DPIT127
Networks and Communications

WEEK 5

TCP/IP & OSI LAYERS & LOCAL AREA NETWORKS

Spring 2019

Introduction

- **Birth of Internet –** Multiple LANS were not able to communicate with each other due to different LAN technologies, encodings and signal specifications.
- **1972 –** Two Researchers from ARPANET work on “Interneting Project”
  - Link different networks so that host on one network can speak with host on other networks.
  - **Problem :** Diverse packet sizes, interfaces, transmission rates and reliability requirements.
  - **Devised :** Gateway to serve as intermediary hardware to transfer packets among networks.

Protocols Development

- 1972 (Telnet, early Email)
- 1975 (File Transfer Protocol (FTP))
- 1977 (TCP/IP was developed)
  - **TCP: Transmission Control Protocol**
    - Higher level functionalities e.g. segmentation, reassembly and error detection.
  - **IP: Internet Protocol**
    - Datagram Routing

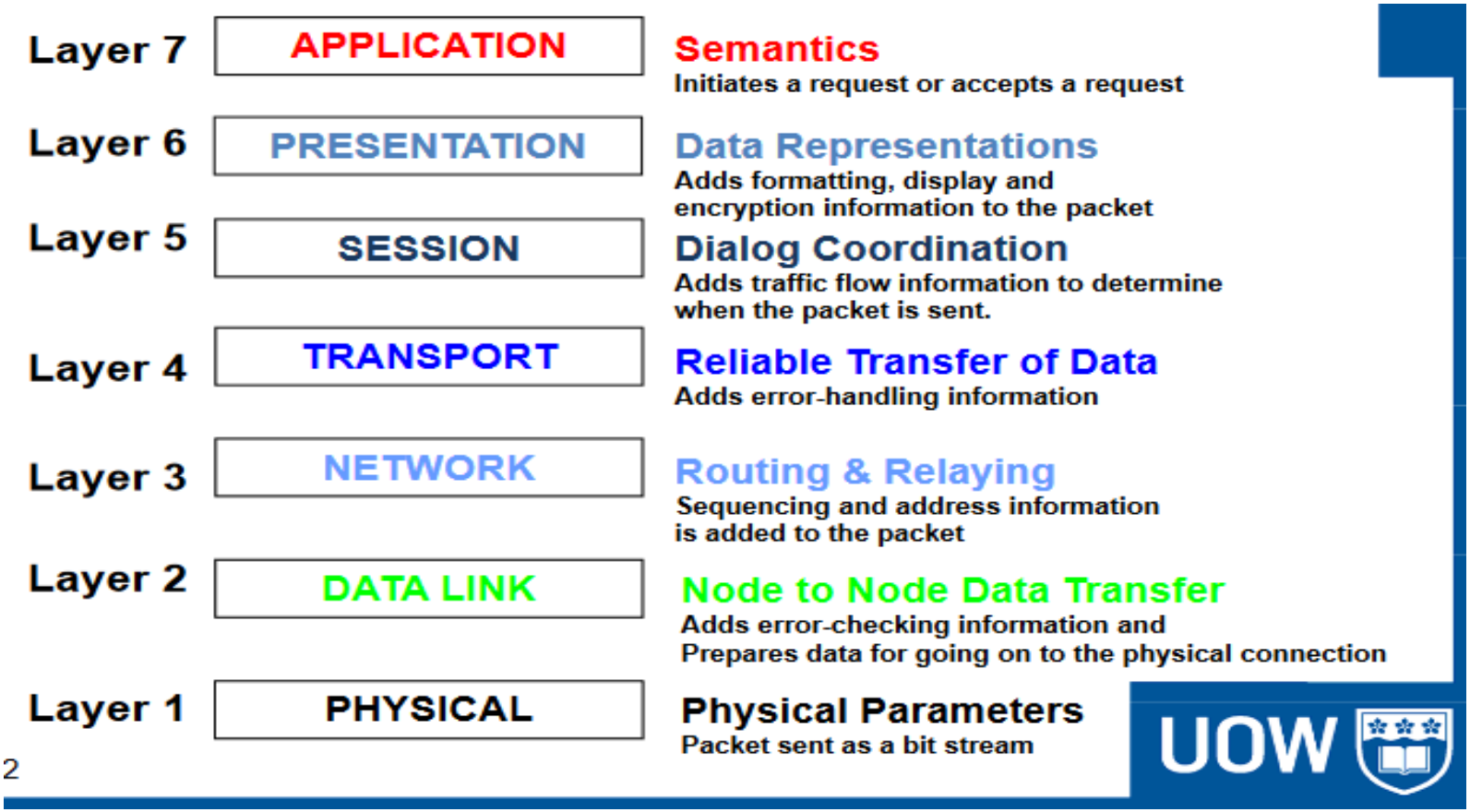
Protocols

- A protocol is a set of rules for communication between devices
- **Syntax.** The structure or the format of the data, meaning the order in which they are presented.
- **Semantics.** The meaning of each section of bits.
- **Timing.** When data should be sent and how fast they can be sent.

Example Network Protocols

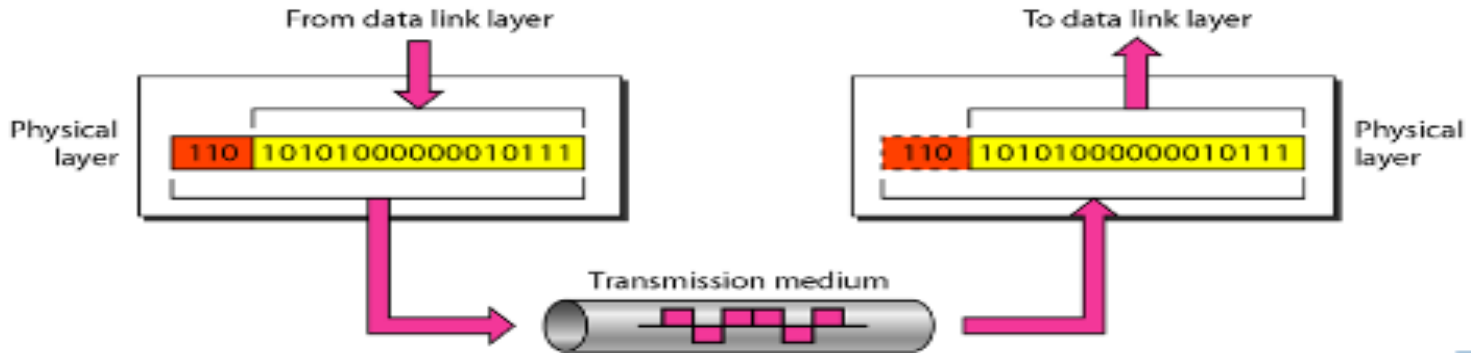
- POP3 - Post Office Protocol 3
- IMAP - Internet Message Access Protocol
- SMTP - Simple mail Transfer Protocol
- HTTP - hypertext transfer protocol
- FTP - file transfer protocol
- TCP/IP - Transmission Control Protocol/Internet Protocol
- PPP - Point-to-Point Protocol, TCP/IP over the phone lines

OSI Reference Model



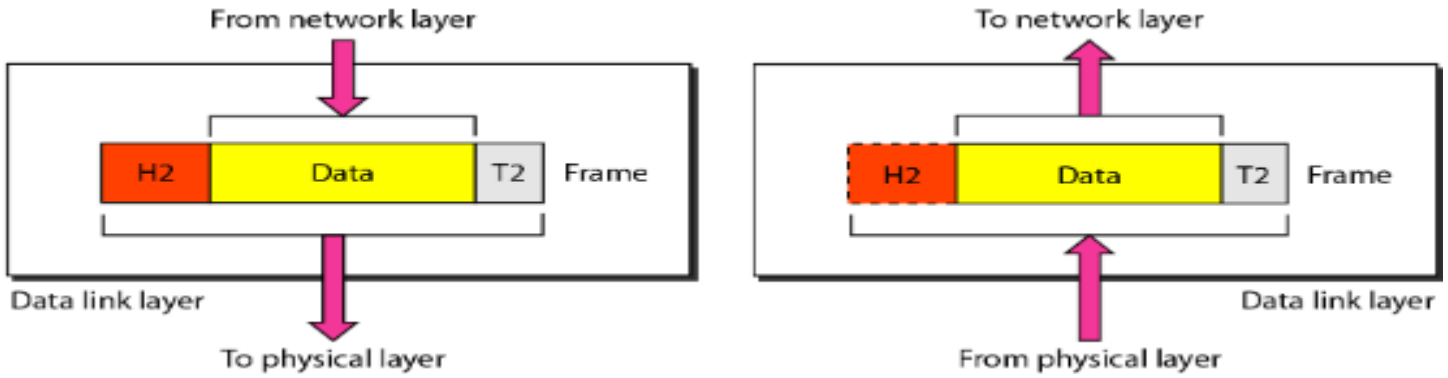
Physical Layer

- Responsible for movements of individual bits from one hop to next.
  - Physical Topology
  - Transmission mode : Simplex, Half Duplex, Full duplex
  - Physical Characteristics of interfaces
  - Data rate
  - Synchronization
  - Bits Representation

