CS120: Computer Networks

Lecture 6. Multiple Access 1

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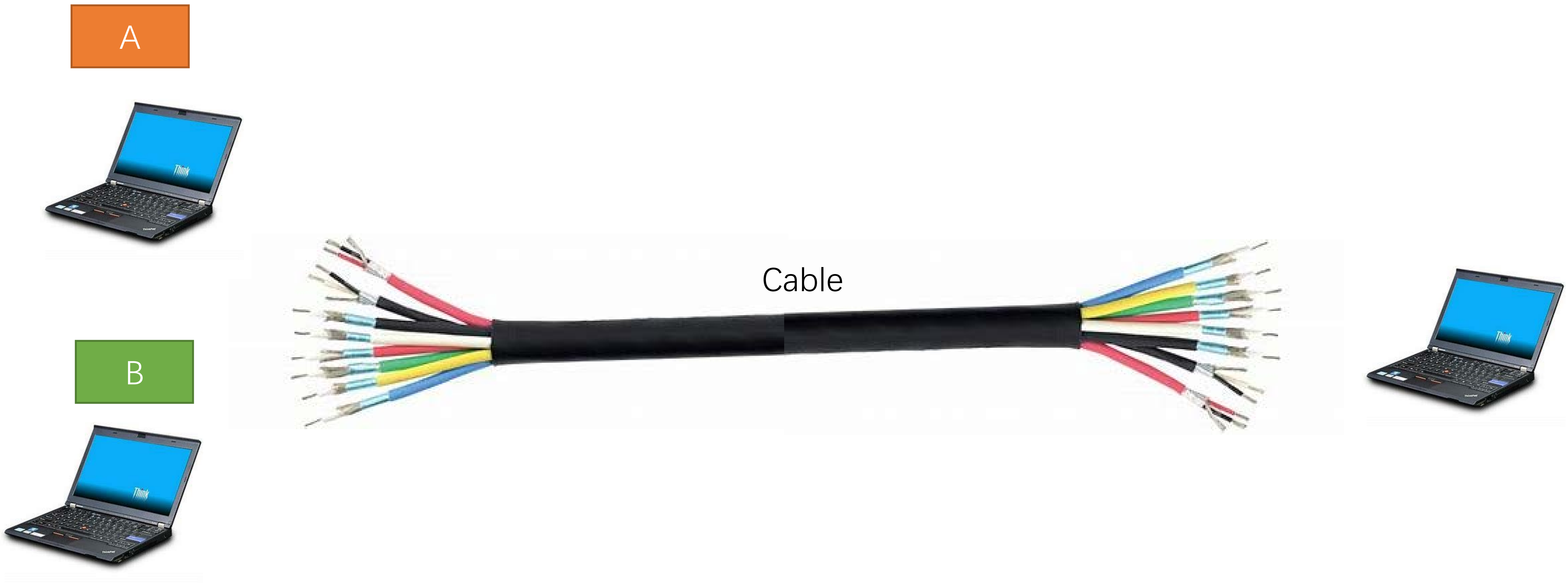
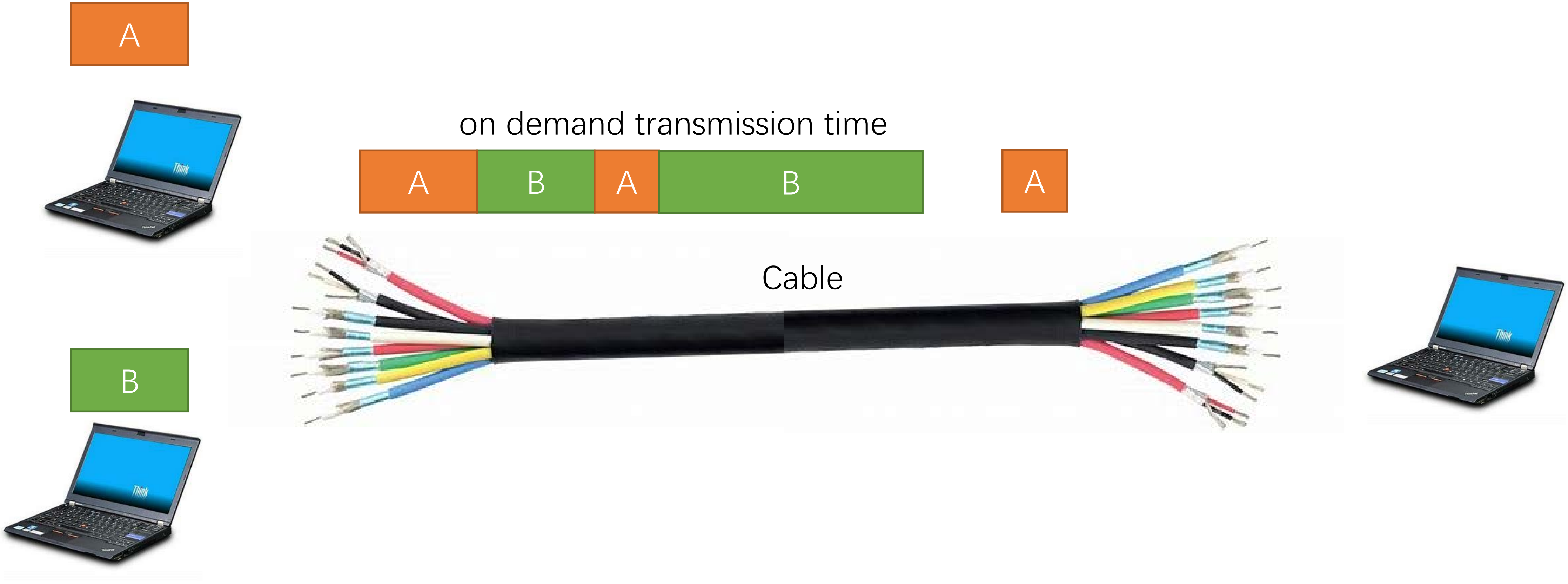
The Multiplexing Problem



