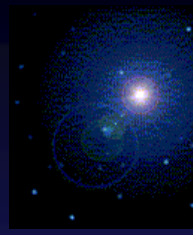
S 4/55231
nternet Engineering

Kent State University
Dept. of Computer Science

LECT-4A4

LAN

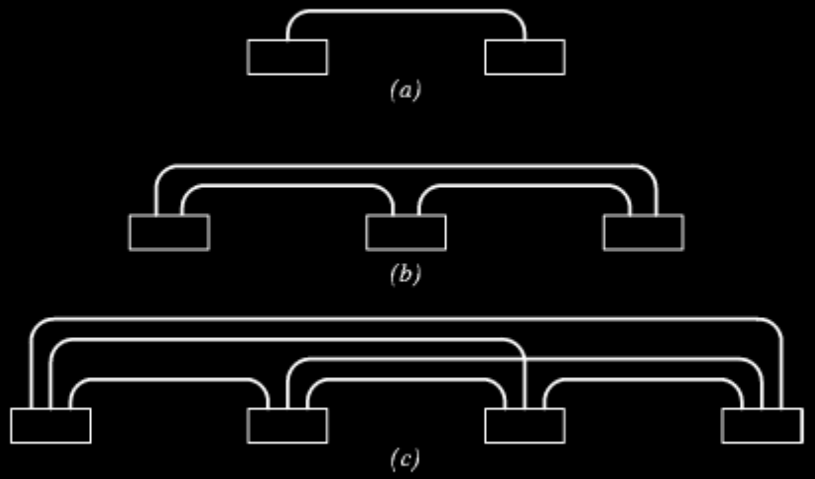


- In the last class we saw how two computers can connect to each other. In this class we will see how a group of computers can communicate to each other over a shared network.

- LAN Topologies
- Example Bus Network: Ethernet
- Example Ring Network: IBM Token Ring
- Example Star Network: ATM
- Hardware Addressing

LAN Topologies-1

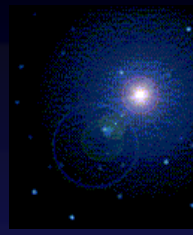
- Point-to-Point Links



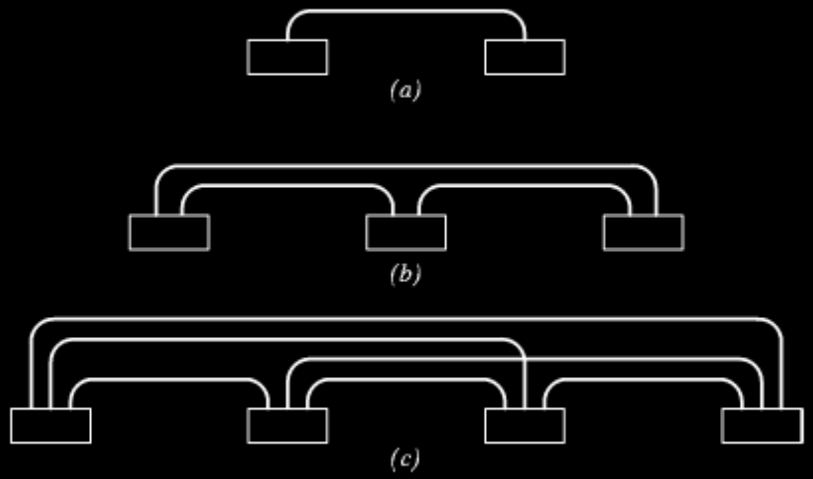
First computers networks were point to point.

Advantages

- Each connection can have appropriate hardware.
- Each connection can have its error detection, frame format and transmission protocol appropriate for the pair.
- Easy to enforce security and privacy.
- No sharing of bandwidth.

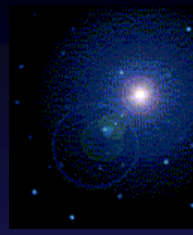


Disadvantage



- $(N^2-N)/2$ links. Too expensive!
- If we have 100 computers how many links will be needed to add another one?
- How do we manage wires?

Sharing of Links



- The history of computer changed dramatically during 1960's and 70s when researchers developed a form of computer network known as Local Area Network which use shared communication media to communicate to each other.

- Various LAN technologies vary based on how computers are connected, the voltage and modulation techniques and mechanism/ protocol to coordinate the communication.

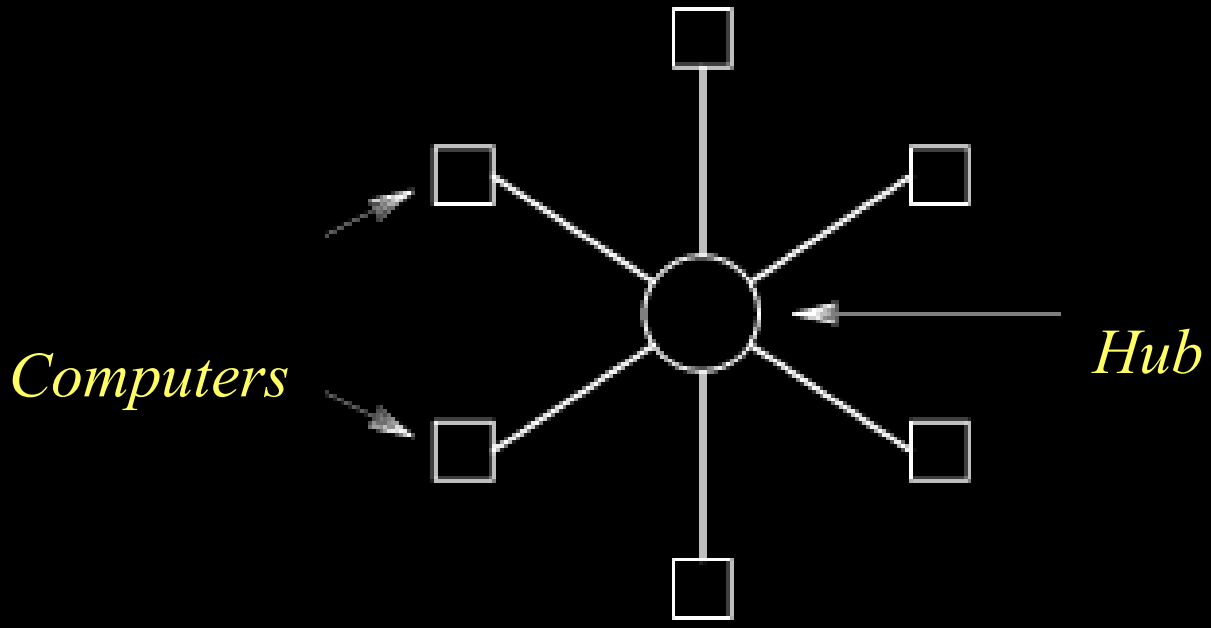
- Primary benefit: Sharing reduces cost.

- If sharing reduces cost why these techniques are not used for long distance communication?

•Coordination
•Temporal & Geographical Locality of Referen in Computer Communication, also in Humans!

LAN Topologies-1

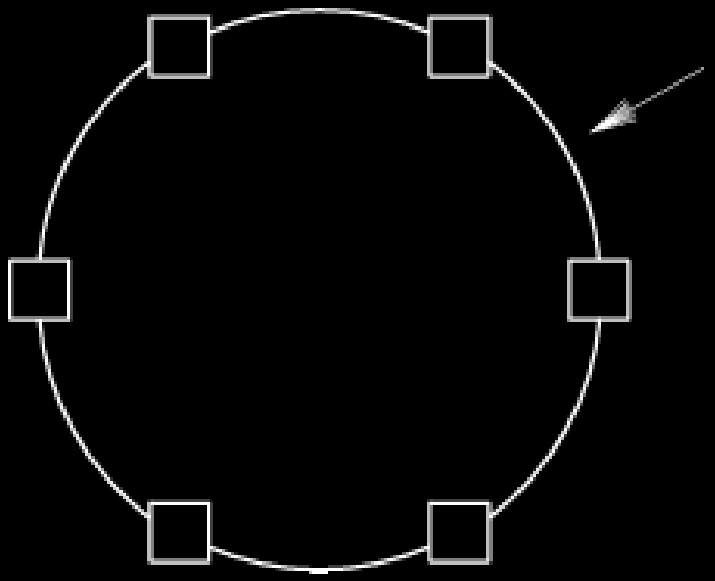
- Star Topology



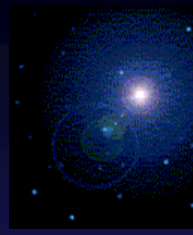
- N links
- Reliability?

