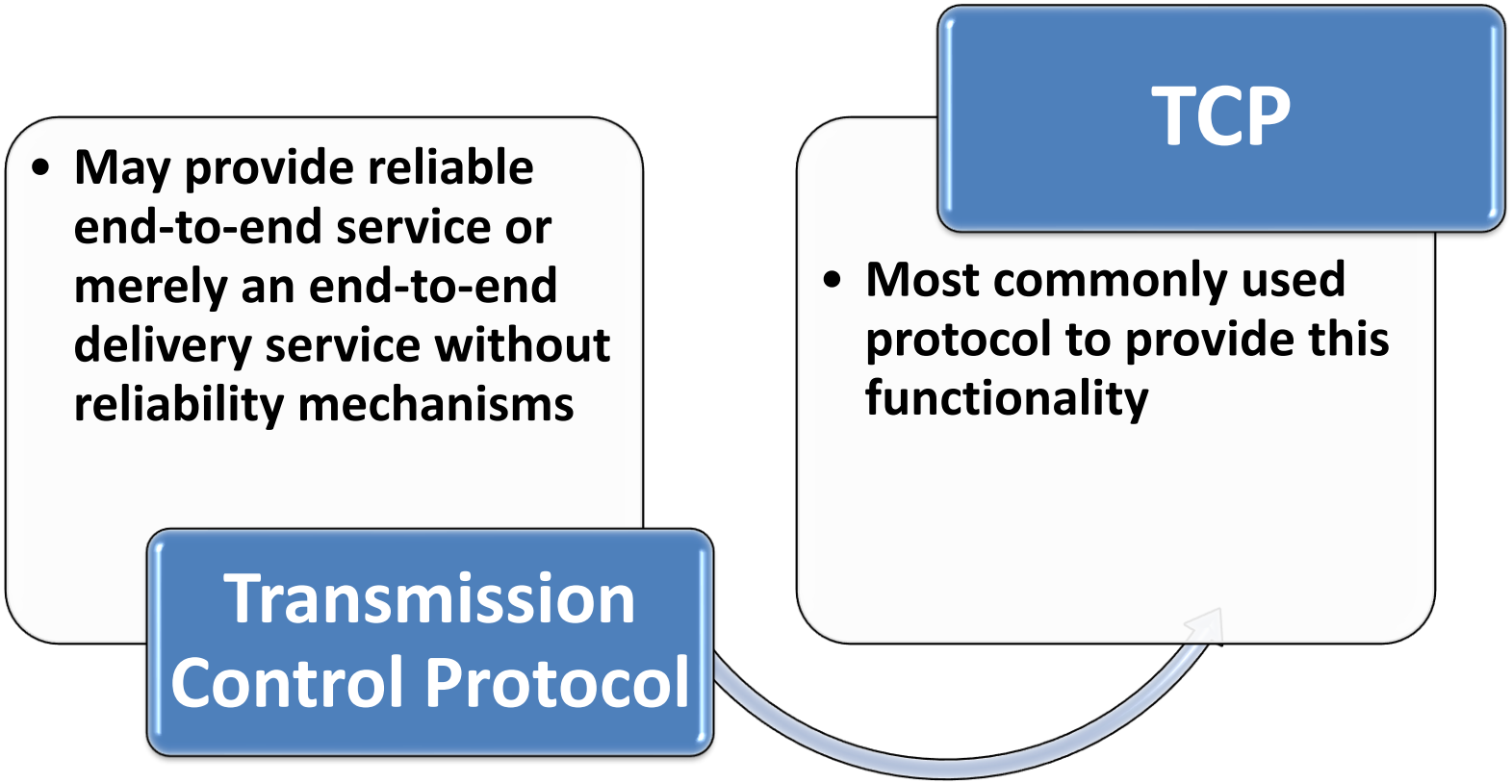
- Covers the exchange of data between an end system and the network that it is attached to
- Concerned with:
  - Access to and routing data across a network for two end systems attached to the same network