Multiplexing Approaches

- Packet Switching



Multiple Access Protocol

- Multiple access protocol determines how multiple users use the multiplexing approach

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 node, e.g., Current Ethernet
  - ✓Broadcast
    - Shared communication medium, e.g., Wireless, Original Ethernet
      - Two or more simultaneous transmissions
        - ➢ collision

Targeting Scenarios

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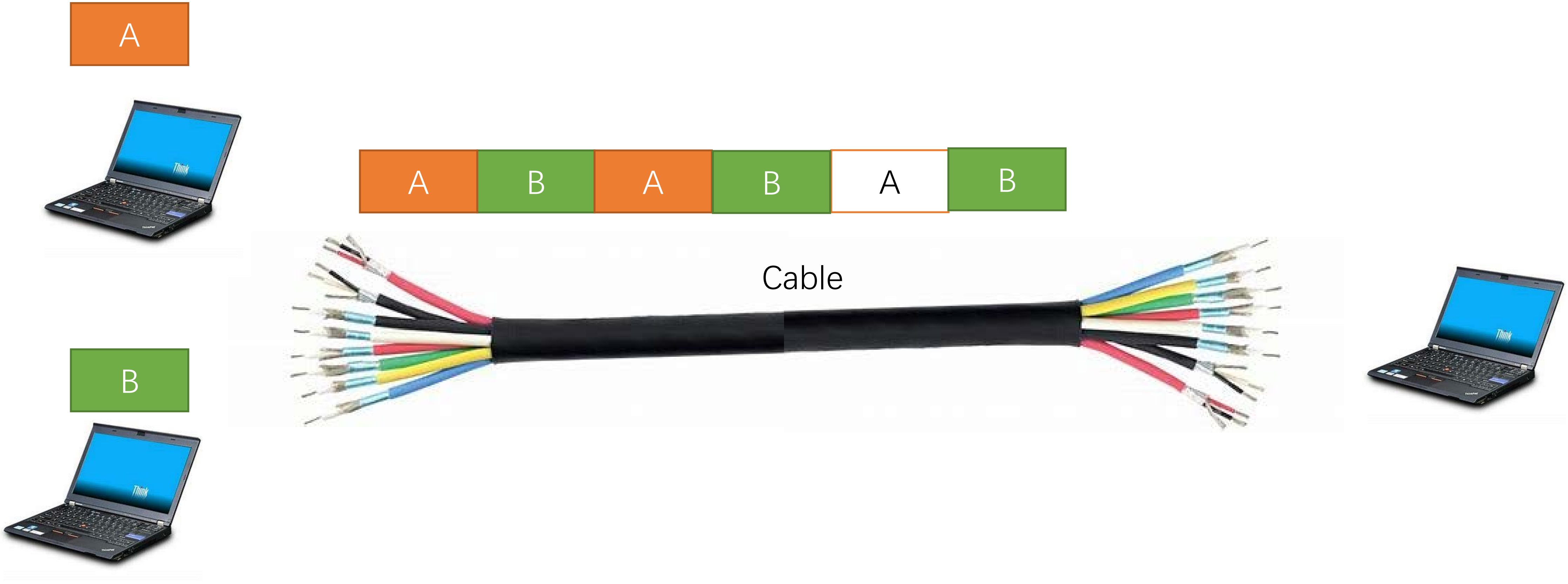
- Protocol: Media Access Control (MAC)
  - Access Control: determines how nodes share channel, i.e., determine when node can transmit
  - Link Control: reliable point-to-point data link

