Computer Networks
Data Link Layer

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Lecture 5

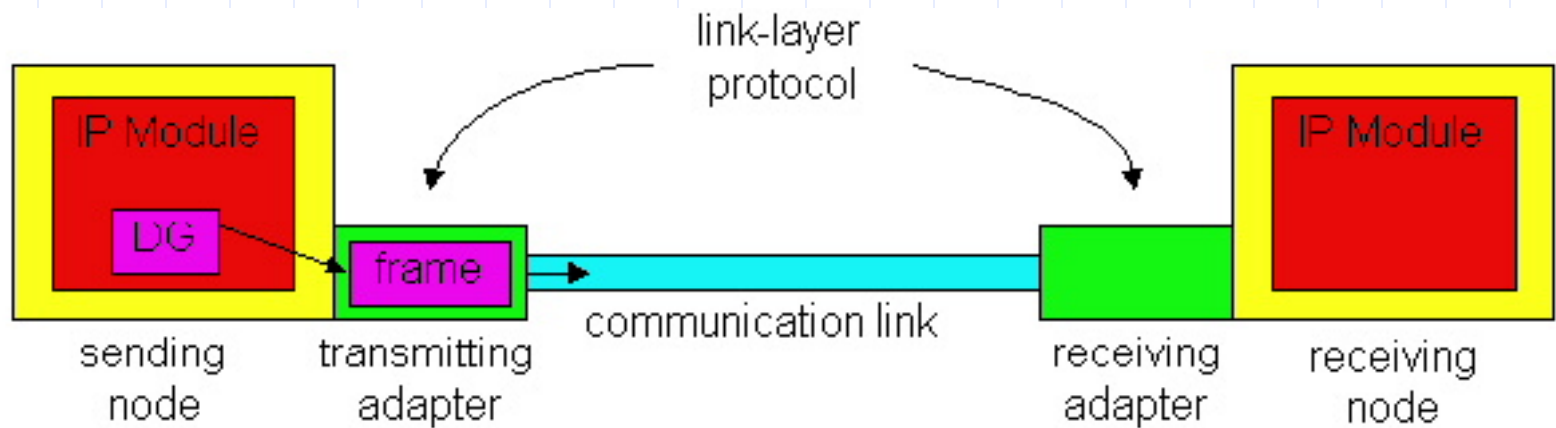# The Data Link Layer
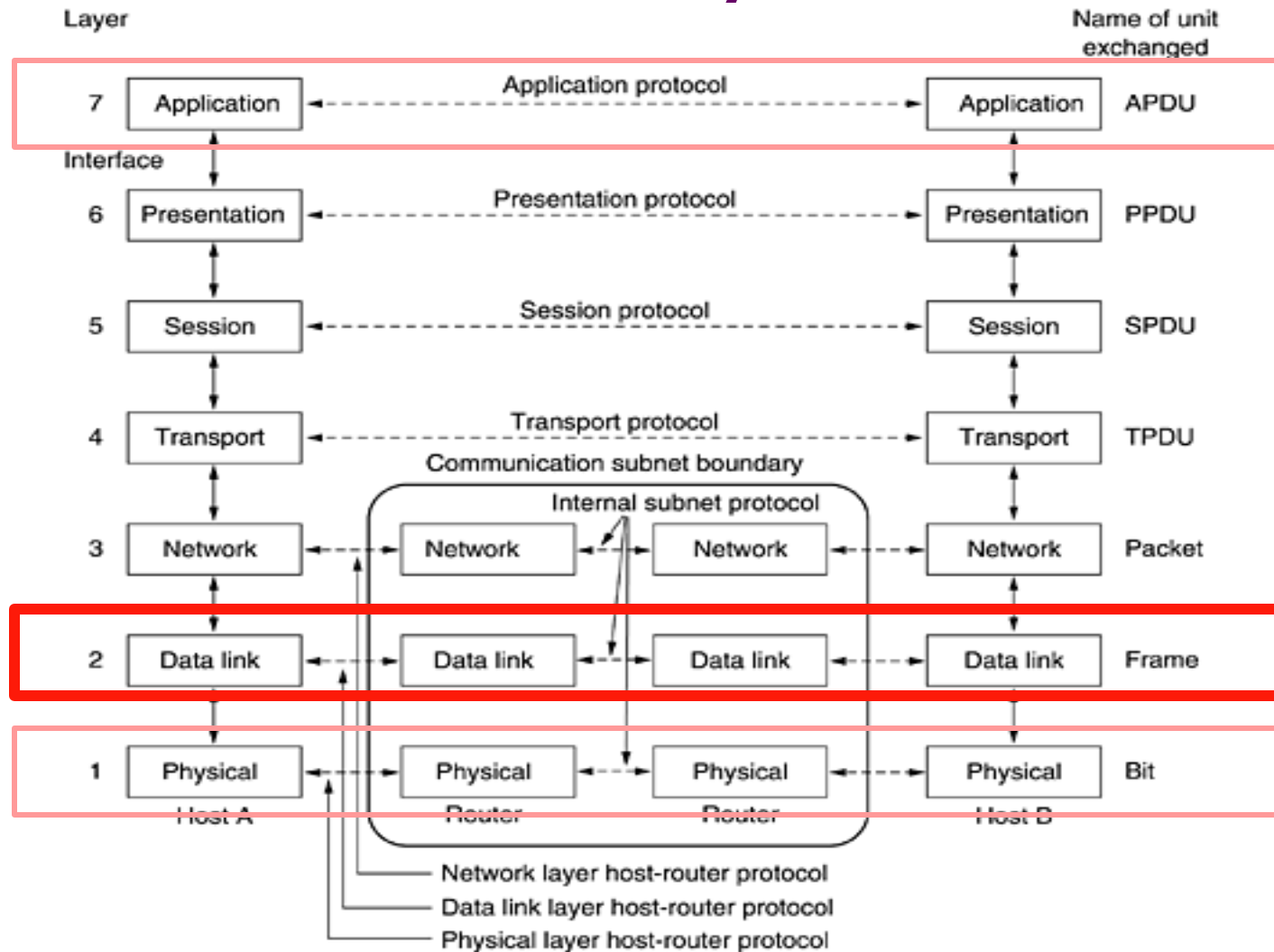
All **P**eople **S**eem **T**o **N**eed **D**ata **P**rocessing

