Computer Networks
COL 334/672

Link Layer

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Slides adapted from KR

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Quiz on Moodle

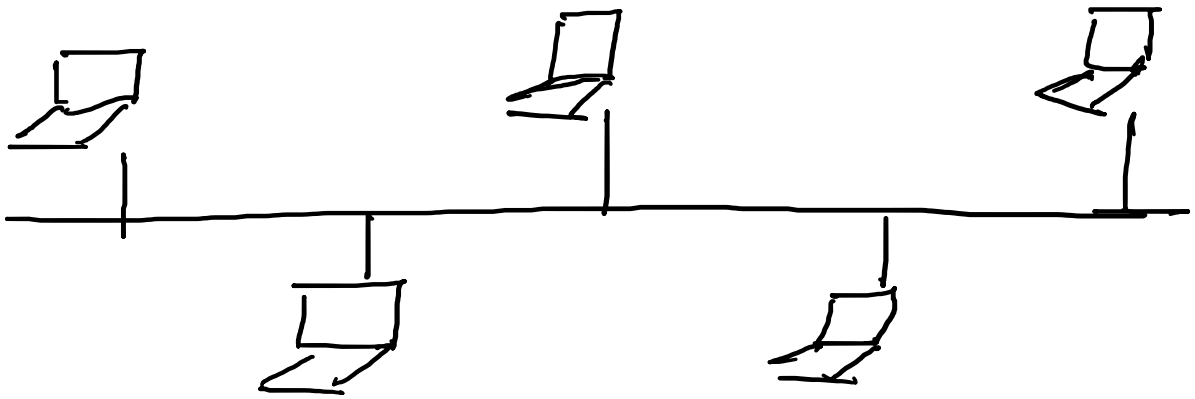
Password: oddsbodikins

Link Layer: Services

- Framing
- Error detection
- Reliability
- **Link access**

Medium Access Control (MAC) protocol

Broadcast link



- algorithm that determines how nodes share channel, i.e., determine when node can transmit
  - *Assumptions: distributed, no out-of-band channel for coordination*
- Two classes of protocols
  - Channel partitioning: FDMA, TDMA
  - Random access: Slotted Aloha, Carrier Sense Multiple Access (CSMA) /Collision Detection (CD)

CSMA (carrier sense multiple access)

Simple CSMA: listen before transmit:

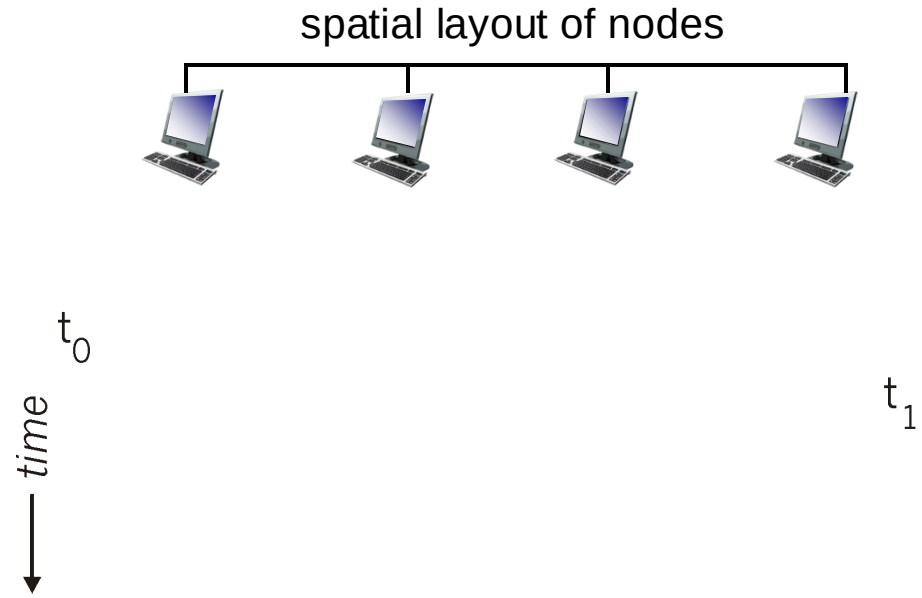
- if channel sensed idle: transmit entire frame
- if channel sensed busy: defer transmission

- Can collisions still occur on such a channel?

