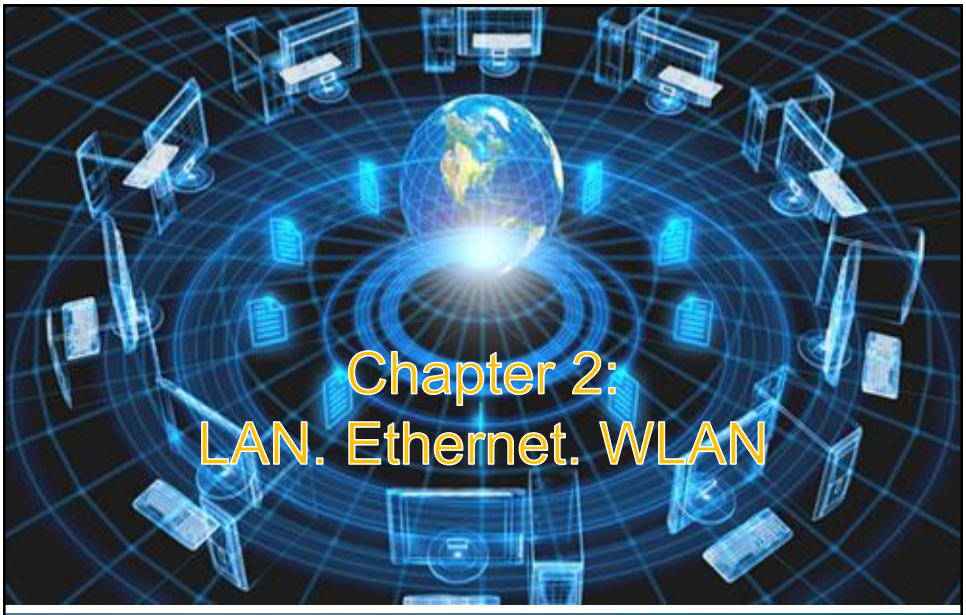


Chapter 2: LAN. Ethernet. WLAN

Lecturer: Nguyễn Thị Thanh Vân – FIT - HCMUTE

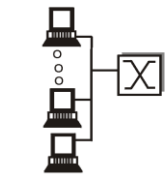
Contents

- Multiple access protocols
- LAN technologies:
- Ethernet
- Network Devices:
  - repeat, Hubs, bridges, and switches, router…
- Token Ring
- FDDI
- ATM
- WLAN

Multiple Access Links and Protocols

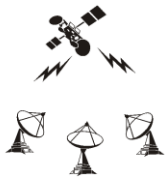
Two types of "links":

- point-to-point
  - PPP (point-to-point protocol) for dial-up access
  - point-to-point link between Ethernet switch and host
- broadcast (shared wire or medium)
  - traditional Ethernet
  - upstream HFC (Hybrid fiber coaxial cable)
  - 802.11 wireless LAN



shared wire (e.g. Ethernet)

shared wireless (e.g. Wavelan)



satellite

cocktail party

Multiple Access protocols

- single shared broadcast channel
- two or more simultaneous transmissions by nodes: interference
  - only one node can send successfully at a time

multiple access protocol

- distributed algorithm that determines how nodes share channel, i.e., determine when node can transmit
- communication about channel sharing must use channel itself!
  - no out-of-band channel for coordination

Ideal Mulitple Access Protocol

What to look for in multiple access protocols?

Broadcast channel of rate R bps

1. When one node wants to transmit, it can send at rate R.
2. When M nodes want to transmit, each can send at average rate R/M
3. Fully decentralized:
   - no special node to coordinate transmissions
   - no synchronization of clocks, slots
4. Simple

MAC Protocols: a taxonomy

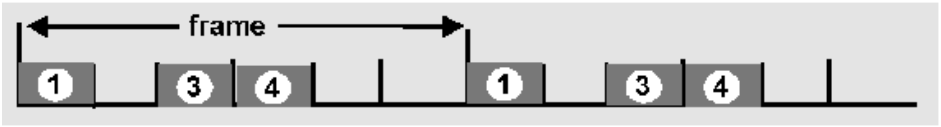
Three broad classes:

- Channel Partitioning protocols
  - divide channel into smaller “pieces” (time slots, frequency, code)
  - allocate piece to node for exclusive use
- Random Access protocols
  - channel not divided, allow collisions
  - “recover” from collisions
- Taking-turns protocols
  - tightly coordinate shared access to avoid collisions

Channel Partitioning MAC protocols: TDMA

TDMA: time division multiple access

- channel divided into N time slots, one per user
- access to channel in "rounds"
- each station gets fixed length slot (length = packet trans time) in each round
- unused slots go idle
- inefficient with low duty cycle users and at light load
- example: 6-station LAN, 1,3,4 have packets, slots 2,5,6 idle



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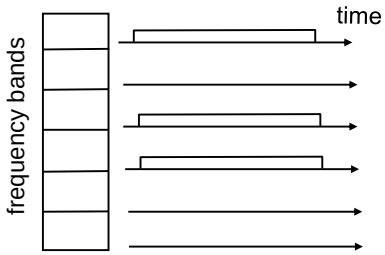
Channel Partitioning MAC protocols: FDMA

FDMA: frequency division multiple access

- channel spectrum divided into frequency bands
- each station assigned fixed frequency band
- unused transmission time in frequency bands go idle
- example: 6-station LAN, 1,3,4 have packets, frequency bands 2,5,6 idle



Random Access Protocols

- When node has packet to send
  - transmit at full channel data rate R.
  - no *a priori* coordination among nodes
- two or more transmitting nodes -> “collision”,
- random access MAC protocol specifies:
  - how to detect collisions
  - how to recover from collisions (e.g., via delayed retransmissions)
- Examples of random access MAC protocols:
  - slotted ALOHA
  - ALOHA
  - CSMA, CSMA/CD, CSMA/CA

Slotted ALOHA

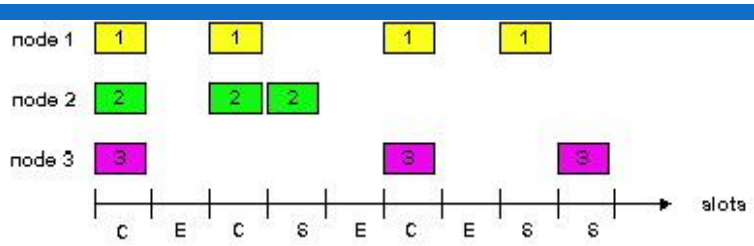
Assumptions

- all frames same size
- time is divided into equal size slots (length of a slot equals time to transmit 1 frame)
- nodes start to transmit frames only at beginning of slots
- nodes are synchronized
- if 2 or more nodes transmit in a slot, all nodes detect collision

Operation

- when a node has a fresh frame to send , it transmits in the next slot
- If no collision, the frame is transmitted successfully
- if collision, the node retransmits the frame in each subsequent slot with probability p until success

Slotted ALOHA



Pros

- single active node can continuously transmit at full rate of channel
- highly decentralized: only slots in nodes need to be in sync
- simple

Cons

- collisions, wasting slots
- idle slots due to probabilistic retransmission
- nodes may be able to detect collision in a time interval of length less than the time to transmit a packet

Slotted Aloha efficiency

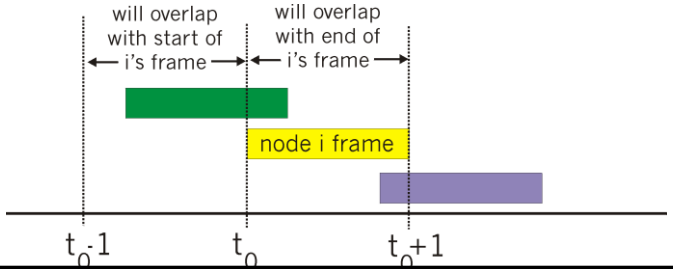
Efficiency is the long-run fraction of successful slots when there are many nodes, each with many frames to send

To derive the maximum efficiency

- Modified protocol: each node attempts to transmit a fresh frame in each slot with probability p
- Suppose N nodes with many frames to send
- Probability that 1st node has success in a slot = $p(1-p)^{N-1}$
- Probability that any node has a success = $Np(1-p)^{N-1}$

Pure (unslotted) ALOHA

- unslotted Aloha: simpler, no synchronization
- when frame first arrives
  - transmit immediately
  - If collision, retransmits with probability p, or waits for another frame With probability 1-p
- collision probability increases:
  - frame sent at t_0 collides with other frames sent in $[t_0-1,t_0+1]$



Pure Aloha efficiency

P(success by given node) = P(node transmits) ·
P(no other node transmits in $[t_0-1, t_0]$ ·
P(no other node transmits in $[t_0, t_0+1]$
$= p \cdot (1-p)^{N-1} \cdot (1-p)^{N-1}$
$= p \cdot (1-p)^{2(N-1)}$

… choosing optimum p and then letting n -> infinity ...

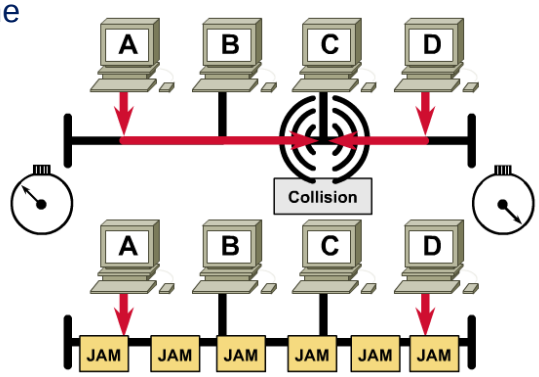
maximum efficiency = 1/(2e) = .18 Even worse !

- The use of a random-access channel in ALOHAnet led to the development of carrier sense multiple access (CSMA), a "listen before send" random-access protocol that can be used when all nodes send and receive on the same channel.

CSMA (Carrier Sense Multiple Access)

CSMA: listen before transmit: The first implementation of CSMA was Ethernet

- If channel sensed idle: transmit entire frame
- If channel sensed busy, defer transmission for a random amount of time



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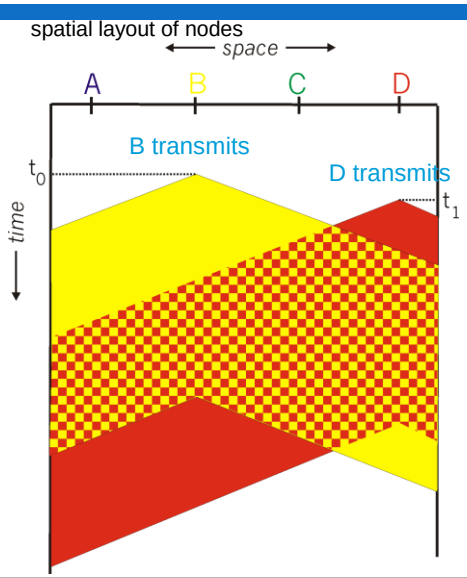
CSMA collisions

collisions *can* still occur:
propagation delay means two nodes may not hear each other's transmission

collision:
entire packet transmission time wasted

note:
The larger the end-to-end propagation delay, the larger the chance that a node is not able to sense a transmission that has already begun at another node



CSMA/CD (Collision Detection)

CSMA/CD: Listen While transmit, carrier sensing, deferral as in CSMA

- collisions *detected* within short time
- colliding transmissions aborted, reducing channel wastage

- collision detection:
  - easy in wired LANs: measure signal strengths, compare transmitted and received signals
  - difficult in wireless LANs: receiver shut off while transmitting; i.e., cannot transmit and receive at the same time
- human analogy: the polite conversationalist

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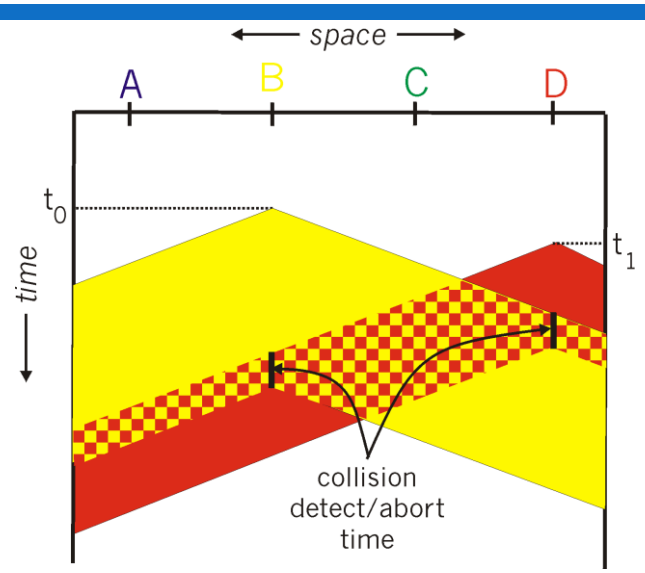
CSMA/CD collision detection



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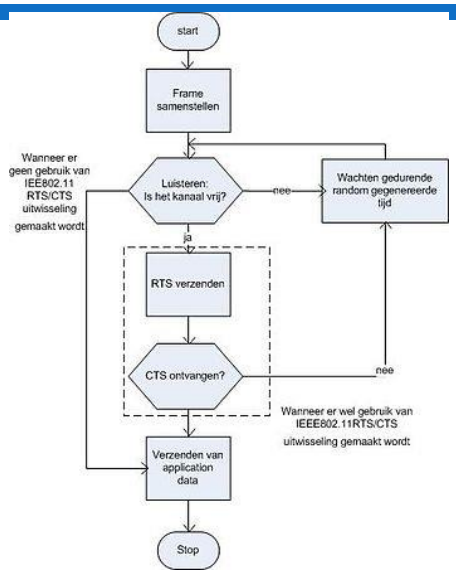
CSMA/CA

- The method used by Local Talk is called CSMA/CA (Carrier Sense Multiple Access / Collision Avoidance).
- Local Talk transmits data up to 230 kbps only.
- Each Local Talk Mac or printer has its own
  - Local Talk adapter to connect each other as a chain.
- Two Mac computers can use a serial port instead of Local Talk adapters.