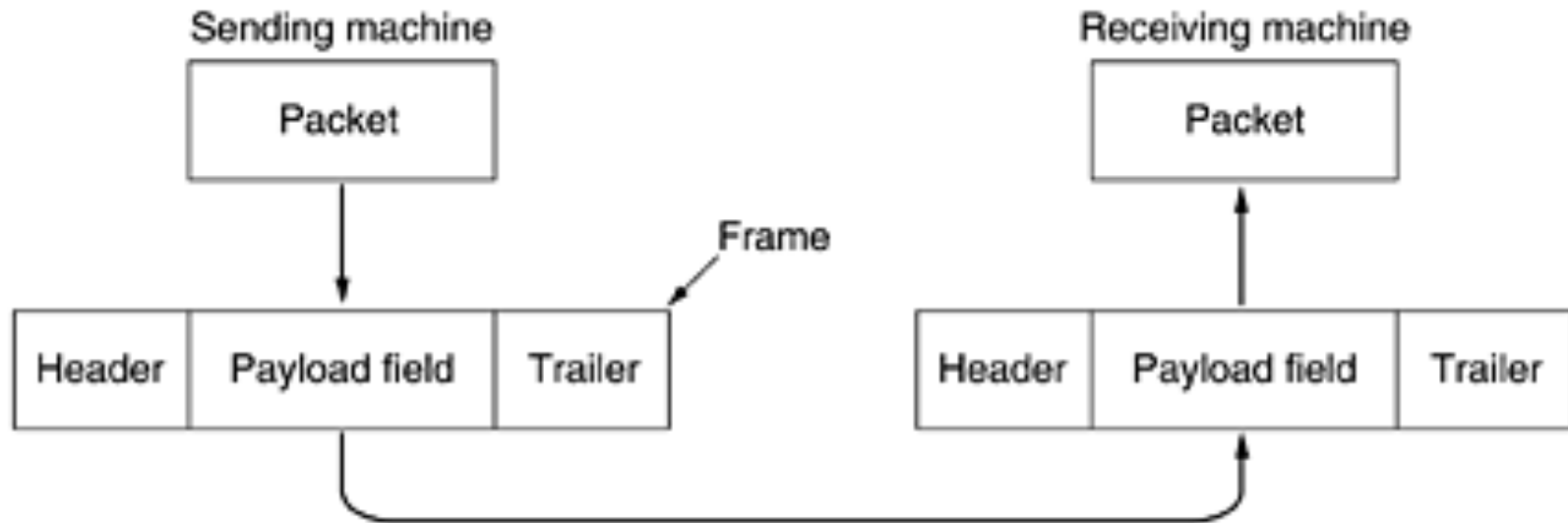# Data Link Layer Services

- Framing and link access
- Reliable delivery
- Flow Control
- Error Detection
- Error Correction
- Half-Duplex, Full-Duplex

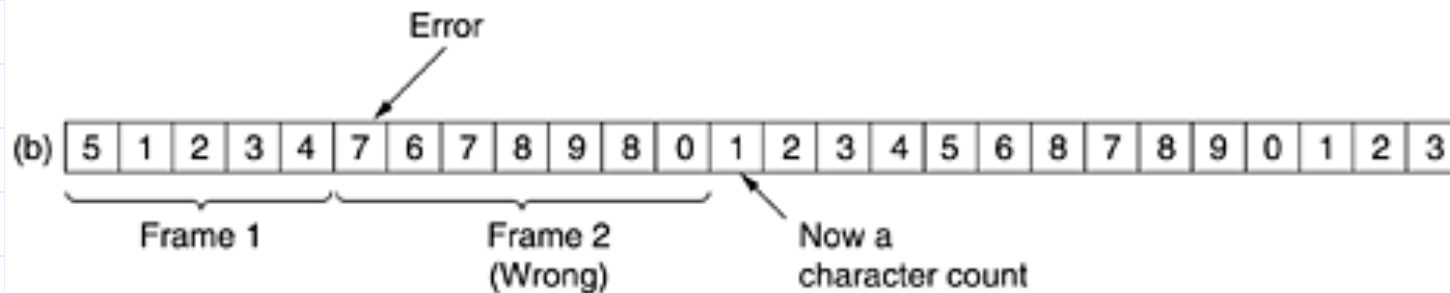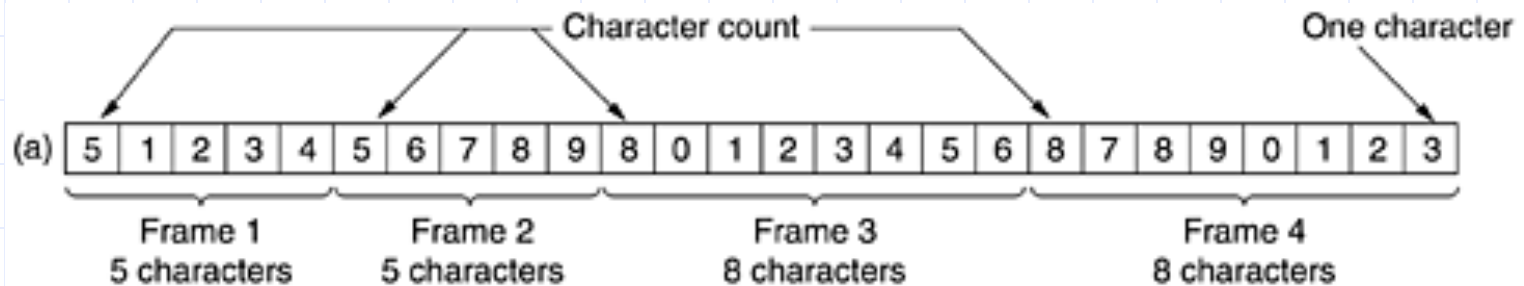# Adapters implementing the Link layer protocol

Packets-Frames Relationship

Services provided for the Network Layer

◆ Unacknowledged connectionless

◆ Acknowledged connectionless

◆ Acknowledged connection-oriented
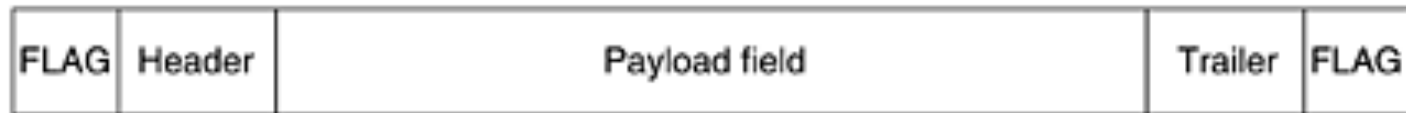
Framing

- Character Count
- Flag byte with stuffing
- Starting and ending flags with bit stuffing;
- Physical Layer coding violations

Character Count

Flag byte + Byte Stuffing

FLAG	Header	Payload field	Trailer	FLAG

(a)

Original characters → After stuffing

| A | FLAG | B | → | A | ESC | FLAG | B |

| A | ESC | B | → | A | ESC | ESC | B |

| A | ESC | FLAG | B | → | A | ESC | ESC | ESC | FLAG | B |

| A | ESC | ESC | B | → | A | ESC | ESC | ESC | ESC | B |
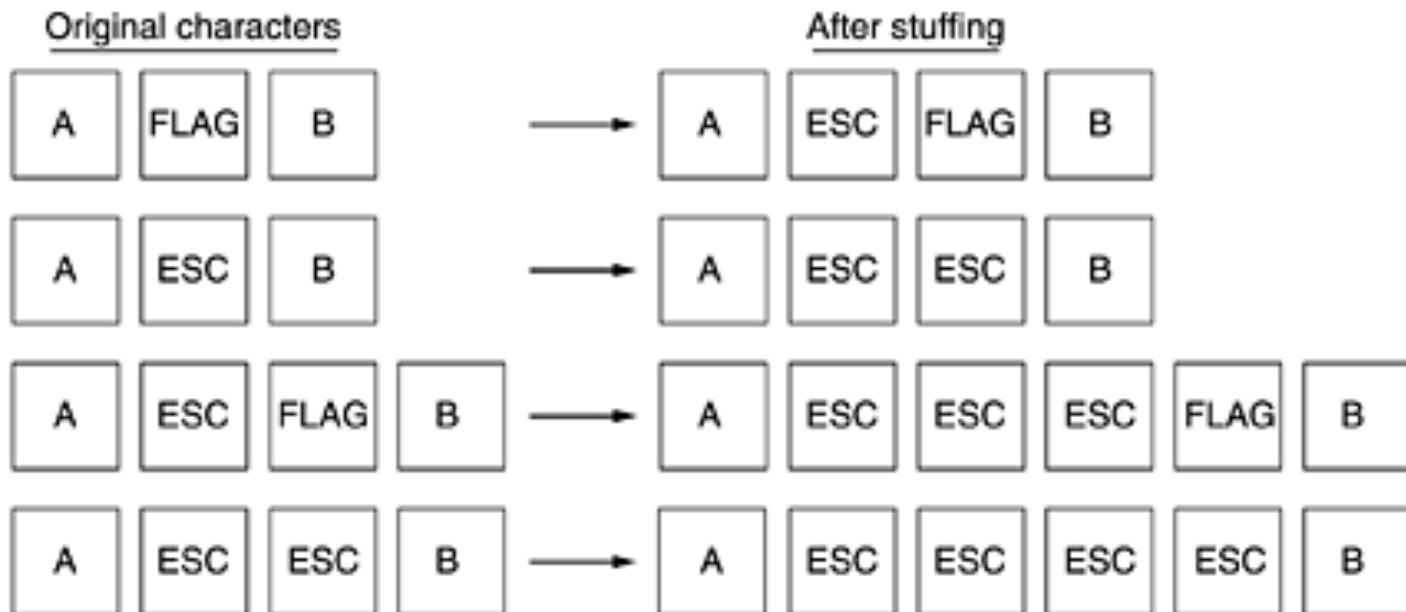
(b)

