

Key Features Of a LAN

- High throughput
- Relatively low cost
- Limited to short distance
- Often rely on *shared media*
- No separate cable or Modem

Point to point connection vs. Shared media LAN
in the TEXT.

Scientific Justification For Local Area Networks

- *A computer is more likely to communicate with computers that are nearby than with computers that are distant.*

Known as the *locality principle*

→ *Temporal locality of ref. (the same set of computer in time) + physical locality of reference (nearby computer)*

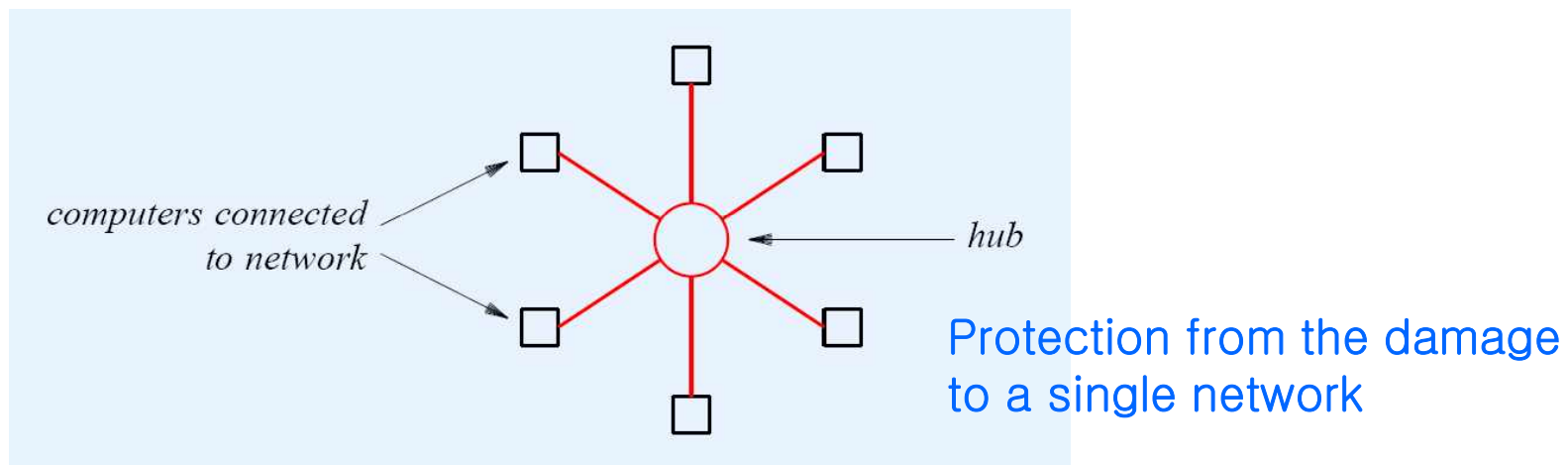
Topology

- Mathematical term
- Roughly interpreted as “geometry for curved surfaces”

Network Topology

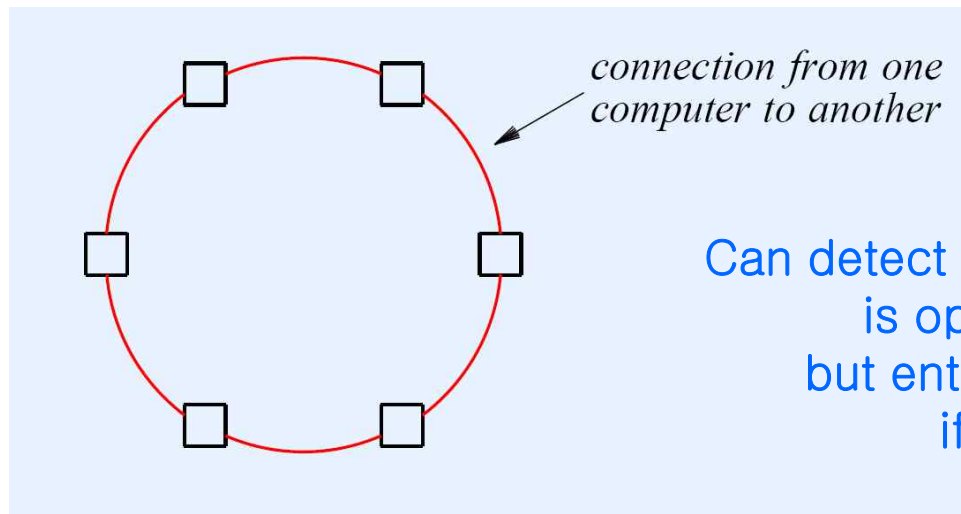
- Specifies general “shape” of a network
- Handful of broad categories
- Often applied to LAN
- Primarily refers to interconnections
- Hides details of actual devices

Star Topology



- Central component of network known as *hub*
- Each computer has separate connection to hub

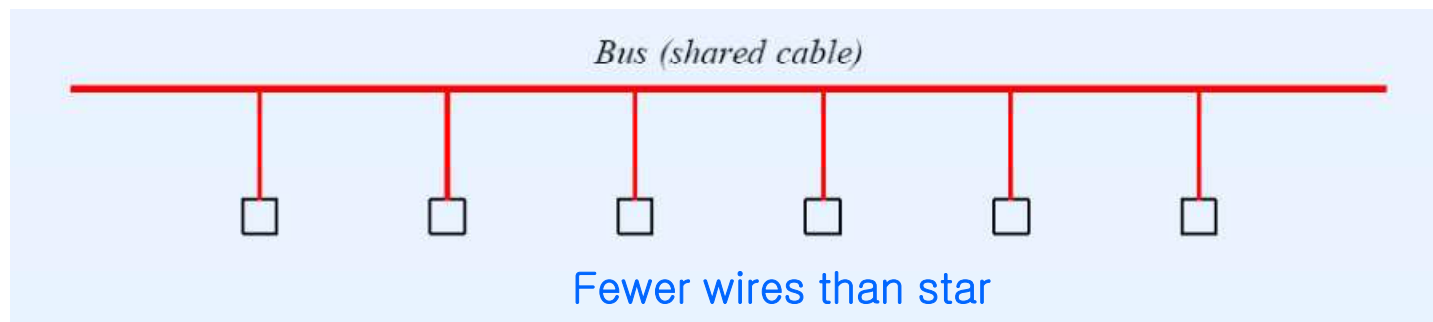
Ring Topology



Can detect whether the network is operating easily but entire network fails if one fails.