CSMA/CA



Taking-Turns MAC protocols

channel partitioning MAC protocols:

- share channel efficiently and fairly at high load
- inefficient at low load: 1/N bandwidth allocated even if only 1 active node!

Random access MAC protocols

- efficient at low load: single node can fully utilize channel
- high load: collision overhead

Taking-turns protocols

look for best of both worlds!

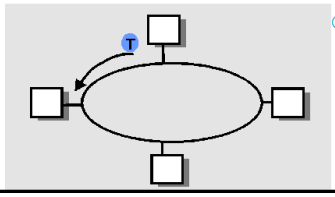
"Taking Turns" MAC protocols

Polling:

- master node "invites" slave nodes to transmit in turn
- concerns:
  - polling delay
  - single point of failure (master)

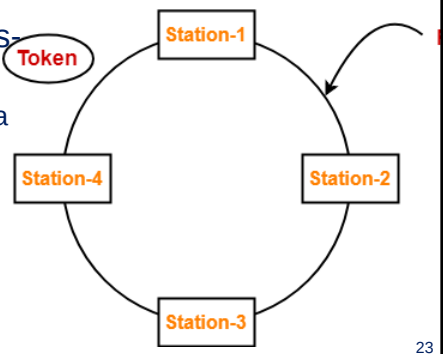
Token passing:

- control **token** passed from one node to next sequentially.
- When a node receives a token, it can transmits up to a maximum number of frames
- concerns:
  - token overhead
  - latency
  - single point of failure (token)



Token passing

- A token:
  - is a small message composed of a special bit pattern.
  - represents the permission to send the data packet.
  - A station is allowed to transmit a data packet if and only if it possess the token otherwise not.
- Token passing method assumes-
  - Each station has the data to send.
  - Each station sends exactly one data packet after acquiring the token.
- 2 strategies are used
  - Delayed Token Reinsertion
  - Early Token Reinsertion



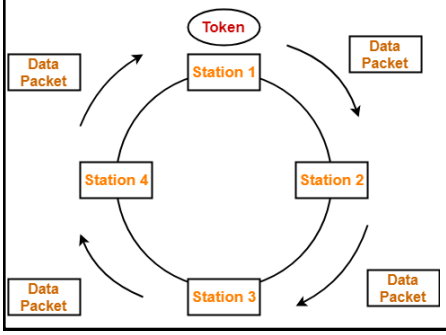
Token passing

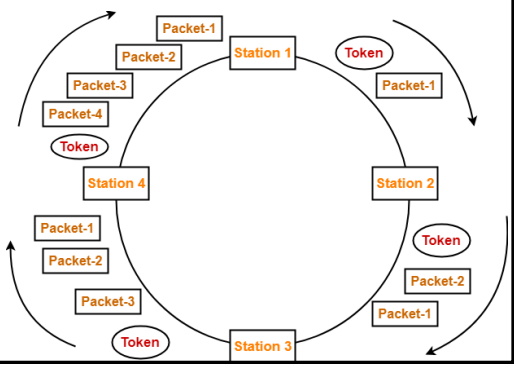
- **Delayed Token Reinsertion**

Station keeps holding the token until the last bit of the data packet transmitted by it takes the complete revolution of the ring and comes back to it.

- **Early Token Reinsertion**

Station releases the token immediately after putting its data packet to be transmitted on the ring.





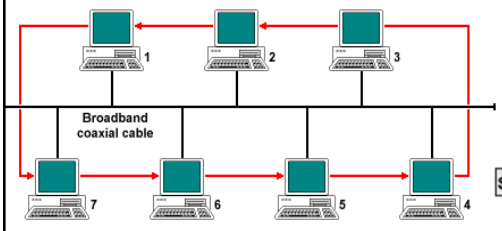
Token passing

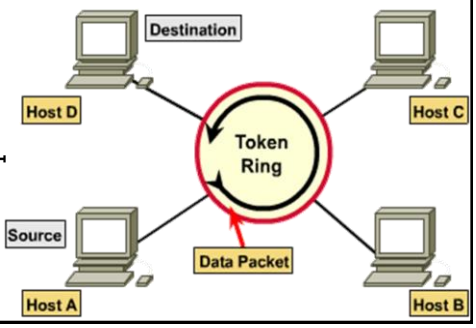
Token bus

- *Logically organized* into a ring structure by order d*escending* node ID
- A node must be *inserted to ring*
- Some nodes may *not* participate

Token ring

The same physical ring





Summary of MAC protocols

- What do you do with a shared media?
  - Channel Partitioning, by time, frequency or code
    - Time Division, Code Division, Frequency Division
  - Random partitioning (dynamic),
    - ALOHA, S-ALOHA, CSMA, CSMA/CD
    - carrier sensing: easy in some technologies (wire), hard in others (wireless)
    - CSMA/CD used in Ethernet
  - Taking Turns
    - polling from a central site, token passing

LAN technologies

Data link layer so far:

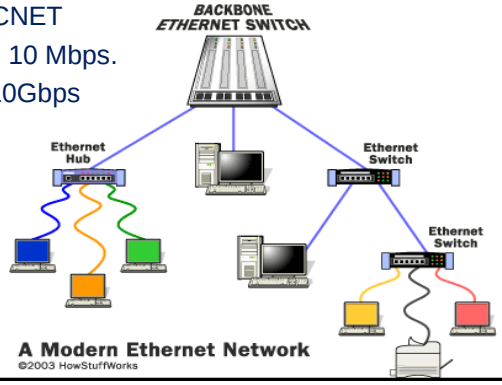
- services, error detection/correction, multiple access

Next: LAN technologies - Logical topology represents the way that data travel through the computer network.

- Ethernet
- Token Ring
- FDDI
- ATM

Ethernet

- Ethernet is a family of computer networking technologies for wired LAN technology
- It was commercially introduced in 1980 and first standardized in 1983 (802.3)
- It has largely replaced competing wired LAN technologies such as token ring, FDDI, and ARCNET
- Base Ethernet standard is 10 Mbps.
- Later: 100Mbps, 1Gbps, 10Gbps



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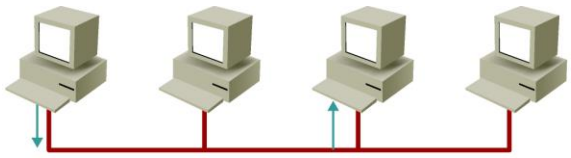
Ethernet: transmission types

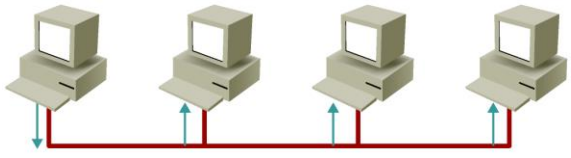
- 1-1. des/src address

Unicast



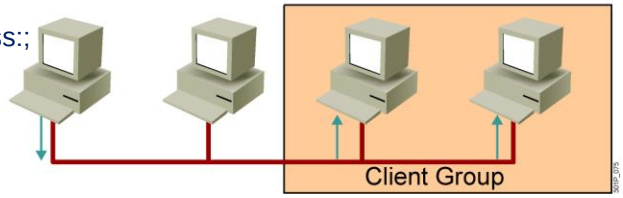
- 1-n. Des address:
  - FF:FF:FF:FF:FF:FF

Broadcast



- 1-some. Des address:;
  - Group address

Multicast



Ethernet Frame Structure

Ethernet-II(DIX 2.0)					
7+1	6	6	2	46-1500	4
Preamble	Dest. Address	Source Address	Type	Data	FCS

- Preamble: used to synchronize receiver, sender clock rates pattern: 10101010 followed by one byte with pattern 10101011.
- Addresses: 6 bytes
  - if adapter receives frame with matching destination address, or with broadcast address (eg ARP packet), it passes data in frame to net-layer protocol
  - otherwise, adapter discards frame
- Data: 46 to 1500 bytes
- Type: indicates the higher layer protocol (mostly IP but others may be supported such as Novell IPX and AppleTalk)
- CRC: checked at receiver, if error is detected, the frame is simply dropped

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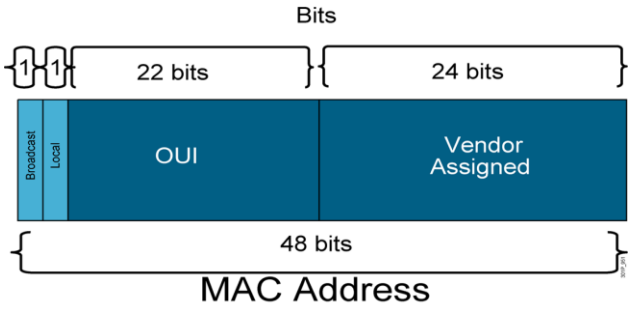
Ethernet: MAC Address

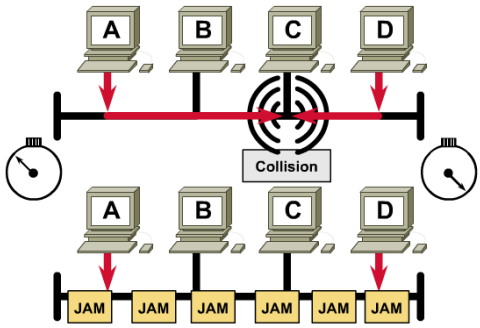


Unreliable, connectionless service

- Connectionless: No handshaking between sending and receiving adapter.
- Unreliable: receiving adapter doesn't send acks or nacks to sending adapter
  - stream of datagrams passed to network layer can have data gaps due to discarded fames if the application is using UDP
  - data gaps will be filled by retransmissions if application is using TCP
  - otherwise, application will see the gaps

Ethernet uses CSMA/CD

- adapter may begin to transmit at anytime, i.e., no slots are used
- adapter doesn't transmit if i senses that some other adapter is transmitting, that is, carrier sense
- transmitting adapter aborts when it senses that anothe adapter is also transmitting that is, collision detection
- Before attempting a retransmission, adapter waits a random time, that is, random access



Ethernet CSMA/CD algorithm

1. Adaptor receives datagram from network layer and creates frame
2. If adapter senses channel idle, it starts to transmit frame.
   If it senses channel busy, waits until channel idle and then transmits
3. If adapter transmits entire frame without detecting another transmission, the adapter is done with frame !
4. If adapter detects another transmission while transmitting, aborts and sends jam signal
5. After aborting, adapter enters **exponential backoff**: after the n*th* collision, adapter chooses a K at random from {0,1,2,…,2^m-1} where m = min(n, 10). Adapter waits K*512 bit times and returns to Step 2

Ethernet's CSMA/CD (more)

Jam Signal: make sure all other transmitters are aware of collision; 48 bits;

Bit time: 0.1 microsec for 10 Mbps Ethernet ;
for K=1023, wait time is about 50 msec

Exponential Backoff:

- *Goal*: adapt retransmission attempts to estimated current load
  - heavy load: random wait will be longer
- first collision: choose K from {0,1}; delay is K x 512 bit transmission times
- after second collision: choose K from {0,1,2,3}…
- after ten collisions, choose K from {0,1,2,3,4,…,1023}

CSMA/CD efficiency

- T_{prop} = max propagation delay between 2 nodes in LAN
- t_{trans} = time to transmit max-size frame
- Efficiency: the long-run fraction of time during which frames are being transmitted on the channel without collisions when there are a large number of active nodes

$$\text{efficiency} = \frac{1}{1 + 5t_{prop} / t_{trans}}$$

[Lam 1980, Bertsekas 1991]

- Efficiency goes to 1 as t_{prop} goes to 0
- Goes to 1 as t_{trans} goes to infinity
- Much better than ALOHA, but still decentralized, simple, and cheap

