Computer Networks

Introduction to computer networking

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Computer Networks

Introduction to computer networking

Objective:

To be acquainted with:

- The definitions of networking
- Networking paradigms
- Network topology and classification
- Network peripherals and hardware
- Network software architecture

Definitions

Network Definition :

- A network can be defined as two or more devices (computer, smart phone, etc) connected together in such a way that they can share resources.

The purpose of a network is to share resources:

- A file, a folder
- A printer
- A disk drive
- Internet access
- Or just about anything else that exists on a computer.

Definitions (cont..)

- A network is simply a collection of computers or other hardware devices that are connected together, either physically or logically, using special hardware and software, to allow them to exchange information and cooperate.
- Networking is the term that describes the processes involved in designing, implementing, managing and otherwise working with networks and network technologies.

Applications of Networks

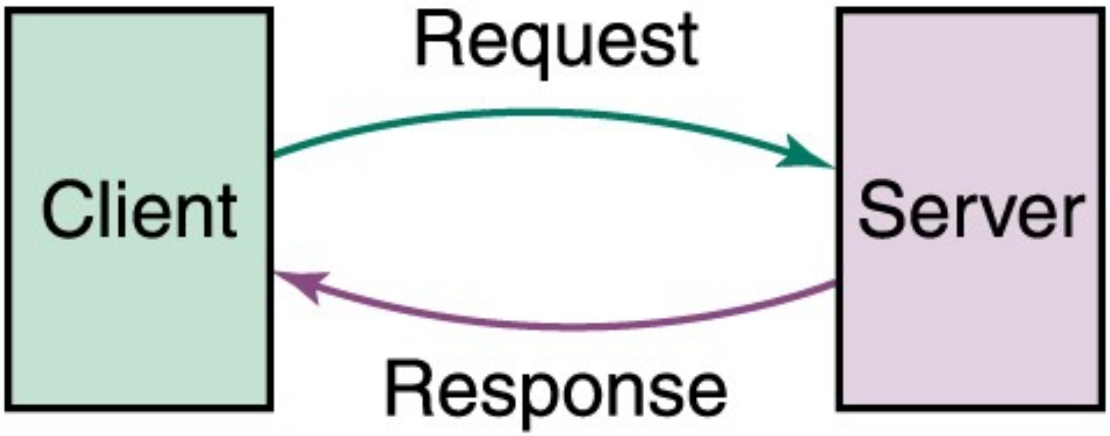
- ✓ **Resource Sharing**
  - Hardware (computing resources, disks, printers)
  - Software (application software)
- ✓ **Information Sharing**
  - Easy accessibility from anywhere (files, databases)
  - Search Capability (WWW)
- ✓ **Communication**
  - Email
  - Message broadcast
- ✓ **Remote computing**
- ✓ **Distributed processing (GRID Computing)**

Networking paradigms

- Client-Server
- Peer-to-Peer

Client-Server Networking

- A distributed application structure that partitions the tasks between providers of a service (called servers) and service requesters (called **Clients**)
- A client is a piece of computer hardware or software that accesses a service made available by a server.
- Servers operate within a client-server architecture, servers are computer programs running to serve the requests of other programs, the clients. Thus, the server performs some task on behalf of clients



Peer-To-Peer Networking

- In a peer-to-peer network, computers act as both clients and servers.
- Every computer is an equal, a *peer* in the network.
- Network resources are those shared by different peers.
- There is no assigned role for any particular device, and each of the devices usually runs similar software.
- Good solution for small, simple, and inexpensive networks.

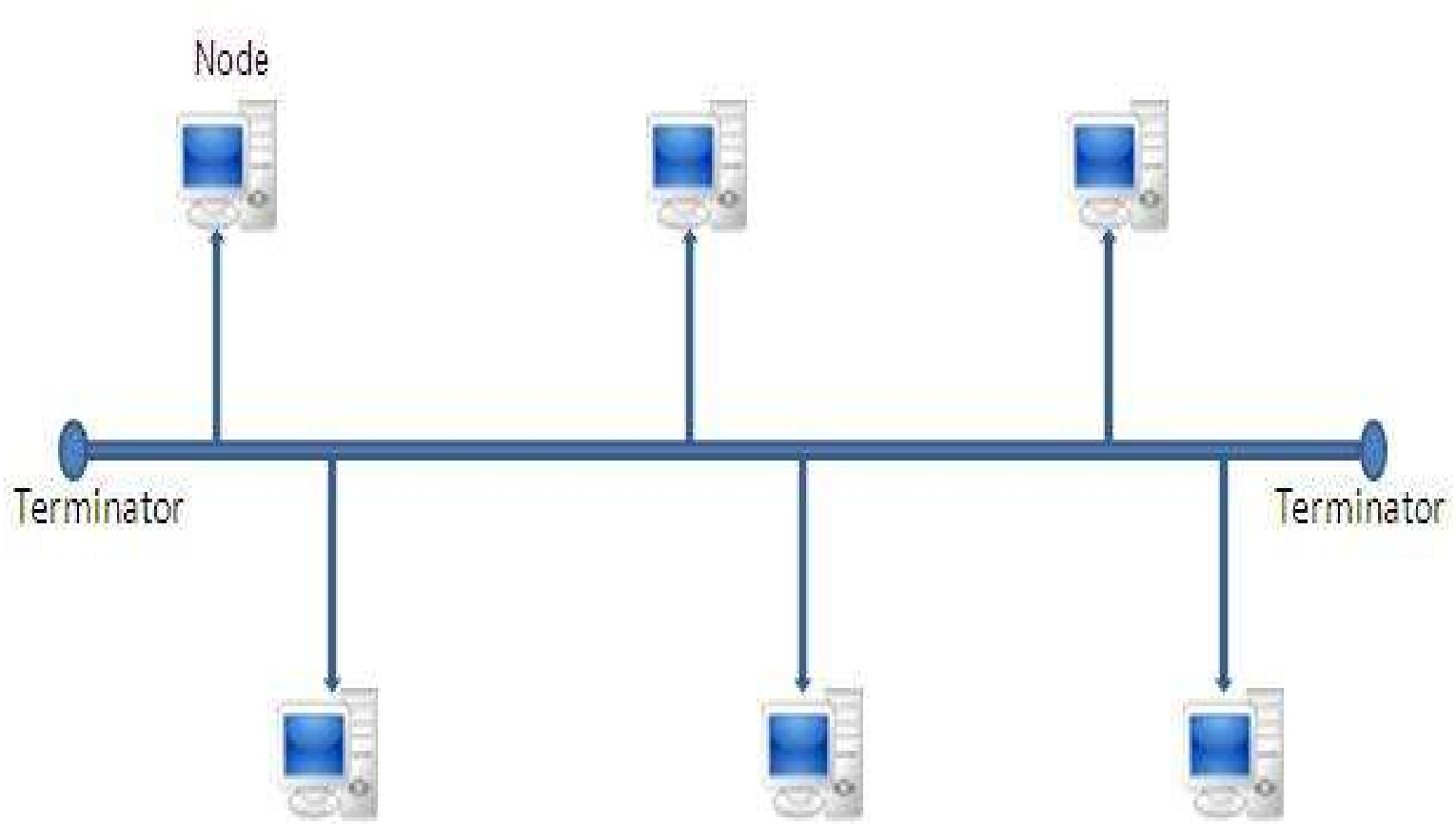
Network Topology

- A *topology* is a way of "laying out" the network. Topologies can be either physical or logical.
- *Physical topologies* describe how the cables are run.
- *Logical topologies* describe how the network messages travel

Bus topology

- All networked nodes are interconnected, peer to peer, using a single, open-ended cable
- Both ends of the bus must be terminated with a terminating resistor to prevent signal bounce

Bus topology



Advantages of Bus topology

1) Easy to implement and extend
2) Well suited for temporary networks that must be set up in a hurry
3) Typically the least cheapest topology to implement
4) Failure of one station does not affect others

Disadvantages of Bus topology

1) Difficult to administer/troubleshoot
2) Limited cable length and number of stations
3) A cable break can disable the entire network; no redundancy
4) Maintenance costs may be higher in the long run
5) Performance degrades as additional computers are added

