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Chapter 8
LAN Topologies

Point-to-Point Networks

- In a Point-to-Point network, each wire connects exactly two computers

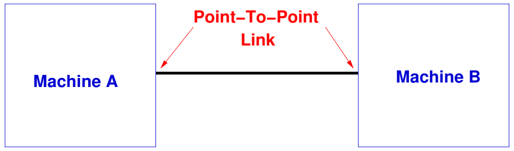
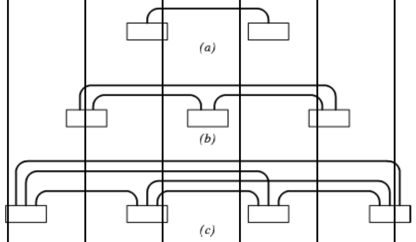


Figure 1: Each line connects two machines

- Advantages

P-t-P Networks: (continued)

- Disadvantages



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Multiaccess Networks

- Problem: P-t-P networks have many lines => high cost
- Solution:
- IDEA:
  - the computers must take turns
  - we need an allocation strategy to determine who's turn it is (TDM, FDM, Statistical Multiplexing)
- Shared lines reduce cost
- But it means you only get a fraction of the line's bandwidth

LAN Topologies

- Networks are typically classified by their shape
- There are three popular shapes:

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Bus Topologies

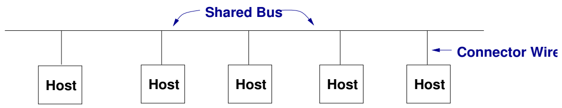
- 

Figure 2: Example Bus Topology

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- Must solve the Channel Allocation Problem .

Ring Topologies

- Computers are connected in a closed loop/ring

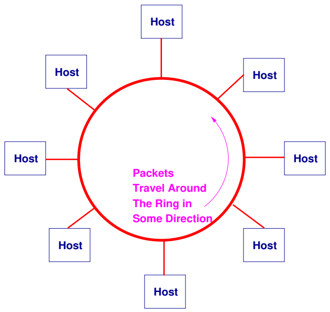

Figure 3: Example Ring Topology

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Star Topologies

- All computers connect to
-
- If it is a multiaccess star, hosts must synchronize their sending.
- If hub does store-n-forwarding of messages, then hosts do not need to synchronize.

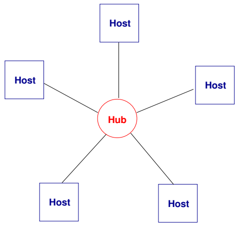

Figure 4: Example Star Topology

Why Multiple Topologies

Each topology has advantages and disadvantages

- Advantages
  - Bus:
  - Ring:
  - Star:
  - Ring:
- Disadvantages
  - Bus:
  - Ring:
  - Ring:
  - Star:

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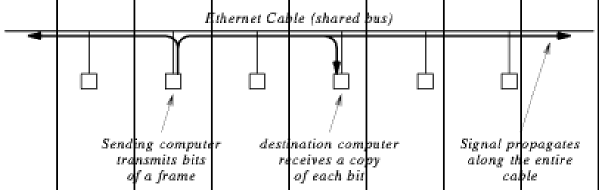
Ethernet: A Bus Network

- is probably most popular LAN technology
- developed at Xerox PARC by R. Metcalf and D. Boggs 1976
- DEC, Intel, and Xerox developed the DIX ethernet standard
- later IEEE defined the ethernet standard
- first versions ran at 3 Mbps
- current versions run at 10 Mbps and 100 Mbps
- is a multiaccess network technology
- is a broadcast-based technology
- is inexpensive because it uses a passive cable
- only provides best-effort service
- higher level protocols do all the real work
- comes in three varietys: thick net, thin net, twisted pair

Ethernet Basics



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Sending Animation

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CSMA/CD

- Carrier Sense, Multiple Access with Collision Detection
- Ethernet is just one example of a CSMA/CD protocol
- The goal is to
- There is no
- THE BASIC IDEA of CSMA/CD protocols is:

CSMA/CD Animation

Ethernet Collision Detection

- Note that CSMA does not prohibit two machines from sending at the same time!
- Consequently, their signals may collide
- How do you detect collisions?
- (Short Packet Animation)

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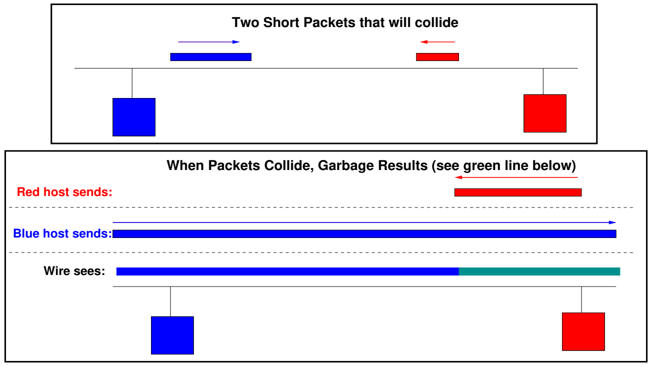

Figure 5: Short Packets might not detect collision

Collision Detection: (continued)