CSMA: collisions

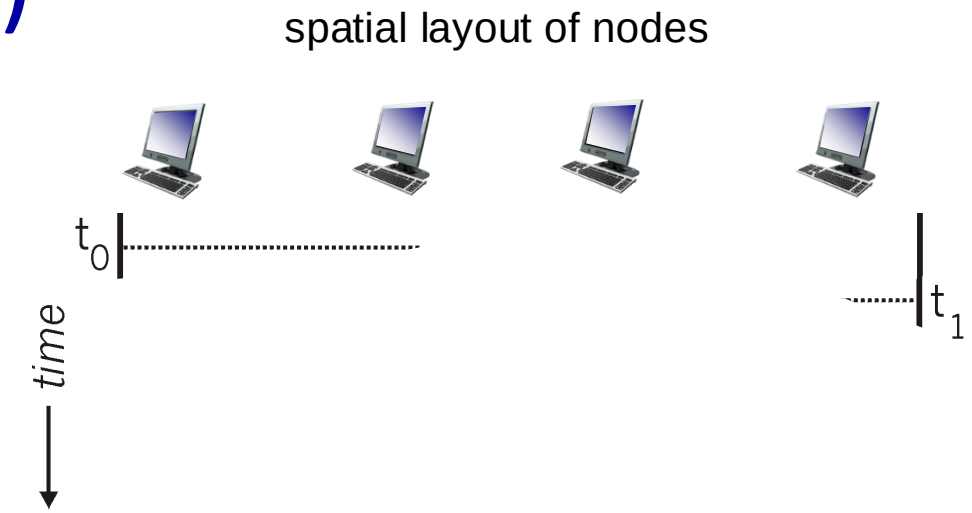
- collisions can *still* occur with carrier sensing:
  - propagation delay means two nodes may not hear each other's just-started transmission
- collision: entire packet transmission time wasted

What to do in case of collision?