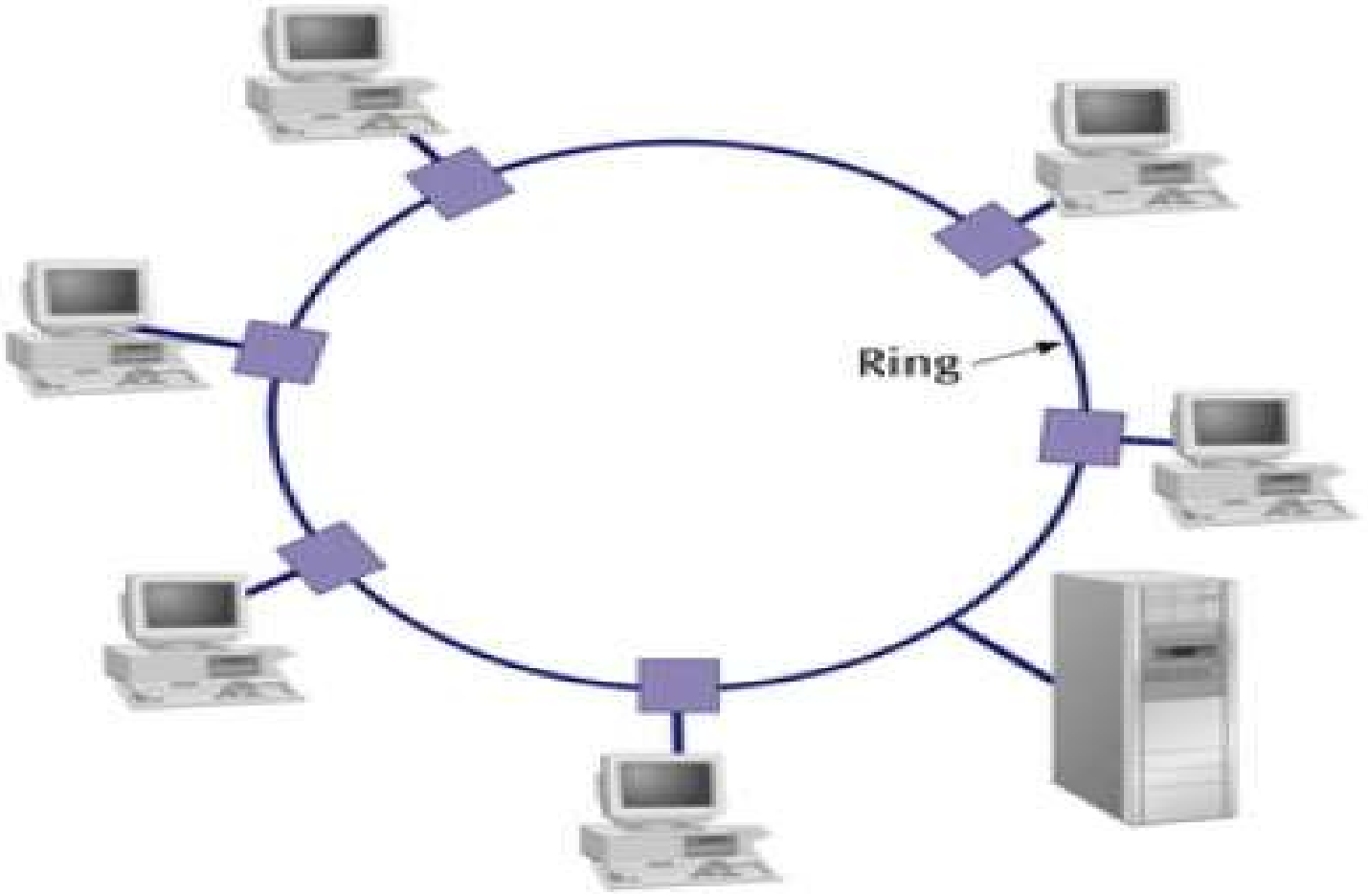
Ring topology

- started out as a simple peer-to-peer LAN topology
- Each networked workstation had two connections: one to each of its nearest neighbors
- Data was transmitted unidirectionally around the ring
- Sending and receiving of data takes place by the help of TOKEN

Token Passing

- Token contains a piece of information which along with data is sent by the source computer
- This token then passes to next node, which checks if the signal is intended to it
  - If yes, it receives it and passes the empty to into the network
  - otherwise passes token along with the data to next node

Ring topology



Advantages of Ring topology

1) This type of network topology is very organized
2) Performance is better than that of Bus topology
3) No need for network server to control the connectivity between workstations
4) Additional components do not affect the performance of network
5) Each computer has equal access to resources

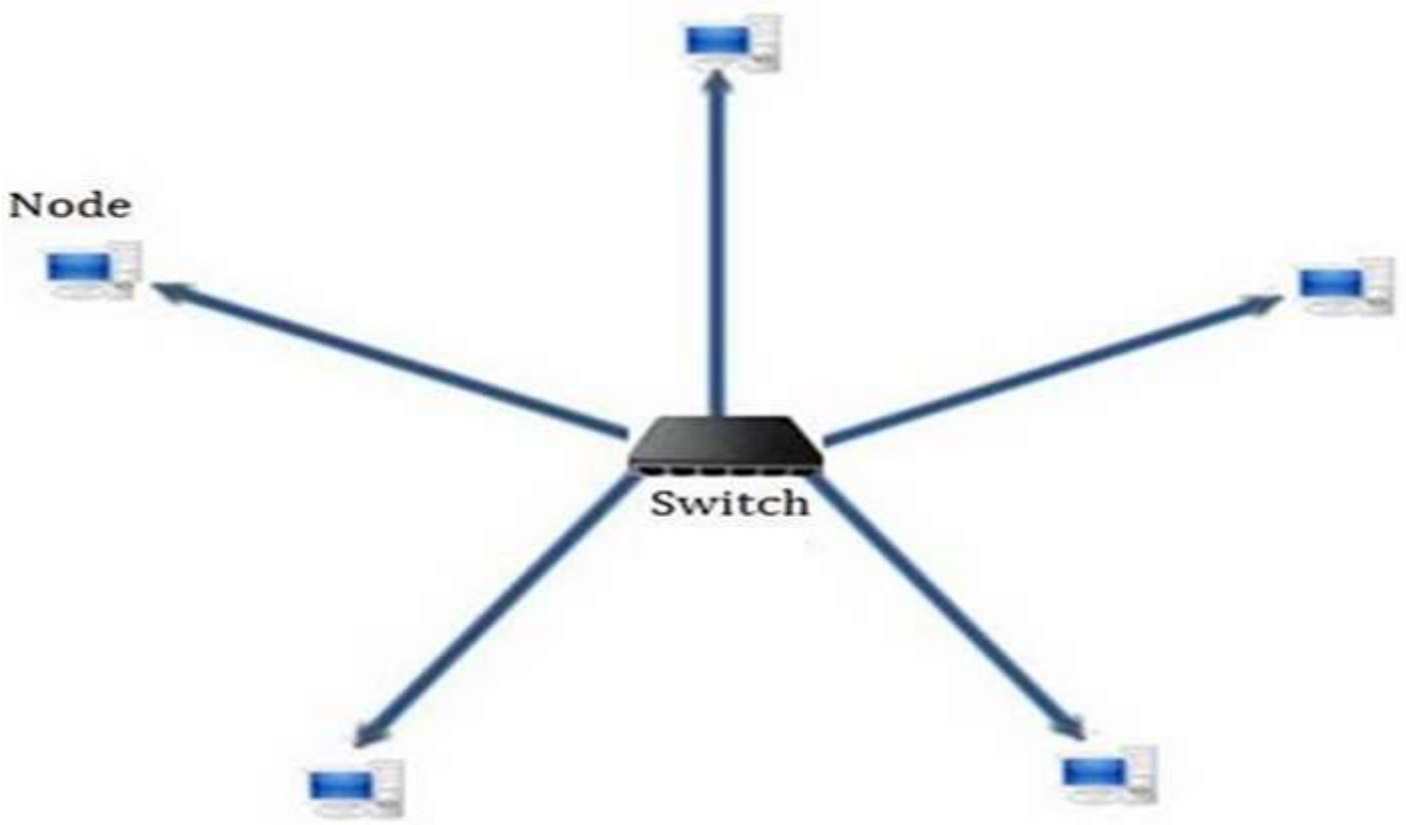
Disadvantages of Ring topology

1) Each packet of data must pass through all the computers between source and destination, slower than star topology
2) If one workstation or port goes down, the entire network gets affected
3) Network is highly dependent on the wire which connects different components

Star topology

- Have connections to networked devices that “radiate” out form a common point
- Each networked device in star topology can access the media independently
- Have become the dominant topology type in contemporary LANs
- Stars have made buses and rings obsolete in LAN topologies

