Computer Networks
Data Link Layer

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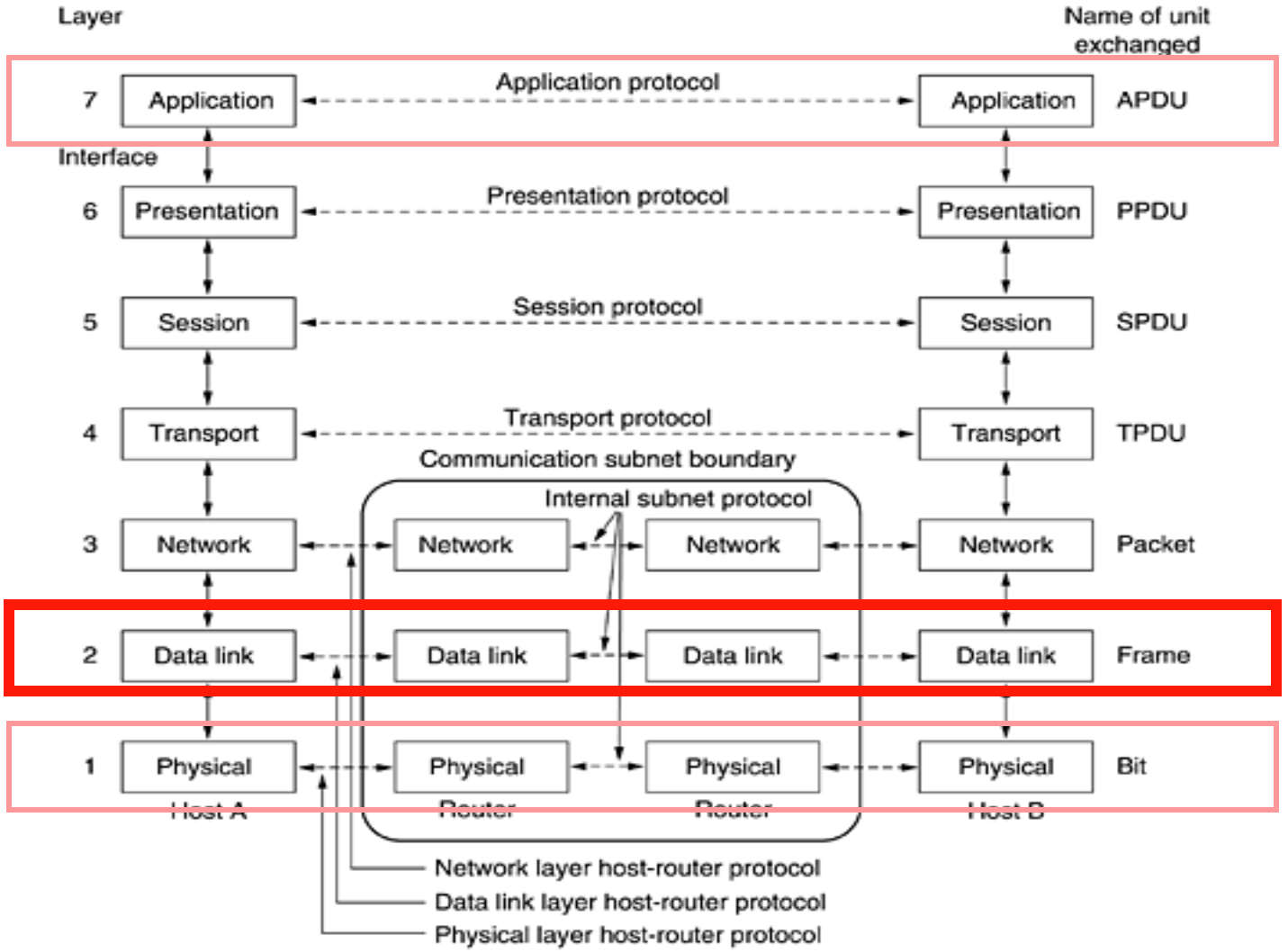
Lecture 5