Internet Layer



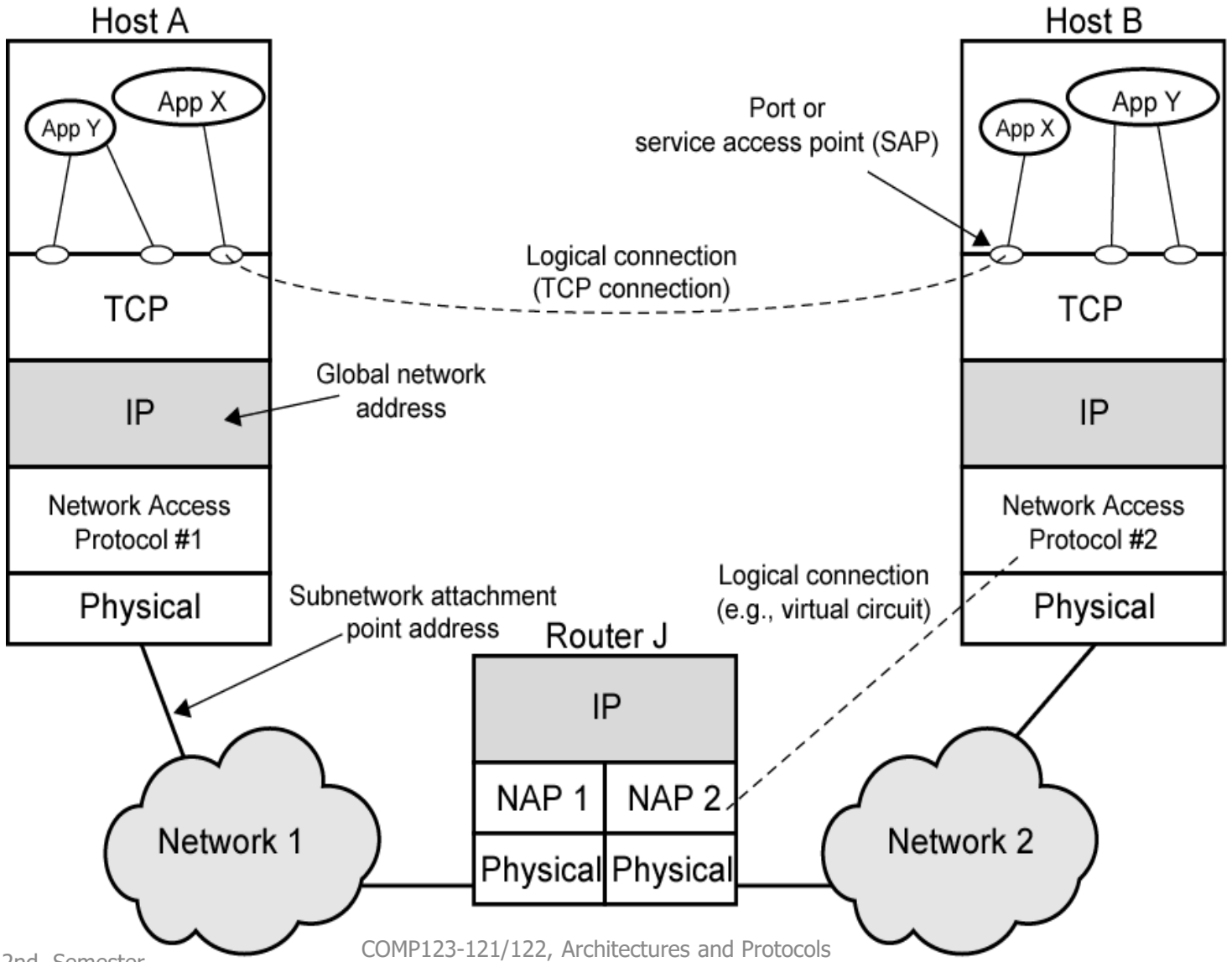
Host-to-Host (Transport) Layer



Application Layer

- Contains the logic needed to support the various user applications
- A separate module is needed for each different type of application that is peculiar to that application

