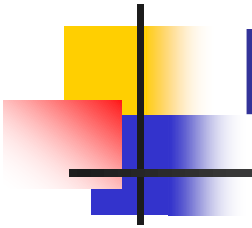
Introduction to Network Technologies & Layered Architecture

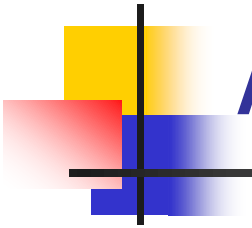
BUPT/QMUL

2019-3-4



Review

- What is the Internet?
- How does it work?
- When & how did it come about?
- Who controls it?
- Where is it going?



Agenda

- Basic Network Definitions
- Layered Architecture

Refer to Section 2.2, 2.3 and Chapter 10 of the Textbook

Basic Network Definitions

- Terms for Network Devices
- Terms for Network Performance Parameters
- Ways to connect to the Internet
- Terms for Network Types

Basic Network Definitions

—— Terms for network devices

Node

- a device that is connected as part of a network with a network address
  - E.g. Computer, PDA, Cell Phone, router, switch, bridge etc.

Host Node

- the computer attached directly to the Internet (eg: ISPs and NSPs) - end point of a network

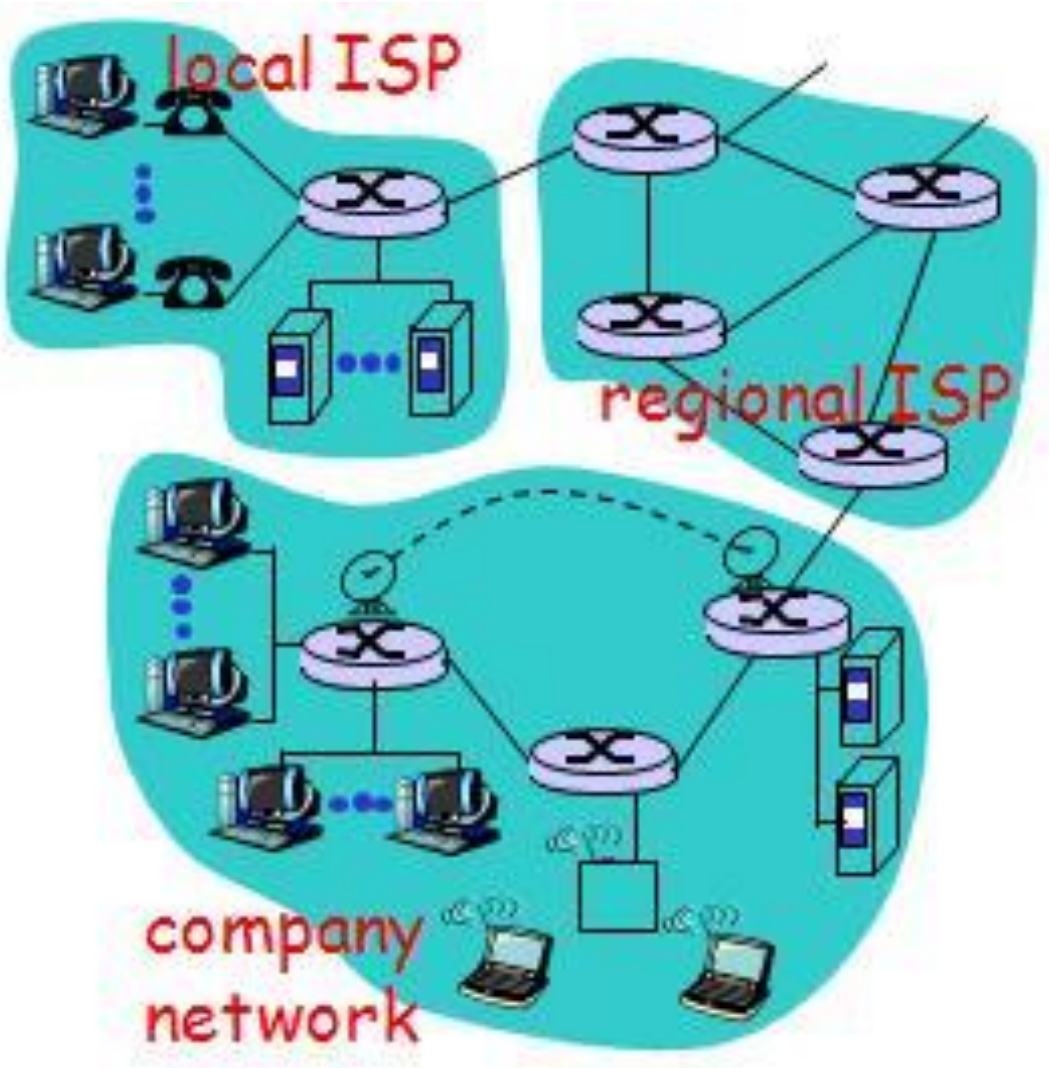
Link

- the inter-connection between network devices

Network Component

- the equipment that is part of the network infrastructure
  - E.g. Gateway, router, bridge/switch, hub/repeater

Example of Nodes



Basic Network Definitions

- Terms for Network Devices
- Terms for Network Performance Parameters
- Ways to connect to the Internet
- Terms for Network Types

Basic Network Definitions

—— Terms for network performance parameters

Bandwidth

- Indicates how much stuff you can send through a connection
- bps (bit per second)
- Bps (Byte per second)

Delay (Latency)

- is an expression of how much time it takes for a packet of data to get from one designated point to another
- Contributors
  - Propagation
  - Transmission
  - Processing
  - Storage(Queuing)

Jitter

- The variation in delay

Error Rate

- The probability of the data units which are transmitted in error, are lost or are retransmitted
- BER (Bit Error Rate)
- FER (Frame Error Rate)
- PER (Packet Error Rate)

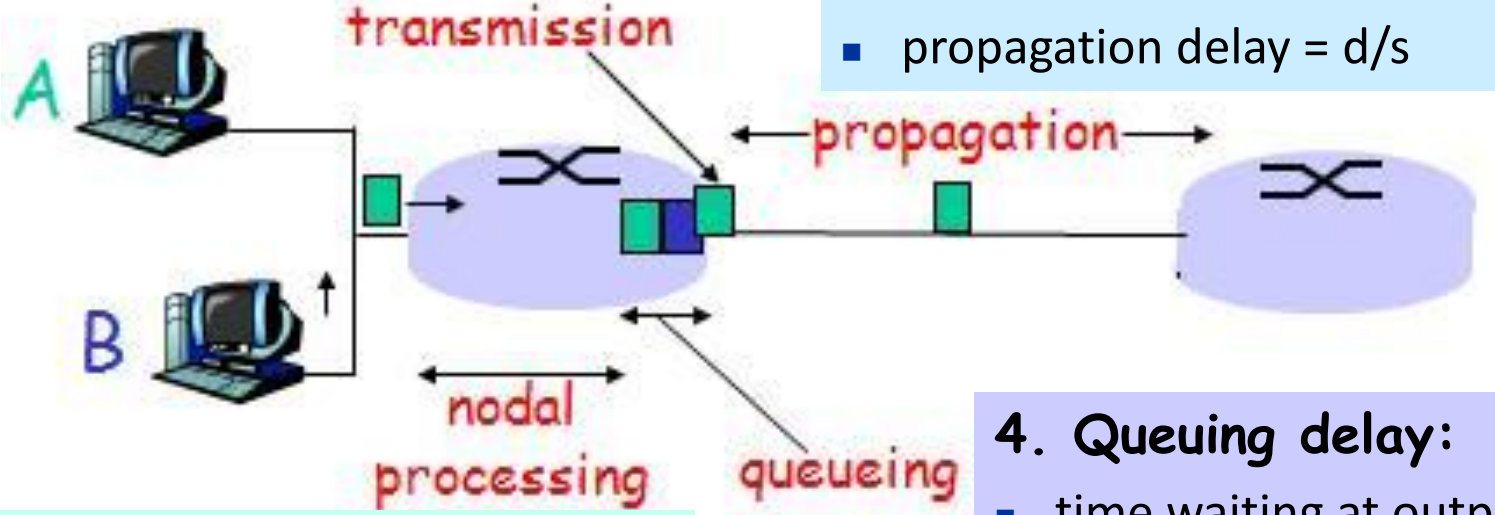
Sources of Delay

1. Transmission delay:

- R=link bandwidth (bps)
- L=packet length (bits)
- time to send bits into link = L/R