The Data Link Layer

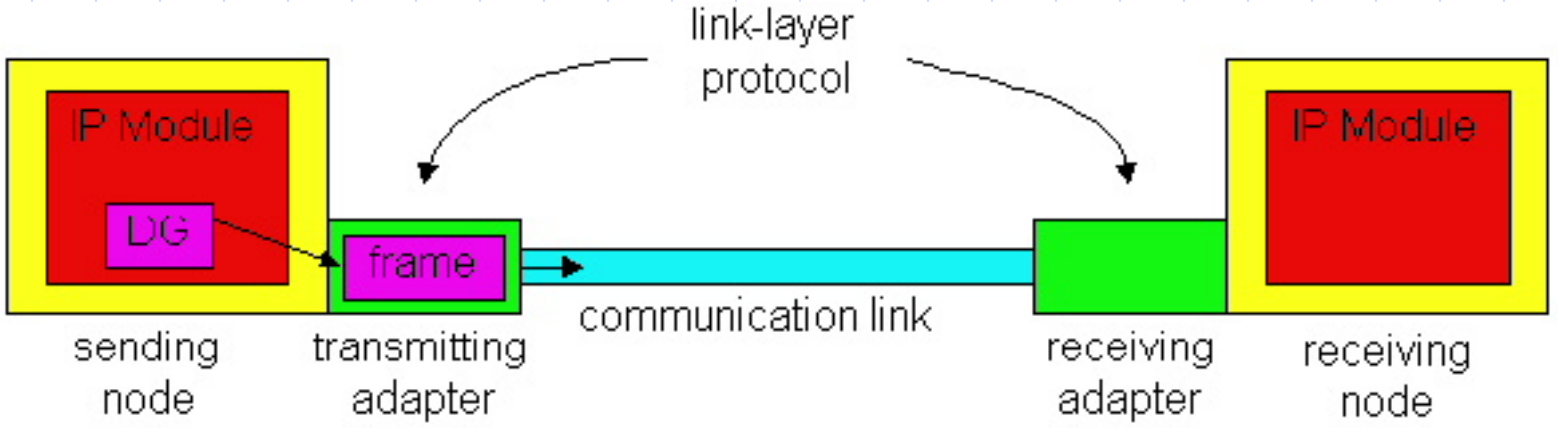


All **P**eople **S**eem **T**o **N**eed **D**ata **P**rocessing

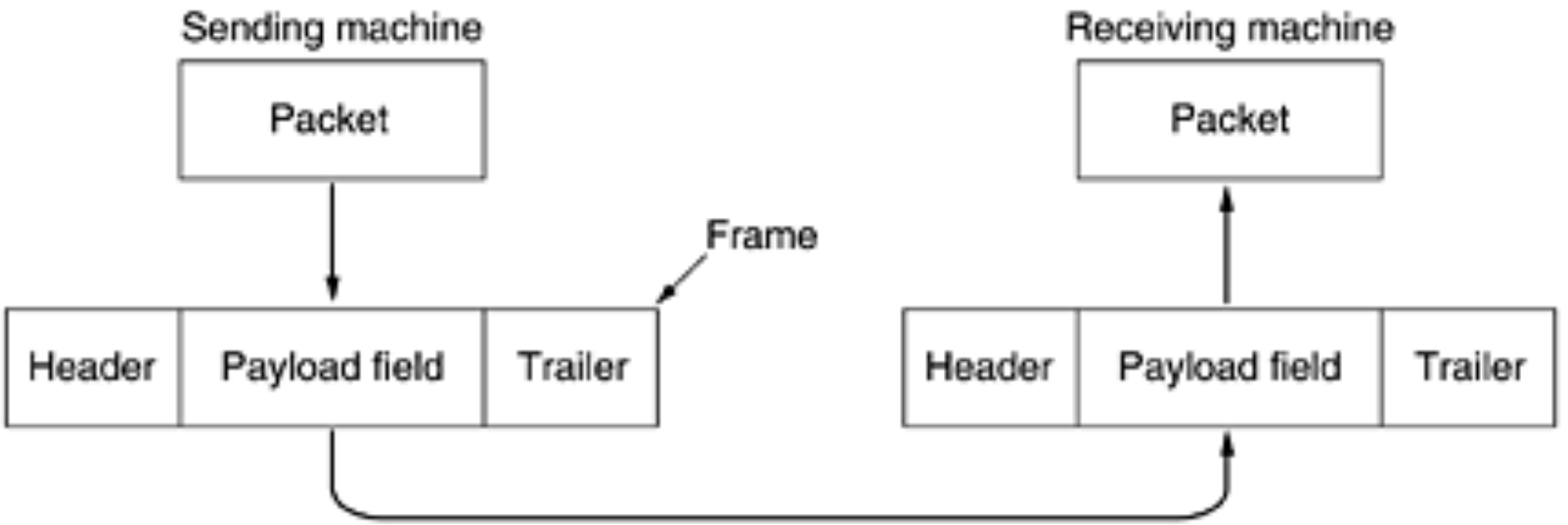
Data Link Layer Services

