Data Link Layer: Ethernet -- Overview

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Background

- Very successful and widely used technology (as of 2010, market of $16 billion per year)

- Cheap: Only 5$ (300Rs) for 100Mbps

- Kept up with speed race: 10Mbps to 100Gbps

  10,000   *30 y ears*

- IEEE 802.3 working group

  - Many standards (different speeds, different physical media)

History

- 1970's: Metcalfe conceived the idea

- Up to early 1990's: Bus topology based on co-axial cable

  Mbps *Baseband* *500 m*

  - Thicknet (10Base5)

  - Thinnet (10Base2) → *200 m*

- Media Access Control: CSMA/CD

Bus
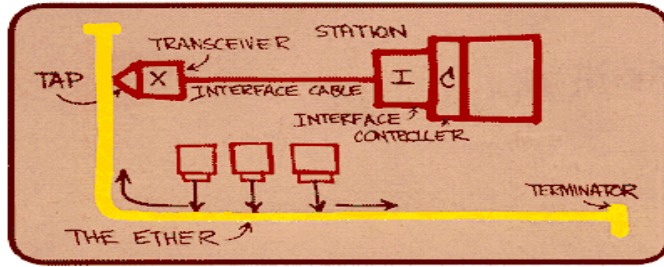
Metcalfe's Ethernet sketch

Problems with Bus Topology

- Co-axial cables were expensive

- Break/Fault in co-axial cable affects all nodes

- Adding/removing nodes disrupts the entire network

- Cabling Issues lead to star topology

Star Topology

- Connect via hub or switch

- 10BaseT, 100BaseT (Fast Ethernet), 1000BaseT (Gigabit Ethernet)

  (handwritten: → 10Mbps)

  - Based on twisted pair cables

  - Low cost, reliable, easy management/troubleshooting
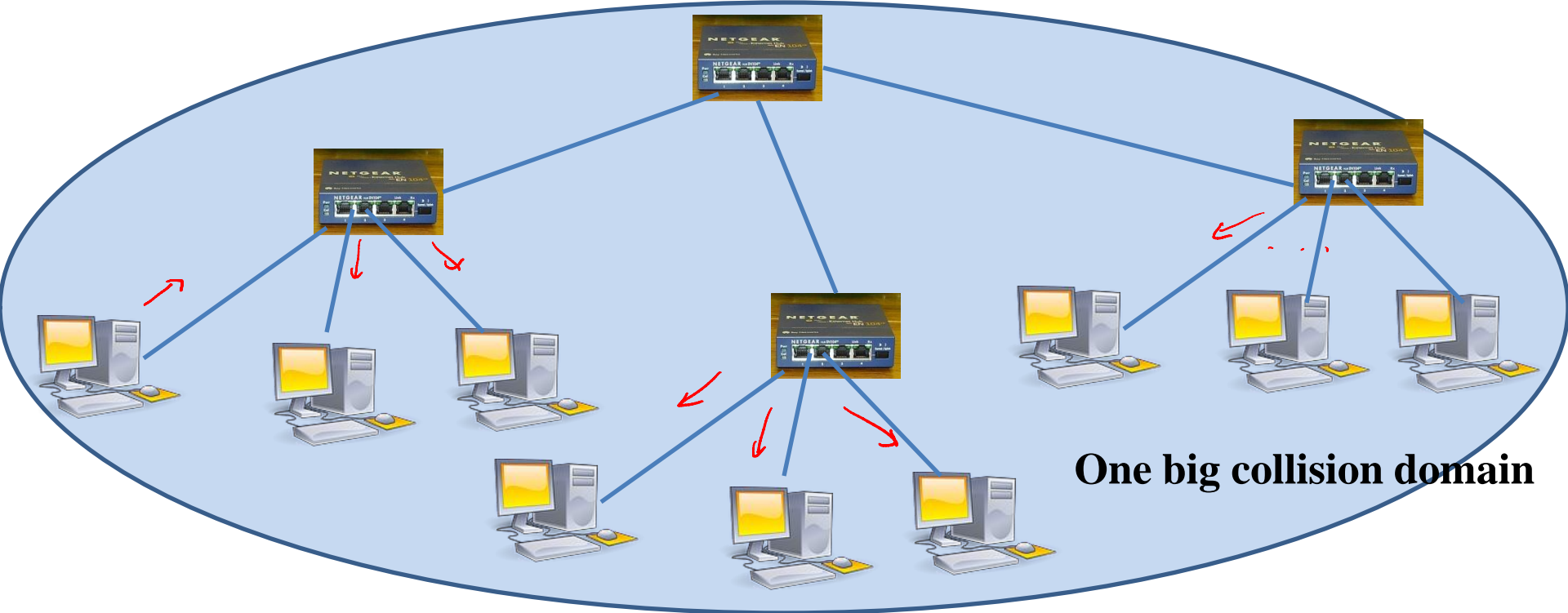