2. Propagation delay:

- d = length of physical link
- s = propagation speed in medium
- propagation delay = d/s



3. Nodal processing delay:

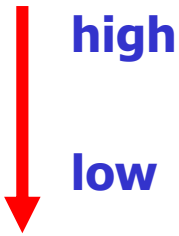
- check bit errors
- determine output link

4. Queuing delay:

- time waiting at output link for transmission
- depends on congestion level of router

Basic Network Definitions
—— Terms for network performance parameters

- Other similar parameters used for QoS (Quality of Service)
  - Throughput : the average rate of successful message delivery over a communication channel (*wikipedia)*
  - PLR (Packet Loss Rate)
- Different applications have different QoS requirements
  - E.g., four application classes defined by 3GPP according to their sensitivity to delay
    - Session Class
    - Interactive Class
    - Streaming Class
    - Background Class

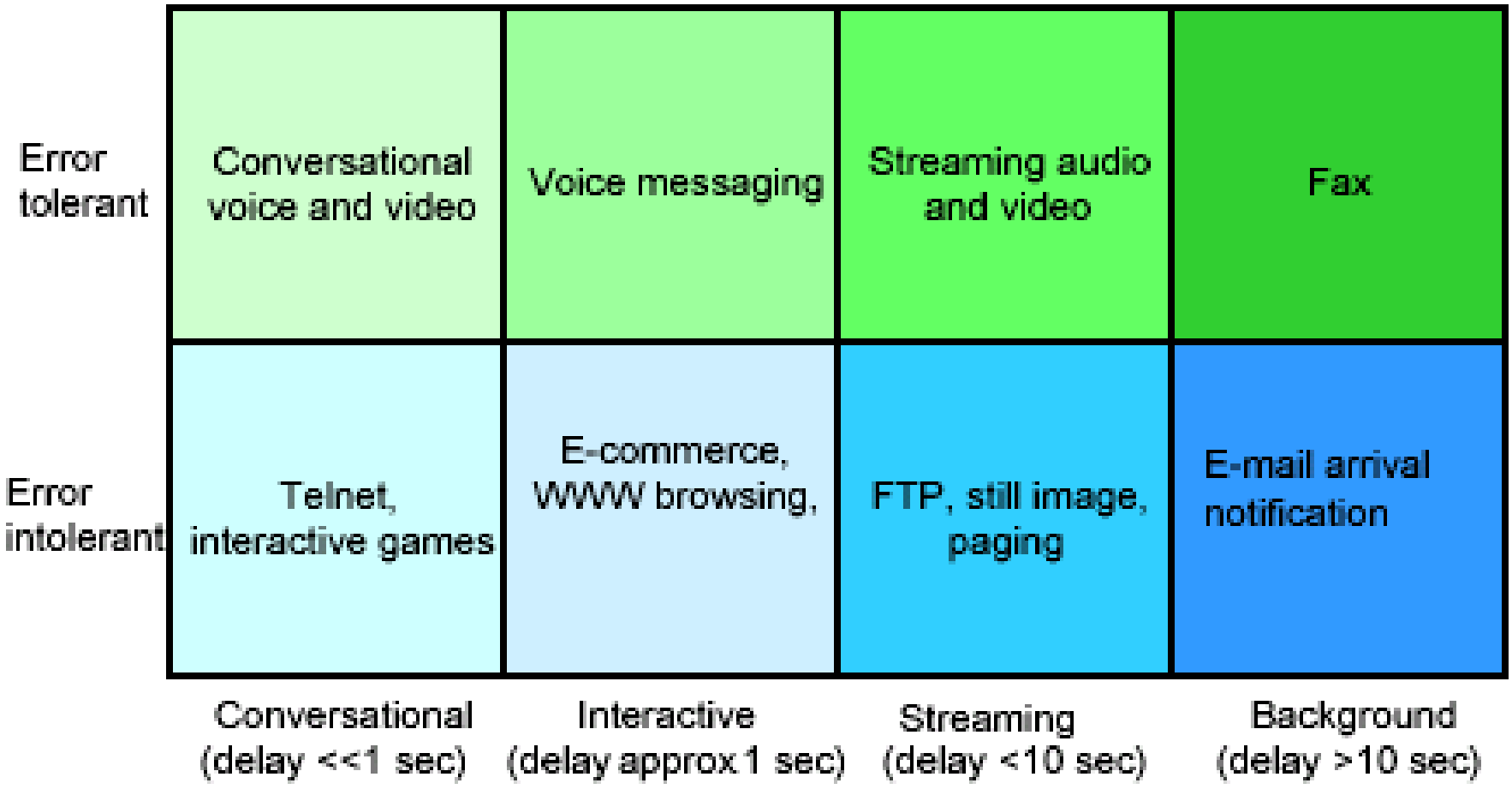


Basic Network Definitions

—— Terms for network performance parameters

Class	Requirements	Examples
Session Class	Low delay, low jitter, without high requirements on BER	VoIP Video conference
Interactive Class	Low BER, low response delay, without high requirements on jitter	Web browsing
Streaming Class	Low jitter, without high requirements on delay and BER	Video/audio streaming
Background Class	Low BER, without high requirements on delay and jitter	Email

Application classification of 3GPP



Basic Network Definitions

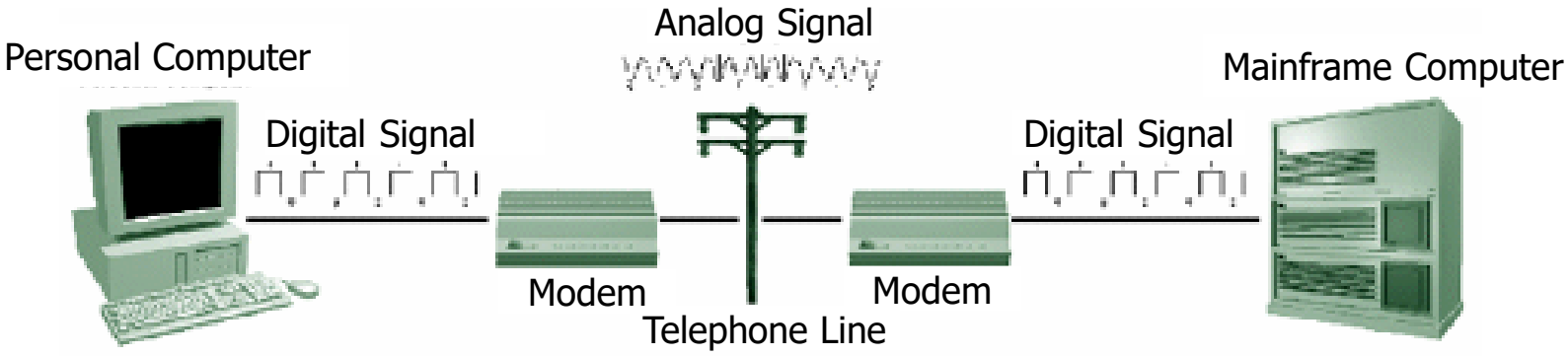
- Terms for Network Devices
- Terms for Network Performance Parameters
- Ways to connect to the Internet
- Terms for Network Types

Basic Network Definitions
—— Ways to connect to the Internet

- **Dialup**
  - Via twisted pair phone lines
- **ISDN**
  - Integrated Services Digital Network (64-128Kbps)
- **(A)DSL**
  - (Asymmetric) Digital Subscriber Line
  - 8 Mbps download, 2Mbps upload – 1M bps download, 256Kbps upload
  - Usually provided by telephone companies
- **Cable Modem**
  - CATV: 500 Kbps - 30 Mbps
  - Usually provided by cable companies
- **LAN**
  - Ethernet connections
- **Satellite**
- **Cellular**
  - GPRS/CDMA/3G/4G and other cellular wireless technologies
- **Broadband wireless access**
  - WLAN(WiFi)/WiMAX

Basic Network Definitions
—— Ways to connect to the Internet

- Dialup: MODEM (MOdulator-DEModulator)
  - Converting analog signal to digital and vice versa



