CS120: Computer Networks

Lecture 6. Multiple Access 1

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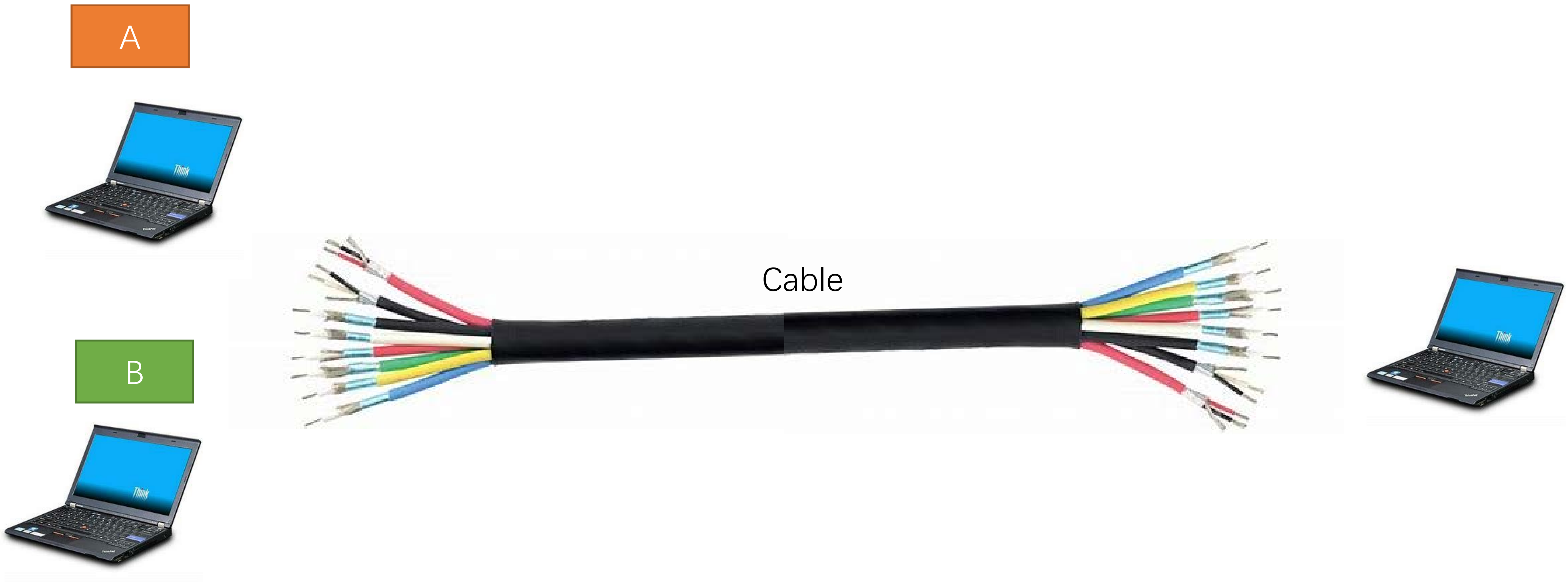
The Multiplexing Problem



Multiplexing Approaches

- FDM
- TDM
- Packet Switching

Multiple Access Protocol

- Multiple access protocol determines how multiple users use the multiplexed resource

Multiplexing Method – Multiple Seats in One Cabin

Multiple Access Method

Ticket

First come first served

Targeting Scenarios

- Two Types of Channels:
  - Private
    - Point-to-point link between nodes, e.g., 1Gbps Ethernet
  - ✓Broadcast
    - Shared communication medium, e.g., Wi-Fi, 10Mbps Ethernet
      - Two or more simultaneous transmissions => collision

Targeting Scenarios

- Two Types of Channels:
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- Protocol: Medium Access Control (MAC)
  - Access Control: determines how nodes share the channel, i.e., determine when the node transmits
  - Link Control: reliable point-to-point data link

An Ideal Multiple Access Method

- Consider a Broadcast Channel of Rate **R** bps
  - When one node wants to transmit, it can send at rate **R**.
  - When **M** nodes want to transmit, each can send at average rate **R/M**
  - Fully decentralized
    - No special node to coordinate transmissions
    - No synchronization of clocks, slots, etc.