LAN Topologies-2

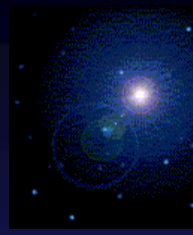
Ring Topology



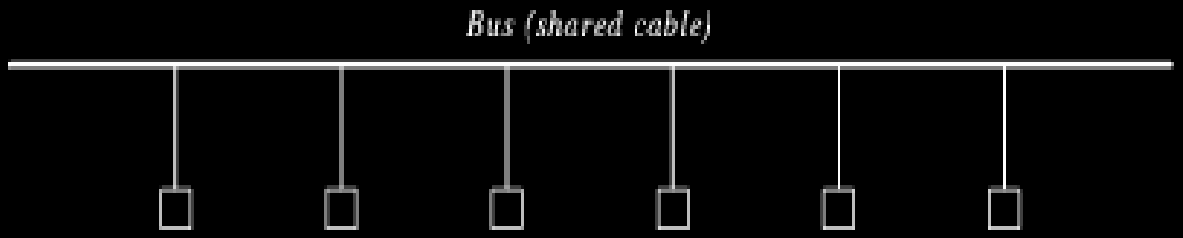
- N links, But 2 way reachability!
- But, Entire ring can stop if two wires are cut!



LAN Topologies-3



- Shared Bus



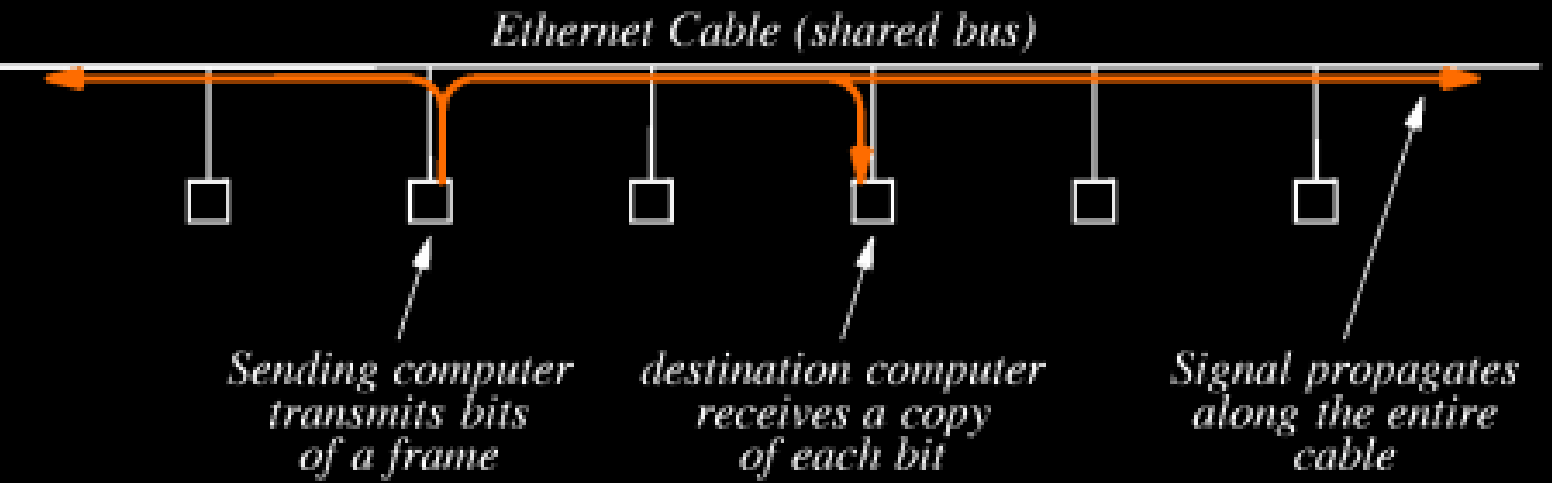
- 1 link only

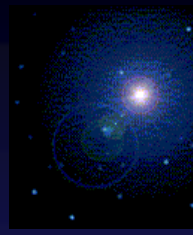
•Logical vs.
•Physical Topilogy

Example Bus: Ethernet

- Invented in Xerox Palo Alto lab in early 1970s. DEC, INTEL, XEROX contributed. IEEE now controls it (IEEE802.3). Popular in campus labs.

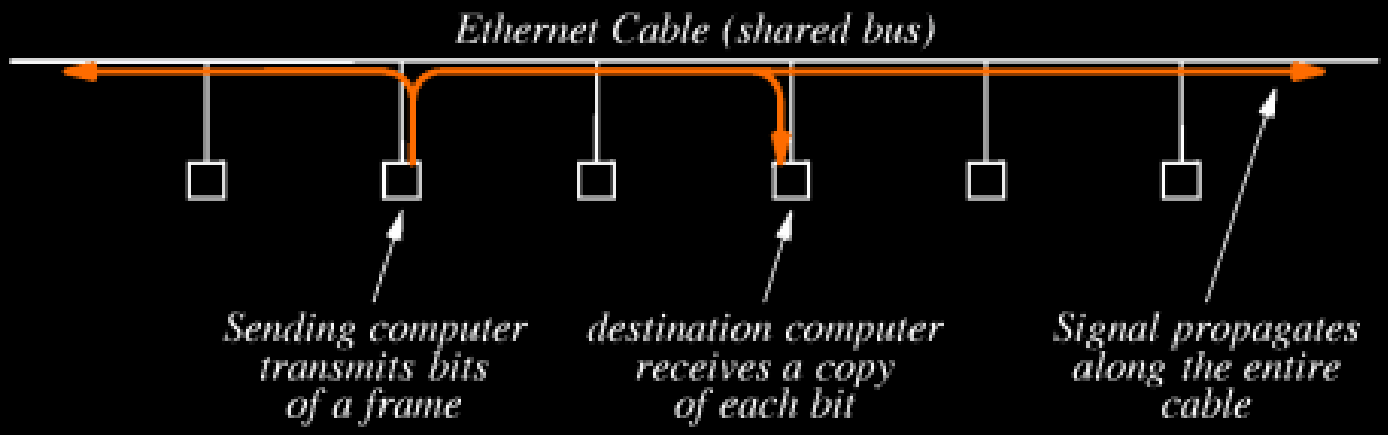
- Computers are connected by a single coaxial cable which is the 'ether'.



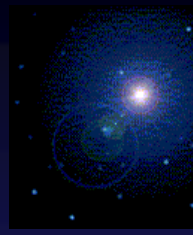


Example Bus: Ethernet (cont..)

- Maximum cable length 50 feet.
- Minimum distance between two computers must be 3 feet.
- Operates at 10MBps speed.
  - A faster version now operates at 100 Mbps (like this laptop).
  - A later version operates at 1 Gbps (1000 Mbps) speed.



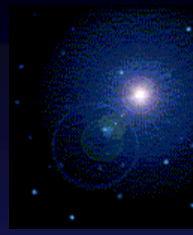
How Ethernet Works?



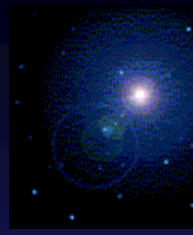
- Carrier Sense Multiple Access (CSMA). Invented at University of Hawaii as ALOHA Protocol by Norman Abramson.

- How it Works:
  - There is no centralized controller.
  - A computer which wants to send listens for a carrier signal.
  - When it detects no signal, it transmits a frame.
  - When it transmits all other computers listen.
  - Only the receiver opens the packet.
  - All other listen, but do nothing.

What if two computers send together?

