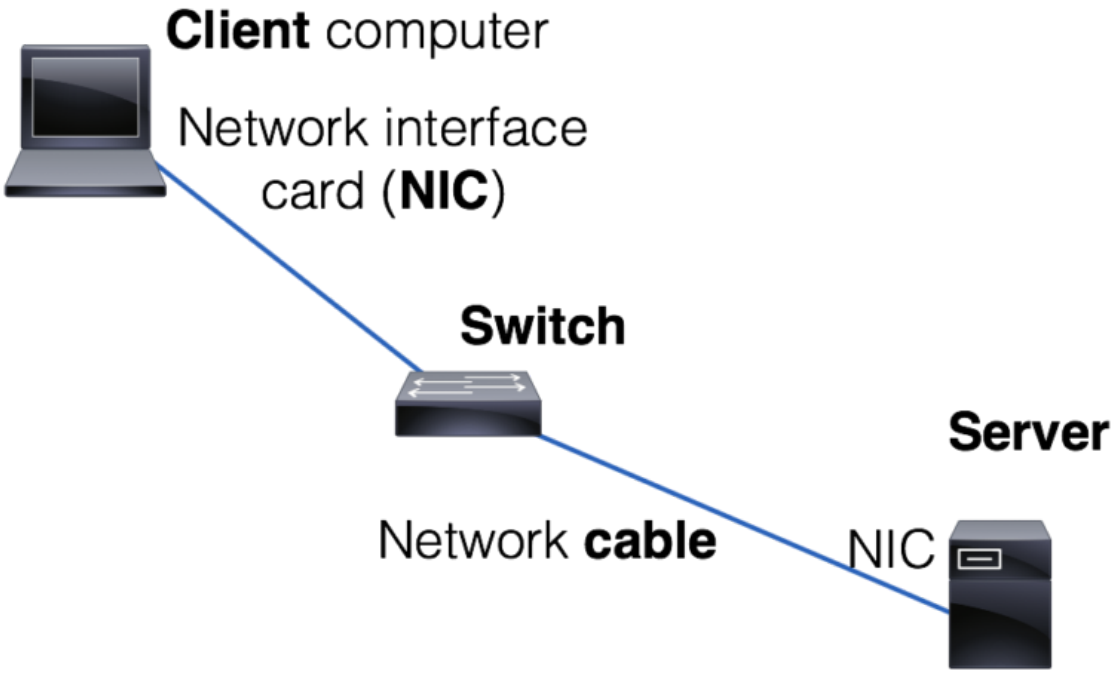
FIT1047 PASS WEEK 9

Physical Layer

Data Link Layer

Physical layer

- Lowest-level layer
- Contains actual network hardware - cable, antennas, network interfaces
- 2 devices directly connected by cable/radio link exchange message at physical layer



How does the client send messages to the server?