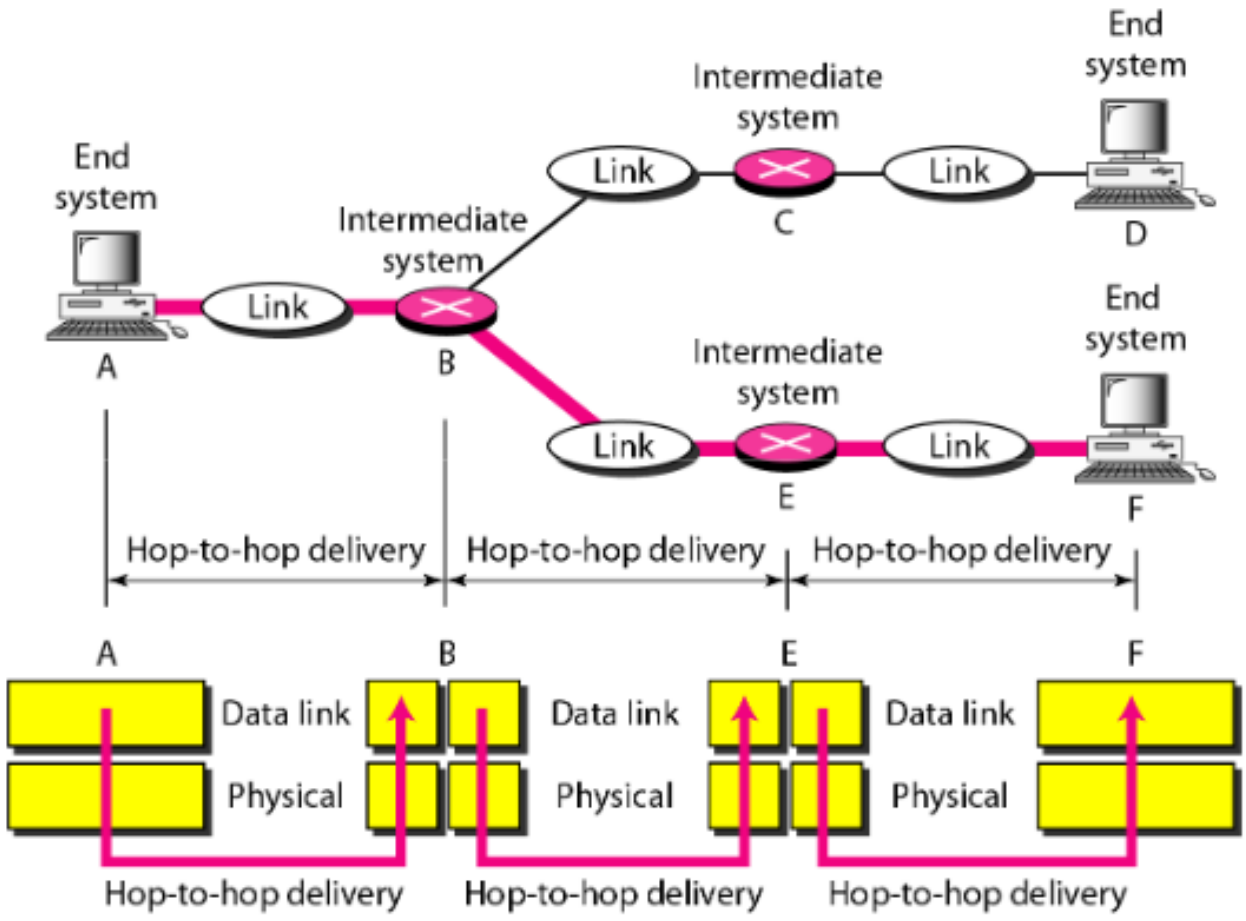


Data Link Layer

- Frames : Encapsulation data in a way that is suitable for transmission on physical layer
  - Framing
  - Physical addressing
  - Flow control
  - Error control
  - Access control



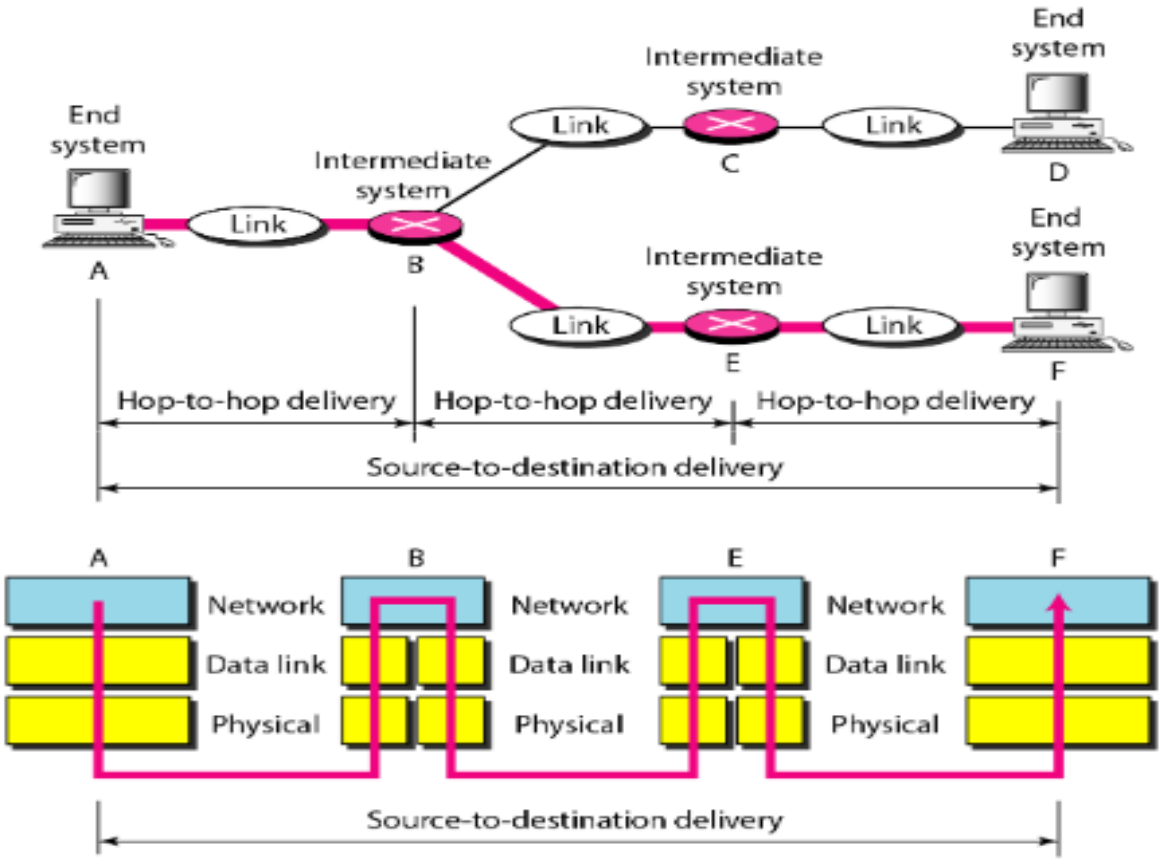
Hop to Hop Delivery (Fig 2.7)



Network Layer

- Responsible for the delivery of individual packets from the source host to the destination host
  - Logical (IP) addressing
  - Routing
    - Compute best route to destination

Source to Destination Delivery (Fig 2.9)



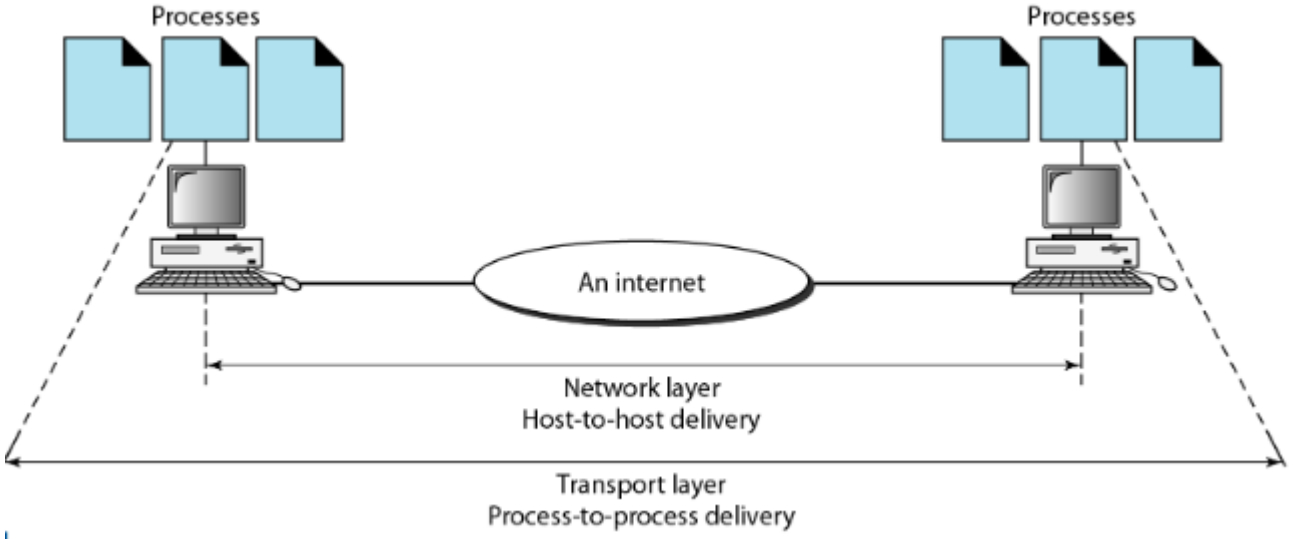
Internet Protocol

- Determines format of packet at network layer
- Format and structure of addresses used in network layer
- Routing packet from source to destination
- IP is a connectionless protocol
  - No Flow control, error control or congestion control
- Auxiliary Protocols : (ICMP, IGMP, DHCP and ARP)

Transport Layer

- Responsible for process-to-process delivery of the entire message
  - Segmentation and reassembly.
  - **Error control:** process-to-process rather than across a single link.
  - **Flow control:** end-to-end rather than across a single link.