Unicode (multiple bytes characters) Bit Stuffing

(a) 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

(b) 0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 0 0 1 0

Stuffed bits

(c) 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

Flag - 01111110

"In data sequence" 01111110 transmitted as 011111010

Flow Control

- ◆ Feedback based
 - ▪ Receiver sends information back to the sender allowing it to send more data
- ◆ Rate-based
  - ▪ No feedback

Data Link Protocols

- HDLC- High Level Data Link Protocol
- PPP – Point to Point Protocol
- **Ethernet 802.3 and Wireless 802.11**

- All are bit oriented protocols
- All differ only on minor yet irritating aspects

Bit oriented protocols – Frame structure

Bits	8	8	8	≥ 0	16	8
	0 1 1 1 1 1 1 0	Address	Control	Data	Checksum	0 1 1 1 1 1 1 0
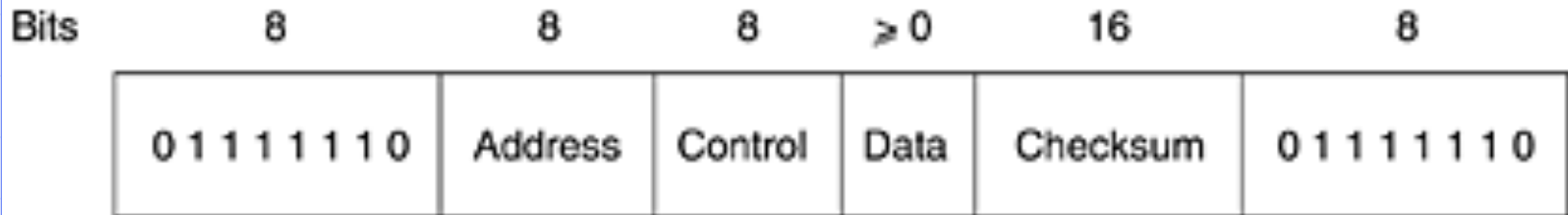
01111110 – flag – end start
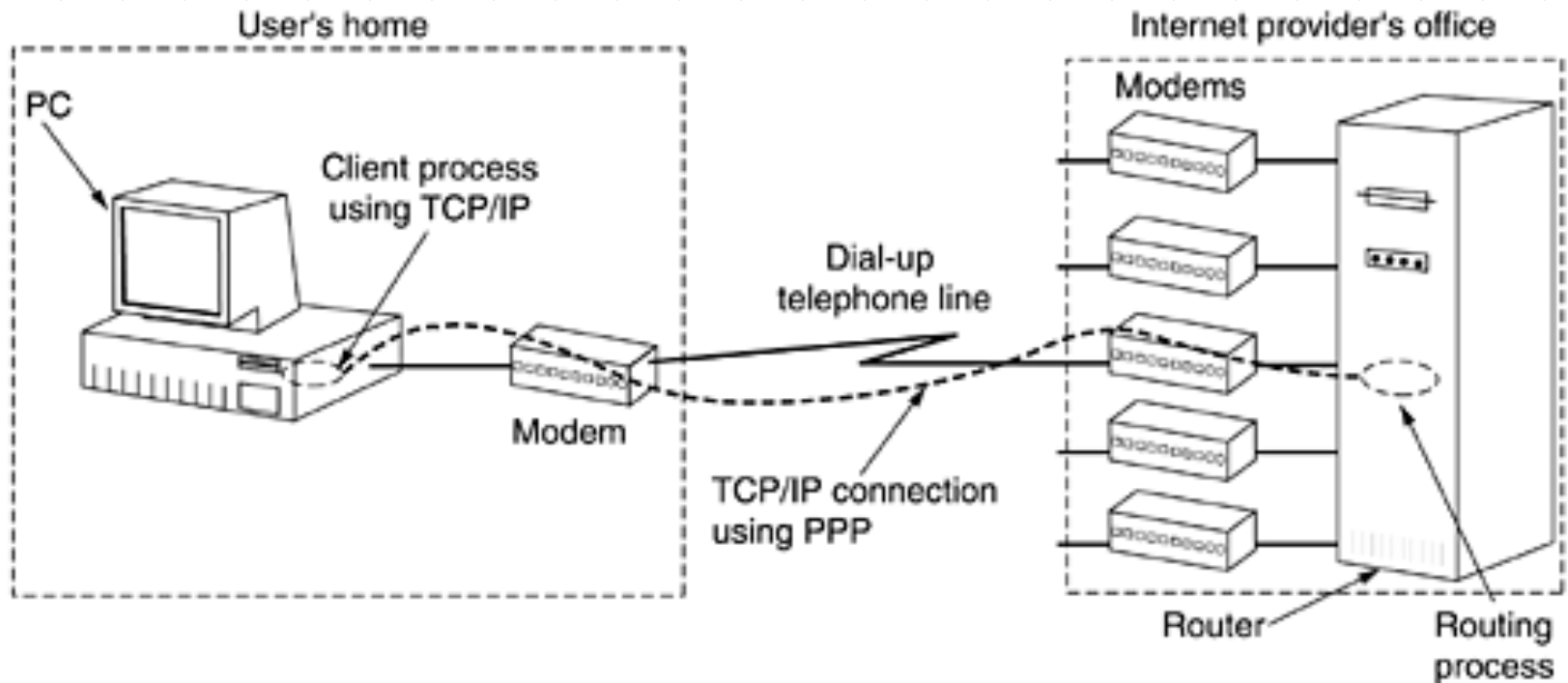
Address – for identifying the terminal

