CS 540
Computer Networks II

Sandy Wang
sandy.w@svuca.edu

2. LAN SWITCHING

Topics

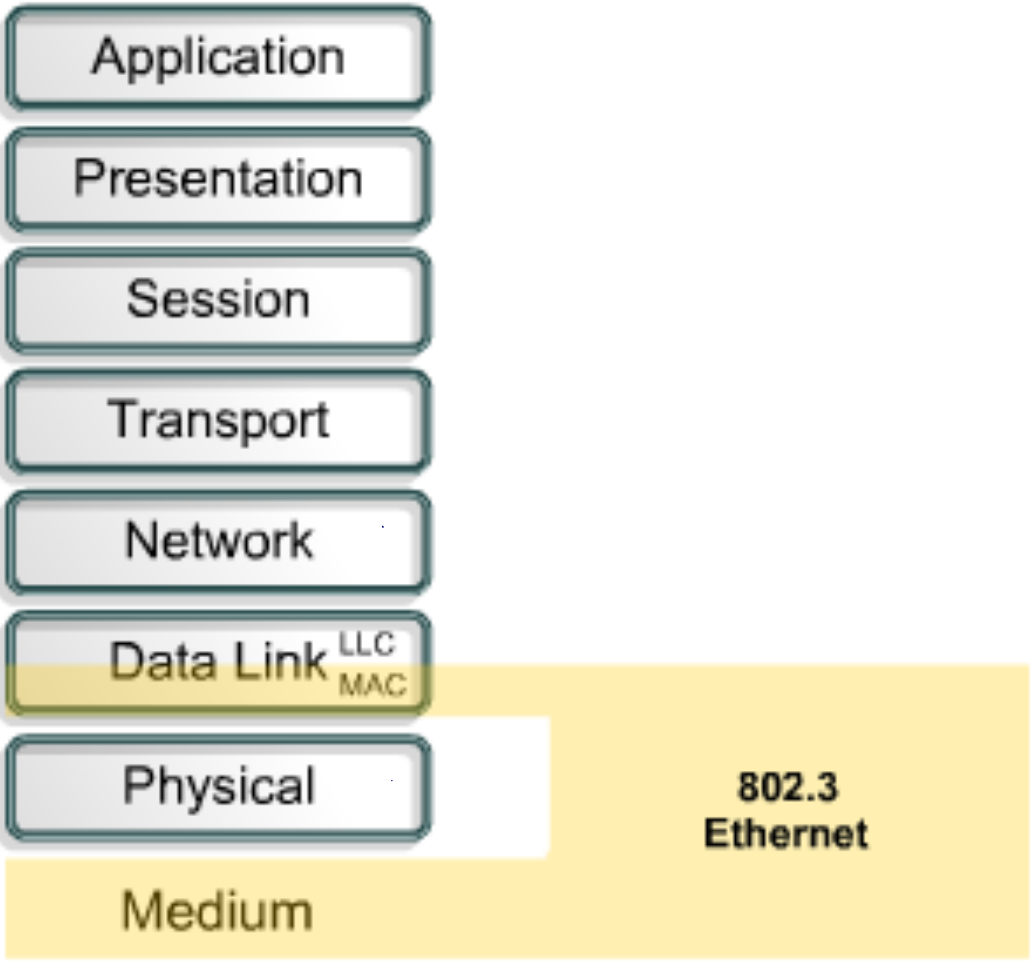
1. Overview
2. **LAN Switching**
3. IPv4
4. IPv6
5. Tunnels
6. Routing Protocols -- RIP, RIPng
7. Routing Protocols -- OSPF
8. IS-IS
9. Midterm Exam
10. BGP
11. MPLS
12. Transport Layer -- TCP/UDP
13. Congestion Control & Quality of Service (QoS)
14. Access Control List (ACL)
15. Final Exam

Reference Books

- **Routing TCP/IP Volume I, 2nd Edition** by Jeff Doyle and Jennifer Carroll

  ISBN: 1-57870-089-2
- **Routing TCP/IP Volume II** by Jeff Doyle and Jennifer DeHaven
  ISBN: 1-57870-089-2
- **Cisco CCNA Routing and Switching ICND2 200-101 Official Cert Guide, Academic Edition** by Wendel Odom -- July 10, 2013**.**
  ISBN-13: 978-1587144882
- **The TCP/IP Guide: A Comprehensive, Illustrated Internet Protocols Reference** by Charles M. Kozierok – October 1, 2005.
  ISBN-13: 978-1593270476
- **CCNA Routing and Switching 200-120 Network Simulator.** By Wendell Odom, Sean Wilkins. Published by Pearson IT Certification.
- http://class.svuca.edu/~sandy/class/CS540/

Ethernet and the OSI Model



Ethernet and the OSI Model

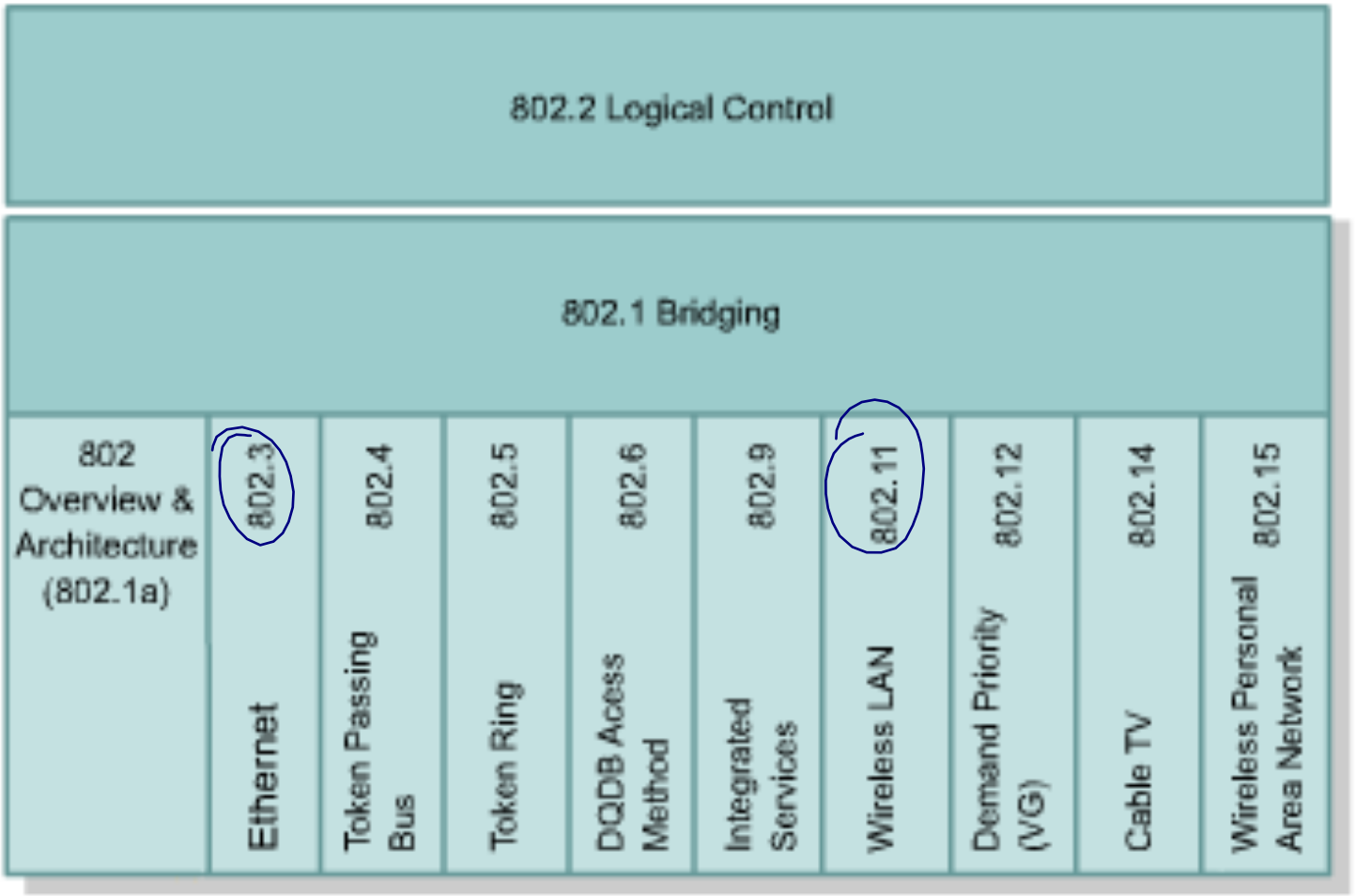
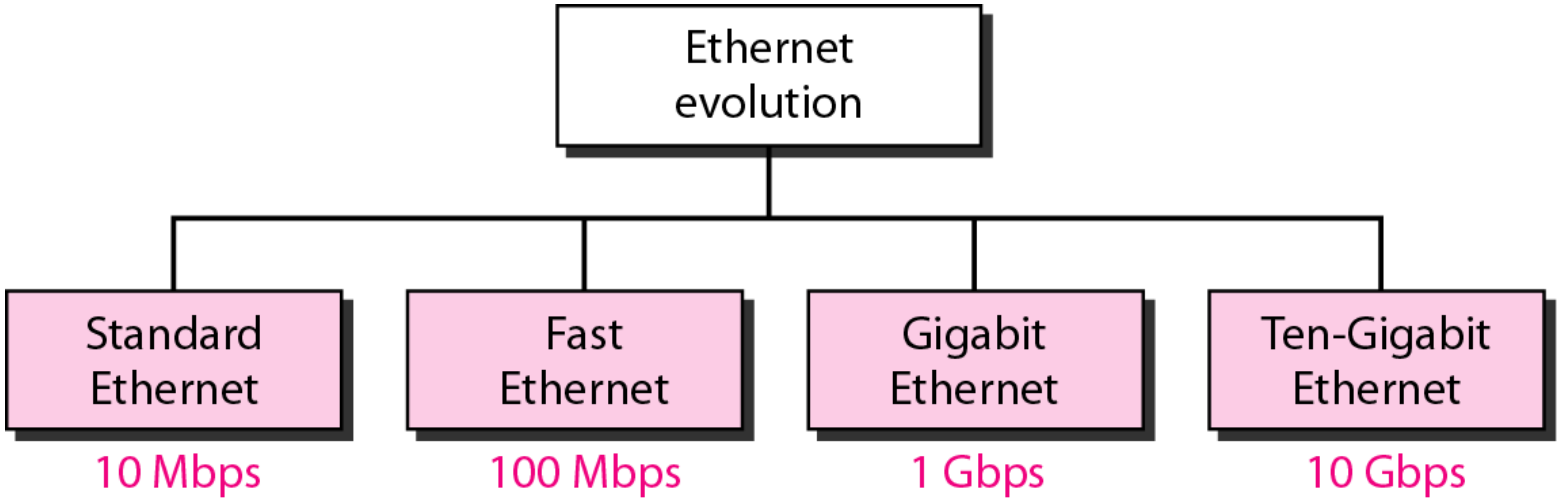
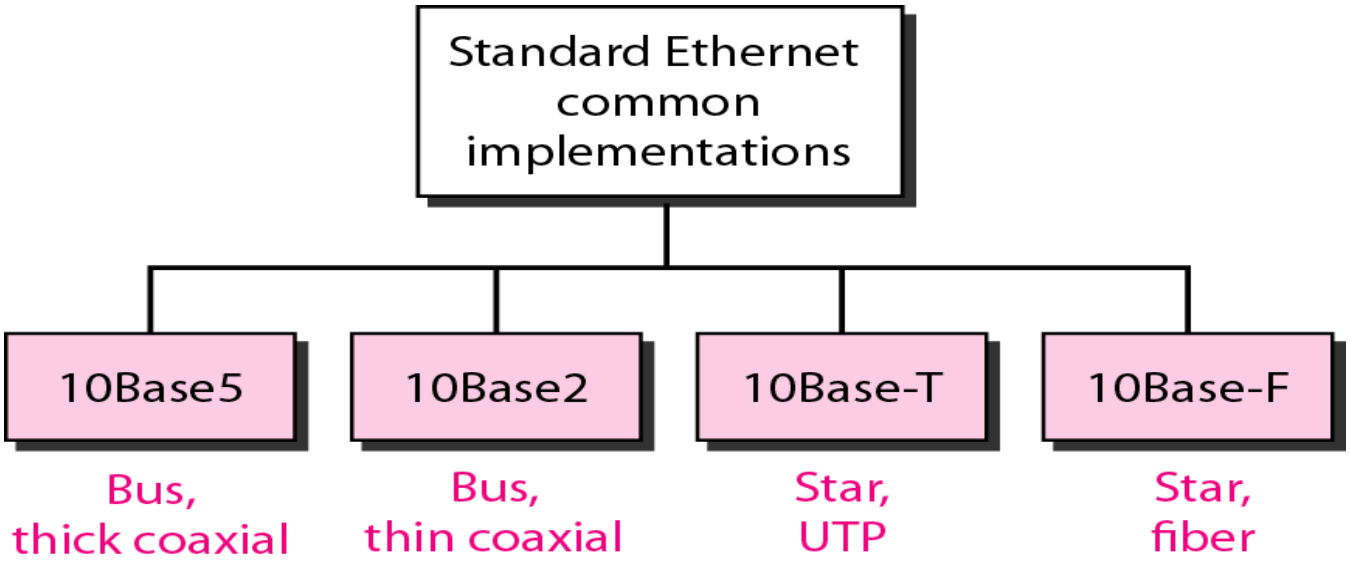