Reliable Process to Process Delivery (Fig 2.11)



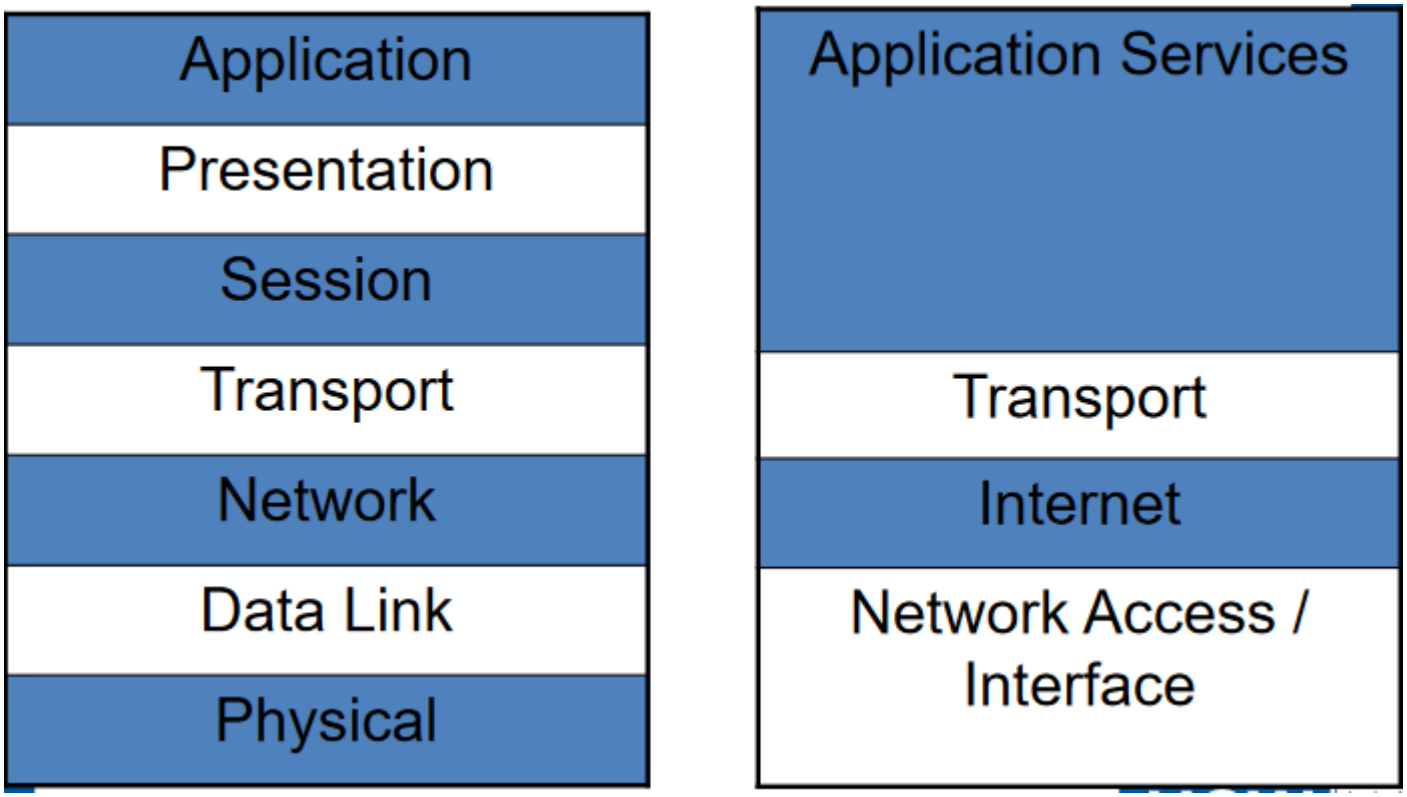
Transmission Control Protocol

- TCP is connection-oriented protocols
  - First establish a logical connection
  - Flow control
  - Error control
  - Congestion control
- User Datagram Protocol (UDP)
  - Connectionless
  - No flow, error, congestion control

Other Layers

- **Session Layer**
  - Responsible for dialog control and synchronization.
- **Presentation Layer**
  - Concerned with syntax and semantics of information exchange between two system.
  - Translation, Encryption and Compression
- **Application Layer**
  - Responsible for providing application to users. E.g. Web browsers, File transfers, Email, IP telephony, FTP

TCP/IP Protocol Suite



TCP/IP Protocol Suite

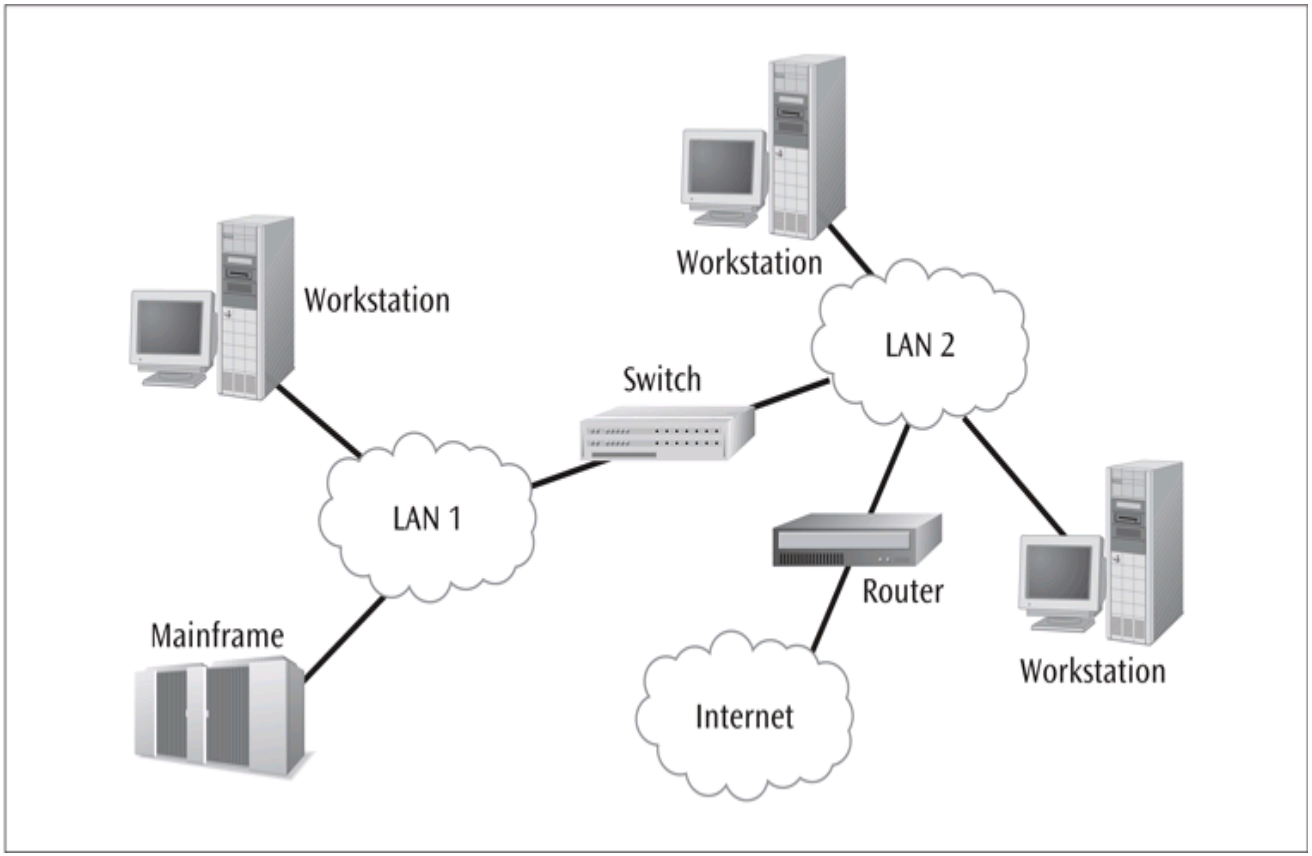
- **Application layer**
  - Equivalent to OSI's application and presentation layers
- **Transport layer**
  - Equivalent to OSI's transport layer
- **Internet layer**
  - Equivalent to OSI's network layer
- **Network access / interface layer**
  - Equivalent to OSI's data link and physical layers

LAN

- A local area network is a communication network that interconnects a variety of data communicating devices within a *small geographic area* and broadcasts data at high data transfer rates
- Since the local area network first appeared in the 1970s, its use has become widespread in commercial and academic environments

Functions of Local Area Networks

Figure 7-1
A local area network interconnecting another local area network, the Internet, and a mainframe computer



Advantages of Local Area Networks

- Ability to share hardware and software resources
- Individual workstation might survive network failure
- Component and system evolution are possible
- Support for heterogeneous forms of hardware and software
- Access to other LANs and WANs
- Private ownership (maybe a disadvantage)
- Secure transfers at high speeds with low error rates

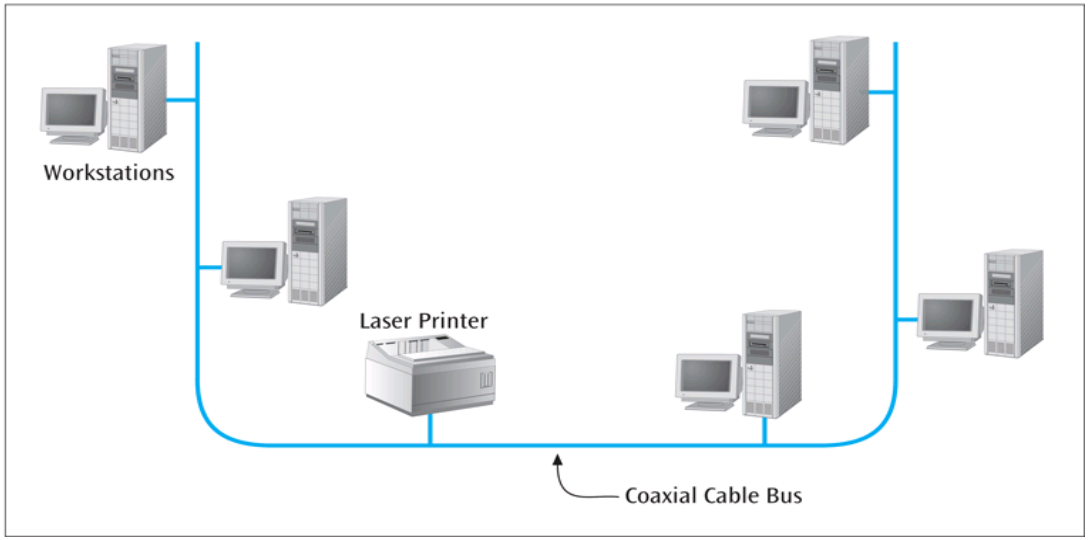
Disadvantages of Local Area Networks

- Equipment and support can be costly
- Level of maintenance continues to grow
- Private ownership (lease option attractive for some)
- Some types of hardware may not interoperate
- Just because a LAN can support two different kinds of packages does not mean their data can interchange easily
- LAN is only as strong as its weakest link, and there are many links

