Ethernet Product Training

(bit/Byte/Packet of Ethernet)

Part 1

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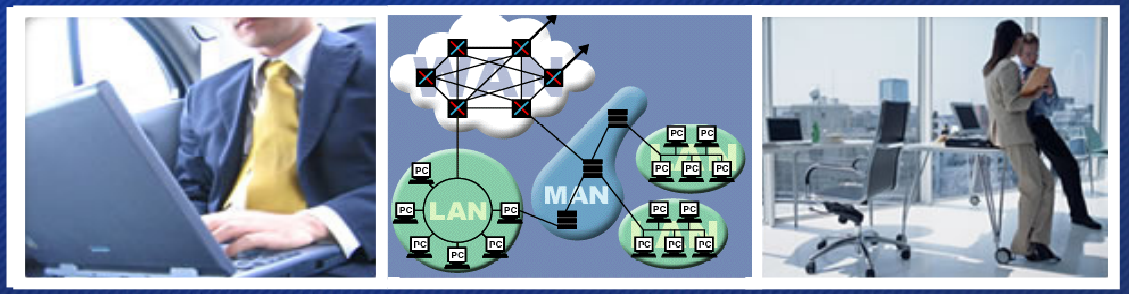

Introduction

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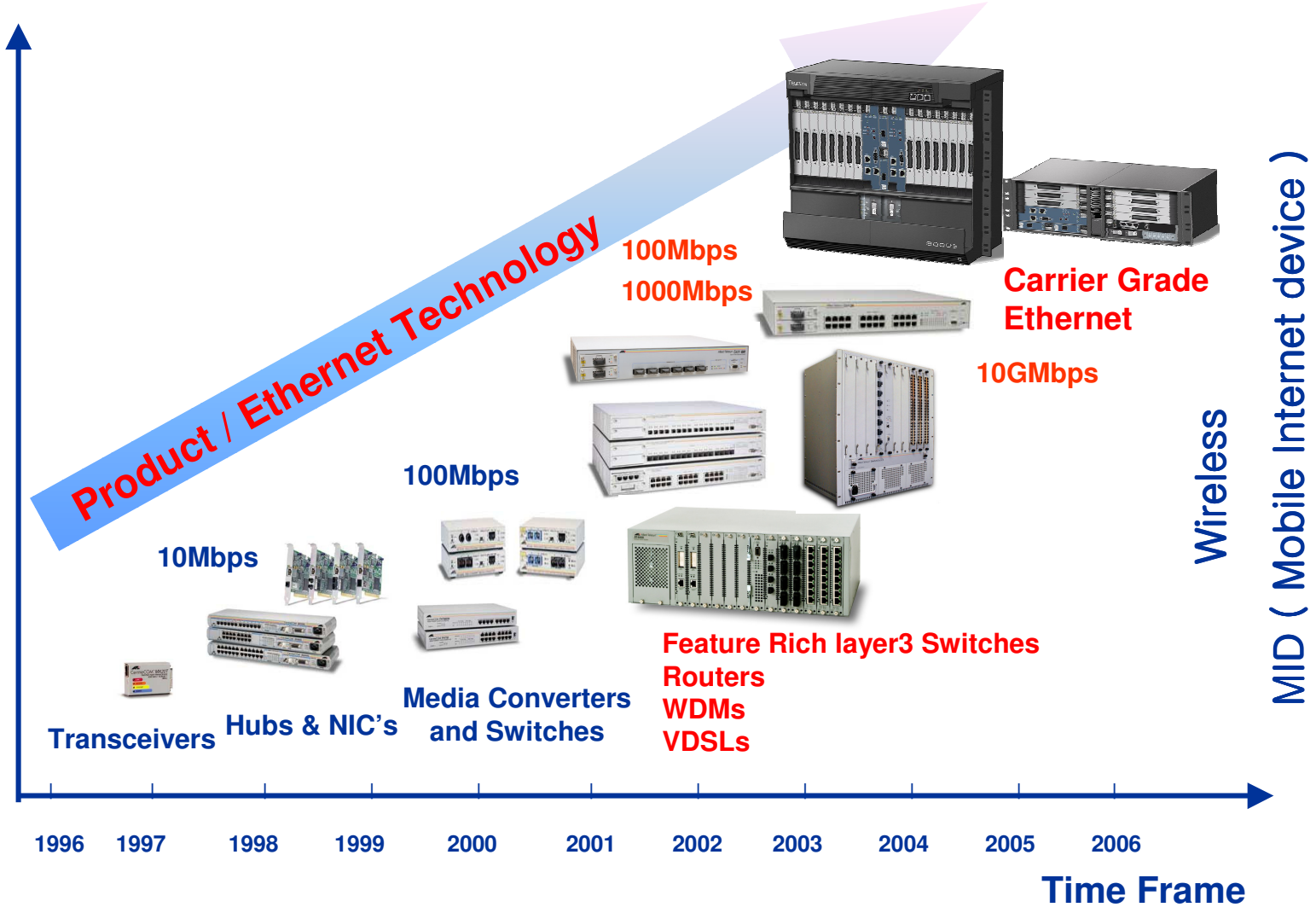
Where are we now ?



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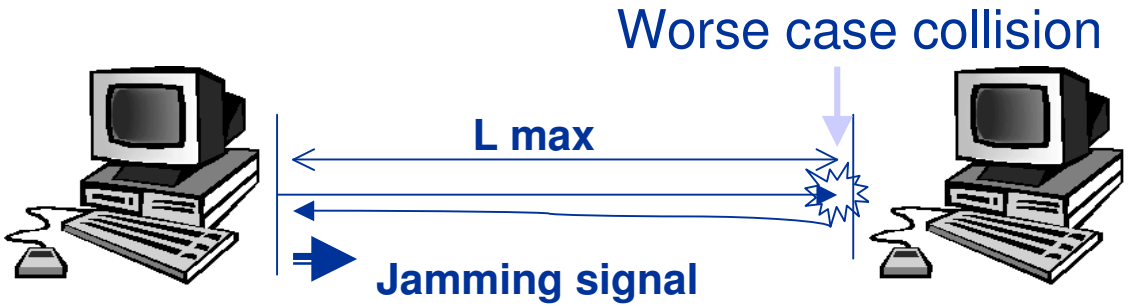
Network Technology

Ethernet

- Most widely use protocol for LAN application
- Being extended to MAN and WAN
- Packet based Local Area Network (TCP/IP)
- Start with 10Mbps HUB
  Build on Carrier Sense Multiple Access with collision Detection (started with 10Mbps , half duplex)

  Media Access Control (MAC) responsible for CSMA/CD
- Fast Ethernet (10/100Mbps) Switch (HUB is not practical for 100Mbps due to wire length constraint to support CSMA/CD)
- Gigabit Ethernet Switch – full duplex only for 1Gigabit speed
- 10 Gigabit Ethernet Switch
- Any More ???