- What should the minimum Length Packet be? (See min-length animation)
- What is the Round Trip Delay of and Ethernet?
- if we transmit for 51.2 usecs, we will have seen the first few bits of a colliding host before we get done transmitting
- thus the minimum transmission time = 51.2 usec
- minimum packet size =

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Ethernet Transmission Algorithm

- wait till idle line, send immediately, and monitor
- you may only send 1500 bytes. Why?
- you must wait 9.6 usec before sending again
- if you detect a collision, continue sending a jam signal until the end of the 51.2 usec interval (the minimum packet length) to make sure everyone sees the collision.
- wait a certain (with slight randomness) amount of time and try again
- if you collide again, double the wait time, then try again, etc.
- called **exponential backoff**

Receiever Algorithm

- the ethernet card sees all packets sent over the ether
- the ethernet card runs in one of two modes:

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LocalTalk

- LAN technology that uses bus topology
- Interface included with all Macintosh computers
- Relatively low speed (230.4 Kbps)
- Low cost (“free” with a Macintosh); easy to install and connect

CSMA/CA

- LocalTalk uses collision avoidance rather than collision detection
- CA = Collision Avoidance
- Transmitting computer sends very short message to reserve bus
- If reservation succeeds, transmitter can use bus without conflict

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Example Ring Networks

- Two popular examples:
  - IBM Token Ring
  - FDDI

IBM Token Ring

- network manages access to the shared ring via a token

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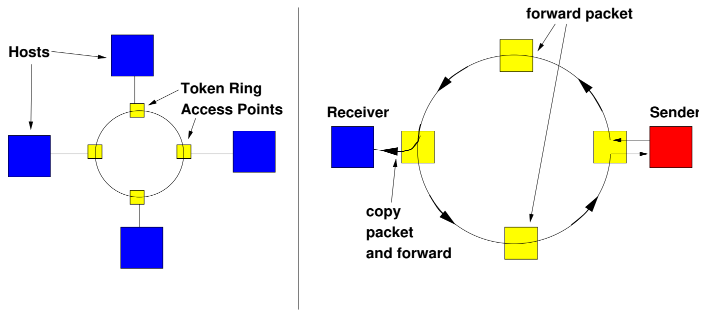

Figure 6: (Left) Abstract Ring (Right) Ring in Operation

Token Ring Animation

The Token

- The token is
- There is only
- A computer must hold the token

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Token Passing Algorithm

-
-
-
-

Token Ring Failures

- What kinds of problems/failurs can occur?

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FDDI (Fiber Distributed Data Interface)

- FDDI was a very popular ring technology
- Ran at 100 Mbps
- Still used in some places, but has been largely replaced by other technologies.
- Gigabit ring networks (follow-ons to FDDI) have also been developed (CSMA/RN)

Physical Characteristics

- runs over fiber
- an alternative version called CDDI runs over copper
- the attachment stations form a Dual, Counter-Rotating Ring

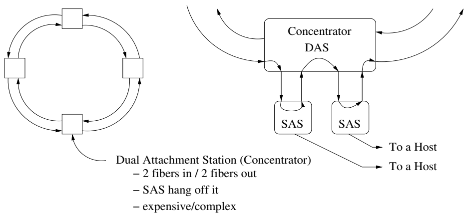

Figure 7: Rings, DAS, and SAS

- only use the outer ring, the inner ring is idle until a failure occurs

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Physical Characteristics: (continued)

- two types of attachments
  - Dual Attachment Stations (DAS)
  - Single Attachment Stations (SAS)
- the network is said to be self-healing
  - a DAS has an optical by-pass that fixes SAS failures
  - each DAS monitors connectivity and reverses the ring if a failure occurs

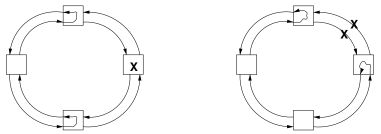

Figure 8: Self-Healing Capability

Physical Characteristics: (continued)

- has a bandwidth of 100 Mbps, latency depends on ring size
- max ring size is 100 Kilometers (really 200 Km / 2 rings)
- max dist between stations is 2 Km
- max of 500 stations
- each station adds a 50 ns delay because of an elasticity buffer.
- uses 4B/5B encoding
- max packet length is approx 4500 bytes

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Token Rotation Algorithm

- you are allowed to send data as long as you hold the token
- How long can you hold the token?

Setting THT

- if (THT is small)
- if (THT is large)
- **TTRT (Target Token Rotation Time)**
  - want a TTRT Target Token Rotation Time for the ring that is as big as possible to get the best efficiency, but small enough so that everyone is happy
  - FDDI selects the minimum of all hosts desired TRT's as the ring's TTRT (vie a bidding algorithm)
  - each machine tries to keep the token rotating at the TTRT speed

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Setting THT: (continued)

- each hosts measures the last rotation time MTRT (Measured Token Rotation Time)
- if (MTRT $<$ TTRT)
  - ∗ the token is moving faster than it needs to
  - ∗ you are allowed to hold the token for a maximum of THT = (TTRT - MTRT)

- if (MTRT $>=$ TTRT)
  - the token is behind schedule
  - you must forfeit your turn and send the token on immediately

When do you send the token?