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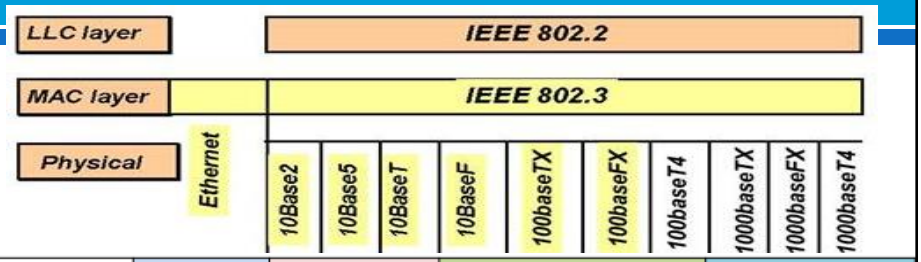
Ethernet Technologies

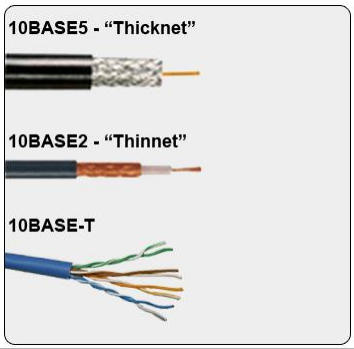


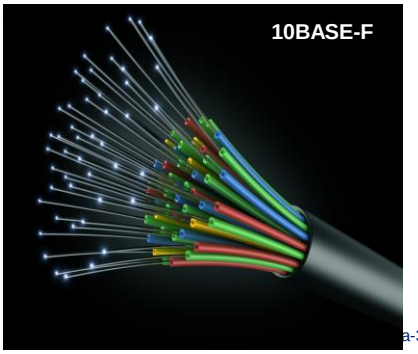
	Ethernet	Fast Ethernet	Gigabit Ethernet	10-Gigabit Ethernet
IEEE standard	802.3	802.3u	802.3z	802.3ae
Bandwidth	10Mbps	100Mbps	1Gbps	10Gbps
Access method	CSMA/CD		CSMA/CD in Half Duplex Central Switch in Duplex	Central Switch in Duplex
Topology	Bus , Star	Star	Star	Star
Transmission Media	Coaxial cable Twist pair / Fiber	Twisted pair / Fiber	Twisted pair / Fiber	Fiber

Ethernet Technologies: 10Base

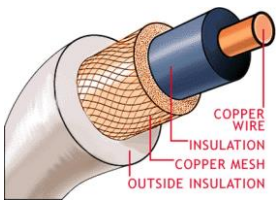
	Topology	Maximum segment length	Transmission Media
10Base-5	Bus	500m	Coaxial cable (thick) 50 ohm
10Base-2	Bus	185m	Coaxial cable (thin) 50 ohm
10Base-T	Star	100m	Twisted pair 100 ohm
10Base-F	Star	2000m	Fiber

- Media





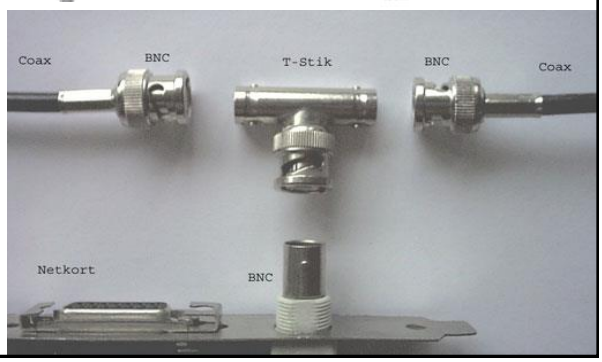
Ethernet Technologies: 10Base
Thinnet and thicknet



Đầu nối BNC-T

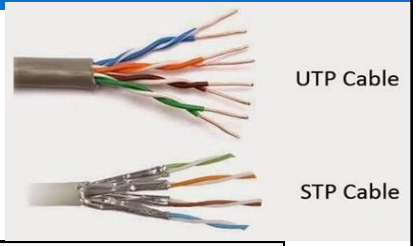
Terminator

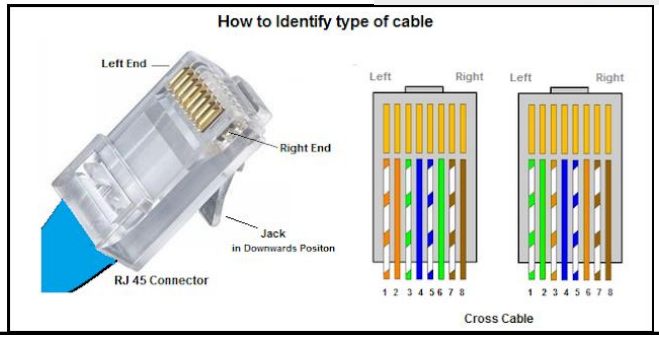
BNC Extension Cables



Ethernet Technologies: 10Base
Twisted pair

- Twisted pair: UTP and STP
  - UTP: faster, popular, cheap
  - Color: orange, green, blue, brown





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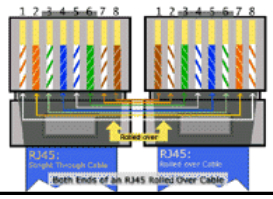
Ethernet Technologies: 10Base
UTP Cable Implementation

Straight: devices having different function:

- router to a hub or switch.
- server to a hub or switch.
- workstations to a hub or switch

Left	1	Tx+			Rx+	1	Left
	2	Tx-			Rx-	2	
	3	Rx+			Tx+	3	
	4					4	
	5					5	
	6	Rx-			Tx-	6	
	7					7	
Right	8					8	Right

Straight Cable



Cross: devices having same functions or

- uplinks between switches.
- hubs to switches or another hub.
- PC to PC or a Router
- 2 routers together without hub or switch

Left	1	Tx+			Rx+	1	Left
	2	Tx-			Rx-	2	
	3	Rx+			Tx+	3	
	4					4	
	5					5	
	6	Rx-			Tx-	6	
	7					7	
Right	8					8	Right

Cross Cable

Rollover: for device configuration:

- need a console cable for same.
- is connected to console port of the router/SW would be connected to NIC port of your laptop or PC

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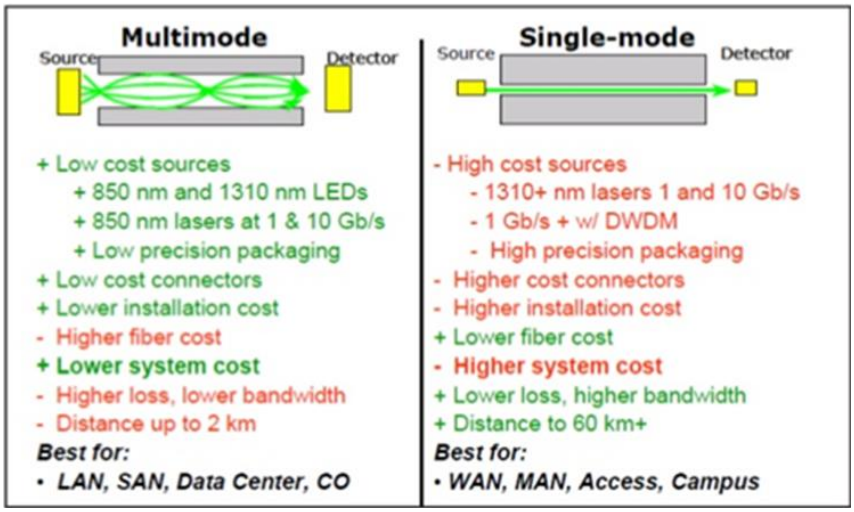
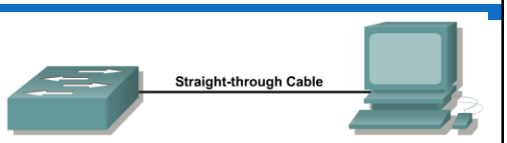
Ethernet Technologies: 10Base
Fiber cable

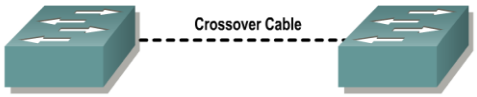


Cable using

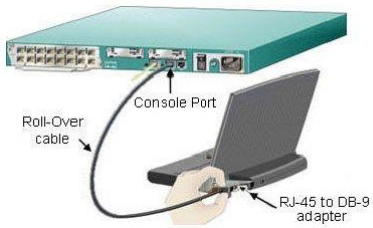
- Straight



- Crossover



- Rollover



Ethernet Technologies: 10Base
Devices

Connector

– Coaxial Cable: DB15, BNC etc.


DB15


BNC

– Twisted Pair: RJ-45 (not RJ-11)


RJ-45


RJ-11

– Optical Fiber: ST, SC, LC etc.


ST


SC


LC

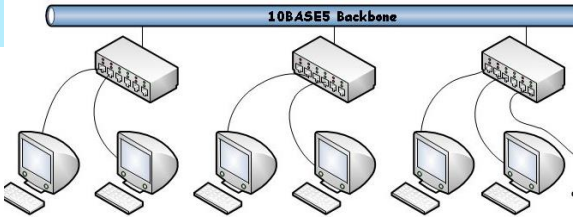
Hub:

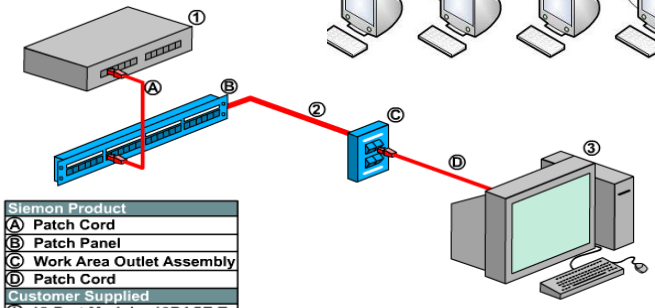
Switch

- NIC

Ethernet Technologies: 10Base
Example

Ethernet 10Base5





Siemon Product
Ⓐ Patch Cord
Ⓑ Patch Panel
Ⓒ Work Area Outlet Assembly
Ⓓ Patch Cord
Customer Supplied
① 12-Port Modular 10BASE-T Hub
② 4-Pair Horizontal Cabling
③ Work Area Equipment

Ethernet 10BaseT

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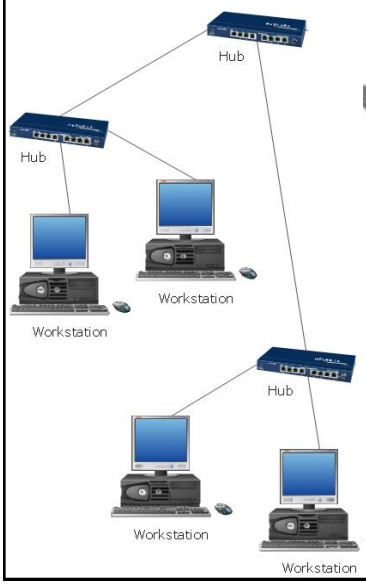
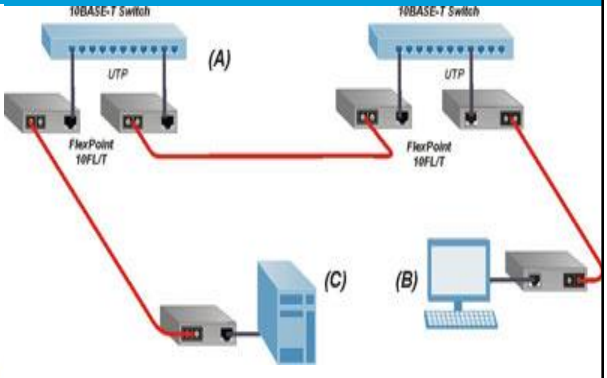
Ethernet Technologies: 10Base
Example

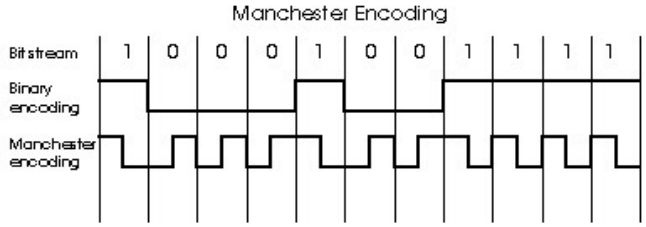




Ethernet 10Base-T with Hubs, Switchs

5a-48

Ethernet Technologies: 10Base
Manchester encoding



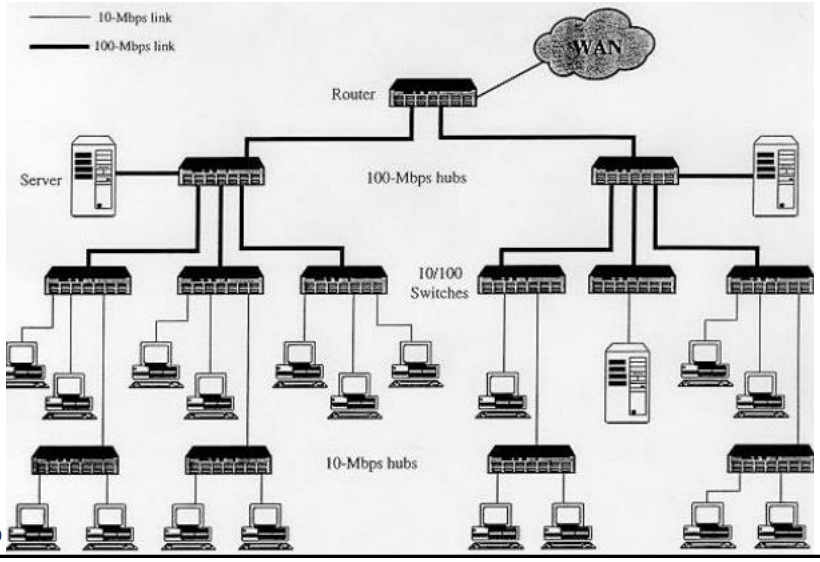
- Used in 10BaseT, 10Base2
- Each bit has a transition – 1: up to down, 0: down to up
- Allows clocks in sending and receiving nodes to synchronize to each other
  - no need for a centralized, global clock among nodes!
- Hey, this is physical-layer stuff!