Hub or Switch
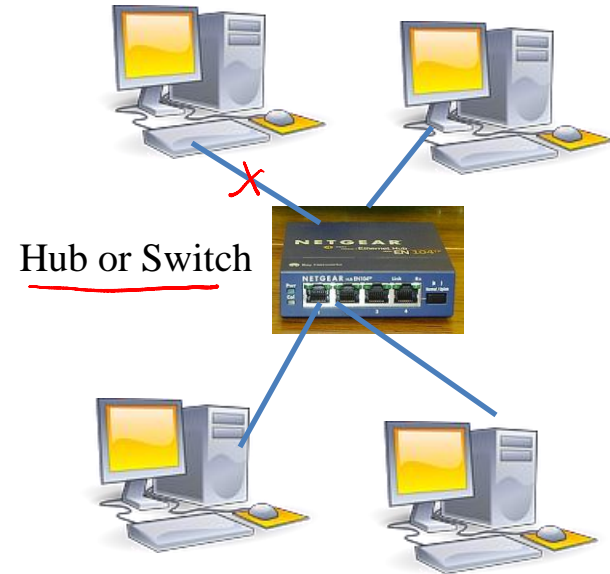
Hub

- Physical layer repeater: bits from one link sent out on all other links at same rate after boosting up the energy
  - No frame buffering
  - No MAC protocol (CSMA/CD) at hub