- No central facility
- Connections go directly from one computer to another → Logical (not physical) concept

Bus Topology



but entire network crashes if one fails as ring topology

- Shared medium forms main interconnect
- Each computer has a connection to the medium
- Only one computer can send signals

Example Bus Network: Ethernet

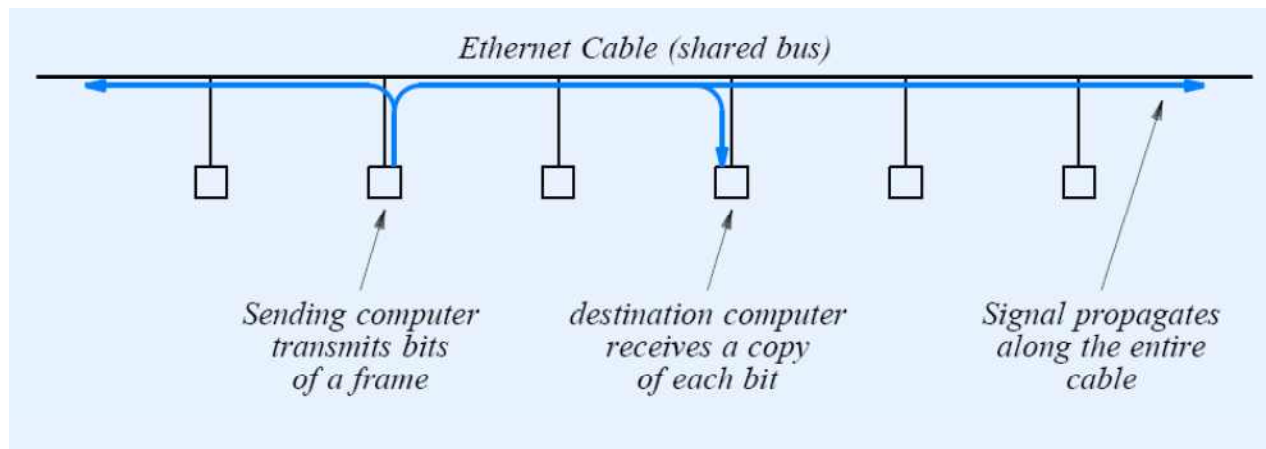
- Most popular LAN
- Widely used
- IEEE standard *802.3*
- Several generations
 - Same frame format
 - Different data rates
 - Different wiring schemes

Ethernet segment (Coax cable) < 500m
Connection distance min. 3m

Shared Medium in a LAN

- Shared medium used for all transmissions
- Only one station transmits at any time
- Stations “take turns” using medium
- Media Access Control (*MAC*) policy ensures fairness

Illustration Of Ethernet Transmission



- Only one station transmits at any time
(Time shared exclusive use of network)
- Signal propagates across entire cable
- All stations receive transmission
- CSMA/CD media access scheme
Carrier Sense Multiple Access/Collision Detection

CSMA/CD Paradigm (not centralized)

- Multiple Access (*MA*)
 - Multiple computers attach to shared media
 - Each uses same access algorithm
- Carrier Sense (*CS*)
 - Wait until medium idle
 - Begin to transmit frame
- Simultaneous transmission possible
- CSMA
 - The presence of a signal to determine when to transmit signals

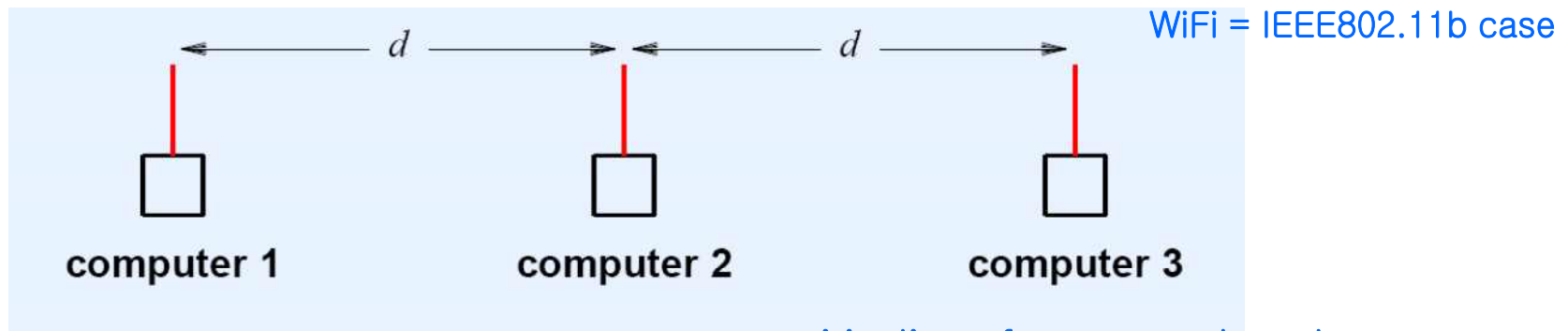
CSMA/CD Paradigm (continued)

- Two simultaneous transmissions
 - Interfere with one another
 - Called *collision*
- CSMA plus *Collision Detection (CD)*
 - Listen to medium during transmission
 - Detect whether another station's signal interferes
 - Back off from interference and try again

Back off After Collision

- When collision occurs
 - Wait random time $t1$, $0 \leq t1 \leq d$
 - Use CSMA and try again
- If second collision occurs
 - Wait random time $t2$, $0 \leq t2 \leq 2d$
- Double range for each successive collision
- Called *exponential back off*

Media Access On A Wireless Net



Media = frequency band
for wireless

- Limited range
 - Not all stations receive all transmissions
 - Cannot use CSMA/CD
- Example in diagram
 - Maximum transmission distance is d
 - Stations 1 and 3 do not receive each other's transmissions

CSMA/CA (Carrier Avoidance)

- Used on wireless LANs
- Both sides send small message followed by data transmission
 - “ X is about to send to Y ”
 - “ Y is about to receive from X ”
 - Data frame sent from X to Y
- Purpose: inform all stations in range of X or Y before transmission
- Known as *Collision Avoidance (CA)*

If collision occurs in the procedure,
back off solves the situation.