Ethernet Collision in Brief (half duplex/HUB)

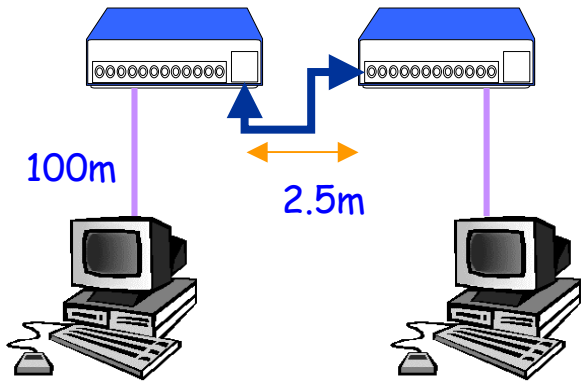


100BaseT HUB/Repeater

- HUB works on Half duplex mode follow collision rule (CSMA/CD)
- Only one Network Device (ND), e.g. PC, can send data at one time. The rest of the PC have to wait till the sending process complete.
- Before a ND send a packet, it will listen to the cable to see if there is any one sending packet. This is detected by voltage surge at the RX line.
- If the cable is quiet, then the ND will send the packet out

Ethernet Collision in Brief (half duplex/HUB)

- If some one is sending data, the ND will wait for certain predetermine time (slot time) before start detection process again
- slot time = round trip time + time required to send jam signal(collision window)
- Collision should be detected by other device when the sender still in the sending process. Thus the listening process depends on the length of cable connected, speed and the packet length
- In order to support CSMA/CA at 100Mbps, the interconnect between two HUB is limited to 2.5 m of UTP cable length which is not practical

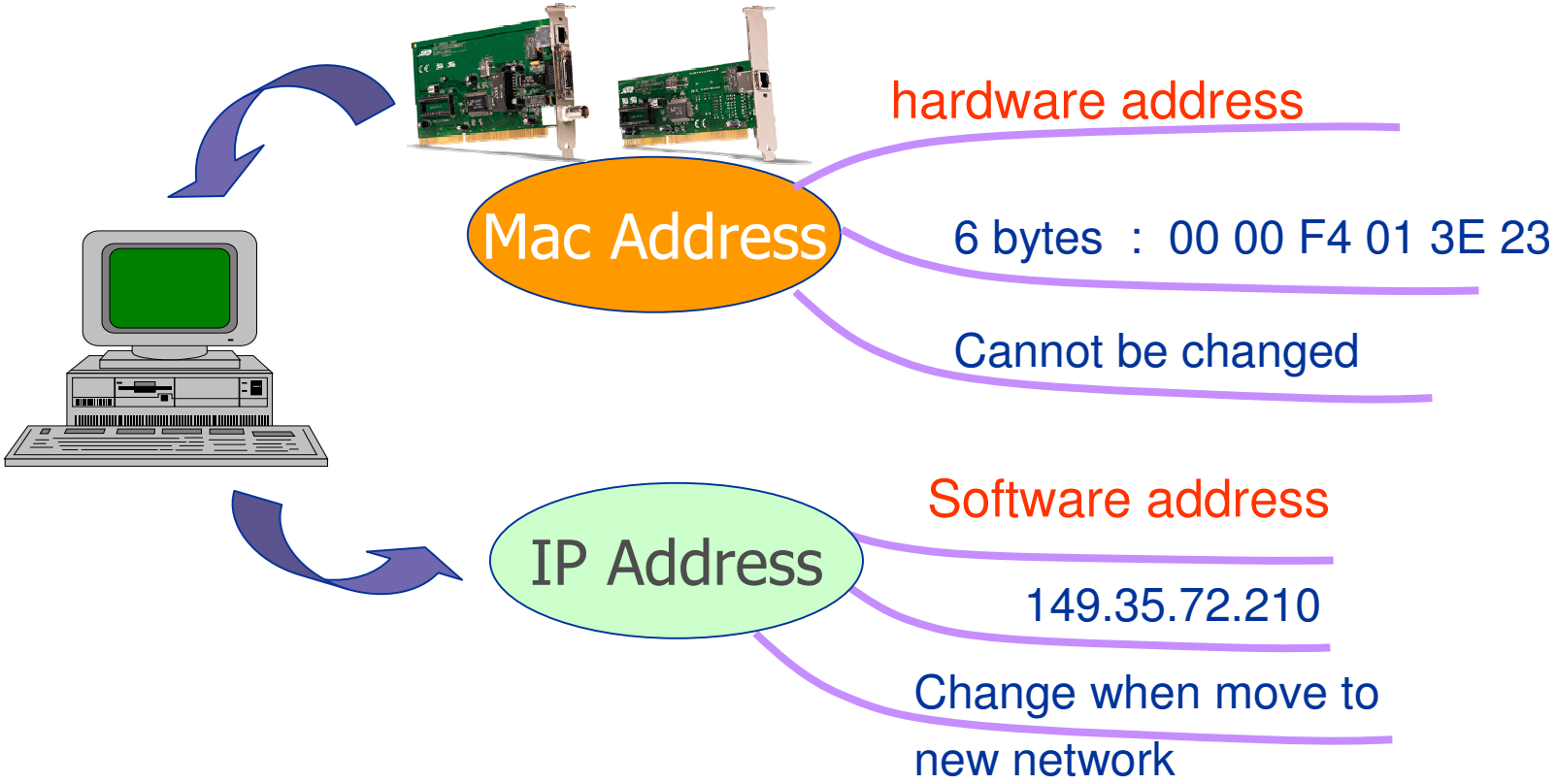


Not Practical !

You will not see >=100Mbps HUB in the market !

Mac Address / IP Address

- Two kind of addresses in Network : Mac and IP
- All PCs on a network MUST have one Mac Address and one IP address



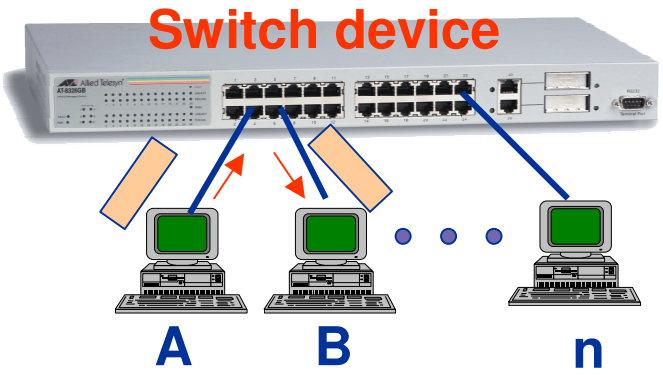
- Duplication Mac address or IP address - PC will not receiving the correct packet

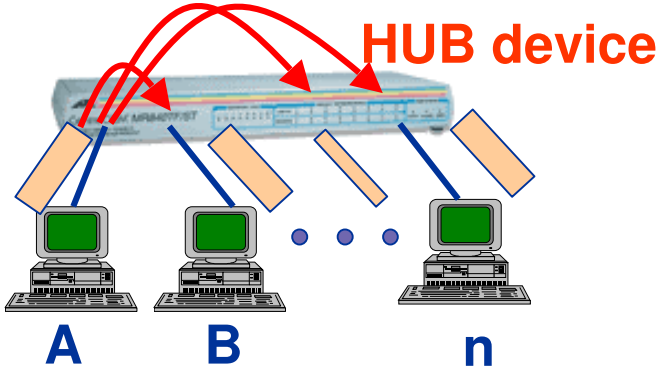
How computer communicate on Network ?

- Each PC has a hardware address call MAC address
- Computers communicate on the network by sending packet to each other.
- Packet traveling on a network will have a destination mac address and a source mac address
- When a PC connected to a Switch ,by looking at the source mac address of a packet sent , the Switch will know which port has what MAC address.

  the Switch's address learning process will keep the relationship of its hardware port number with the MAC address in a memory called lookup table
- After the address learning process, packet which designated to a particular designation MAC address will be forwarded by the Switch to its attached hardware port
- The PC high level will than analyze the packet for further action

How computer communicate on Network ?





- A to B or B to A, only A and B get the packet
- A to B ,every PC (B to n) on the network can get the packet if it want to , promiscuous mode
- For HUB device, every PC can listen to every one talking on the network because HUB will forward packet to every port. That is the reason that only one PC (port) can send packet at any time within a HUB device. No privacy !
- For Switch, each port is a collision domain by itself. Hence CSMA/CD does not apply

Why understand the Packet is important

- Once a network device can capture all the packet, it can store it and go to an analyze process to understand what is going on to the network .
- It shows which PC (source MAC address or IP address) is communicating to which PC , LAN or WAN PC(IP address) , downloading some thing from external site causing jam up on the network, Chatting on the network …etc
- From the packet, it know what protocol is being use, in case of an security attack is going on. e.g. Ping flooding.
- By analyze the protocol use and data pattern behavior, it can know whether a virus attack is happening.
- … a lot more to understand PACKET.
- The only problem is fake MAC address or IP address that confuse the analysis.

