Key Features Of A LAN

- High throughput
- Relatively low cost
- Limited to short distance
- Often rely on *shared media*

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*

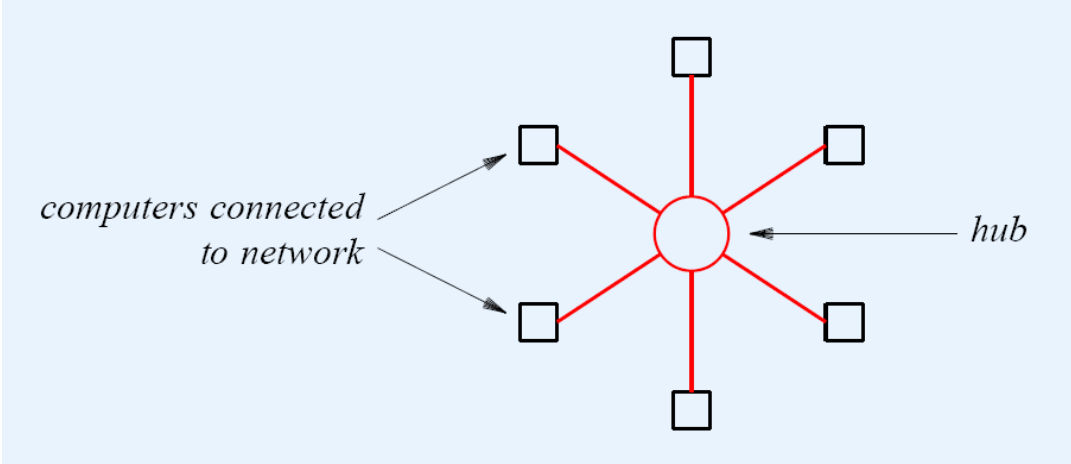
Topology

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

Network Topology

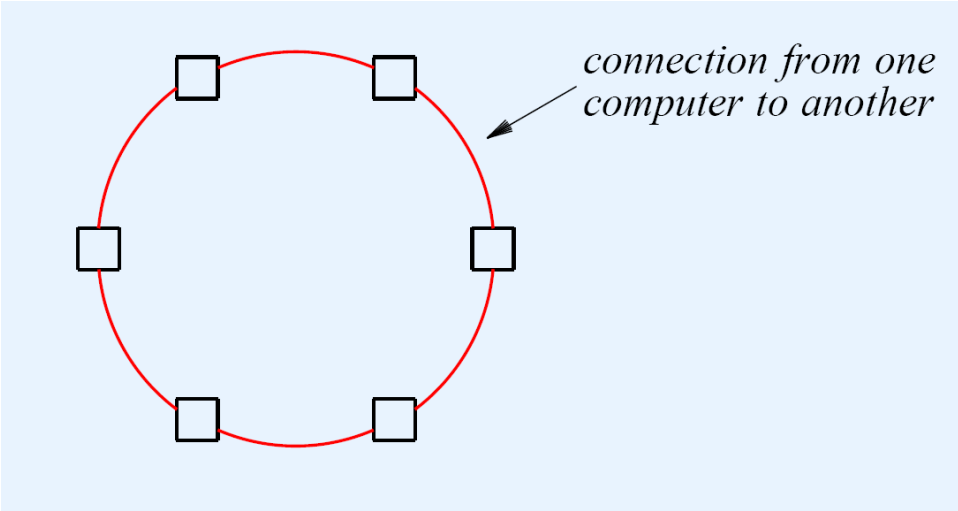
- Specifies general “shape” of a network
- Handful of broad categories
- Often applied to LAN
- Primarily refers to interconnections
- Hides details of actual devices