Star topology



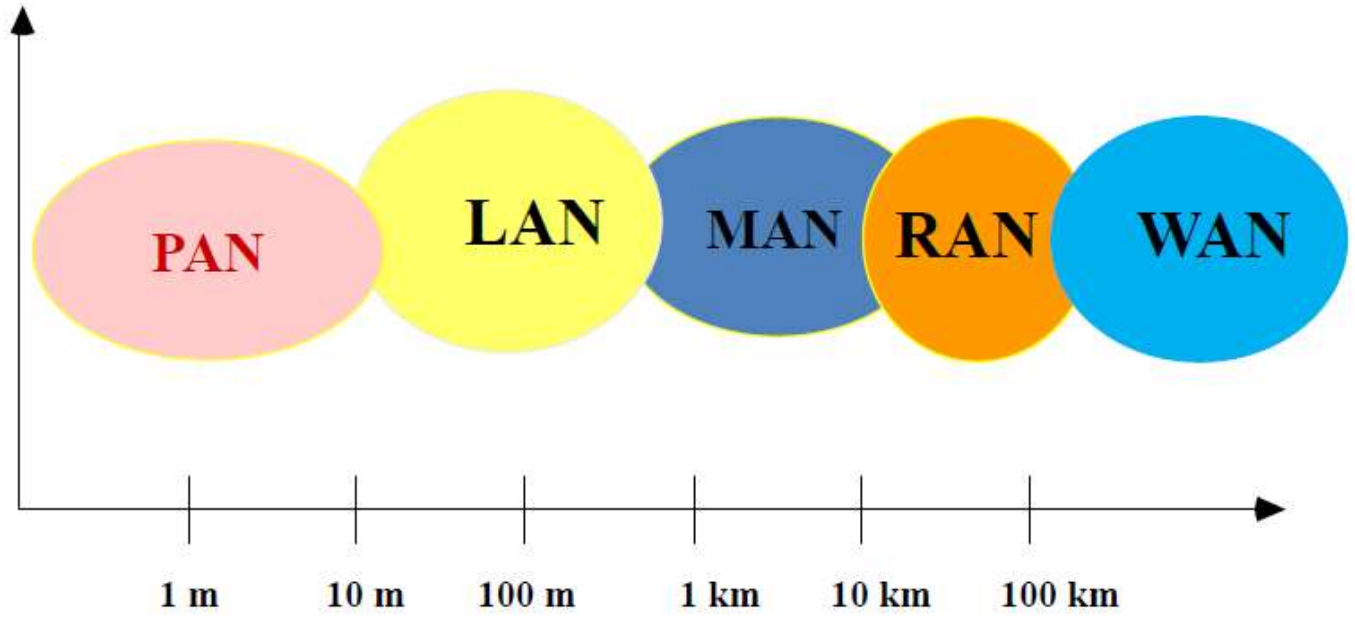
Advantages of star topology

1) Compared to Bus topology it gives far much better performance
2) Easy to connect new nodes or devices
3) Centralized management. It helps in monitoring the network
4) Failure of one node or link doesn’t affect the rest of network

Disadvantages of star topology

1) If central device fails whole network goes down
2) The use of a switch as central device increases the overall cost of the network
3) Performance and as well number of nodes which can be added in such topology is depended on capacity of central device

Network classification



- PAN Personal Area Network
- LAN Local Area Network
- MAN Metropolitan Area Network
- RAN Regional Area Network
- WAN Wide Area Networks

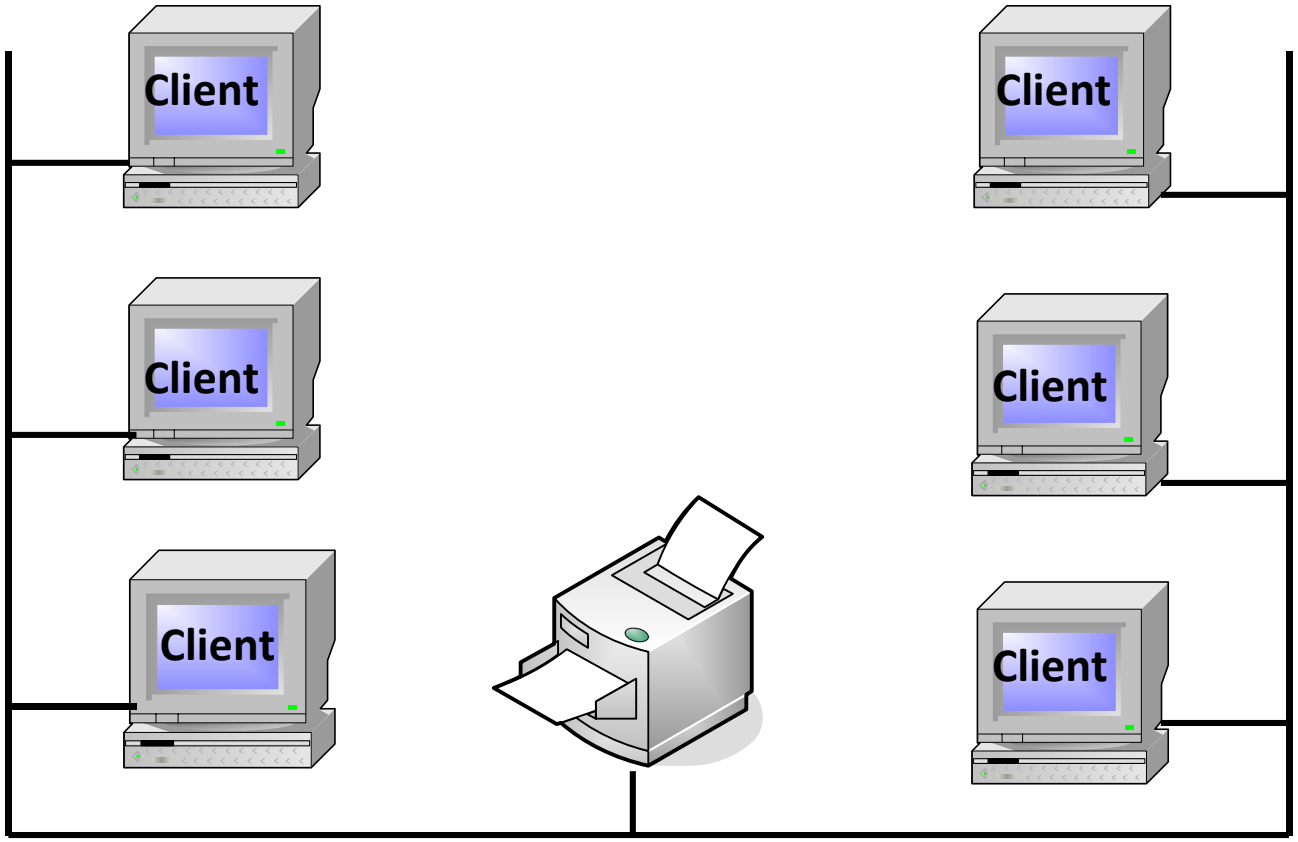
Network classification

Inter-processor distance	Processors located in same	Class
1 m	Square meter	PAN
10 m	Room	LAN
100 m	Building	LAN
1 km	Campus	LAN
10 km	City	MAN
100 km	Country	WAN
1000 km	Continent	WAN
10,000 km	Planet	Internet

Network types [1]

Local Area Network (LAN)

A **local area network (LAN)** is a computer network covering a small geographical area, like a home, office, or group of buildings

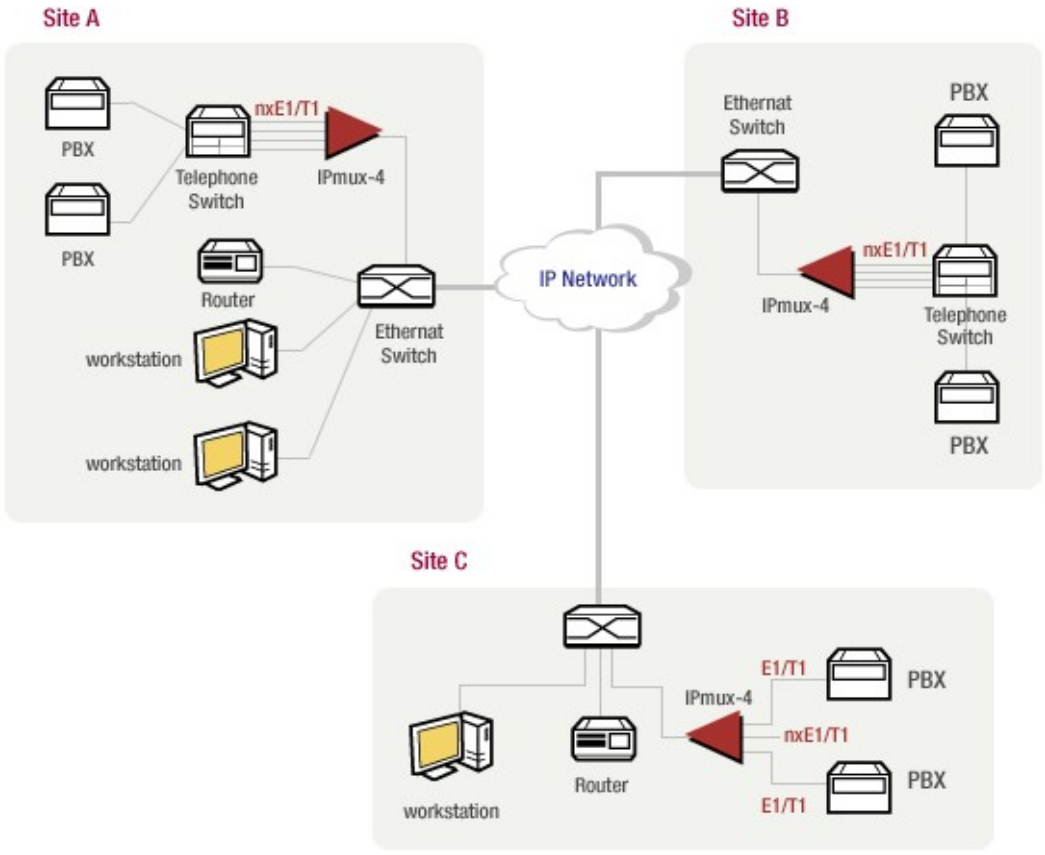


Metropolitan Area Network (MAN):

Metropolitan Area Network (MAN):

- A MAN a network that interconnects users with computer resources in a geographic area or region larger than that covered by even a large local area network (LAN) but smaller than the area covered by a wide area network (WAN).
- It is also used to mean the interconnection of several local area networks by bridging them with backbone lines.

