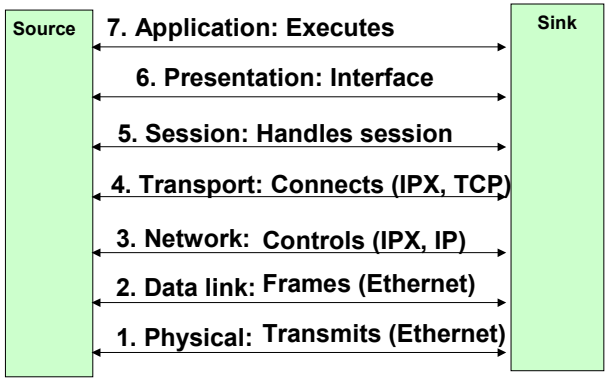
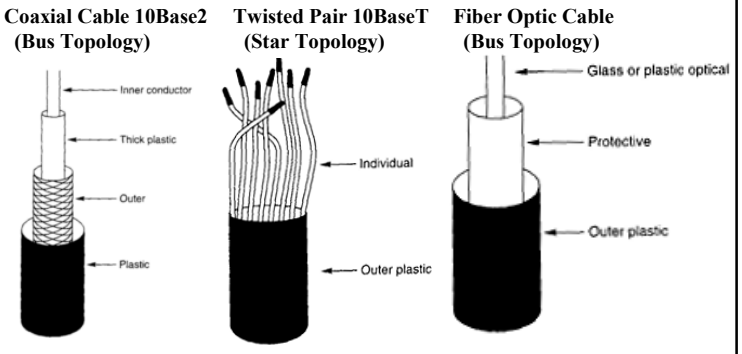
OSI Model for LAN
(Open Systems Interconnection)



1

Layer 1: Physical, Cabling

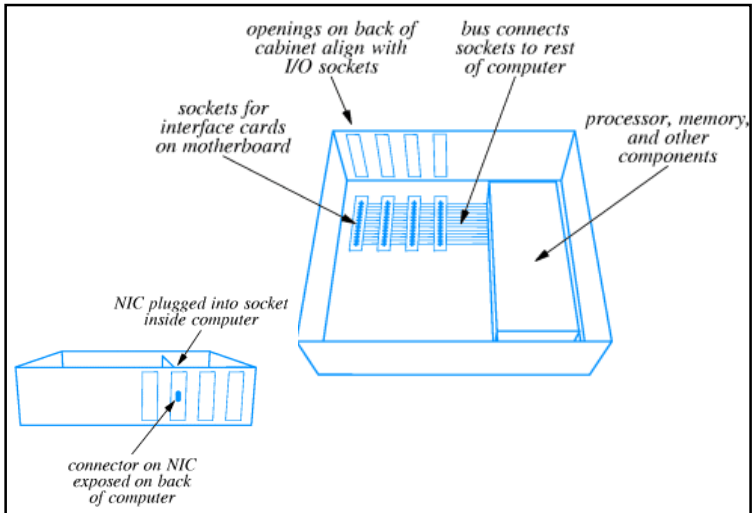


2

Layer 1: Physical, NIC

- CPU can't process data at network speeds
- Computer systems use special purpose hardware for network connection
  - Typically a separate card in the motherboard
  - Network adapter card or network interface card (NIC)
- Connector at back of computer then accepts cable to physical network

3



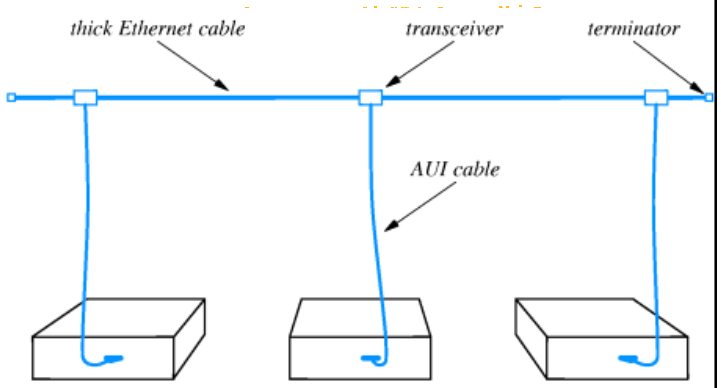
Layer 1: Physical, Ethernet

- Most Widely used LAN technology
  - Invented at Xerox PARC in 1970s
  - Standard now managed by IEEE defines frame formats, voltages, and cables
- Three Physical Layer 1 formats available:
  - 10Base5: Thick-net, Original, (Archaic)
  - 10Base2: Thin-net, Thinner flexible Coax
  - 10Base-T: Twisted Pair wires to Hub