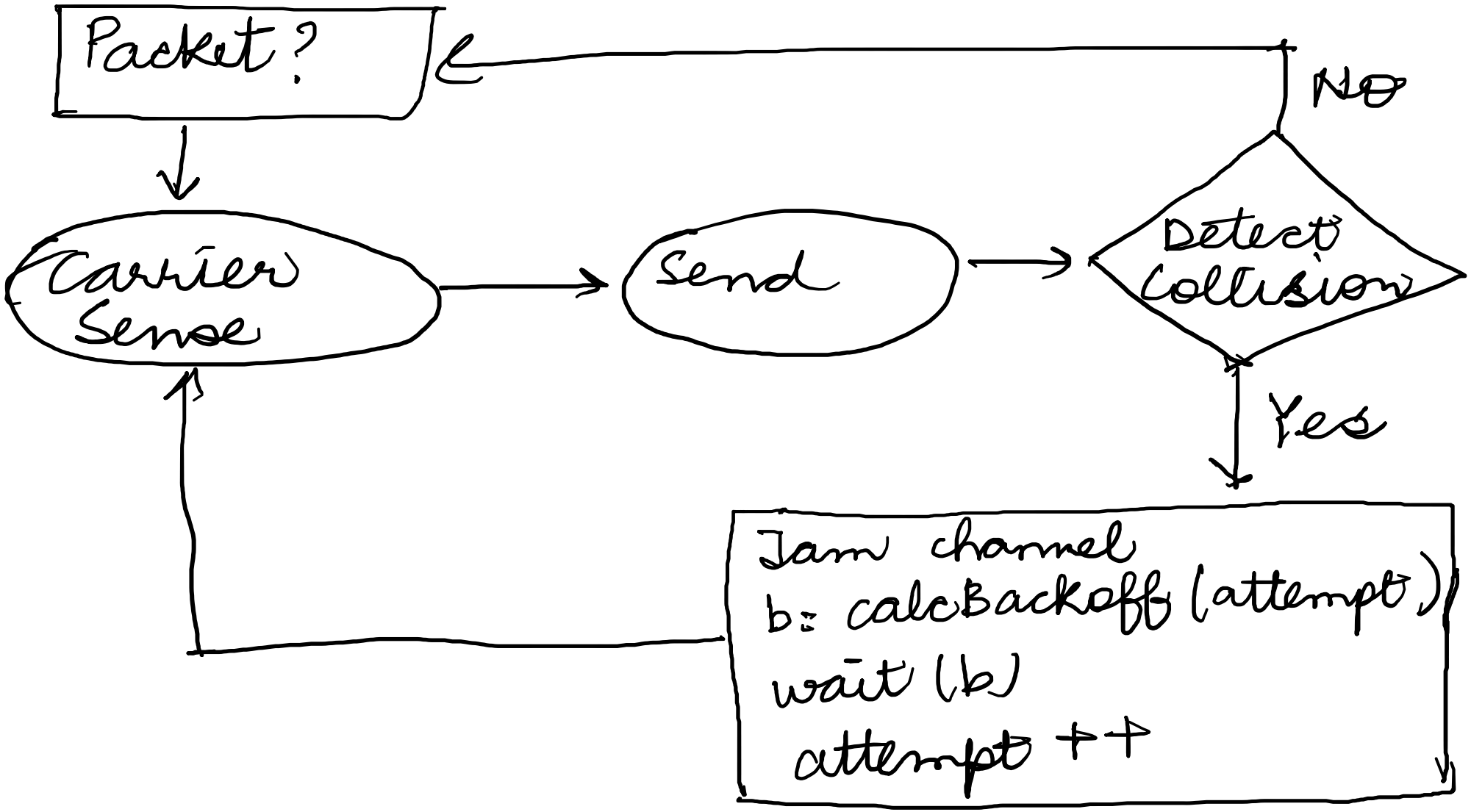


CSMA/Collision Detection (CD)

- CSMA/CD reduces the amount of time wasted in collisions
  - Transmission aborted on collision detection
  - Send a jamming signal
- What happens after?
  - *Backoff:* Try after some random time!
- How to decide the backoff time?
  - Use binary exponential backoff
  - after *m*th collision, chooses *K* at random from $\{0,1,2, \ldots, 2^m-1\}$