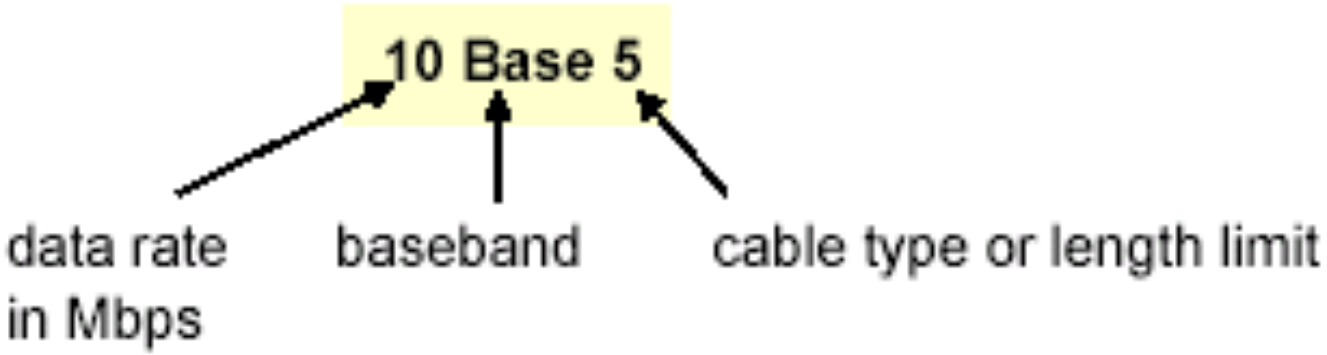
Figure 13.3 *Ethernet evolution through four generations*



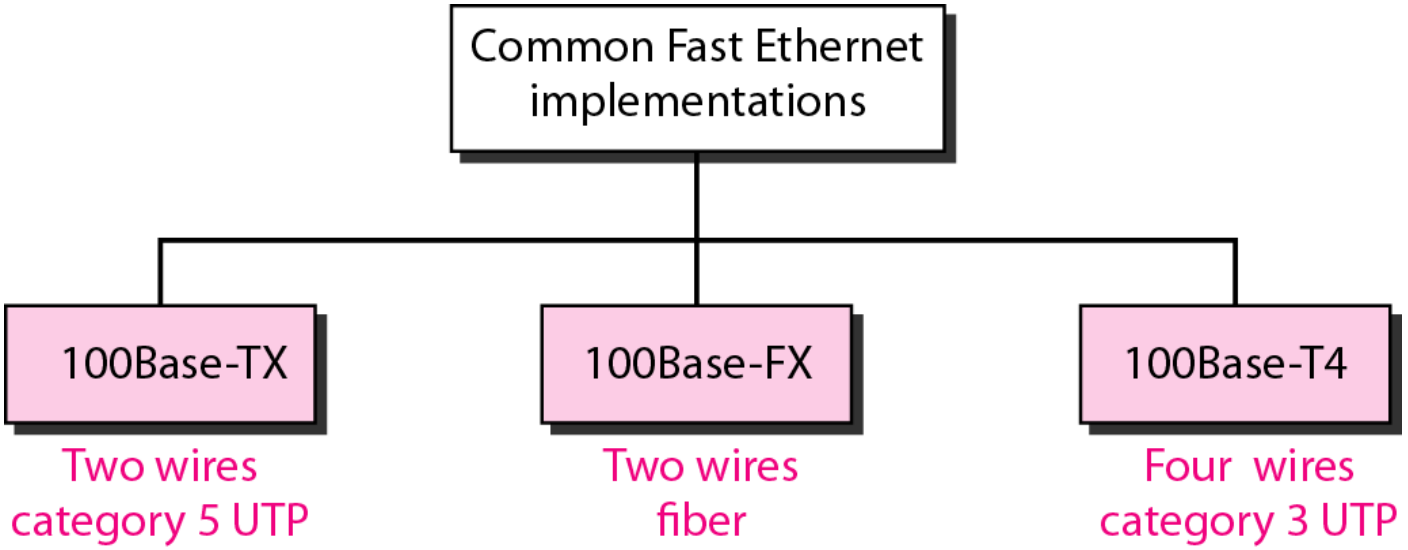
Categories of traditional Ethernet



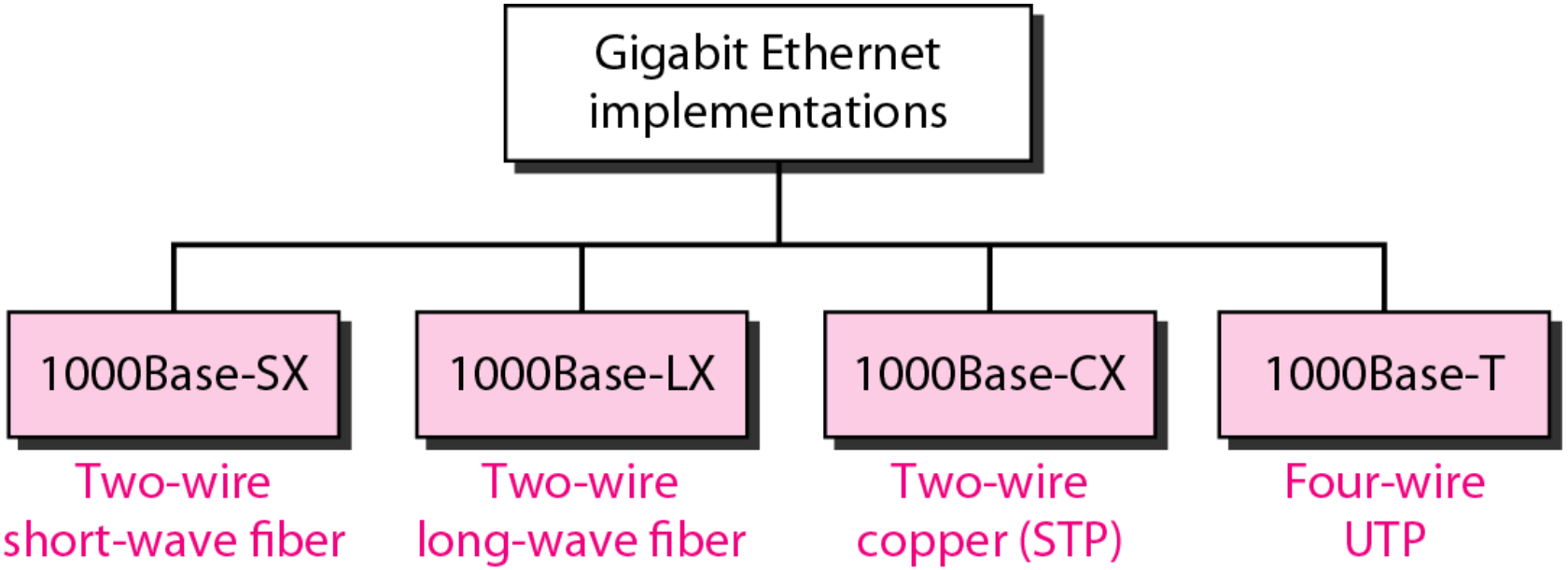
- <data rate><Signaling method><Max segment length or cable type>



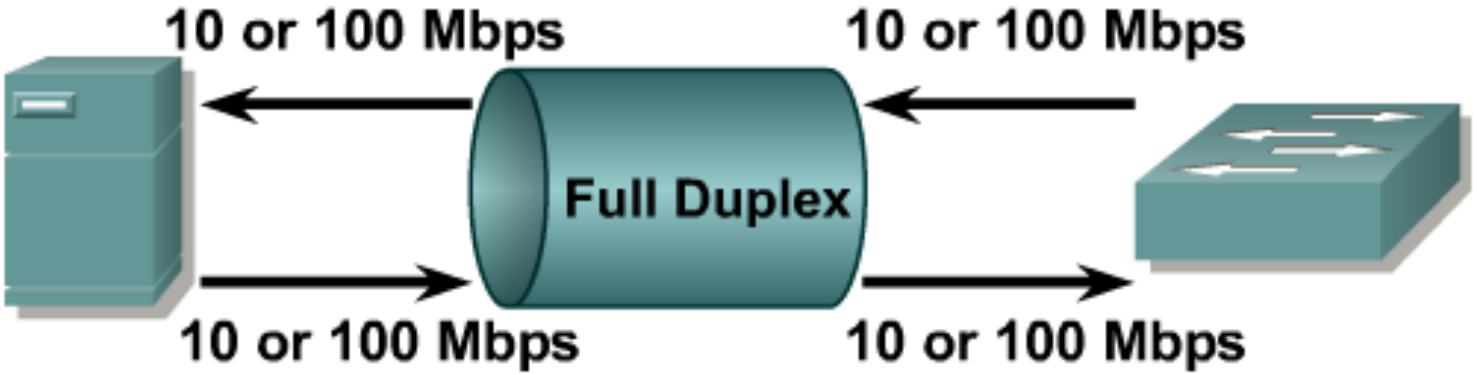
Fast Ethernet implementations



Gigabit Ethernet implementations



Full Duplex

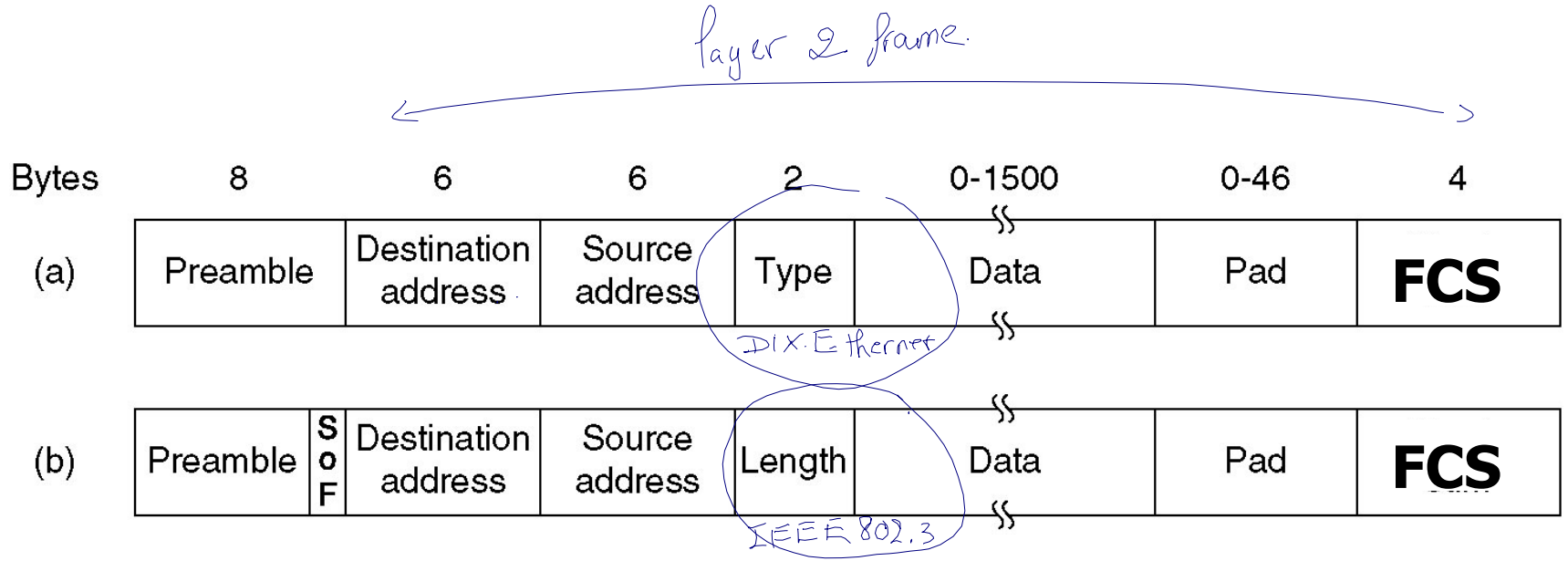


- Doubles bandwidth between nodes
- Collision-free transmission
- Two 10- or 100- Mbps data paths

Switch Modes

- Store and Forward - A switch receives the entire frame before sending it out the destination port.
- Cut-Through - A switch starts to transfer the frame as soon as the destination MAC address is received. (it does not even wait for the full frame to complete. This it may send error/corrupted frame since there is no CRC check)
  ↑
  MAC trailer

Ethernet Frame Format



Frame formats. (a) DIX Ethernet, (b) IEEE 802.3.