This informs farthest
computer.

Wi-Fi Wireless LAN Technology

- Popular
- Uses CSMA/CA for media access
- Standards set by IEEE
 - 802.11b (11 Mbps, shared channel)
 - 802.11a (54 Mbps, shared channel)
- Named *Wi-Fi* by consortium of vendors (to enhance popular appeal)

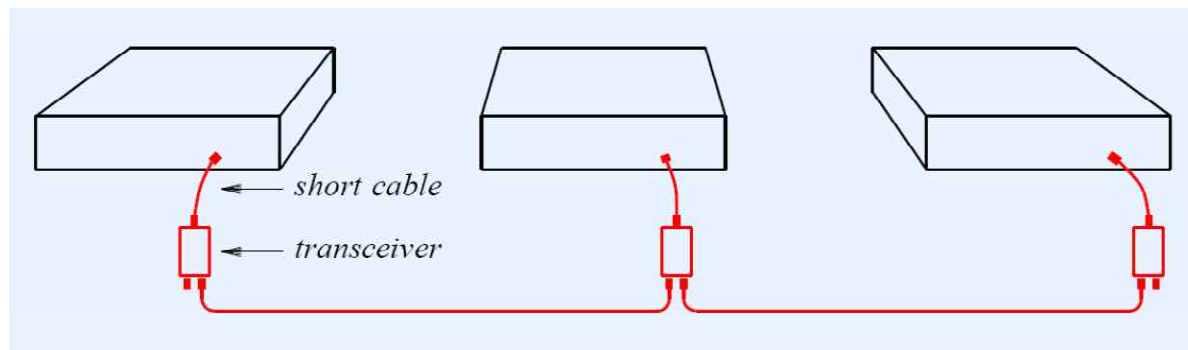
Another LAN Using Bus Topology

(Example)

(Relocated Compared to Original Slide)

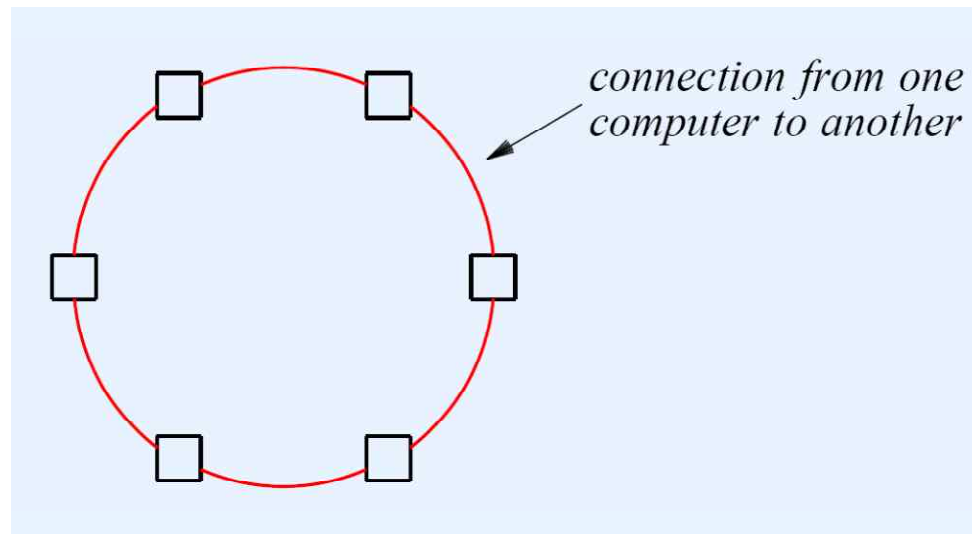
- LocalTalk
 - Developed by Apple Corp.
 - Simple to use
 - Slow by current standards

Illustration Of Local Talk



- Transceiver required per station
- Transceiver terminates cable

Ring Topology



- Once a popular topology for LANs
- Bits flow in single direction

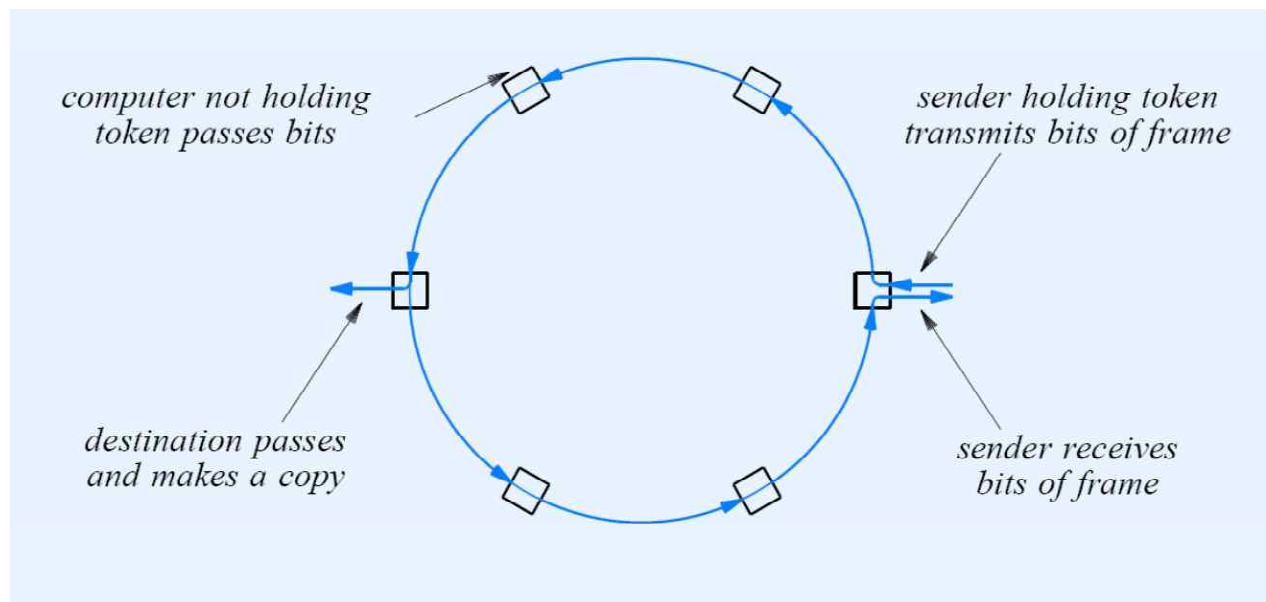
Token Passing

- Designed for ring topology
- Guarantees fair access
- *Token*
 - Special (reserved) message
 - Small (a few bits)