- 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



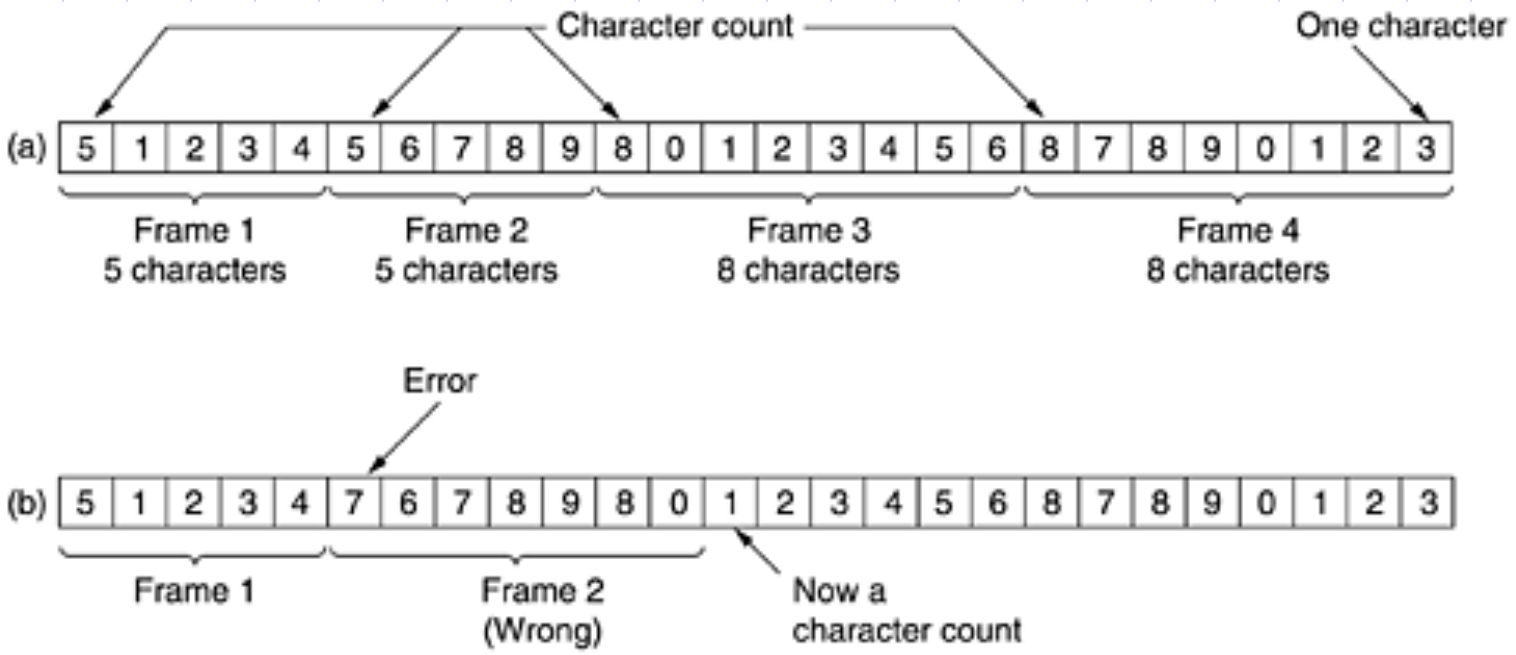
Services provided for the Network Layer

- Unacknowledged connectionless
- Acknowledged connectionless
- Acknowledged connection-oriented