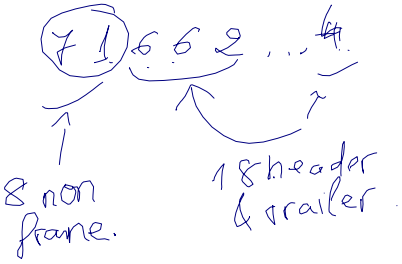
2^8 2^8 Type. Length.

MAC address : MM:MM:MM:SS:SS:SS

1 byte

6 bytes (48 bits)

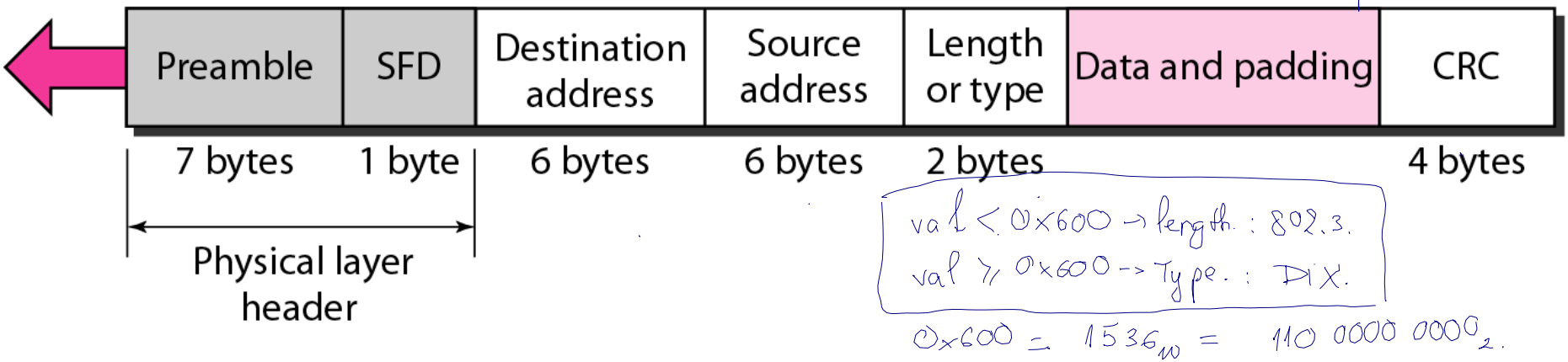
802.3 MAC frame



Preamble: 56 bits of alternating 1s and 0s.

SFD: Start frame delimiter, flag (10101011)

min 46 bytes., smaller needs padding.



val < 0x600 → length. : 802.3.
val ≥ 0x600 → Type. : DIX.

$0x600 = 1536_{10} = 110\ 0000\ 0000_2$.

- Length/Type – Length if less than 0x0600, otherwise protocol type
- If less than 46 bytes data, padding is required

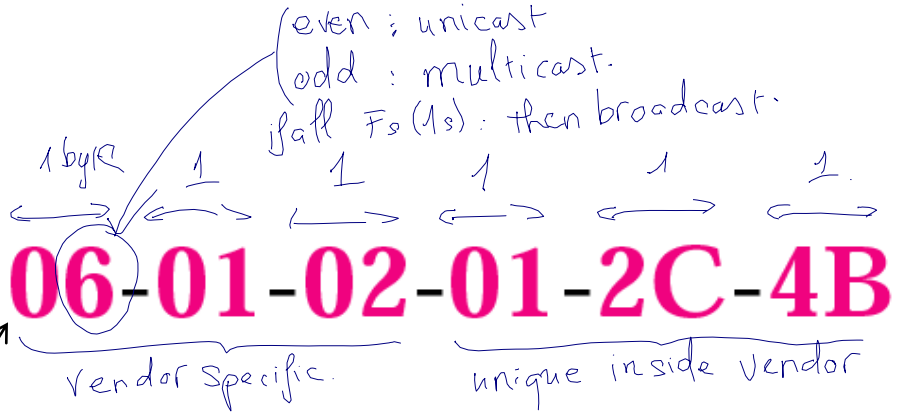
Ethernet Frame

- Preamble:
  - 8 bytes with pattern 10101010 used to synchronize receiver, sender clock rates. (SFD)
  - In IEEE 802.3, eighth byte is start of frame (10101011)
- Addresses: 6 bytes (explained latter)
- Type (DIX) > 0x600
  - Indicates the type of the **Network layer protocol** being carried in the **payload** field such as IP (**0800**), Novell IPX (**8137**) and AppleTalk (**809B**), ARP (**0806**))
  - Allow **multiple network layer** protocols to be supported on a single machine (multiplexing)
  - Its value starts at **0600h (=1536 in decimal)**
- Length (IEEE 802.3): number of bytes in the **data field**. < 0x600
  - Maximum 1500 bytes **(= 0x5DC)**
- CRC: checked at receiver, if error is detected, the frame is **discarded**
- Data: carries data encapsulated from the upper-layer protocols
- Pad: Zeros are added to the data field to make the **minimum data length = 46 bytes**

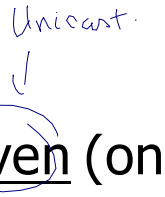
Ethernet Provides Unreliable, connectionless Service

- **Ethernet data** link layer protocol provides **connectionless service** to the network layer
  - No handshaking between sending and receiving adapter.
    - No sequence/order.
    - Frame has no relation to others.
- **Ethernet protocol provides *Unreliable* service to the network layer :**
  - Receiving adapter doesn't send ACK or NAK to sending adapter
  - This means stream of datagrams passed to network layer can have gaps (missing data)
    - Gaps will be filled if application is using reliable transport layer protocol
      - Otherwise, application will see the gaps

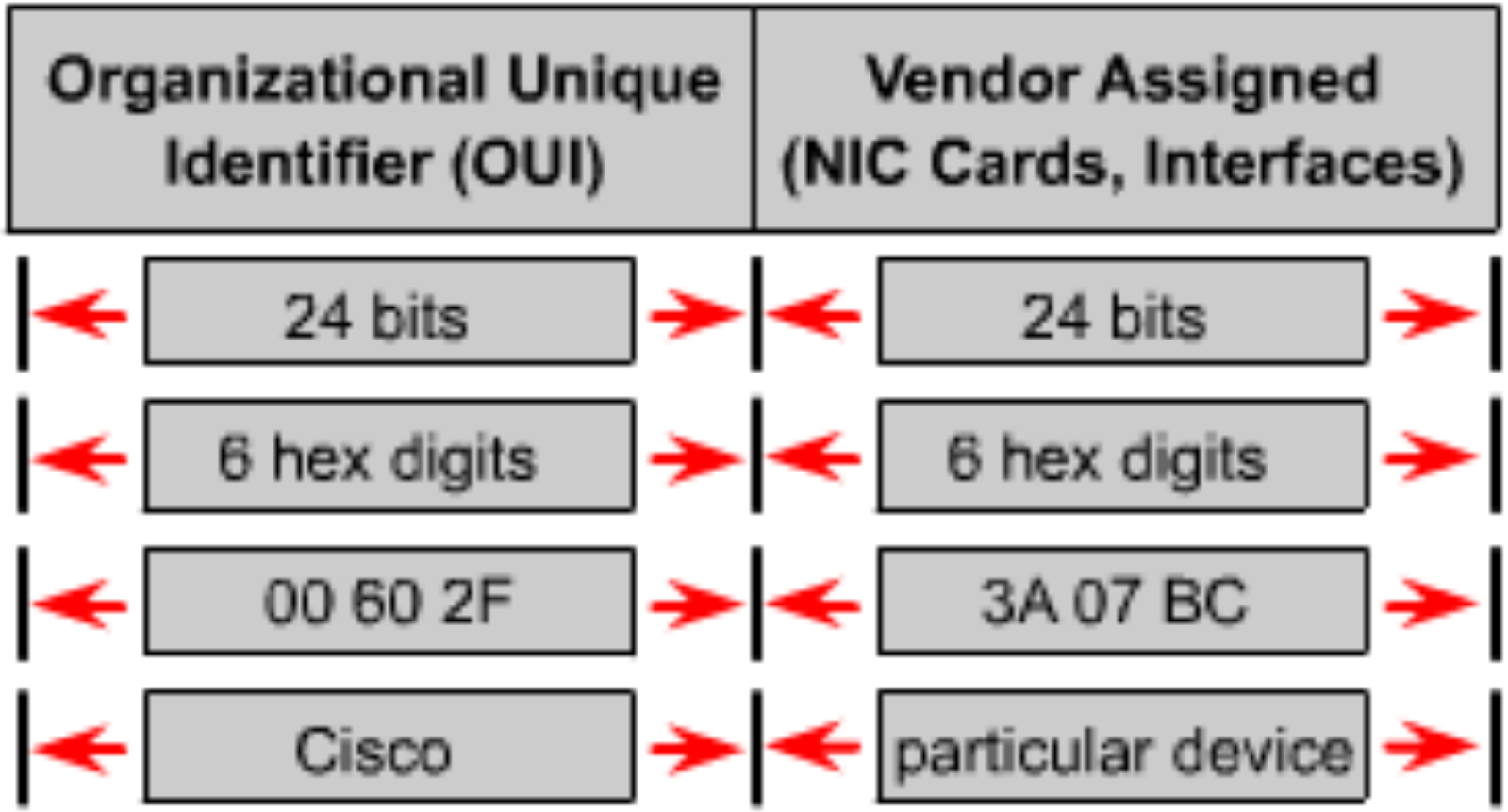
Ethernet address



- 6 bytes = 48 bits
- Flat address not hierarchical
- Burned into the NIC ROM
- First three bytes from left specify the vendor. Cisco 00-00-0C, 3Com 02-60-8C and the last 24 bit should be created uniquely by the company
- Destination Address can be:
  - Unicast: second digit from left is even (one recipient)
  - Multicast: Second digit from left is odd (group of stations to receive the frame – conferencing applications)
  - Broadcast (ALL ones) (all stations receive the frame)
- Source address is always Unicast



Naming


Organizational Unique Identifier (OUI)
Vendor Assigned (NIC Cards, Interfaces)
24 bits
24 bits
6 hex digits
6 hex digits
00 60 2F
3A 07 BC
Cisco
particular device

Note

The least significant bit of the first byte defines the type of address. If the bit is 0, the address is unicast; otherwise, it is multicast.