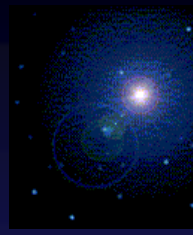


- Collision:
  - It is possible that more than one can start transmitting together.
  - If two computers sense no carrier together they may try to transmit together. This is known as collision.
- How it is Resolved:
  - On collision, each computer backs off.
  - Picks a random delay d between 0 and R seconds
  - Waits, and retransmits after d sec.
  - If there is again collision, they perform *binary exponential backoff*, they double their delay range R.



Data Delivery in Ethernet

Click Here



Bus Arbitration in Ethernet

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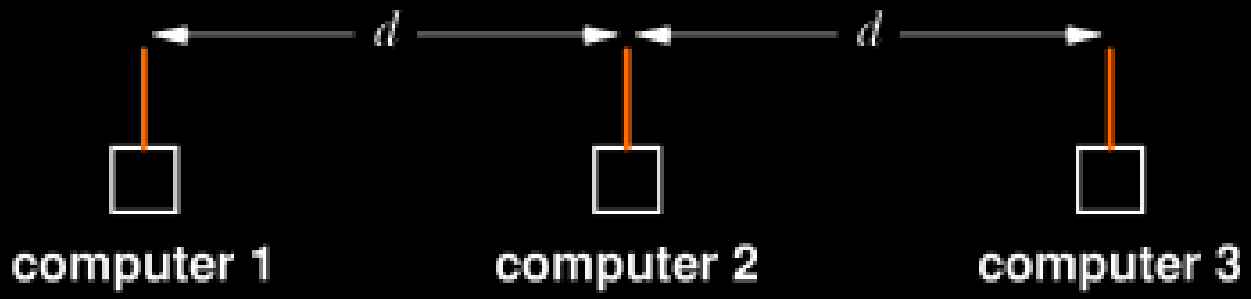
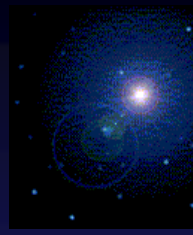
- *Apple LocalTalk*
- *another bus,*
- *but with reservation.*

Example: CSMA/CA Wireless LAN

- Uses Radio Frequency instead of a cable. Examples are NCR's WaveLAN, Solectek's AirLAN, Proxim's RageLAN.

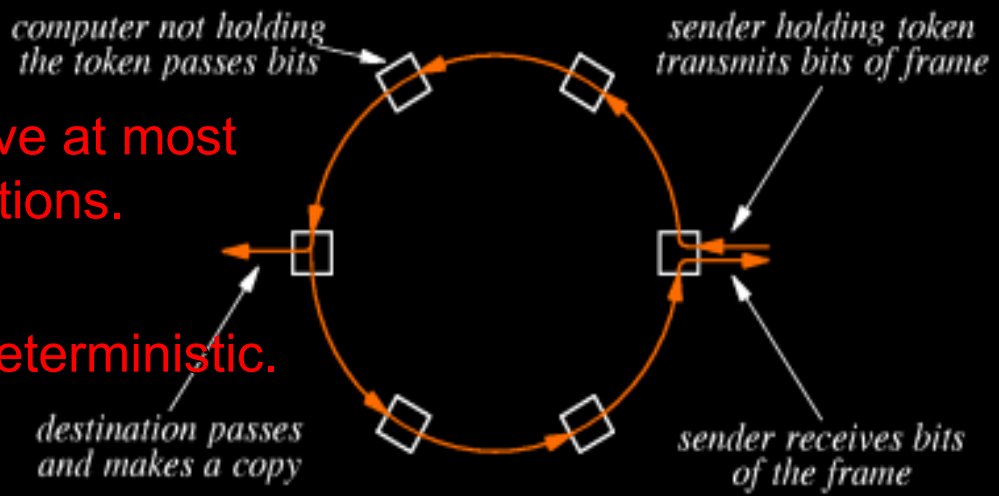


- How they work
  - Uses 900 Mhz frequencies, permits 2Mbps data rate.
  - They cannot directly use CD technique. Because of weak power all of them may not be within the reach of other.
  - They use control message first. Once reply is received from the intended recipient only then the sender sends.
  - Collision can happen during control message.
  - That is handled using random backoff.



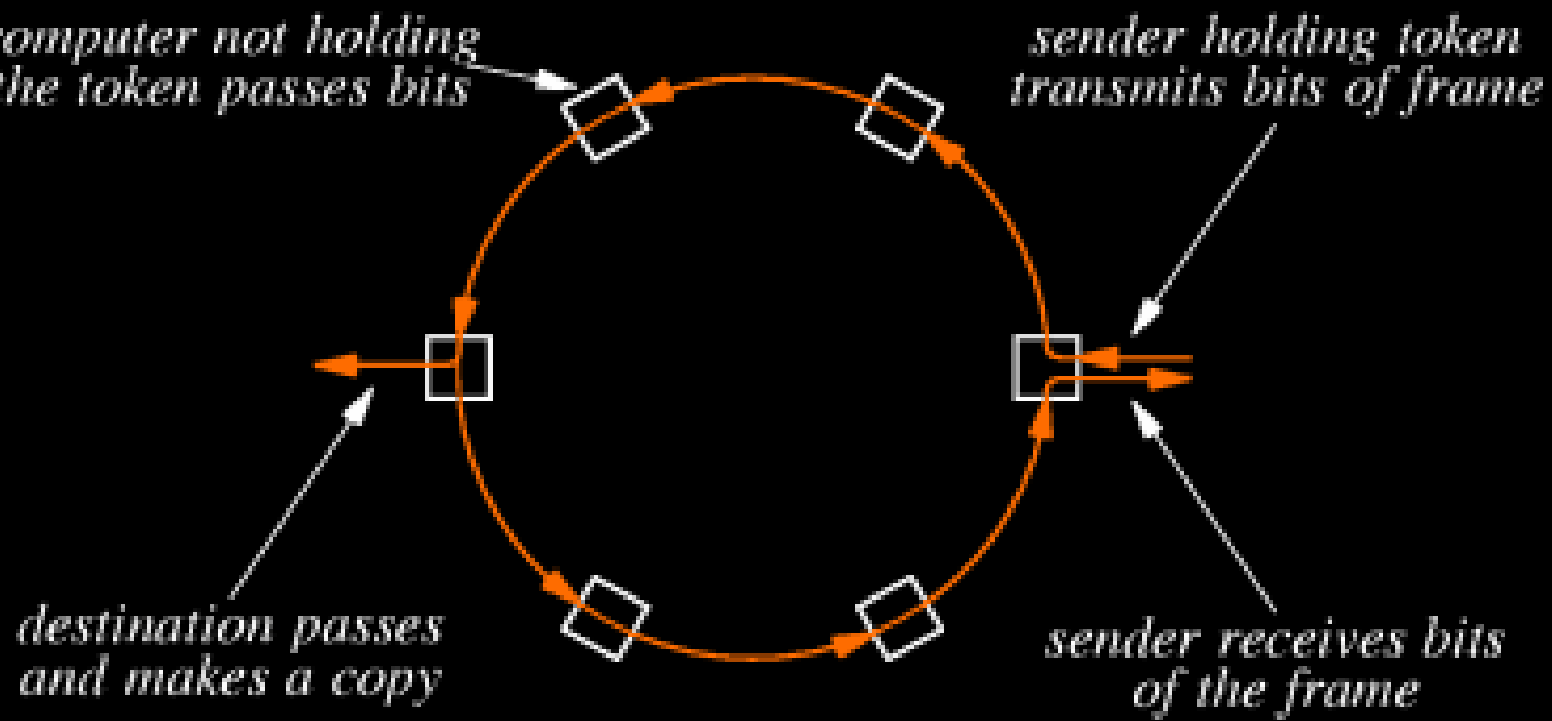
Example Ring: IBM Token Ring

- Developed by IBM in 1970s. Now it is also IEEE 802.5. Used almost in all IBM network, 2nd in popularity.
- A ring made of twisted pair cables and multi-station access units (MSAU).
- Operates at 16 Mbps
- Each ring can have at most 260 (76 UTP) stations.
- Performance is deterministic.