Existing Methods

- Fixed Partitioning
  - e.g., TDMA, FDMA
  - Avoid Collisions
- Scheduling
  - e.g., Token Ring, Polling
- Random Access
  - e.g., CSMA
  - Allow Collisions

Random Access

- When node has packet to send
  - Try best to transmit at full channel data rate **R**
  - Two or more transmitting nodes => collisions
- Core Design Goals
  - How to detect collisions
  - How to recover from collisions
- Protocols
  - Transmit and Pray
  - Slotted ALOHA
  - CSMA

Transmit and Pray

- Good solution at low load
- Plenty of collisions at high load
    - Low throughput

Slotted ALOHA

- Assumptions
  - Same frame length
  - Nodes are synchronized
  - Nodes start to transmit only at the beginning of slot
  - Nodes can detect collision
- Operation Rule
  - No collision: node sends a new frame in the next slot
  - Collision: node retransmits the frame in each subsequent slot with probability **p** until success

Slotted ALOHA

- Cons:
  - Collisions waste the entire slot
  - There are idle slots
    - None of the transmitter gain the slot
  - (minor) Clock synchronization
    - Improved in un-slotted ALOHA

- For each slot, the probability of successful transmission is $Np(1-p)^{(N-1)}$
- p is the probability of transmission. It is determined by the number of nodes N in the network, when N is large, p should be small.
- The optimal p can be calculated by derivation
  - $f(p)=Np(1-p)^{(N-1)}$
  - $f'(p)=N(1-p)^{(N-1)}-Np(N-1)(1-p)^{(N-2)}$
  - Thus the optimal p is 1/N
- So when p=1/N, the probability of successful transmission is $(1-1/N)^{(N-1)}$, when N is large, it is close to 1/e. Thus the utilization of the channel is about 30%

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potential improvements:

1. take actions to handle collision
2. sense the idle slot

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Ethernet

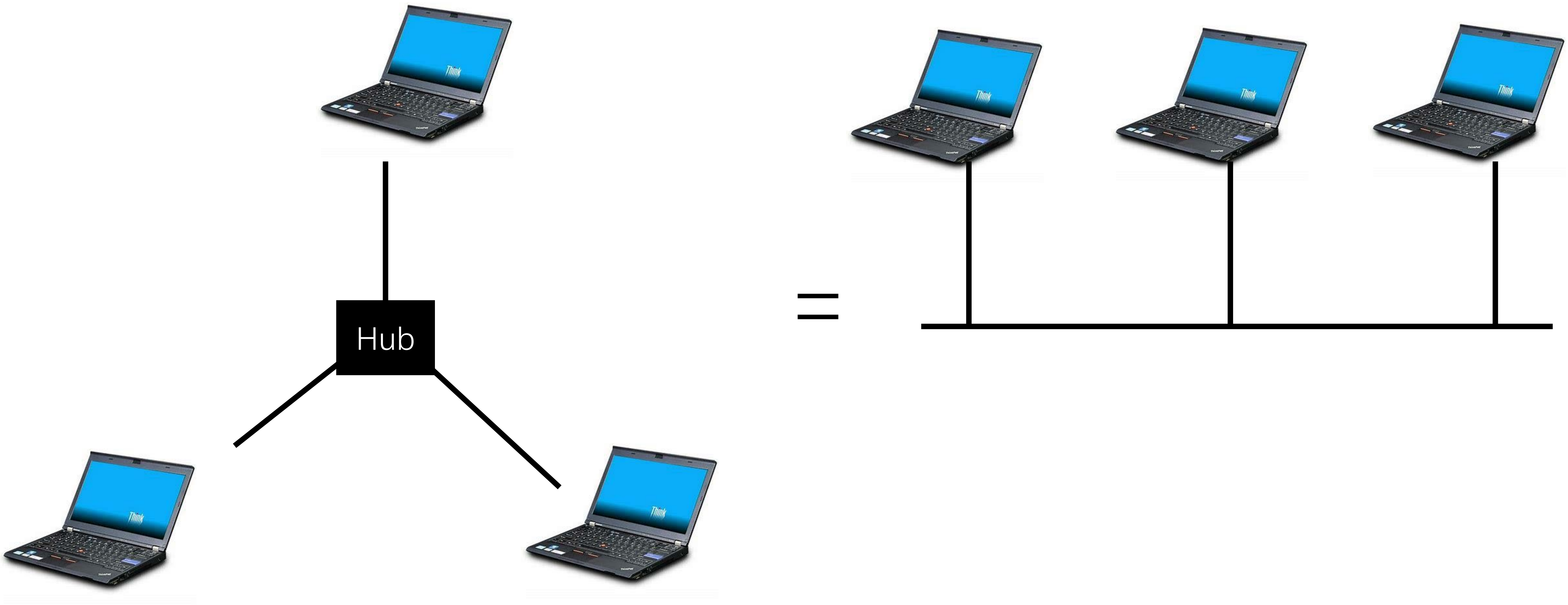
- Brief History

parc
A Xerox Company

3com

IEEE 802.3

Ethernet



Carrier Sense Multiple Access (CSMA)

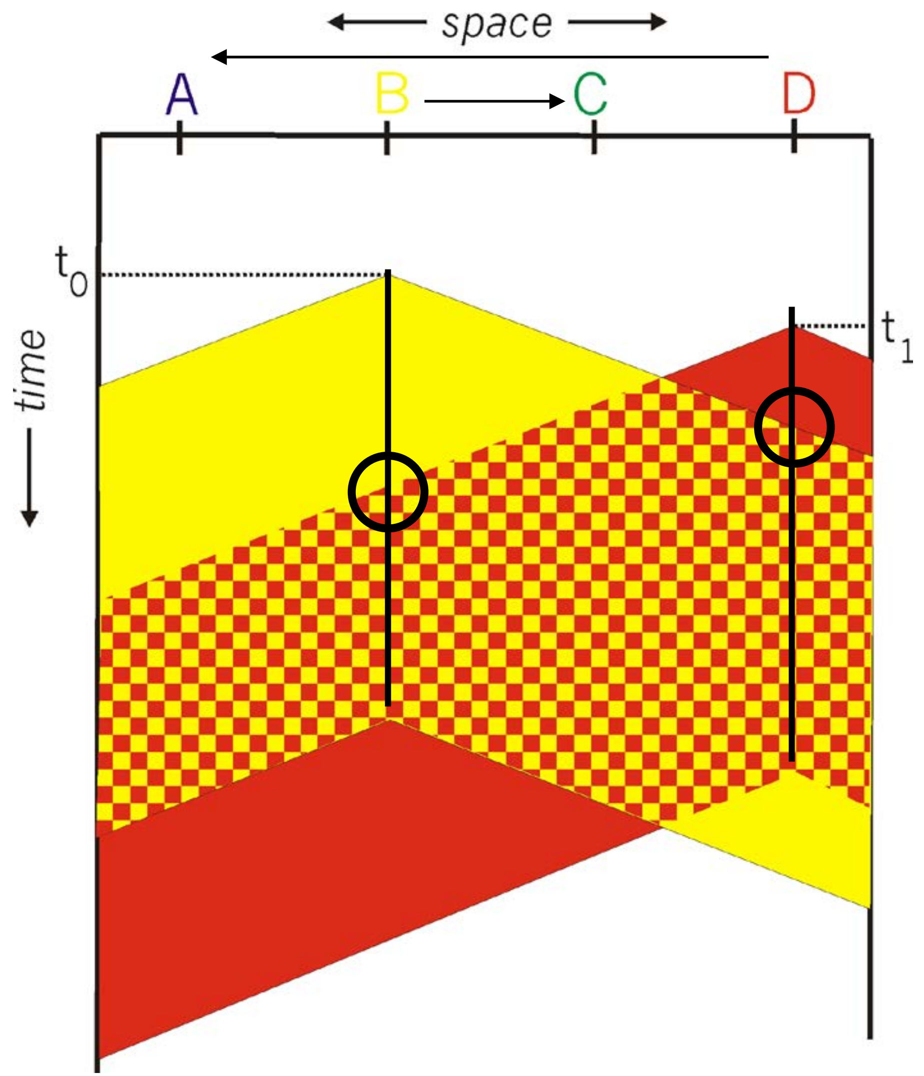
- CSMA: Listen before Transmit
  - If the channel is sensed idle: transmit the entire frame
  - If the channel is sensed busy: defer the transmission