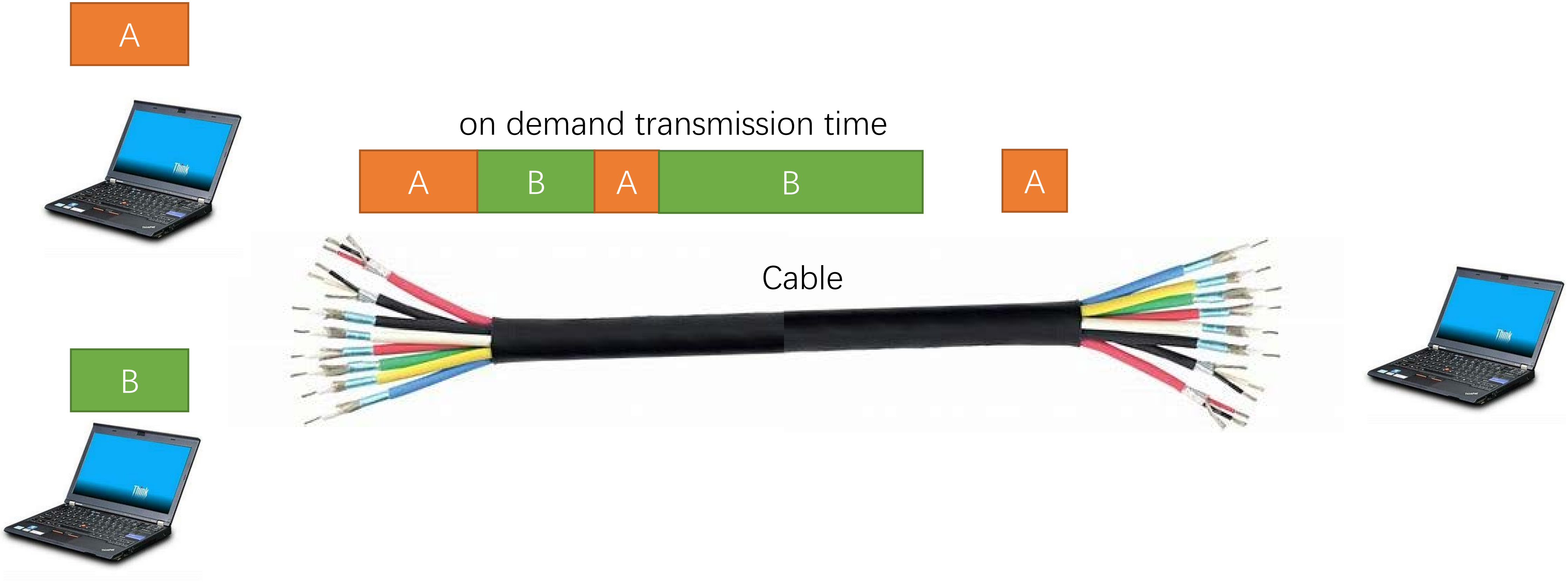
Multiplexing Approaches

- Synchronous Time-division Multiplexing (STDM)