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Frame / Packet

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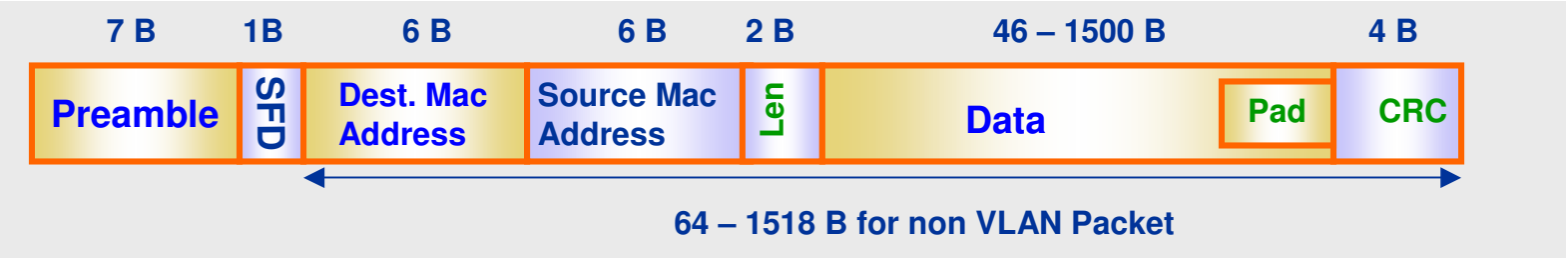
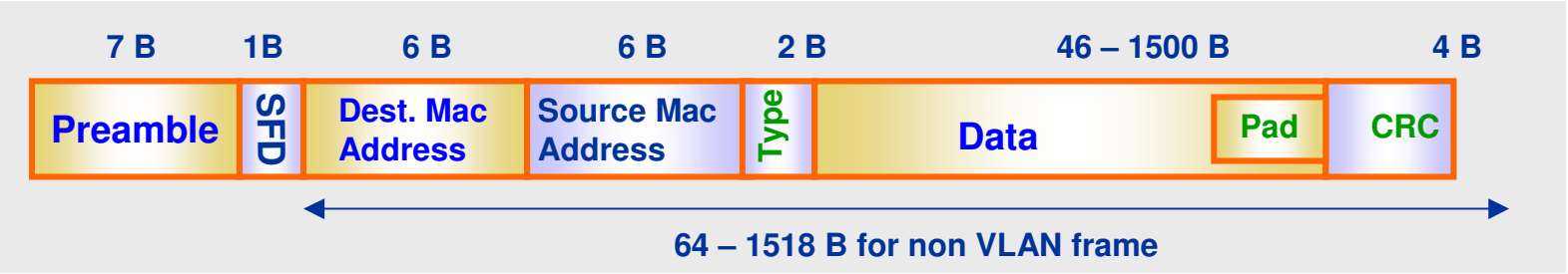
Ethernet Packet/Frame

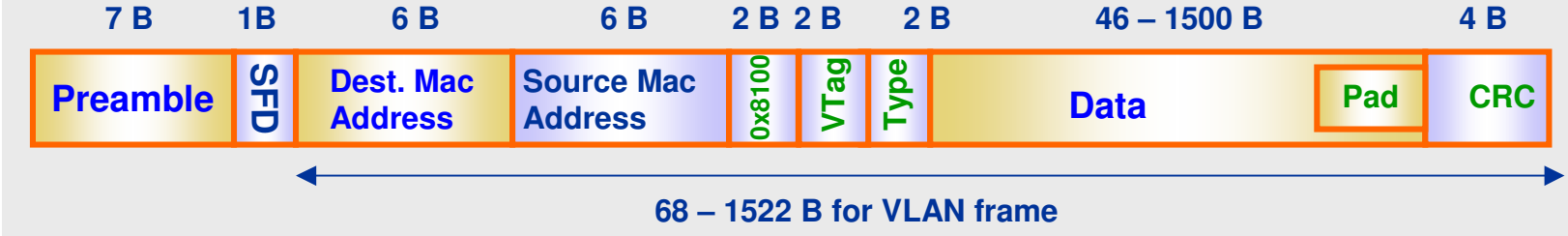
DIX Ethernet(Packet) – Layer 2 *(DEC-Intel-Xerox standard)*



IEEE 802.3 Frame (Non-VLAN) – Layer 3



IEEE 802.3 Frame (VLAN) – Layer 3



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Ethernet Frame

Preamble

- consists of 7 bytes of 1 and 0 pattern
- indicate to the physical layer that a frame is coming
- Added at Physical layer (for TX) 10 Mbps receiver use it to synchronize their bit timing with the sender's clock.
- Fast Ethernet and gigabit Ethernet don't need the preamble signal but is preserved for backward compatibility
- Preamble received in the network is not passed through the MAC to the host system. But MAC function is responsible for the generation of preamble for packet to be transmitted.

Start Frame Delimiter (SDF)

- pattern is 10101011
- Marks the beginning of a frame

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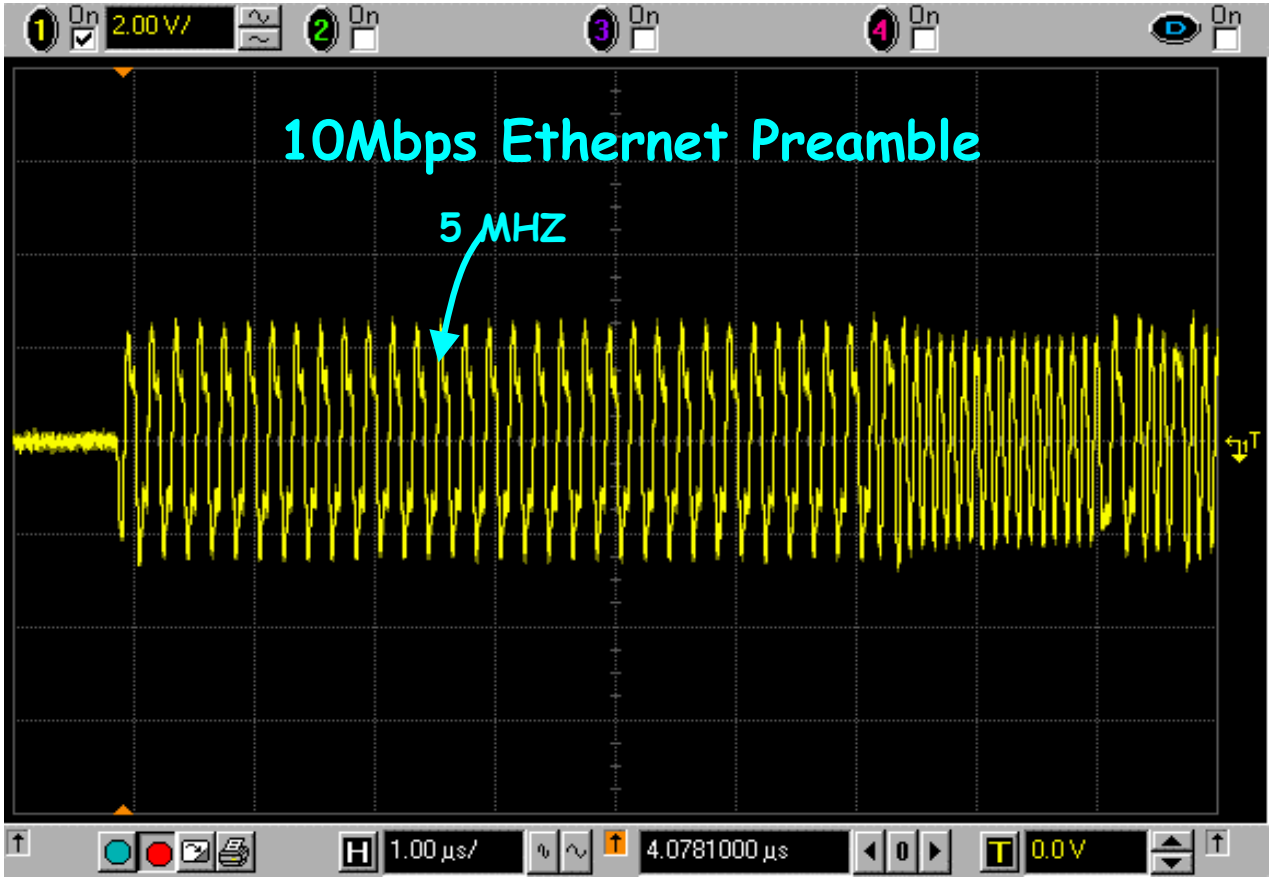
Ethernet Frame