Source - Transmitter - Channel - Receiver - Destination

Basic Network Definitions
—— Ways to connect to the Internet

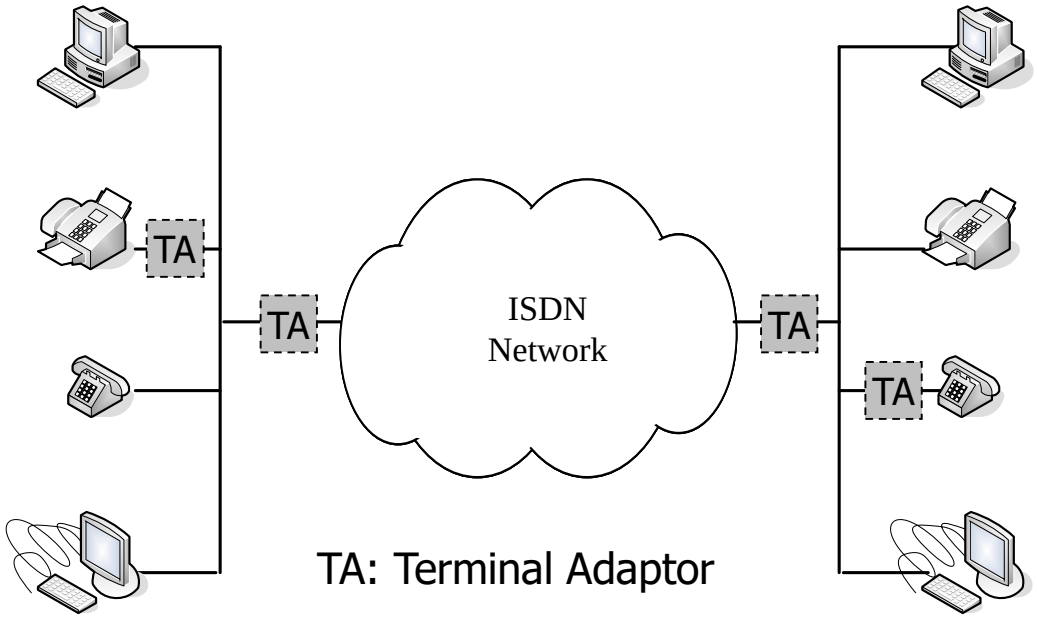
- Data codes

Code	Bits	Max Chars
Baudot	5	32 or 64
ASCII	7	128
Extended ASCII	8	256
EBCDIC	8	256
UNICODE	16	> 65,000
ISO 10646	32	> 4 billion

Basic Network Definitions

—— Ways to connect to the Internet

- ISDN: Integrated Services Digital Network
- Developed based on telephony IDN (Integrated Digital Network)
- A set of CCITT/ITU standards



Basic Network Definitions
—— Ways to connect to the Internet

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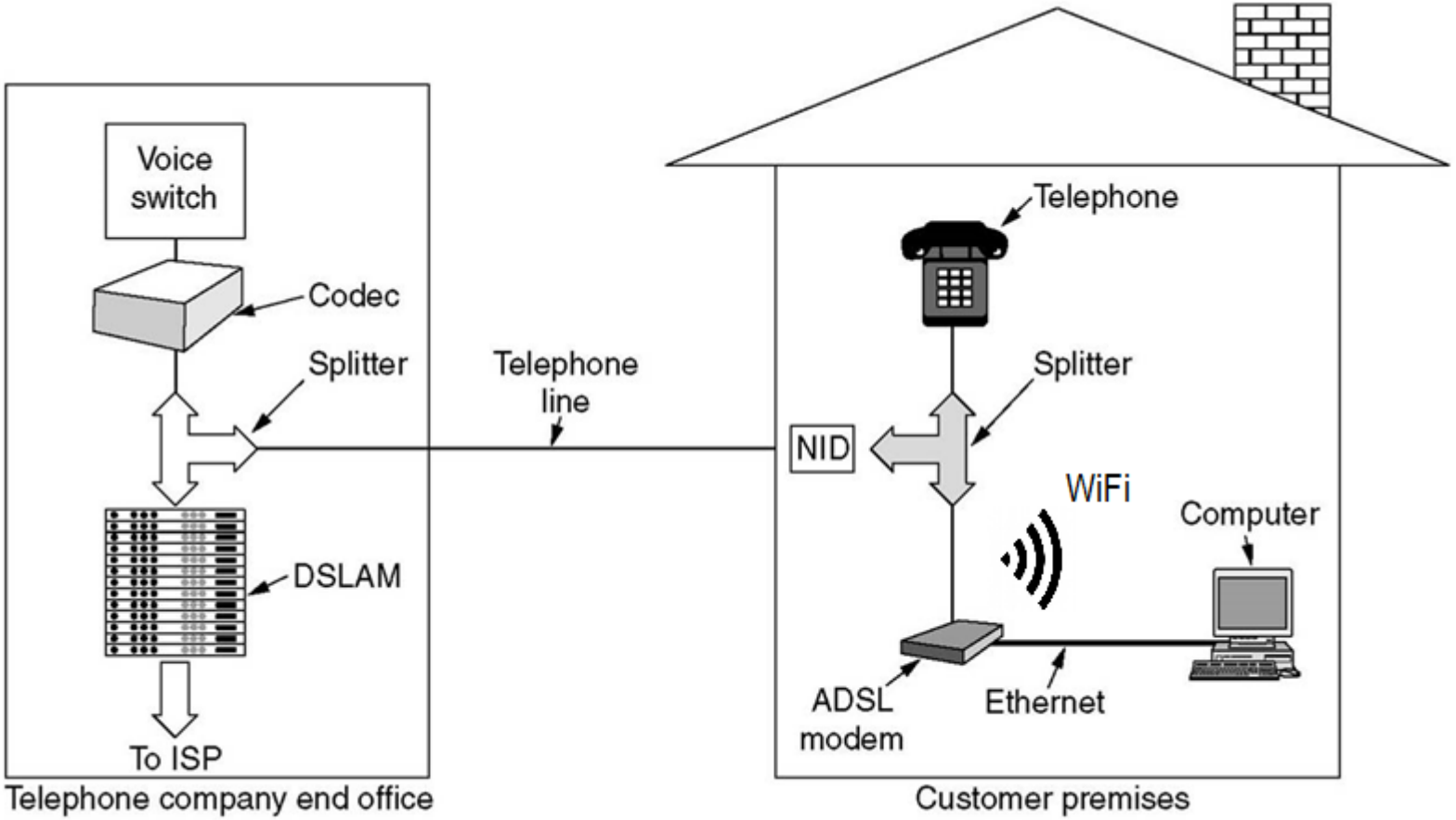
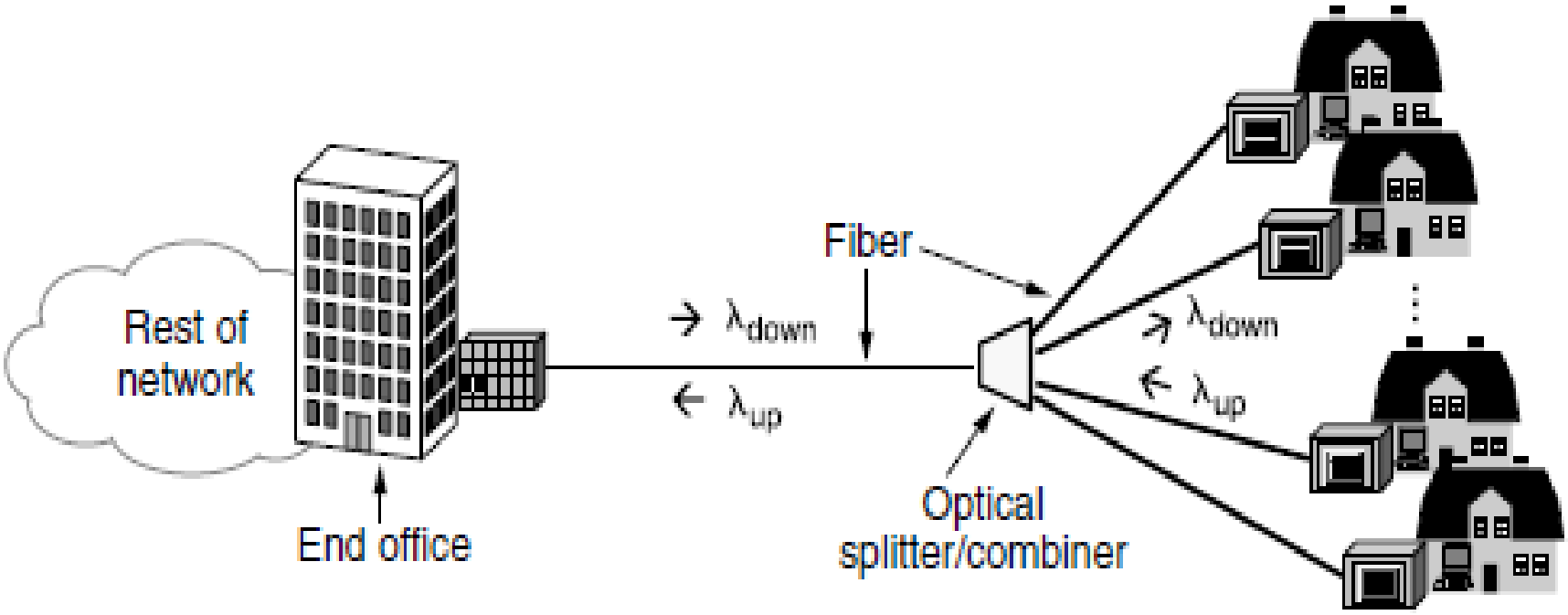
ADSL: typical configuration