The First LAN – The Bus/Tree

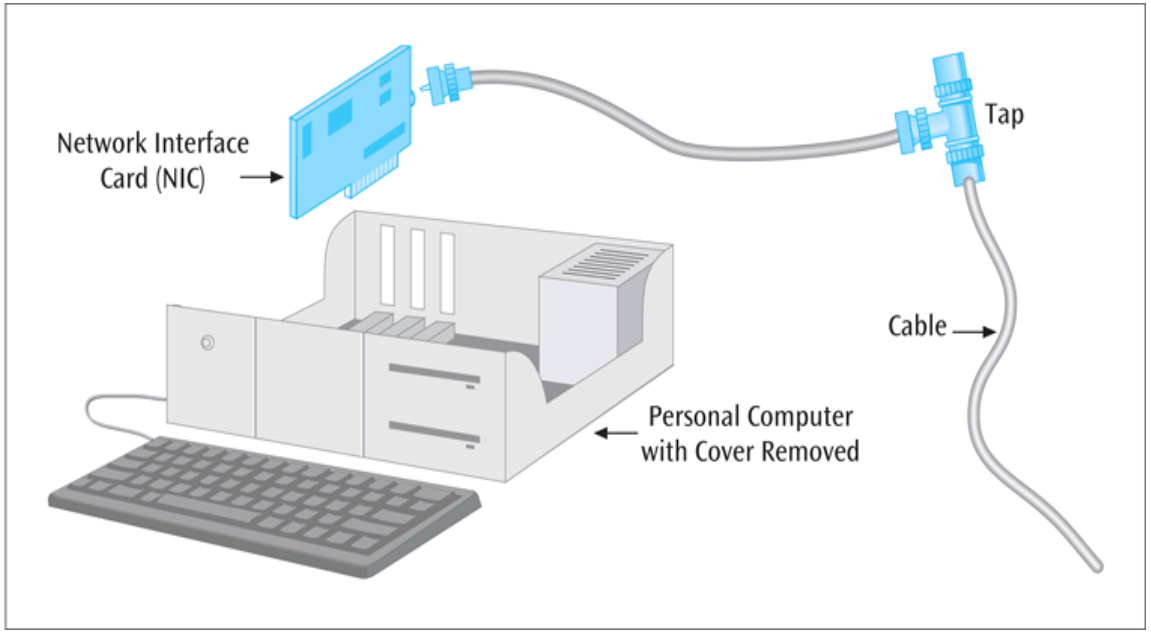
- Workstation has a network interface card (NIC) that attaches to the bus (a coaxial cable) via a tap
- Data can be transferred using either baseband digital signals or broadband analog signals

Figure 7-2
Simple diagram of a local area network bus topology



Bus/Tree

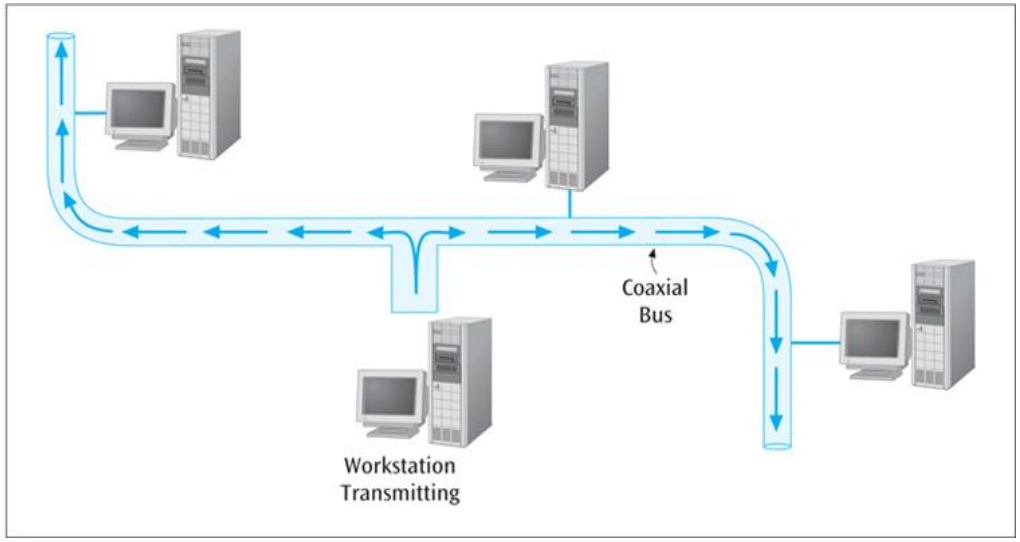
Figure 7-3
Tap used to interconnect a workstation and a LAN cable



Bus/Tree

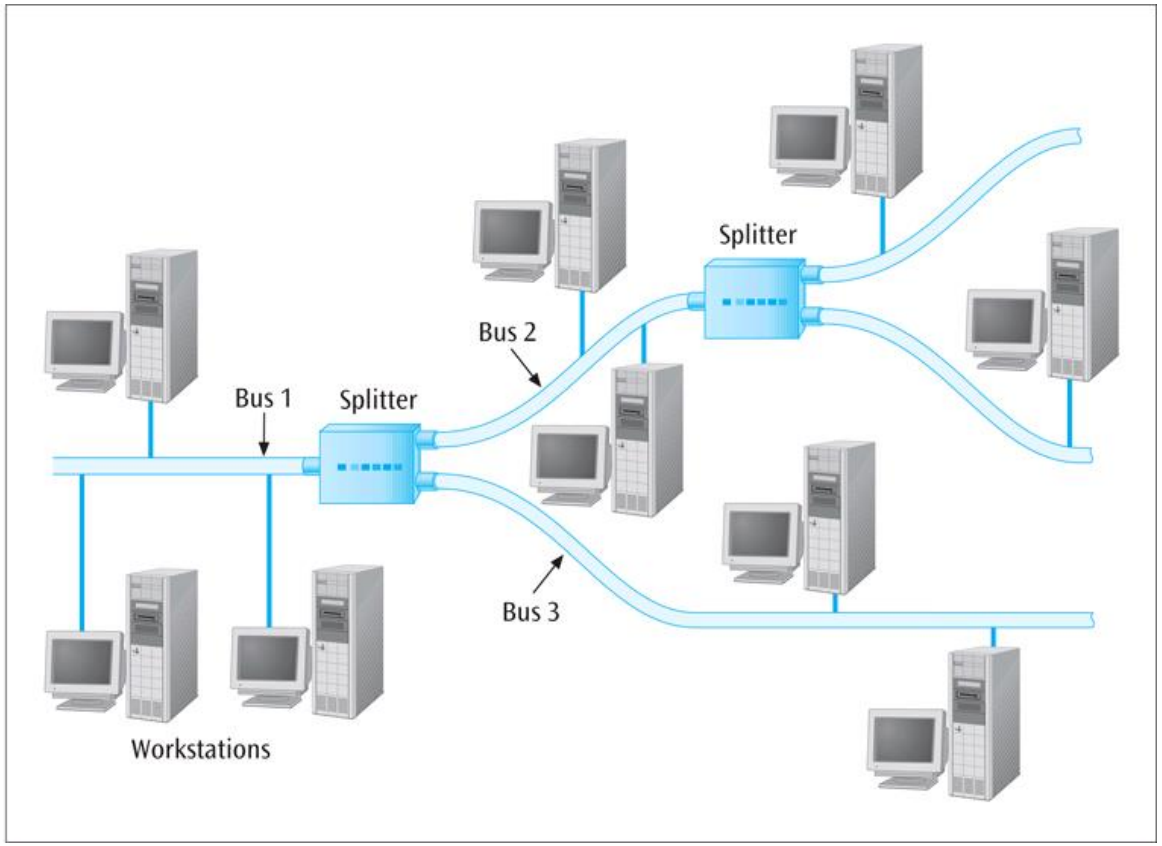
- Baseband signals are bidirectional and more outward in both directions from the workstation transmitting.
- Broadband signals are uni-directional and transmit in only one direction
  - Because of this, special wiring considerations are necessary.
- Buses can be split and joined, creating trees.

Figure 7-4
Bidirectional propagation of a baseband signal



Bus/Tree

Figure 7-5
Simple example of a broadband tree topology

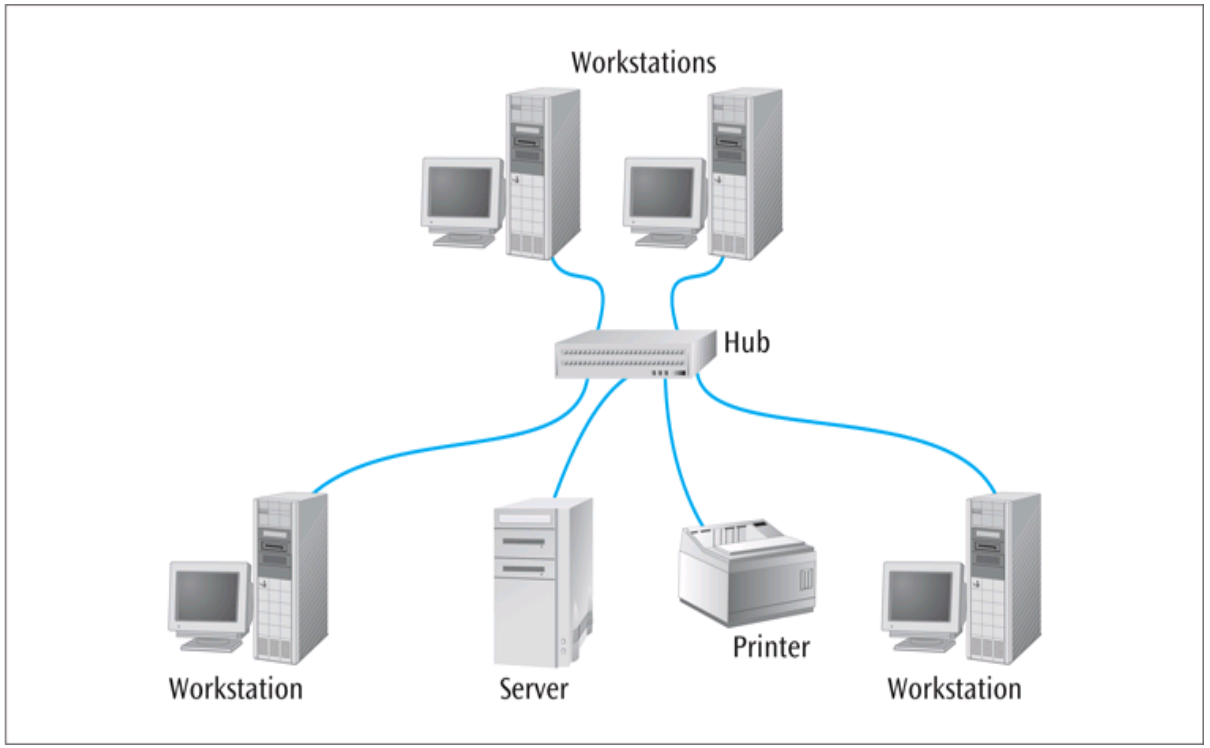


A More Modern LAN –The Star-Wired Bus

- Logically operates as a bus, but physically looks like a star
- Star design is based on hub
  - All workstations attach to hub
- Unshielded twisted pair usually used to connect workstation to hub
- Originally, hub takes incoming signal and immediately broadcasts it out all connected links
- Hubs can be interconnected to extend size of network