Can collisions still occur?

CSMA: Collisions

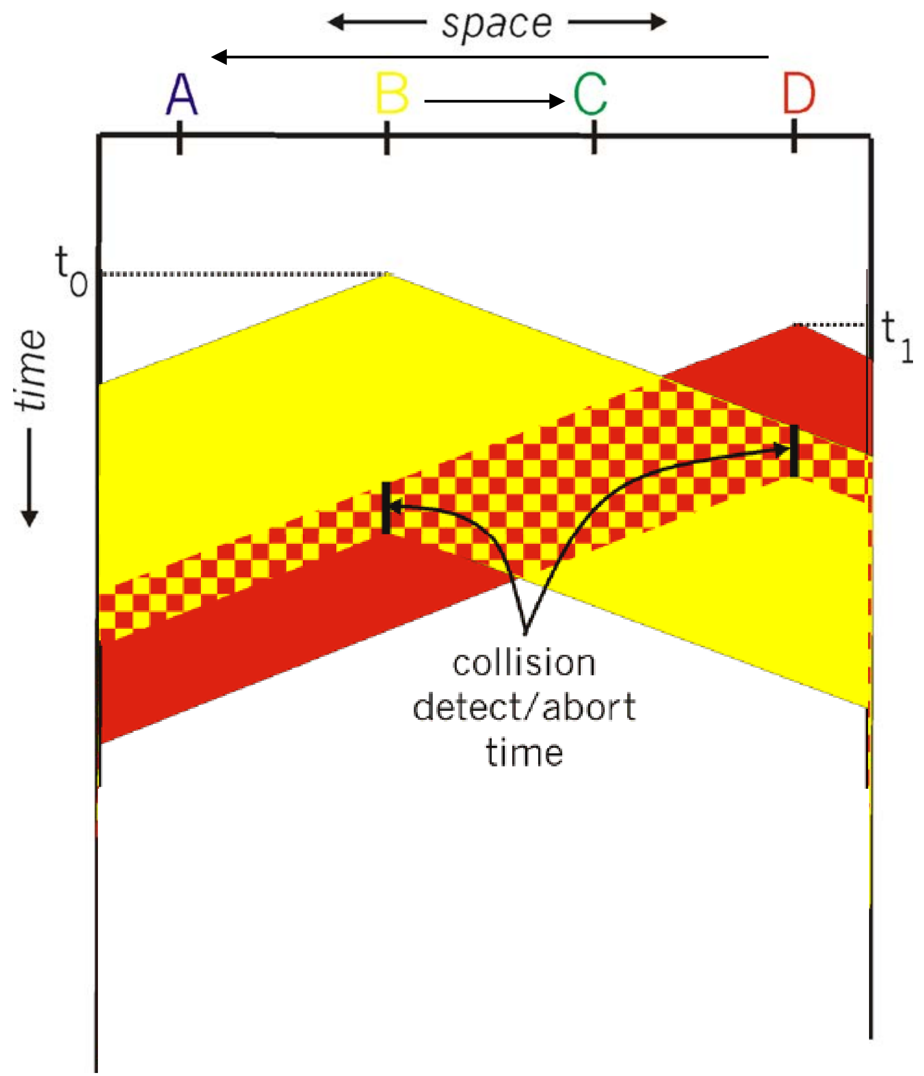
- Collisions can still occur
    - Due to propagation delay
- When collision occurs
    - Entire packet wasted

How to better handle collisions ?