Star Topology



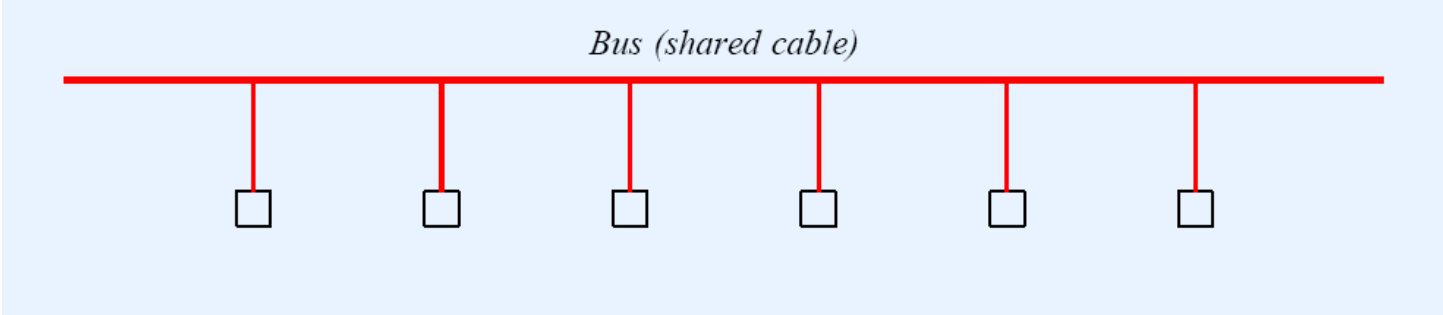
- Central component of network known as *hub*
- Each computer has separate connection to hub

Ring Topology



- No central facility
- Connections go directly from one computer to another

Bus Topology



- Shared medium forms main interconnect
- Each computer has a connection to the medium

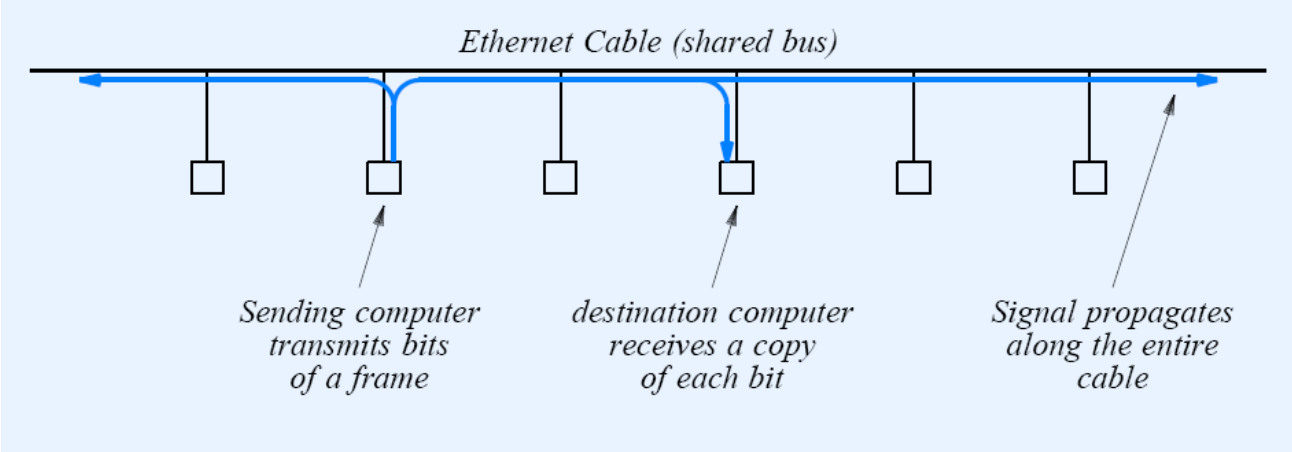
Example Bus Network: Ethernet

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

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
- Signal propagates across entire cable
- All stations receive transmission
- CSMA/CD media access scheme