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Ethernet Frame

What is Physical Address (Mac / Hardware Address) ?

- 48 bits written in six 8-bit format
- transmission starting from the LSB to MSB of 8 bit
- LAN address required for information to be delivered to a network
- Process by the Data Link Layer
- If all the 48 bits are all 1, it means broadcast address (ff:ff:ff:ff:ff:ff)
- Every Ethernet interface read in the frame up to at least the destination address field. If the destination is not its own address, multicast or broadcast, the frame will be discarded

Destination Mac Address

48 bits of receiver's MAC address

Source Mac Address

48 bits of sender's MAC address

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Ethernet Frame

Data Length (DIX) / Data Type (IEEE802.3)

- <= 1500 indicates the data length (bytes) in the data field
- >1536 (0x0600) – indicates it is an optional type frame

Importance of Data Length

Maximum 1500 byte , Minimum 46 byte

Proper operation of CSMA/CD :

- Minimum length - ensure collision (if happen) to be detected before the frame is fully send out
- Maximum length - reduces the buffer memory size prevent one station to monopolizing access to the shared medium

Complete Ethernet frame = 64 byte x 8 bit = 512 bit= 51.2 us for 10Mbps

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Ethernet Frame

Ethernet Type Example

Type Number	Type Description
2048 (0800h)	IP datagram
2054 (0806h)	ARP message
33079(8137h), 33080(8138h)	Netware data
… etc	

Data – 46 to 1500 bytes

Pad – if data is less 46 bytes

Frame Check Sequence (FCS/CRC)

- for error detection.
- calculated using destination , source, type,data fields. At receiving, the CRC is re-calculated and compare with the received CRC value to check if there is an error.

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Ethernet Frame

End of Frame Detection

- Present of signal on the Ethernet channel is called carrier
- For 10Mbps Ethernet, after the last bit of the frame channel goes idle. Only Link pulse is present
- Fast / Gigabit Ethernet uses special symbols to signal the start and end of a frame. Therefore the UTP cable always appear as data is transmitting.

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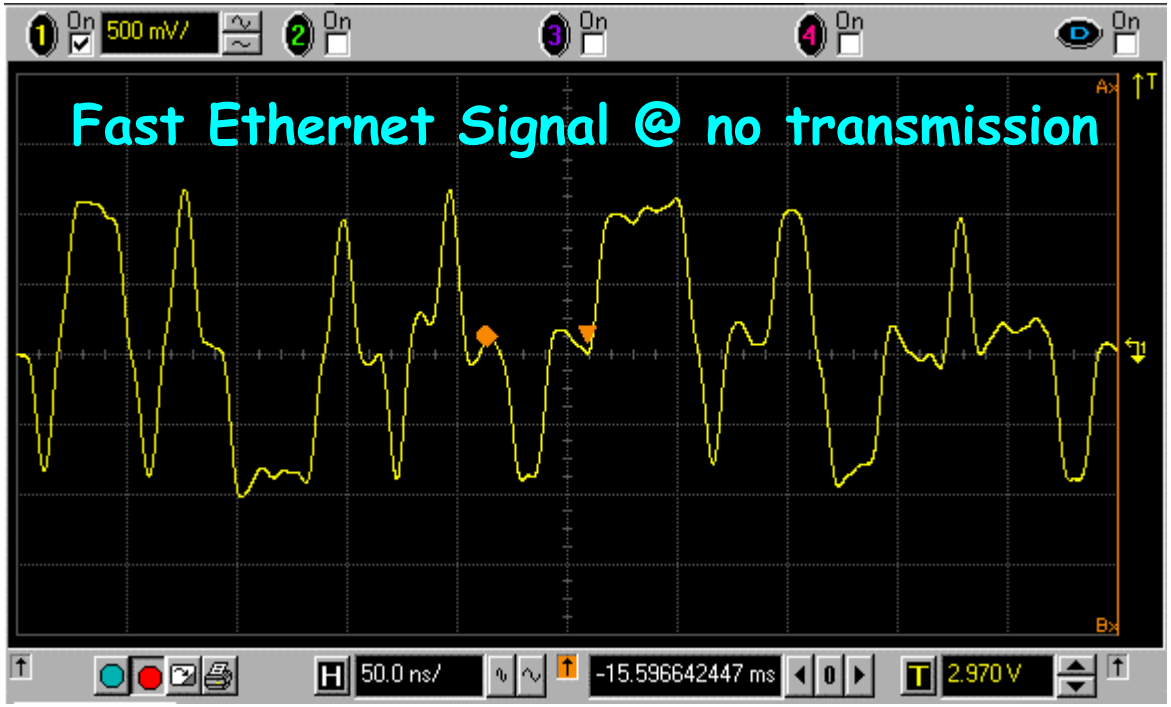
Ethernet Frame



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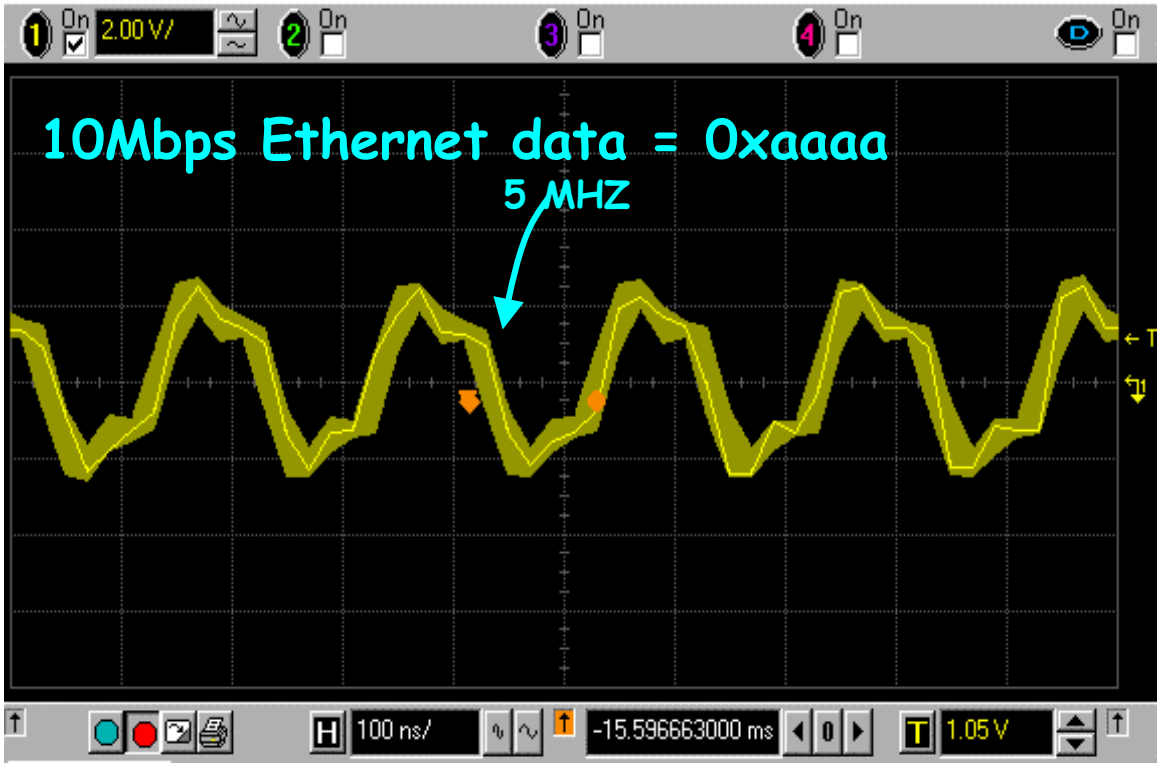
Ethernet Frame