Ethernet Technologies: 100Base (Fast)

	Topology	Maximum segment length	Transmission Media
100Base-TX	Star	100m	STP
100Base-T4	Star	100m	UTP
100Base-FX	Star	100m	Fiber

- use standard Ethernet frame format
- the nominal rate of 100 Mbit/s
- Most switches and other networking devices with ports capable of Fast Ethernet can perform autonegotiation
  - standard specifies the use of CSMA/CD
- A full-duplex mode is also specified

Ethernet Technologies: 100Base
Example

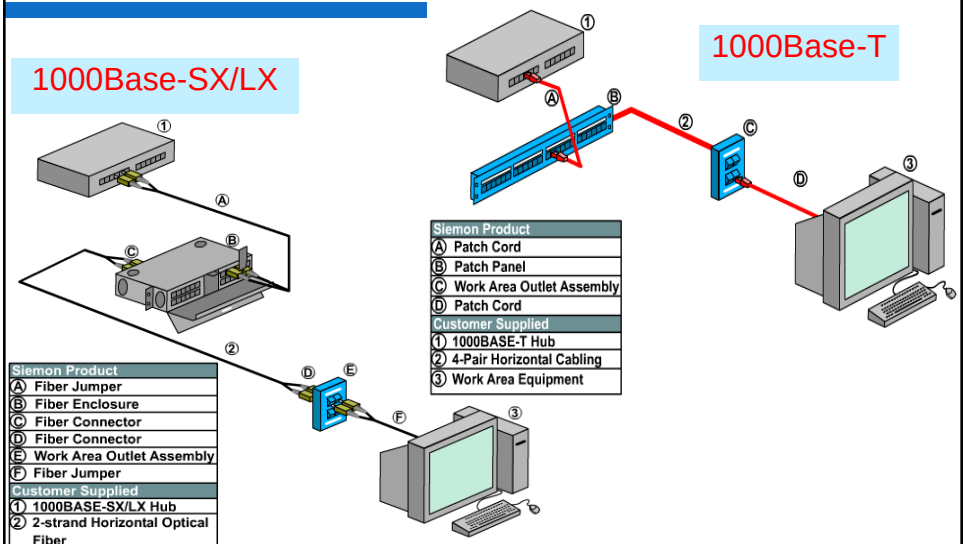


Ethernet Technologies: 1G

	Topology	Maximum segment length	Transmission Media
1000Base-SX	Star	550m	Fiber
1000Base-LX	Star	5000m	Fiber
1000Base-CX	Star	25m	STP

- 1GBase:
  - use standard Ethernet frame format
  - allows for point-to-point links as well as shared broadcast channels. Point-to-point links use switches
  - Shared broadcast channels use hubs called “Buffered Distributors”
  - CSMA/CD is used; short distances between nodes to be efficient

Ethernet Technologies: 1G



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Ethernet Technologies: 10G

	Topology	Maximum segment length	Transmission Media
10GBase-S	Star	300m	Multi Mode Fiber
10GBase-L	Star	10000m	Single Mode Fiber

- 10GBase was standardized in 2007,
  - providing yet higher Ethernet LAN capacities
  - 10GB defines only full-duplex point-to-point links which are generally connected by network switches;

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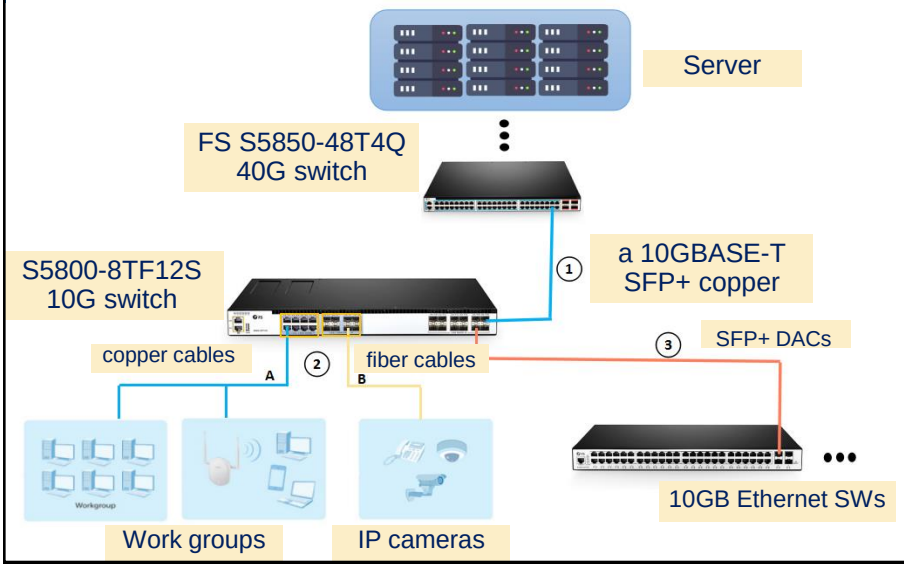
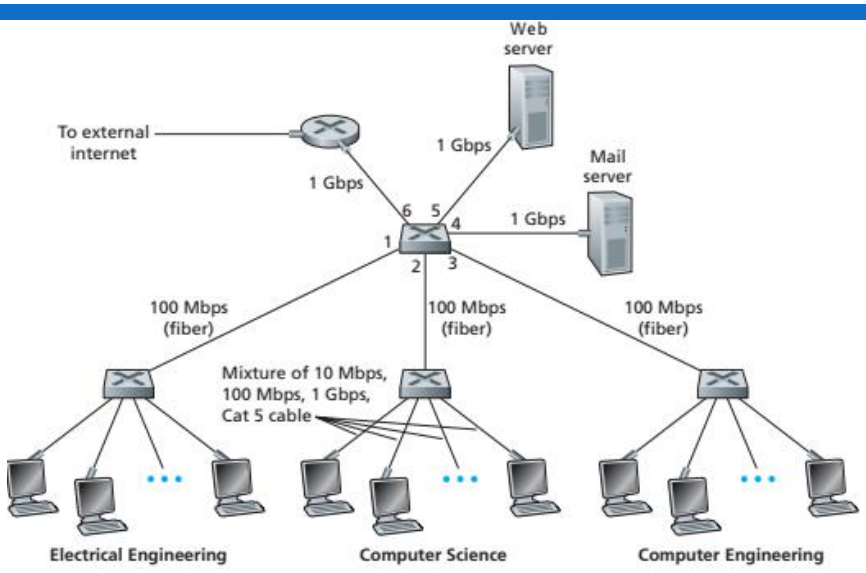
Ethernet Technologies: 10G



Sending Data in Ethernet Networks

- When you send information across the Internet:
  - first breaks the information up into packets
  - smaller blocks of information that also contain a variety of data that helps the packets travel across the Internet.
- The packets travel through many of networks, computers, and communications lines before they reach their final destinations.
- A variety of hardware processes those packets and routes them to their proper destinations. Five of the most important pieces of hardware are:
  - hubs, bridges, repeaters, and routers

Institutional network



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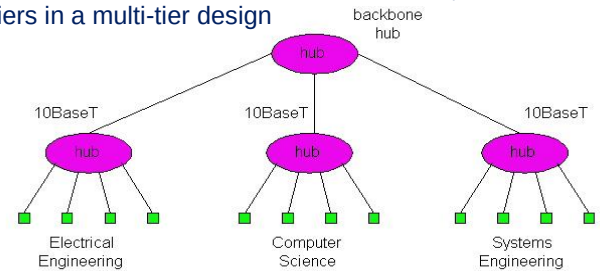
Interconnecting with hubs

- Backbone hub interconnects LAN segments
- Extends max distance between nodes
- Limitations:
  - But individual segment collision domains become one large collision domain – all hosts share 10Mbps
    - if a node in CS and a node EE transmit at same time: collision
  - Can't interconnect 10BaseT & 100BaseT
  - A collision domain has restrictions on the maximum allowable number of nodes, the maximum distance between two hosts, the maximum number of tiers in a multi-tier design



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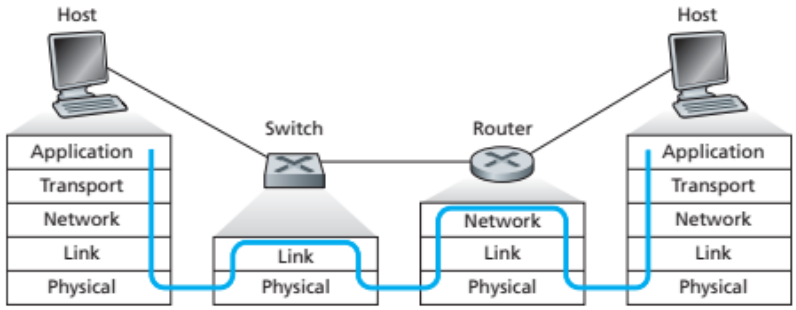
Switches vs. Routers

- both store-and-forward devices
  - routers: network layer devices (examine network layer headers)
  - switches are link layer devices
- routers maintain routing tables, implement routing algorithms
- switches maintain switch tables, implement filtering, learning algorithms



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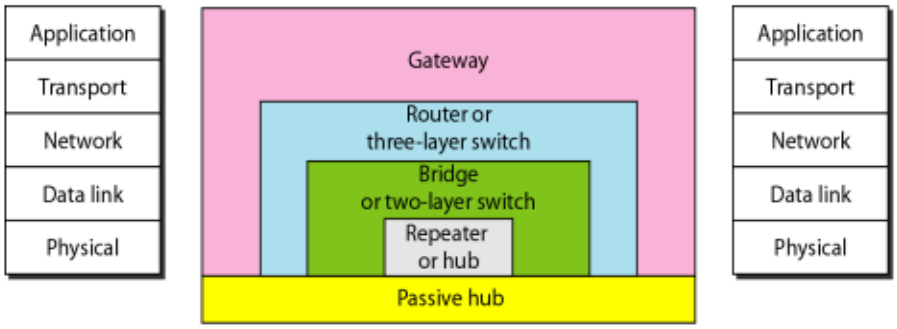
Network devices

1. Repeater
2. Hub
3. Bridge
4. Switch
5. Router
6. Brouter
7. Gateway
8. Modem

Functions of network devices

- As Organizations grow, so do their networks
  - Growth in number of users
  - Geographical Growth
- Network Devices :
  - Are products used to expand or connect networks.
  - Can control the amount of traffic on a network.
  - Can speed up the flow of data over a network.
  - Manage data transfer
- End user devices or hosts
  - Computers (Client / Servers), Printers, Scanners, etc
- Separating (connecting) networks or expanding network
  - repeaters, hubs, bridges, switches, routers, brouters, gateways
- Remote access
  - e.g. 56K Modems and ADSL modems

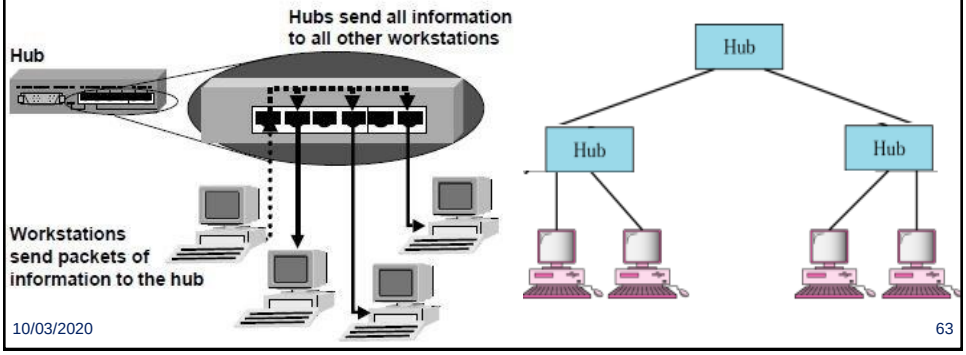
Five Categories of Network Devices



- Below the physical layer such as a passive hub
- at the physical layer (a repeater or an active hub)
- at the physical and data link layers: a bridge or a two-layer switch
- operate at the physical, data link, and network layers (a router or a three-layer switch)
- at all five layers (a gateway).