CSMA + Collision Detection (CSMA/CD)

- Keep listening to the channel while transmitting
- Abort the transition if collision is detected
  - Opt1: transmitted signal != sensed signal
  - Opt2: energy detection
  - Then, retransmit



Ethernet CSMA/CD Protocol

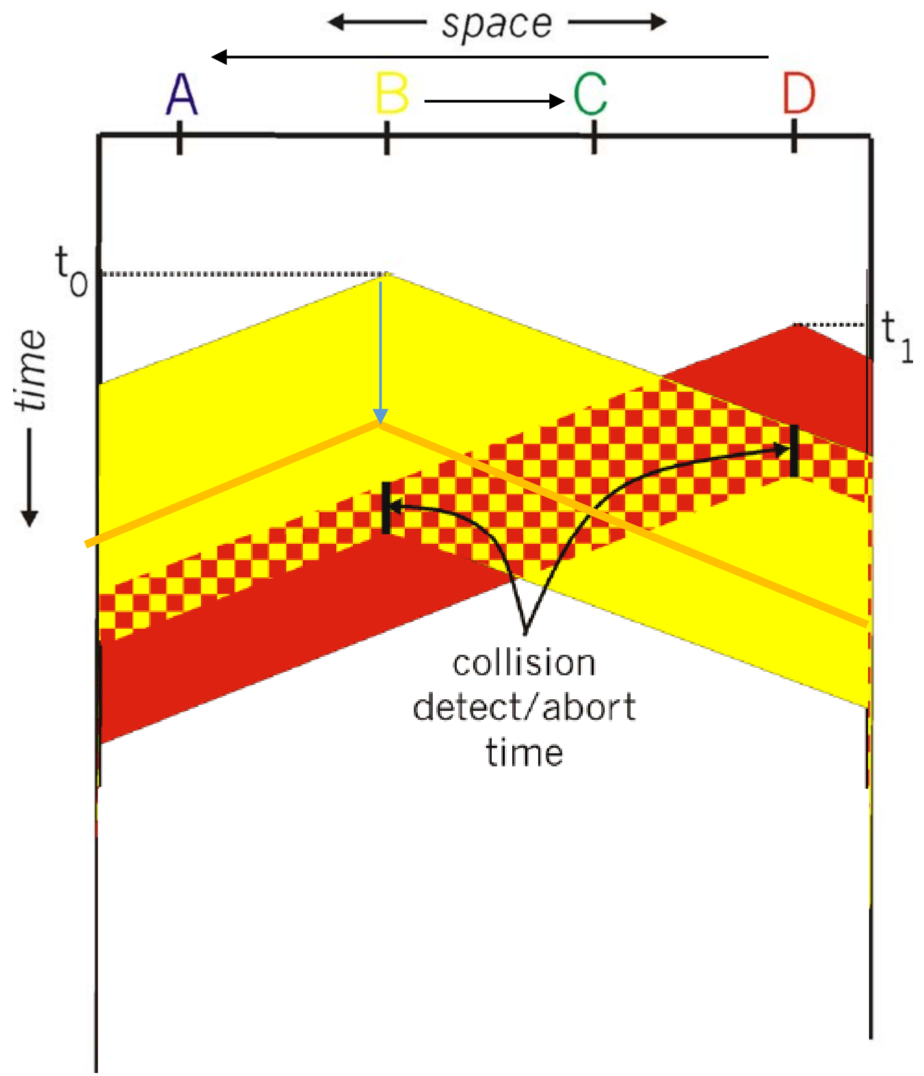
- If channel idle
  - starts transmission
- Else (channel busy)
  - Waits until channel idle.
- If the entire frame is transmitted without detecting another transmission
  - done
  - go idle
- Else
  - Aborts the transmission and sends jam signals
    - to make sure that all the transmitting adapters become aware of the collision
  - Backoff
  - go idle to retransmit (max 16 times)