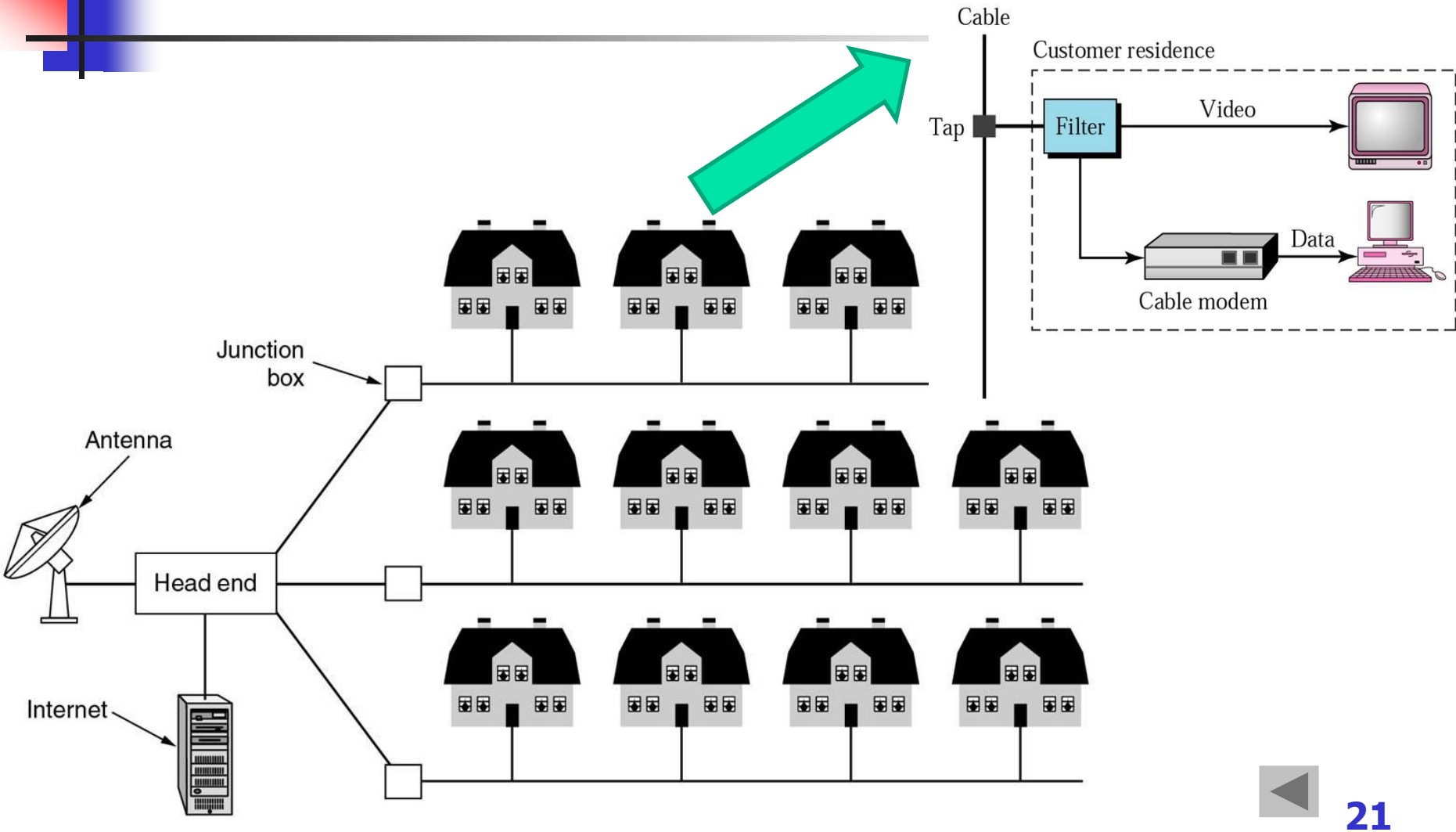


FTTH: Fiber to the Home



PON(Passive Optical Network)

A Network based on Cable TV



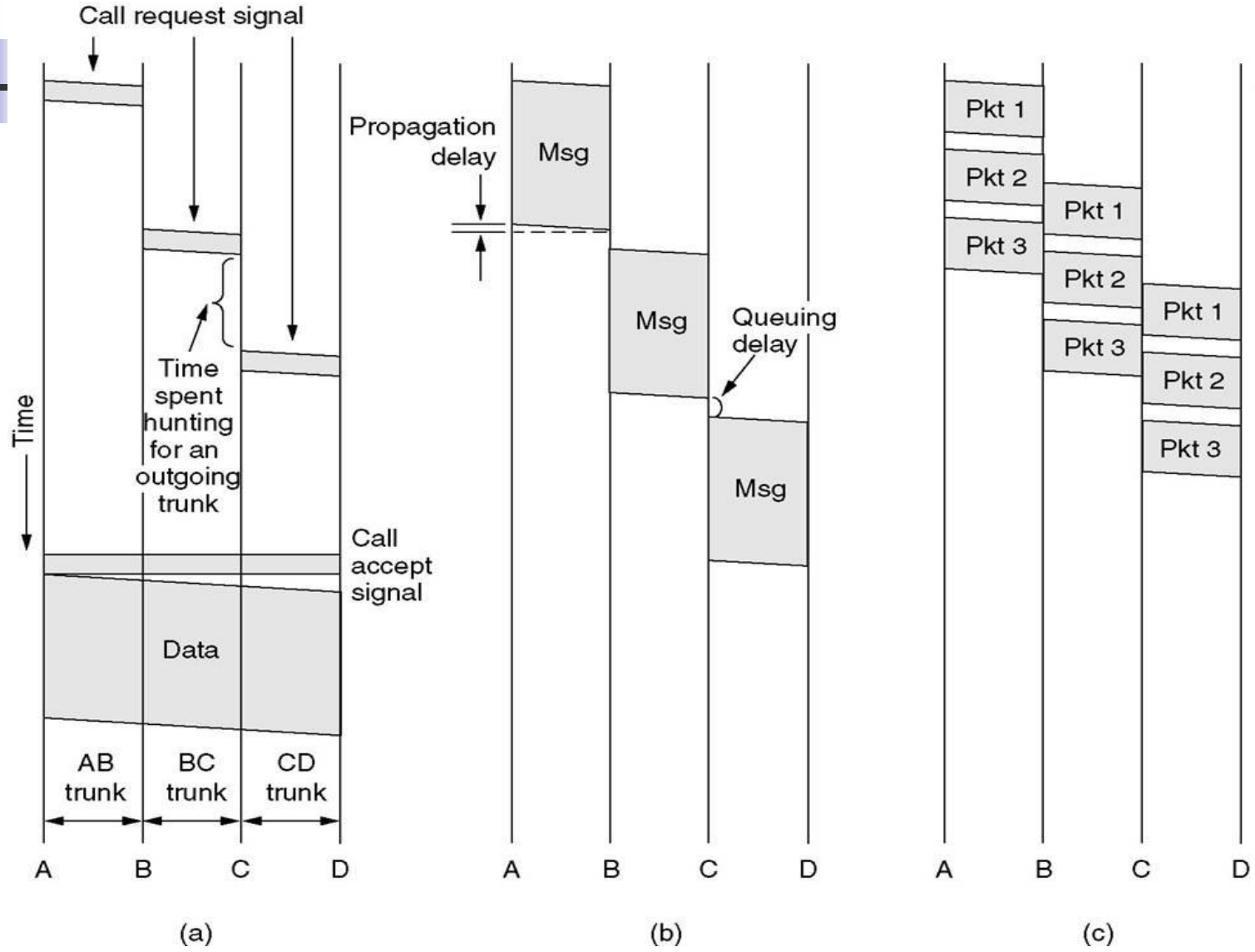
Basic Network Definitions

- Terms for Network Devices
- Terms for Network Performance Parameters
- Ways to connect to the Internet
- Terms for Network Types