State Diagram for CSMA/CD



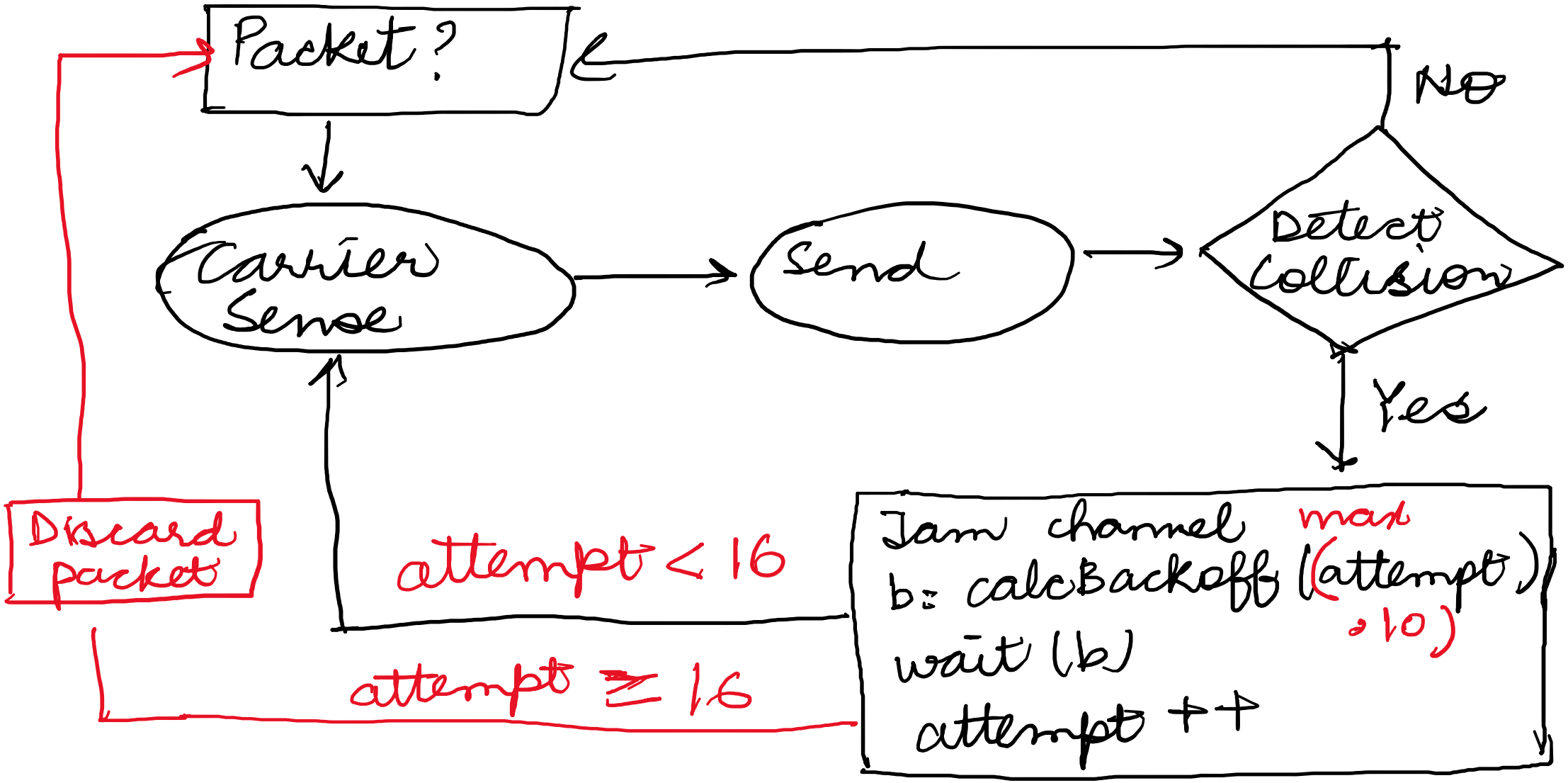
Ethernet MAC Protocol

- Ethernet uses CSMA/CD
- Gap between two frames is **96-bit times** Why?
- Uses a minimum frame size (e.g. 64 bytes on 10 Mbps Ethernet) Why?
  - What if the frame is smaller?
  - Zero-pad for smaller packets

Ethernet MAC Protocol

- Ethernet uses CSMA/CD
- Gap between two frames is **96-bit times** Why?
- Uses a minimum frame size (e.g. 64 bytes on 10 Mbps Ethernet) Why?
  - What if the frame is smaller?
  - Zero-pad for smaller packets
- Uses a maximum frame size Why?
  - Larger frames → higher probability of bit error
  - Others need to wait longer
  - Memory requirements on the network adapter

State Diagram for Ethernet MAC



CSMA/Collision Avoidance (CA): MAC for wireless network

- Two challenges
  - Detecting collisions
  - Hidden terminal problem

- How to know packet has been correctly transmitted?
  - Rely on acknowledgements, no ack ➔ loss
  - But it is slow

- ***Can we do better?***

CSMA/CA

- Use control frames before sending data frames
  - Request To Send (RTS)
  - Clear To Send (CTS)
- Only transmit if CTS is received
- Any node that hears RTS/CTS will remain silent for some duration
- Duration specified in RTS/CTS frames known as **Network Allocation Vector (NAV)**
- Does this solve hidden terminal problem?

Summary: Ethernet Frame Structure

802.3 Ethernet packet and frame structure

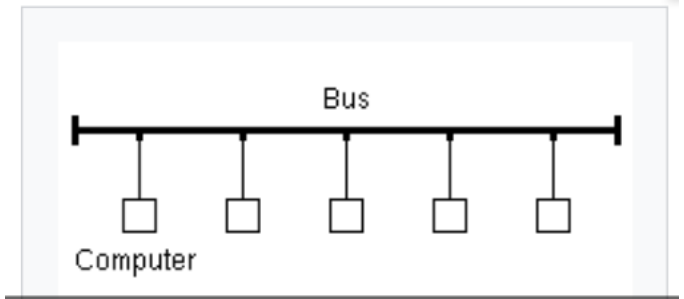
Layer	Preamble	Start frame delimiter (SFD)	MAC destination	MAC source	802.1Q tag (optional)	Ethertype (Ethernet II) or length (IEEE 802.3)	Payload	Frame check sequence (32-bit CRC)	Interpacket gap (IPG)
Length (octets)	7	1	6	6	(4)	2	42–1500[c]	4	12
Layer 2 Ethernet frame	(not part of the frame)		← 64–1522 octets →						(not part of the frame)
Layer 1 Ethernet packet & IPG	← 72–1530 octets →								← 12 octets →

Can you detect headers related to link layer functions?

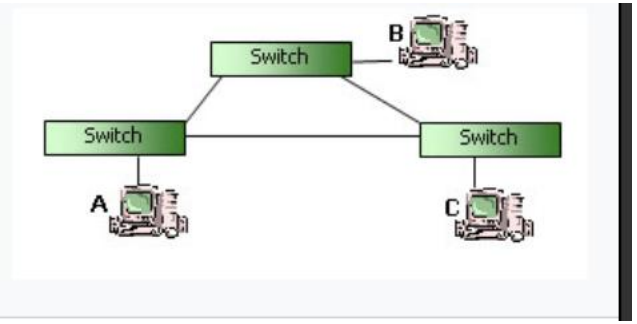
- Framing
- Error detection
- Reliability
- Link access

Ethernet Evolution

- Ethernet has been dominant technology over 40 years
- Does it mean it has not changed? NO!
- Bus topology → Hub topology → Switched topology (collision free)
- What are the factors for its success?
  - Easy to administer and manage
  - Inexpensive
  - Newer versions were backward compatible --> incremental deployment



Alt Text: A close-up of a switch



Attendance