CSMA/CD Paradigm

- 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

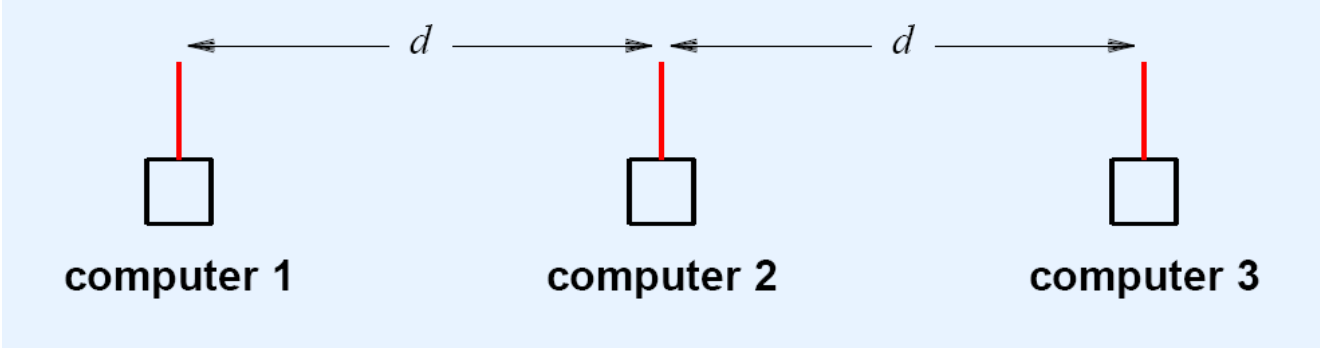
CSMA/CD Paradigm (continued)

- 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

Backoff After Collision

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

Media Access On A Wireless Net



- 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

- 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*)

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)

Identifying A Destination

- All stations on shared-media LAN receive all transmissions
- To allow sender to specify destination
  - Each station assigned unique number
  - 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
- All stations receive a transmission
- Station discards any frame addressed to another station
- Important: interface hardware, not software, checks address

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 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
  - Determines multicast address to accept
  - Informs network interface card

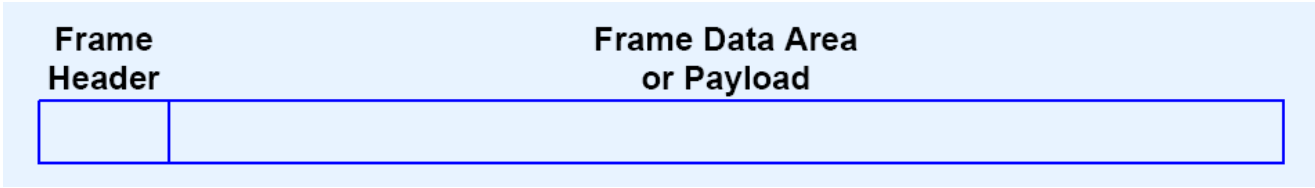
Promiscuous Mode

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

Identifying Frame Contents

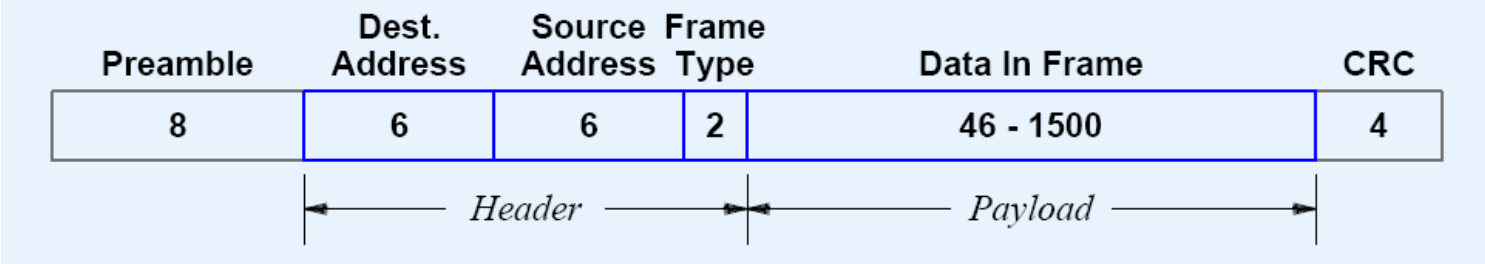
- Integer *type field* tells recipient the type of data being carried
- Two possibilities
  - *Self-identifying* or *explicit type* (hardware records type)
  - *Implicit type* (application sending data must handle type)