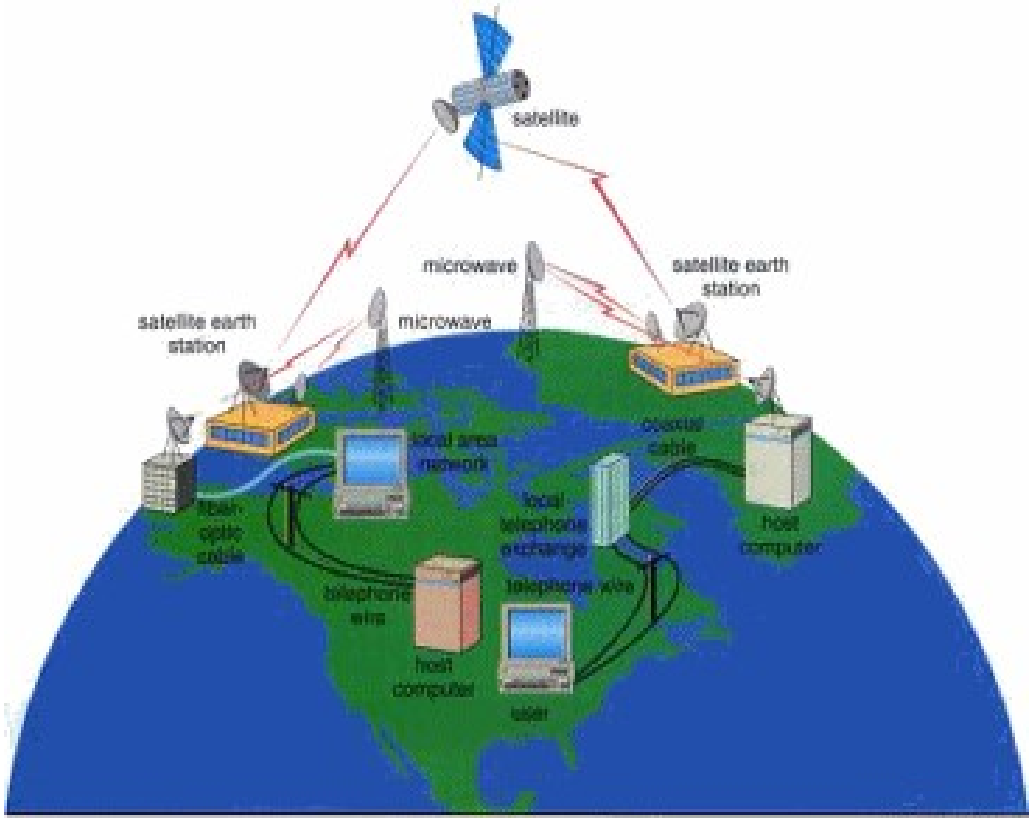
MAN Example


Site A
PBX
PBX
Telephone Switch
nxE1/T1
IPmux-4
Router
workstation
workstation
Ethernat Switch
IP Network
Site B
Ethernat Switch
PBX
nxE1/T1
IPmux-4
Telephone Switch
PBX
Site C
workstation
Router
IPmux-4
E1/T1
nxE1/T1
E1/T1
PBX
PBX

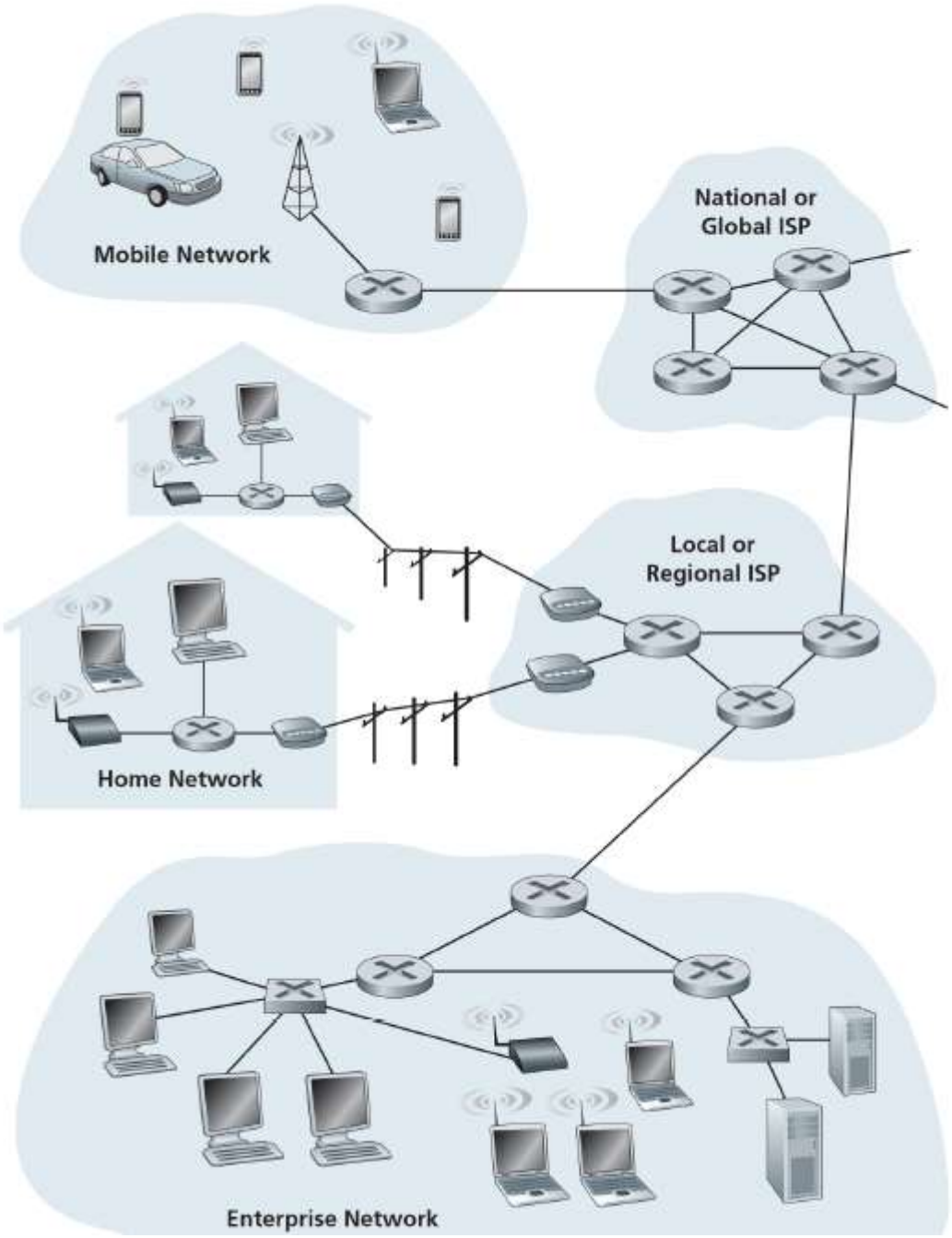
WideArea Network (WAN):

- **Wide Area Network** (**WAN**) is a computer network that covers a broad area (i.e., any network whose communications links cross metropolitan, regional, or national boundaries).
- It is a network that uses routers and public communications links
- The largest and most well-known example of a WAN is the **Internet**.
- WANs are used to connect LANs and other types of networks together so that users that are on different networks can communicate together.

WAN Example


satellite
microwave
satellite earth station
satellite earth station
microwave
local area network
coaxial cable
fiber optic cable
local telephone exchange
host computer
telephone wire
telephone wire
host computer
user

THE INTERNET

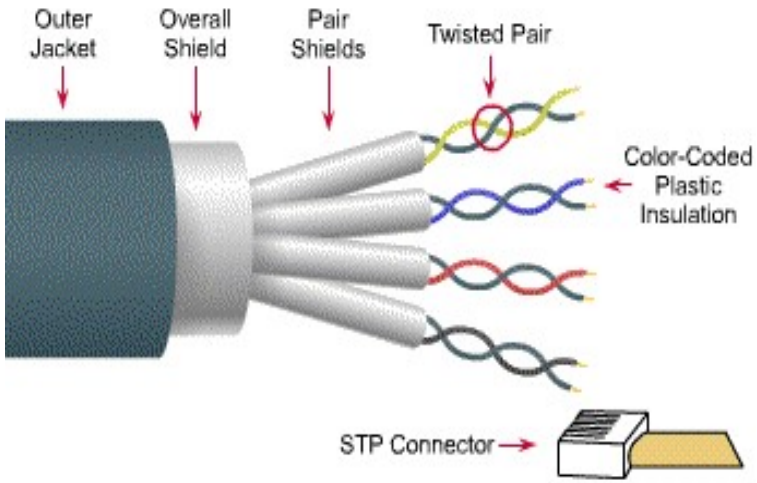


Hardware, Software and Networks
Peripherals (device)