Operation of TCP/IP



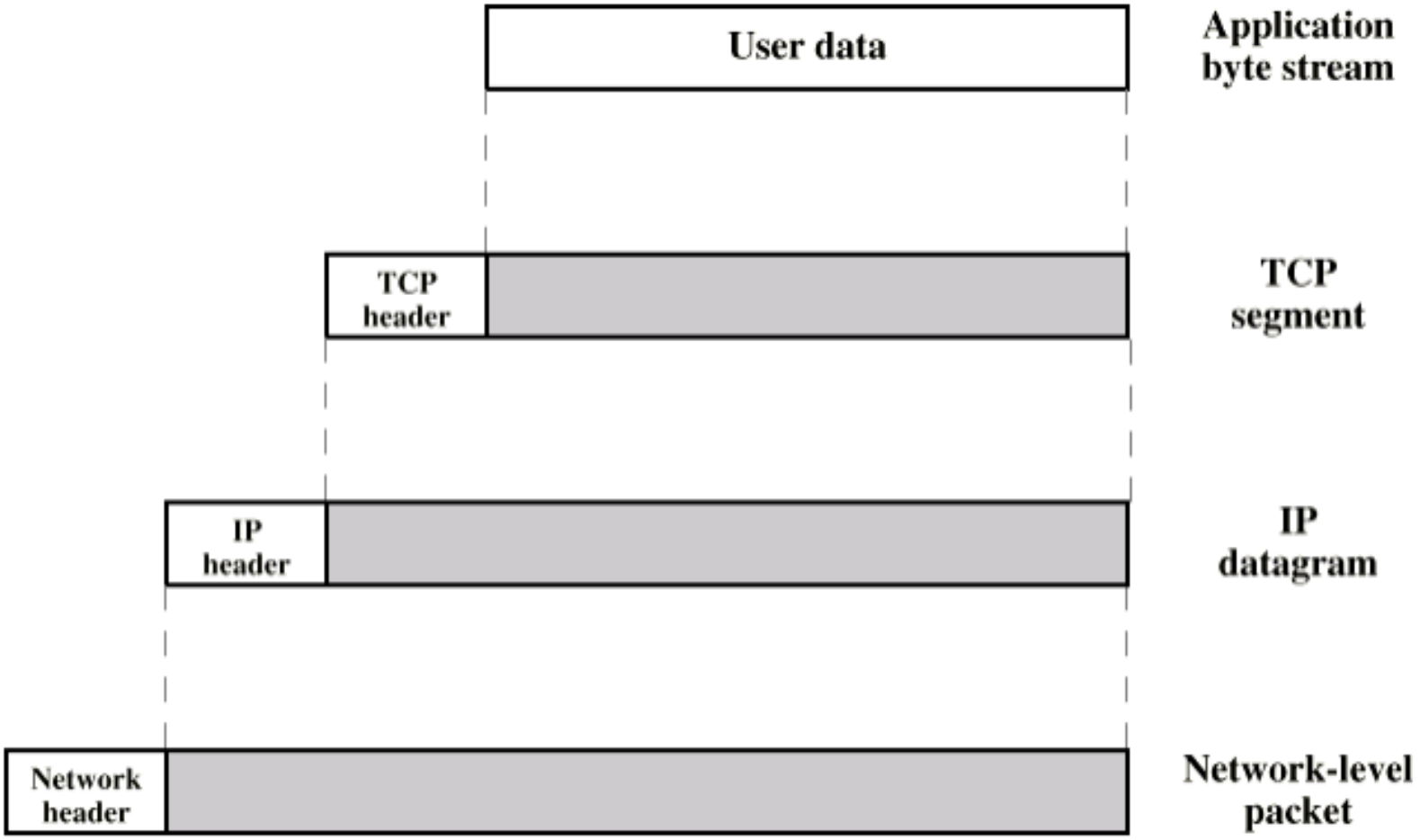
TCP/IP Address Requirements

- Two levels of addressing are needed:

each host on a subnetwork must have a unique global internet address, e.g. IP address

each process with a host must have an address (known as a port) that is unique within the host, e.g. Port Number

Operation of TCP/IP

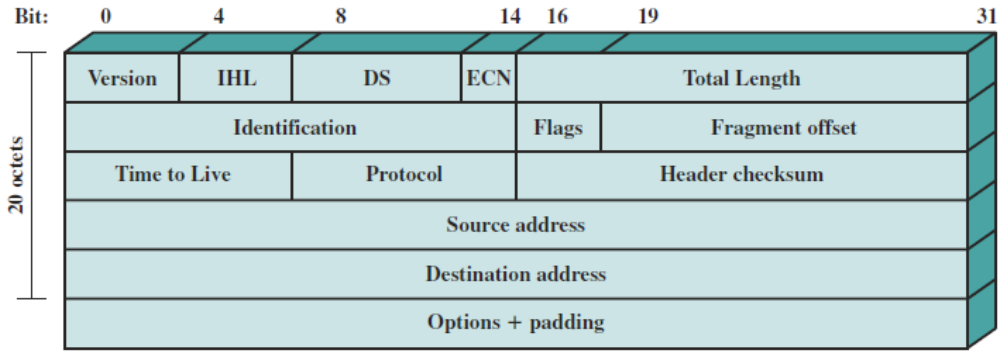


Transmission Control Protocol (TCP)