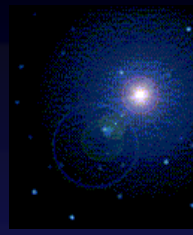


How Token Ring Works?

- The communication is mediated by a circulating Token in the network.



- Not a CSAMA
- Token is a spec reserved messag
- Bitstuffing is us often to avoid multiple token.



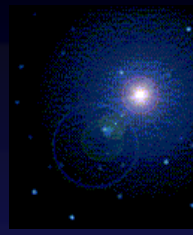
Communication in Token Ring

Click Here

Advantages of Token Ring

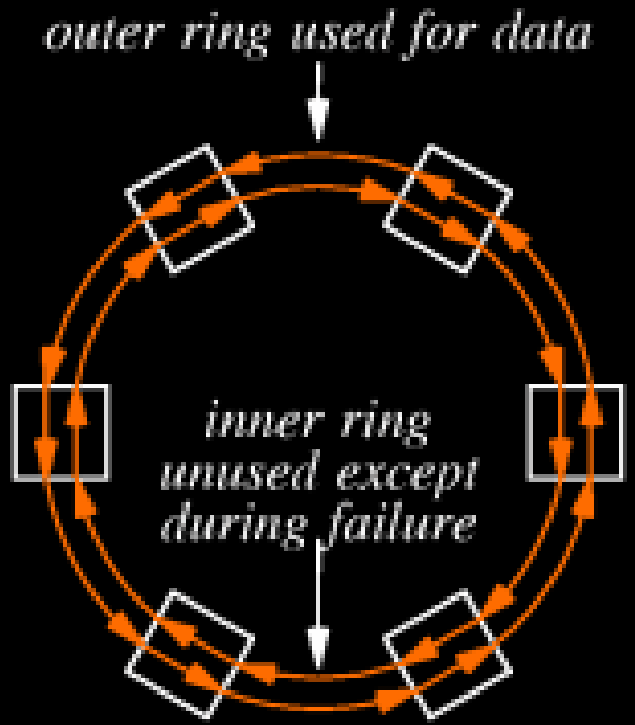
- If all has data to send, they take turn. It is fair.
- If none has data to send, the token circulates once in every millisecond.
- It is still fast because the ring is small and the token passing is done in hardware.
- Only problem is if only one computer fails it can halt all the communication.
  - MAU can be made intelligent to continue token passing, even if the hardware is not there.
  - But cannot recover from single link failure.

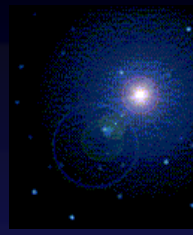
- There are other Token Passing technology, but IBM token ring is the most popular.



Example Ring: FDDI
(fiber distributed data interconnect)

- Developed by ANSI (X3T9.5) in mid 80s. Robust and fast. Popular as high speed LAN.
- Use special Optical Fiber as media (copper version is CDDI).
- Operates at 100MBps (8x15 or 10x10)
- Two counter rings in same fiber housing. Extremely robust.
- 2 km between segments with multimode fiber (100 m CDDI)





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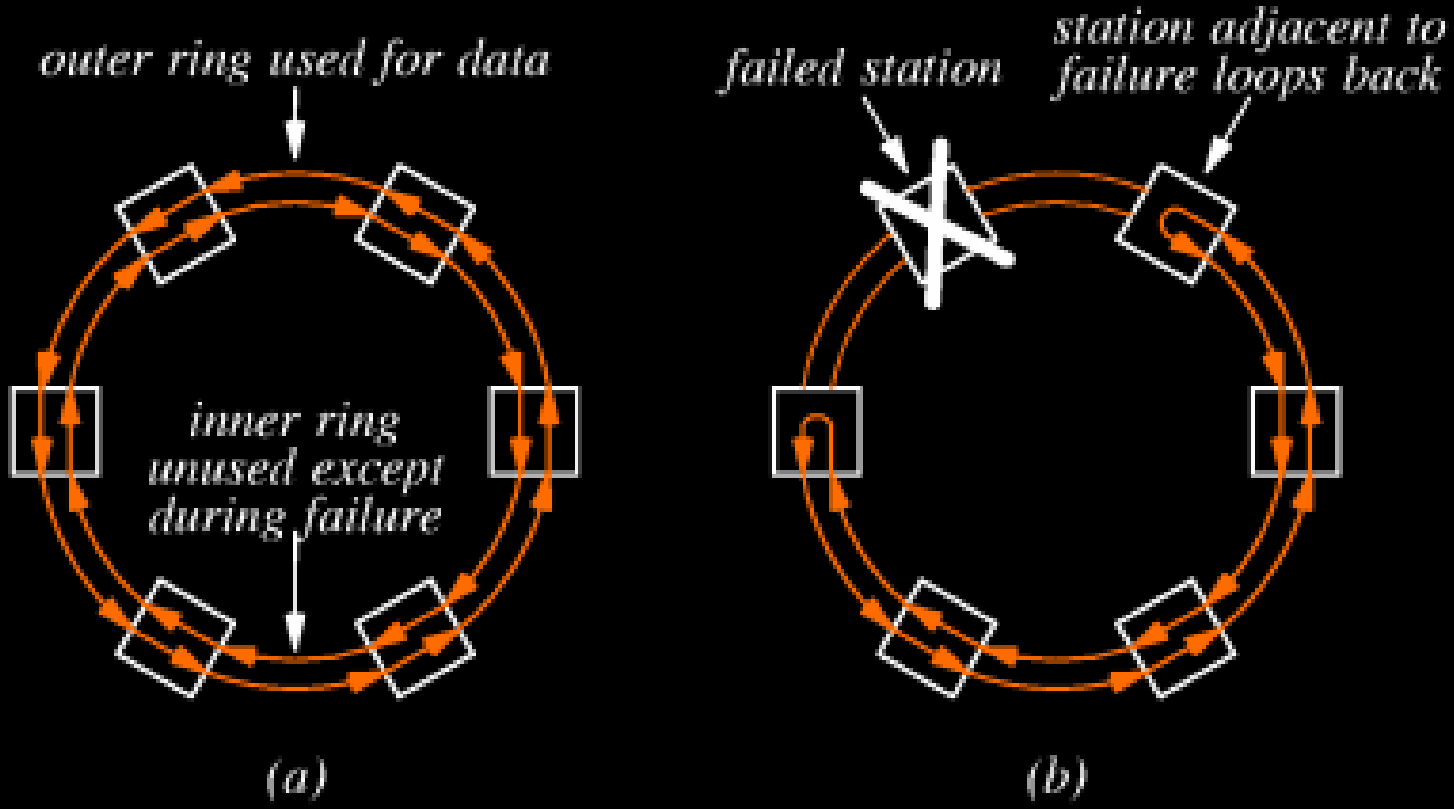
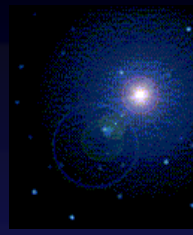
What if both
links are cut
together?

How it Works?





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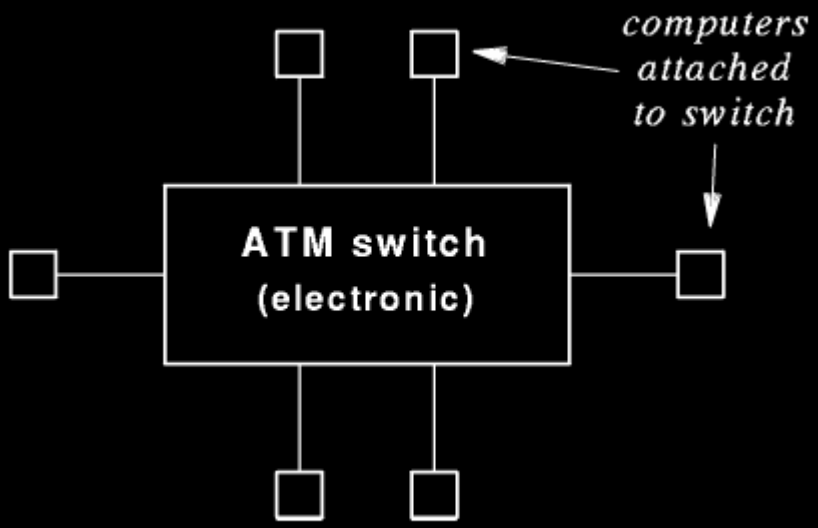
What if both
links are cut
together?