LAN: 10Base5 Ethernet

- Uses thick coax cable
- AUI cable
  - Connects from computer to transceiver
  - AUI cable carries digital signal
- Transceiver generates analog signal on coax
- Thick Ethernet requires termination to avoid signal reflectance

LAN: 10Base5 Ethernet

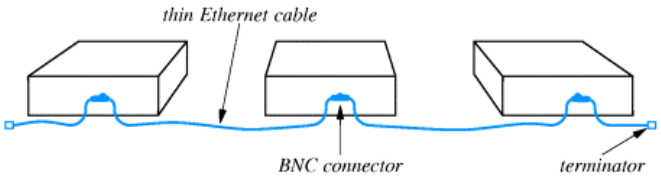


LAN: 10Base2 Ethernet

- Uses thin coax that is cheaper and easier to install than thick-net Ethernet coax
- Transceiver electronics built into NIC
- NIC connects directly to network medium
- Coax cable uses standard BNC connector

LAN: 10Base2 Connections

- Coax runs directly to back of each connected computer
- T connector attaches directly to NIC
- A broken wire will bring network down

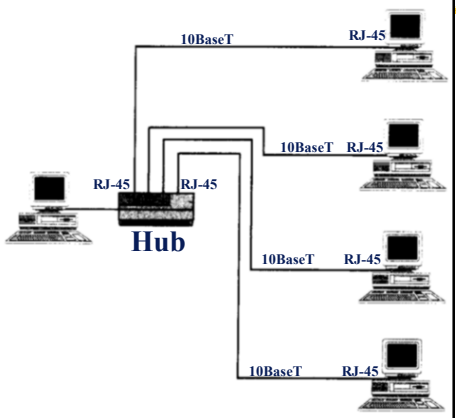


LAN: 10Base-T Ethernet

- Uses twisted pair wires connected to Hub
- Replaces AUI cable with twisted pair cable
- Replaces thick coax with hub
- Uses RJ45 jacks at NIC and Hub

LAN: 10Base-T Ethernet

- Hub contains the bus
- Effectively a very short bus with very long AUI cables



Comparison of wiring schemes

- 10Base5: Separate transceiver allows computer to be disconnected from network without disrupting other communication
  - Finding bad transceiver can be difficult
- 10Base2: Thin coax requires minimum of cable
  - Disconnecting one computer can disrupt entire network
- 10Base-T: Hub wiring centralizes electronics and connections, making management easier

Layer 1: Ethernet Limitations

- Cable Lengths
  - Limited to 500 meters in length
  - Minimum separation is 3 meters
- Speed
  - Originally 3Mbps
  - Current standard is 10Mbps
  - Fast Ethernet operates at 100Mbps

13

LAN: Layer 2, Data Link, NICs

- Network Interface Cards (NICs)
- Dependent on Network Topology Used
  - Bus Topology: Ethernet
    - Contention-based
    - First-come, first-served
    - Collisions occur when load is heavy
  - Star Topology: AT&T STARLAN
  - Ring Topology: IBM Token Ring
    - Token required to send a message

14

Sharing communication media

- Circuit Switching
  - Telephone and dedicated channel
- Packet Switching
  - Shared media interconnects all computers
  - One source can transmit data at a time

15

Packets

- Most networks divide data into small blocks called *packets* for transmission
- Each packet sent individually
- Resource sharing - allows multiple computers to share network infrastructure
- Packet Networks enforce *fair use* - each computer can only send one packet at a time

16

Frames

- Each hardware technology uses different packet format
- *Frame* or *hardware frame* denotes a packet of a specific format on a specific hardware technology

Beginning flag	Address	Control	Message	Frame check character	Ending flag

Time-division multiplexing

- Dividing data into small packets allows *time-division multiplexing*
- Each packet leaves the source and is switched onto the shared communication channel through a *multiplexor*
- At the destination, the packet is switched through a *demultiplexor* to the destination
- Animation available:
  http://www.islandman.org/umuc/ifsm450/anim05_1.htm