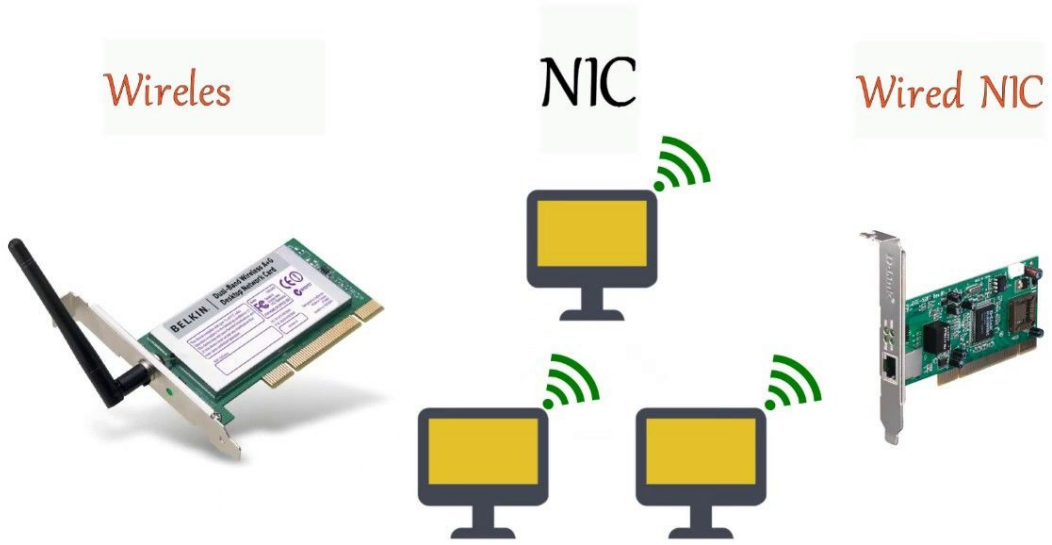
1. Message represented as bits in client software.
2. NIC establishes network connection. Client requests NIC to send the message (with *address* of sender and receiver).
3. NIC hardware translates bits of messages into *signals*.
4. In the switch, physical layer hardware receives signals, decodes it back into bits, which are interpreted by switch's Data Link Layer software. Physical layer in switch converts bits into signals and is transmitted to server.
5. In the NIC insider server, physical layer receives the signals and translates them back into bits. Data link layer reconstructs and checks message before passing it to higher-level layers.

FIT1047 PASS WEEK 9

Physical Layer
Data Link Layer

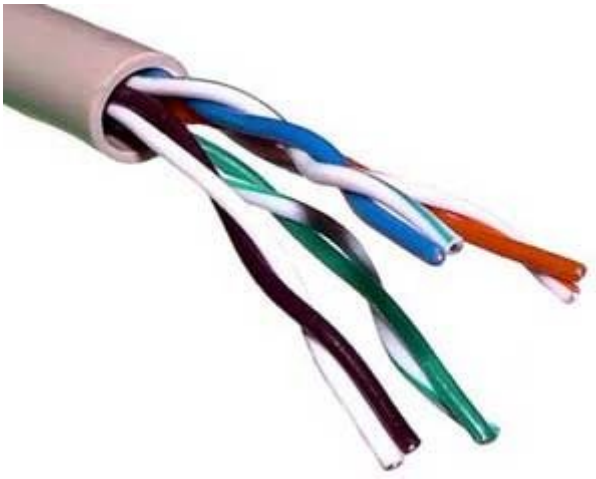
Network Hardware

Network Interface Card (NIC)



- Hardware components that connect devices to network
- Wired - in the form of socket network cable is plugged to
- Wireless - NIC connected to antenna

Network Cables

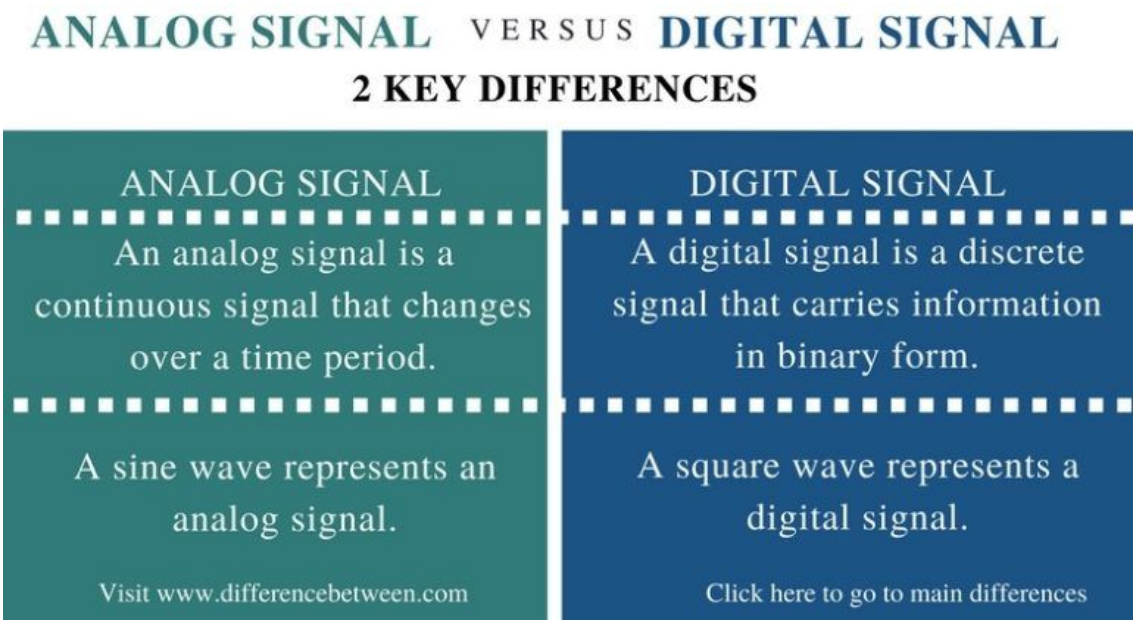
Unshielded Twisted Pair (UTP)	 • Most common LAN cable