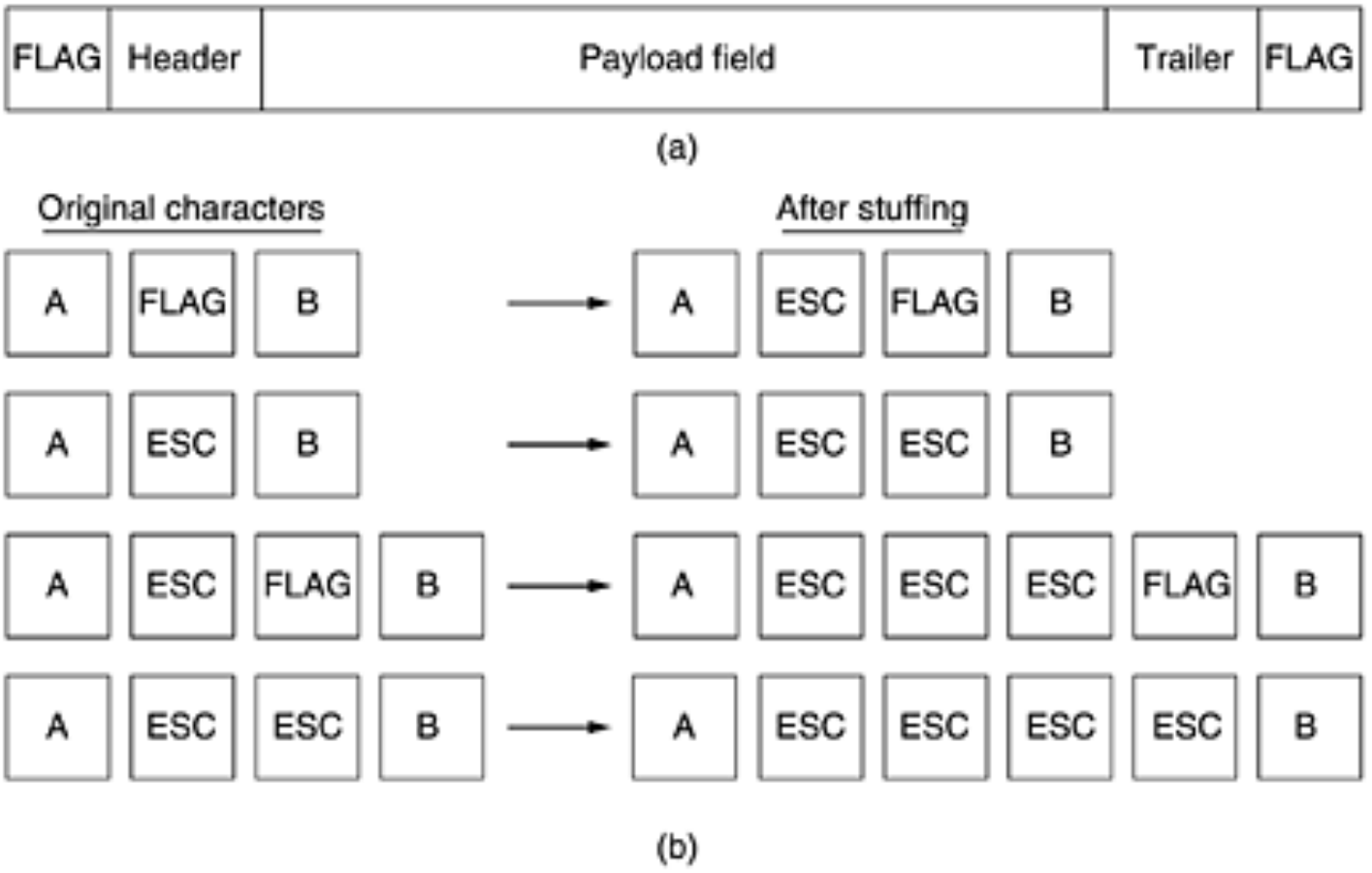
Framing

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

Character Count



Flag byte + Byte Stuffing



Unicode (multiple bytes characters) Bit Stuffing

Flag - 01111110

"In data sequence" 01111110 transmitted as 011111010

Flow Control

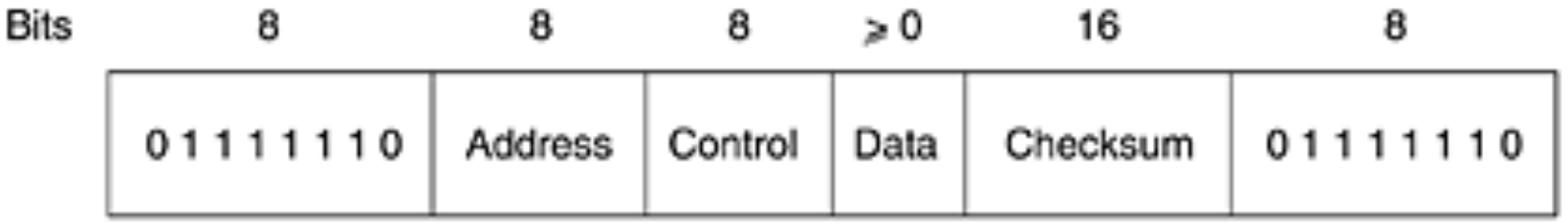
- Feedback based
  - Receiver sends information back to the sender allowing it to send more data
- Rate-based
  - No feedback