Multiplexing Approaches

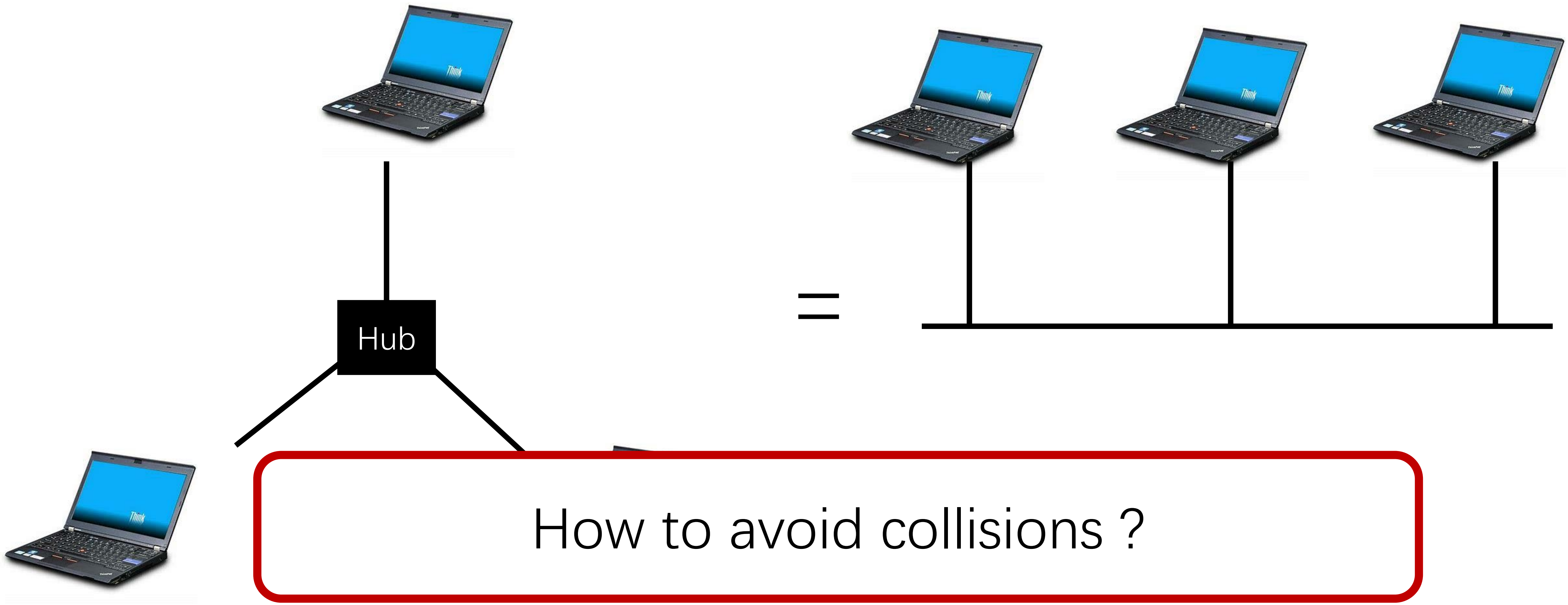
- Packet Switching



Ethernet

- Brief History

Ethernet



How to avoid collisions ?

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
  - eg.: TDMA, FDMA
  - Avoid Collisions
- Scheduling
  - eg.: Token Ring, Polling
- Random Access
  - eg.: 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-> Collision
- Core Design Goals
  - How to detect collisions
  - How to recover from collisions (e.g., via delayed retransmissions)
- Protocols
  - Transmit and Pray
  - Slotted ALOHA
  - CSMA

Trivial Design

- 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 new frame in next slot
  - Collision: node retransmits 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 with 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%

Slotted ALOHA

- Cons:
  - Collisions waste the entire slot Take actions to handle collision
  - There are idle slots Sense the idle slot
    - None of the transmitter gain the slot
  - (minor) Clock synchronization
    - Improved with un-slotted ALOHA

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Carrier Sense Multiple Access (CSMA)