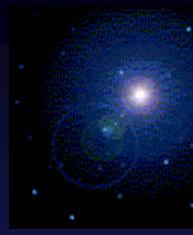
Example STAR: ATM

- Telephone companies have developed the asynchronous transfer mode switches in mid 80s. A serious contender in WAN.
- Uses Optical Fiber
- Operates at 100MBps/ 612 MBps
- Each link can be 2 km with multimode fiber



LAN
ADDRESSING & FRAMING

Hardware Addressing

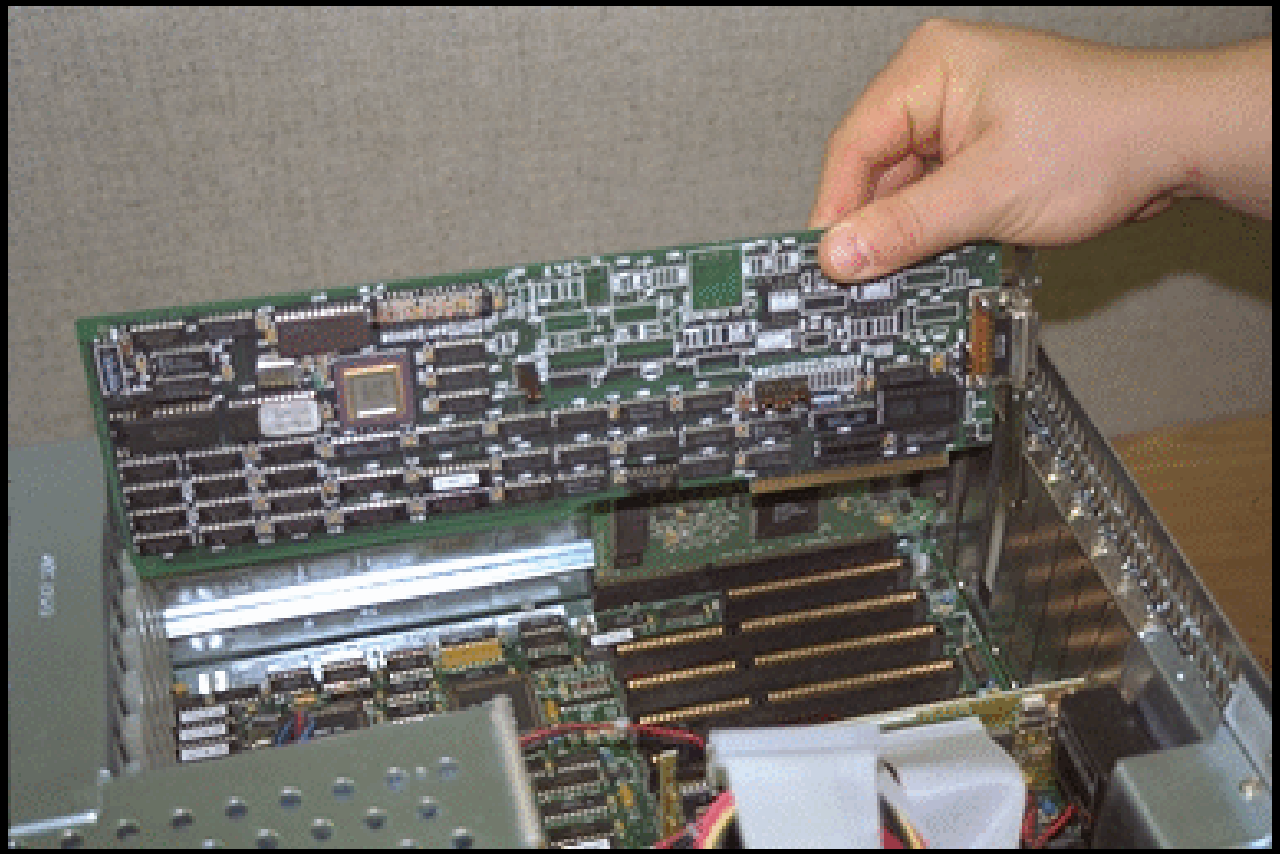


- How a computers identify which computer or computers should receive a copy of a given frame?
  - Each station on a LAN is assigned a unique numeric value called a hardware address or the physical address.
  - When a sender transmits a frame across the LAN, the sender includes the physical address of the intended recipient in the header.
  - Although sharing allows all stations to receive a copy of the bits the LAN hardware on each station takes the address of each incoming frame to determine if it should accept the frame.

How can CP
do any other
thing when
connected to
Network?

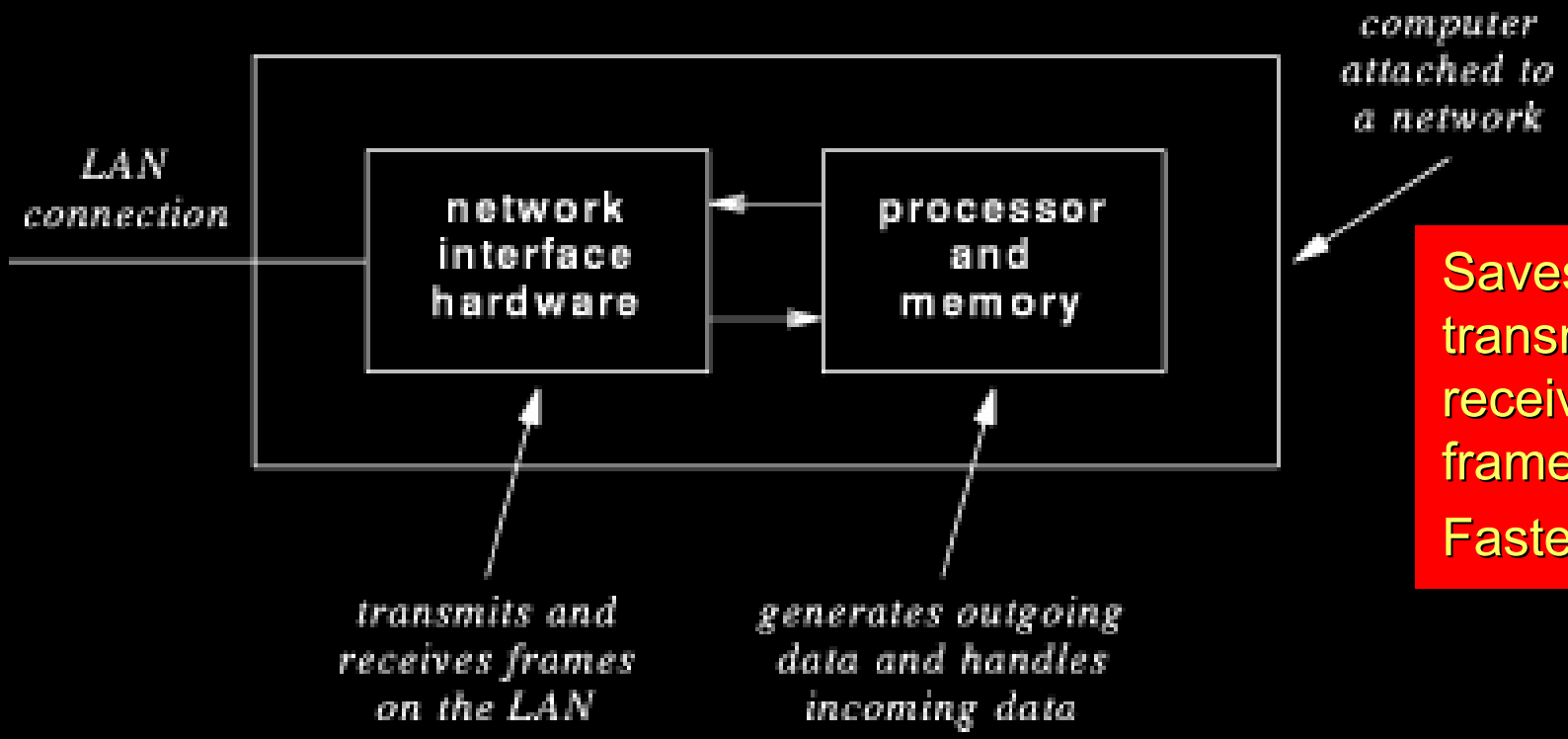
Network Interface Card

- Each computer is connected to the network via a network interface card.