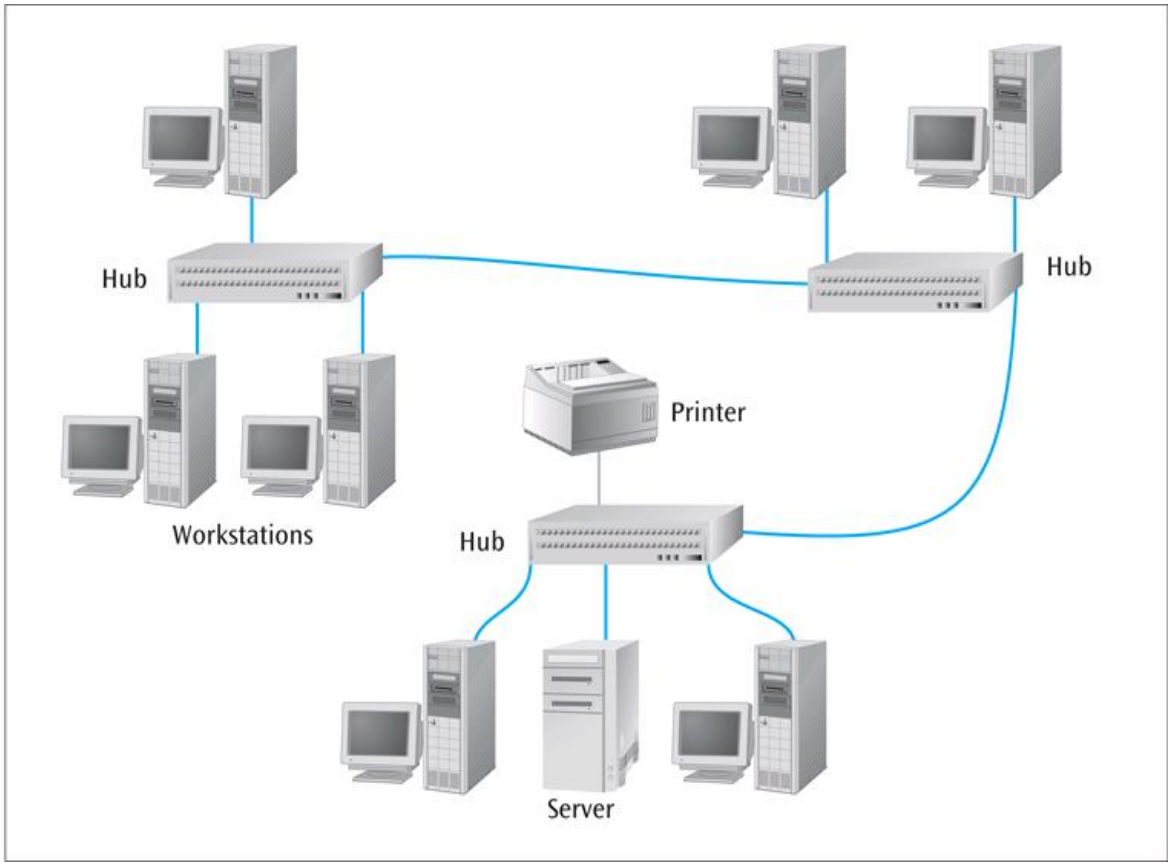
Star-Wired Bus

Figure 7-6
Simple example of a star-wired bus local area network



Star-Wired Bus

Figure 7-7
Interconnection of three hubs in a star-wired bus local area network



Star-Wired Bus

- Modular connectors and twisted pair make installation and maintenance of star-wired bus better than standard bus
- Hubs can be interconnected with twisted pair, coaxial cable, or fiber-optic cable
- Biggest disadvantage: when one station talks, everyone hears it
  - This is called a shared network
    - All devices are sharing the network medium

Medium Access Control Protocols

- How does a workstation get its data onto the LAN medium?
- A medium access control protocol is the software that allows workstations to “take turns” at transmitting data
- **Two basic categories:**
  - Contention-based protocols
  - Round-robin protocols

Contention-Based Protocols

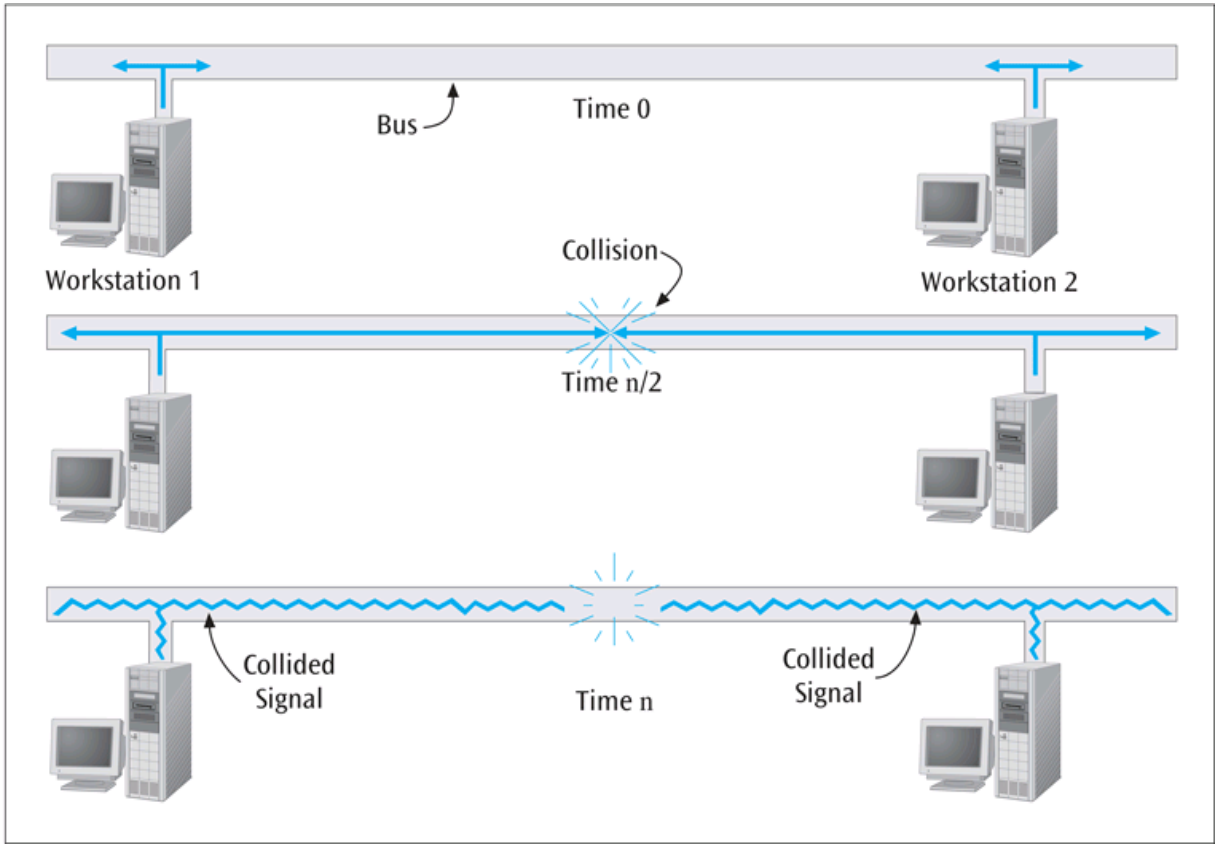
- Essentially first-come, first-served
- Most common example is carrier sense multiple access with collision detection (CSMA/CD)
- If no one is transmitting, workstation can transmit
- If someone else is transmitting, workstation “backs off” and waits

Contention-Based Protocols

- If two workstations transmit at same time, collision occurs
  - When two workstations hear collision, they stop transmitting immediately
  - Each workstation backs off a random amount of time and tries again
  - Hopefully, both workstations do not try again at exact same time
- CSMA/CD is an example of a non-deterministic protocol