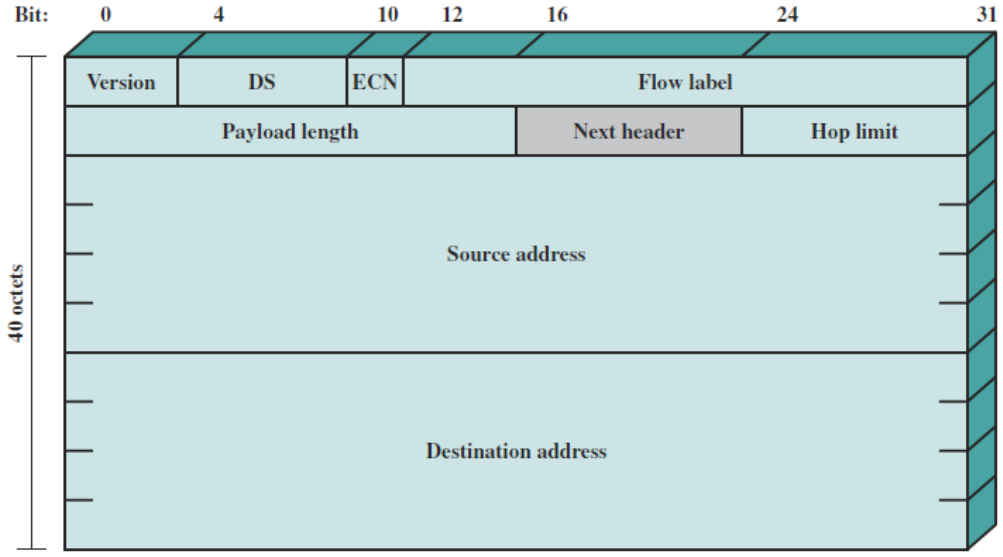
- TCP is the transport layer protocol for most applications
- TCP provides a reliable connection for transfer of data between applications
- A TCP segment is the basic protocol unit
- TCP tracks segments between entities for duration of each connection

IPv6

- Provides enhancements over existing IP, i.e. IPv4
- Designed to accommodate higher speeds and the mix of graphic and video data
- Driving force was the need for more addresses due to growth of the Internet
- IPv4 has 32-bit source and destination address fields while IPv6 has 128-bit.