Conceptual Frame Format



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

Illustration Of Ethernet Frame



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

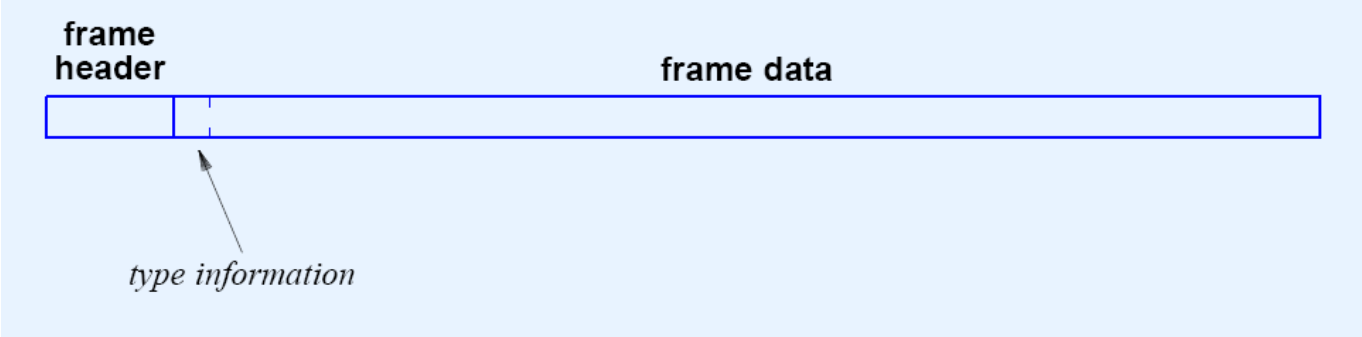
Example Ethernet Types

Value	Meaning
0000-05DC	Reserved for use with IEEE LLC/SNAP
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

When Network Hardware Does Not Include Types

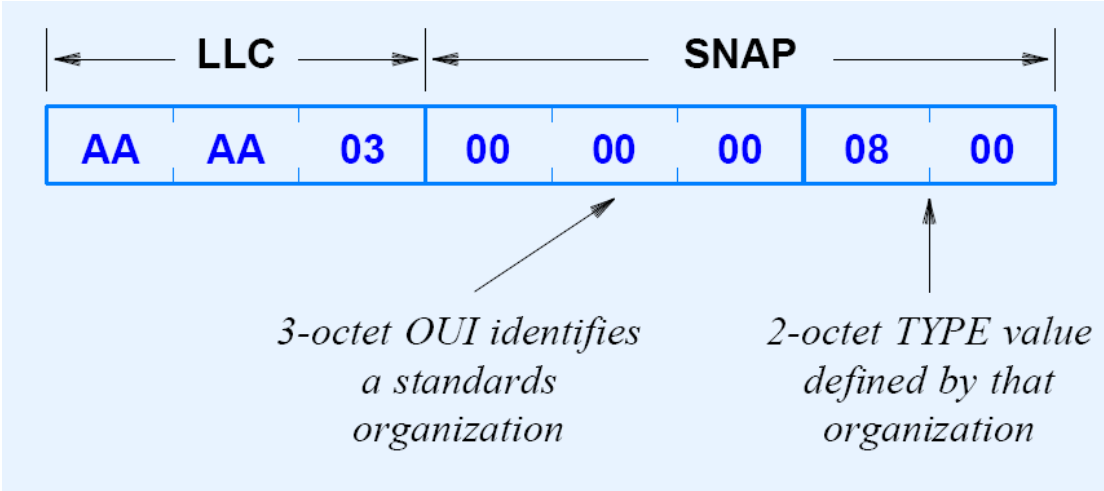
- Sending and receiving computers must agree
  - To only send one type of data
  - To put type information in first few octets of payload
- Most systems need type information