Shielded Twisted Pair (STP)	 • Similar to UTP, but adds metal shielding for better protection from electromagnetic interference. • Very high speed Ethernet (> 10 Gb/s)
Coaxial cables	 • Used by original Ethernet • Not common anymore

Optical fibre	 • Light signals - laser light sent through fibre • Higher data transfer rates than copper cables • Not affected by electromagnetic interference at all • Commonly used in backbone networks

Signals

- Defined as *energy* or *waves* travelling through a *medium*
- In computer networks:
    - electrical signals travel through copper cables
    - radio waves travel through space
    - light waves travel through optical fibres



FIT1047 PASS WEEK 9

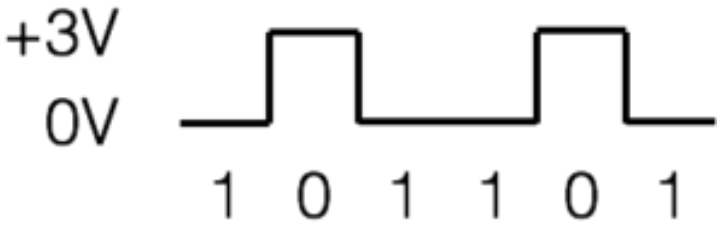
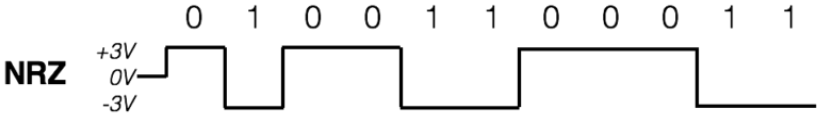
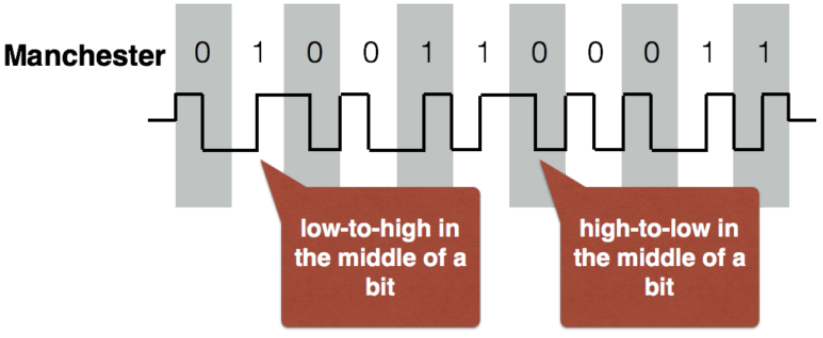
Physical Layer
Data Link Layer

Digital signal

- Sequence of 0s and 1s sent through wires
- 0 = no electricity; 1 = electricity
- Digital signal encodes 0s and 1s into different *voltage levels* on a copper cable.

How does the receiver distinguish between two 1s in a row rather than a single 1?