Token Passing Paradigm

- Station
 - Waits for token to arrive
 - Transmits **one packet** around ring
 - Transmits token around ring
- When no station has data to send
 - Token circulates continuously

Token Passing Ring Transmission



- Station waits for token before sending
- Signal travels around entire ring
- Sender receives its own transmission

Strengths Of Token Ring Approach

- Easy detection of
 - Broken ring
 - Hardware failures
 - Interference

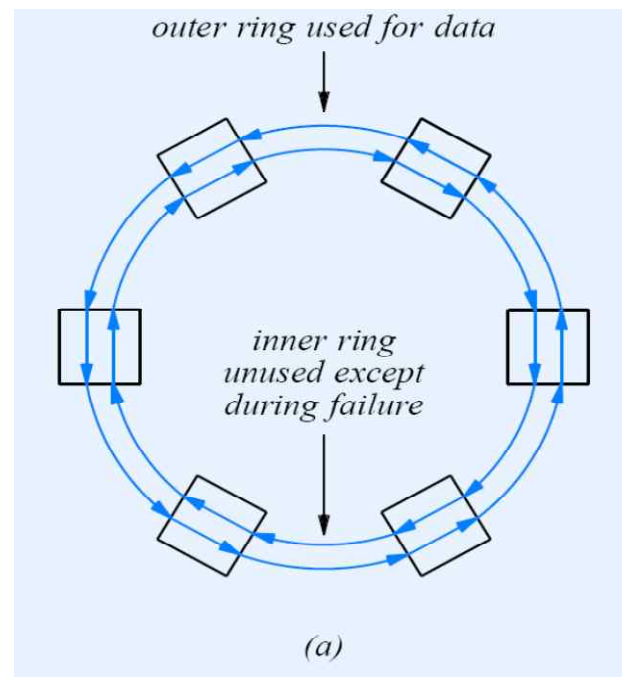
Weaknesses Of Token Ring Approach

- Broken wire disables entire ring
- Point-to-point wiring
 - Awkward in office environment
 - Difficult to add/move stations

Failure Recovery In Ring Networks

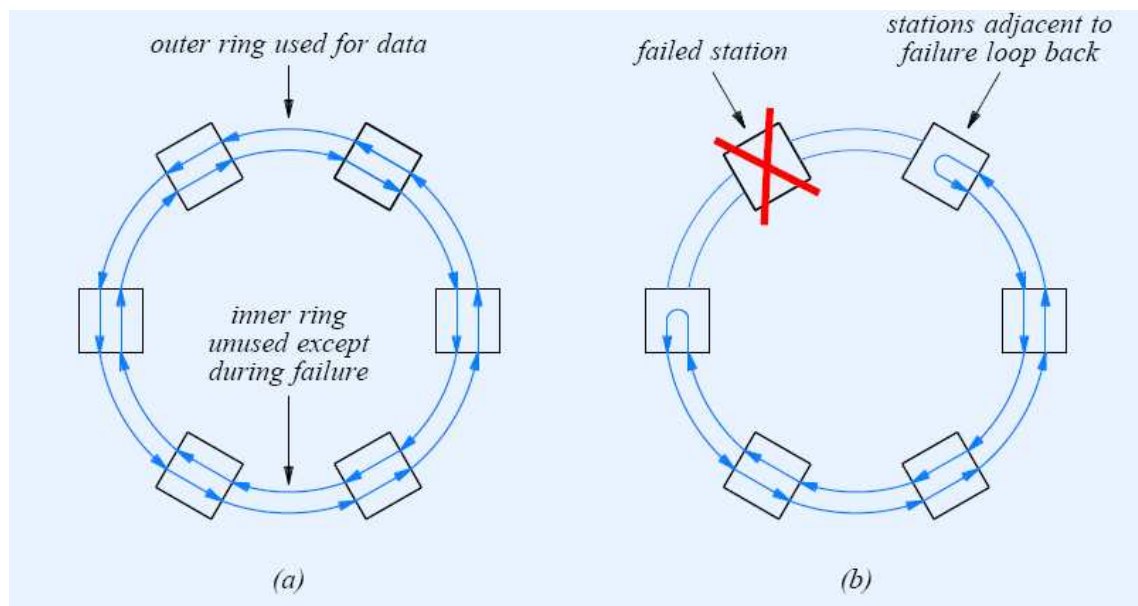
- Automatic failure recovery
- Introduced by FDDI (Fiber Distributed Data Interconnect)
- Uses two rings
- Terminology
 - *Dual-attached*
 - *Counter rotating*
 - *Self healing*

Illustration Of Failure Recovery



- Normal operation uses one of two rings

Illustration Of Failure Recovery



Self Healing

- Normal operation uses one of two rings
- Second ring used for loopback during failure

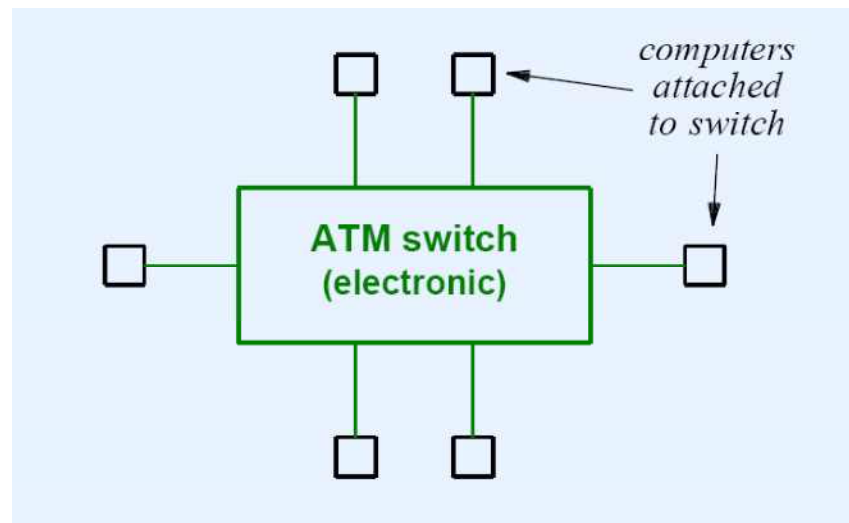
Token Passing Ring Technologies

- *ProNet-10*
 - Operated at 10 Mbps
- *IBM Token Ring*
 - Originally operated at 4 Mbps
 - Later version operated at 16 Mbps
- *Fiber Distributed Data Interconnect (FDDI)*
 - Operates at 100 Mbps
- All are now virtually obsolete