Hub

- A hub is used as a central point of connection among media segments. It propagate signals through the network
- Hubs operate at the physical layer of the OSI model.
- Some hubs have an additional interface port that connects to another hub, thus increasing the size of the network.

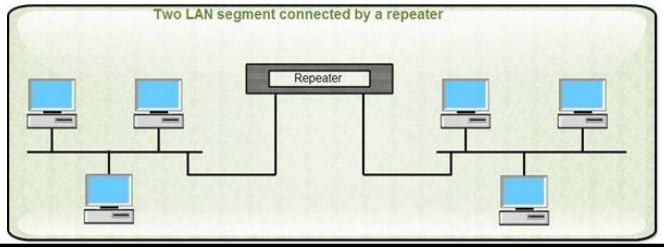


Hub

- Types of HUBS :
  - A passive hub is just a connector. The signal without regeneration or amplification. Connect several networking cables together.
  - Active hubs or Multiport repeaters: regenerate or amplify the signal before they are retransmitted.
  - Intelligent Hubs (Switches)
- Advance:
  - Regenerate and repeat signals
  - Broadcast signals through the network
  - Are used as network concentration (focal) points
- Disadvance
  - Can not filter network traffic
  - Can not determine the best path

Repeaters

- repeater connects segments of a LAN.
- Repeaters work at the physical layer
- regenerate the network's signal and resend them to other segments

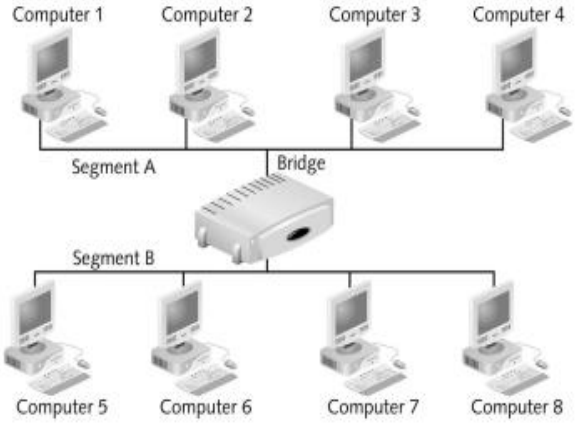


Repeaters

- Adv:
  - Extend network physical distance,
  - do not seriously affect network performance
  - Special repeaters connect different media: copper to fiber
  - Repeaters repeat signals
    – Clean and boost digital transmission
    – Analog networks use amplifiers to boost signal
- Disadvance
  - Cannot connect different network architectures: Token Ring and Ethernet (Star)
  - Cannot reduce network traffic
  - Repeaters do not filter data
  - Do not segment (divide) the network
  - Repeat everything without discrimination
  - Number of repeaters must be limited

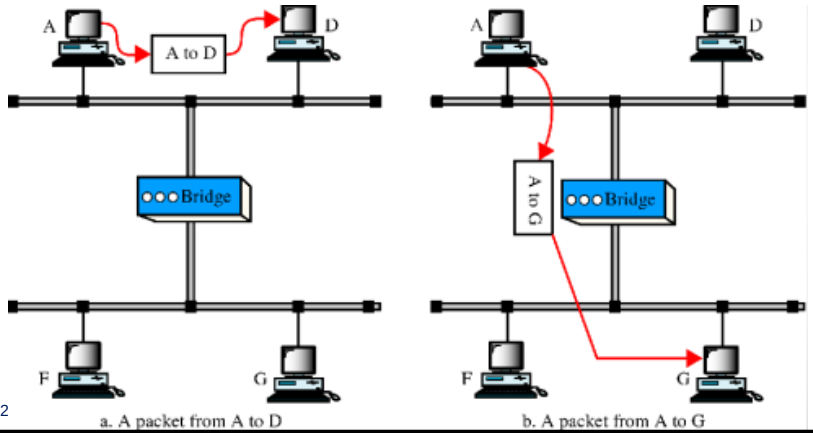
Bridges

- Bridges divide a network into segments and filter traffic to avoid collision domain
- It operate at the Data Link Laver



Bridges

- If destination address is in the same segment as the source address, stop transmit
  - Otherwise, forward to the other segment



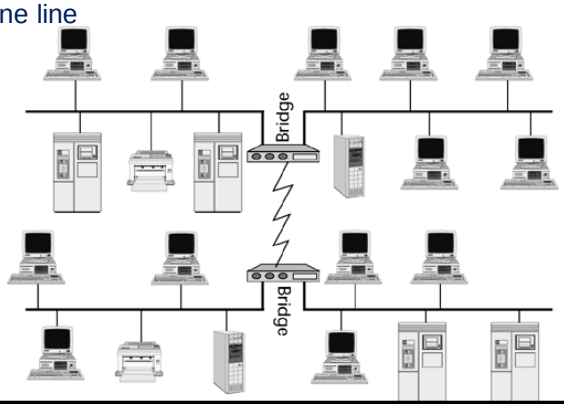
a. A packet from A to D b. A packet from A to G

Bridges

- **Routing Tables**
  - *Contains one entry per station of network to which bridge is connected.*
  - *Is used to determine the network of destination station of a received packet.*
- **Filtering**
  - *Is used by bridge to allow only those packets destined to the remote network.*
  - *Packets are filtered with respect to their destination and multicast addresses.*
- **Forwarding**
  - *The process of passing a packet from one network to another.*
- **Learning Algorithm**
  - *The process by which the bridge learns how to reach stations on the internetwork.*

Bridges

- Remote Bridges
- Bridges are often used in large networks that have widely dispersed segments
- Remote bridges can be used to connect remote segments via data-grade telephone line

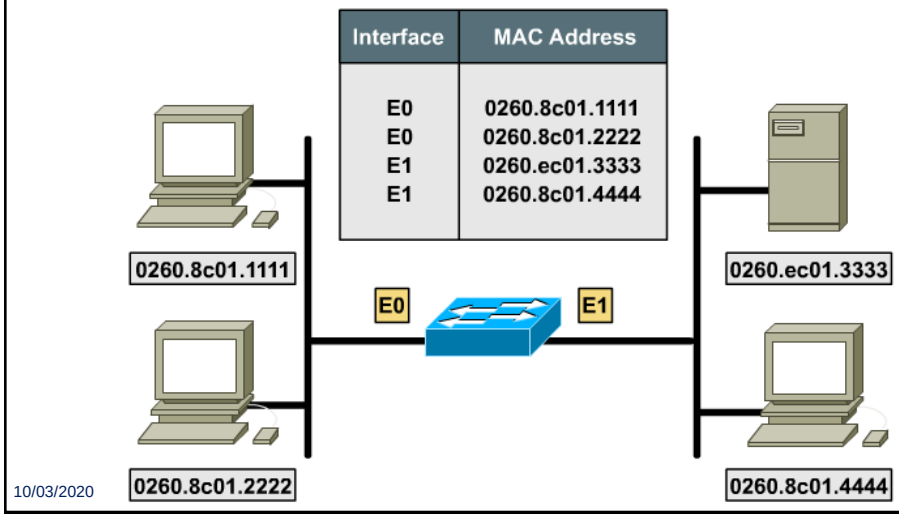


Bridges

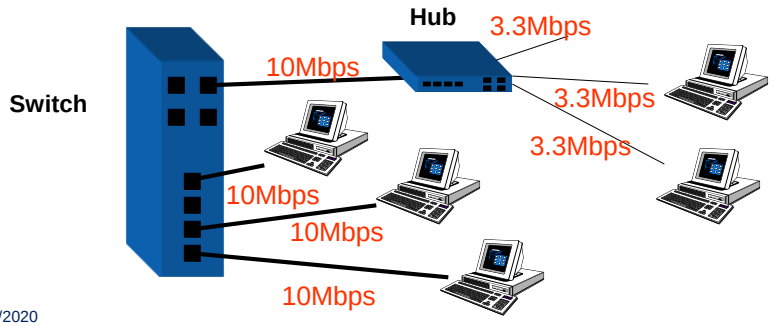
- Advantages of using a bridge
  - • Extend physical network
  - • Reduce network traffic with minor segmentation
  - • Creates separate collision domains
  - • Reduce collisions
  - • Connect different architecture
- Disadvantages of using bridges
  - • Slower than repeaters due to filtering
  - • Do not filter broadcasts
  - • More expensive than repeaters

Switch

- Switches operate at the Data Link layer (layer 2)
- Can interpret address information
- Switches resemble bridges and can be considered as multiport bridges => can better use limited bandwidth and prove more cost-effective than bridge
- Network Switch Types
  - Layer 2 switches (unmanaged switches)
    Using MAC addresses of connected devices
  - Layer 3 switches (managed switches)
    Using IP addresses of connected devices.
    Providing more features than layer 2 switches and expensive.



- Switches divide a network into several isolated channels
- Packets sending from 1 channel will not go to another if not specify
- Each channel has its own capacity and need not be shared with other channels



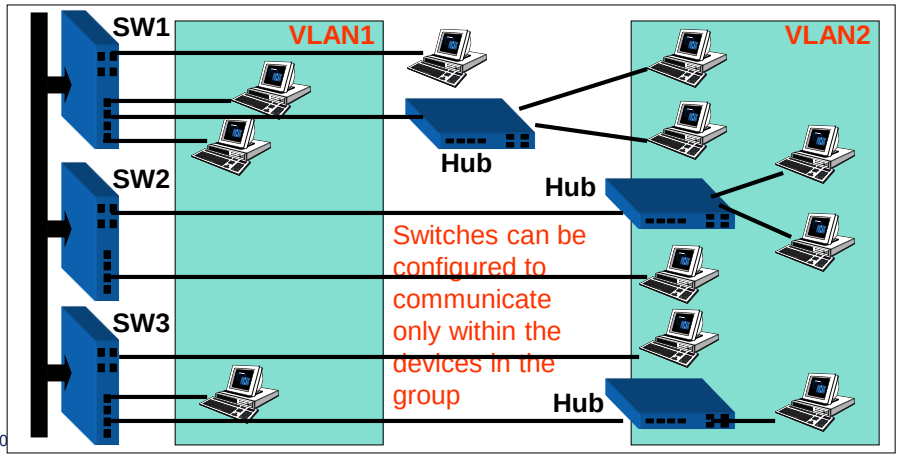
Switch

- Advantages
  - Reduce the possibility of collision
    - Collision only occurs when two devices try to get access to one channel
    - Can be solved by buffering one of them for later access
  - Each channel has its own network capacity
  - Suitable for real-time applications, e.g. video conferencing
  - Since isolated, hence secure
    - Data will only go to the destination, but not others
- Disadvantages
  - Device cannot detect collision when buffer full
  - CSMA/CD scheme will not work since the data channels are isolated, not the case as in Ethernet
  - Some higher level protocols do not detect error, E.g. UDP
  - Those data packets are continuously pumped to the switch and introduce more problems

Method of Switching

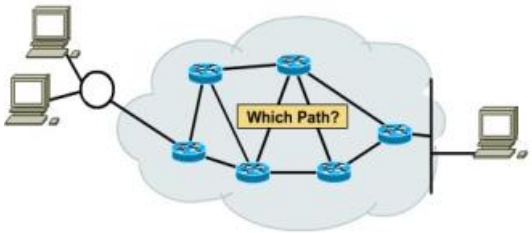
- Cut Through Mode
  - Much faster
  - Cannot detect corrupt packets
  - Can propagate the corrupt packets to the network
  - Best suited to small workgroups
- Store and Forward Mode
  - Slower than the cut-through mode
  - More accurate since corrupt packets can be detected using the FCS
  - More suit to large LAN since they will not propagate error packets

- Switches can logically group together some ports to form a virtual local area network (VLAN)