- define a fixed time window for each bit that's being transmitted

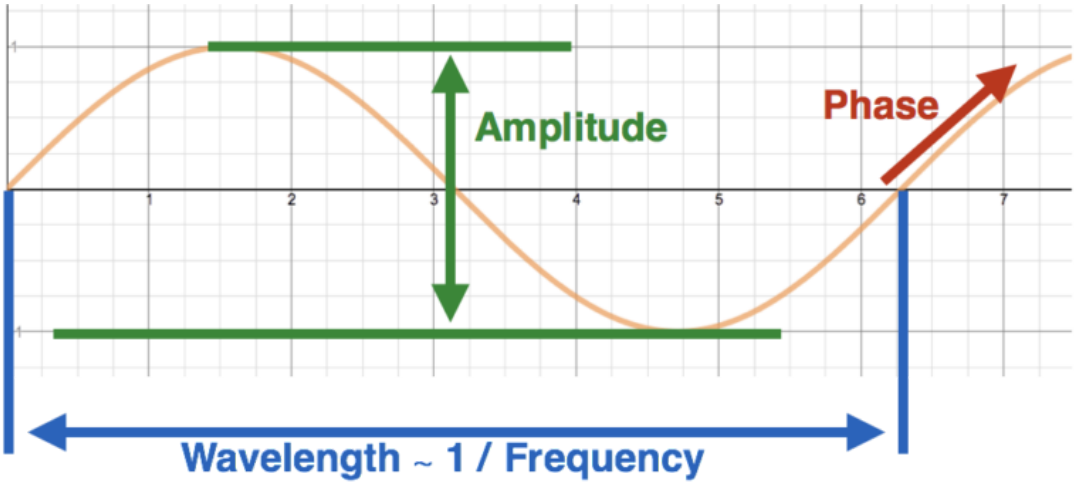
Unipolar encoding	• Use one polarity (+ve) • Difficult to distinguish between 0V and a small positive voltage 
Bipolar encoding	• Use both +ve and -ve voltage to achieve bigger difference in signal • Simplest - Non-Return to Zero, NRZ 
Manchester Encoding	• Provides *self-clocking* signal 