Example of a physical Star Topology

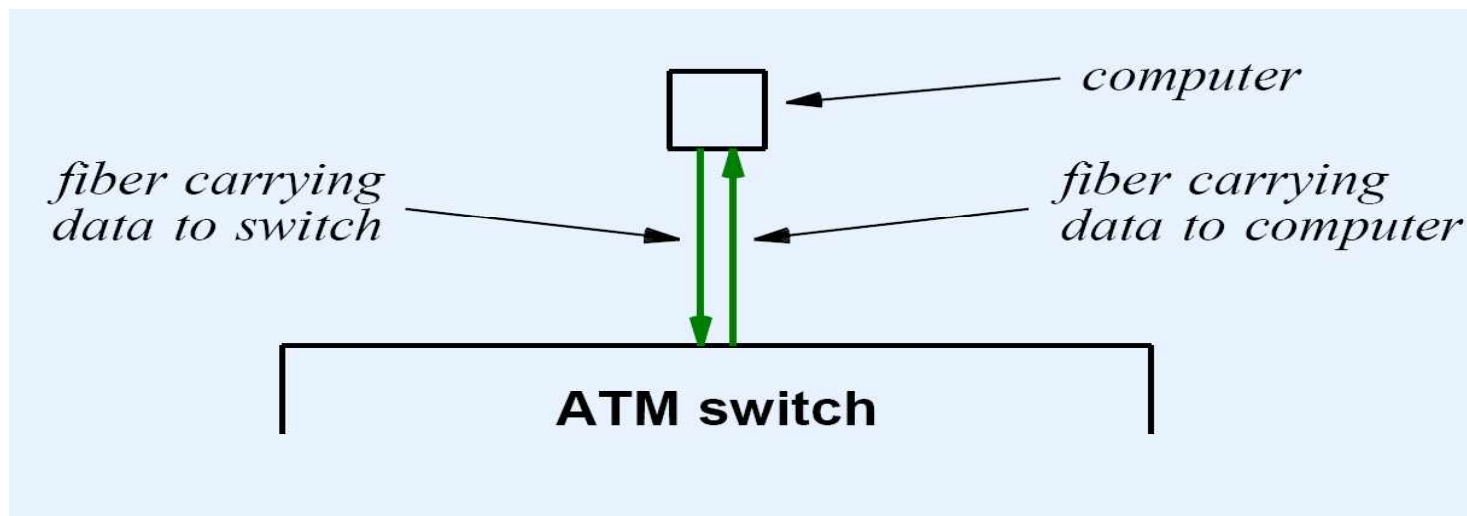
- *Asynchronous Transfer Mode (ATM)*
- Designed by telephone companies
- Intended to accommodate
 - Voice
 - Video
 - Data

ATM



- Building block known as *ATM switch*
- Each station connects to switch
- Switches can be interconnected

Details Of ATM Connection



- Full-duplex connections
- Two fibers used

ATM Characteristics

- High data rates (e.g. 155 Mbps)
- Fixed size packets
 - Called *cells*
 - Important for voice
- Cell size is 53 octets
 - 48 octets of data
 - 5 octets of header

Identifying a Destination

- All stations on shared-media LAN receive all transmissions
- To allow sender to specify destination
 - Each station assigned unique numbers
(physical address = hardware address = MAC address)
 - Known as station's *address*
 - Each frame contains address of intended recipient

Ethernet Addressing

- Standardized by IEEE
- Each station assigned unique 48-bit address
- Address assigned when network interface card (*NIC*) manufactured

Ethernet Address Recognition

- Each frame contains destination address (also source address for reply)
- All stations receive a transmission
- Station discards any frame addressed to another station
- Important: interface hardware (independent from processor), not software, checks address
→ basically compares the destination address with own MAC address (+ frame length check, CRC) Discard the frames with errors)

Format of a Physical Address

Static,
Configurable (during installation),
Dynamic address (during booting)
in the Text (pp.126)

Possible Destinations

- Packet can be sent to:
 - Single destination (*unicast*)
 - All stations on network (*broadcast*)
 - Subset of stations (*multicast*)
- Address used to distinguish

Advantages Of Address Alternatives

- Unicast
 - Efficient for interaction between two computers
- Broadcast
 - Efficient for transmitting to all computers
- Multicast
 - Efficient for transmitting to a subset of computers

Broadcast On Ethernet

- All 1s address specifies broadcast
- Sender
 - Places broadcast address in frame
 - Transmits one copy on shared network
 - All stations receive copy
- Receiver always accepts frame that contains
 - Station's unicast address
 - The broadcast (multicast) address

Multicast On Ethernet

- Half of addresses reserved for multicast
- Network interface card
 - Always accepts unicast and broadcast
 - Can accept zero or more multicast addresses
- Software (Application Program)
 - Determines multicast address to accept
(after boot, only computer's address and broadcast address are recognized.)
 - Informs network interface card by software

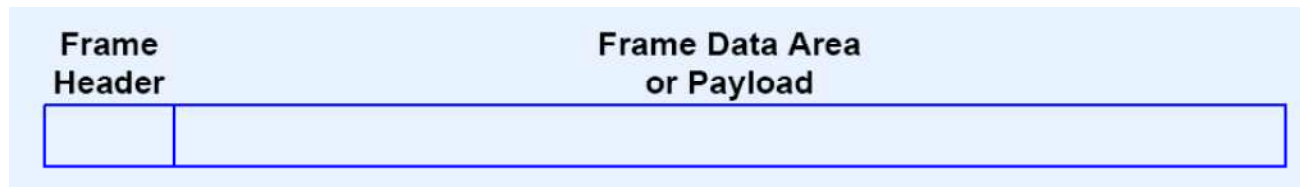
Promiscuous Mode

- Designed for testing/debugging
- Allows interface to accept *all* packets
- Available on most interface hardware