- Physical Media
- Hub
- Switch
- Routers

Hardware Networks Peripherals

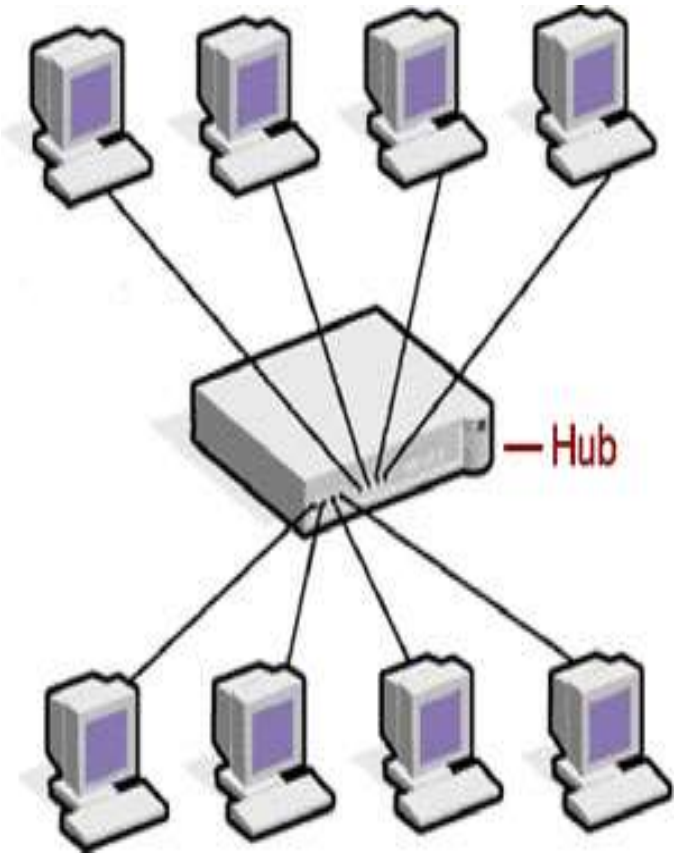
Physical media can be defined simply as the means by which signals (data) are sent from one computer to another (either by cable or wireless means).



Hardware Networks Peripherals

Hubs

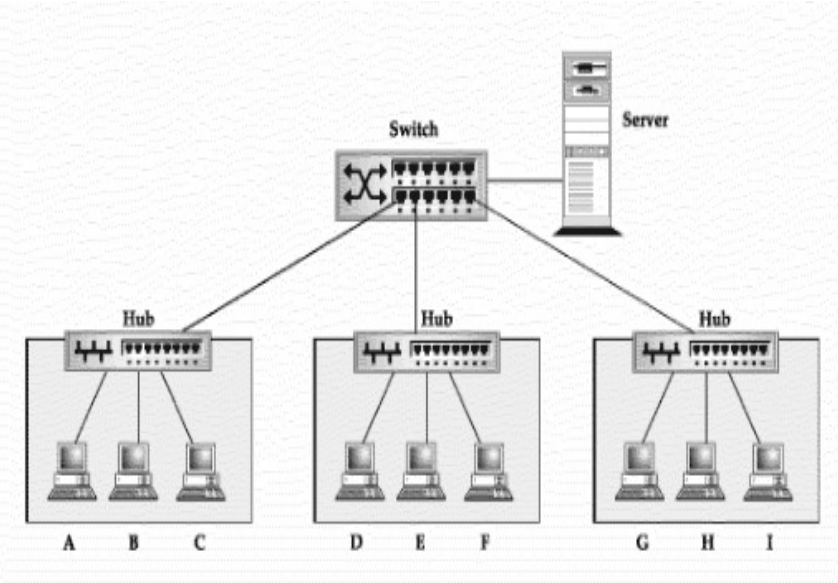
- Hubs are devices used to link several computers together.
- They repeat any signal that comes in on one port and copy it to the other ports (a process that is also called *broadcasting*).
- There are two types of hubs: active and passive.
- *Passive hubs* simply connect all ports together electrically and are usually not powered.
- *Active hubs* use electronics to amplify and clean up the signal before it is broadcast to the other ports.
- In the category of active hubs, there is also a class called “intelligent” hubs, which are hubs that can be remotely managed on the network.
- Hubs nowadays are rarely used



Hardware Networks Peripherals

Switch

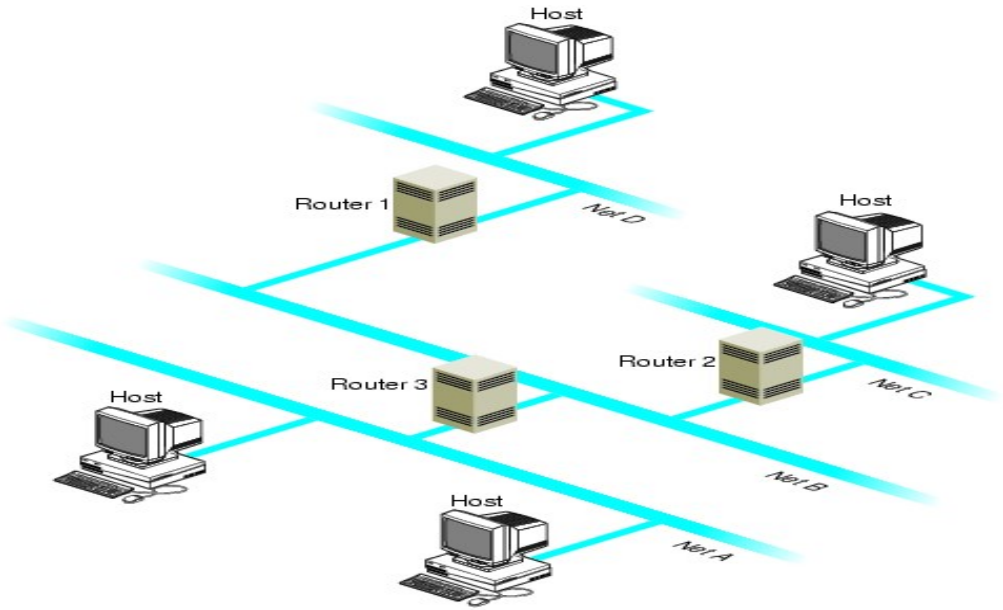
- A **network switch** is a computer networking device that connects network segments.
- Low-end network switches appear nearly identical to network hubs, but a switch contains more "intelligence" (and a slightly higher price tag) than a network hub.
- Network switches are capable of inspecting data packets as they are received, determining the source and destination device of that packet, and forwarding it appropriately.
- By delivering each message only to the connected device it was intended for, a network switch conserves network bandwidth and offers generally better performance than a hub.
- A **vital difference** between a **hub** and a **switch** is that all the nodes connected to a hub share the bandwidth among themselves, while a device connected to a switch port has the **full bandwidth** all to itself.



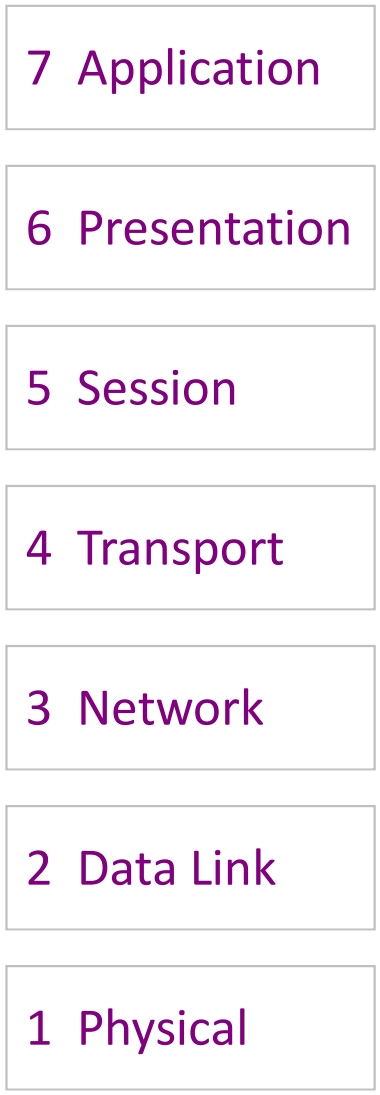
Hardware Networks Peripherals

Routers

- Routers are highly intelligent devices that connect multiple network types and determine the best path for sending data.
- routers can determine the best path that data can take to get to its destination.
- they can segment large networks and can filter out noise.
- Routers are normally used to connect one LAN to another.
- Typically, when a WAN is set up, there will be at least two routers used.



Network Software



NETWORK ARCHITECTURES

A set of layers and protocols is called the network architecture.

1. Protocol Hierarchies

Networks are organized as layers to reduce design complexity. Each layer offers *services* to the higher layers. Between adjacent layers is an *interface*.

Services – connection oriented and connectionless.

Interface – defines which *primitives* and services the lower layer will offer to the upper layer.

Primitives – operations such as request, indicate, response, confirm.

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

NETWORK ARCHITECTURES

2. Design Issues for the Layers

- Mechanism for connection establishment
- Rules for data transfer
- Error control
- Fast sender swamping a slow receiver
- Inability of processes to accept long messages
- Routing in the case of multiple paths

7 Application

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2 Data Link

1 Physical

OSI REFERENCE MODEL

The Open Systems Interconnection is the model developed by the International Standards Organization.

Benefits

- Interconnection of different systems (open)
- Not limited to a single vendor solution

Negative Aspect

- Systems might be less secure
- Systems might be less stable

7 Application

6 Presentation

5 Session

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2 Data Link

1 Physical

OSI REFERENCE MODEL

1. Physical Layer

a) Convert the logical 1's and 0's coming from layer 2 into electrical signals.

b) Transmission of the electrical signals over a communication channel.

Main topics:

- Transmission mediums
- Encoding
- Modulation

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

2. Data Link Layer

a) Error control to compensate for the imperfections of the physical layer.

b) Flow control to keep a fast sender from swamping a slow receiver.