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

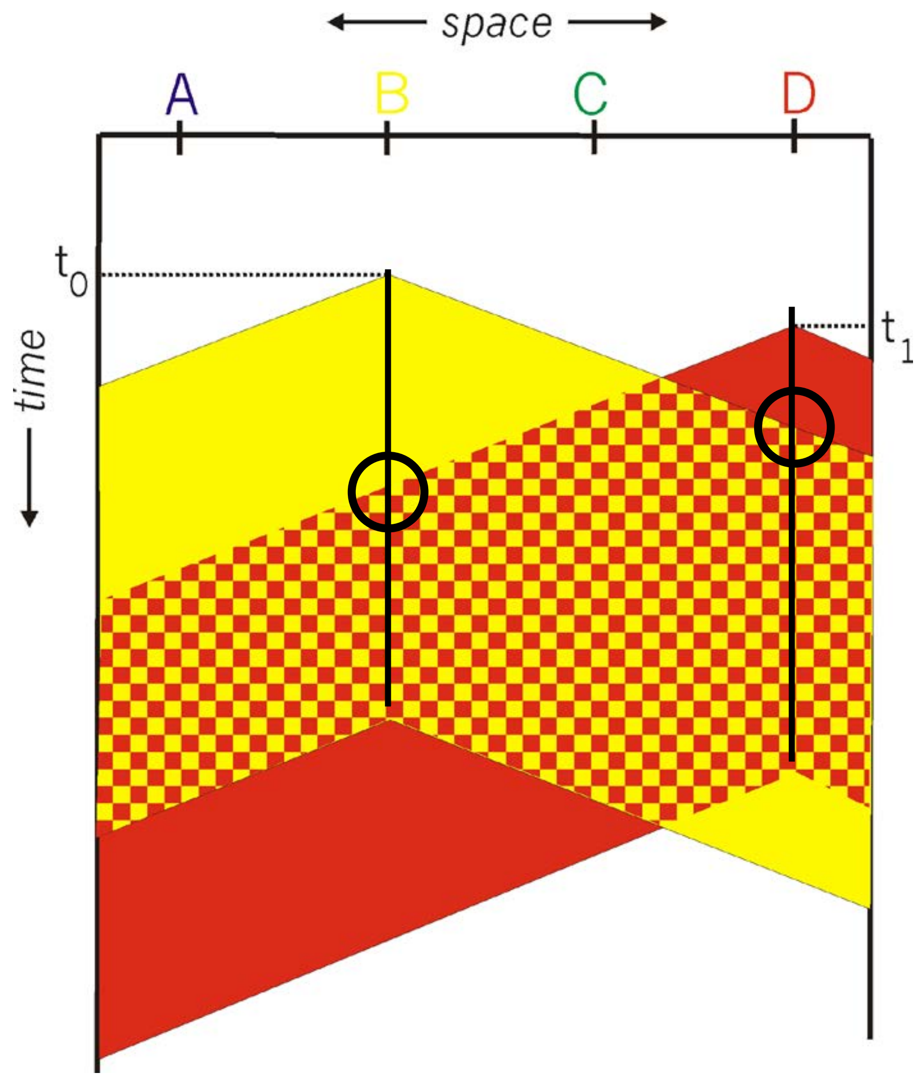
Can collisions still occur?