Basic Network Definitions
—— Terms for network types

- According to the switching function in the network
  - Circuit switching network
  - Message switching network
  - Packet switching network
  - Hybrid switching network

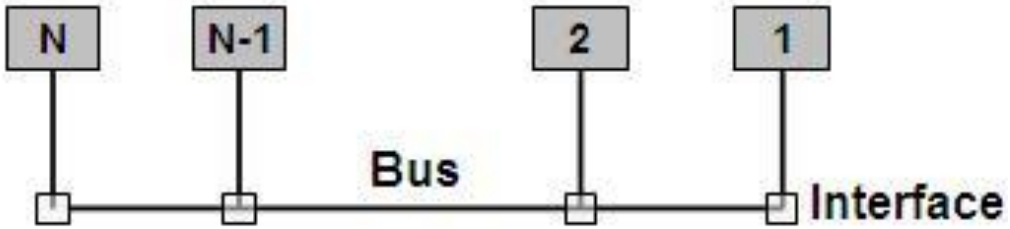
Timing in CS, MS and PS



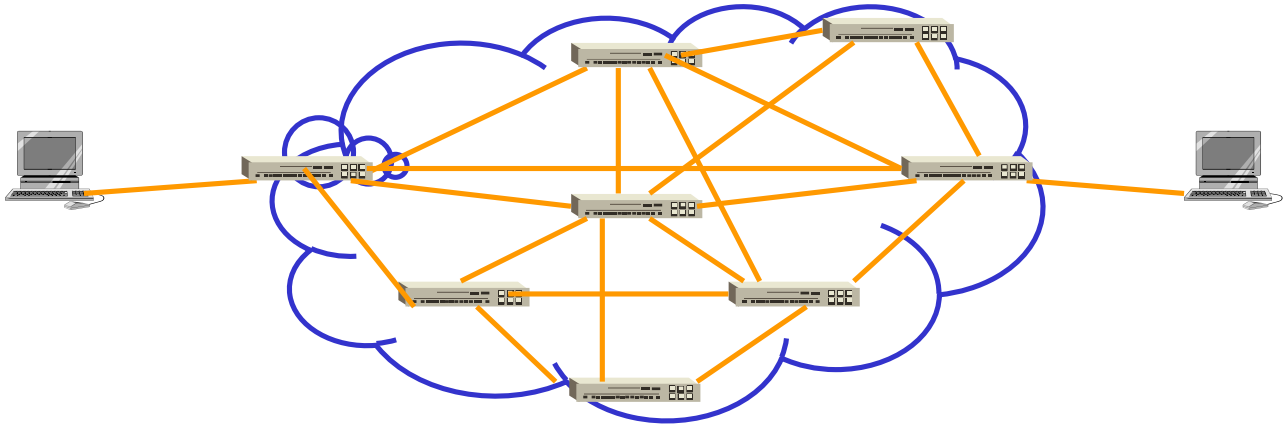
Basic Network Definitions
—— Terms for network types

- Different channel access technologies
  - Multi-access means **shared medium**
    - Many end-systems share the same physical communication resources (wire, frequency, etc.)
    - There must be some arbitration mechanism
    - Complex channel access control, efficient resource usage
    - Example: LANs
  - point-to-point
    - Between two points in the network, there must exists a physical channel
    - No contention or collision
    - Simple access control, bandwidth waste
    - Example: WANs

Channel access technologies



Multi-access network



Point-to-point network

Basic Network Definitions
—— Terms for network types

- According to the range of the network
  - WAN (Wide Area Network) - network that spans a large geographic area
  - MAN (Metropolitan Area Network) - network that spans a medium area such as a campus to a city
  - LAN (Local Area Network) - network that spans a limited area such as a lab, or a building
  - PAN (Personal Area Network) – network that spans a small space such a room, less than 10m

Basic Network Definitions

—— Terms for network types

LAN (Local Area Network)

Features

- Connects computers that are physically close together
- Range: < 1 km
- high speed
- multi-access

Technologies

- Ethernet 10 M, 100M, 1000M/1G, 10G, 100Gbps
- Token Ring 16 Mbps
- FDDI 100 Mbps
- Wireless IEEE802.11b/a/g/n/ac

Basic Network Definitions

—— Terms for network types

MAN (Metropolitan Area Network)

Features

- Larger than a LAN and smaller than a WAN
- Range: < 10 km
- Example: city network
- multi-access

Technologies

- coaxial cable
- Microwave, IEEE802.16/WiMAX

Basic Network Definitions

—— Terms for network types

WAN (Wide Area Network)

Features

- Connects computers that are physically far apart. "long-haul network"
- Traditionally slower and less reliable than a LAN
- Range: 10 - 1000 km
- Point-to-point ring or partial mesh

Technologies

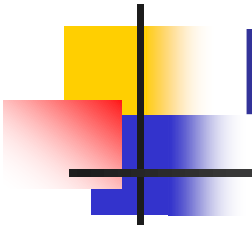
- D-WDM, SDH + ATM, Frame Relay
- PSTN Telephone lines
- Satellite communications
- Cellular mobile communications

Basic Network Definitions
—— Terms for network types

- According to the user of the network
  - Public network
    - The large scale network built by the telecommunication companies
    - All the users can use the network as long as they pay the money
  - Private network
    - The network built by a certain agency for its special requirements
    - Only providing services to the user inside this agency
    - E.g., the military network, the railway network

Basic Network Definitions
—— other related terms

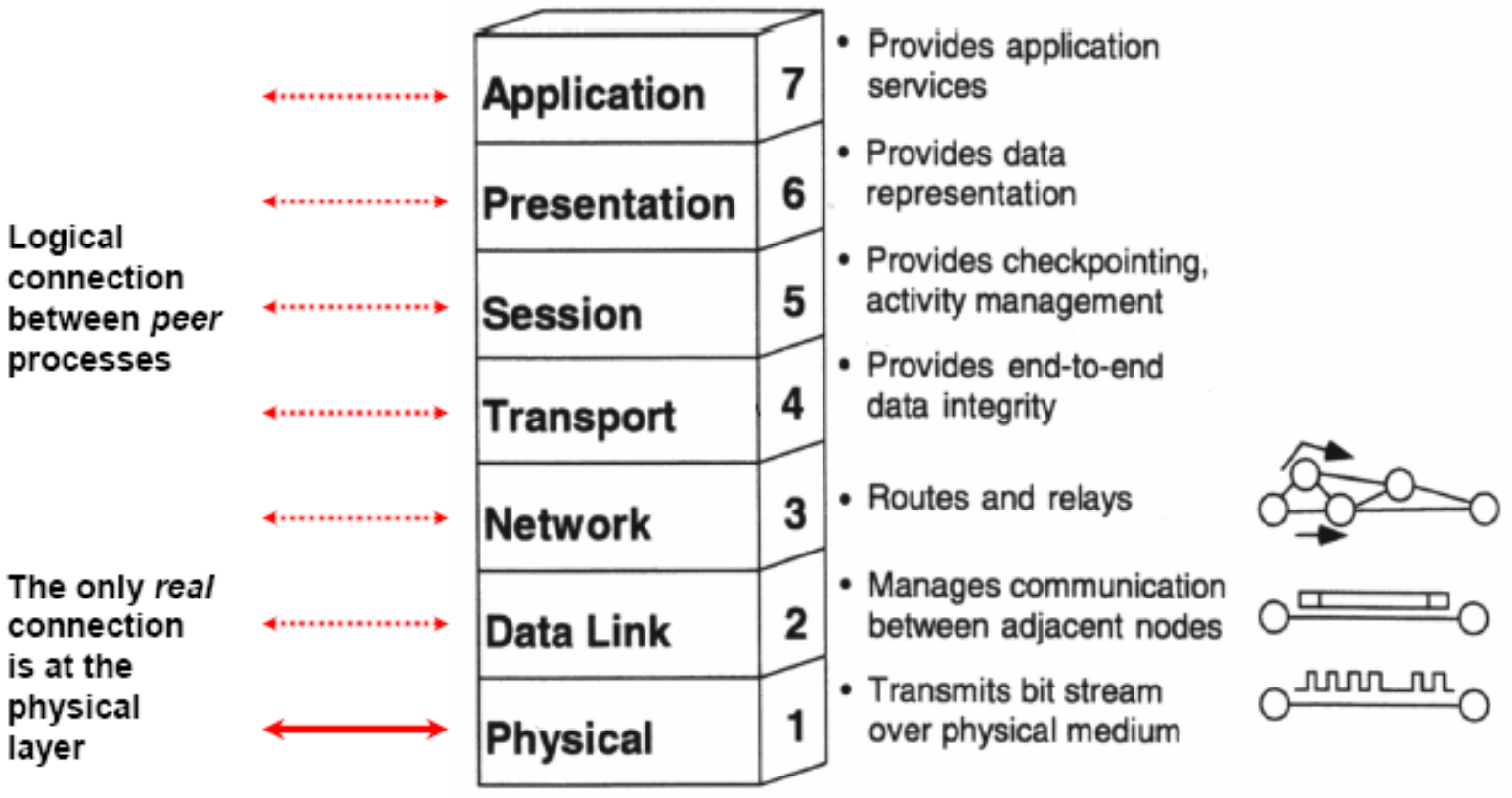
- NIC (Network Interface Card) - circuit board that allows a PC to connect to a network
- Response time - time waiting for host computer to reply back to terminal
- Real-Time - where the response time between remote entities is sufficiently low to provide interactive communication (< 400msec round-trip)
- Contention - 2 or more devices trying to use the same resource at the same time
- Protocol - rules that define how devices communicate data on a communication network