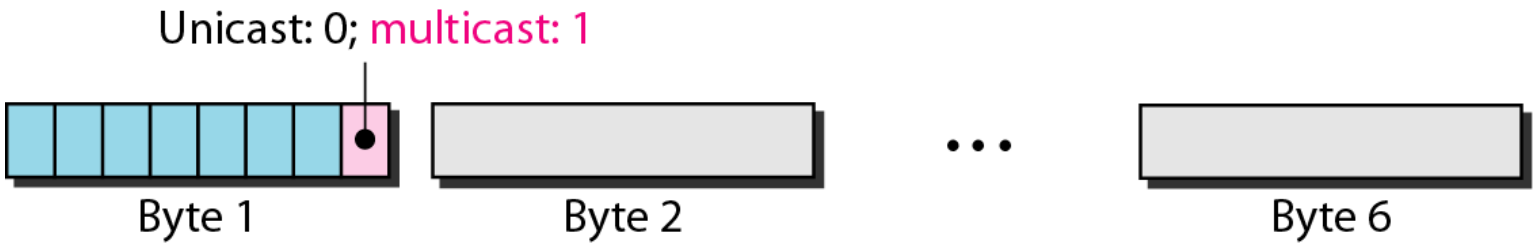
hex digit even.
otherwise: odd.

Note

The broadcast destination address is a special case of the multicast address in which all bits are 1s.

Fs.

Figure 13.7 *Unicast and multicast addresses*



Example 13.1

Define the type of the following destination addresses:

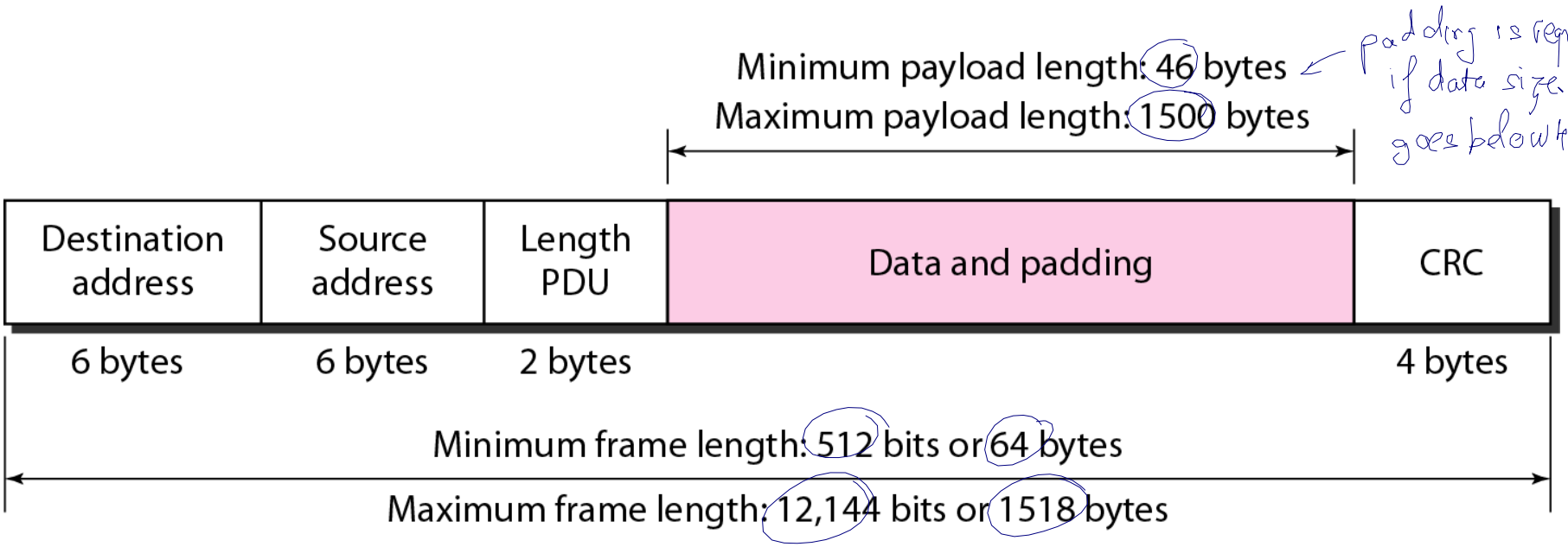
a. 4A:30:10:21:10:1A
b. 47:20:1B:2E:08:EE
c. FF:FF:FF:FF:FF:FF

Solution

To find the type of the address, we need to look at the second hexadecimal digit from the left. If it is even, the address is unicast. If it is odd, the address is multicast. If all digits are F's, the address is broadcast. Therefore, we have the following:

a. This is a unicast address because A in binary is 1010.
b. This is a multicast address because 7 in binary is 0111.
c. This is a broadcast address because all digits are F's.

Figure 13.5 *Minimum and maximum lengths*



Padding is required if data size goes below 46.

3 reasons frame is dropped:
- CRC check fail.
- oversize (1518)
- undersize (64).

Data: 46 – 1500 bytes.

Frame: 64 - 1518. bytes.

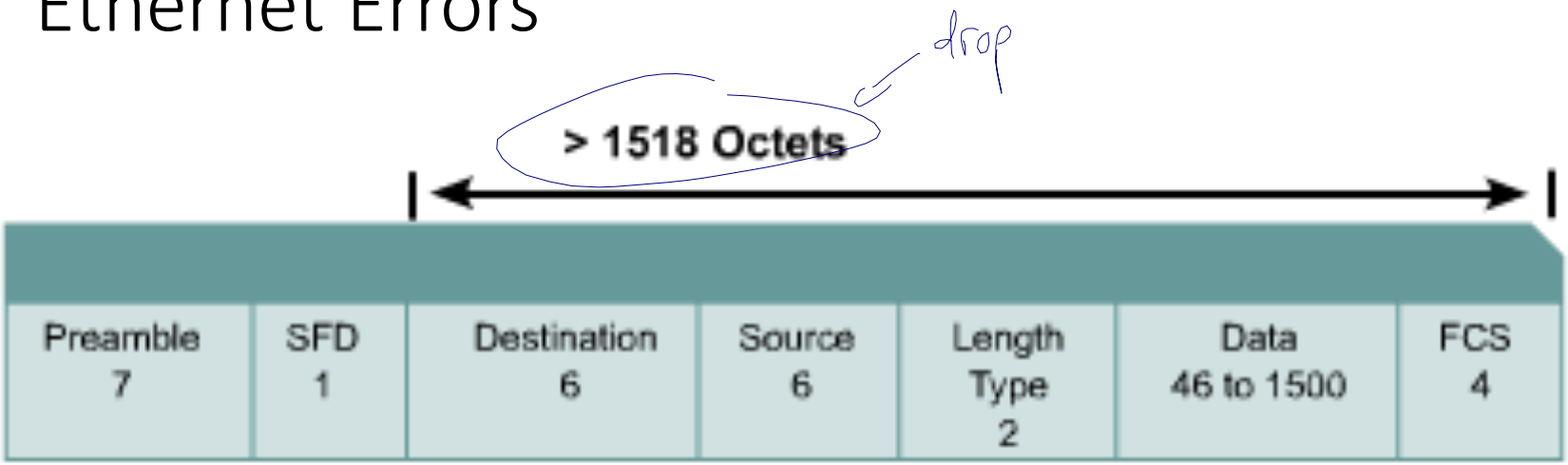
Note

Frame length:

Minimum: 64 bytes (512 bits)

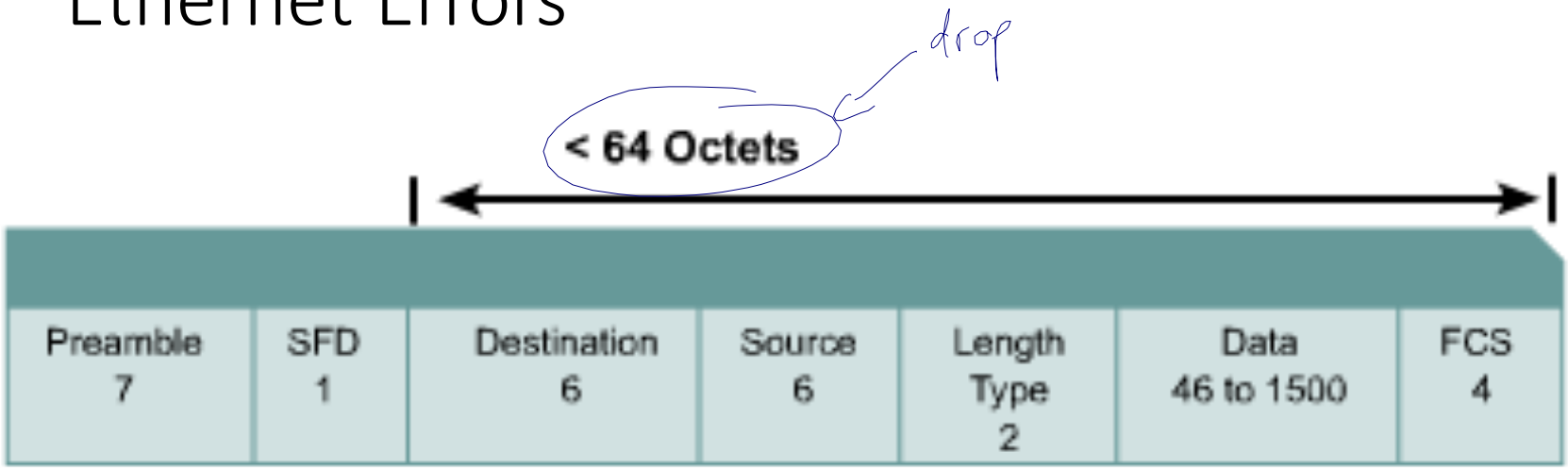
Maximum: 1518 bytes (12,144 bits)

Ethernet Errors



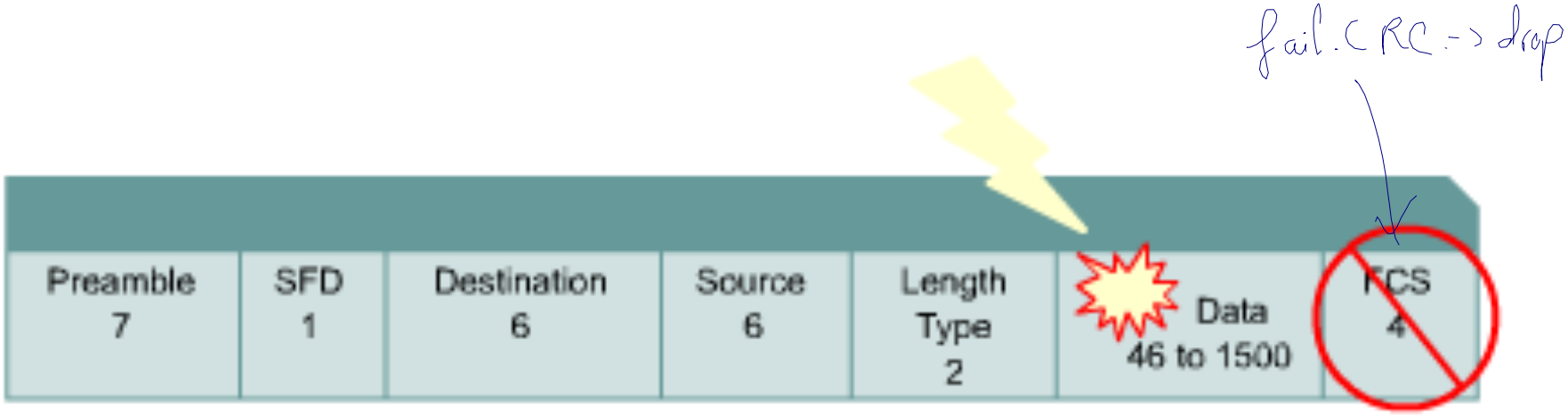
Jabber and Long Frames are both in excess of the maximum frame size. Jabber is significantly larger.