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



- Defined by IEEE
- Used when hardware does not include type field
- Called *LLC/SNAP header*

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

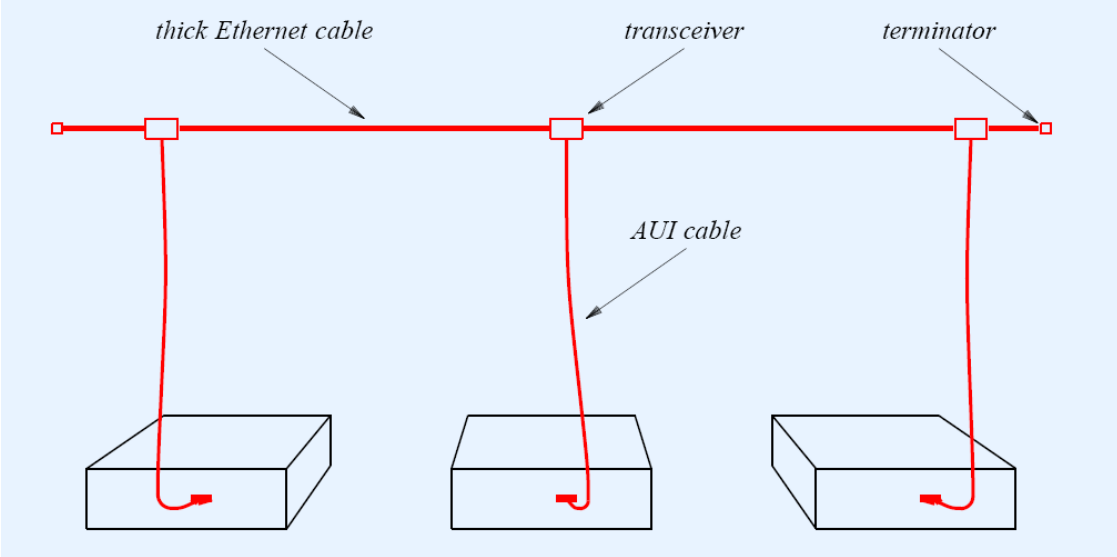
Network Analyzer

- 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)

Ethernet Wiring

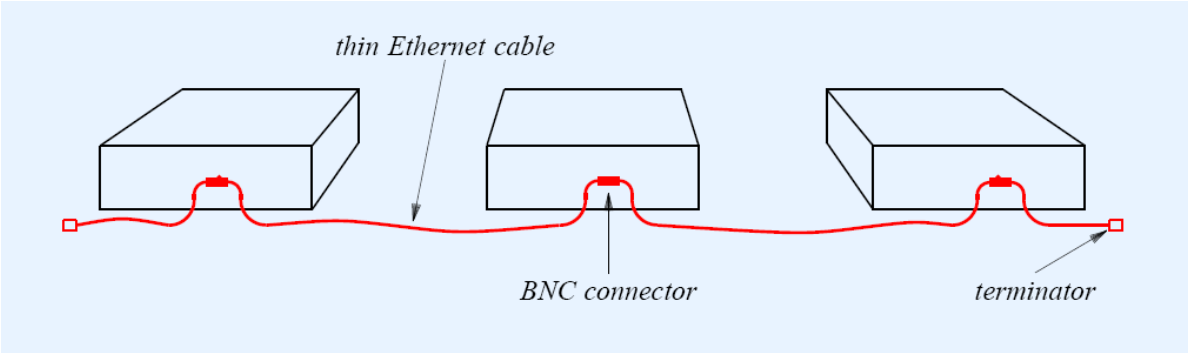
- Three schemes
  - Correspond to three generations
  - All use same frame format