Identifying Frame Contents

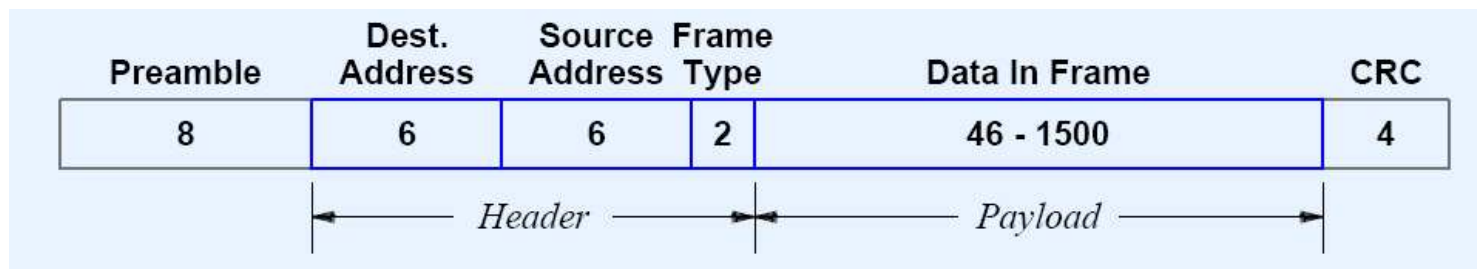
- Integer *type field* tells recipient the type of data being carried
- Two possibilities
 - *Self-identifying* or *explicit type* (hardware records frame type field in a frame)
 - *Implicit type* (application program must handle type implicitly)

Conceptual Frame Format



- *Header*
 - Contains address and type information
 - Layout fixed
- *Payload*
 - Contains data being sent

Illustration Of Ethernet Frame



Preamble: series of alternating 1's and 0's for sync.

- Sender places
 - Sender's address in *source*
 - Recipient's address in *destination*
 - Type of data in *frame type*
 - Cyclic redundancy check in *CRC*

Example Ethernet Types (Frame Type)

(2 bytes – 4 HEX number)

Value

0000–05DC
0800
0805
0900
0BAD
1000–100F
6004
6559
8005
8008
8014
8035
8038
805C
809B
80C4–80C5
80D5
80FF–8103
8137–8138
818D
FFFF

Meaning

Reserved for use with IEEE LLC/SNAP
Internet IP Version 4
CCITT X.25
Ungermann–Bass Corporation network debugger
Banyan Systems Corporation VINES
Berkeley UNIX Trailer encapsulation
Digital Equipment Corporation LAT
Frame Relay
Hewlett Packard Corporation network probe
AT&T Corporation
Silicon Graphics Corporation network games
Internet Reverse ARP
Digital Equipment Corporation LANBridge
Stanford University V Kernel
Apple Computer Corporation AppleTalk
Banyan Systems Corporation
IBM Corporation SNA
Wellfleet Communications
Novell Corporation IPX
Motorola Corporation
Reserved

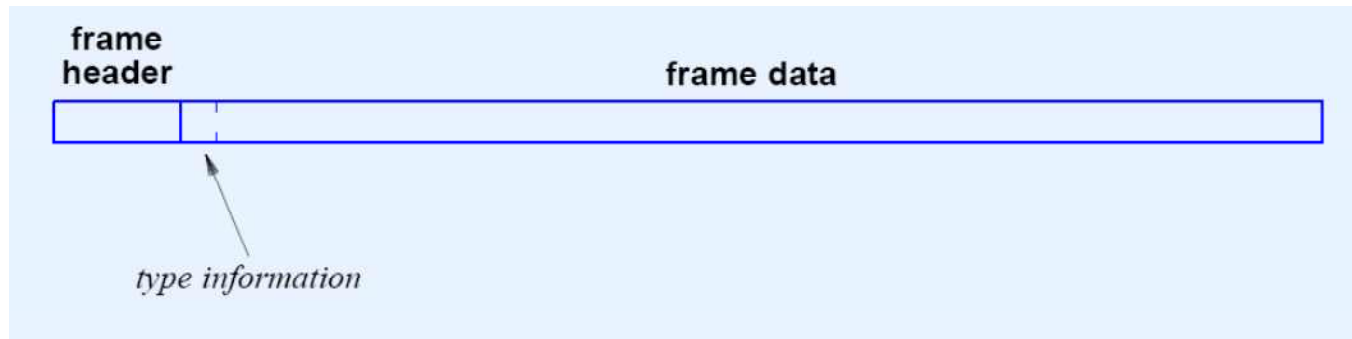
All 1's in 48 bit: Broadcast

Other addresses starting with 1: Multicast

When Network Hardware Does Not Include Types

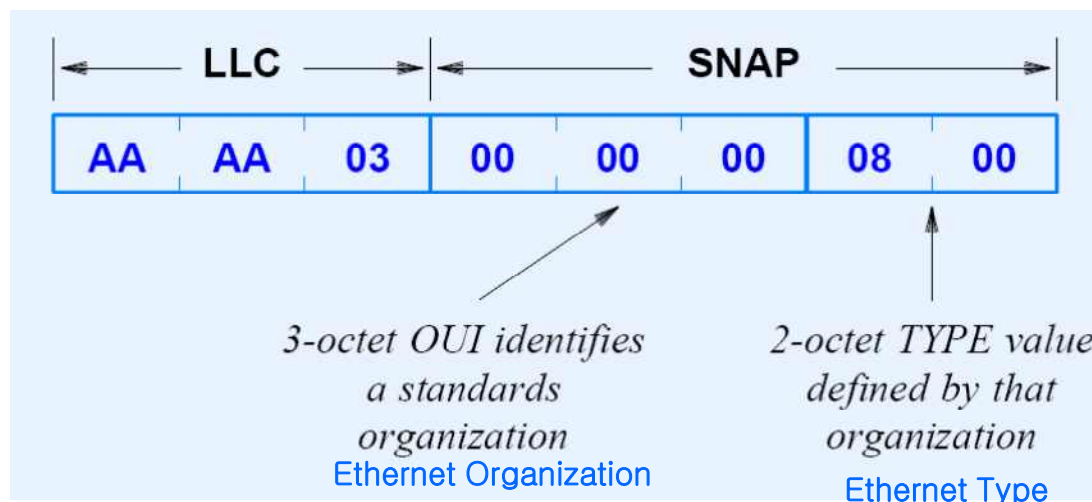
- Sending and receiving computers must agree
 - To only send one type of data
 - To put type information in first few octets of payload
- Most systems need type information