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



01111110 – flag – end start

Address – for identifying the terminal

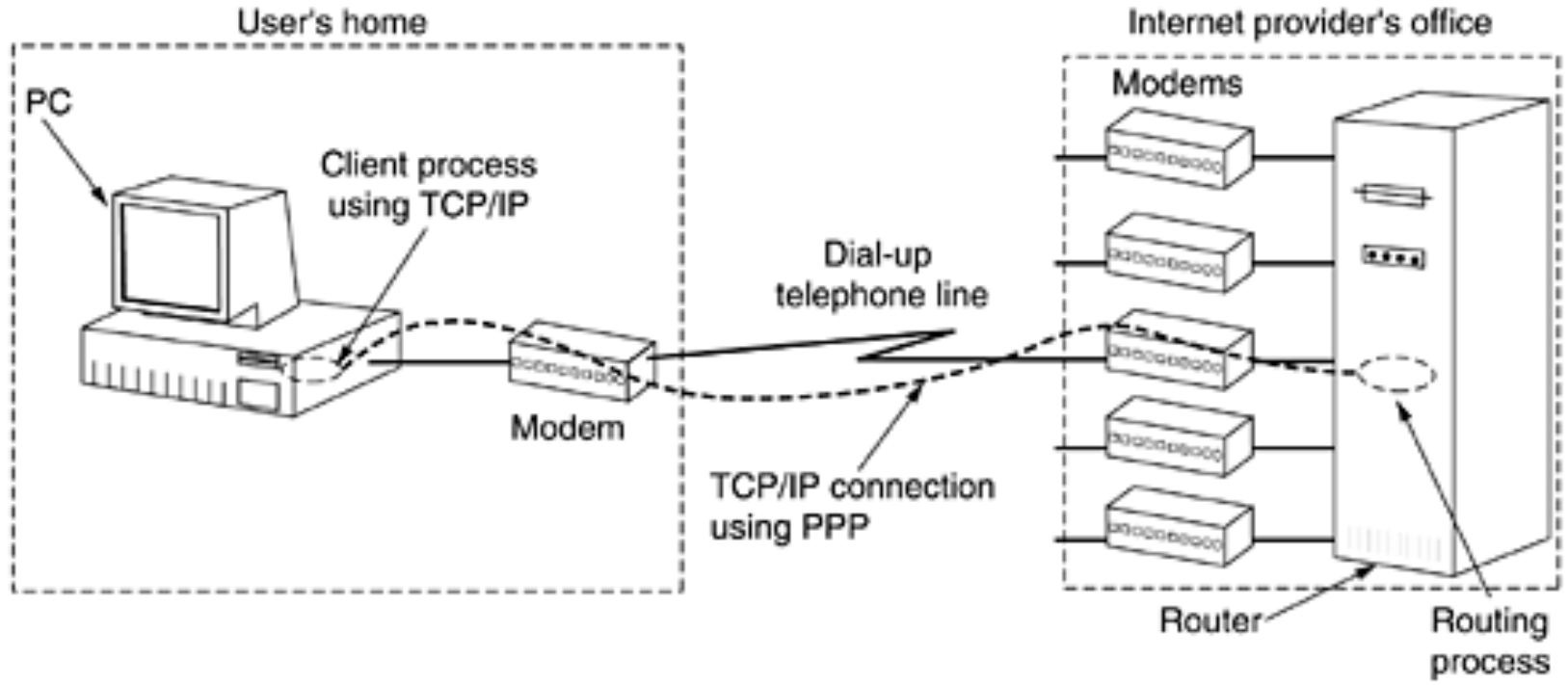
Control – sequence numbers, ack, etc

Data – any information

Checksum – cyclic redundancy code

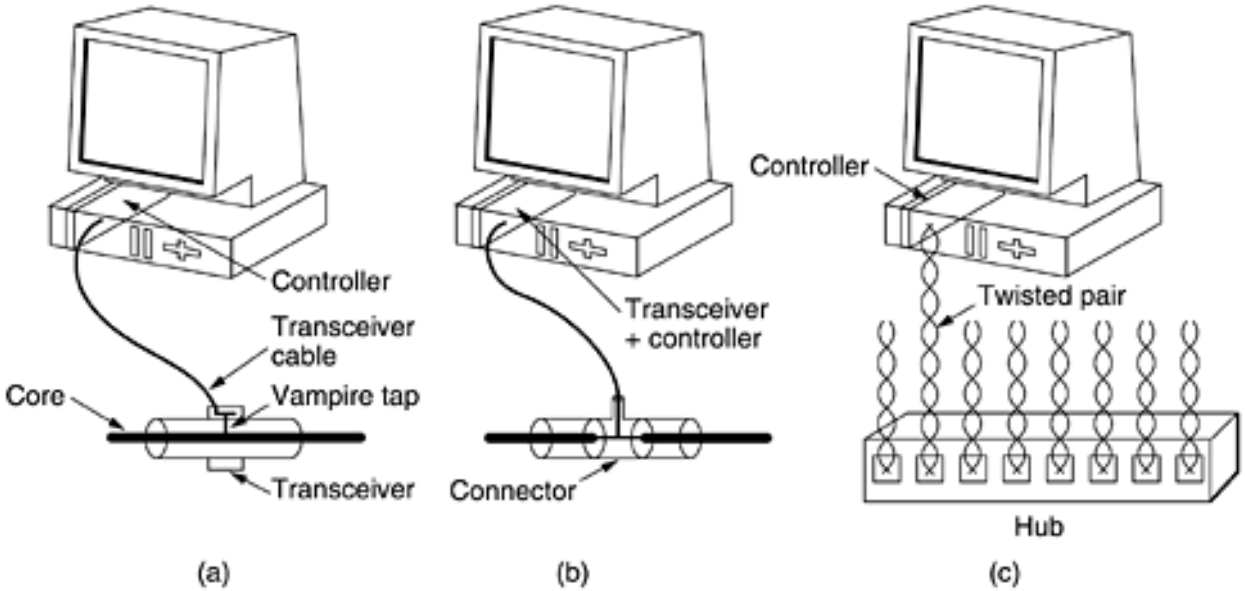
On idle lines – flag seq sent continuously

The Internet Data Link Layer

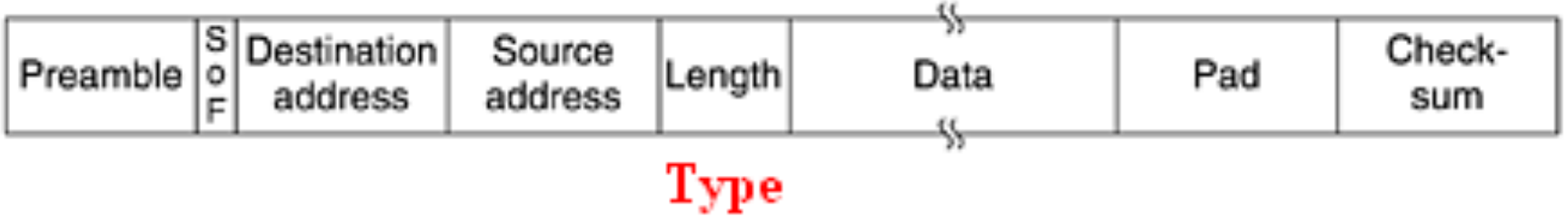


Ethernet

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



Ethernet 802.3



- Preamble – 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

- Linux – ifconfig eth0

```
[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)
```