(a) IPv4 header



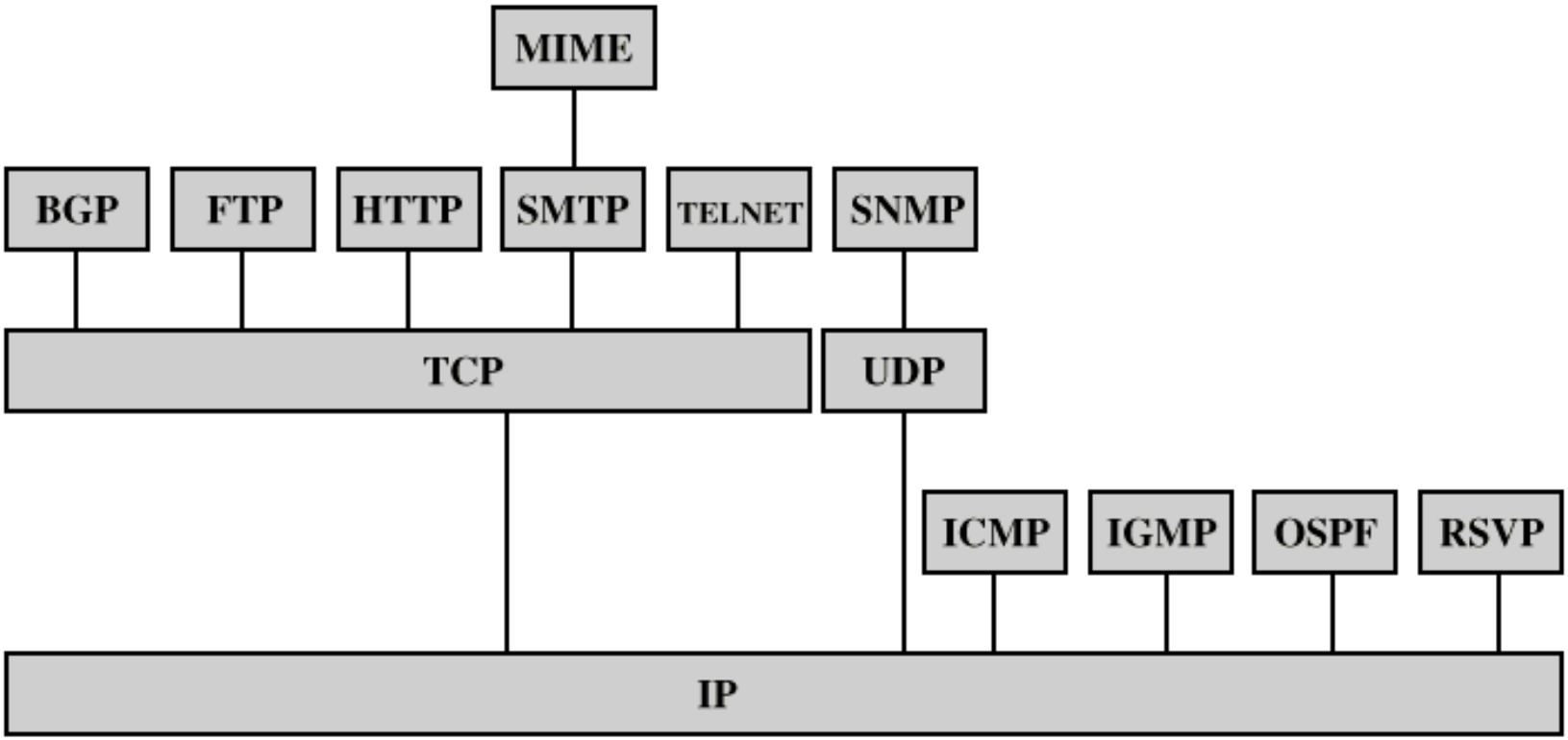
(b) IPv6 header

DS = Differentiated Services field
ECN = Explicit Congestion Notification field

Note: The 8-bit DS/ECN fields were formerly known as the Type of Service field in the IPv4 header and the Traffic Class field in the IPv6 header.

Figure 2.7 IP Headers

TCP/IP Protocols



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

Addressing

Two levels of addressing are needed:

each computer on the network has a unique network address

each application has an address that is unique with that computer

Logical Address

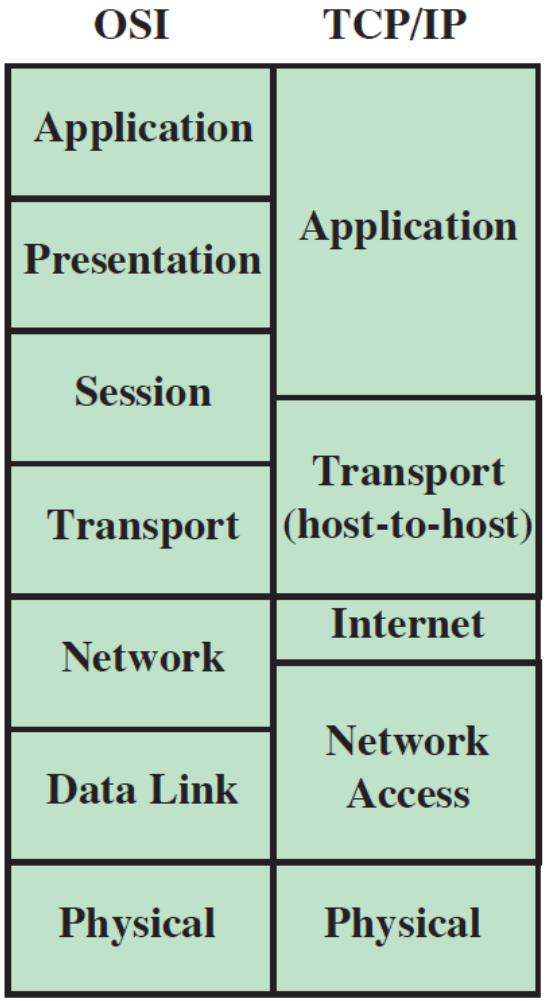
- An *IP address* of the system is called logical address.
- This address is the combination of Net ID and Host ID.
- This address is used by *network layer*.
- This address can be changed by changing the host position on the network. So it is called logical address.
- For example, 202.175.25.224 (IPv4, *dot-decimal notation*) and fe80::31b9:1da5:7d4d:9f22%15 (IPv6)

Physical Address

- Each system has a *NIC (Network Interface Card)* through which two systems physically connected with each other.
- The address of the NIC is called physical address, or *MAC (Media Access Control)* address, e.g. 40-61-86-37-BE-C2
- *Media Access Control* address *(MAC address)* is an *unique identifier* assigned to most *network adapters* or *NICs* by the manufacturer for identification.
- A MAC address usually encodes the manufacturer's registered identification number.
- This address is used by *data link layer*

Comparison of the OSI and TCP/IP Protocol Architectures

- Presentation and Session layer are not included in TCP/IP Suite
- Question: we don't need them in TCP/IP?



Summary

- Needs and key elements for protocol architecture
- OSI model & protocol architecture standardization
- TCP/IP protocol architecture