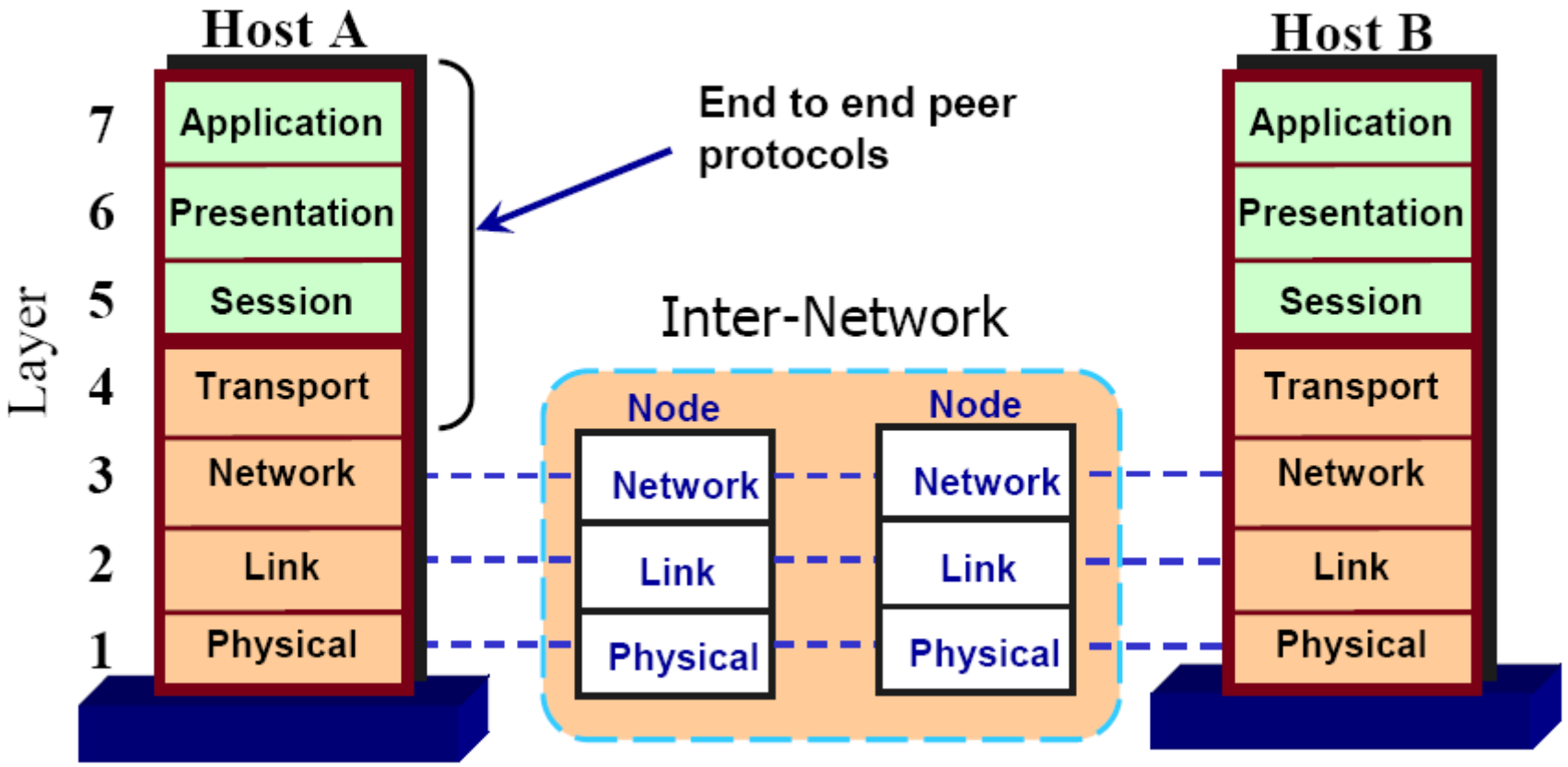
Layered Architecture

- OSI Layer Model
- TCP/IP Layer Model
- Benefits from layered structure: simplify the task to
  - Design
  - Implement
  - Maintain