Illustration Of Type Information Added To Data



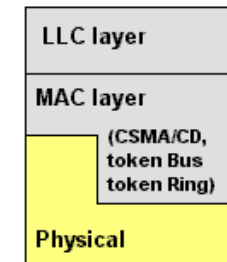
- In practice
 - Type information small compared to data carried
 - Format of type information standardized

A Standard For Type Information



(Octet: group of 8 bits)
(OUI: Organization Unique Identifier)

- Defined by IEEE
- Used when hardware does not include type field
- Called {LLC (*Logical Link Control*) → *Common Interface to MAC* ← *Data Link Layer* /SNAP (*Subnetwork Attachment Point*) } header



IEEE 802

Demultiplexing On Type

- Network interface hardware
 - Receives copy of each transmitted frame
 - Examines address and either discards or accepts
 - Passes accepted frame to system software
- Network device software
 - Examines frame type
 - Passes frame to correct software module

Network Analyzer (Packet Analyzer)

- Device used for testing and maintenance
- Listens in promiscuous mode
- Produces
 - Summaries (e.g., % of broadcast frames)
 - Specific items (e.g., frames from a given address)
 - Avg. frame size, Avg. # of frames/sec., # of collisions

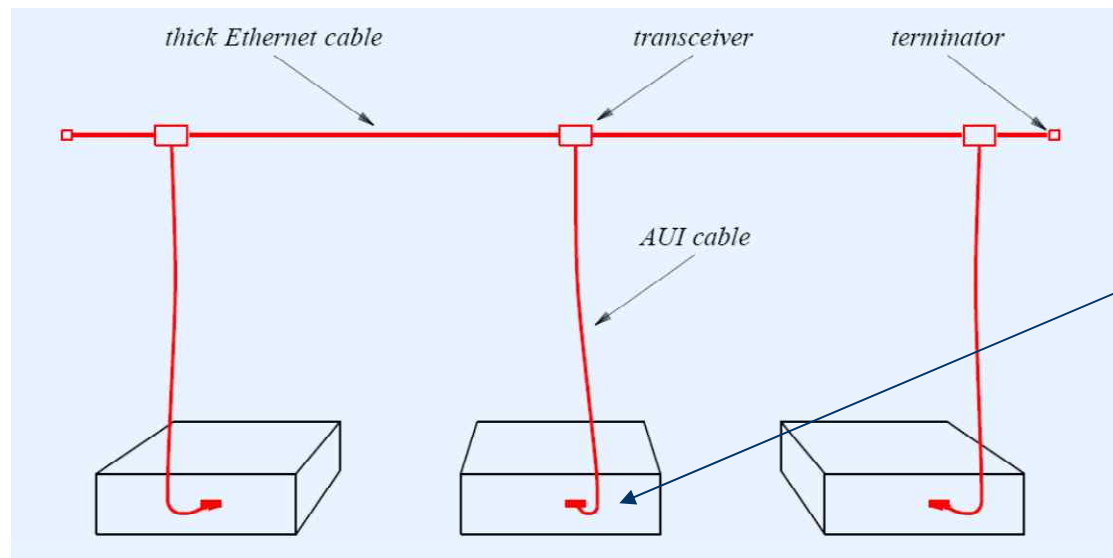
Ethernet Wiring

- Three schemes
 - Correspond to three generations
 - All use same frame format

Network Interface Card (NIC)

- Handles the speed gap btw. Processor and Network (more demanding)
 - DMA, Interrupt based, I/O like mechanism
 - Processor allows buffer area solely for NIC
 - NIC copies the frame, verify checksum and check destination address is correct (including broadcast and multicast)
 - interrupt processor
- (How to mitigate the speed gap btw. Comp. & Network)

Original Ethernet Wiring

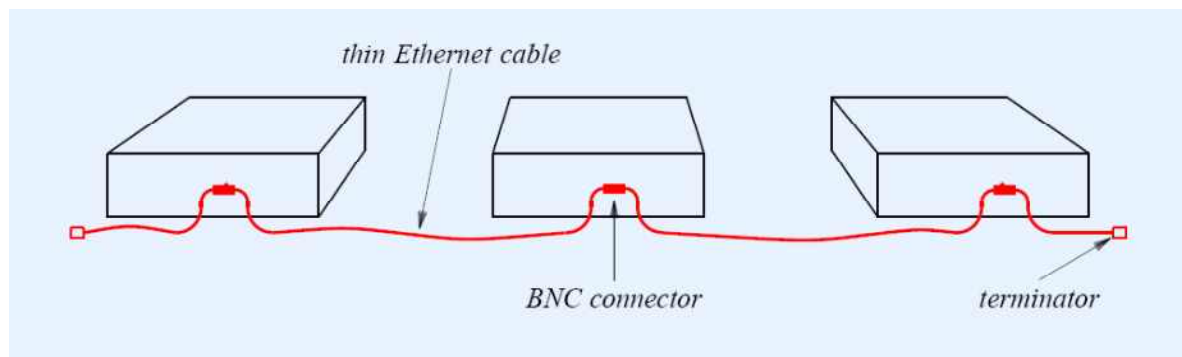


AUI: Attachment Unit Interface

NIC: (digital side)
(error detection,
address recognition,
CRC generation
and verification, bus based
processor communication,
interrupt)