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Frame Timing

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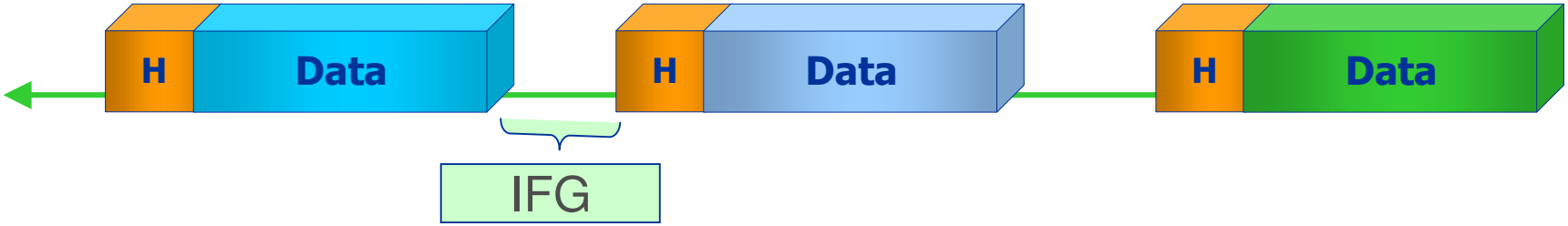
Inter Frame Gap



Inter-frame Gap

- Separation between two frames
- Inter-frame gap = 96 bit time (100% traffic)
- gap shrinks as frames travel on the network due to delay and other influences
- Must > 47 bit time for 10Mbps or 64 bit time for Gigabit

Note

For some equipments, it is possible to force IFG=0. In this case, the PCs on the share media will be hang as there is no way for other PC to access the media (CSMA/CA) other than the sending PC. By controlling the IFG gap, we can make the half-duplex network appear to be very busy.

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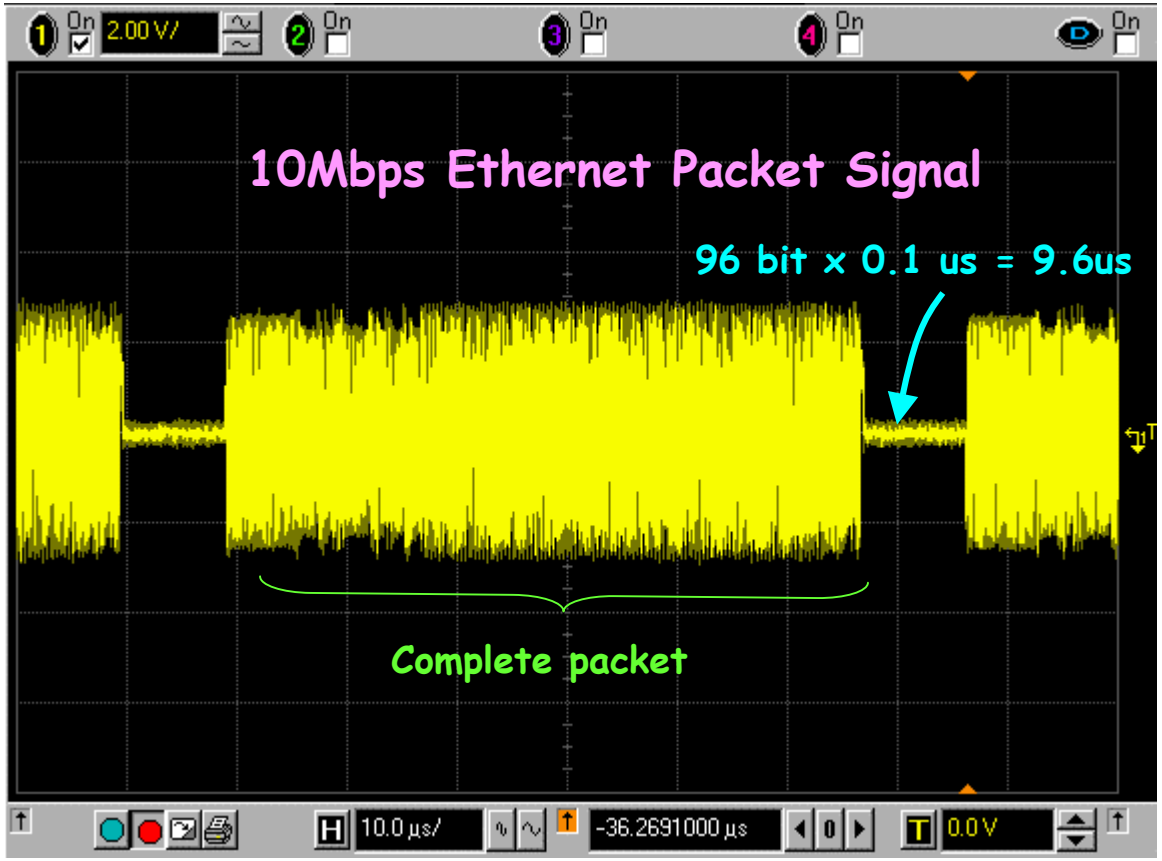
Inter Frame Gap



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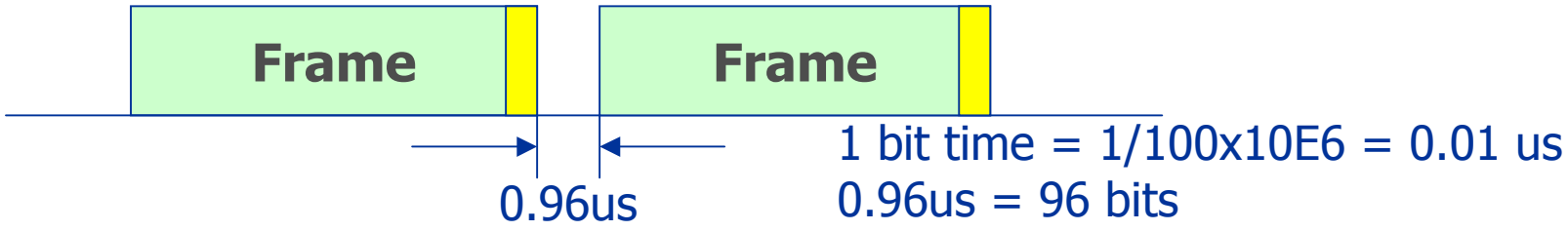
Frame Speed Calculation



- Measure in Packet/Sec (layer3) or Frame/Sec (layer 2)
- Minimum packet size , 64 bytes, maximum packet rate (100Mbps Ethernet 148810 packet/sec , Gigabit Ethernet 1488100 packet/sec)
- Maximum packet size , 1518 byte, minimum packet rate

(100Mbps Ethernet 8127packet/sec, Gigabit Ethernet 81274 packet/sec)