FIT1047 PASS WEEK 9

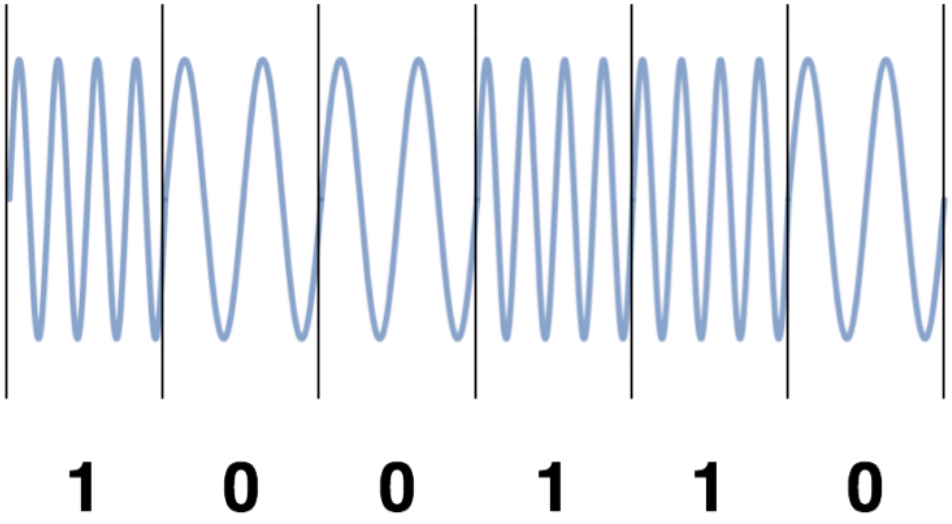
Physical Layer

Data Link Layer

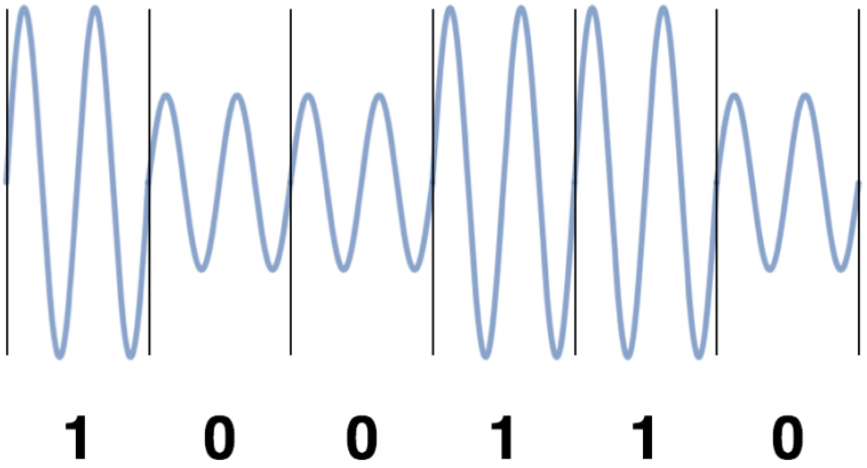
Analog signals



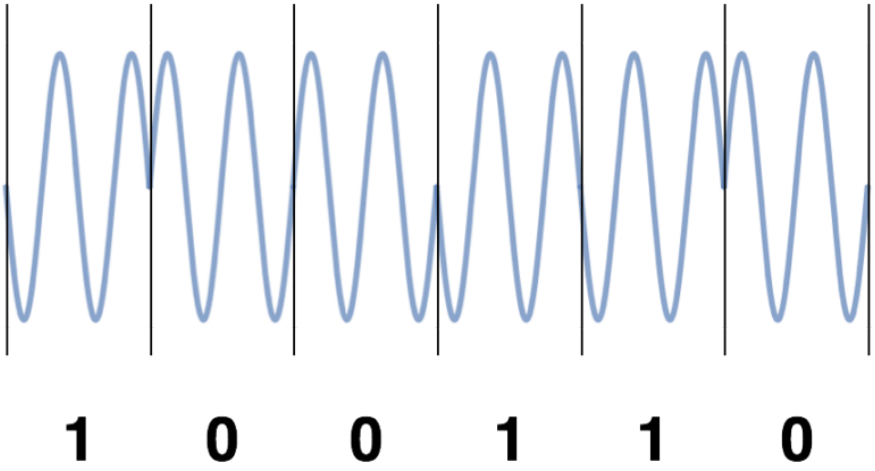
- Gradually changes between different state
- Describe the waves using parameters:
    - Amplitude - height of wave
    - Frequency - number of oscillations per second
    - Phase - direction wave is going at a particular time point
- Modify parameters to transmit data:
    - Modify frequency:



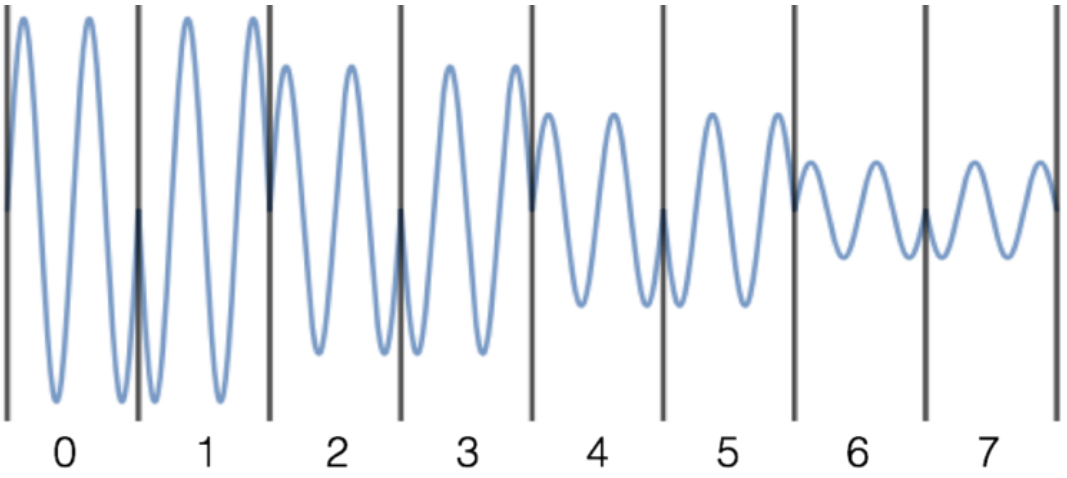
- Modify amplitude:



- Modify phase:



- Combining amplitude and phase modulation at the same time
  - Transmit 4x the amount of data in same time unit



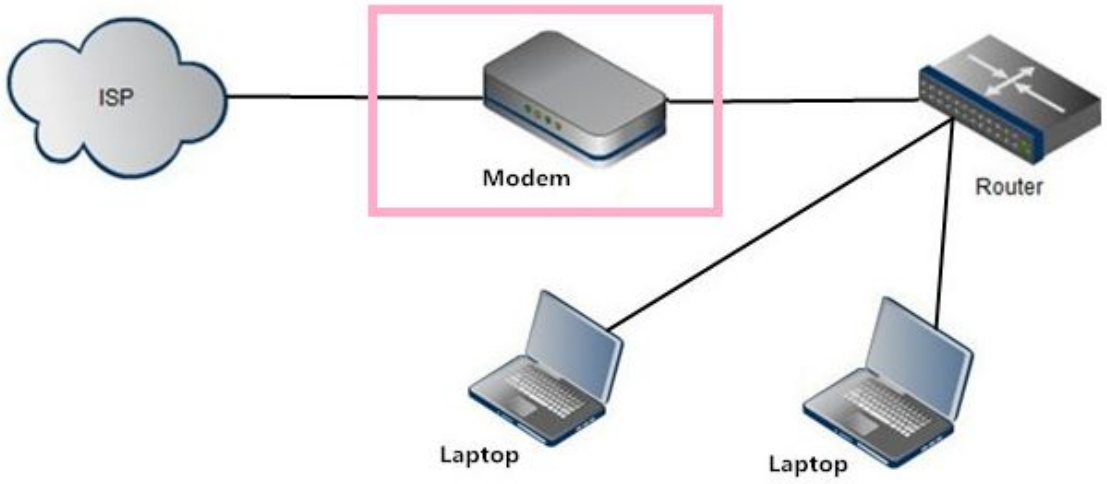
FIT1047 PASS WEEK 9

Physical Layer
Data Link Layer

Attenuation

- weakening of the signal with increasing distance from the transmitter
- Caused by obstacles - door or wall

Modems



- **Modulation** - turning digital data into analog signals
- **Demodulation** – turning analog signals into digital signals

Data Link Layer

- Controlling hardware & error detection

Media Access Control (MAC)

- Controls *when* the device can transmit.
- 2 approaches:

Controlled access	1 device has permission to send at any point in time
Contention-based access	access is provided on a first-come first-served basis, i.e., any device can start transmitting at any time

What happens when two devices start transmitting at exactly the same time?
The frames that are being sent **collide** with each other and cannot be decoded anymore.

