Simplex, Duplex, Multiplex

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How do we share a transmission medium?

Simplex One-way communication (one-way road)
    Example: Optical fiber

Duplex Two-way communication (two-way road); transmit and receive simultaneously
    Example: 'Full' optical fiber cable, with some fibers for transmitting and some for receiving

Half-Duplex Two-way communication (two-way road); transmit and receive, but not simultaneously
    Example: Walkie-talkie, construction zone with alternating traffic

Multiplexing the process of sharing a tranmission medium among multiple devices / signals.
    Take several distinct signals and interleave them in a way that can be be separated at the receiving end.

Multiplexing

Frequency Division Multiplexing (FDM)

- Divides medium into different frequency bits

- Each signal is sent simultaneously but on a different frequency band

    - FM Radio
    - Cable TV

Time Division Multiplexing (TDM)

- Devices take turns using the medium in a round-robin manner.

- Multiplexes signals at the baseband level by assigning different time slots to each signal.

- Is 'baseband' if the signal uses the entire bandwidth of the medium.

Statistical Time Division Multiplexing

A more dynamic version of TDM where time slots are based on needs rather than fixed turns. Efficient use of bandwidth by allocating time only when devices need it. FDM and TDM are not mutually exclusive and can be combined.

Ethernet and Network Technologies

We know how data is sent across a transmission medium. How is data transferred over a local network?

WAN and LAN

WAN is strictly in Layer 2.

LAN Small geographic span

- 10s to 1000s of meters
- Used in offices and homes
- Modest bandwidth
- Low latency
- ethernet / WiFi

WAN Large geographic span

- state, country, globe
- Connects networks via routers
- Huge bandwidth
- High latency
- Optical fiber / satellite

Principles of Ethernet

Designed as a simple way to connect multiple devices in a local network.

1. All devices connect to a *common communication channel*, sharing access to transmit data.

2. Any message sent is *broadcasted to all hosts* on the network, and each host determines if the message is relevant to them.

3. Data transmission is *unreliable* - there is no guarantee of delivery, and no acknowledgment of receipt.

4. There is no *central authority* managing access to the channel. Hosts *negotiate access* amongst themselves.

Thicknet (10Base5)

- Shared coaxial cable bus

- Attachment Unit Interface (AUI) cable run to a transceiver, which connects to the computer's network card.

- 10Base5: 10 Mbps, Baseband, max length 500 meters.

- Thich rigid cables (hard to install).

Thinnet (10Base2)

- Replaced thicknet with thinner coaxial cables

- Shared bus runs from computer to computer using BNC-T connectors

- More flexible and easier to work with.

- Chained directly from one computer to the next.

- 10Base2: 10 Mbps, Baseband, max length 200 meters.

Hub-Based Twisted Pair (10BaseT / 100BaseTX)

- Uses twisted pair wires (CAT5, 6, 8, etc.)

- All devices connect to a central hub ('bus in a box')

- No taps, instead connects directly from network card to hub

- 10BaseT: 10 Mbps, Baseband, max length 100 meters.

- Speeds increased to 10 / 100 / 1000 Mbps

Switch-Based Twisted Pair (1000BaseTX)

- Switches replace hubs for more efficient data transmission

- Each device has dedicated ethernet cable running to switch

- Switch enables all devices to connect and communicate efficiently

Ethernet Hardware Addressing

On a shared bus network, every device (host) receives all messages. Thus, each host must determine 'is this frame for me?' To achieve this, every frame contains:

- Source HW address

- Destination HW address

MAC Address

Media Access Control address used for frame delivery. Structure

- 48 bits (6 bytes)

- Written in hexadecimal format (e.g., B8:27:EB:1E:2D:4F)

- Colons separate octets

Assignment of MAC Addresses   Manufacturers buy blocks of MAC addresses from IEEE.

$$\underbrace{B8}_{asdf} : CA : 3A : B9 : F3 : D2$$

Can temporarily change (spoof)

- Debugging

- Malicious activities

Unicast Specifies a single device.

Broadcast All devices on the network.
    All 1s in binary, FF:FF:FF:FF:FF:FF in hexadecimal.

Multicast Sent to a specific group of devices.

Promiscuous Mode

- Allows a network card to accept all frames, regardless of destination.

- Commonly used for network debugging or Wi-Fi monitoring.

Ethernet Frames

Link Layer exists to exchange messages across a *physical network*.
    Messages are frames...