Contention-Based Protocols

Figure 7-8
Two workstations at opposite ends of a bus experiencing a collision

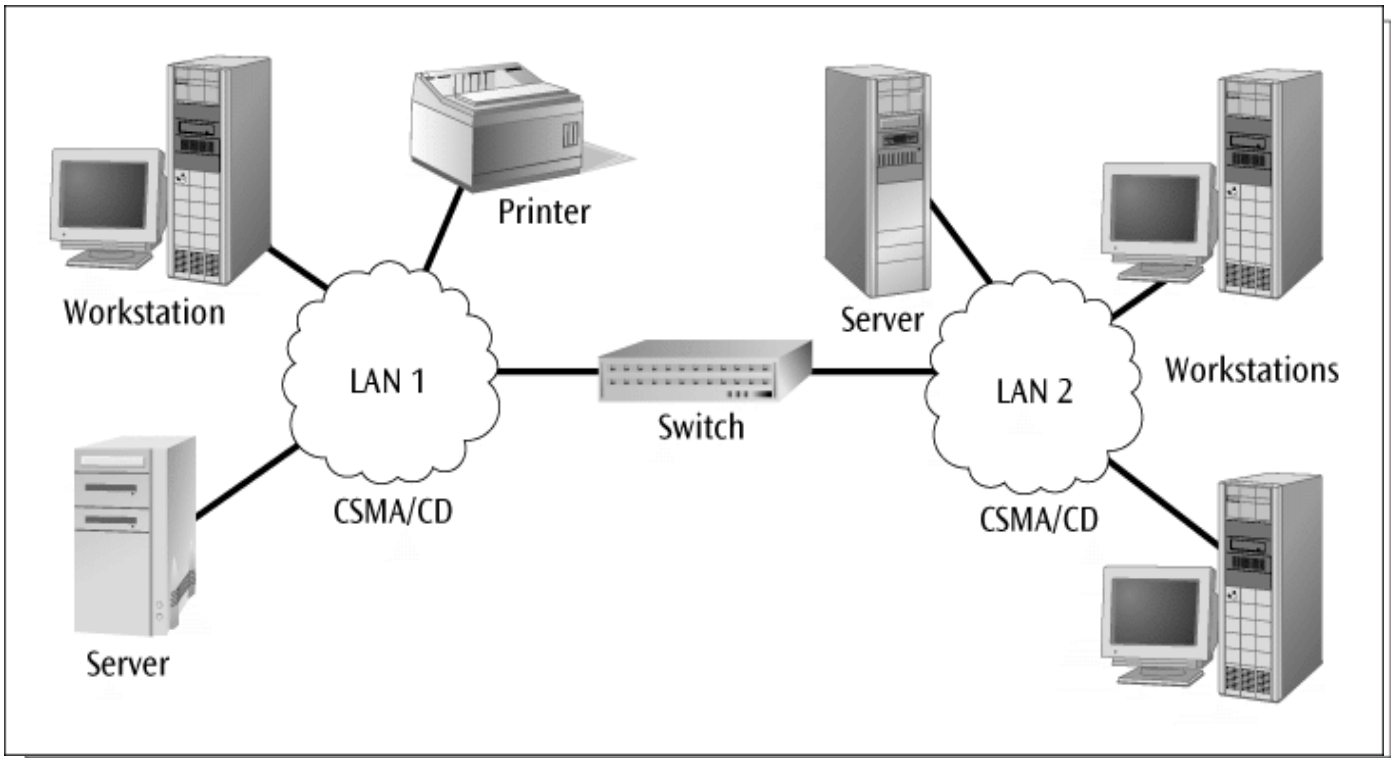


Switches

- The hub is a simple device that transmits an incoming frame out all the other ports on the hub
- The switch has intelligence and can filter out and forward frames based on their NIC address
- A switch maintains internal port table(s) that keep track of which frames arrived on which ports
- Switches have eliminated many hubs
- A switch observes each frame that arrives at a port, extracts the source address from the frame, and places that address in the port's routing table
- A *transparent switch* is found with CSMA/CD LANs

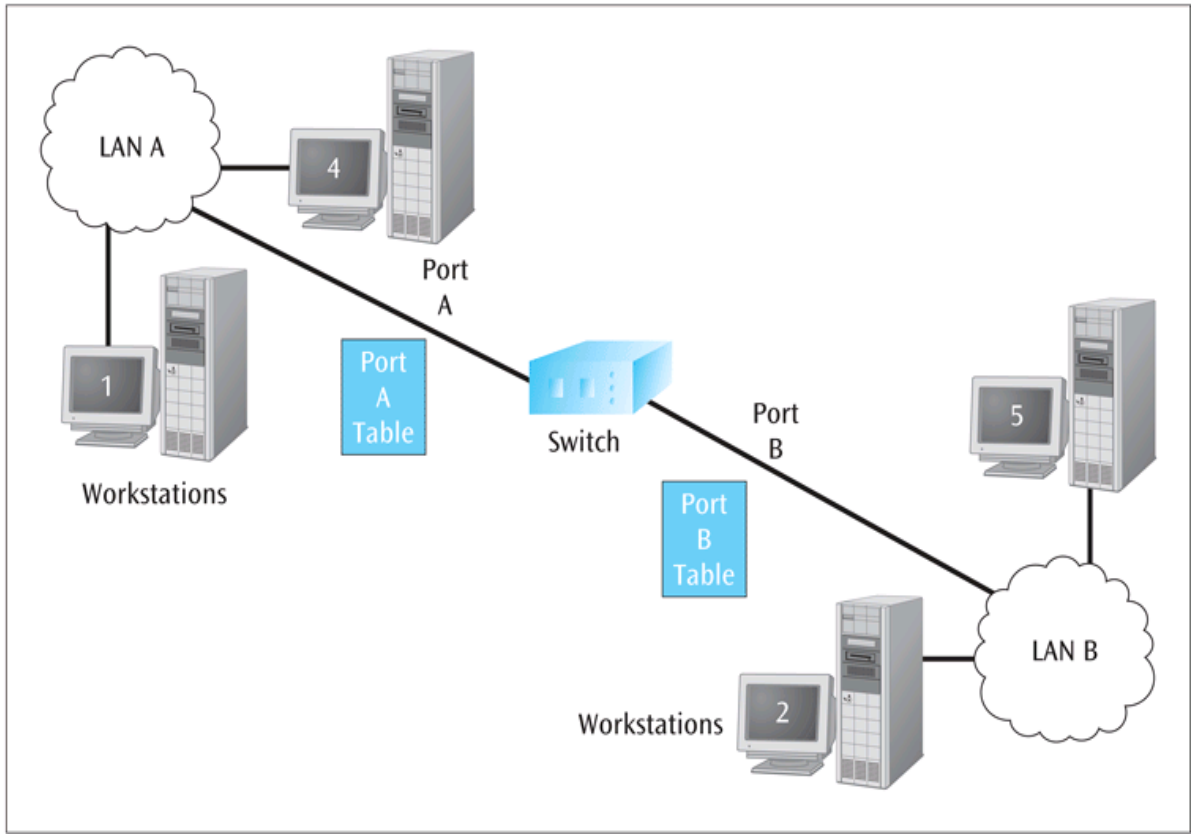
Switches

Figure 7-9
A switch interconnecting two local area networks



Switches

Figure 7-10
A switch interconnecting two local area networks has two internal port tables

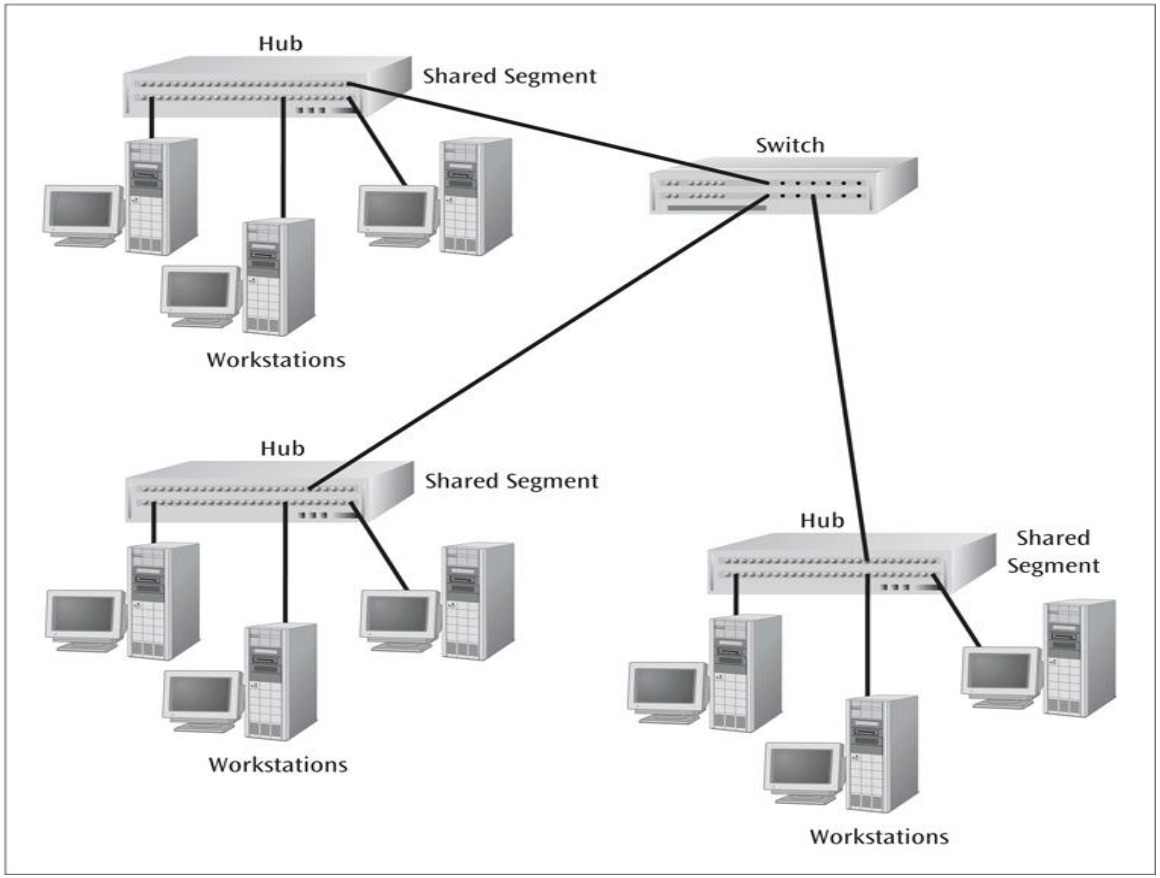


Switches

- Workstations that connect to a hub are on a shared segment
- Workstations that connect to a switch are on a switched segment
- The backplane of a switch is fast enough to support multiple data transfers at one time

Switches

Figure 7-12
Workstations connected to a shared segment local area network

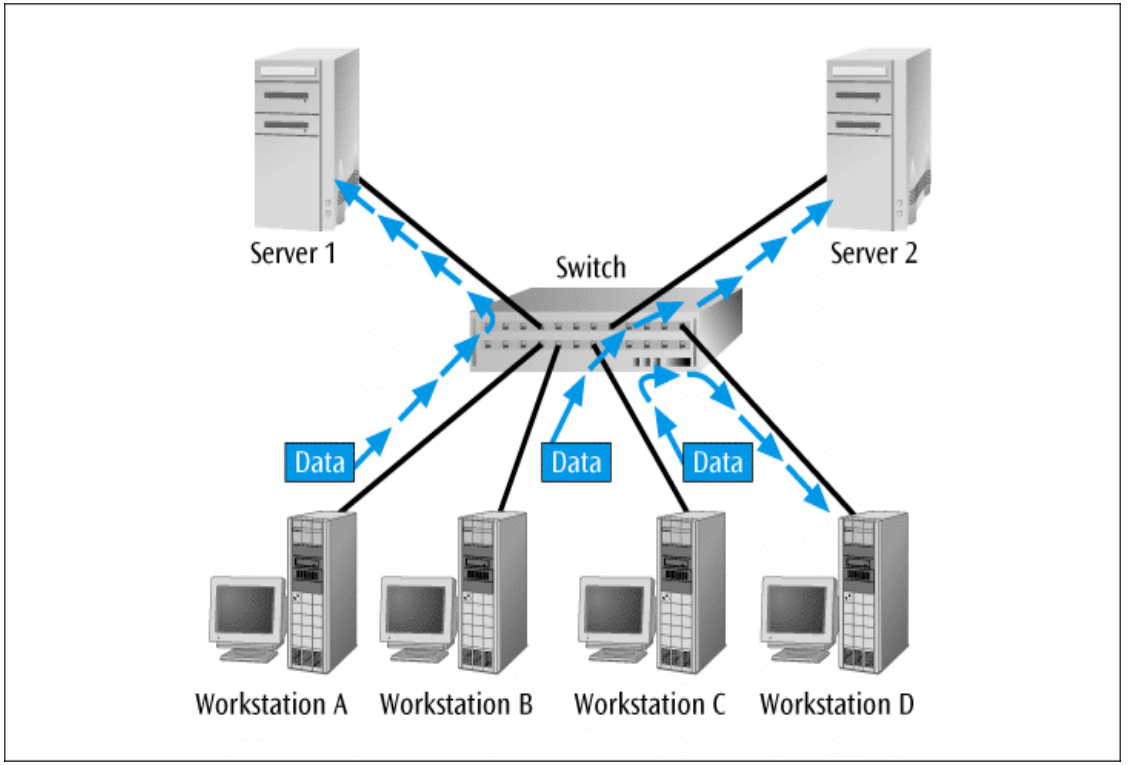


Isolating Traffic Patterns & Providing Multiple Access

- Whether shared or dedicated segments are involved, the primary goal of a switch is to isolate a particular pattern of traffic from other patterns of traffic or from the remainder of the network
- Switches, because of their backplane, can also allow multiple paths of communications to simultaneously occur