Control – sequence numbers, ack, etc

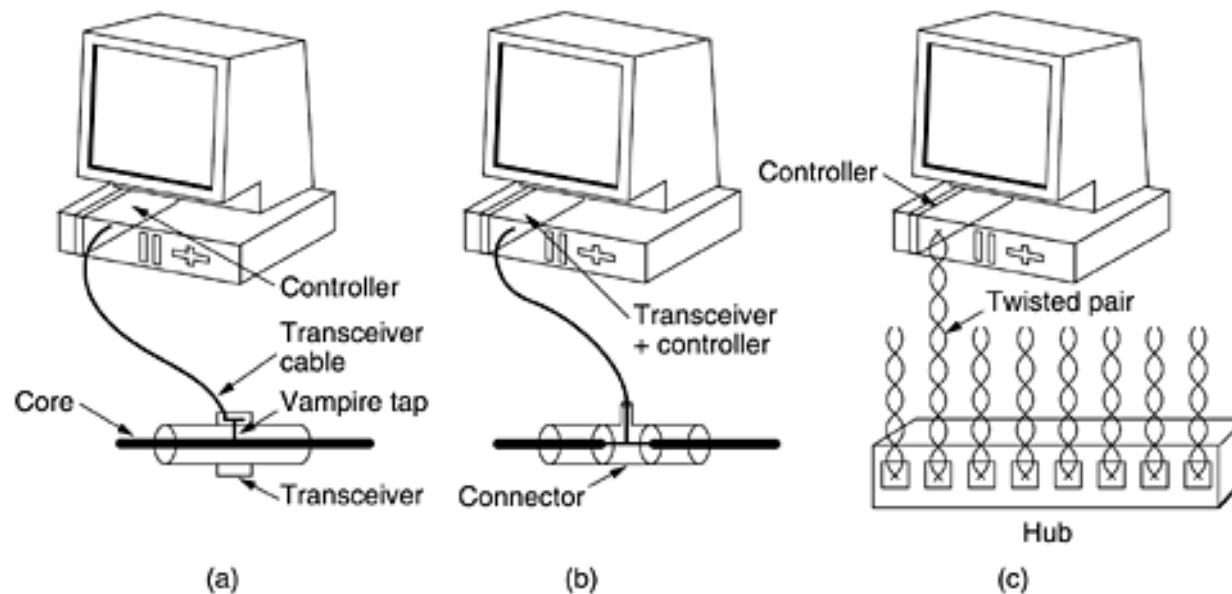Data – any information

Checksum – cyclic redundancy code

On idle lines – flag seq sent continuously
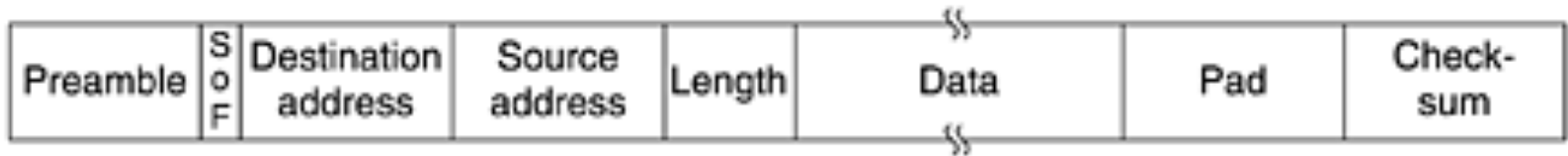
The Internet Data Link Layer

Ethernet

Three kinds of Ethernet cabling. (a) 10Base5. (b) 10Base2. (c) 10Base-T.

Ethernet 802.3

Preamble	S O F	Destination address	Source address	Length	Data	Pad	Check-sum

Type

- ◆ Preamble – 56 bit alternating 1 & 0s
- ◆ SOF – Start of Frame Delimiter=10101011
- ◆ Dest & Source – MAC addresses
- ◆ Length – data length
- ◆ If Lenght< 46 bytes ➔ pad
- ◆ If Length>=1536 ➔   is a **type=protocol**

MAC Addresses

◆ MAC address – 6 bytes –2^{48} addresses
- 281.474.976.710.656 distinct addresses

◆ MAC addresses are burned into the network adapter's ROM

◆ Each Net. Adapt. Has a UNIQUE MAC
- Address space managed by IEEEE
- 2^{24} – company ID
- 2^{24} – adapter ID

MAC Addresses on a host

◆ <u>Linux – ifconfig eth0</u>
 [root@dell ~]# ifconfig
 eth0   Link encap:Ethernet **HWaddr 00:B0:D0:20:71:AA**
         inet addr:172.30.106.3 Bcast:172.30.255.255 Mask:255.255.0.0
         UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
         RX packets:952440 errors:0 dropped:0 overruns:0 frame:0
         TX packets:542834 errors:0 dropped:0 overruns:0 carrier:0
         collisions:0 txqueuelen:1000
       RX bytes:66501640 (63.4 MiB) TX bytes:781222697 (745.0 MiB)
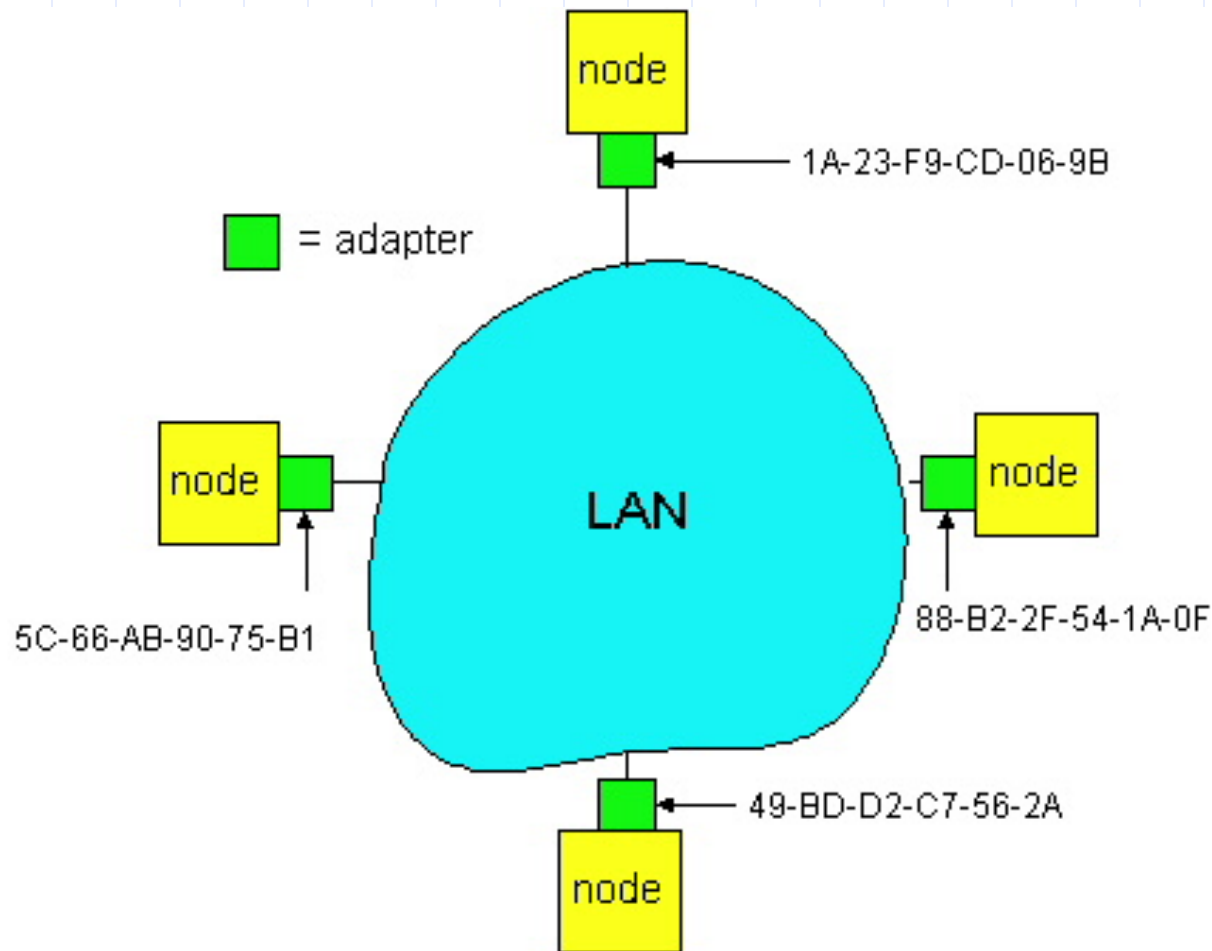
◆ <u>Windows – ipconfig /all</u>
 Ethernet adapter Local Area Connection:
  Connection-specific DNS Suffix . : lan
  Description . . . . : Broadcom NetXtreme 57xx Gigabit Controller
  Physical Address. . . . . : 00-15-C5-0A-26-FE
  Dhcp Enabled. . . . . : Yes
  Autoconfiguration Enabled . . . . : Yes
  IP Address. . . . . : 192.168.0.13
  Subnet Mask . . . . : 255.255.255.0
  Default Gateway . . . . : 192.168.0.254
  DHCP Server . . . . : 192.168.0.254
  Lease Obtained. . . . . : 5 mai 2008 09:10:25
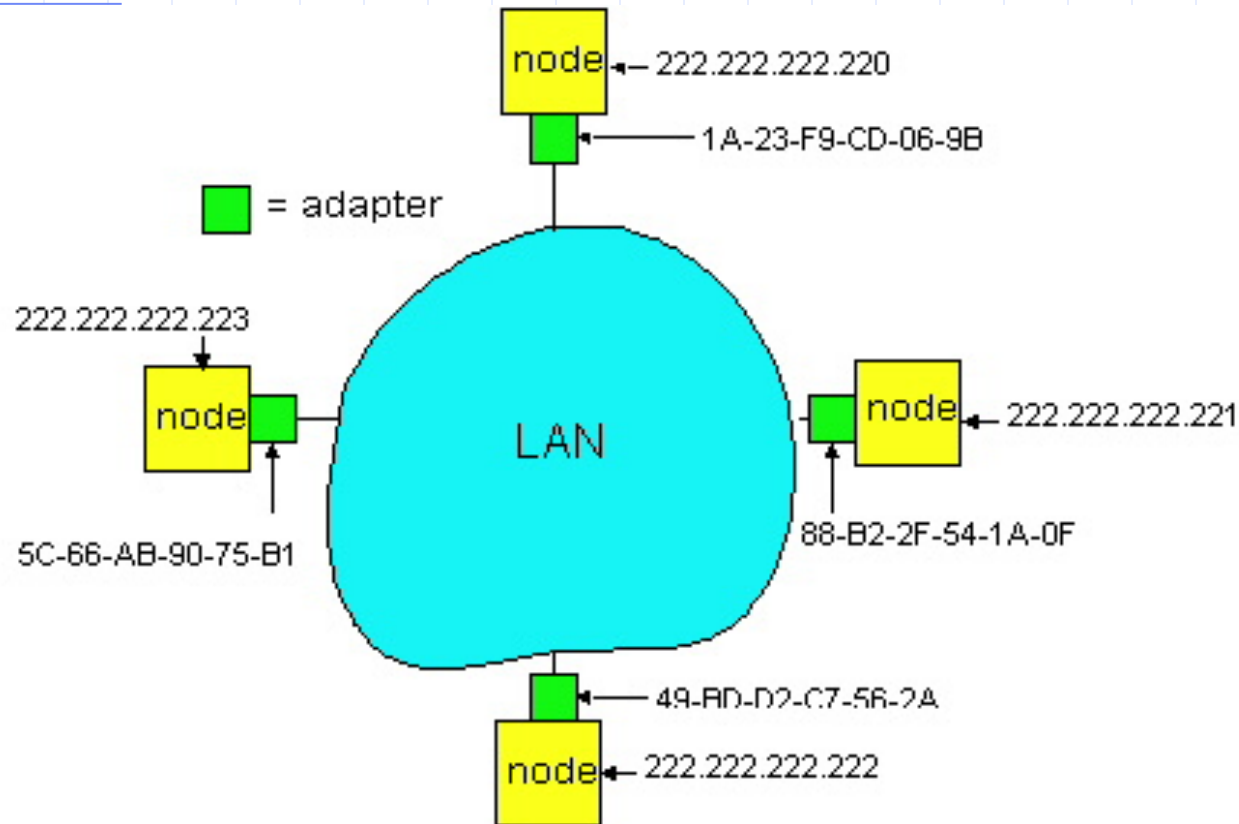 Lease Expires . . . . : 6 mai 2008 09:10:25