Interconnecting Hubs

- Can increases reach

- Cannot connect 10BaseT with 100BaseT
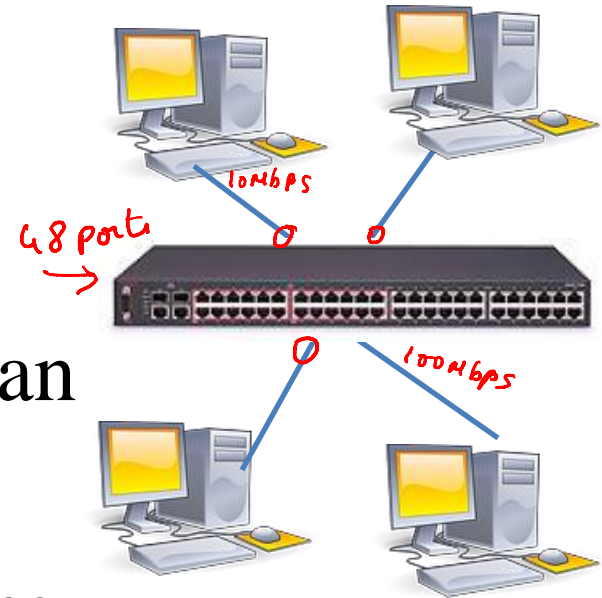
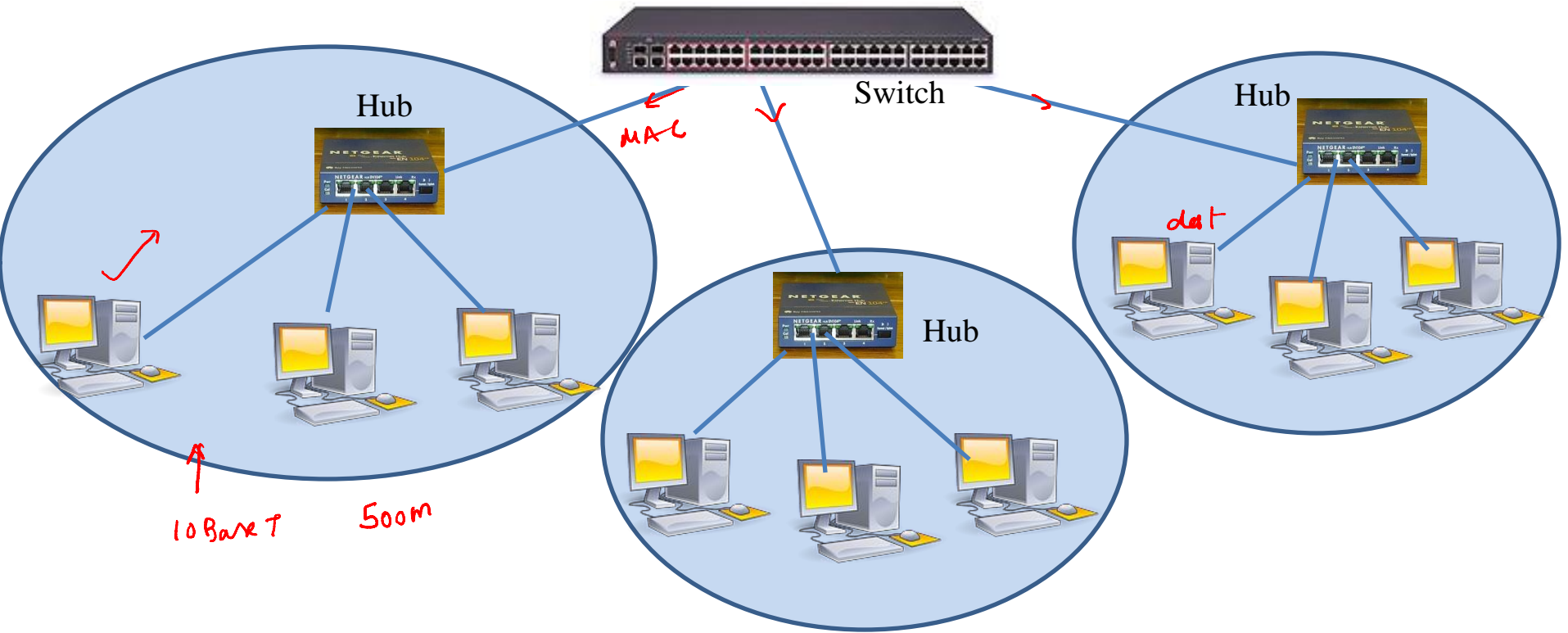One big collision domain

Restrictions

- Can increase distance but many restrictions

  - 10BaseT: terminal to hub 100m; at most 4 repeaters; network diameter 500m

  - 10Base5: terminal to hub 500m; at most 4 repeaters; network diameter 2.5km *max distance two hosts*

  - 100BaseT: terminal to hub *100m* 200m; at most 2 repeaters; network diameter 200m

  - Maximum number of hosts: 1024

Layer-2 Switch

- Also called Ethernet Bridge

- Most used configuration

- Transfers frames from an input to an output link

  - Runs MAC protocol on each interface

  - Buffer packets

  - Break up collision domains

  - Can switch speeds (10Mbps, 100Mbps)

Interconnection with Switch

Hub

Switch

MAC

Hub

10BaseT

500M

dat
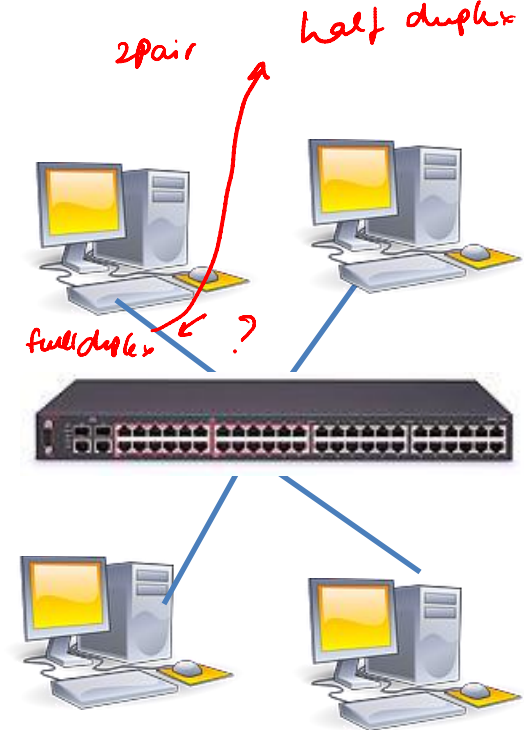
Hub

Three separate collision domains

Modes of operation

- Shared Mode (Half-duplex)