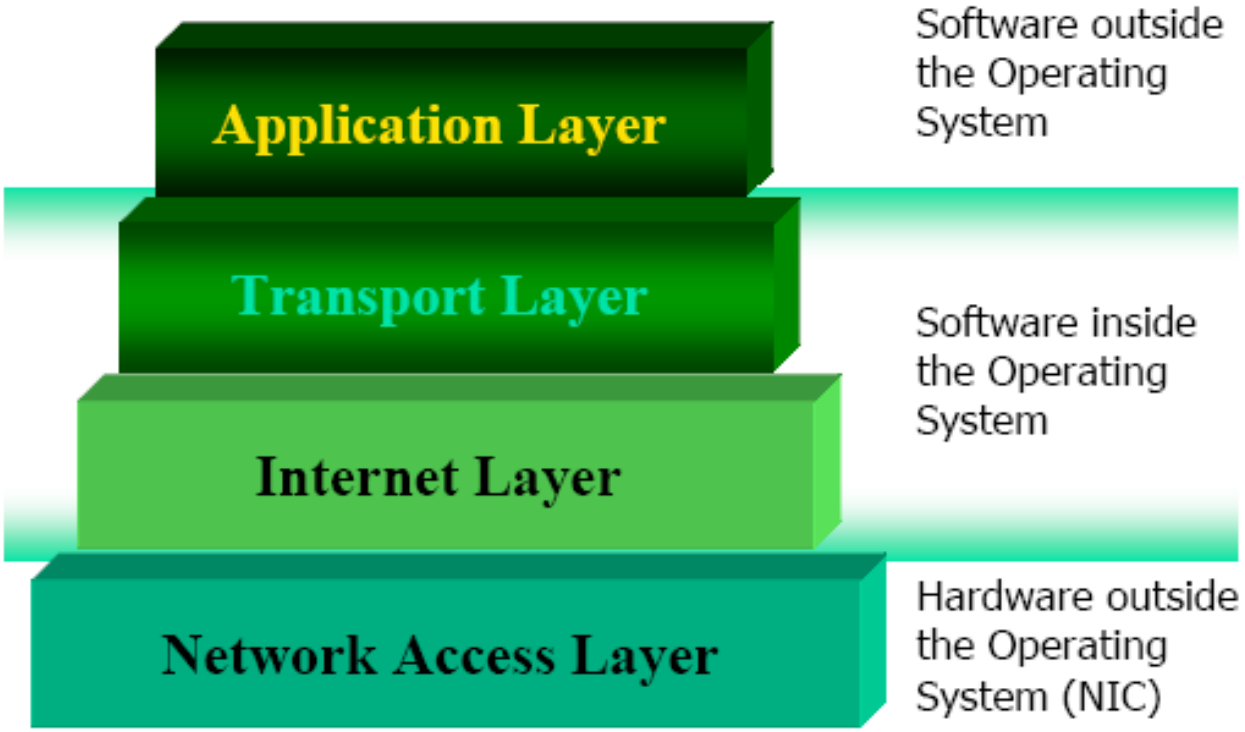
Layered Architecture
—— OSI Layer Model



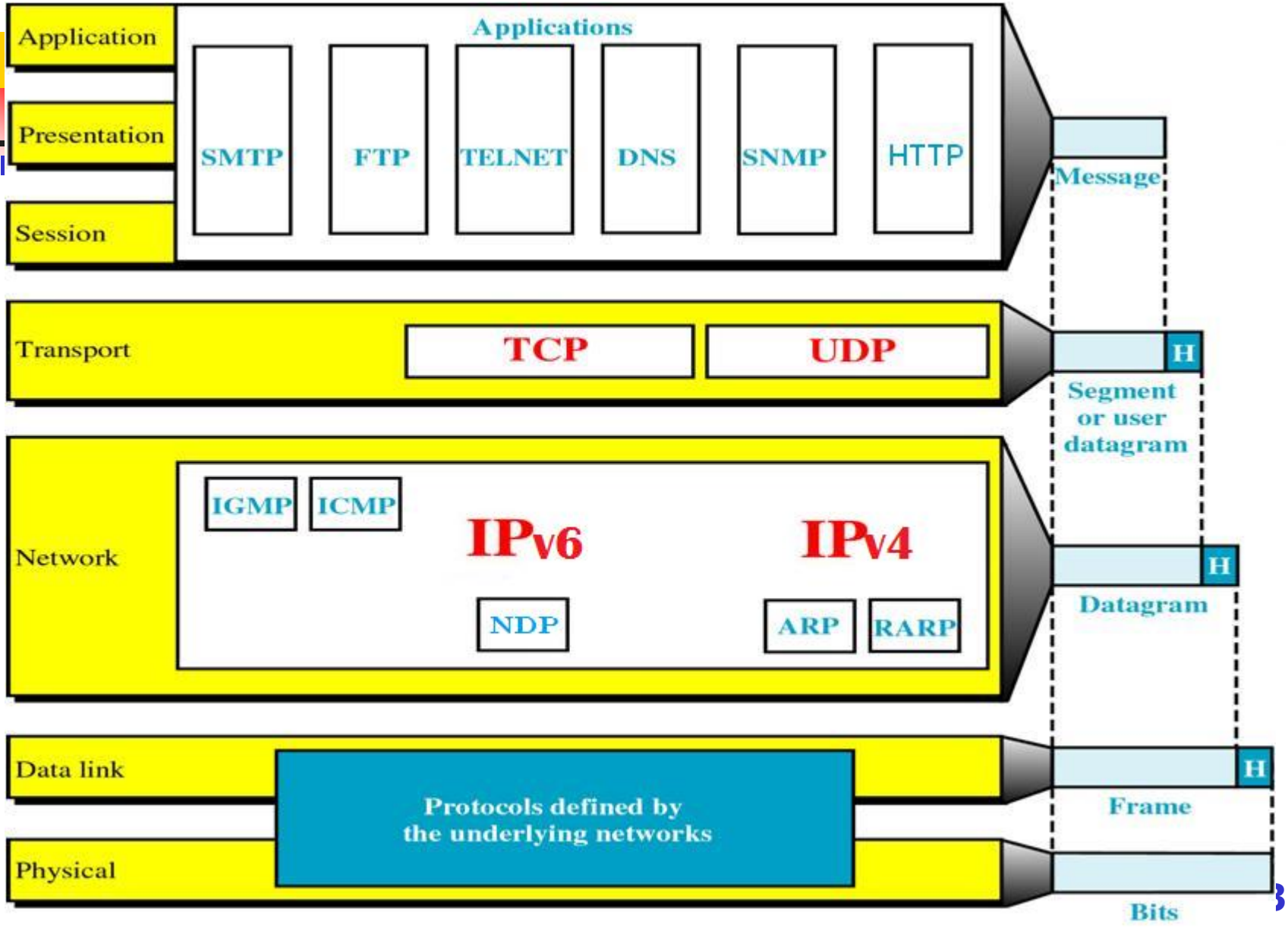
Layered Architecture
—— OSI Layer Model



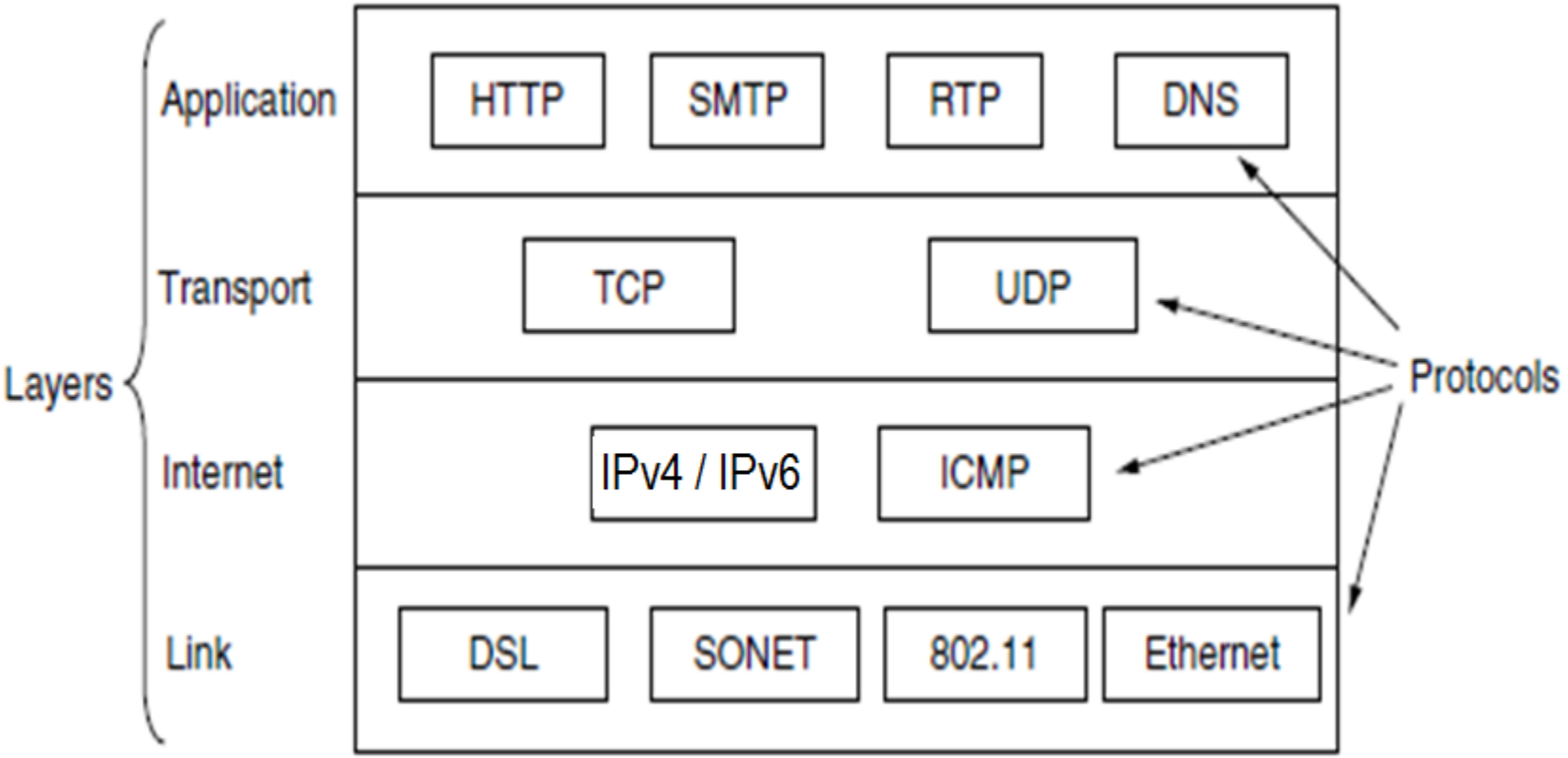
Layered Architecture
—— TCP/IP Layer Model