Why MAC addresses ?

- ◆ To accommodate different protocols (not just IP)
- ◆ Why not store IP addresses as MAC ?
    - ▪ Need to rewrite the addresses whenever the computer moves
- ◆ Broadcast media – why not pass every frame to the node ?
    - ▪ To much processing….

MAC Addresses and ARP

node

1A-23-F9-CD-06-9B

= adapter

node

LAN

node

88-B2-2F-54-1A-0F

5C-66-AB-90-75-B1

49-BD-D2-C7-56-2A

node

ARP- Address Resolution Protocol

FF-FF-FF-FF-FF-FF – broadcast address

ARP Tables

IP address	LAN address	TTL
222.222.222.221	88-B2-2F-54-1A-0F	13:45:00
222.222.222.223	5C-66-AB-90-75-B1	13:52:00

ARP – similar to DNS – just on local LANs

(/sbin/)arp –a **(Windows + Linux)**
l338_06.scs.ubbcluj.ro (172.30.38.6) at 00:50:70:D7:0E:7A [ether] on eth1
win.scs.ubbcluj.ro (172.30.0.14) at 00:30:05:C2:36:C8 [ether] on eth1
l336_09.scs.ubbcluj.ro (172.30.36.9) at 00:1D:60:9F:16:9D [ether] on eth1
l308_04.scs.ubbcluj.ro (172.30.8.4) at 00:50:70:D7:14:72 [ether] on eth1
rares_sun (193.226.40.145) at 00:19:21:30:4C:3C [ether] on eth1
? (172.30.111.6) at 00:13:02:D3:DC:B4 [ether] on eth1
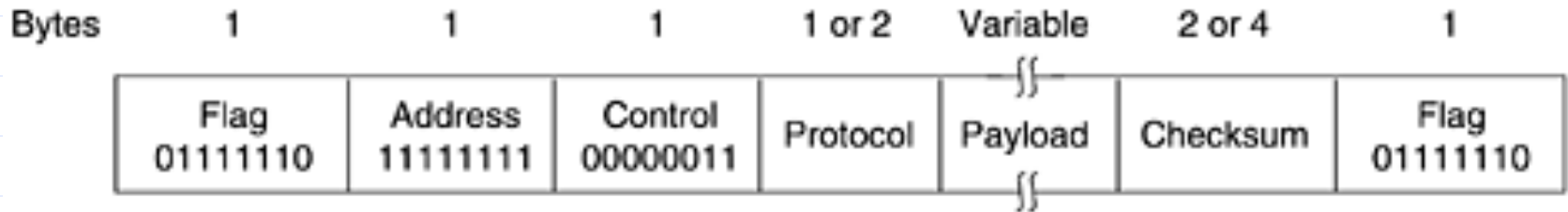dan (193.226.40.147) at <incomplete> on eth1