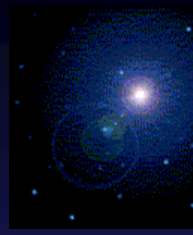
Network Interface Card

- NIC cards Handles:
  - frame transmission and reception,
  - compares the address with station's and physical address.
  - checks CRC.



Saves CPU when transmitting or receiving bits of a frame.

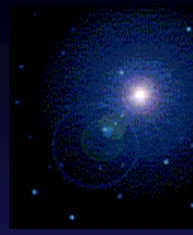
Faster than CPU!



Format of Physical Address

- Address Forms:
  - static addressing: hardware manufacture assigns unique physical address to each network interface. A static physical address does not change unless the hardware is replaced.
  - Advanced configurable addressing customer can set a physical address.

SA: +easy to mainta
+no conflict, but larg
address size.



Broadcast Address

- In addition to the NIC addresses, a network also generally reserves one particular address as broadcast address.

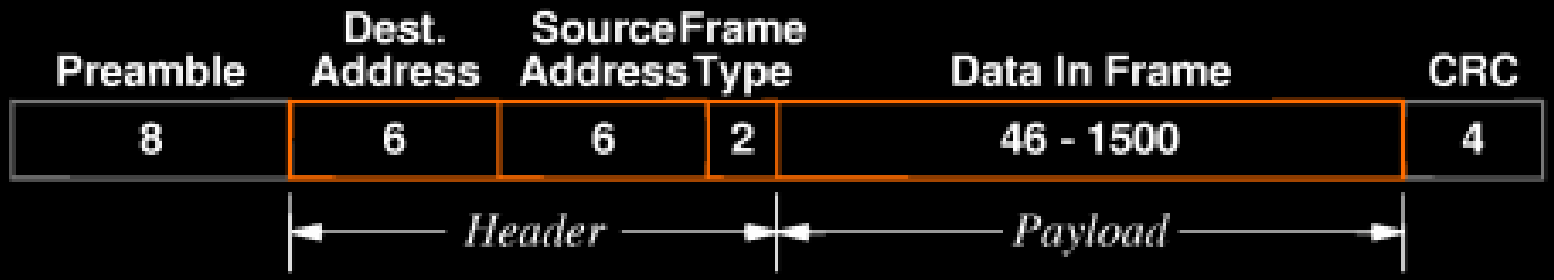
Afterall, all NICs actually receive the packet anyway!

Frame Format

- Each LAN technology defines the exact frame format used with the technology. However, almost all frames has two parts. Header and Body.

Example: Ethernet Frame Format

- Preamble 64 (8 octates) '10101010..' synchronizes hardware.



- 48 bits static destination and source address.
- 16 bit frame type describe content forms.
  - 0800 IP Version 4
  - 8035 Internet reverse ARP, etc.
- 46-1500 byte data.
- 32 bit CRC.

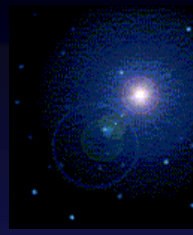
IEEE assigns an unique hardware address to every NIC manufactured in this world!

Example of Frame Types used with Ethernet

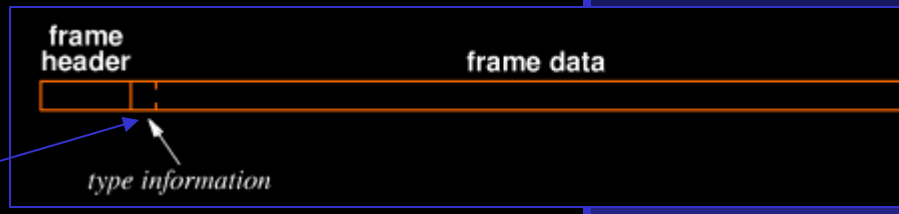
Value	Meaning
0000-05DC	Reserved for use with IEEE 802.3
0800	Internet IP Version 4
0805	CCITT X.25
0900	Ungermann-Bass Corporation network debugger
0BAD	Banyan Systems Corporation VINES
1000-100F	Berkeley UNIX Trailer encapsulation
6004	Digital Equipment Corporation LAT
6559	Frame Relay
8005	Hewlett Packard Corporation network probe
8008	AT&T Corporation
8014	Silicon Graphics Corporation network games
8035	Internet Reverse ARP
8038	Digital Equipment Corporation LANBridge
805C	Stanford University V Kernel
809B	Apple Computer Corporation AppleTalk
80C4-80C5	Banyan Systems Corporation
80D5	IBM Corporation SNA
80FF-8103	Wellfleet Communications
8137-8138	Novell Corporation IPX
818D	Motorola Corporation
FFFF	Reserved

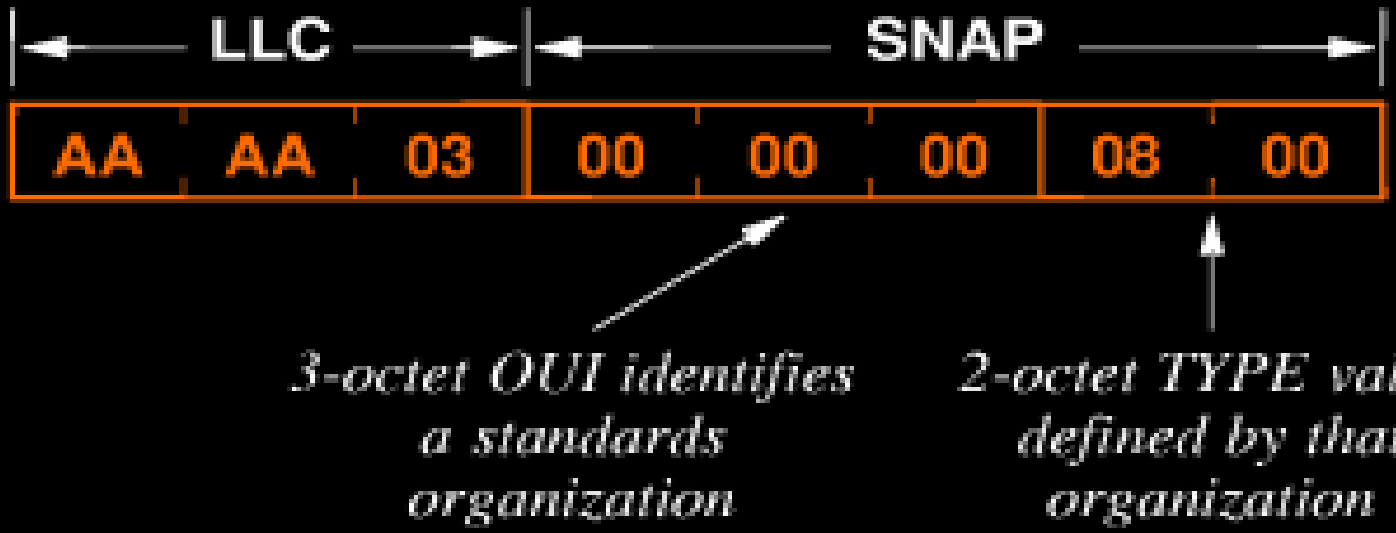
It is important to have standard values for each types of content. However, there are too many standardization organizations!

Solution is….