Ethernet CSMA/CD Protocol

- Exponential Backoff
  - After m_{th} collisions, chooses K at random from $\{0,1,2, \cdots, 2^{m-1}\}$
    - if m>11
      - chooses K at random from $\{0,1,2, \cdots, 1024\}$
    - if m=16
      - done
      - go idle
  - Waits K*one time slot

More about Ethernet CSMA/CD Protocol

- Ethernet does not use ACK
  - It uses local collision detection to estimate the receiver's conditions
    - collision free => success
    - collision => retransmit
- But what if B stopped transmission before it detects collisions ?
  - B failed to identify C's collision
    - => no retransmission => transmission failure

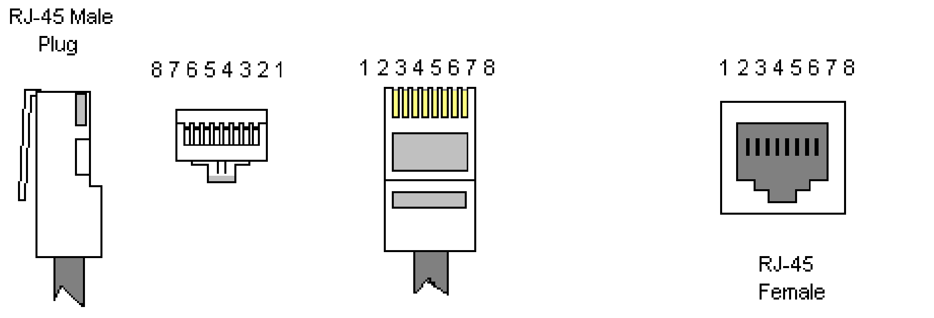


More about Ethernet CSMA/CD Protocol

- Effective Range
  - The larger the network, the more likely to miss the collisions
  - Minimum Packet Size
    - e.g., Range 2500m (Local Area Network)
    - => MaxRTT * rate

Other Aspects of Ethernet

Ethernet Cable



Color Standard
EIA/TIA T568A

Ethernet Patch Cable

	RJ45	Pin#	Pin#	RJ45	
TX+	Green/White Tracer	1	1	Green/White Tracer	PR 3
TX-	Green	2	2	Green	
RX+	Orange/White Tracer	3	3	Orange/White Tracer	PR 2
	Blue	4	4	Blue	PR 1
	Blue/White Tracer	5	5	Blue/White Tracer	
RX-	Orange	6	6	Orange	PR 2
	Brown/White Tracer	7	7	Brown/White Tracer	PR 4
	Brown	8	8	Brown	

Color Standard
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Ethernet Crossover Cable

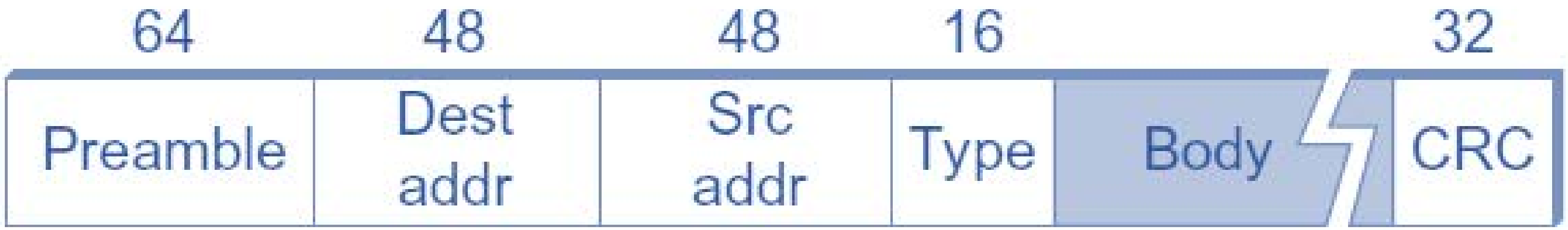
RJ45	Pin#	Pin#	RJ45
Green/White Tracer	1	1	Orange/White Tracer
Green	2	2	Orange
Orange/White Tracer	3	3	Green/White Tracer
Blue	4	4	Brown/White Tracer
Blue/White Tracer	5	5	Brown
Orange	6	6	Green
Brown/White Tracer	7	7	Blue
Brown	8	8	Blue/White Tracer