Main topics:

- Framing methods
- Error detection and correction methods
- Flow control
- Frame format
- IEEE LAN standards
- Bridges
- Switches (multi-port bridges)

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

3. Network Layer

a) Controls the operation of the subnet.

b) Routing packets from source to destination.

c) Logical addressing.

Main topics:

- Internetworking
- Routing algorithms
- Internet Protocol (IP) addressing
- Routers

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

4. Transport Layer

a) Provides additional Quality of Service.

b) Heart of the OSI model.

Main topics:

- Connection-oriented and connectionless services
- Transmission Control Protocol (TCP)
- User Datagram Protocol (UDP)

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

5. Session Layer

a) Allows users on different machines to establish *sessions* between them.

b) One of the services is managing dialogue control.

c) Token management.

d) Synchronization.

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

6. Presentation Layer

a) Concerned with the syntax and semantics of the information.

b) Preserves the meaning of the information.

c) Data compression.

d) Data encryption.

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

7. Application Layer

a) Provides protocols that are commonly needed.

Main topics:

- File Transfer Protocol (FTP)
- HyperText Transfer Protocol (HTTP)
- Simple Mail Transfer Protocol (SMTP)
- Simple Network Management Protocol (SNMP)
- Network File System (NFS)
- Telnet

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

SERVICES

Each layer provides services to the layer above it.

1. Terminologies

Entities – active elements in each layer (e.g. process, intelligent I/O chip).

Peer Entities – entities in the same layer on different machines.

Service Provider – Layer N.

Service User – Layer N + 1.

Service Access Points – places where layer N + 1 can access services offered by layer N.

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

SERVICES

2. Connection-Oriented and Connectionless

Connection-Oriented – before data is sent, the service from the sending computer must establish a connection with the receiving computer.

Connectionless – data can be sent at any time by the service from the sending computer.

Q: Is downloading a music file from the Internet connection-oriented or connectionless?

Q: Is email connection-oriented or connectionless?

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

SERVICES

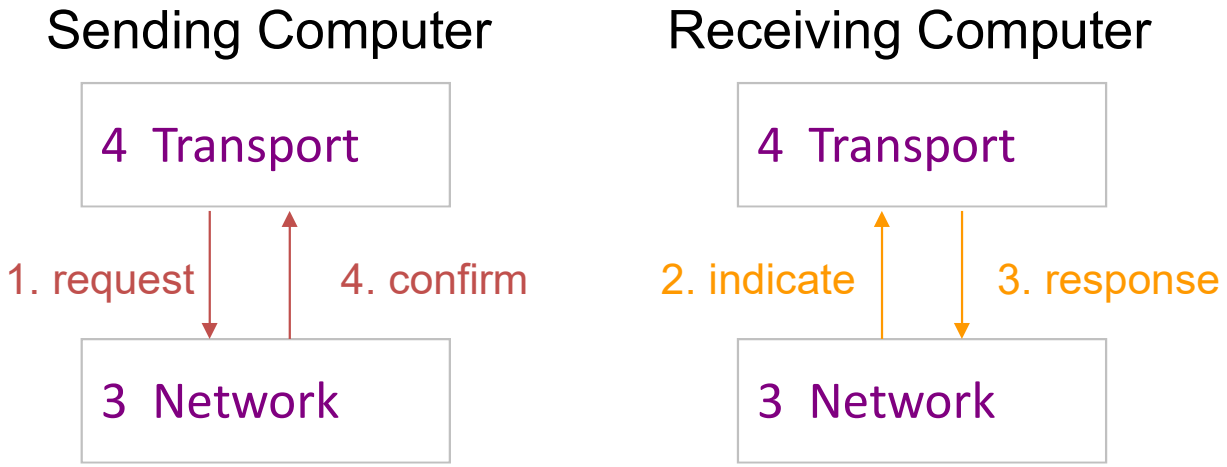
3. Service Primitives

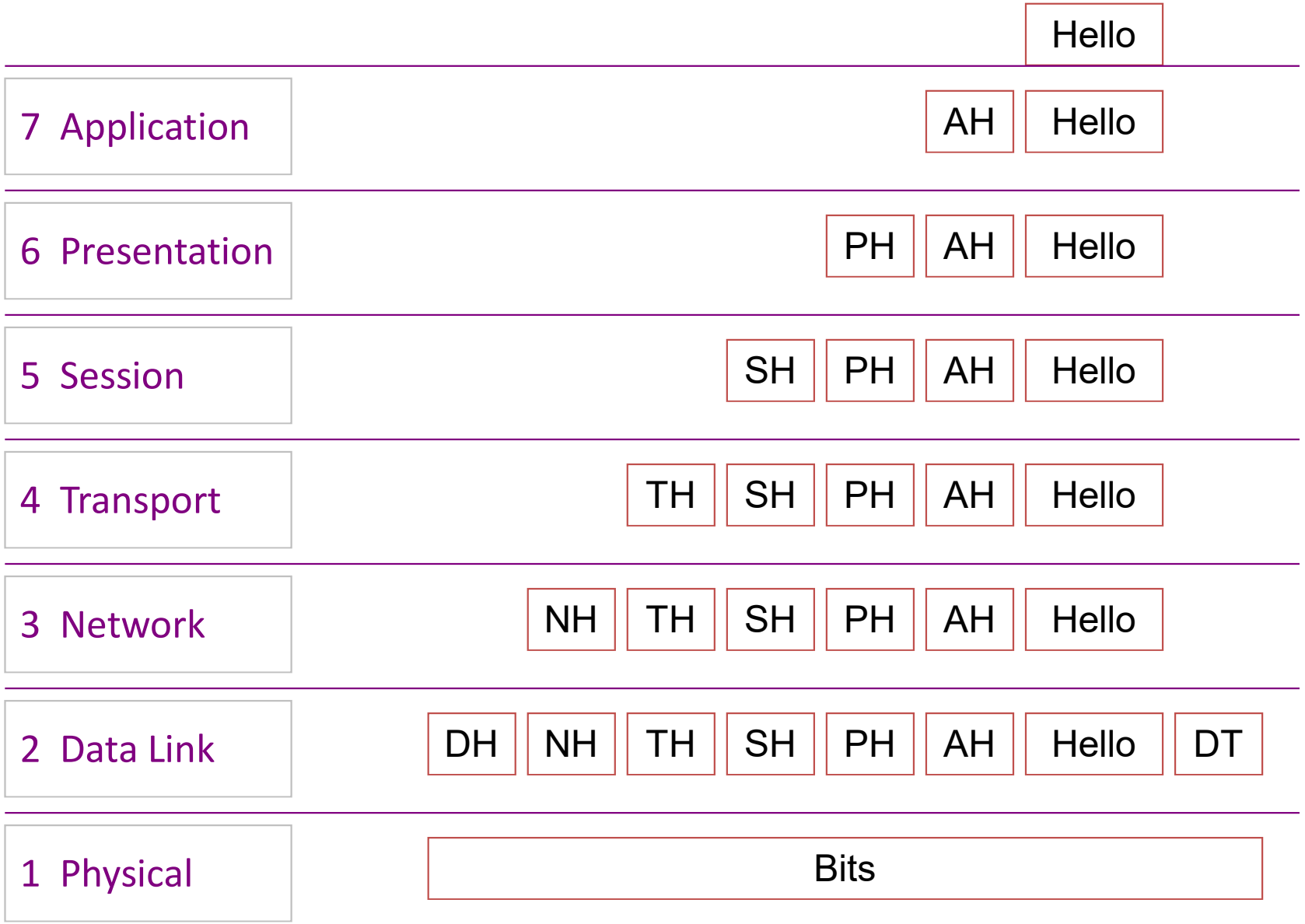
Request – entity wants the service to do some work