Original Ethernet Wiring



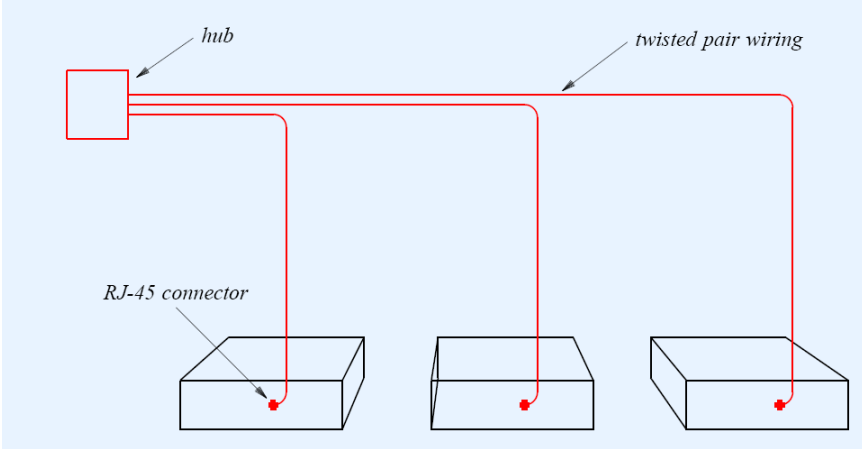
- Used heavy coaxial cable
- Formal name *10Base5*
- Called *thicknet*

Second Generation Ethernet Wiring



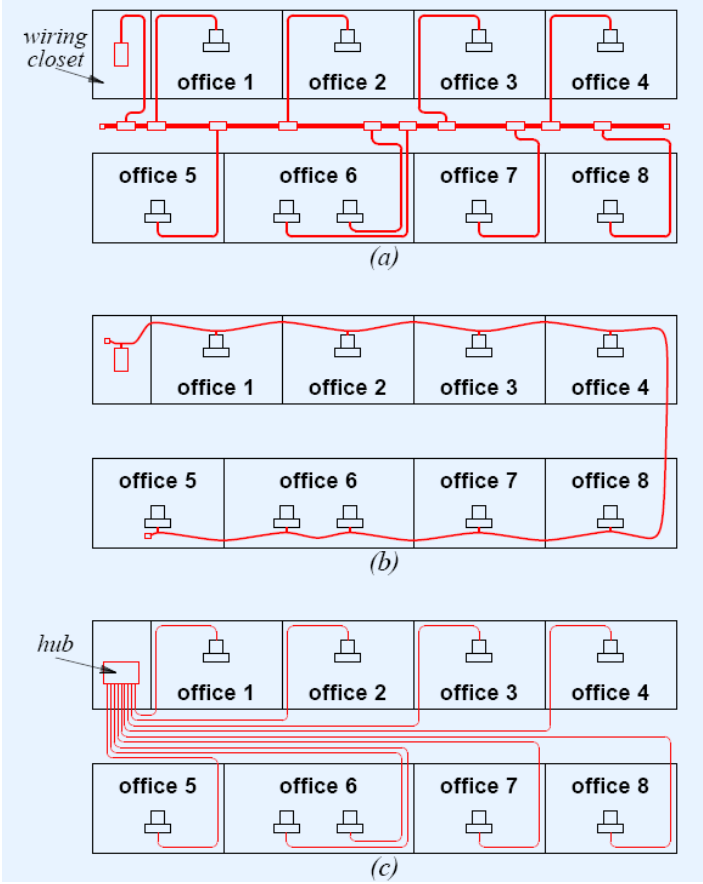
- Used thinner coaxial cable
- Formal name *10Base2*
- Called *thinnet*