Switches

Figure 7-13
A switch with two servers allowing simultaneous access to two servers



Full-Duplex Switches

- Allow for simultaneous transmission and reception of data to and from a workstation
- This full-duplex connection helps to eliminate collisions
- To support a full-duplex connection to a switch, at least two pairs of wires are necessary
  - One for the receive operation
  - One for the transmit operation
  - Most people install four pairs today, so wiring is not the problem

Virtual LANs

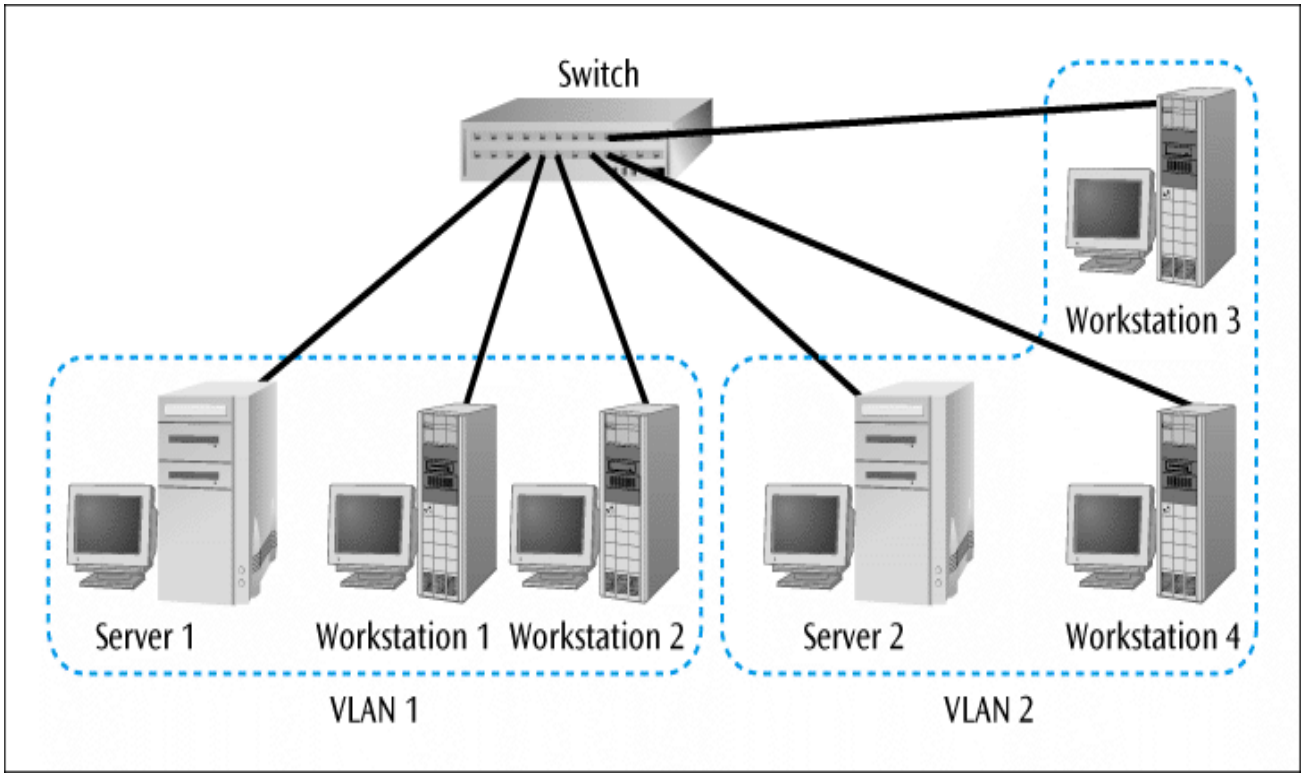
- **Virtual LAN (VLAN) –** logical subgroup within a LAN that is created via switches and software rather than by manually moving wiring from one network device to another
- Even though employees and their actual computer workstations may be scattered throughout the building, LAN switches and VLAN software can be used to create a "network within a network"

Virtual LANs

- A relatively new standard, IEEE 802.1Q, was designed to allow multiple devices to intercommunicate and work together to create a virtual LAN
- Instead of sending technician to a wiring closet to move a workstation cable from one switch to another, an 802.1Q-compliant switch can be remotely configured by a network administrator

Virtual LANs

Figure 7-14
A switch with two VLANs configured



Link Aggregation

- Allows you to combine two or more links into one higher-speed link
- Why would we want to do this?
  - What if you want more bandwidth between a device and a switch?
  - What if you want to provide a back-up link between a device and a switch?
  - What if you want to provide a higher-speed connection to a server?

Link Aggregation

- An IEEE protocol (802.3ad-2000) which typically runs in most LAN devices can support link aggregation
- Link aggregation attempts to balance the flow of messages over the multiple paths, unless the flow of frames belong to a particular conversation; then the frames are sent over one of the links.

Quality of Service

- On a standard Ethernet LAN, all frames have the same priority, which is none
- What if you want to make video-conferencing frames a higher priority than email frames?
- You can use IEEE 802.1p standard which is installed in most if not all switches
- The 802.1p standard adds a 3-bit field to the front of each Ethernet frame
- This 3-bit field can be used to establish a priority

Quality of Service

- Here are the PCP values and the associated traffic types

PCP Value	Traffic Type
0	Best effort
1	Background (lowest priority)
2	Excellent effort
3	Critical applications
4	Video
5	Voice
6	Internetwork control
7	Network control (highest priority)

Wired Ethernet

- Most common form of LAN today
- Star-wired bus is most common topology but bus topology still not totally dead yet
- Comes in many forms depending upon medium used and transmission speed and technology

Wired Ethernet

- Originally, CSMA/CD was 10 Mbps
- Then 100 Mbps was introduced
  - Most NICs sold today are 10/100 Mbps
- Then 1000 Mbps (1 Gbps) was introduced
- 10 Gbps is now being installed in high-end applications
- 40 Gbps (GbE) and 100 GbE are now appearing in high-end switches and networks

Wired Ethernet

- 1000 Mbps introduced a few interesting wrinkles:
  - Transmission is full-duplex (separate transmit and receive), thus no collisions
  - Prioritization is possible using 802.1p protocol
    - Topology can be star or mesh (for trunks)

Wired Ethernet

Table 7-1 Summary of Ethernet Standards

Ethernet Standard	Maximum Transmission Speed	Signal Type	Cable Type	Maximum Segment Length
10BaseT	10 Mbps	Baseband	Twisted pair	100 meters
100BaseTX	100 Mbps	Baseband	2-pair Category 5 or higher unshielded twisted pair	100 meters
100BaseFX	100 Mbps	Baseband	Fiber optic	1000 meters
1000BaseSX	1000 Mbps	Baseband	Fiber optic	300 meters
1000BaseLX	1000 Mbps	Baseband	Fiber optic	100 meters
1000BaseCX	1000 Mbps	Baseband	Specialized balanced copper	25 meters
1000BaseT	1000 Mbps	Baseband	Twisted pair—four pairs	100 meters
10GBase-fiber	10 Gbps	Baseband	Fiber optic	various lengths
10GBase-T	10 Gbps	Baseband	Cat 6	55–100 meters
10GBase-CX4	10 Gbps	Baseband	Twin axial	~30 meters
40 GbE / 100 GbE	40 Gbps / 100 Gbps	Baseband	Backplane / fiber optic	various lengths

Wired Ethernet

- One of the more recent features is power over Ethernet (PoE)
- What if you have a remote device that has an Ethernet connection?
  - It will require a power connection
- What if you don’t have an electrical outlet nearby?
  - Use PoE
    - Power to drive Ethernet NIC is sent over wiring along with usual Ethernet signals

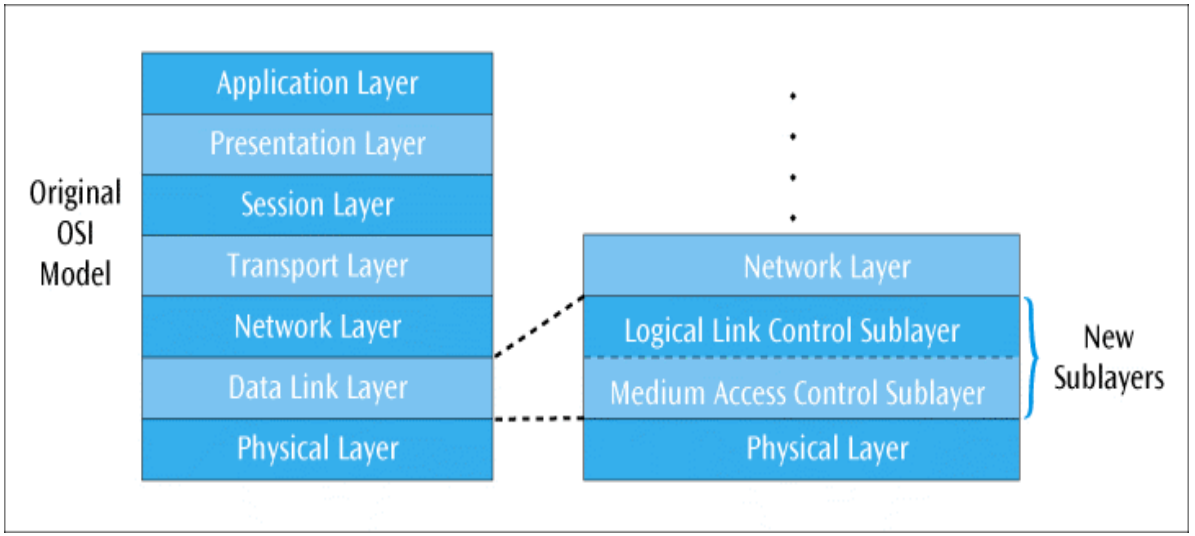
IEEE 802

- To better support local area networks, the data link layer of the OSI model was broken into two sublayers:
  - Logical link control sublayer
  - Medium access control sublayer
- Medium access control sublayer defines frame layout and is more closely tied to a specific medium at the physical layer
  - Thus, when people refer to LANs they often refer to its MAC sublayer name, such as 10BaseT