Packet size = 64 bytes = DA+SS+BL+Data+CRC=(6+6+2+46+4) x 8 = 512 bits
IFG = 96 bits, Preamble + SFD = (7+1) bytes = 64 bits
Total bits for a 64 byte packet = 96+64+512= 672
For 100 Mb/s speed, the # of packet processed = 100E6 / 672 = 148809.5
Similarly, for a packet size of 1518 bytes,
the # of packet processed = 100E6 / 12304 = 8127.4

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Link Pulse

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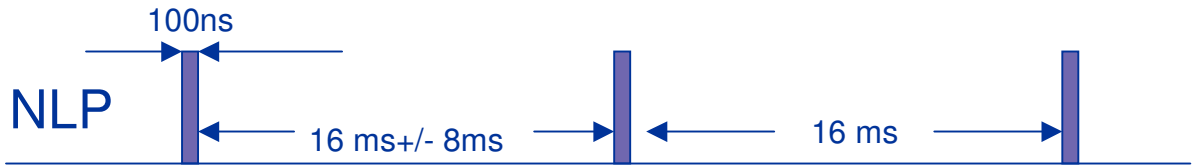
10Mbps Link Pulse (NLP)

- 10Base-T include a link test mechanism to ensure network integrity
- Link fail if no link pulse received within 50-150ms
- Link failure condition disables the data transmit, data receive and loop back function
- Link pulse continue to transmit and receive during link failure
- Link re-establish when two consecutive link test pulse or single data packet received.



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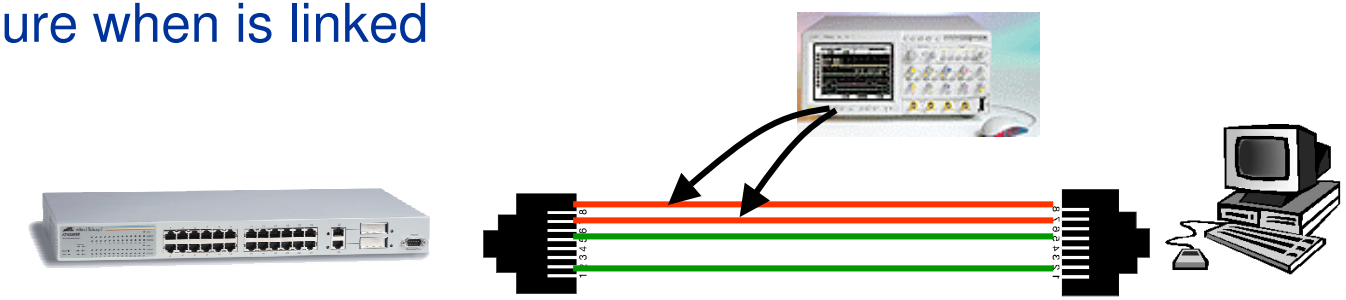
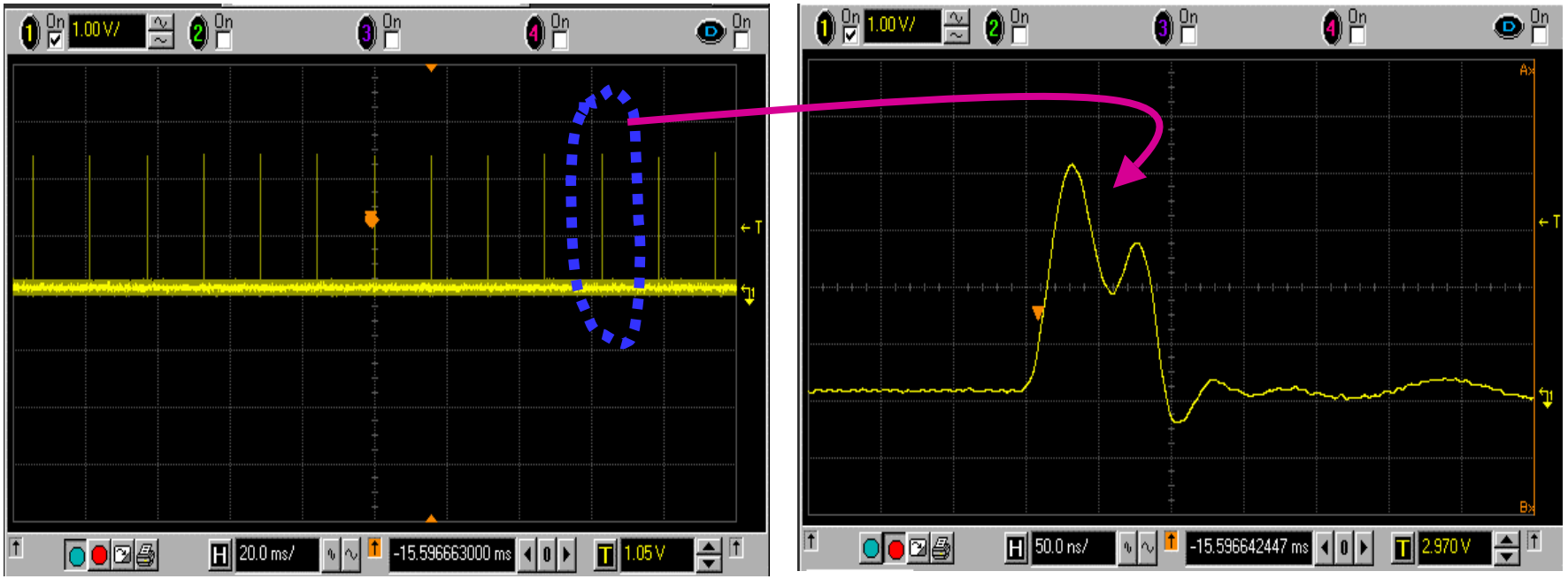
10Mbps Link Pulse (NLP)

Capture when is linked





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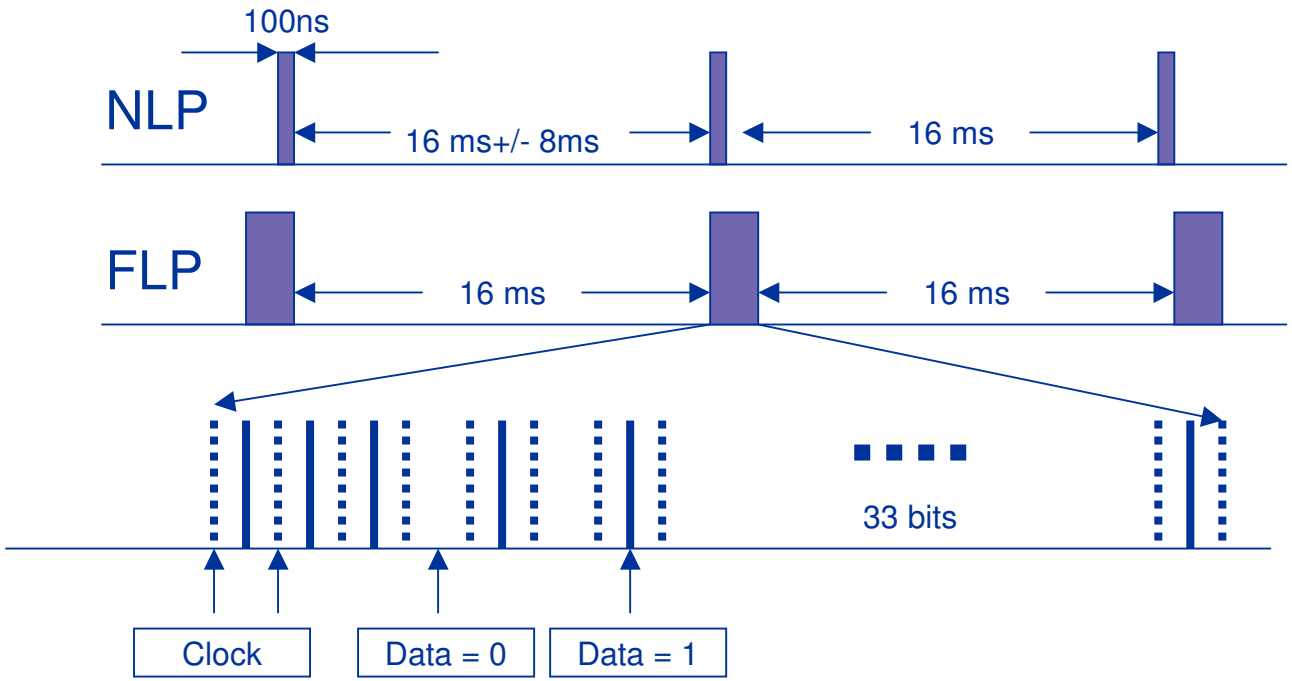
100Mbps Link pulse (FLP)