Ethernet Errors



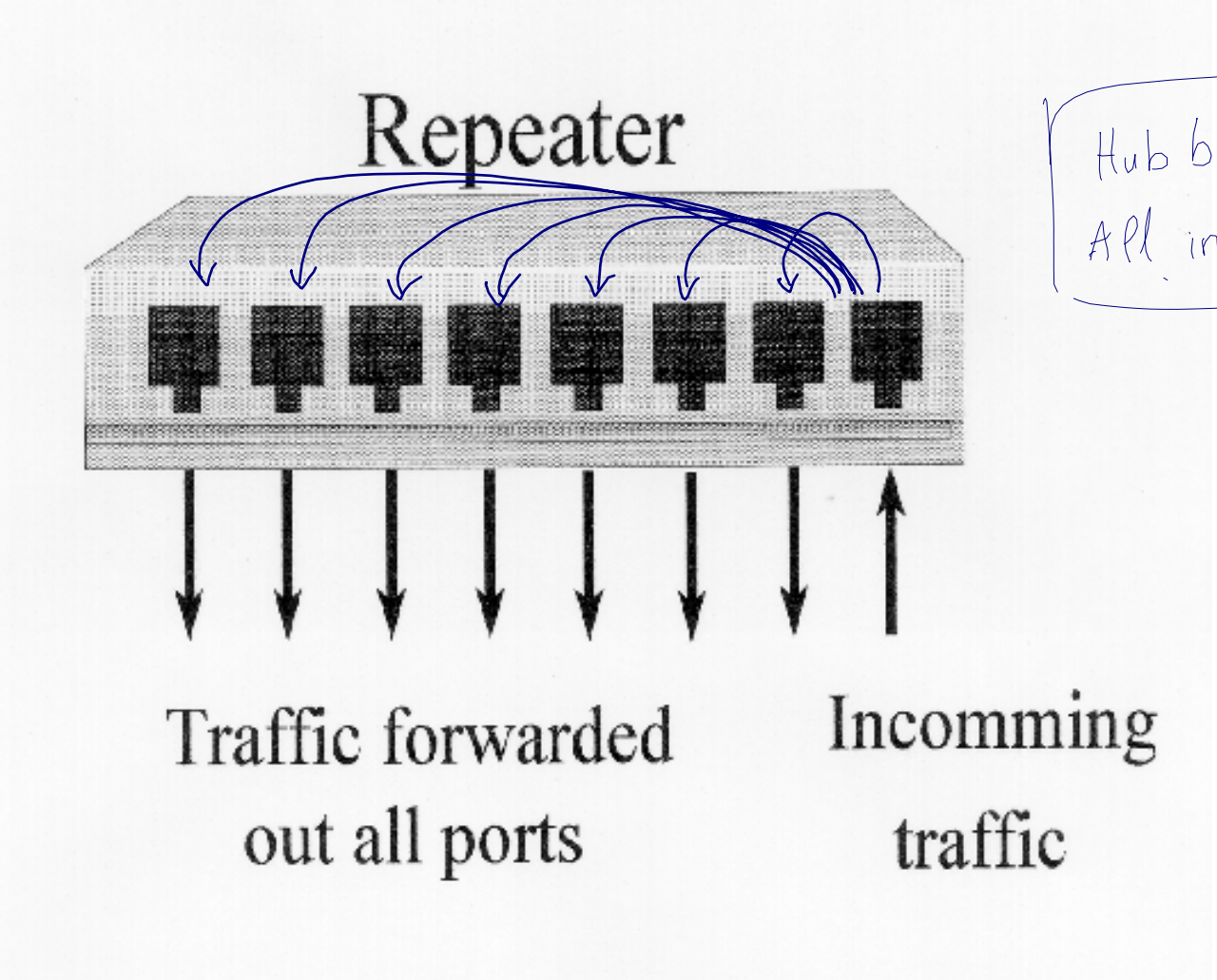
Short frames are properly formed in all but one aspect and have valid FCS checksums, but are less than the minimum frame size (64 octets).

FCS Errors


fail CRC -> drop
Preamble
7
SFD
1
Destination
6
Source
6
Length
Type
2
Data
46 to 1500
FCS
4

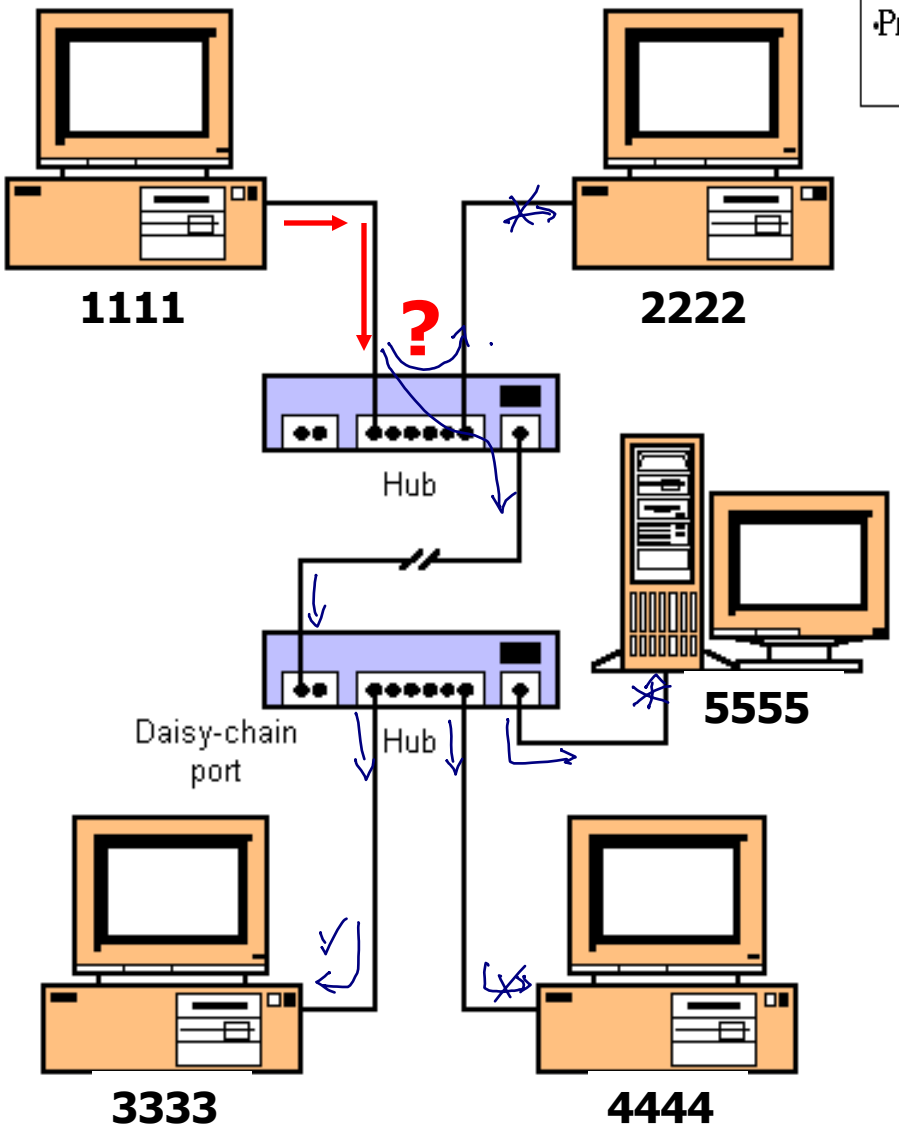
Sending and receiving Ethernet frames via a hub

Hub or



Hub broadcasts
All info it receives

Sending and receiving Ethernet frames via a hub

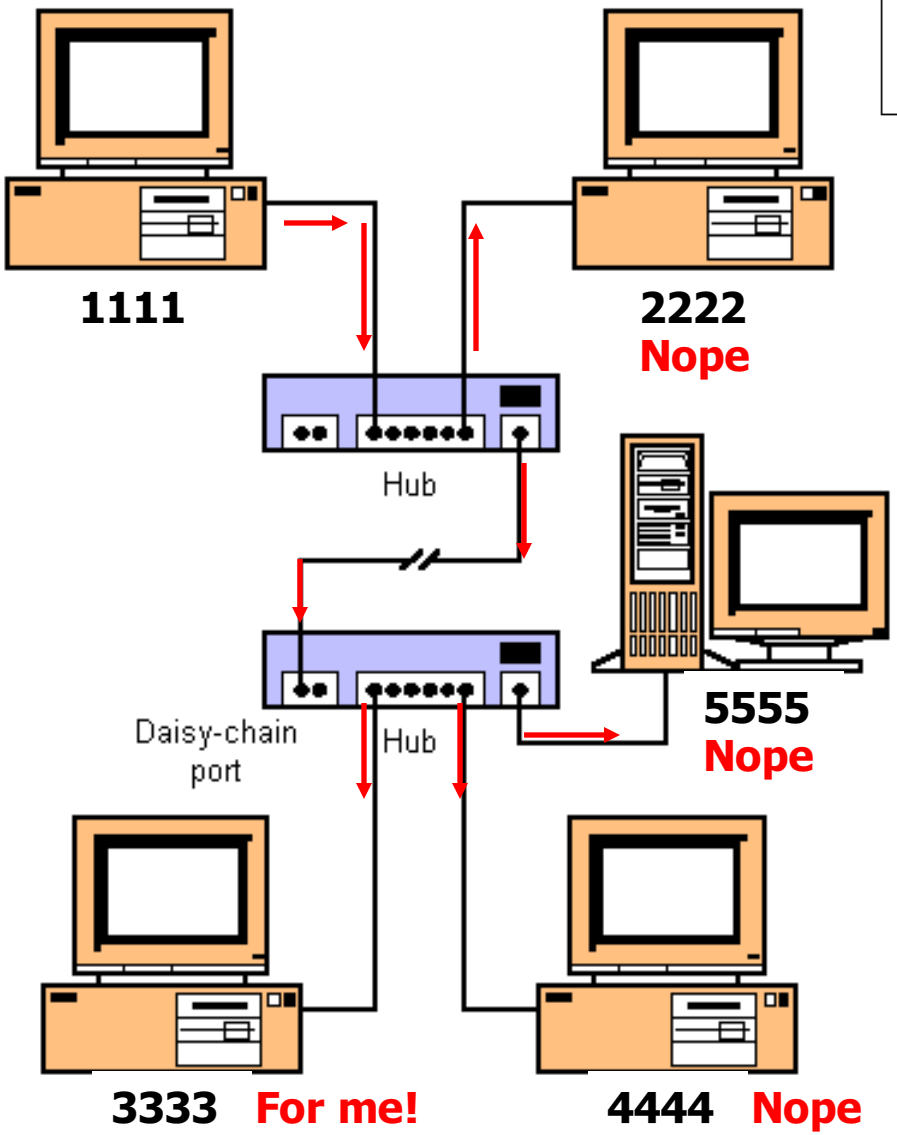


Preamble	Destination Address	Source Address	Type	Data	Pad	CRC

3333 **1111**

- So, what does a hub do when it receives information?
- Remember, a hub is nothing more than a multiport repeater.