Wake on Lan (ethernet only)
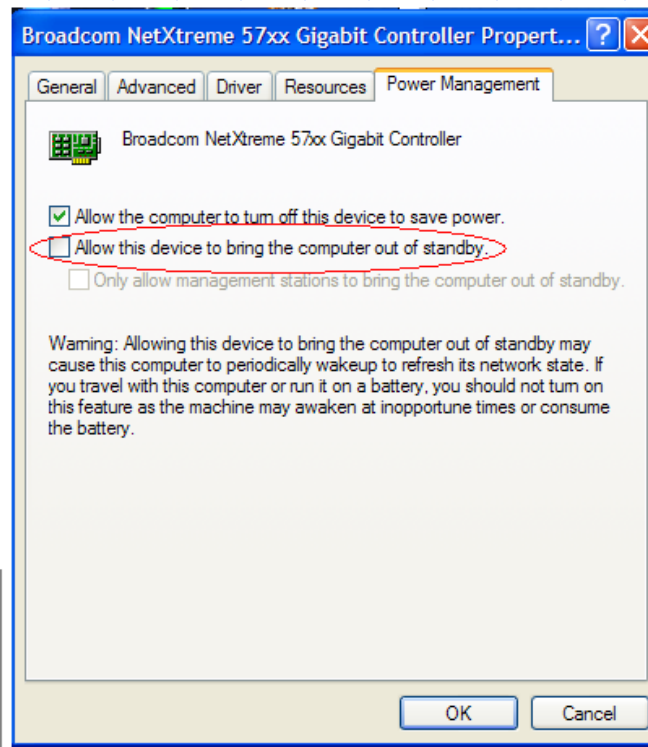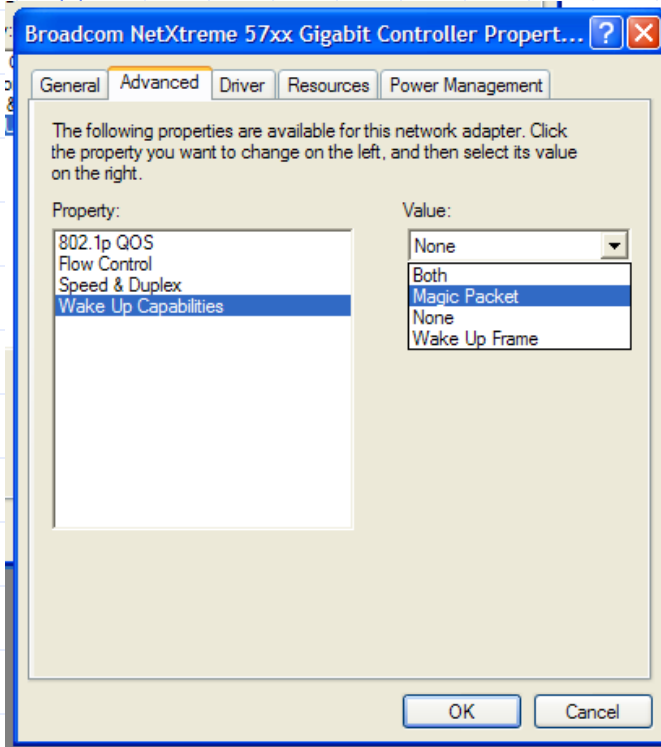
Linux – **ethtool** –s wol g eth0
p| u | g |b | a| s |d= Phys activity|unicast|broadcast|ARP|
|SecureOnPassw|disable

PPP – Point to Point Protocol

◆ Provides
  - Framing + error detection
  - **Link Control Protocol** – brings lines up, tears down, etc
  - **Network Control Protocol** – negotiating network protocol
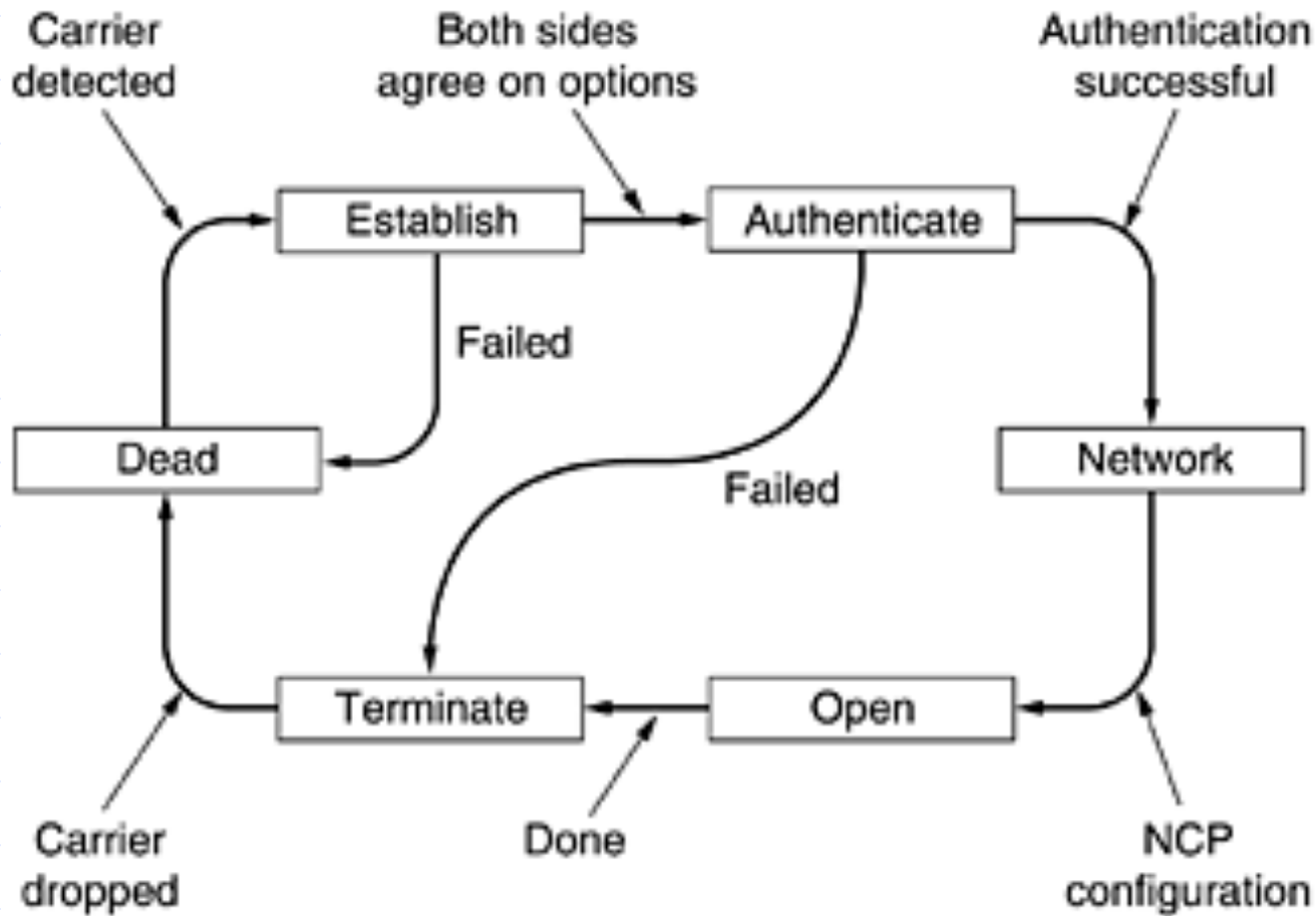
PPP packet structure

Bytes	1	1	1	1 or 2	Variable	2 or 4	1
	Flag 01111110	Address 11111111	Control 00000011	Protocol	Payload	Checksum	Flag 01111110

Protocol

    bit 0=1 Negotiators: LCP, NCP

    bit 0=0 network protocol – IP, IPX, etc

PPP

LCP Frame Types

| Name	Direction	Description
Configure-request	I → R	List of proposed options and values
Configure-ack	I ← R	All options are accepted
Configure-nak	I ← R	Some options are not accepted
Configure-reject	I ← R	Some options are not negotiable
Terminate-request	I → R	Request to shut the line down
Terminate-ack	I ← R	OK, line shut down
Code-reject	I ← R	Unknown request received
Protocol-reject	I ← R	Unknown protocol requested
Echo-request	I → R	Please send this frame back
Echo-reply	I ← R	Here is the frame back
Discard-request	I → R	Just discard this frame (for testing)