- Fast Ethernet (100Mbps) uses Fast Link Pulse for auto-negotiation
- FLP is a group of NLP each of which is 100ns
- Between 2 clock, if there is a pulse, it is a ‘1’ bit. Otherwise it is a ‘0’ bit



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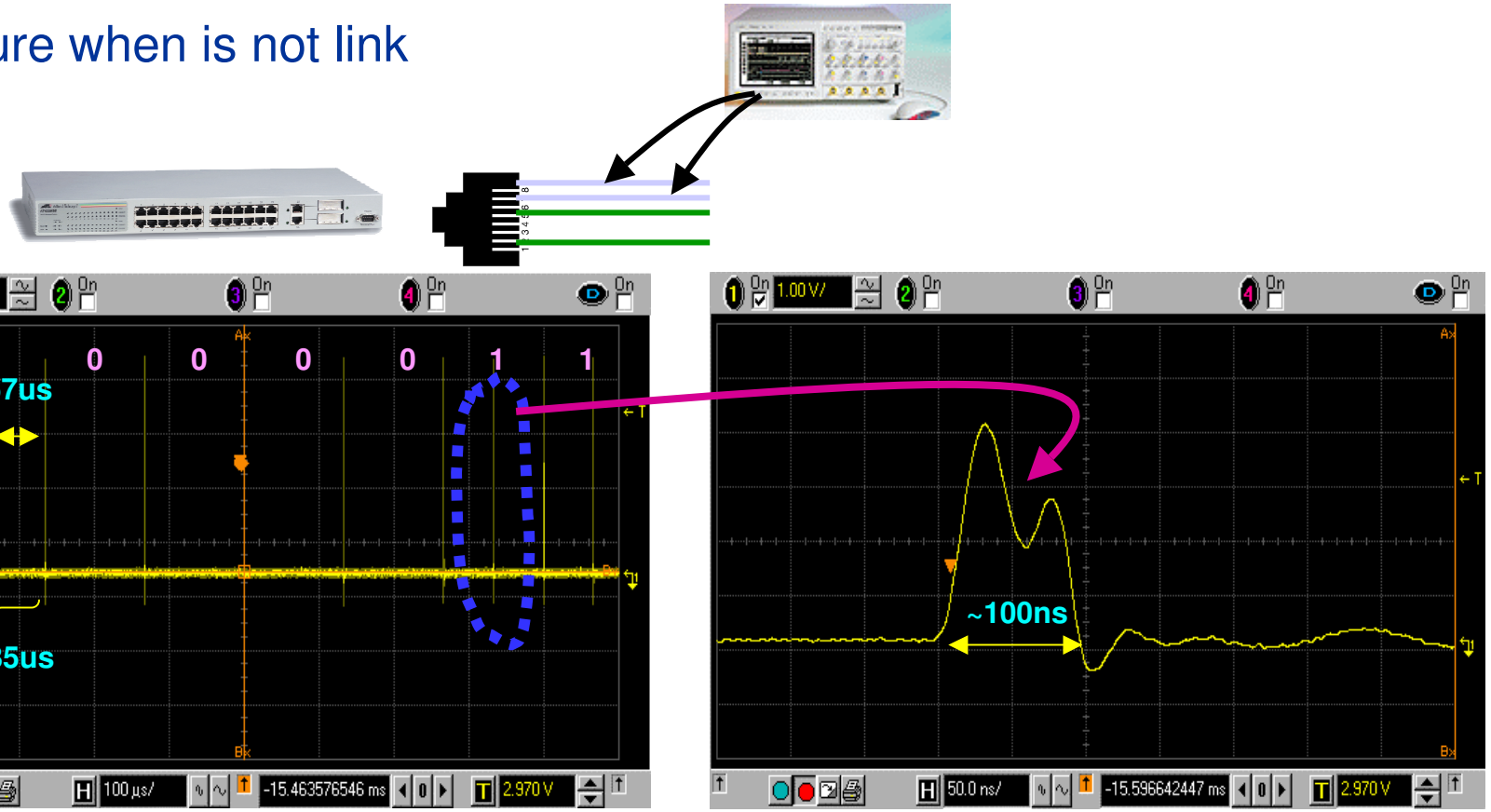
100Mbps Link pulse (FLP)

Capture when is not link



Once it is linked, idle symbol send on the cable when data is not available

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100Mbps Link pulse (FLP)

- FLP are sent on burst which consists of 33 x 100 nsec pulses.
- 10BaseT devices sees as NLP
- 17 odd numbered pulses are clock
- 16 even numbered pulses are data
- transmit 16-bit Code that contain auto-negotiation information
- During initialization,the auto-negotiation sends as many 16-bit messages as are needed.

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Gigabit “Link”

- Gigabit Ethernet setup the link by advertising the PHY capabilities, including duplex, speed, master/slave
- 1000baseT uses Next Page protocol to advertise and configure.
- Next page protocol consists of a two message sequence – number and type of the un-format pages

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Gigabit “Link”

FLP bits in Auto-negotiation

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
S0	S1	S2	S3	S4	A0	A1	A2	A3	A4	A5	A6	A7	RF	Ack	NP

Auto negotiation base page message

Bit	Technology
A0 (D5)	10 Base T
A1 (D6)	10 Base T Full Duplex
A2(D7)	100 Base TX
A3 (D8)	100 Base T Full Duplex
A4(D9)	100 Base T4
A5 (D10)	Pause operation for flow Control
A6 (D11)	Reserved
A7(D12)	Reserved

D13 = 1	Remote Fault Indicator. Send by remote link partner To indicate that the partner has detected a fault.
D14 = 1	Acknowledge Receipt of the 16 bit message. Negotiation messages are sent repeatedly until Partner acknowledges the receipt. Link partner Send an acknowledgement after 3 consecutive Messages received contain identical information.
D15 = 1	Next Page. Capability not listed in the base page Technology Ability field may be advertised in one or More additional next page message (Next page means another message coming)

- D0 to D4 is the Selector field for the type of LAN technology
- for Ethernet S0=1 and S1-S4=0
- D5 to D12 is the Technology Ability Field.