Sending and receiving Ethernet frames via a hub

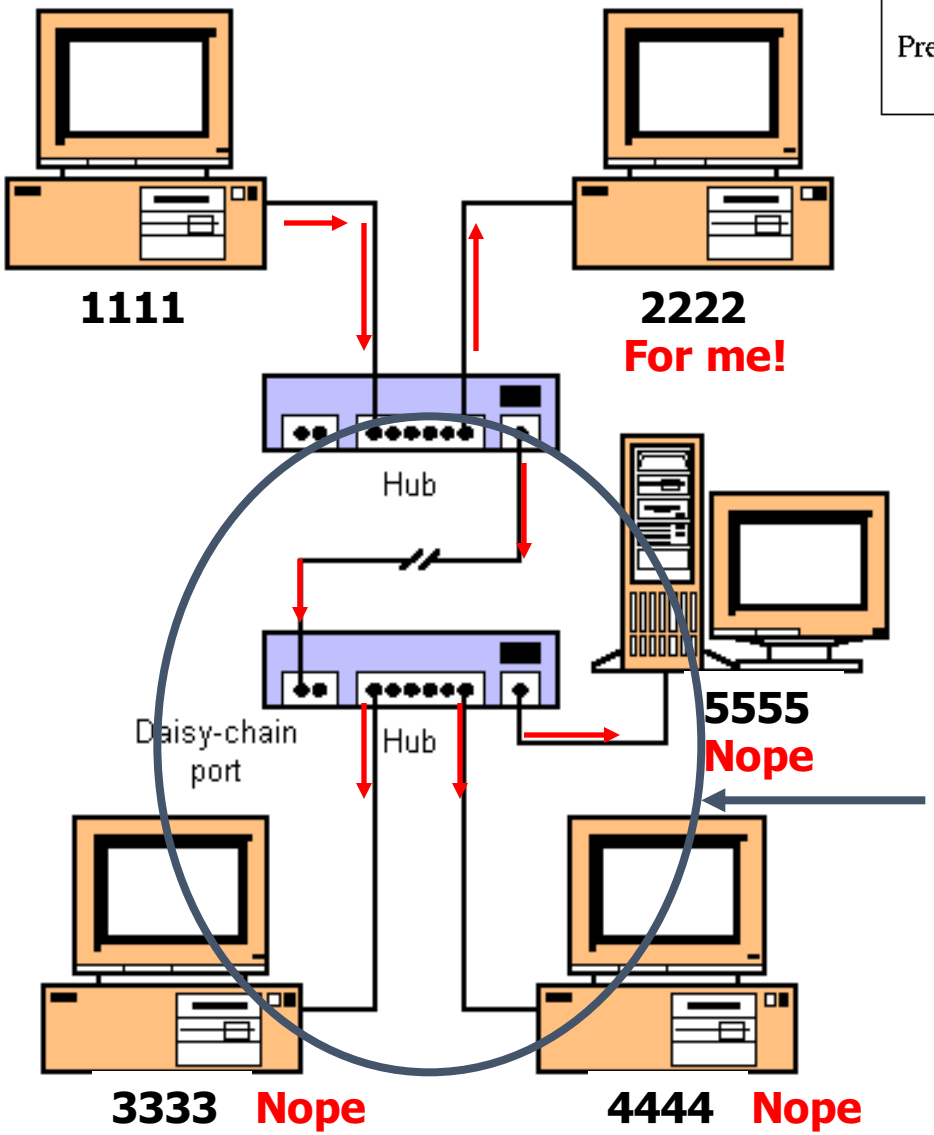


Preamble	Destination Address	Source Address	Type	Data	Pad	CRC

3333 **1111**

- The hub will **flood** it out all ports except for the incoming port.
- Hub is a layer 1 device.
- A hub does NOT look at layer 2 addresses, so it is fast in transmitting data.
- Disadvantage with hubs: A hub or series of hubs is a single **collision domain**.
- A collision will occur if any two or more devices transmit at the same time within the collision domain.
- More on this later.

Sending and receiving Ethernet frames via a hub



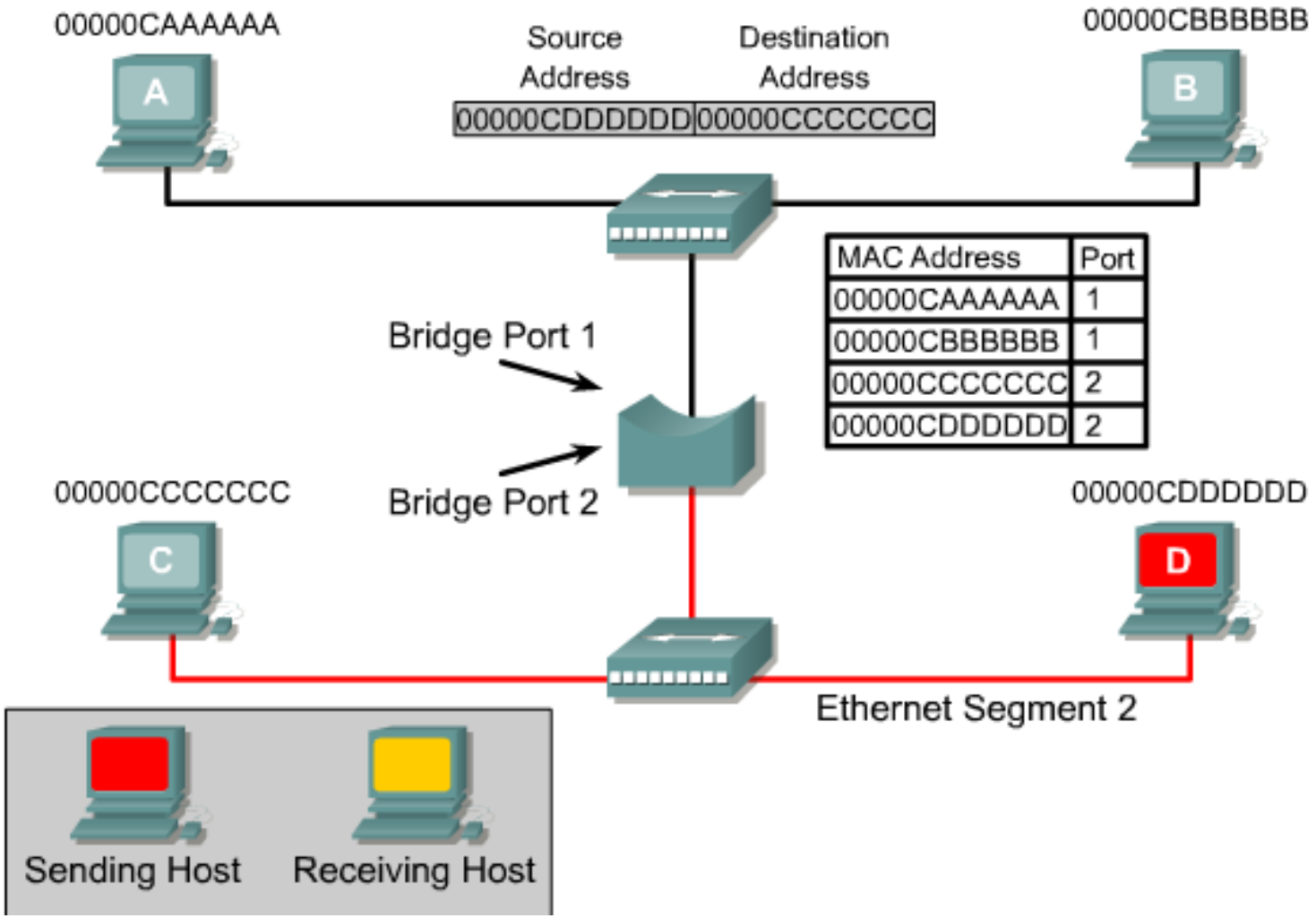
Preamble	Destination Address	Source Address	Type	Data	Pad	CRC

2222 **1111**

- Another disadvantage with hubs is that is take up unnecessary bandwidth on other links.

Wasted bandwidth

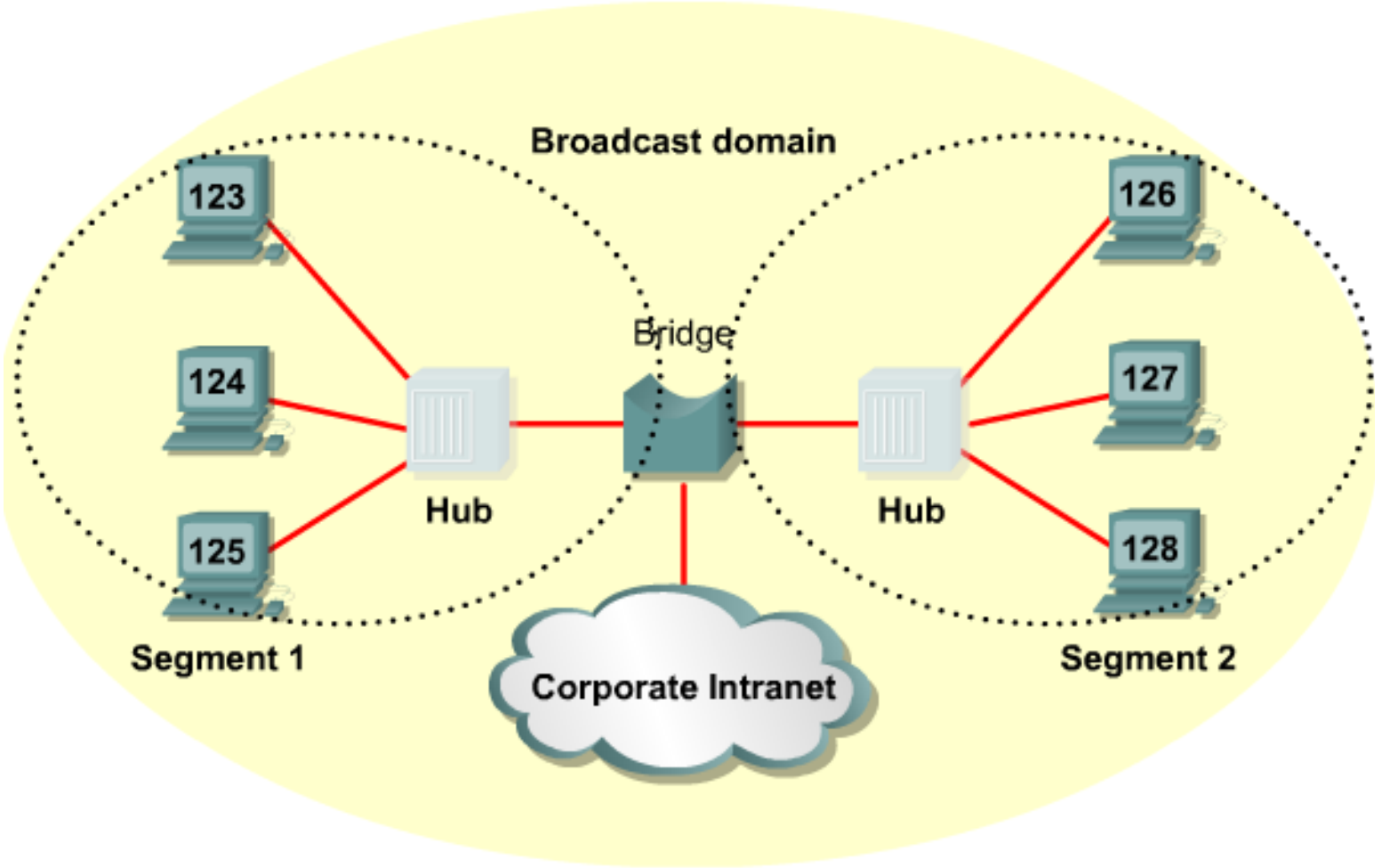
Layer 2 Bridging



Bridges

L2 device

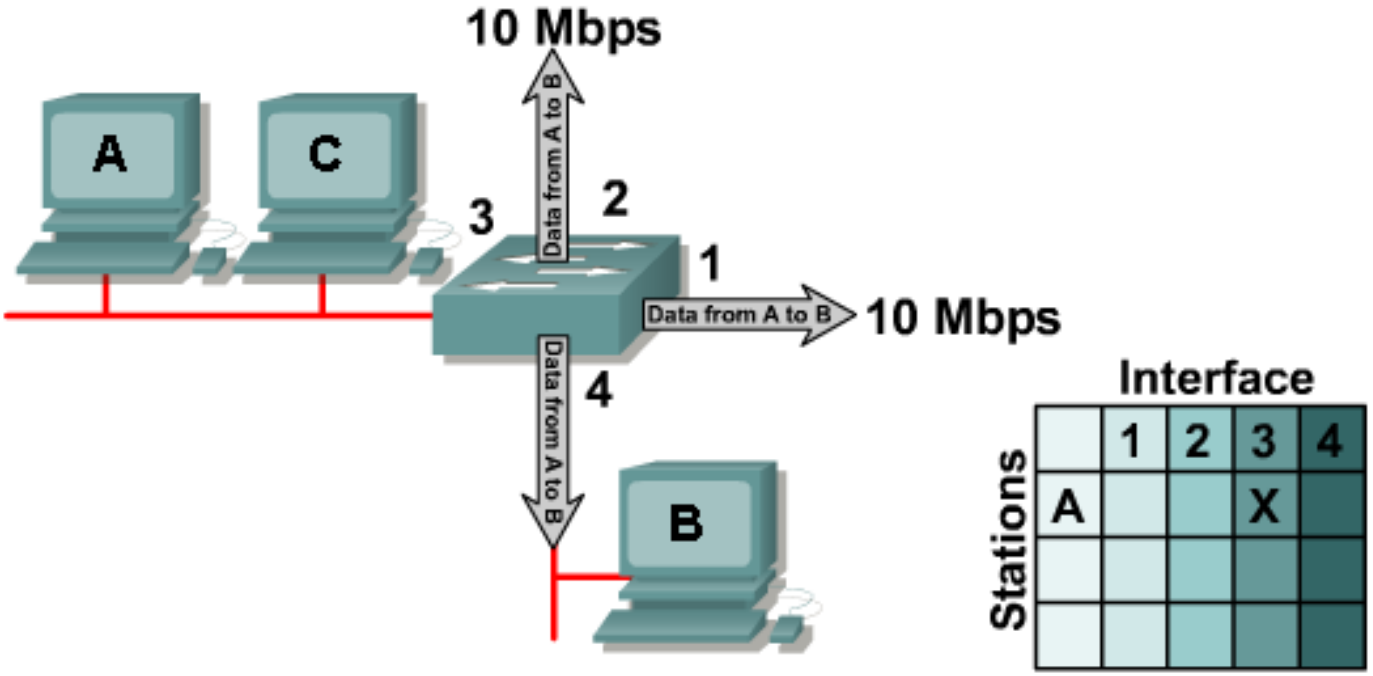
a hub but with smarter check before broadcast/forward