FIT1047 PASS WEEK 9

Physical Layer
Data Link Layer

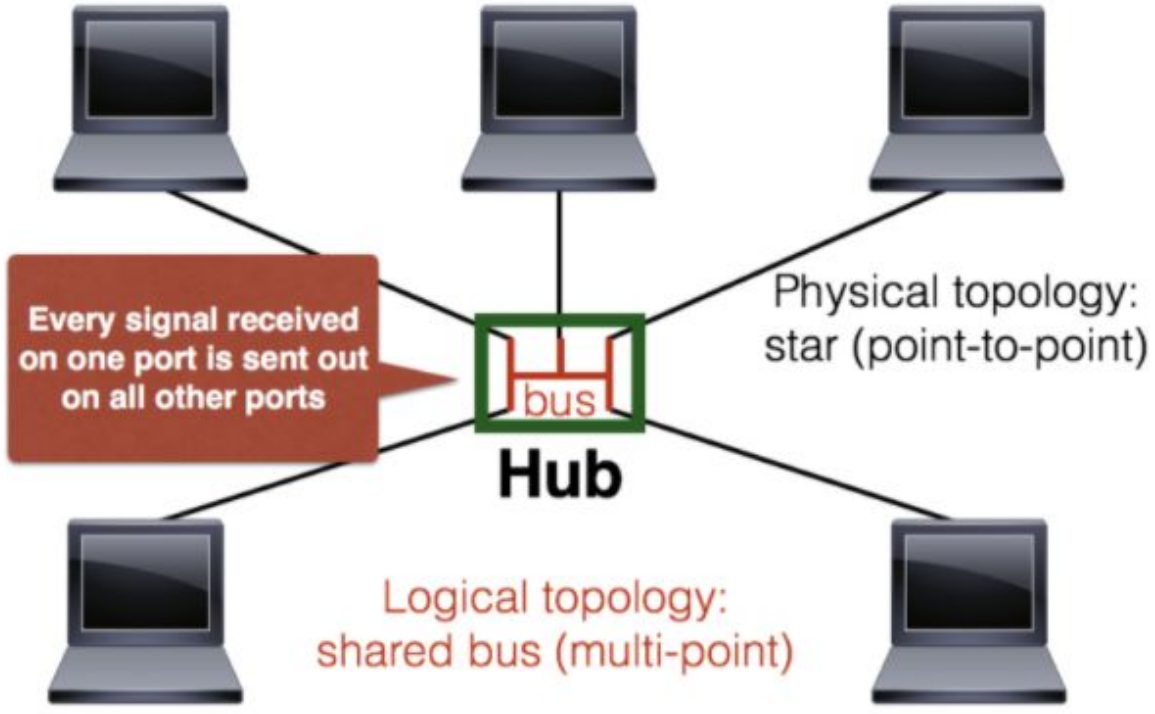
Ethernet

- MAC in Ethernet based on CSMA/CD method:

Carrier sense (CS)	starts a transmission when no other device is currently transmitting.
Multiple access (MA)	multiple devices share the same medium (the same cable)
Collision detection (CD)	When collision happens: ● Stops transmission of actual frame ● Transmits *jam signal* to notify other devices ● Retransmit the frame after *random, short amount of time*

Ethernet as a Shared Bus

- Shared bus topology – all devices share a single bus
- All devices receive all messages that are sent into the network, even the ones that were not meant for them – therefore require *destination address*
- MAC address used as unique address in Ethernet LAN:
    - Hard-wired into NIC
    - 6 bytes - six hexadecimal numbers separated by colons
    - Example: ac:87:a3:14:9e:59