Network Equipment

- Network adapters
- Hubs
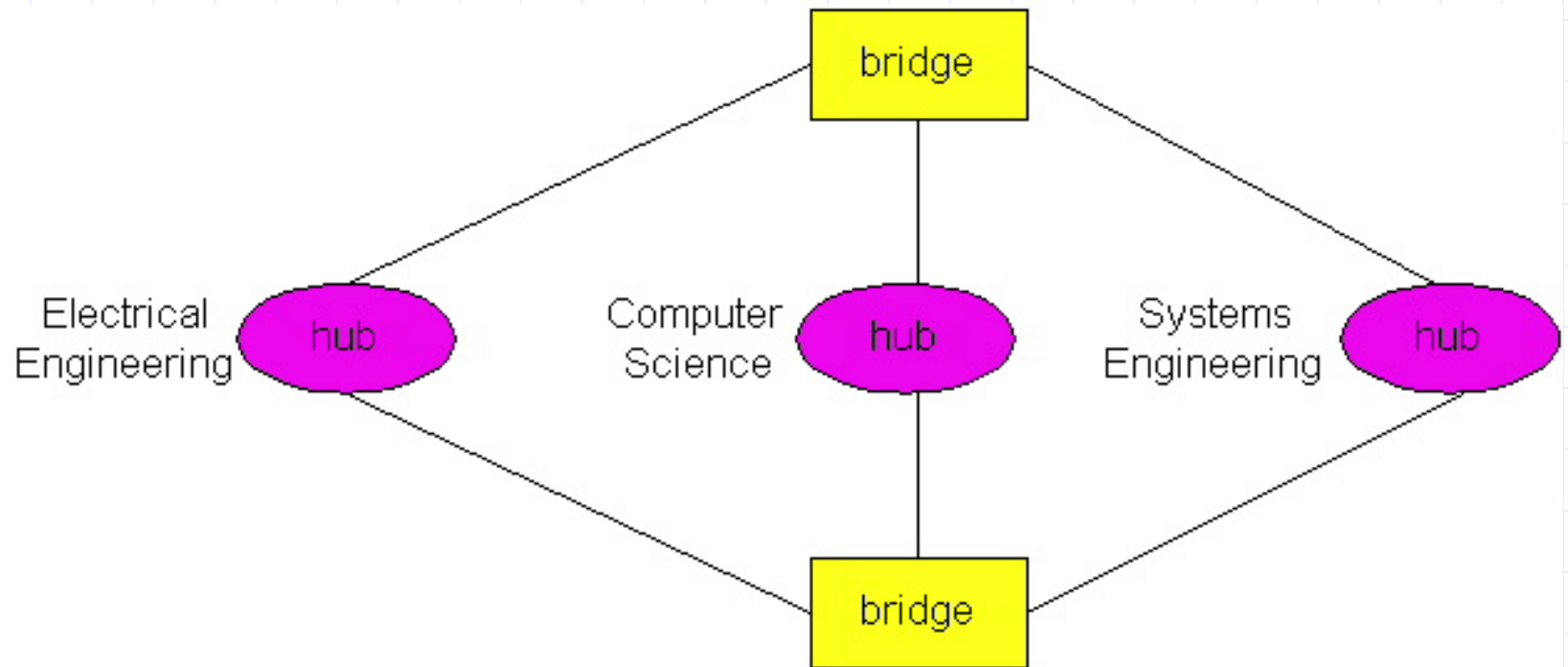- Bridges
- Switches
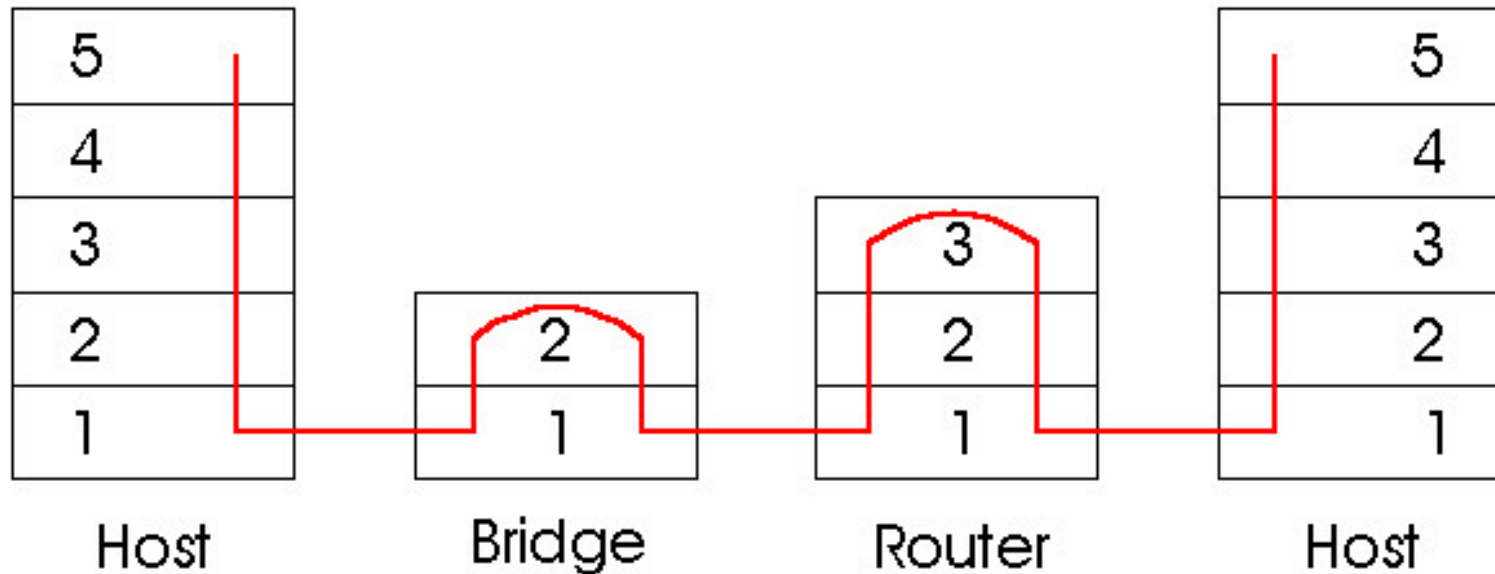
Hubs
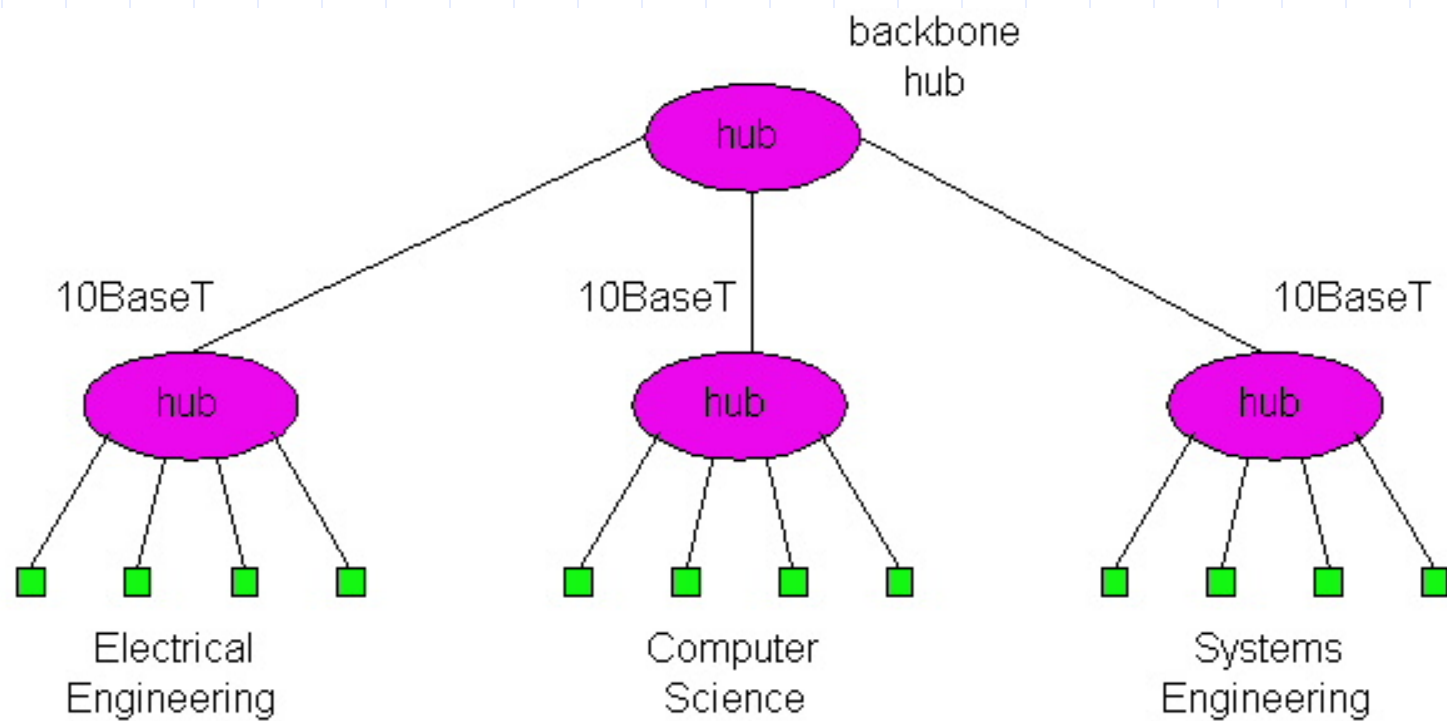
Bridges
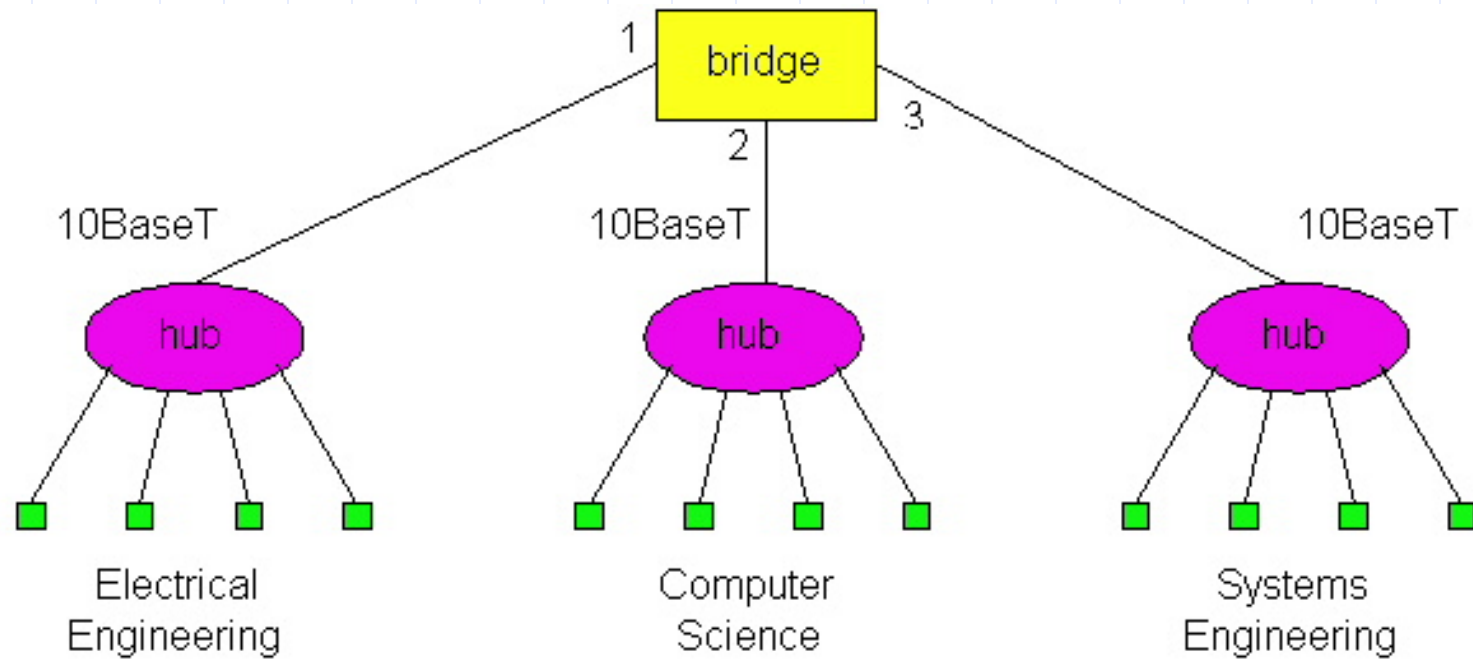
Bridge Forwarding and Filtering