  - Employs MAC protocol

- Full duplex mode

  - Separate wires for transmission and reception

  - No need for MAC

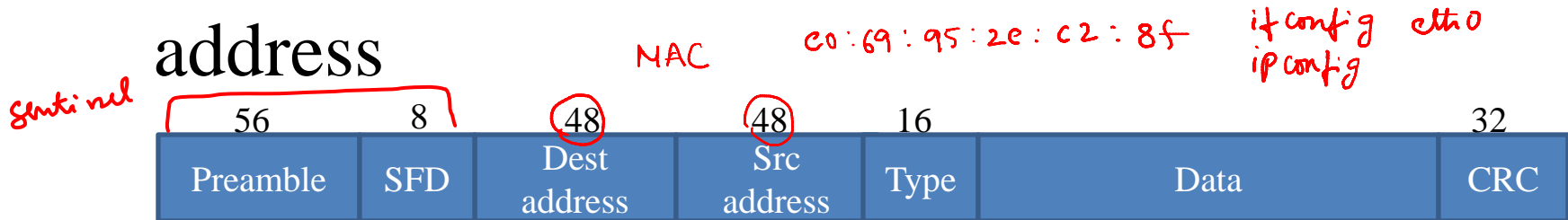 - Works only on point-to-point links

Ethernet Service

- Connectionless: No handshaking between sender and receiver

- Unreliable: Does not provide any means for recovering lost frames

  - If application needs reliability, it needs to employ TCP

Ethernet Frame Structure

- Preamble: Sequence of alternating 1's and 0's for synchronization

  – 10BaseT: Manchester encoding

- SFD: 10101011 (start frame delimiter)

- Source and Destination addresses: 48 bit MAC address

sentinel   *MAC*   *c0:69:95:2e:c2:8f*   *ifconfig eth0*
ipconfig

56	8	48	48	16		32
Preamble	SFD	Dest address	Src address	Type	Data	CRC

Ethernet Frame Structure

- Type: Demultiplexing key – specifies which higher layer protocol the packet is intended

  IP, ICMP

- Data: IP payload

  – Minimum 46 bytes and up to 1500 bytes

- CRC: Error Detection

- Inter Frame Gap: 96 bits (12 bytes)

56	8	48	48	16		32
Preamble	SFD	Dest address	Src address	Type	Data	CRC
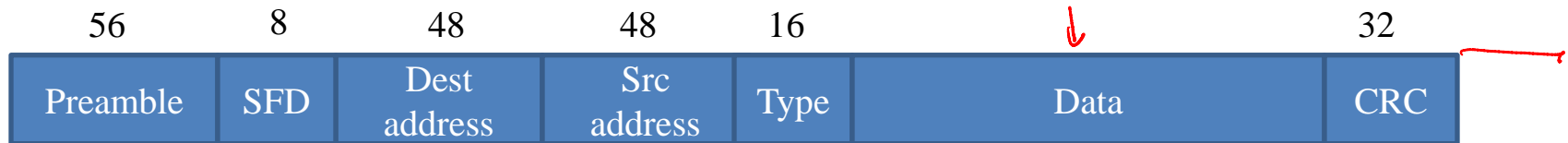
Ethernet Address

- Unique address belonging to the adaptor

  – Each manufacturer allocated different prefix

  – E.g. Intel: C4-85-08 (C4-85-08-30-33-48)

- In normal mode, an adaptor passes up frames if

  – Addressed to it (Unicast)

  ff:ff · · · ·

  – Broadcast address (all 1's)

  – Multicast address (first bit is 1) if it belongs to the group
     and adaptor appropriately configured

Summary

- Ethernet underwent significant evolution over the years *10 Mbps, 100 Gbps*

    - Speed increased by 10,000 times

    - Variety of media (coaxial, twisted pair, fiber optics)

    - Switching circumvented need for MAC

    - Many standards to cater to various versions *802.3i 10BaseT, 802.3u Fast Ethernet*
      802.3ab Gigabit ethernet, 802.3x full duplex

    - Only constant: frame format

- Going Forward: CSMA/CD MAC *↪ Shared Model half-duplex*