Switch Operation

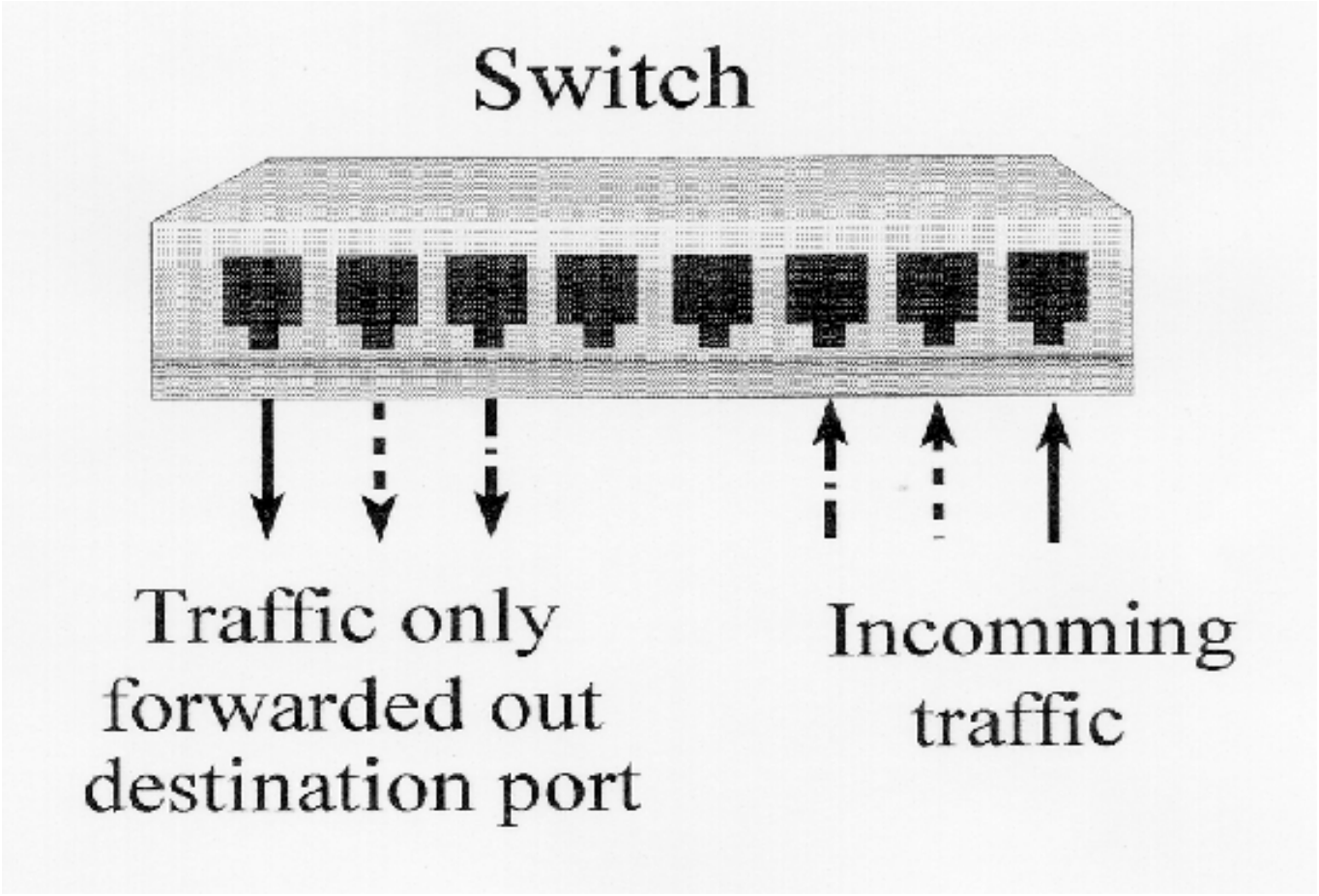
a multi ports bridge.

L2 device



- Forward packets based on MAC address in forwarding table
- Operates at OSI Layer 2
- Learns a station's location by examining source address

Sending and receiving Ethernet frames via a switch



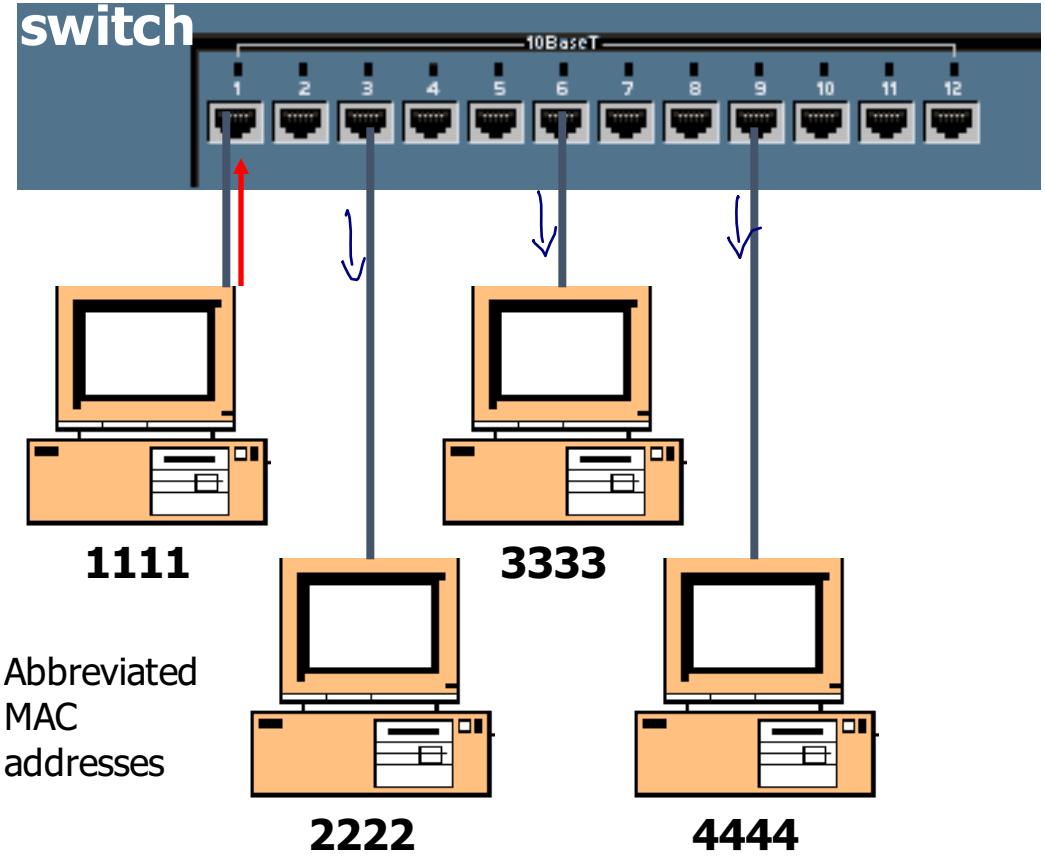
Sending and receiving Ethernet frames via a switch

Source Address Table

Port	Source MAC Add.	Port	Source MAC Add.

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC

3333 1111



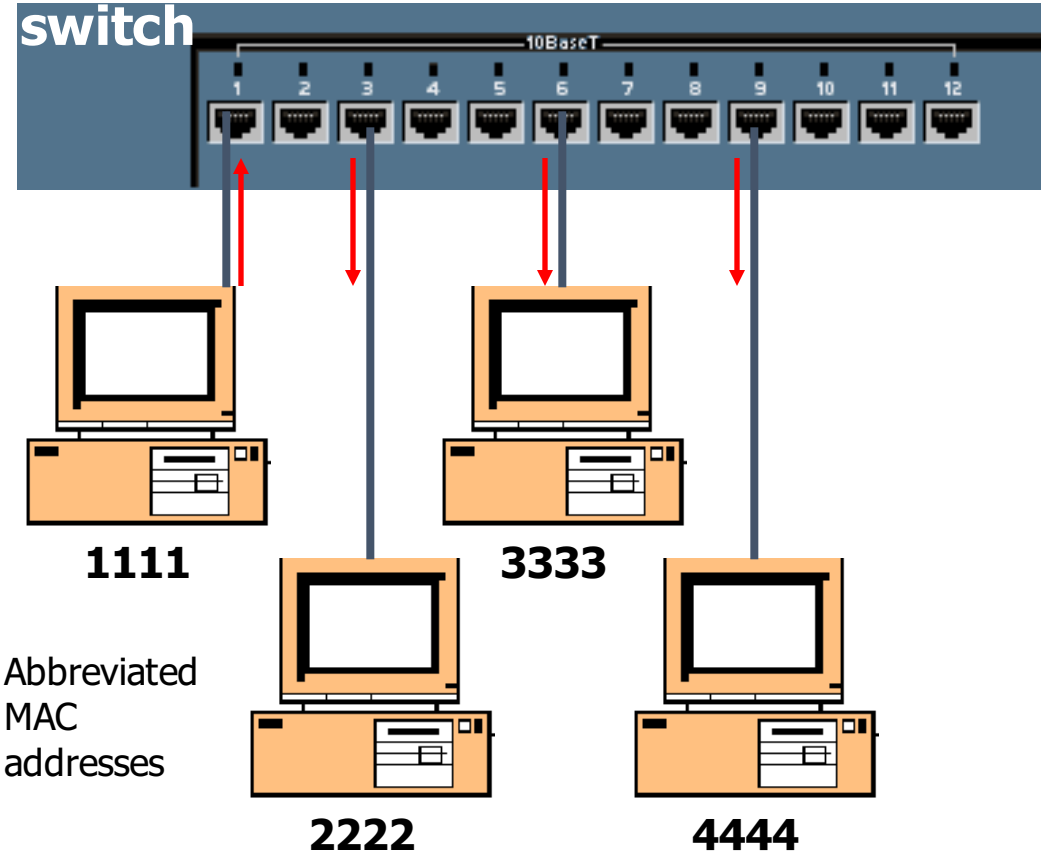
- Switches are also known as **learning bridges** or **learning switches**.
- A switch has a source address table in cache (RAM) where it stores source MAC address after it learns about them.
- A switch receives an Ethernet frame it searches the source address table for the Destination MAC address.
- If it finds a match, it **filters** the frame by only sending it out that port.
- If there is not a match if **floods** it out all ports.