Address	Interface	Time
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
...	...	...

◆ Self learning components

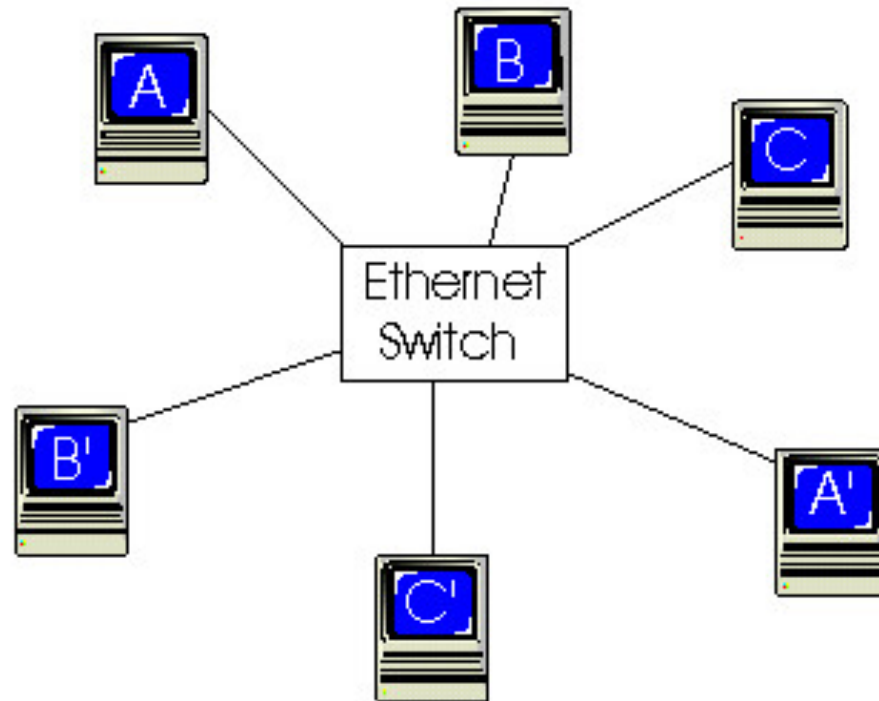◆ Similar to NICs but no MAC Address

Spanning Tree

Bridges vs Routers

Switches

Switch = Bridge with many interfaces (> 4)

Full duplex mode

Dedicated Access – no collision

Features of interconnection devices

	hubs	bridges	routers	Ethernet switches
traffic isolation	*no*	*yes*	*yes*	*yes*
plug and play	*yes*	*yes*	*no*	*yes*
optimal routing	*no*	*no*	*yes*	*no*
cut-through	*yes*	*no*	*no*	*yes*