Modern Ethernet Wiring



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

Ethernet Wiring In An Office



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*

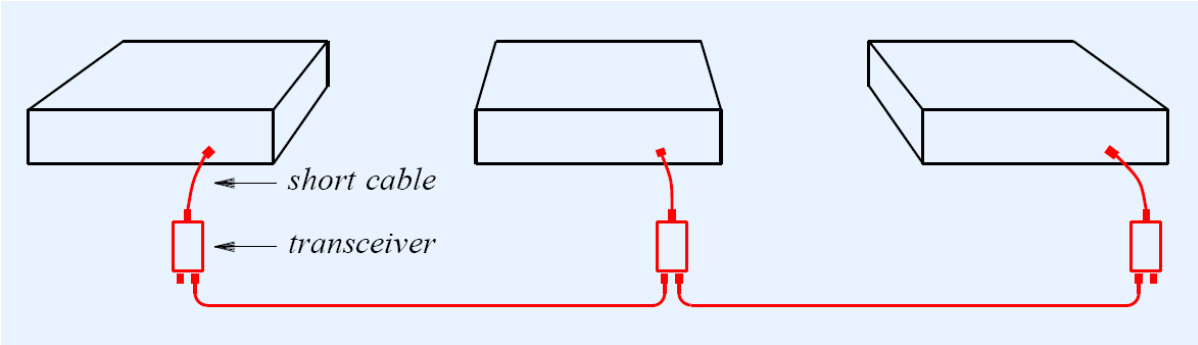
Higher Speed Ethernets

- *Fast Ethernet*
  - Operates at 100 Mbps
  - Formally *100Base-T*
  - Two wiring standards
  - 10/100 Ethernet devices available
- *Gigabit Ethernet*
  - Operates at 1000 Mbps (1 Gbps)
  - Slightly more expensive

Another LAN Using Bus Topology

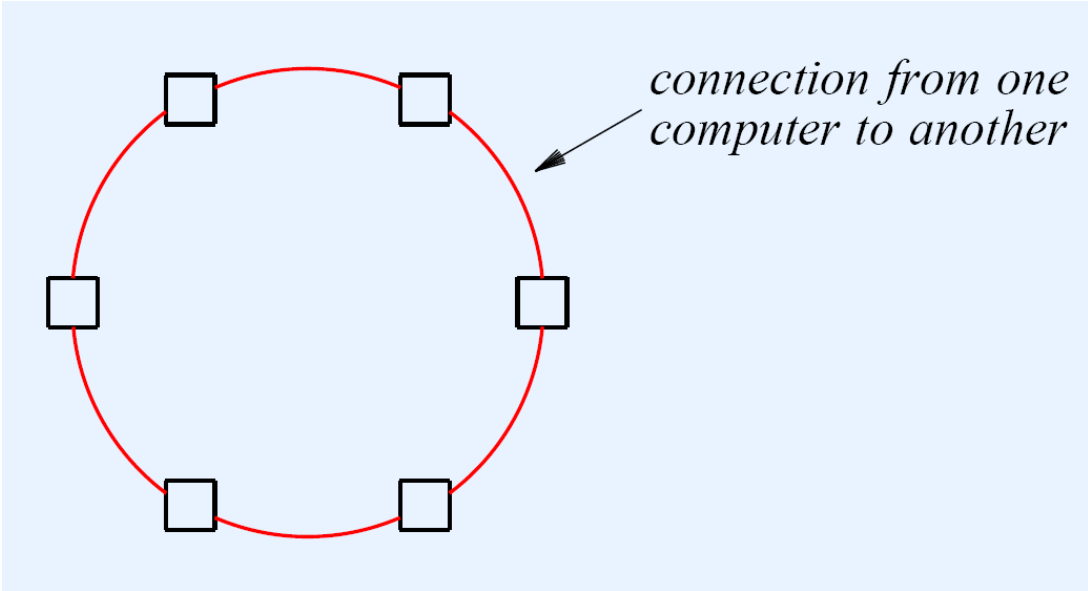
- LocalTalk
  - Developed by Apple Corp.
  - Simple to use
  - Slow by current standards