- Used heavy coaxial cable
- Formal name *10Base5*
- Called *thicknet*

Second Generation Ethernet Wiring



- Used thinner coaxial cable
- Formal name *10Base2*
- Called *thinnet*

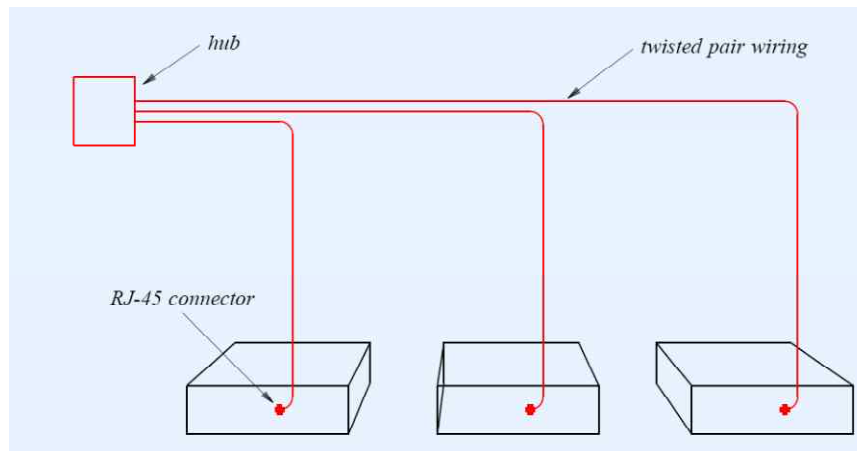
(Transceiver + NIC in 10Base5 → NIC)

Terminator:

(To get rid of reflection,
affects exponential back off
collision detection)

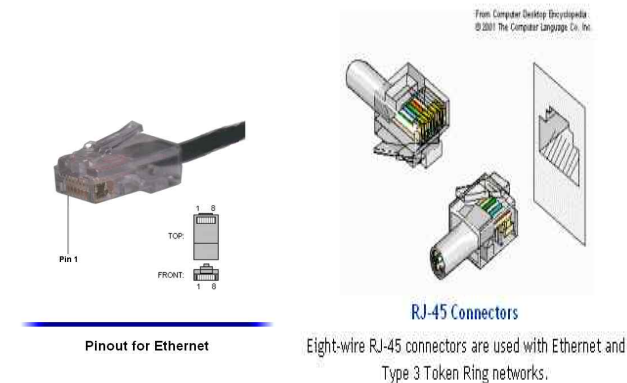
Modern Ethernet Wiring

Pin #	Ethernet 10BASE-T 100BASE-TX	EIA/TIA 568A	EIA/TIA 568B or AT&T 258A
1	Transmit +	White with green stripe	White with orange stripe
2	Transmit -	Green with white stripe or solid green	Orange with white stripe or solid orange
3	Receive +	White with orange stripe	White with green stripe
4	N/A	Blue with white stripe or solid blue	Blue with white stripe or solid blue
5	N/A	White with blue stripe	White with blue stripe
6	Receive -	Orange with white stripe or solid orange	Green with white stripe or solid green
7	N/A	White with brown stripe or solid brown	White with brown stripe or solid brown
8	N/A	Brown with white stripe or solid brown	Brown with white stripe or solid brown

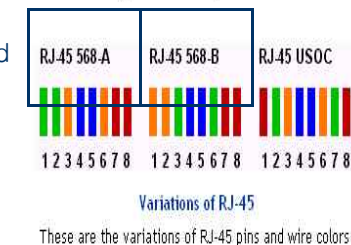


- Uses a *hub*
- Formal name *10Base-T*
- Called *twisted pair Ethernet*

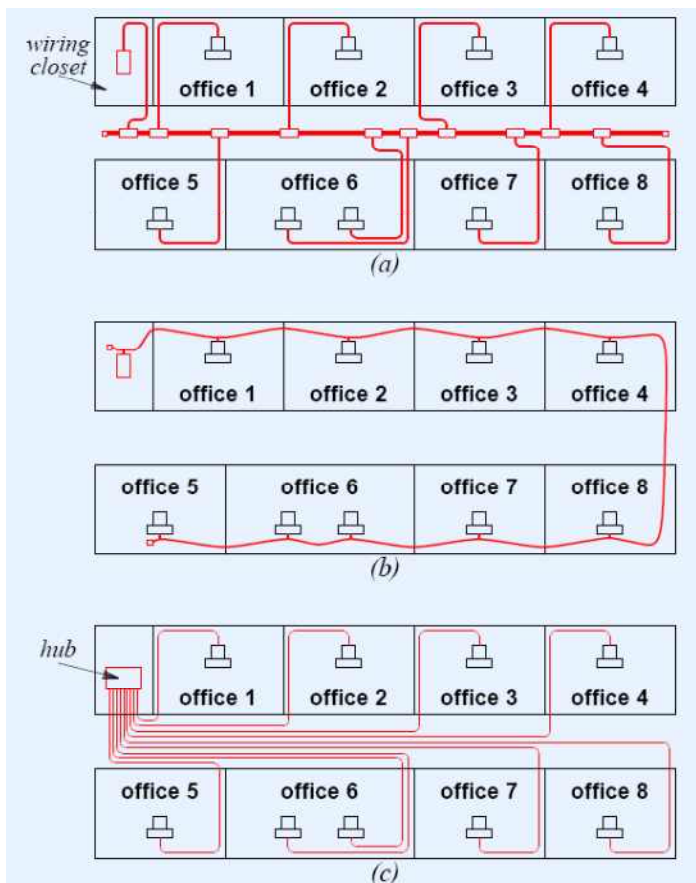
(Registered Jack-45) A telephone connector that holds up to eight wires. RJ-45 plugs and sockets are used in Ethernet and Token Ring Type 3 devices. See [RJ-48](#).



Most commonly used



Ethernet Wiring In An Office



Thick Ethernet

Thin Ethernet

Twisted pair Ethernet
(Basically star topology)

A Note About Ethernet Topology

- Apparently
 - Original Ethernet used bus topology
 - Modern Ethernet uses star topology
- In fact, modern Ethernet is
 - Physical star
 - Logical bus
 - Called *star-shaped bus*

They are using star topology HUB.

Higher Speed Ethernet

- *Fast Ethernet*

- Operates at 100 Mbps
- Formally *100Base-T*
- Two wiring standards
- 10/100 Ethernet devices available

→ Auto-negotiation between NIC
to check both are capable of 100Base-T

- *Gigabit Ethernet*

- Operates at 1000 Mbps (1 Gbps)
- Slightly more expensive