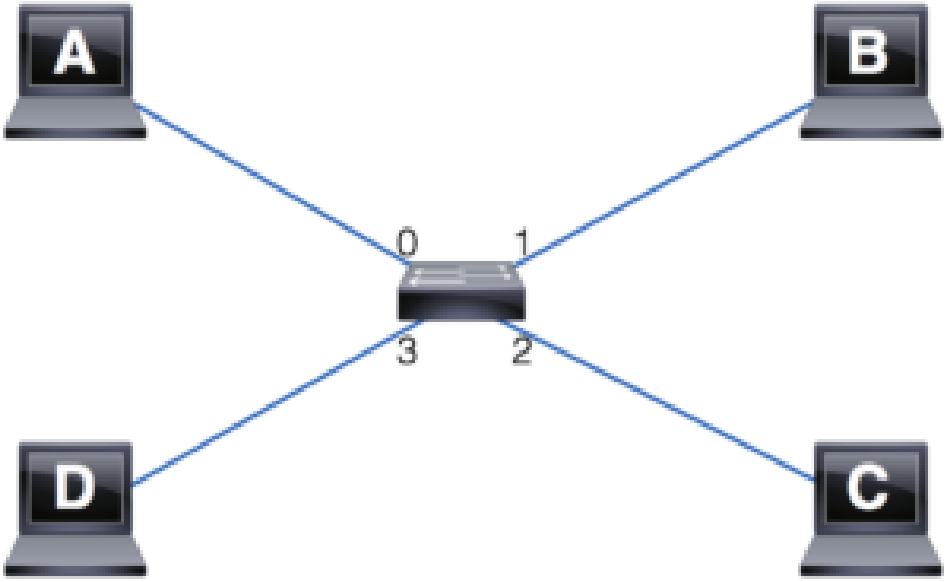


Disadvantage:

- It is half-duplex, meaning that only one device can send at a time.
- The network broadcasts all messages, which means that messages get delivered to all devices rather than just the actual destinations.
- The reliance on collision detection limits the size of the network.

Switched Ethernet

- Messages sent *directly* instead of being broadcasted.
- Switch reads incoming frame, checks destination MAC address, sends to correct port using forwarding table.

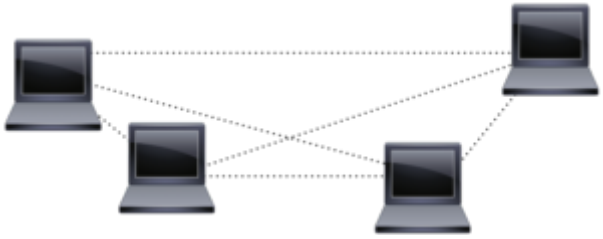


Wireless Local Area Network

- Advantage
  - No cables
  - Flexible network access
  - Enable mobility
- Uses radio waves to communicate – frequencies regulated
- 2 main *bands* WLAN devices use
  - 2.4GHz
  - 5GHz

WLAN Topology

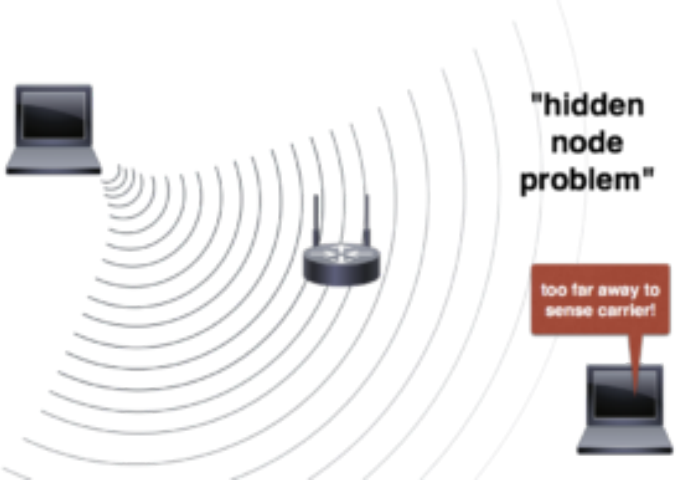
- **Independent Basic Service Set (BSS) –** Ad-hoc/Independent network



- **Infrastructure BSS** – uses central Access point (AP)

WLAN MAC

- similar to MAC in shared Ethernet – still have collision problems.
- Hidden node problem - laptop too far away from the access point & cannot sense the carrier.



WLAN needs to be more proactive than Ethernet:

- Replace CSMA/CD with CSMA/CA
- CA actively avoids collision

Collision Avoidance (CA) has 2 different mechanisms:

- **Automatic Repeat Request (ARQ)**
    - WLAN deceive wait for acknowledgement after sending a frame to access point.
    - If access point doesn't acknowledge, device knows something went wrong and can resend the frame.

- **Controlled Access**
    - Send short “Request to Send” (RTS) to access point.
    - Start transmitting frame when access point replies “Clear to Send” CTS.

High frequency allows more information to be sent in the same time. Why don’t we just pick highest possible frequency to generate?
They have much stronger attenuation, meaning that they become weaker with distance much more quickly than lower frequencies.