Logical Link Control (LLC) Subnetwork Attachment Point (SNAP) Header

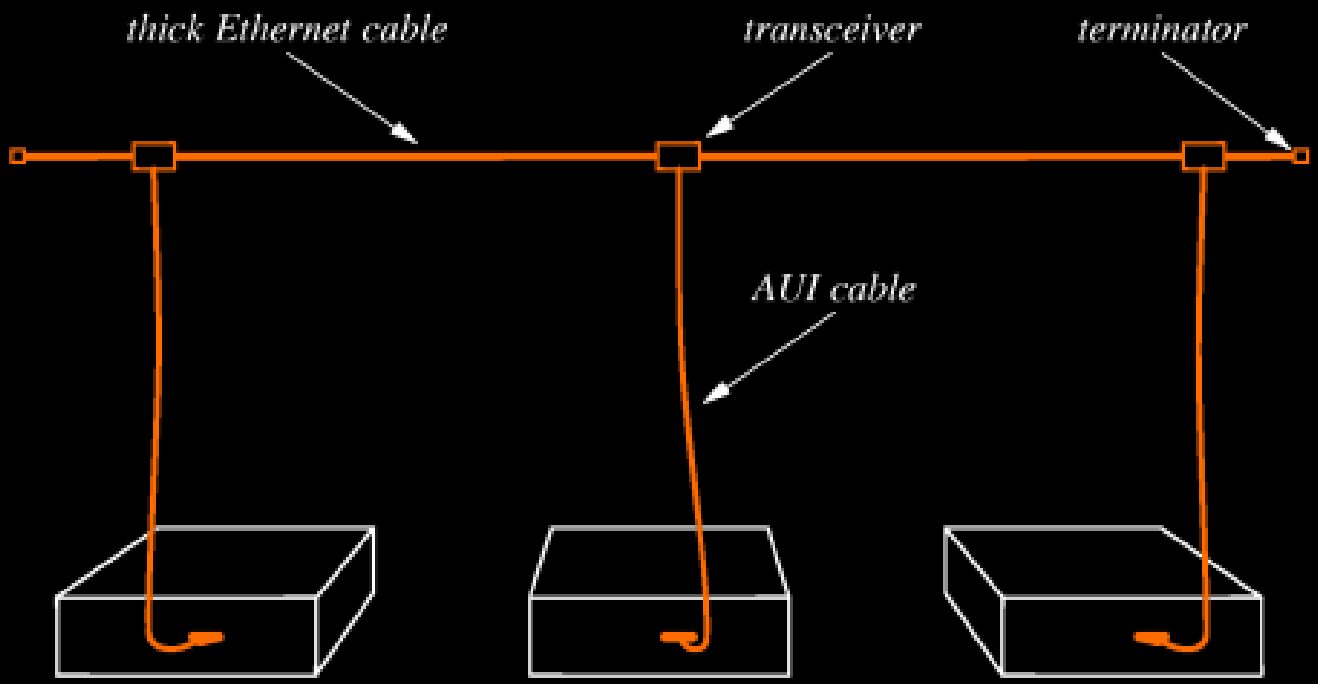


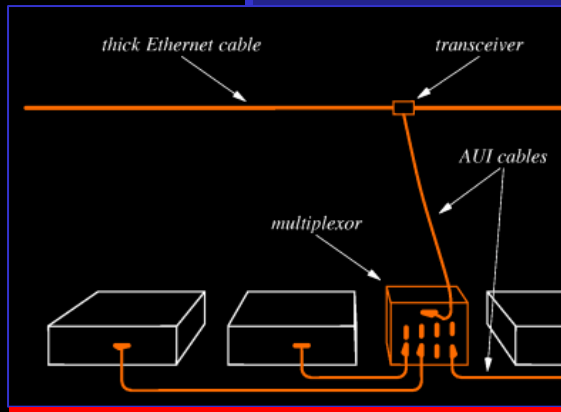


IEEE 802.2 solution to multi standard organizations.

Variations in Physical Topology

Thick Ethernet

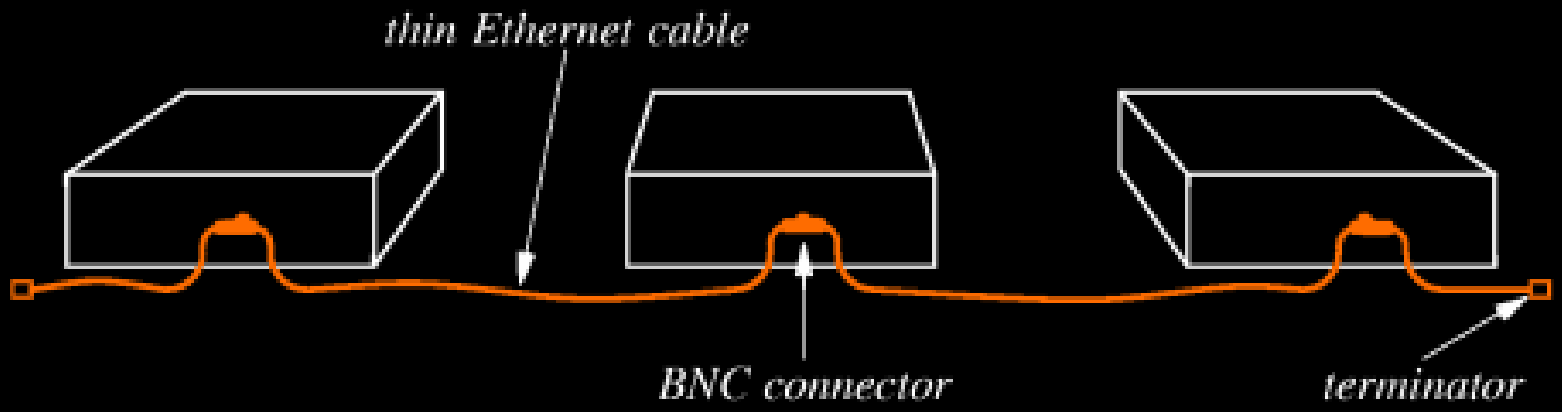




•A connection multiplexor can attach multiple networks using single transreceiver.

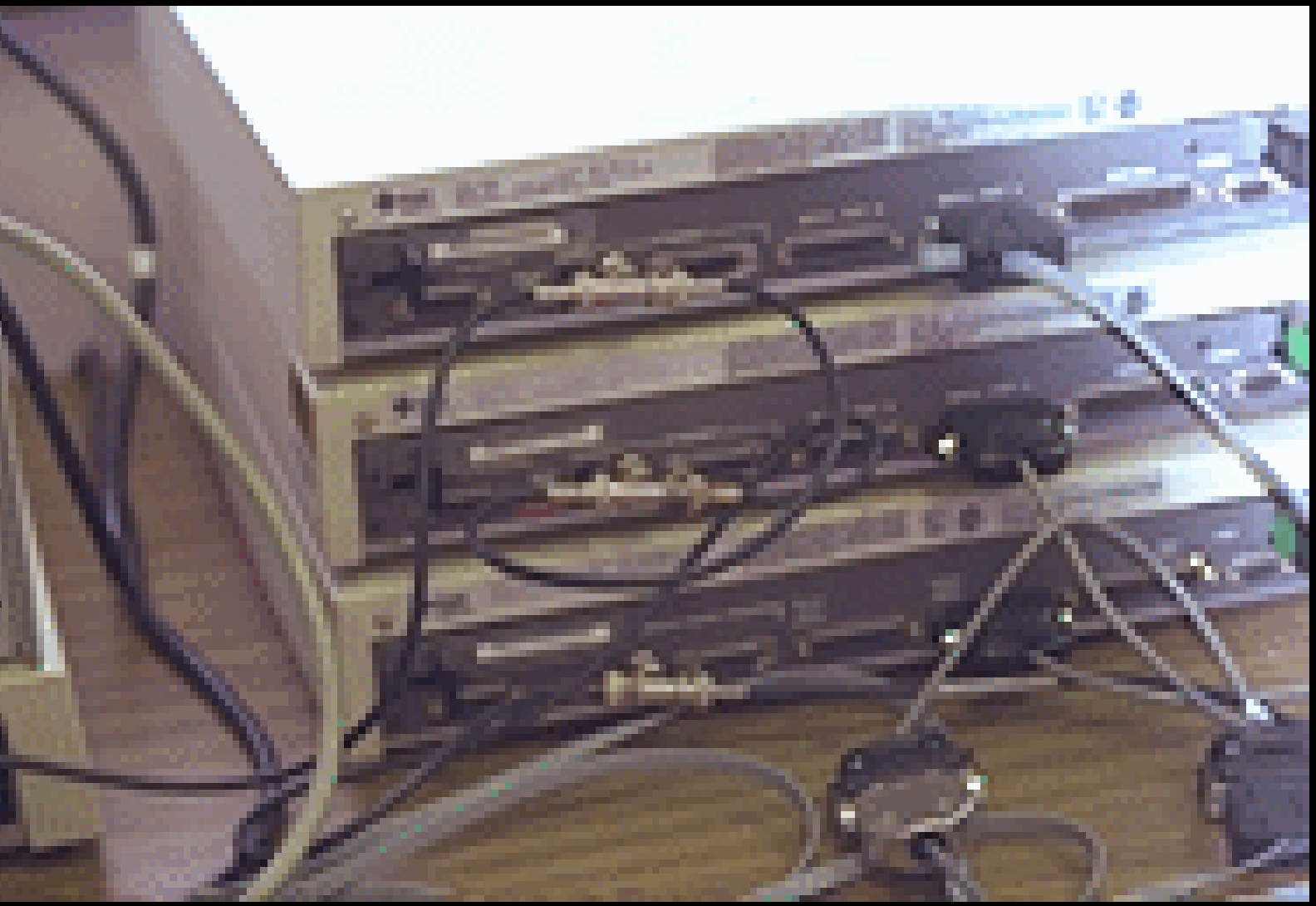
Media: Large coax. NIC is digital. Requires termination.