Frame formats

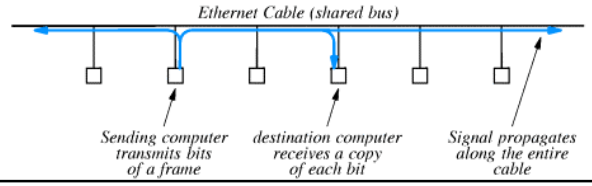
- Need to define a standard format for data to indicate the beginning and end of the frame
- *Header* and *trailer* used to "frame" data
  - ASCII, *start of header"* (soh)
  - ASCII, *end of text"* (eot)

soh	block of data in frame	eot

- Sender sends soh first, then data, finally eot
- Receiver interprets and discards soh, stores data in buffer, and interprets and discards eot
- Animation available:
  http://www.islandman.org/umuc/ifsm450/anim05_2.htm

Ethernet LAN Operation

- One computer transmits at a time
  - Signal is a modulated carrier which propagates from transmitter in both directions along length of segment
- Animation available:
  http://www.islandman.org/umuc/ifsm450/anim06_1.htm



CSMA

- No central controls when computers transmit on ether
  - Ethernet employs CSMA to coordinate transmission among multiple computers
- Carrier Sense with Multiple Access
  - Carrier sense - computer wanting to transmit tests ether for carrier before transmitting
  - Multiple access - multiple computers are attached and any can be transmitter
- Animation available:
  http://www.islandman.org/umuc/ifsm450/anim06_2.htm

21

Collision detection - CD

- Even with CSMA, two computers may transmit simultaneously
  - Both check ether at same time, find it idle, and begin transmitting
- Signals from two computers will interfere with each other
- Overlapping frames is called a collision
  - No harm to hardware
  - Data from both frames is garbled
- Animation available:
  http://www.islandman.org/umuc/ifsm450/anim06_5.htm

22

Recovery from collision

- Computer that detects a collision sends special signal so other computers detect collision
- Computer waits for ether to be idle before transmitting
  - If both computers wait same length of time, frames will collide again
  - Standard specifies maximum delay, and both computers choose random delay less than maximum
- After waiting, computers use carrier sense to avoid subsequent collision
- Other computers may transmit first

23

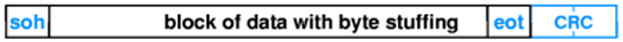
Transmission Error Detection and Correction

- External electromagnetic signals can cause incorrect delivery of data
  - Data can be received incorrectly
  - Data can be lost
  - Unwanted data can be generated
- Error detection - send additional information so incorrect data can be detected and rejected
- Error correction - send additional information so incorrect data can be corrected and accepted

24

Cyclic Redundancy Checks

- The preferred method of error detection for computer network
- Easy to implement in hardware
- CRC bytes added at end of frame



Specifying a destination

- Data sent across a shared network reaches all attached stations - for all LAN topologies
- Interface hardware detects delivery of frame and extracts frame from medium
- But ... most applications want data to be delivered to one specific application on another computer - not all computers

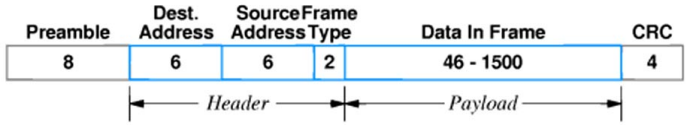
Hardware addressing

- Needs hardware addressing scheme that identifies stations on the network
- Each station is assigned a *numeric hardware address* or *physical address*
- Sender includes hardware address in each transmitted frame
- Only station identified in frame processes copy of frame
- Most LAN technologies include sender's hardware address in frame, too

Assigning LAN hardware addresses

- LAN Hardware addresses must be unique
- Static:
  - Hardware manufacturer assigns permanent address to each interface
- Dynamic:
  - Address can be set by end user, either through switches or software interface
- Automatic:
  - Interface automatically assigns hardware address each time it is powered up

Ethernet frame format



Field	Purpose
Preamble	Receiver synchronization = 101010101
Dest. addr.	Identifies intended receiver 1111111…1 = Broadcast
Source addr.	Hardware address of sender
Frame type	Type of data carried in frame
Data	Frame payload
CRC	32-bit CRC code

NIC hardware processing

- **LAN interface handles all details of frame transmission and reception**
  - **Adds hardware addresses, error detection codes, etc. to outgoing frames**
  - **May use DMA to copy frame data directly from main memory**
  - **Obeys access rules (CSMA/CD) on transmit**
- **Checks destination address on all incoming frames (Accept/Ignore)**

OSI Model

(Open Systems Interconnection)