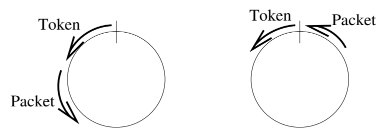

Figure 9: When to send the Token?

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ATM (Asynchronous Transfer Mode)

- does not stand for Automated Teller Machine
- is a packet switching system
- spans the physical, data link, and network levels
- standards are still in development (CCITT and ATM forum)
- highly influenced by the Telephone industry
- a goal of ATM was to be able to send voice, data, and video over the same network (merge computer and voice networks)
- also need to carry control information (things needed to support new telephone services like call forwarding, call-waiting, discount dialing plans, etc) In the past this information ran over a parallel network to the voice network.

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Goals and Assumptions

1. ATM networks will be organized as a two-level hierarchy consisting of user and network level machines/switches
   - we need a network-network interface (NNI)
   - and we need a user-network interface (UNI)
2. should provide connection-oriented service; set up a "channel" to communicate
3. should be run over fiber and have very low error rates
   - subgoal is to provide Quality-of-Service such as guaranteed bandwidth, latency, interpacket arrival times, etc.
   - can only do this is the communication links do not introduce errors
4. should allow low cost attachements (ATM telephone devices)
   - standards body decided to prohibit cell reordering
   - cells must arrive at the receiver in order across the link

- this means end-point devices can be made with much simpler bufferring schemes
- in particular, they can use FIFO memory instead of RAM memory
- ATM telephones can just play the samples as they arrive

- ATM typically carried over some fiber-based data link layer like SONET
- uses cells (really just another term for packet)

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What is a Cell?

- Recall that Packets can be any size (i.e., they adjust their size to fit the data)
- A Cell is just a fixed length packet (usually a small packet)
- Cells are always the same size (even if you want to send a single bit or byte)
- ATM uses 53 byte cells : 48 bytes of payload and 5 bytes of header
-

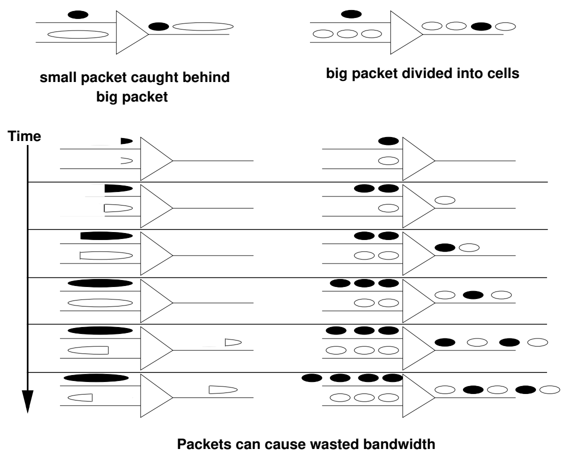

Figure 10: Cells have small queueing delays

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Characteristics of ATM

- each switch is a star topology
- switches can by hooked together
- uses connection-oriented communication between machines
- destination identified by a “connection id”

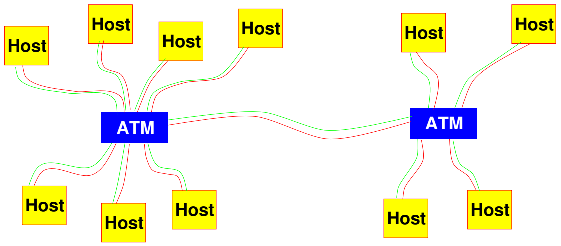

Figure 11: Example ATM Network

Pictures of Real ATM Switches

- Each machine uses two fiber optic lines to connect to the switch
- Typically multimode fiber is used running at 155 Mbps

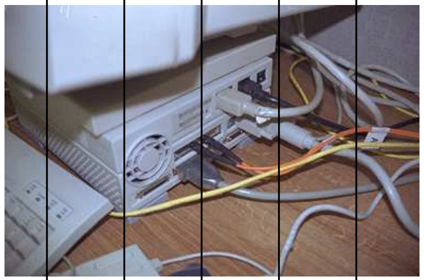

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Figure 12: Fibers into back of a Sparc IPC

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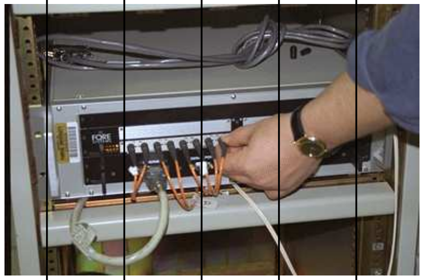
Pictures of Real ATM Switches



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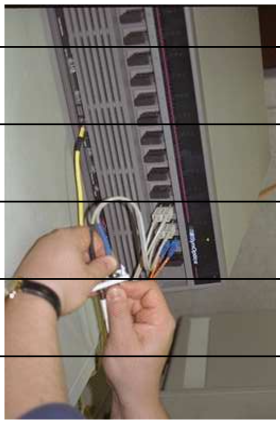

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