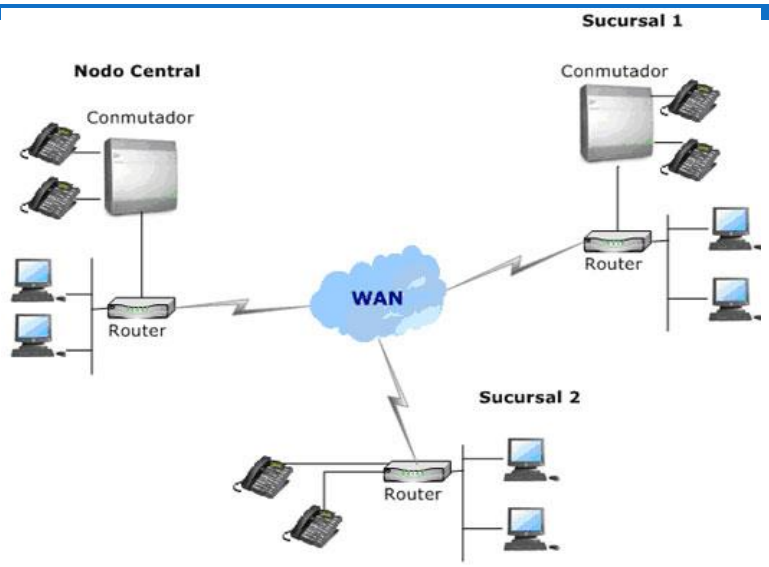


Routers

- Router works at the Network layer
- Routers are use to connect networks together with different layer 2 technologies (Ethernet, Token Ring, FDDI, etc.)
- Goal: Arriving at the destination. Considerations:
  - Direct route (shortest)
  - Reliable route
  - Cheap route
  - Safe route

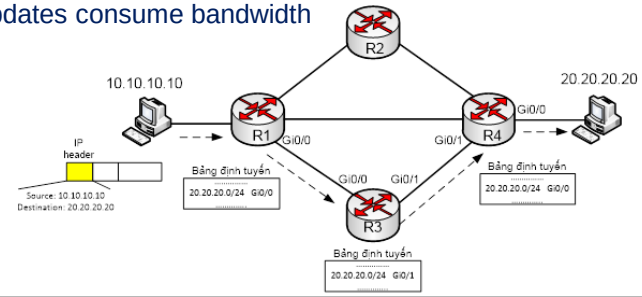


Routers



Routers

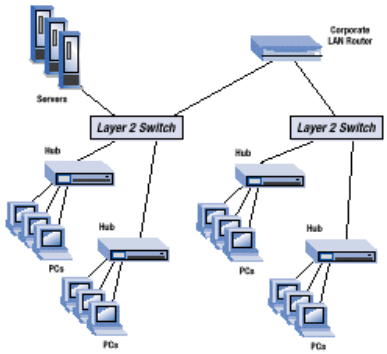
- Advantages of routers
  - Can connect networks of different architecture, Token Ring to Ethernet
  - Choose best path through or to a network
  - Create smaller collision domains. – Create smaller broadcast domains
- Disadvantages of routers
  - Only work with routable protocols such as RIP, OSPF, or BGP
  - More expensive than hubs, bridges, and switches
  - Routing table updates consume bandwidth
  - Increase delay



Layer-3 Switches

- Layer-3 Switches
  - Layer-3 switches operate in both layer 2 (data link) and 3 (network)
  - Can perform both MAC switching and IP routing
  - A combination of switch and router but much faster and easier to configure than router
- Why Layer-3 switches?
  - Traffic of LAN is no longer local
  - Speed of LAN is much faster
  - Need a much faster router, however, very expensive

A Standard Switched Network

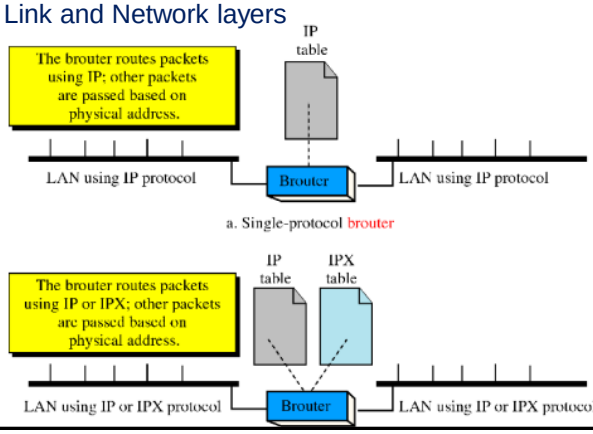


Comparison:
Repeater, Bridge, Switch, Router

- Repeaters are the least expensive way to expand a network, but they are limited to connecting two segments
- Bridges function similar to repeaters, but can understand the node addresses
- Switches can be considered as multiport bridges, can divide a network into some logical channels
- Routers interconnect networks and provide filtering functions. They can determine the best route

Brouters

- Hybrid device
- Functions as a router for routable protocols
- Functions as a bridge for non-routable protocols
- Operates at Data Link and Network layers

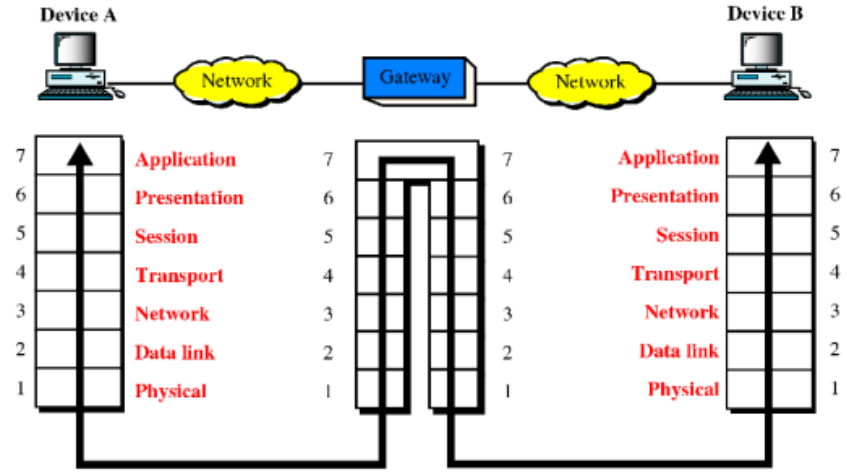


Gateways

- Interchangeably used term router and gateway
- Gateway takes an application message, reads it, and interprets it
- It translates different protocol suites • A gateway is a combination of hardware and software
- A gateway is a network point that acts as an entrance to another network.
- On the internet, in terms of routing, the network consists of gateway nodes and host nodes.
  - **Host nodes** are computer of network users and the computers that serve contents (such as Web pages).
  - **Gateway nodes** are computers that control traffic within your company's network or at your local internet service provider (ISP)

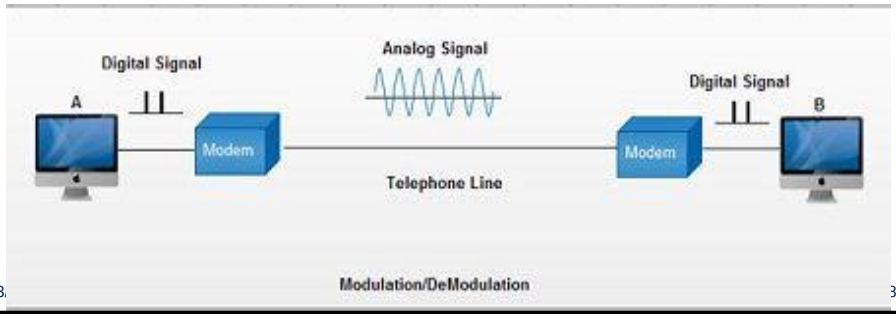
Gateway

- Operates in all 5 layer of the Internet (TCP/IP) and 7 layers of OSI model

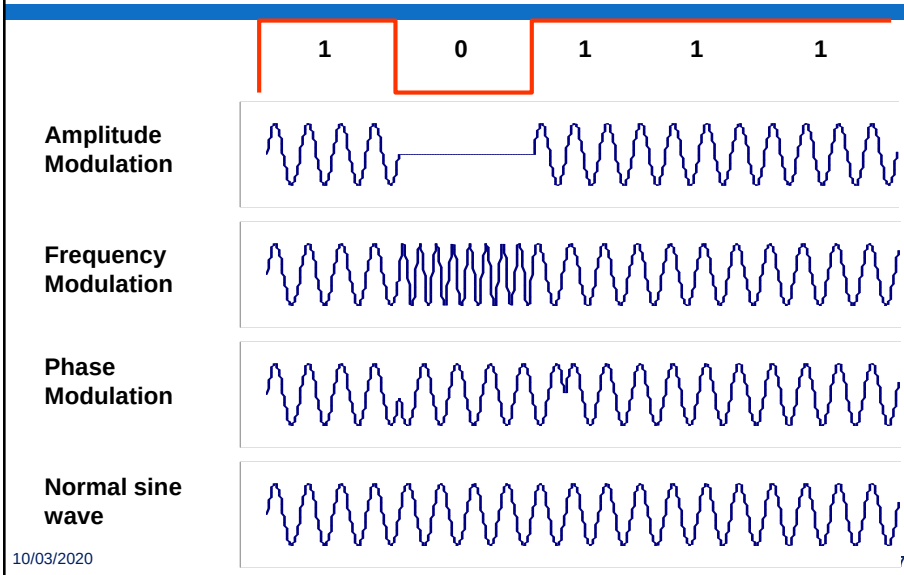


Modem

- Allow computers to communicate over a telephone line
- Enable communication between networks or connecting to the world beyond the LAN
- Cannot send digital signal directly to telephone line
- Sending: MODulate the digital signal into analog signal and transmits
- Receiving end: DEModulate the analog signal back into digital form

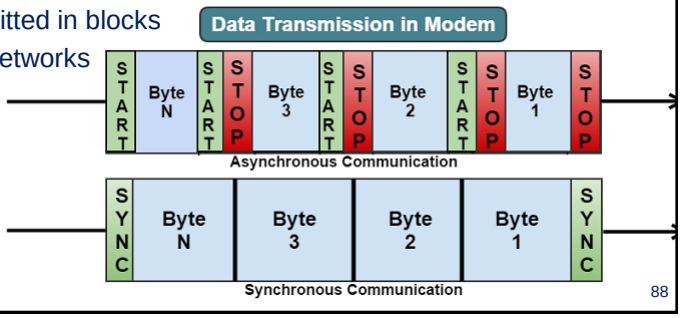


Modem



Types of Modem

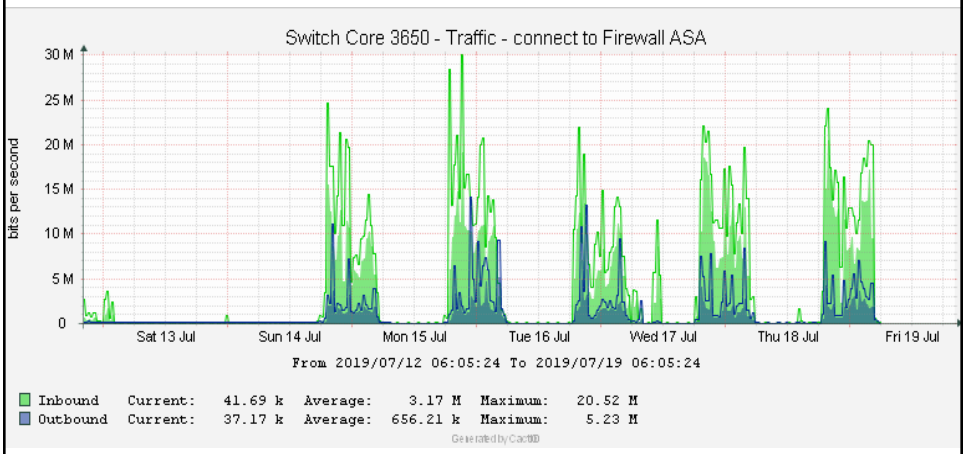
- Asynchronous Modems
  - No clocking devices. Commonly used in telephone networks
  - Data is transmitted in a serial stream. (is turned into a string of 8 bits)
  - (is separated by one start bit and 1 or 2 stop bits)
- Synchronous Modems
  - Need clocking devices
  - Data are transmitted in blocks
  - Used in digital networks



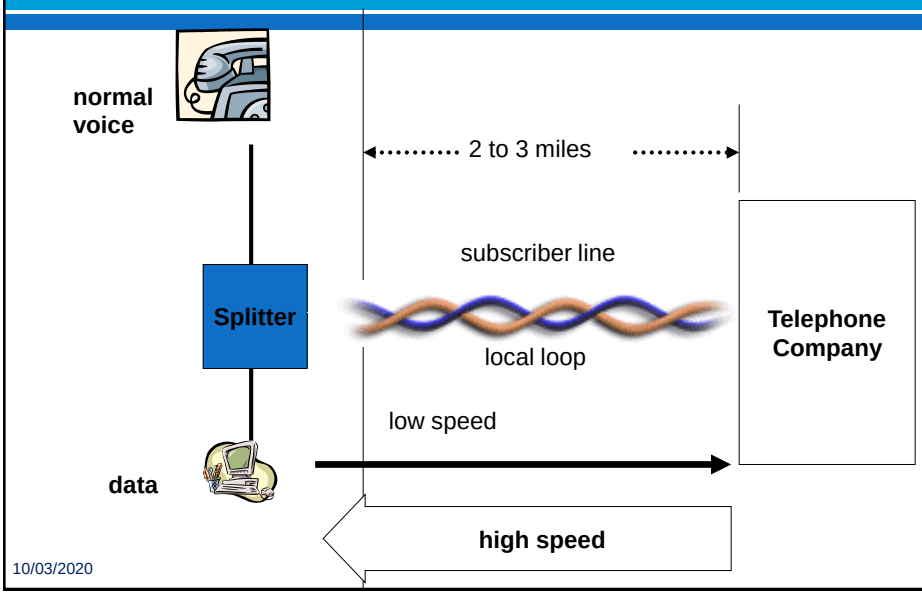
ADSL

- ADSL stands for Asymmetric Digital Subscriber Line
- Particularly suitable for high speed multimedia communications, general Internet applications
- Asymmetric
  - downstream 1.5 to 6.1Mbps
  - upstream 16 to 640kbps
- Digital - mainly for transmitting digital data still require modulation and demodulation
- Subscriber line - make use of the analog connection between household and CO