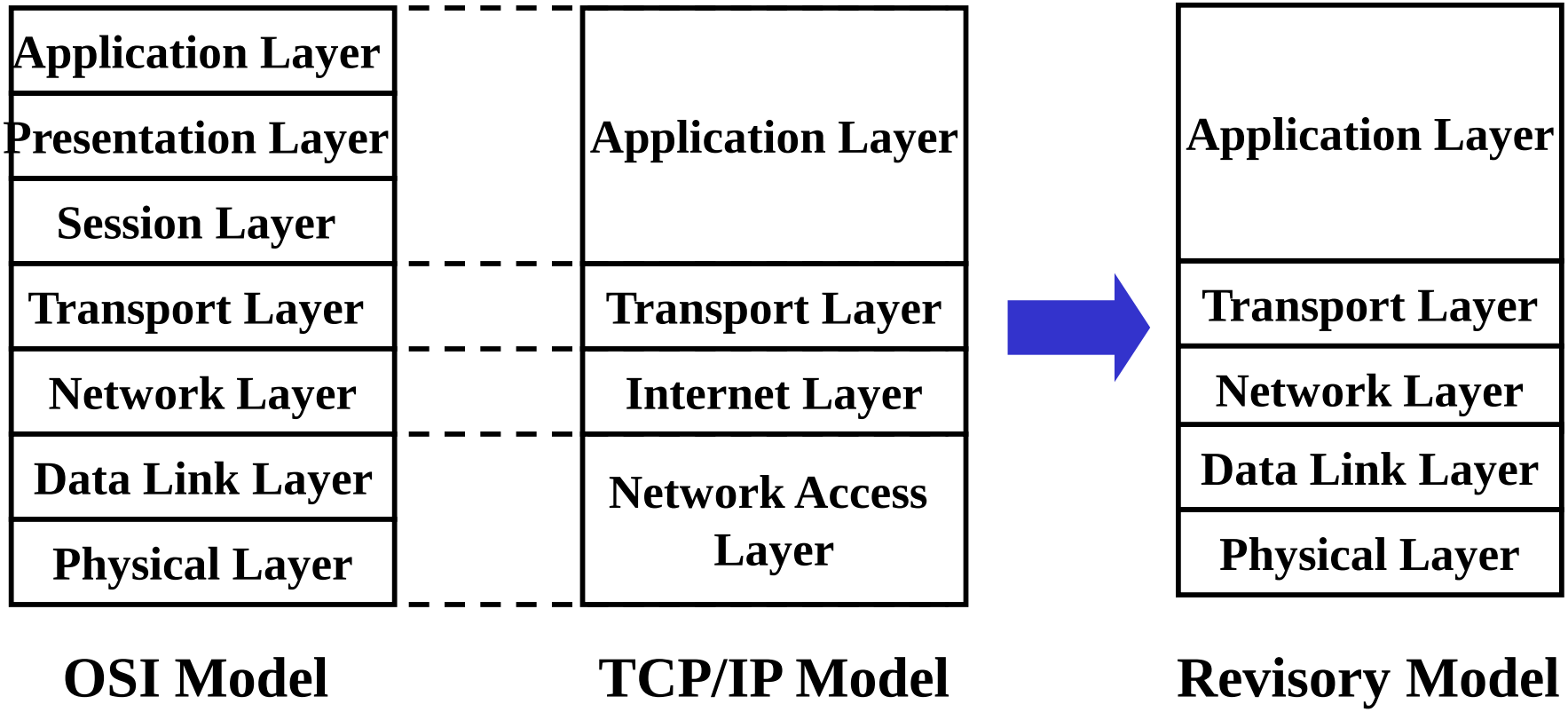
TCP/IP Model: in details



Widely Used Protocols

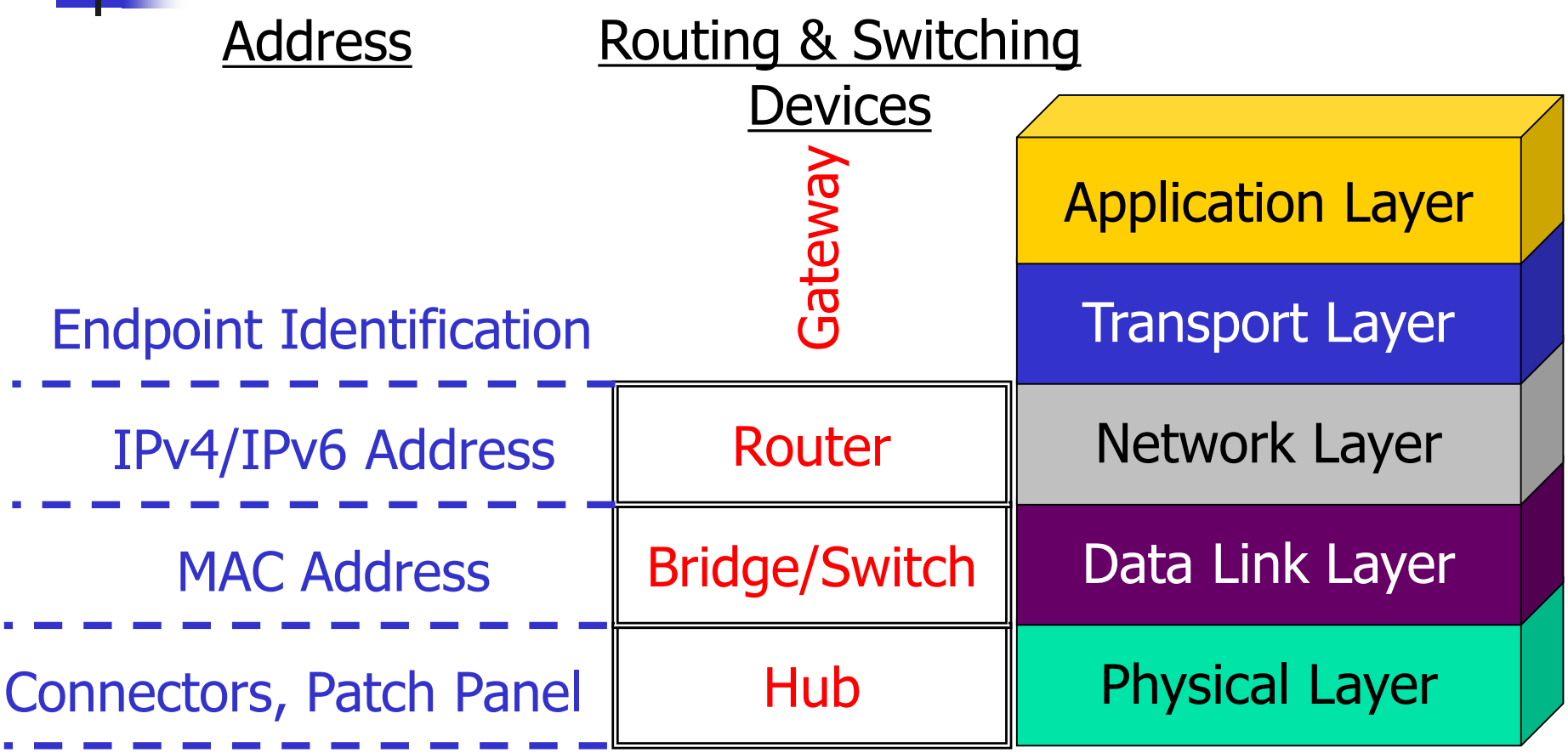


Layered Architecture
——Revisory Model



Layered Architecture

—— devices and addresses at different layers



Abbreviations (1)

ISP	Internet Service Provider
NSP	Network Service Provider
BER	Bit Error Rate
FER	Frame Error Rate
PER	Packet Error Rate
QoS	Quality of Service
3GPP	The 3rd Generation Partnership Project
ISDN	Integrated Services Digital Network
(A)DSL	(Asymmetric) Digital Subscriber Line
CATV	cable TV
GPRS	General Packet Radio Services

Abbreviations (2)

CDMA	Code Division Multiple Access
MODEM	MOdulator-DEModulator
ASCII	American Standard Code for Information Interchange
EBCDIC	Exchanged Binary Coded Decimal Interchange Code
IDN	Integrated Digital Network
CCITT	International Telephone and Telegraph Consultative Committee
ITU	International Telecommunications Union
WAN	Wide Area Network
MAN	Metropolitan Area Network
LAN	Local Area Network
PAN	Personal Area Network
FDDI	Fiber Distributed Data Interface

Abbreviations (3)

DWDM	Dense wavelength division multiplexing
SDH	Synchronous Digital Hierarchy
ATM	Asynchronous Transfer Mode
NIC	Network Interface Card