Thin Ethernet

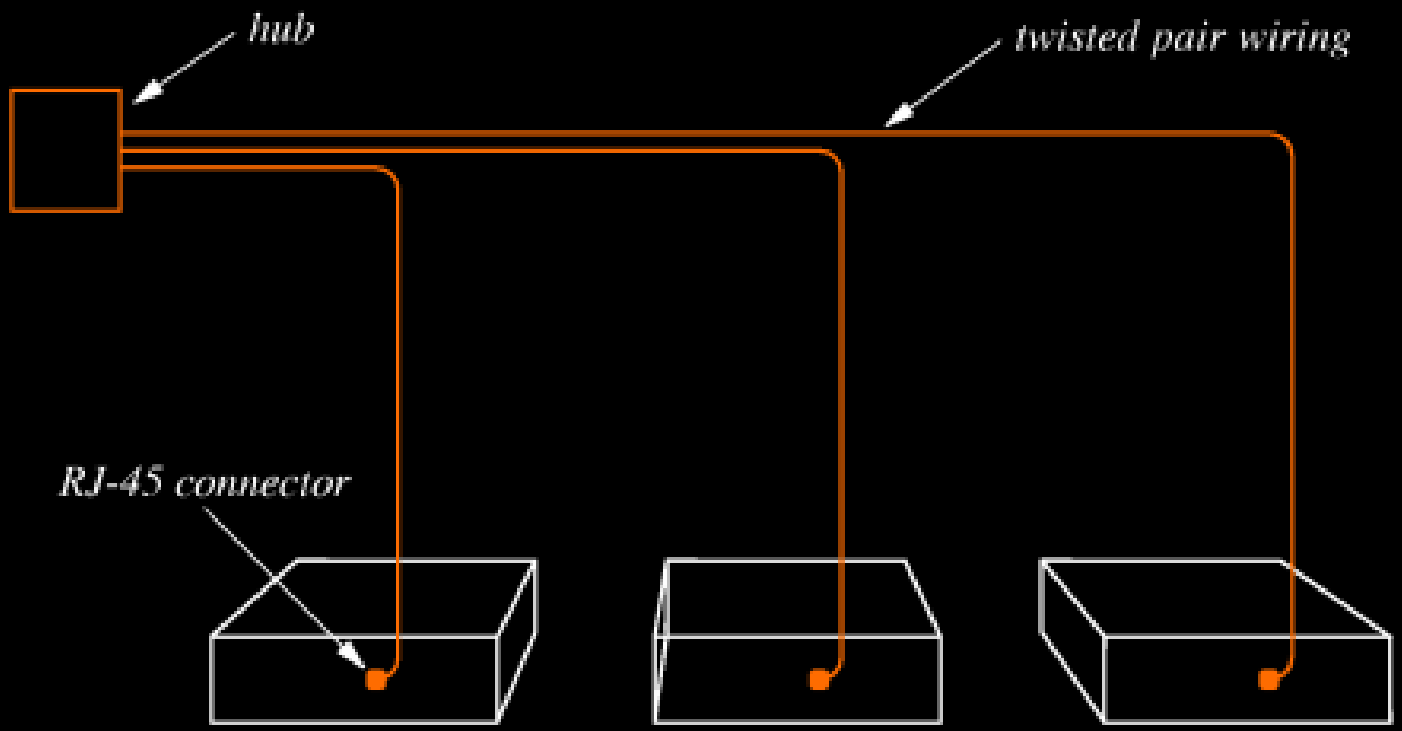


Easy to Insert a new computer!

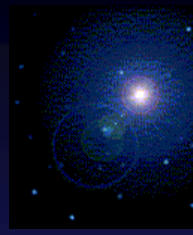
Thin Ethernet Wiring

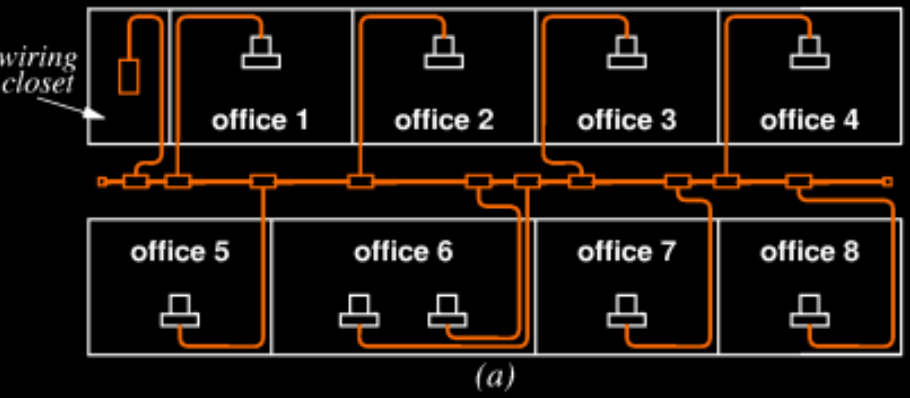


Twisted Pair Ethernet

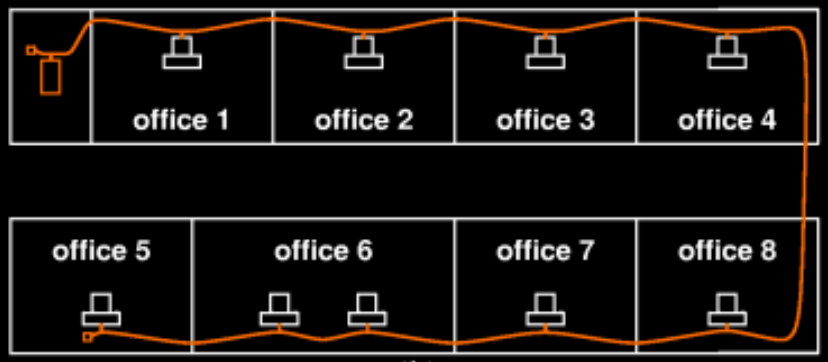


Actually a Star!





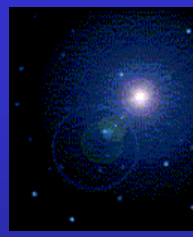
(a)



(b)

(c)

Which is the best way to connect?



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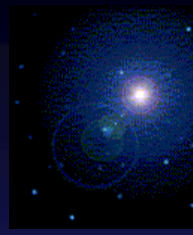

Summary

- Until now we have seen how a group of computers can be connected in a small area Network.
- In the next class we will how these links are established when every computer are not on the same network.
- But before that in the remaining time we will quickly overview the latest technology options available to us to build long distance links.

Next Topic:
Digital Trunk Lines