Illustration Of LocalTalk



- Transceiver required per station
- Transceiver terminates cable

Ring Topology



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

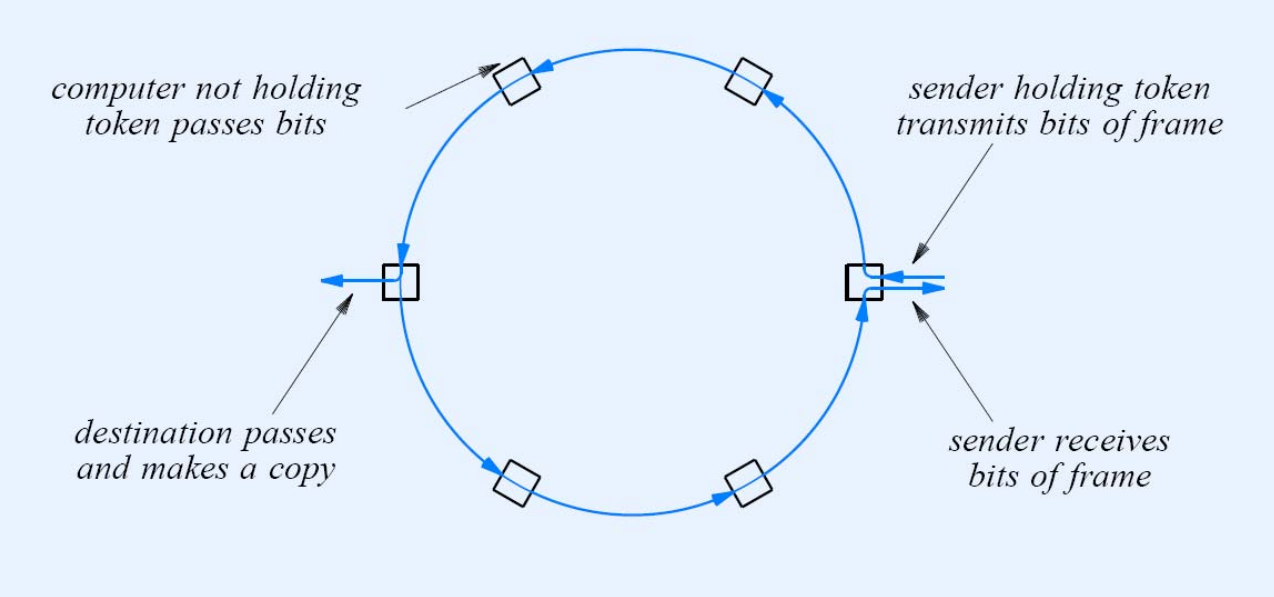
Token Passing

- 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

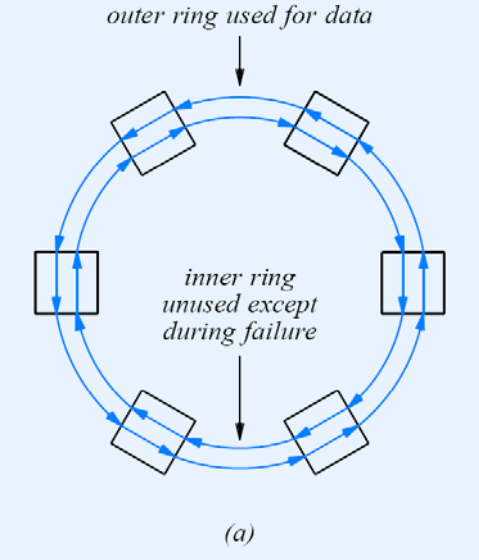
Weaknesses Of Token Ring Approach

- 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
- Uses two rings
- Terminology
  - *Dual-attached*
  - *Counter rotating*
  - *Self healing*

Illustration Of Failure Recovery



- Normal operation uses one of two rings