No Destination Address in table, Flood

Source Address Table

Port	Source MAC Add.	Port	Source MAC Add.
1	**1111**		

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	3333	**1111**				



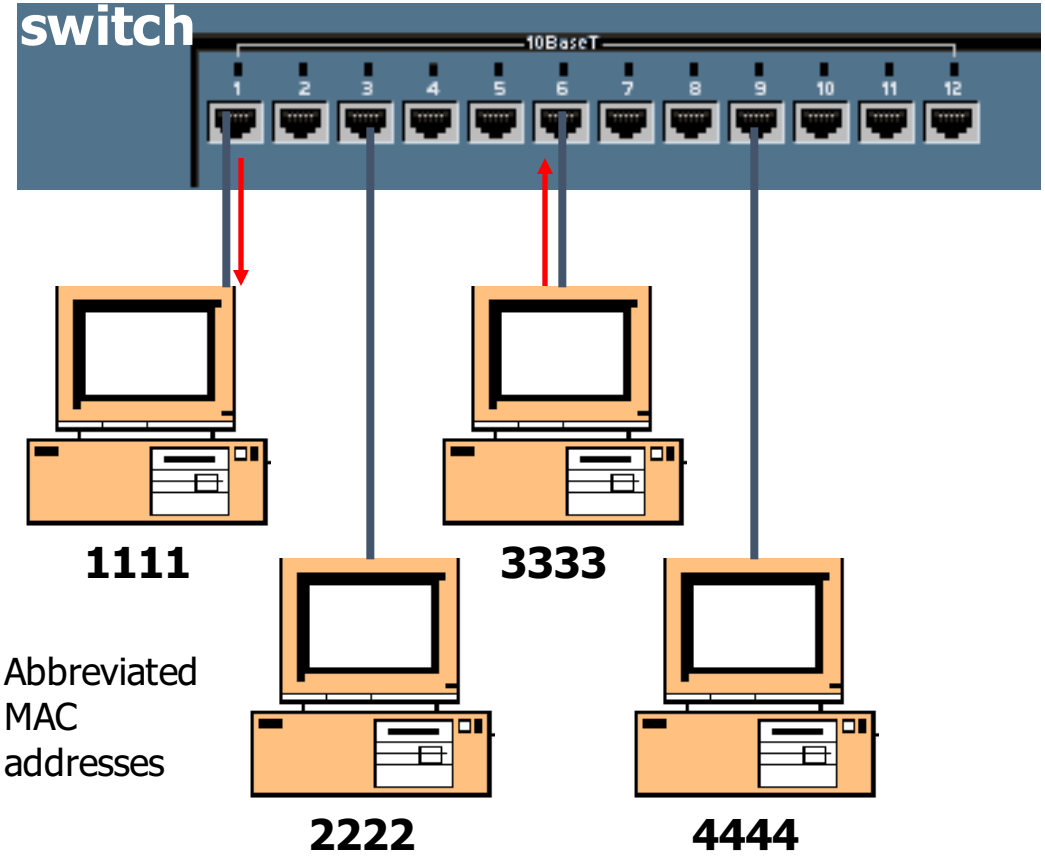
- How does it learn source MAC addresses?
- First, the switch will see if the SA (1111) is in it's table.
- If it is, it resets the timer (more in a moment).
- If it is NOT in the table it adds it, with the port number.
- Next, in our scenario, the switch will **flood** the frame out all other ports, because the DA is not in the source address table.

Destination Address in table, Filter

Source Address Table

Port	Source MAC Add.	Port	Source MAC Add.
1	1111	6	3333

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	1111	3333				



- Most communications involve some sort of client-server relationship or exchange of information. (You will understand this more as you learn about TCP/IP.)
- Now 3333 sends data back to 1111.
- The switch sees if it has the SA stored.
- It does NOT so it adds it. (This will help next time 1111 sends to 3333.)
- Next, it checks the DA and in our case it can **filter** the frame, by sending it only out port 1.

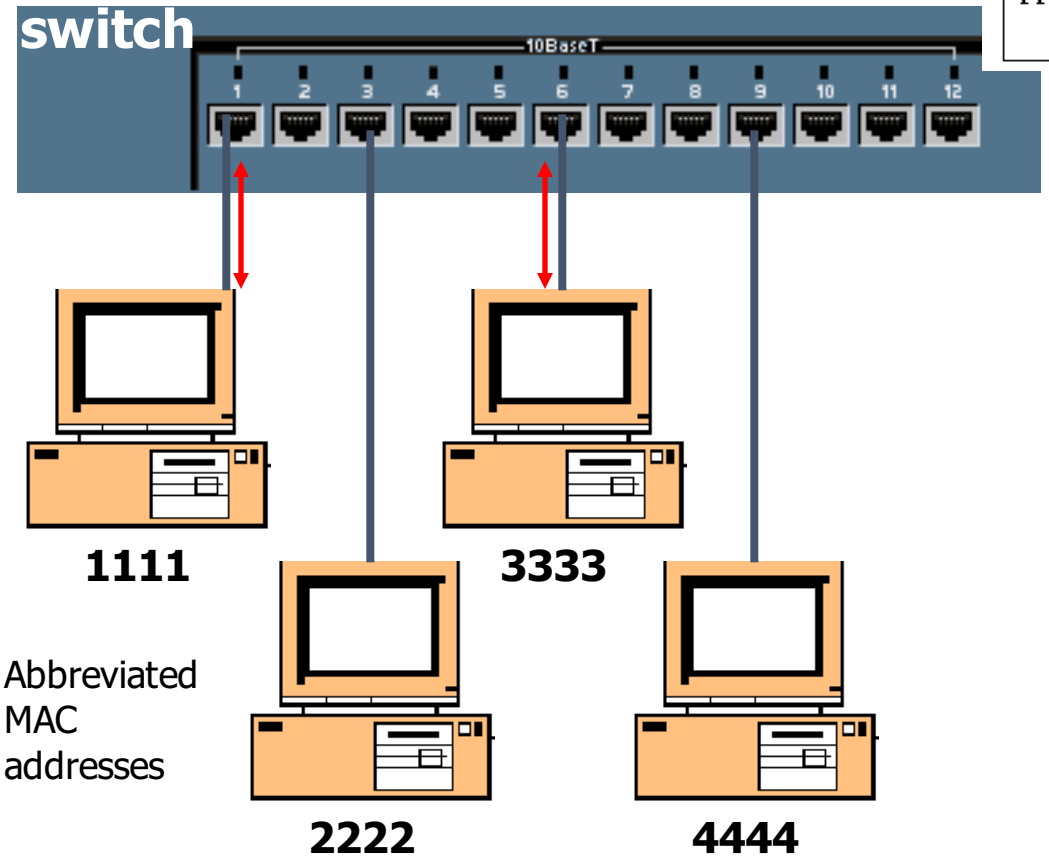
Destination Address in table, Filter

Source Address Table

Port	Source MAC Add.	Port	Source MAC Add.
1	**1111**	**6**	**3333**

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	3333	**1111**				

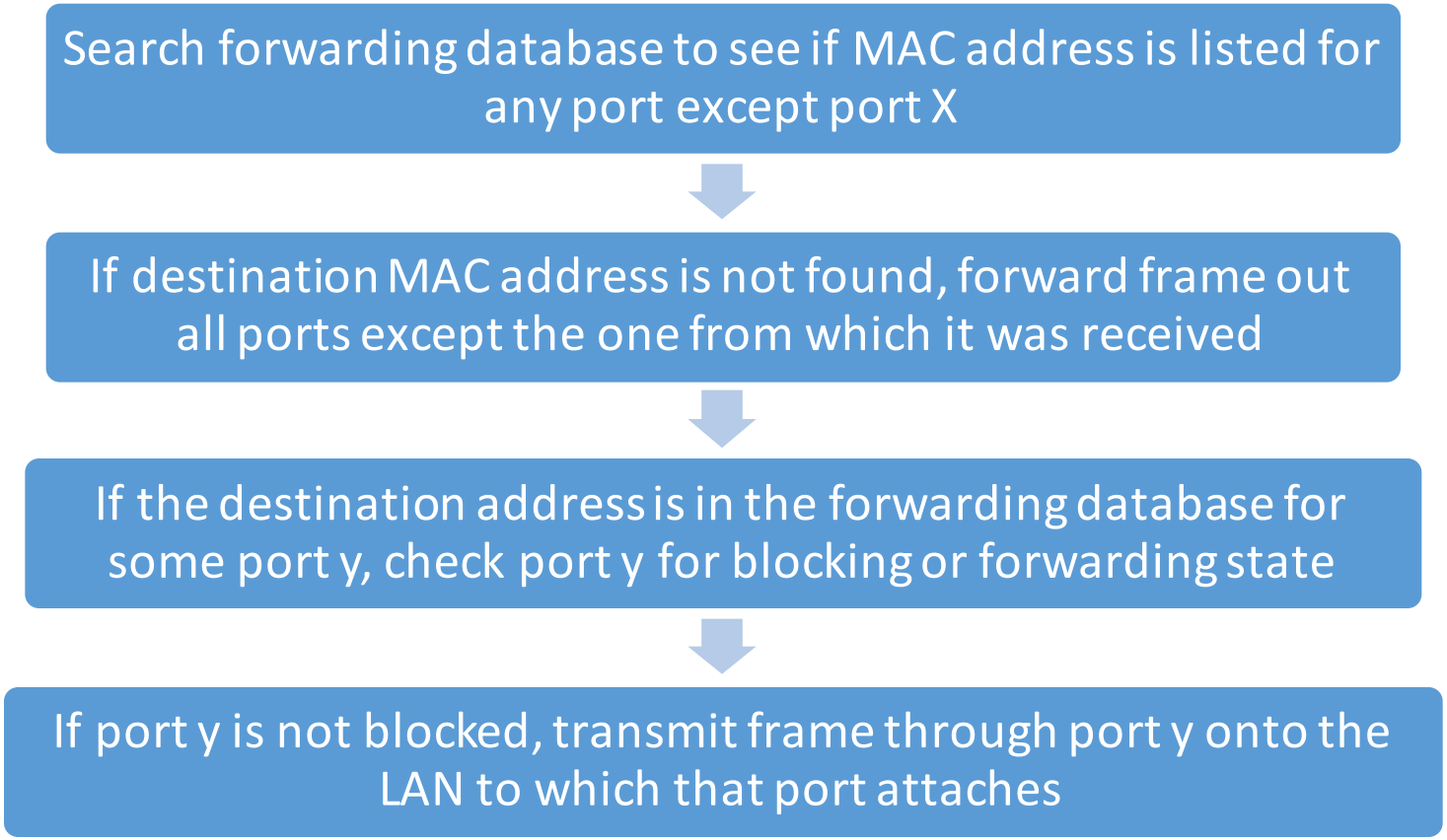
Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	1111	**3333**				



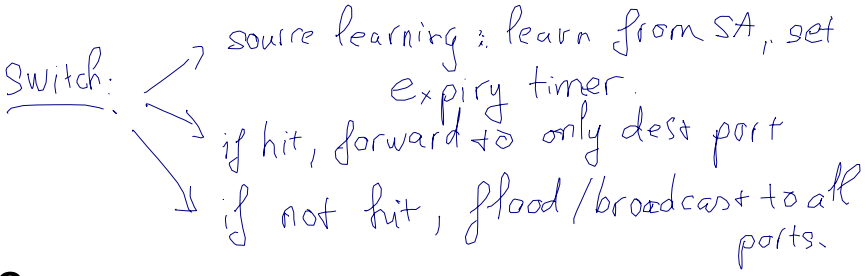
- Now, because both MAC addresses are in the switch's table, any information exchanged between 1111 and 3333 can be sent (filtered) out the appropriate port.

Frame Forwarding

- Maintain forwarding database for each port attached to a LAN
- For a frame arriving on port X:



Address Learning



- Can preload forwarding database
- When frame arrives at port X, it has come from the LAN attached to port X
- Use source address to update forwarding database for port X to include that address
- Have a timer on each entry in database
- If timer expires, entry is removed
- Each time frame arrives, source address checked against forwarding database
  - If present timer is reset and direction recorded
  - If not present entry is created and timer set