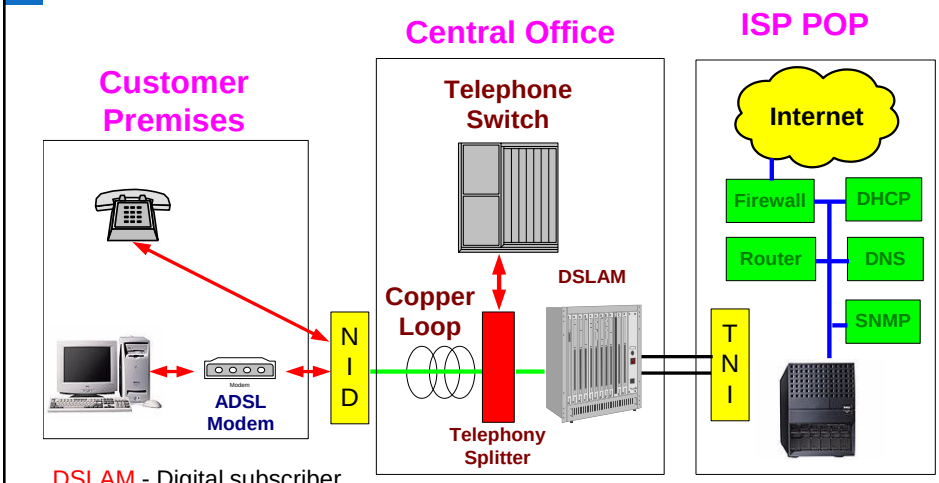
Traffic



ADSL Illustration



Architecture of ADSL Services



DSLAM - Digital subscriber line access module (central office ADSL modem pool)

Transport Network Link (DSx; OCx; frame; ATM)

Other DSL Technologies

- HDSL – High speed DSL
  - 2 twisted pair, 12,000 feet
  - 1.5Mbps (DS1) full-duplex
  - Symmetric
- VDSL – Very high bit rate DSL
  - Downstream: 52 Mbps (SONET STS-1) over 1000 feet; or 15 Mbps over 3000 feet
  - Upstream: 1.5 to 2.3 Mbps
- RDSL – Rate adaptive DSL
  - Intelligent DSL to adjust data rate

LAN technologies

Data link layer so far:

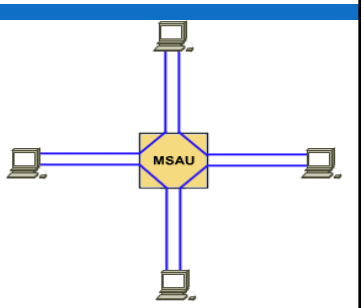
- services, error detection/correction, multiple access

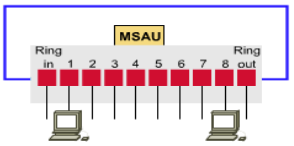
Next: LAN technologies - Logical topology represents the way that data travel through the computer network.

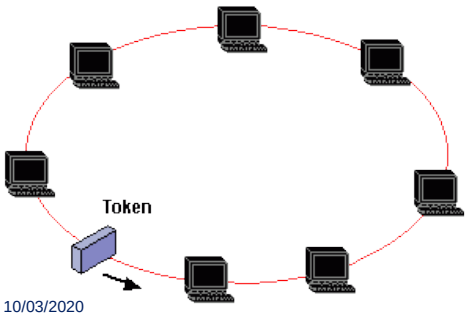
- Ethernet
- Local Talk
- Token Ring
- FDDI
- ATM

Token ring

- It is standardized with protocol IEEE 802.5
- Token Ring also a LAN technology.
  - Physical Topology: Ring and Star
  - MultiStation Access Unit (MSAU): Hub, repeater
  - Cabling System: UTP, STP, RJ45
  - Token Ring network Connector, NIC

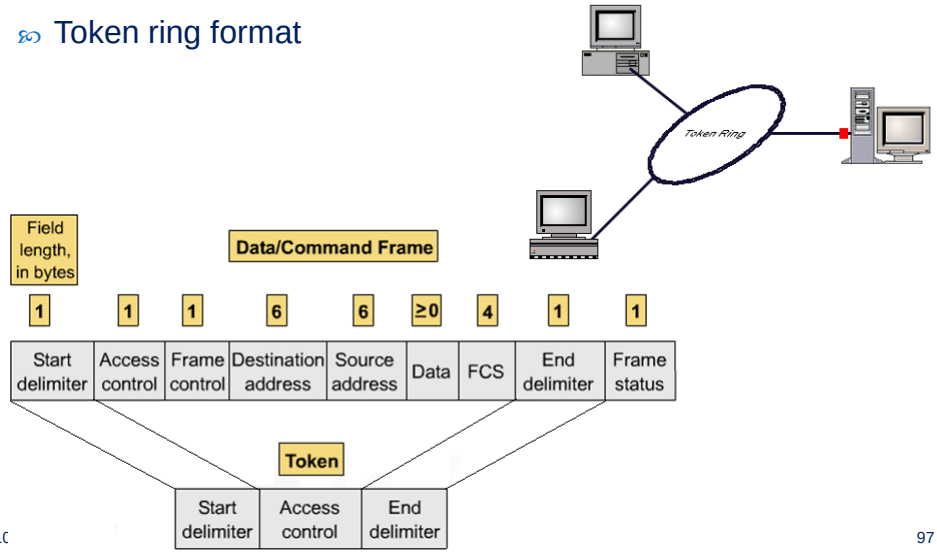




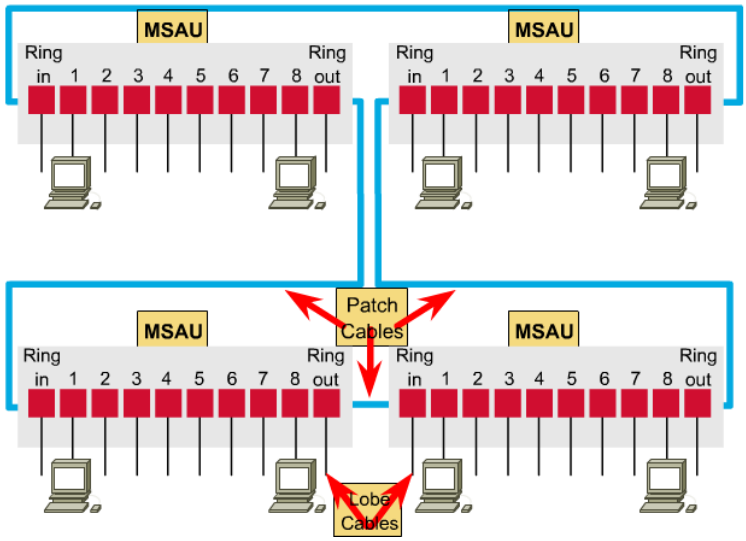


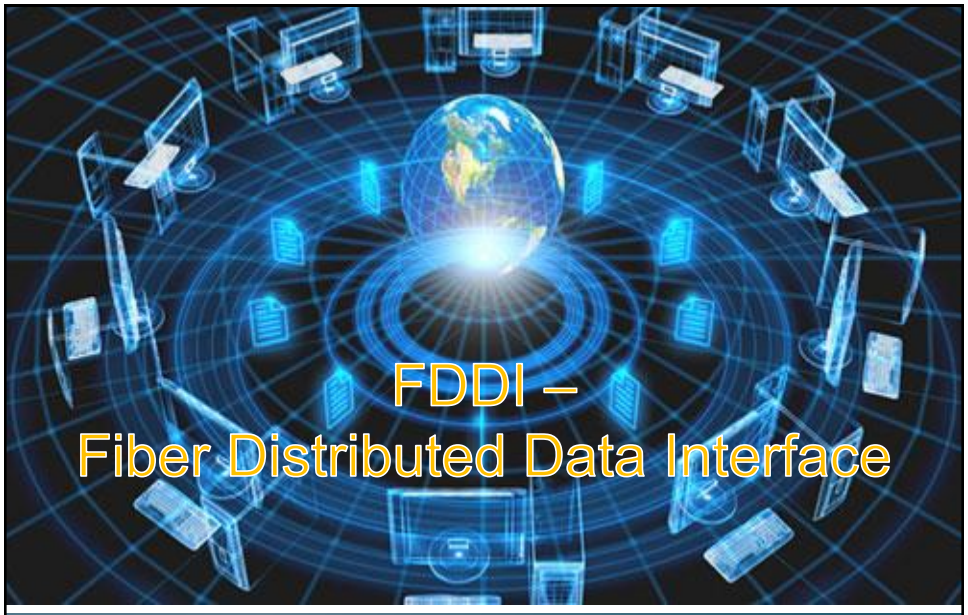
- It uses a special 3-byte frame called a token that travels around the ring.
- No collisions occurred.

- Token ring format



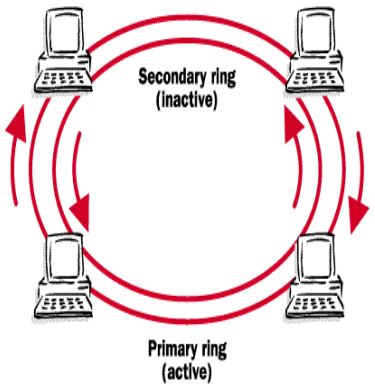
Token ring





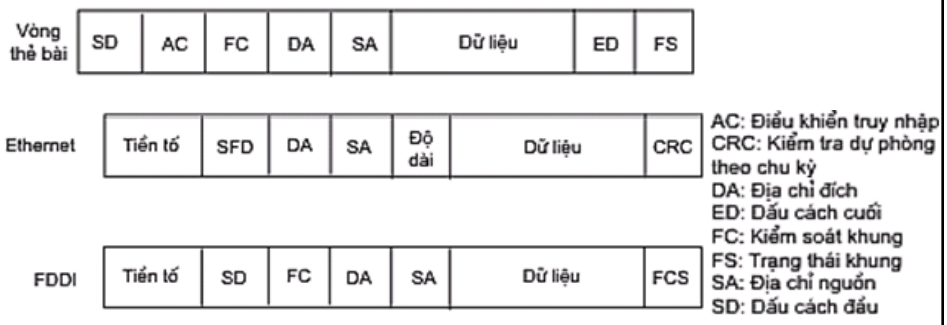
FDDI

- FDDI uses a dual ring physical topology for sending data over fiber optic cables.
- FDDI networks are token-passing networks, and support data rates of up to 100 Mbps.
- FDDI can extend up to 200 km.
- FDDI uses two rings to achieve better results and less chance of failure.
- FDDI is used mainly in mission critical and high traffic networks.