CSMA: Collisions

- Collisions can still occur
  - Due to propagation delay

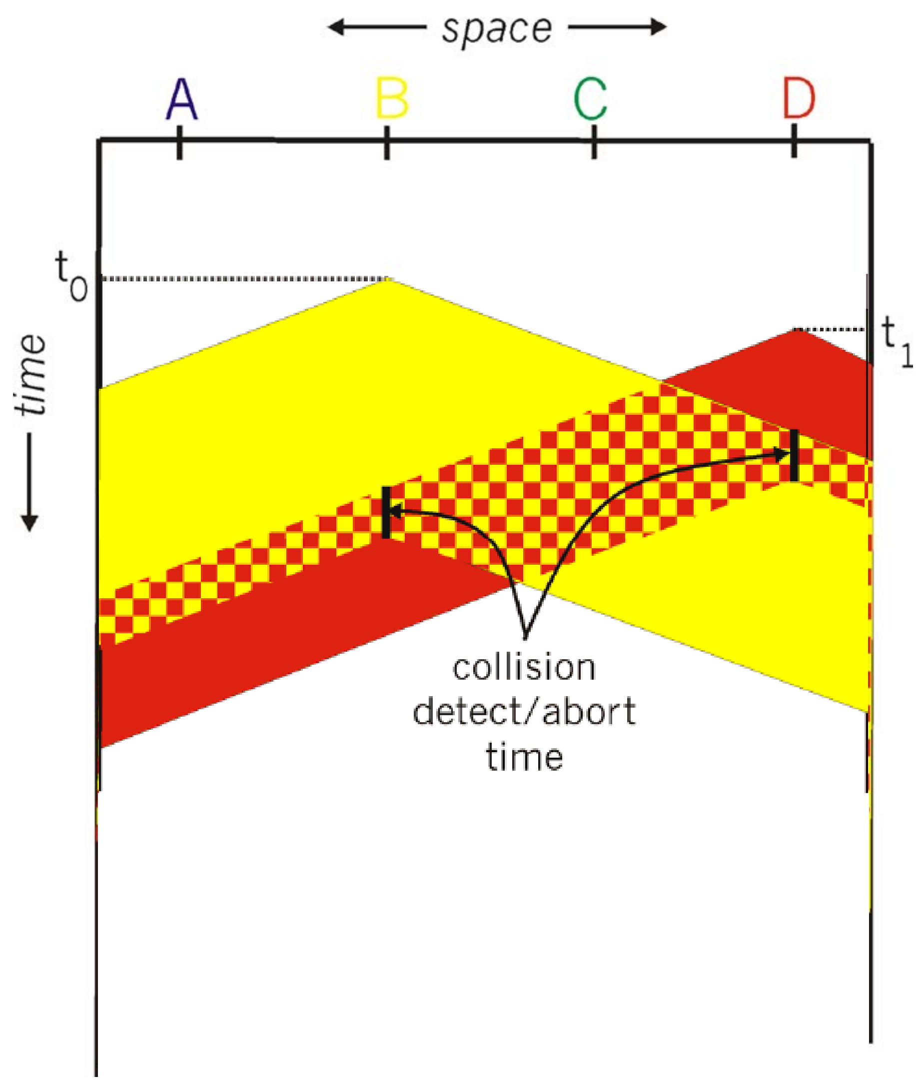
- When collision occurs
  - Entire packet wasted

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



CSMA/CD

- The Effective Range
  - What if B stopped transmission before it detects collisions ?
    - Collision detection failed
      - Ethernet does not use ACK -> no retransmission -> transmission is failed

CSMA/CD

- The Effective Range
  - What if B stopped transmission before it detects collisions ?
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  - Minimum Packet Size
    - eg. Range 2500m (Local Area Network)
    - => MaxRTT * rate

Ethernet CSMA/CD Protocol

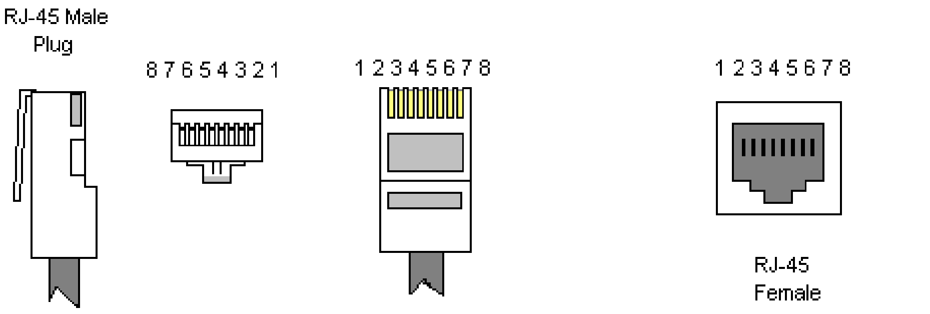
- If channel idle
  - starts transmission
- Else (channel busy)
  - Waits until channel idle.
- If the entire frame is transmitted without detecting another transmission
  - done
  - go idle
- Else
  - Aborts the transmission and sends jam signals
    - to make sure that all the transmitting adapters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