Indicate – entity is to be informed about an event

Response – entity responds to an event

Confirm – entity is to be informed about its request




Hello
7 Application
AH
Hello
6 Presentation
PH
AH
Hello
5 Session
SH
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AH
Hello
4 Transport
TH
SH
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AH
Hello
3 Network
NH
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AH
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2 Data Link
DH
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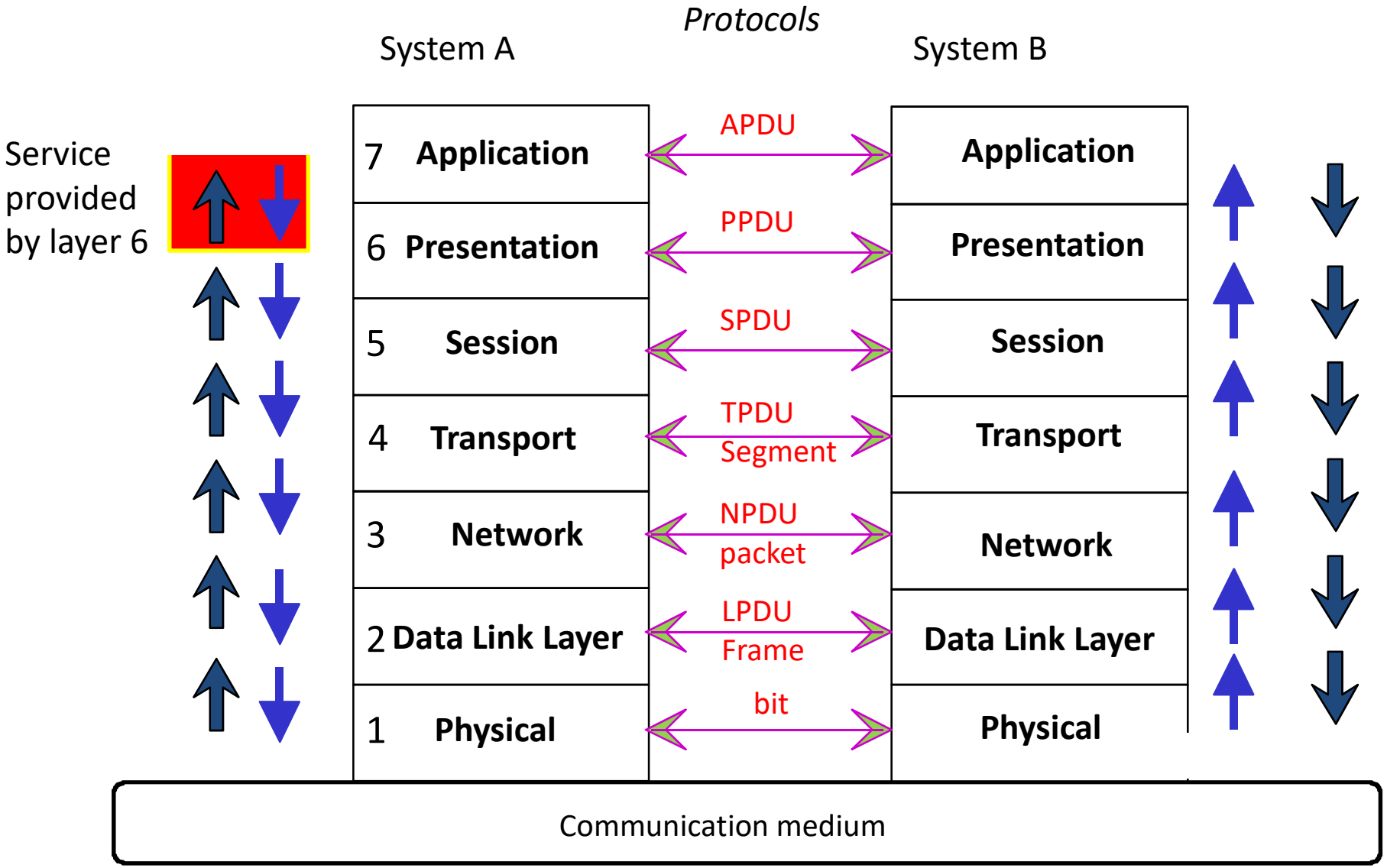
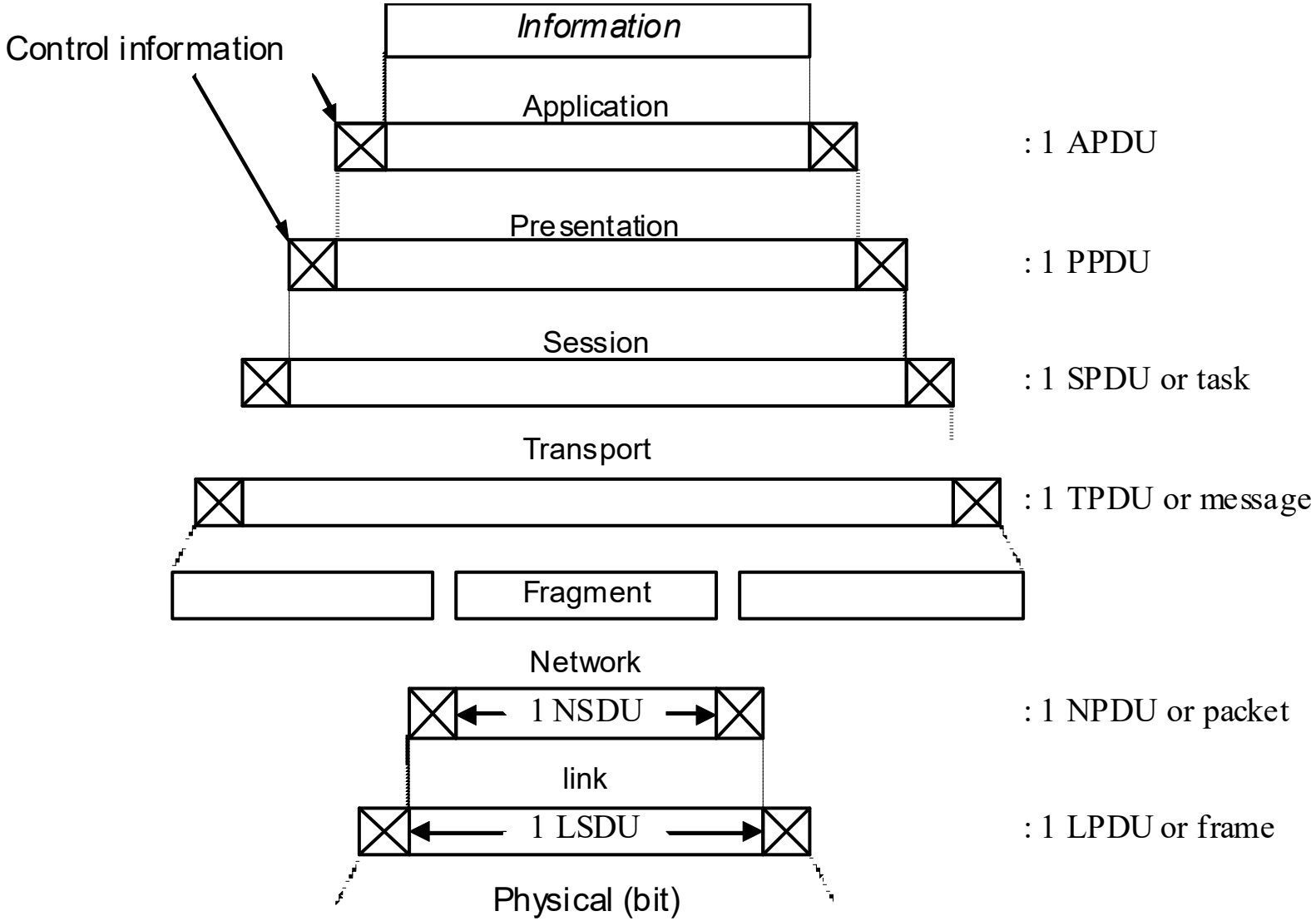
AH
Hello
DT
1 Physical
Bits

Services vs. Protocols



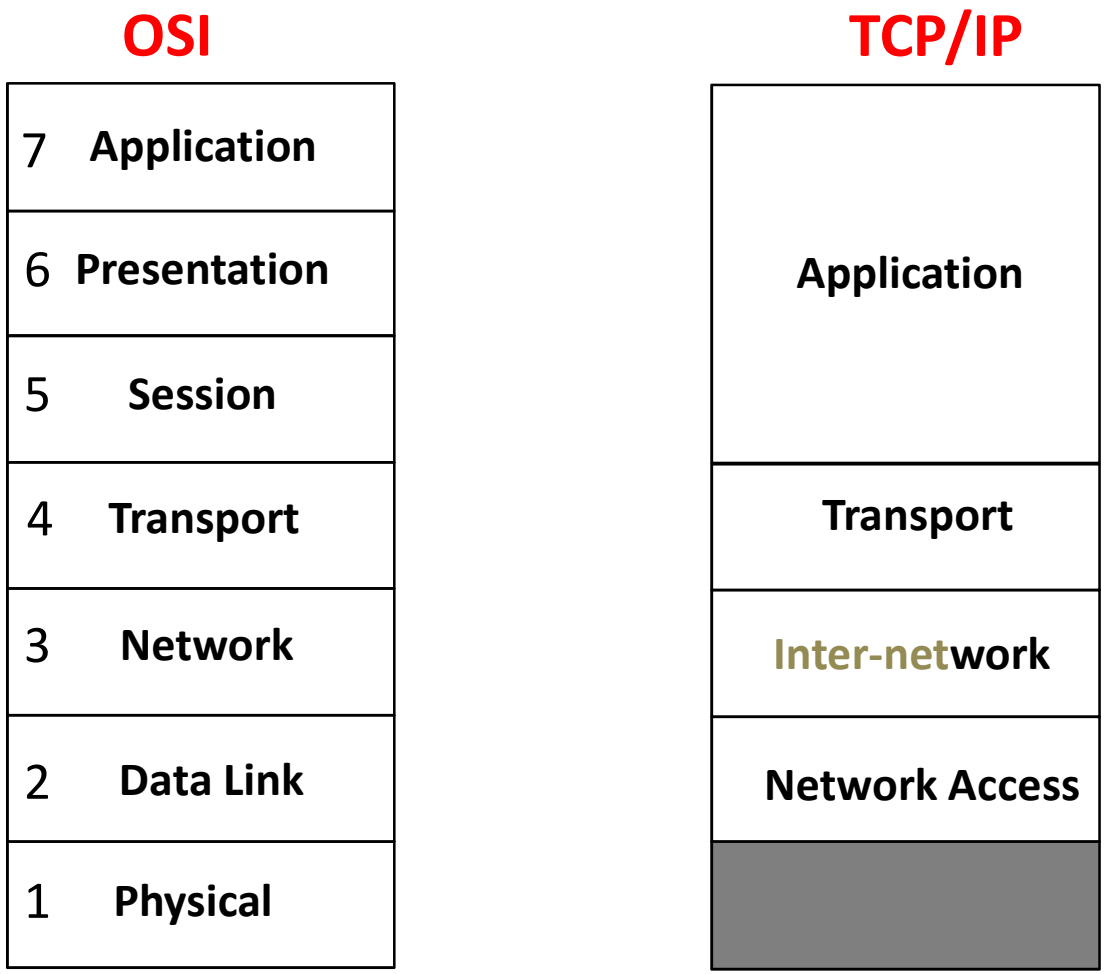
OSI Model


Information
Control information
Application
: 1 APDU
Presentation
: 1 PPDU
Session
: 1 SPDU or task
Transport
: 1 TPDU or message
Fragment
Network
1 NSDU
: 1 NPDU or packet
link
1 LSDU
: 1 LPDU or frame
Physical (bit)