"A" is earlier

CS 120 LEC 6

Ethernet Frame

- Line Code: Manchester coded (10Mbps)
- Preamble
  - 7 bytes with pattern 10101010 followed by one byte with pattern 10101011
  - Sync and Clock Recovery



Ethernet Frame (Address)

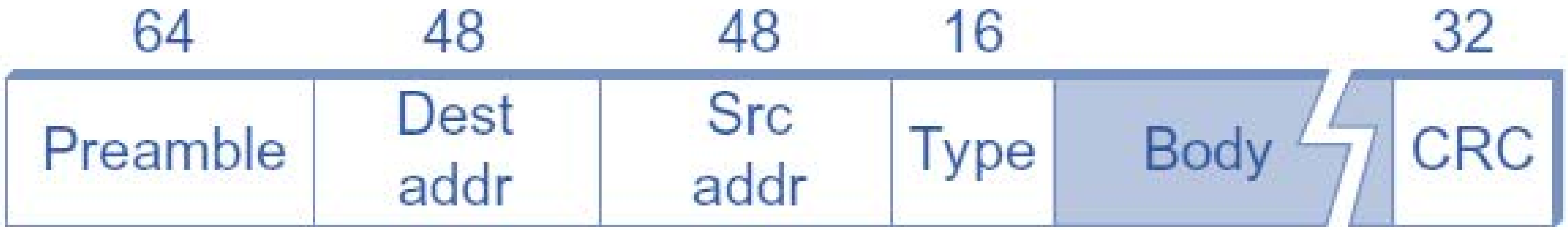
- Every Ethernet adapter has an address, the MAC address
  - 6 bytes
  - Find your MAC addresss
    - `ifconfig`
    - `ipconfig /all`
  - Find the manufacturer of your adapter
    - http://coffer.com/mac_find/

Ethernet Frame (Address)

- Unicast Address
- Broadcast Address
  - All 1s
- Multicast Address
  - First bit 1

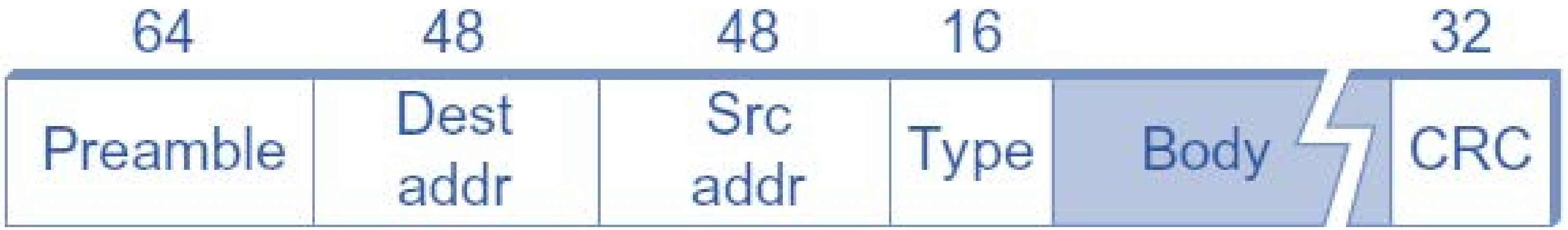
Receiver's Adapter

if the packet dest addr is the receiver's address, then pass the error free packet to the host



Ethernet Frame

- Type
  - IPV4, ARP, RoCE, etc.
  - Length
- Body 46-1500 B
- CRC 32
- NO ACK



Reference

- Textbook 2.6
- http://www.ee.columbia.edu/~bbathula/courses/HPCN/lecture04.pdf