Ethernet CSMA/CD

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

More about 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

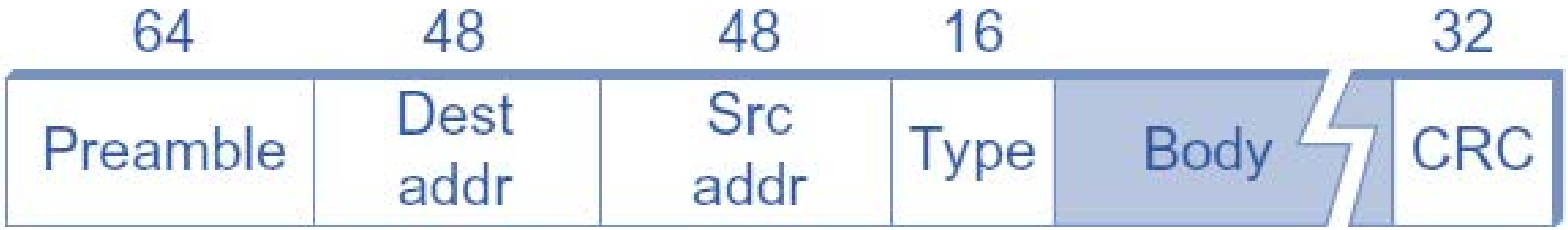
RJ45	Pin#	Pin#	RJ45
Green/White Tracer	1	1	Orange/White Tracer
Green	2	2	Orange
Orange/White Tracer	3	3	Green/White Tracer
Blue	4	4	Brown/White Tracer
Blue/White Tracer	5	5	Brown
Orange	6	6	Green
Brown/White Tracer	7	7	Blue
Brown	8	8	Blue/White Tracer

"A" is earlier

Inside the Ethernet Hub

Ethernet Frame

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



Ethernet Frame (Address)

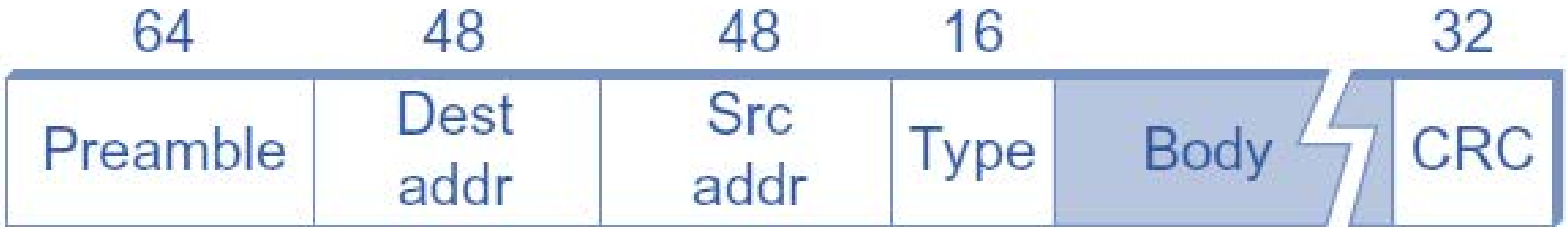
- Every Ethernet adapter has an address, the MAC address
  - 6bytes
  - Find your MAC addresss
    - `ifconfig`
    - `ipconfig /all`
  - Find the manufacturer of your adapter
    - http://coffer.com/mac_find/
  - You can change the MAC address

Ethernet Frame (Address)

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

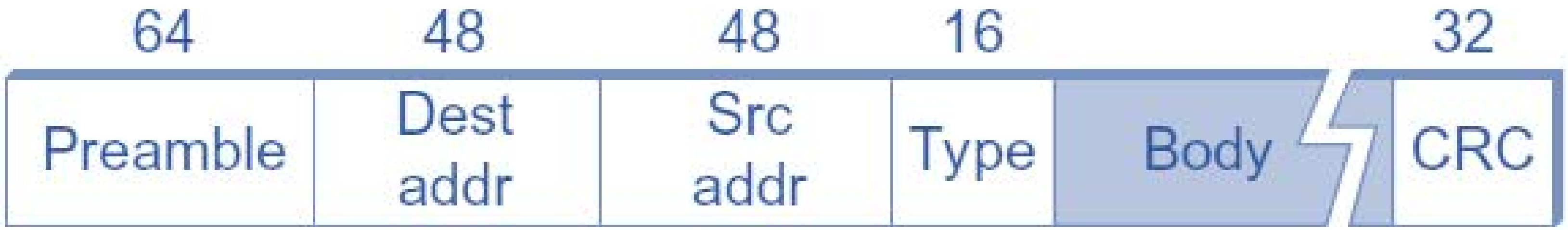
Receiver's Adapter

Find if the received packet contains <u>correct</u> 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