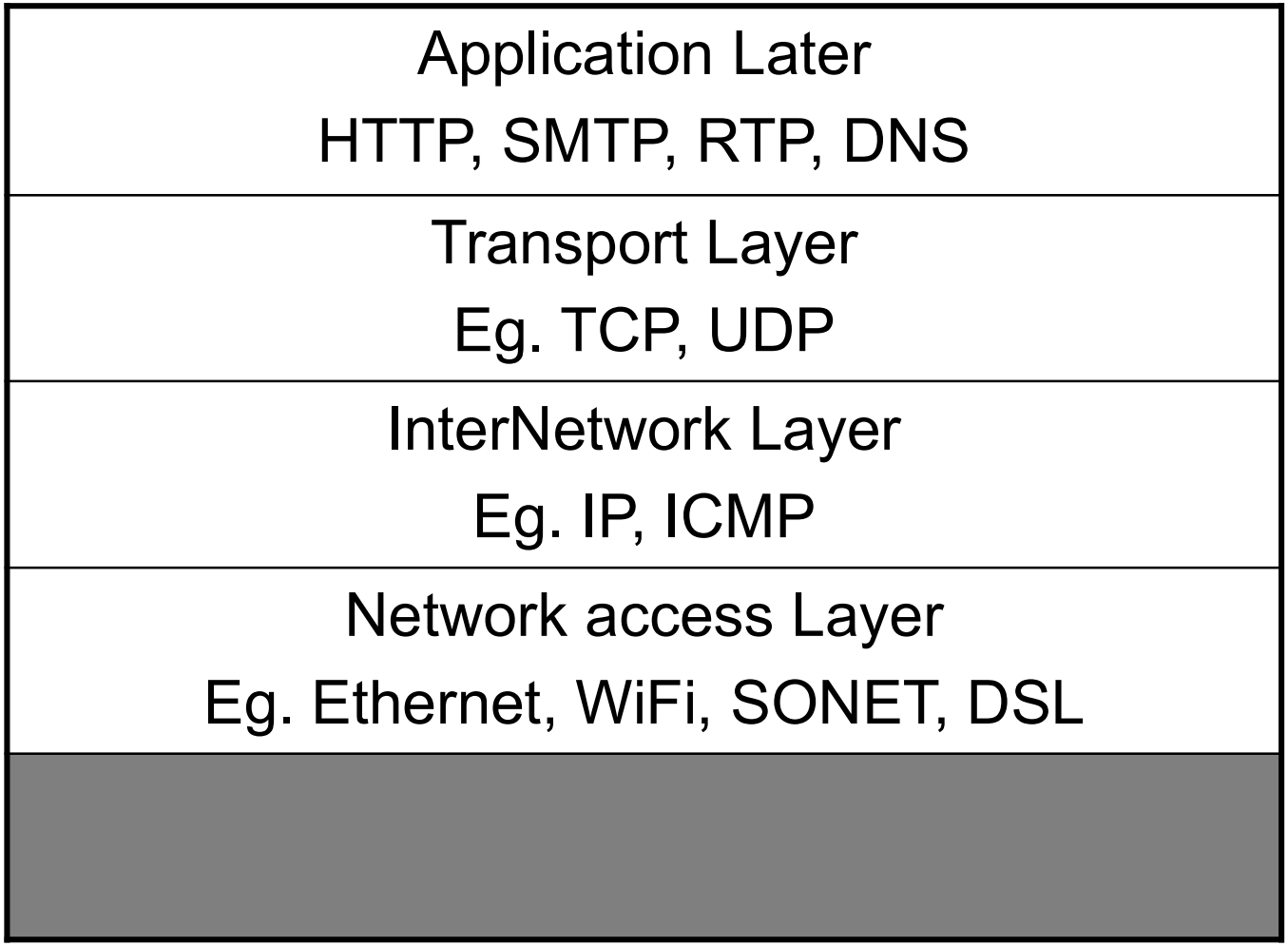
TCP/IP

- A family of protocols that makes the Internet works
- First used for ARPANET: a research network sponsored by DoD (department of defense)

TCP/IP Model


OSI
7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical
TCP/IP
Application
Transport
Inter-network
Network Access

TCP/IP Model



Protocols we will studying this course

TCP/IP

- TCP stands for **Transmission Control Protocol**
  - TCP is the equivalent transport layer protocol in the OSI model
  - It breaks messages into packets, hands them off to the IP layer for delivery
  - It orders and reassembles the packets at their destination
- IP stands for **Internet Protocol**
  - IP layer deals with the routing of packets through the Internet to their final destination

TCP/IP

- UDP stands for **User Datagram Protocol**
  - It is an alternative to TCP
  - The main difference is that TCP is highly reliable, at the cost of decreased performance, while UDP is less reliable, but faster
  - It fits better multimedia applications where increased bandwidth and reduced delay are more important then full reliability

TCP/IP versus OSI

TCP/IP vs. OSI: Similarities

- ✓ Both are based on the concept of a stack of independent protocols.
- ✓ The functionality of the layers is roughly similar.

TCP/IP vs. OSI: Differences

OSI	TCP/IP
OSI makes the distinction between services, interfaces, and protocol.	TCP/IP does not originally clearly distinguish between services, interface, and protocol
The OSI model was defined before the protocols were invented. It can be made to work in diverse heterogeneous networks	TCP/IP model was just a description of the existing protocols.

TCP/IP vs. OSI: Differences

OSI	TCP/IP
OSI emphasis on providing a reliable data transfer service. Each layer of the OSI model detects and handles errors. All data transmitted includes checksums. The transport layer checks source-destination reliability.	TCP/IP treats reliability as an end to end Problem. The transport layer handles all error detection and recovery. The transport layer uses checksums, acknowledgments, and timeouts to control transmissions and provides end-to-end verification.

TCP/IP vs. OSI: Differences

OSI	TCP/IP
OSI has Data Link/Physical layers. Data link layer deals with error detection and correction. Physical layer refer to the physical connection of network.	The lower layers below the Interface or Network layer of TCP/IP are rarely discussed.
OSI has 2 layers: Session and Presentation	TCP/IP leaves the functions of these two layers to application protocols

Protocol Standardization: IETF

Internet Engineering Task Force

- Based on working groups that focus on specific issues
- Produces “Request For Comments” (RFCs)
- Promoted to standards via rough consensus and running code
- E.g.:
  - RFC 1945 on “Hyper Text Transfer Protocol – HTTP/1.0”
  - Internet Protocol version 4 (IPv4) is described in IETF publication RFC 791
- IETF Web site is http://www.ietf.org

IEEE (Institute of Electrical and Electronics Engineers) 802 Standards

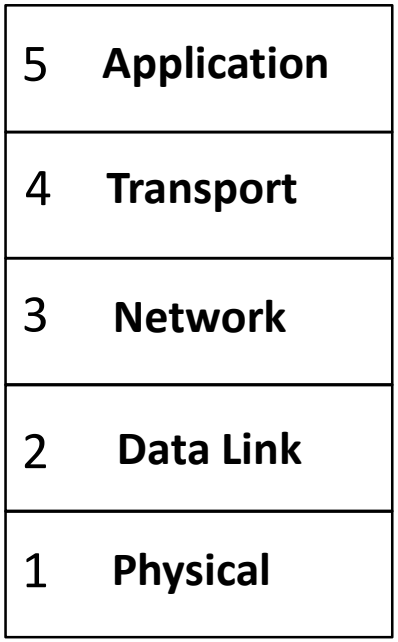
Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring

The 802 working groups. The important ones are marked with *. The ones marked with ↓ are hibernating. The one marked with † gave up.

ITU - International Telecommunication Union

- Main sectors
  - Radiocommunications
  - Telecommunications Standardization
  - Development
- Classes of Members
  - National governments
  - Sector members
  - Associate members
  - Regulatory agencies

Model Used in This Course



References

[1] Andrew S. Tanenbaum, David J. Wetherall, *Computer Network*

[2] Doughlas E. Comer, Computer Networks and Internet

[3] Salim NAHLE and Naceur MALOUCH, “Fast-Converging Scheduling and Routing Algorithms for WiMAX Mesh Networks”, proceedings of Networking 2011.