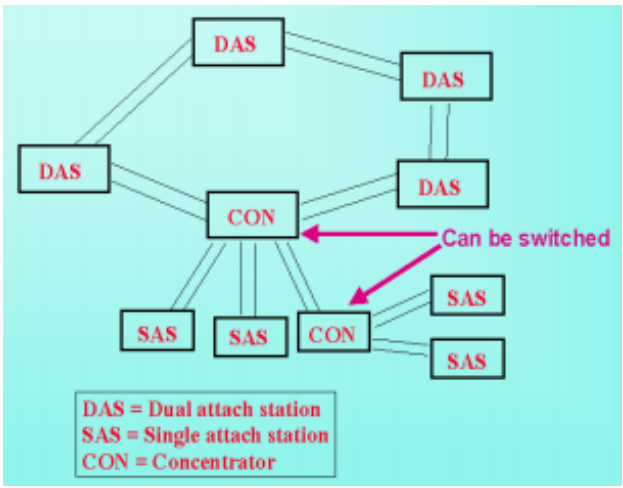


FDDI

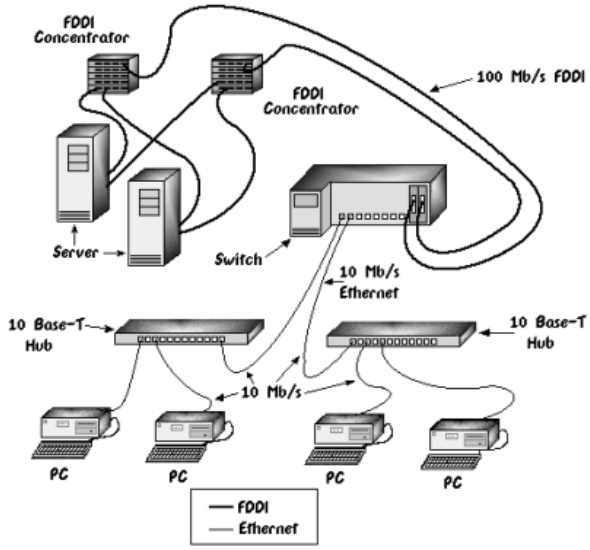
- FDDI Format



FDDI

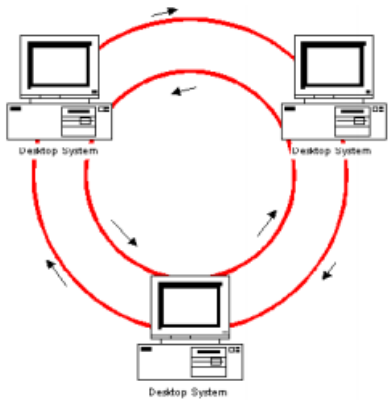


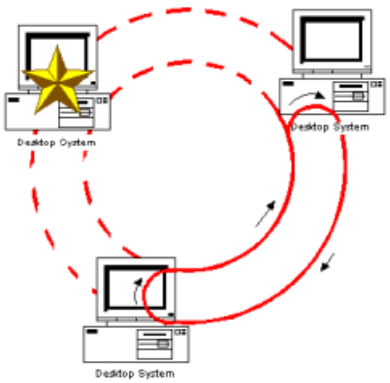
FDDI



FDDI

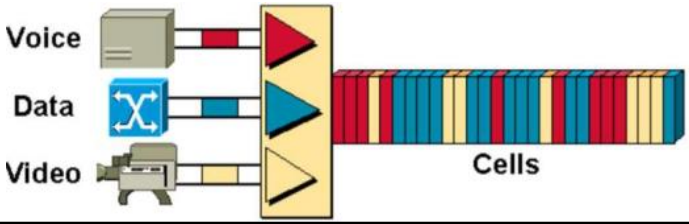
- If a station goes down, the signals are routed
- around it by a loop formed from the rings





ATM

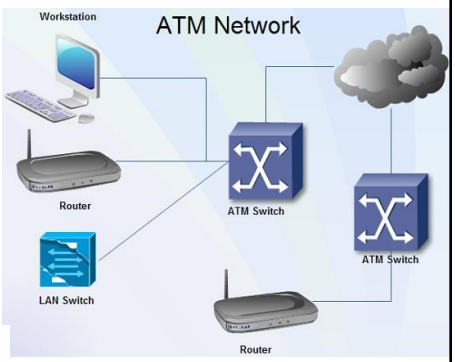
- ATM also called cell relay (transferring data in cells of a fixed size)
- It is operates at the data link layer (Layer 2) of OSI Model over fiber or twisted-pair cable, a high-speed switched network technology
- ATM supports to carry a complete range of user traffic, including voice, data, and video signals.
- ATM transmitting relatively small and fixed data packets compared to units used with other technologies.
- The data transfer rates on ATM are either 155 Mbps or 622 Mbps.
- ATM is a key component of broadband ISDN

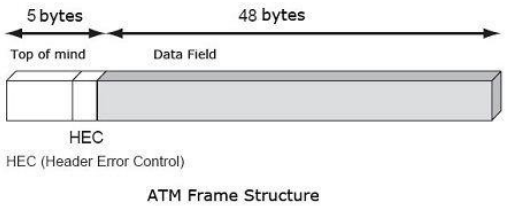


ATM

- It is a small-packet switched system or similar to circuit-switched network,
- which breaks down messages into very small, fixed length packets called cells generally organizes digital data into 53 bytes in length

(48 bytes of data plus a 5-byte header).





ATM Frame Structure

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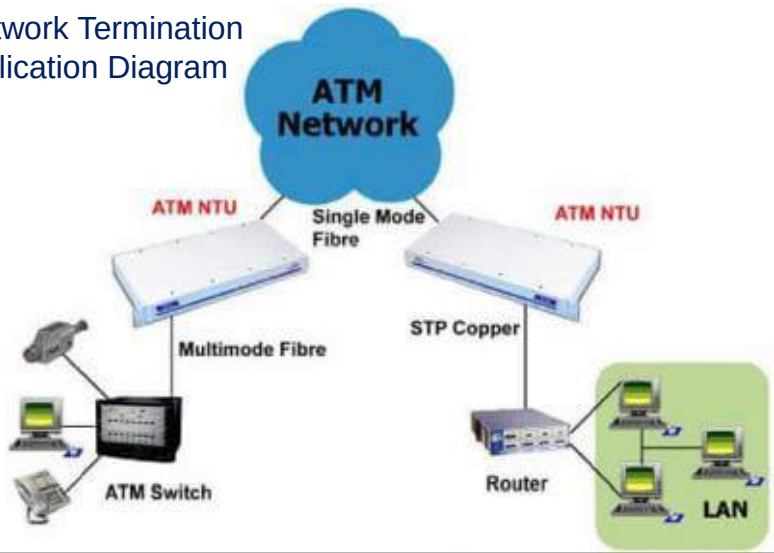
ATM

- ATM Network Termination Unit Application Diagram



10/03/2020

3

WLAN

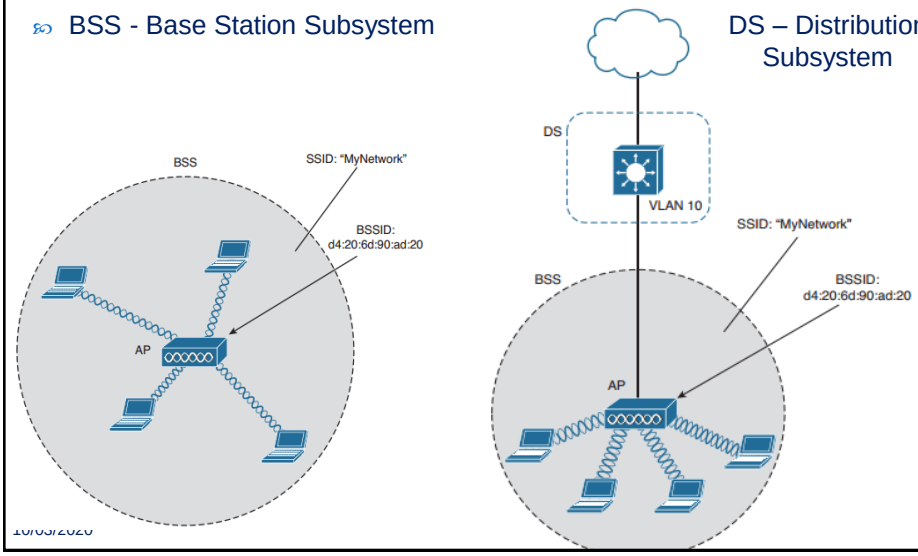
- Mạng WLAN được hiểu là sự mở rộng mạng LAN đối với việc sử dụng các thiết bị không dây như Laptop, Ipad, điện thoại thông minh, các thiết bị IoT.
- Các chuẩn mạng không dây

	Năm ra đời	Tốc độ max	Tần số
802.11a	1999	54Mbps	5GHz
802.11b	1999	11Mbps	2.4GHz
802.11g	2003	54Mbps	2.4GHz
802.11n (Wifi-4)	2009	600Mbps	2.4 và 5GHz
802.11ac (Wifi-5)	2013	1.3Gbps	5GHz
802.11ax (Wifi-6)	2019	14Gbps	2.4 và 5GHz

Các mô hình triển khai mạng Wifi

- BSS - Base Station Subsystem

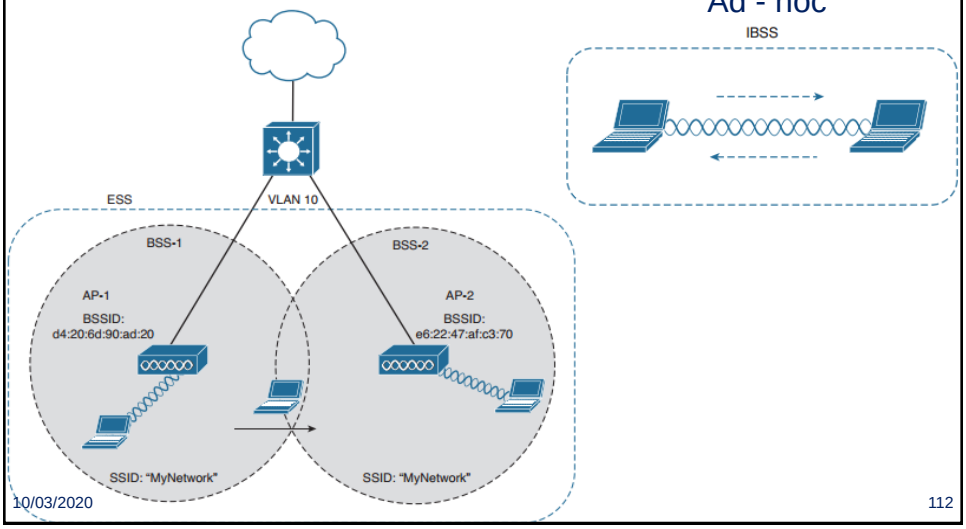
DS – Distribution Subsystem



Các mô hình triển khai mạng Wifi

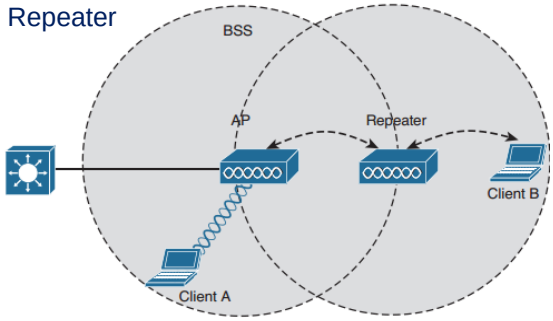
ESS - Extended service set

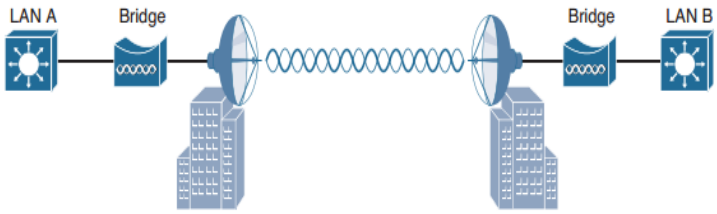
Ad - hoc



Các mô hình triển khai mạng Wifi

Repeater

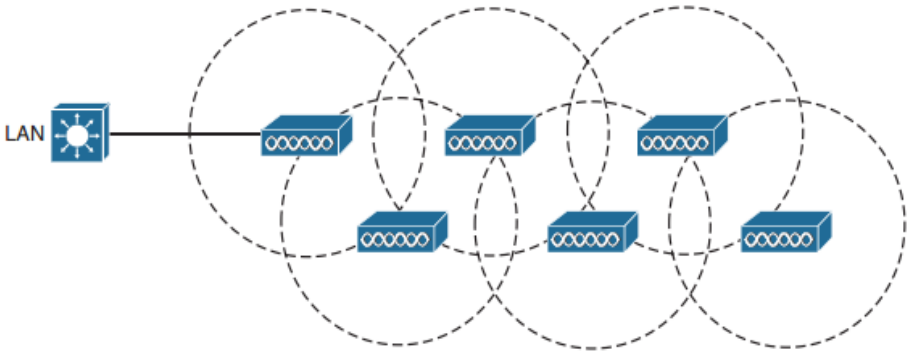




Outdoor

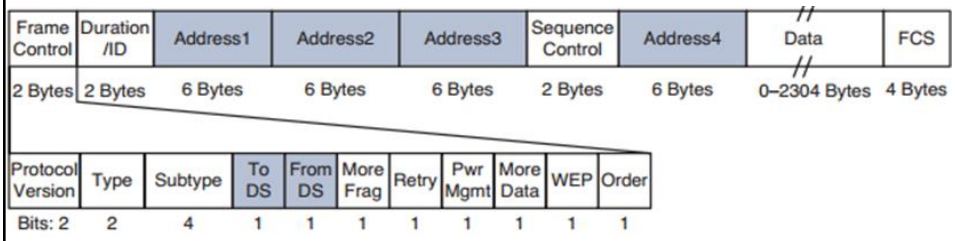
Các mô hình triển khai mạng Wifi

Mesh



802.11 Frame

- Frame bắt đầu với 2-byte của trường Frame-Control, nó xác định loại frame và định hướng frame khi nó di chuyển từ một thiết bị không dây này sang một thiết bị khác.



Bảo mật trong WLAN

- Lọc địa chỉ MAC
- WPA2, WPA3
- Chứng thực người dùng RADIUS Server

Q/A