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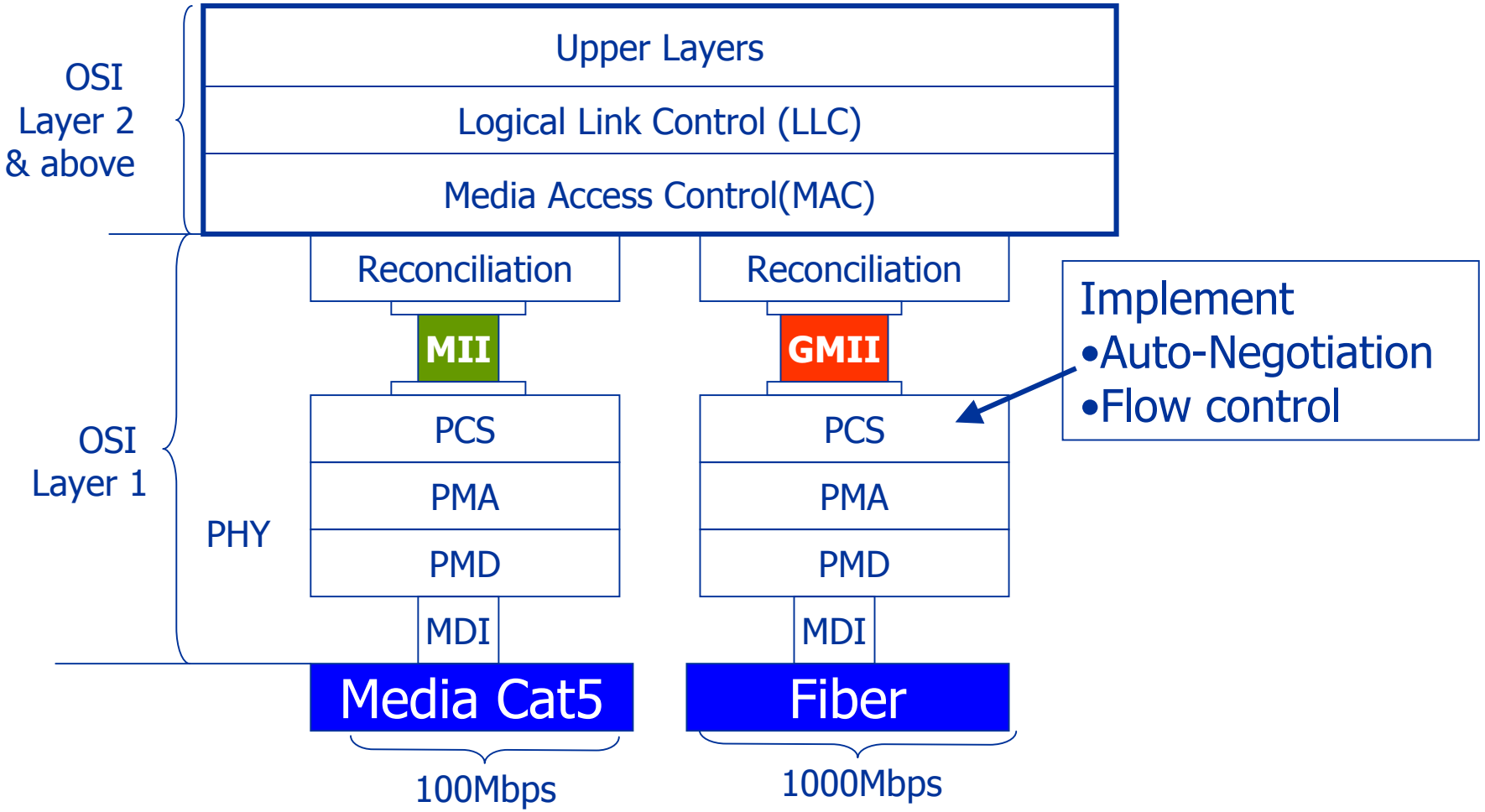
Frame Transmit & Receive



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How Frame Transmit

- LLC request a transmission to MAC Transmitter with address and data
- Information is transferred into the MAC buffer
- Preamble and SFD are inserted
- Destination and Source address are inserted
- LLC's data bytes are counted and inserted in the byte length field
- FCS is generated based on DA, SA, length and data bytes and inserted into the field
- MAC is then transmit the frame out
- IEEE802.3 needs all MAC support half duplex
- Full duplex is an optional MAC capability

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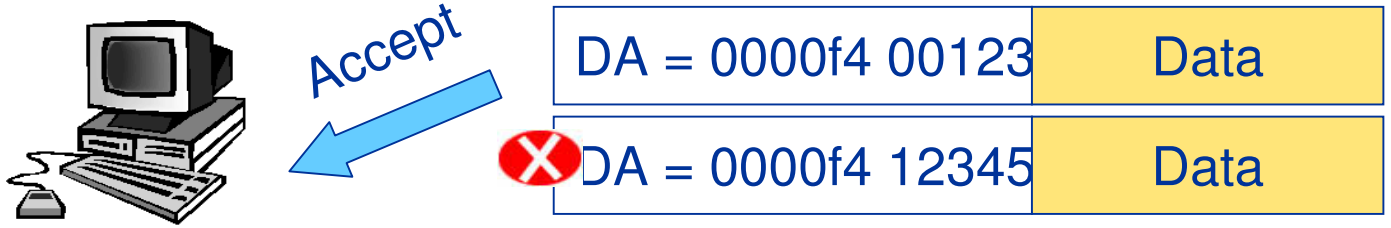
How Frame Received for HUB



Mac Address= 0000f4 001234

- inspect the serial data and look for SFD
- Delineate DA from the receiving frame and check the DA address. Discard the receive frame if it is not for him
- if match its Mac address, MAC will receiving the incoming frame into the receive buffer, compute its own CRC and compare with the CRC obtained from the FCS field.
- If both length and FCS are correct, the frame is forward to the next layer. Otherwise , frame error will be reported

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Ethernet Error Frame

Ethernet Error Frames

CRC error or Bad FCS
calculated CRC(FCS) different from receive CRC (FCS)
Complete frame with no other errors such as alignment or runt

Dribbling bits
additional bits received. It is due to the allowance in the various transmitter and receiver in the signal path. Mac will discard from 1 to 7 of the extra bit.

Alignment error
number of bit received not divisible by eight.
arbitrary length from 64 to 1518 bytes
Normally also has CRC error

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Ethernet Error Frames

Undersize(too short) error
frame < 64 bytes
frame truncated in the process

Runt
frame < 64 bytes
Possible result of a collision (fragmented)

Oversize(too long) error
frame > 1518 bytes

Jabber
Frame too long with a length > 1518 byes
Hardware problem that continuing send out packet without IFG

Jambo frame
frame <=9000 bytes

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Ethernet Error Frames

Summary

	Frame Size		
	< 64 bytes	64 to 1518	> 1518
Good FCS	undersize	Good frame	Oversize
Bad FCS	runt	CRC error	Jabber

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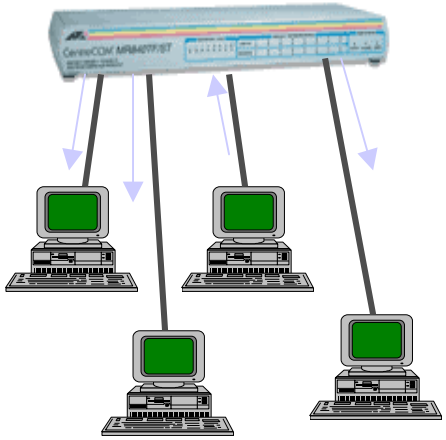
Hub & Switching HUB ?

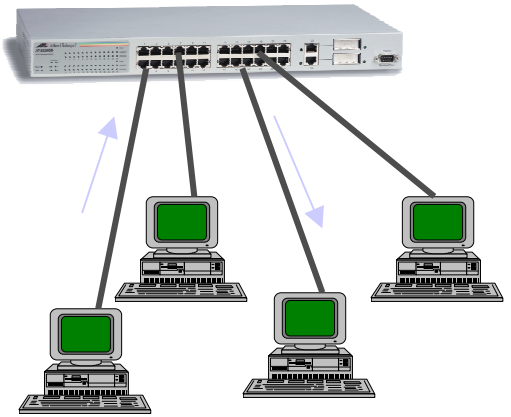
HUBs (Device)



Hub – Ethernet product device called HUB

Switch HUB

Switch(Device)



Hub – collection of DTE's (PC) .
Language call Hub

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