IEEE 802

Figure 7-17

Modification of OSI model to split data link layer into two sublayers

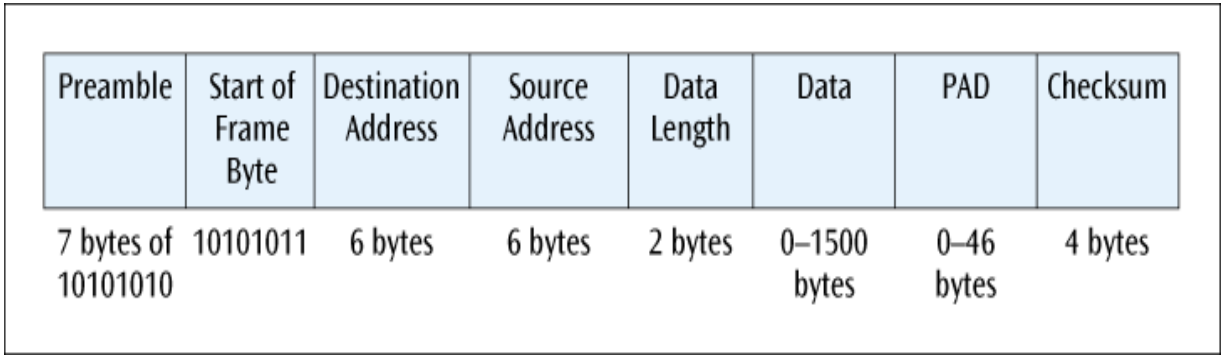


IEEE 802.3 Frame Format

- IEEE 802 suite of protocols defines frame formats for CSMA/CD (IEEE 802.3) and token ring (IEEE 802.5)
- Each frame format describes how data package is formed
- The two frames do not have the same layout
  - If a CSMA/CD network connects to a token ring network, the frames have to be converted from one to another

IEEE 802.3 Frame Format

Figure 7-18
Frame format for IEEE 802.3 CSMA/CD



Preamble	Start of Frame Byte	Destination Address	Source Address	Data Length	Data	PAD	Checksum
7 bytes of 10101010	10101011	6 bytes	6 bytes	2 bytes	0–1500 bytes	0–46 bytes	4 bytes

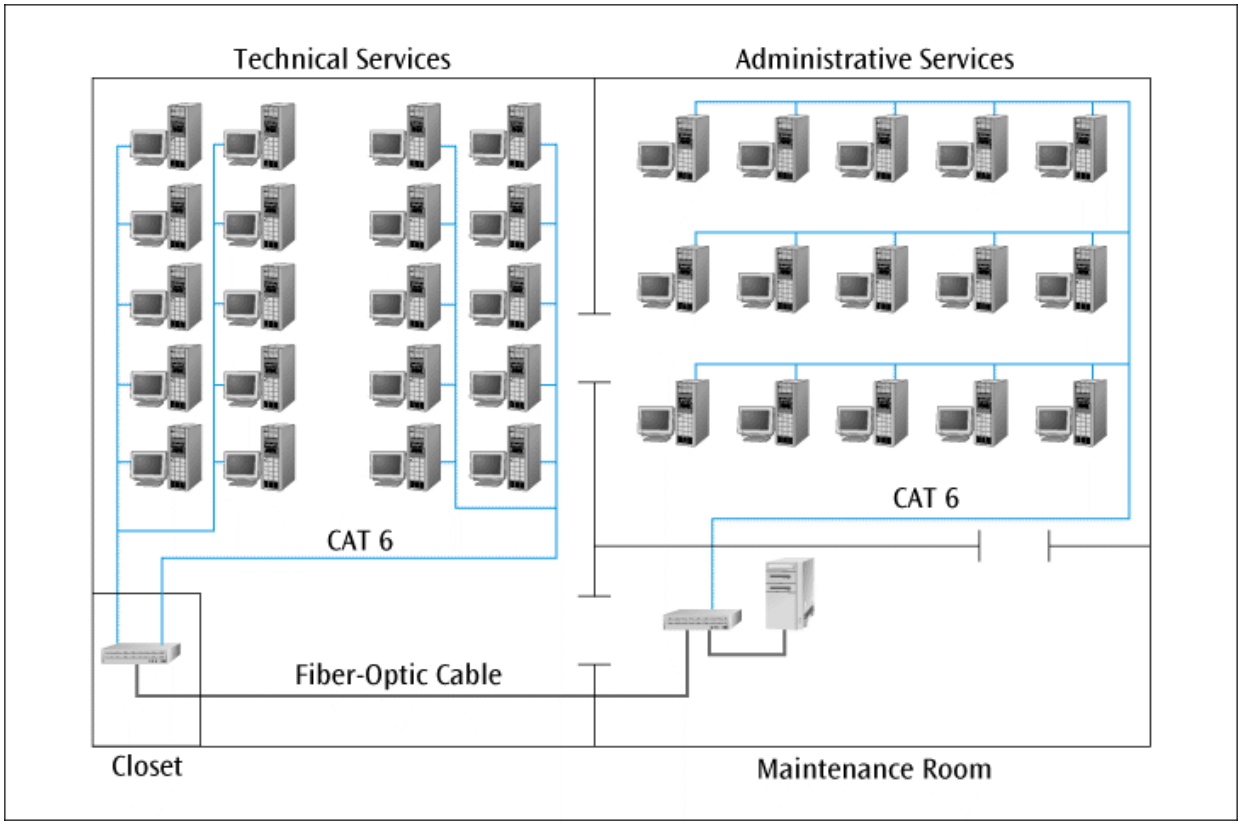
LANs In Action: A Small Office Solution

- What type of system will interconnect 20 workstations in one room and 15 workstations in another room to a central server, which offers:
  - Internal e-mail
  - A database that contains all customer information
  - High-quality printer access

LANs In Action: Small Office Solution

Figure 7-19

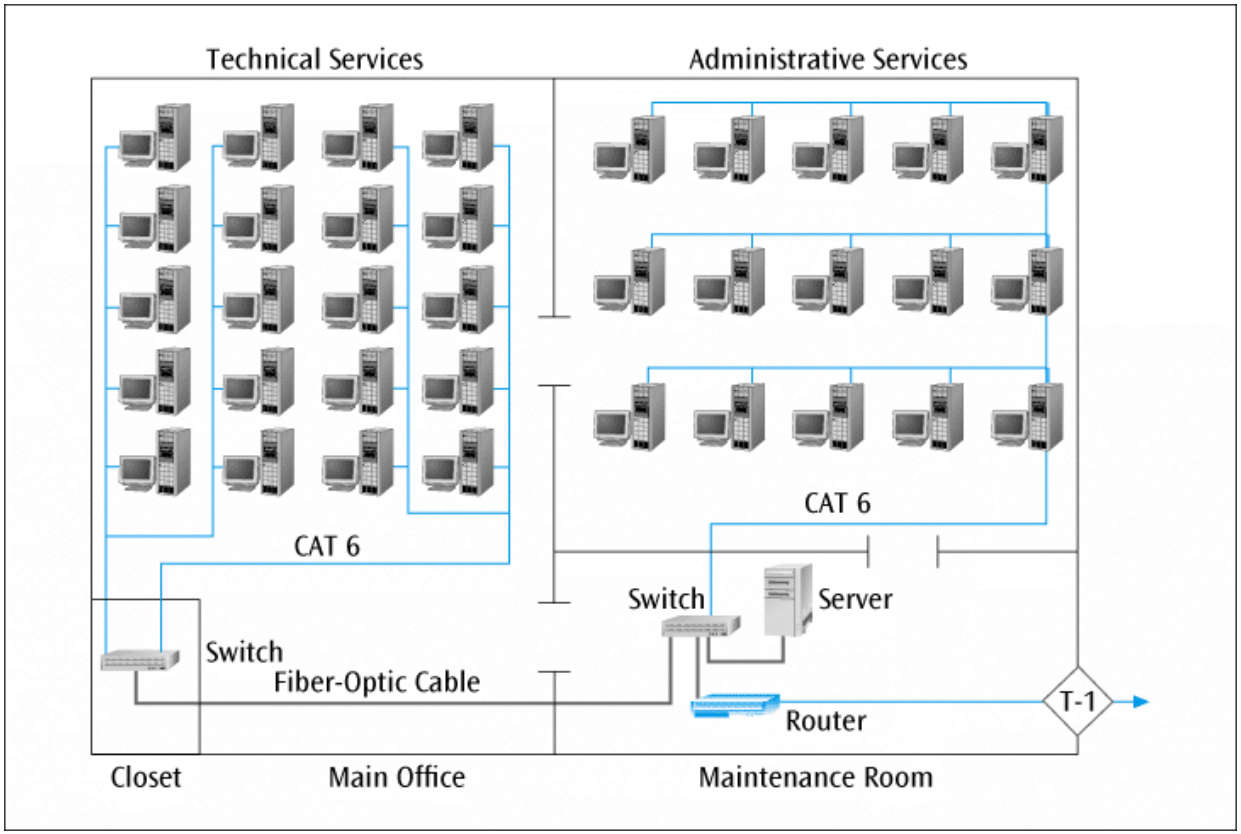
Wiring diagram of Hannah's office space showing the placement of switches and servers



LANs In Action: Small Office Solution

Figure 7-20

The modified network with a router and high-speed phone line



Readings

Chapter 2, 7 of the Textbook