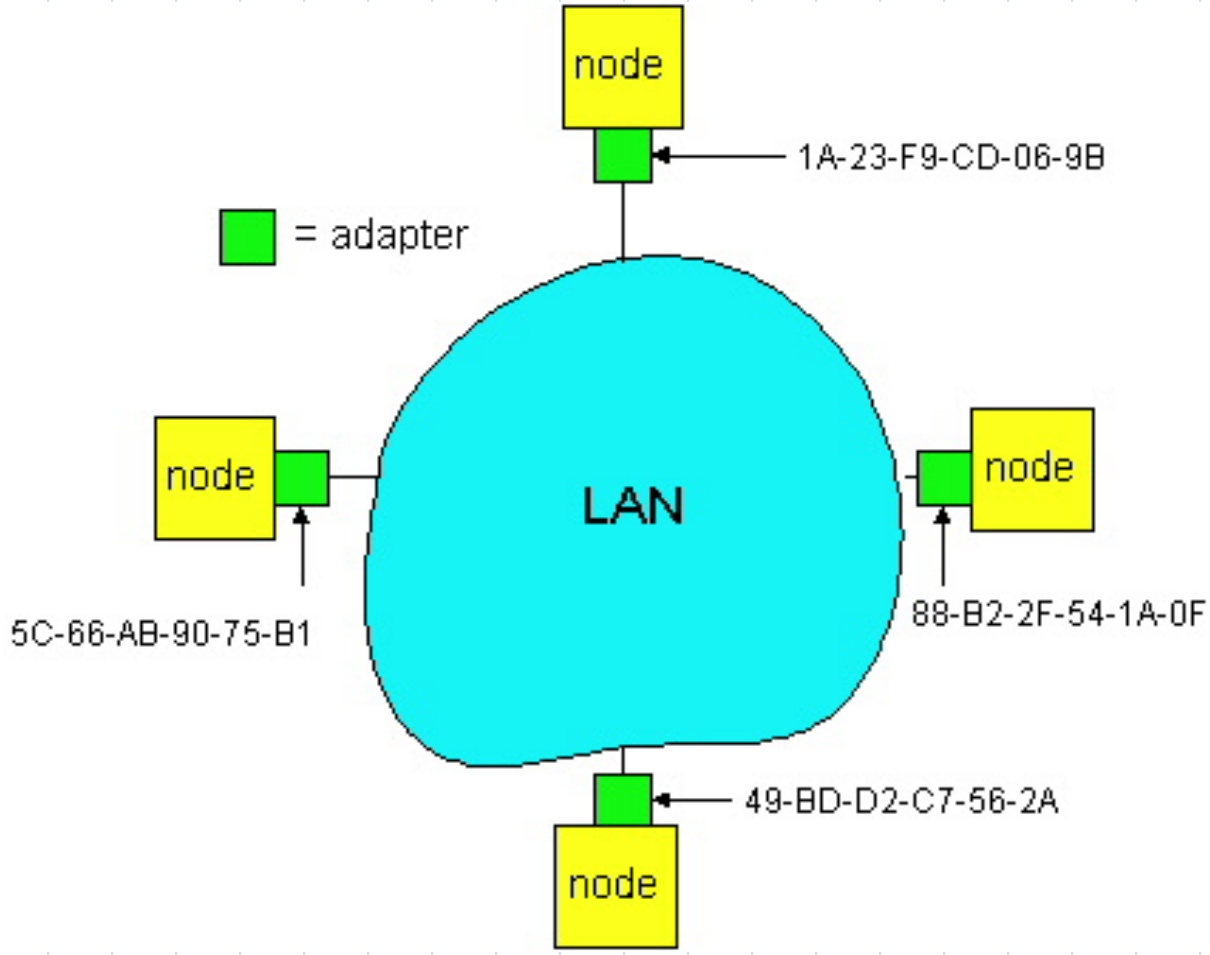
- Windows – ipconfig /all

```
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
```

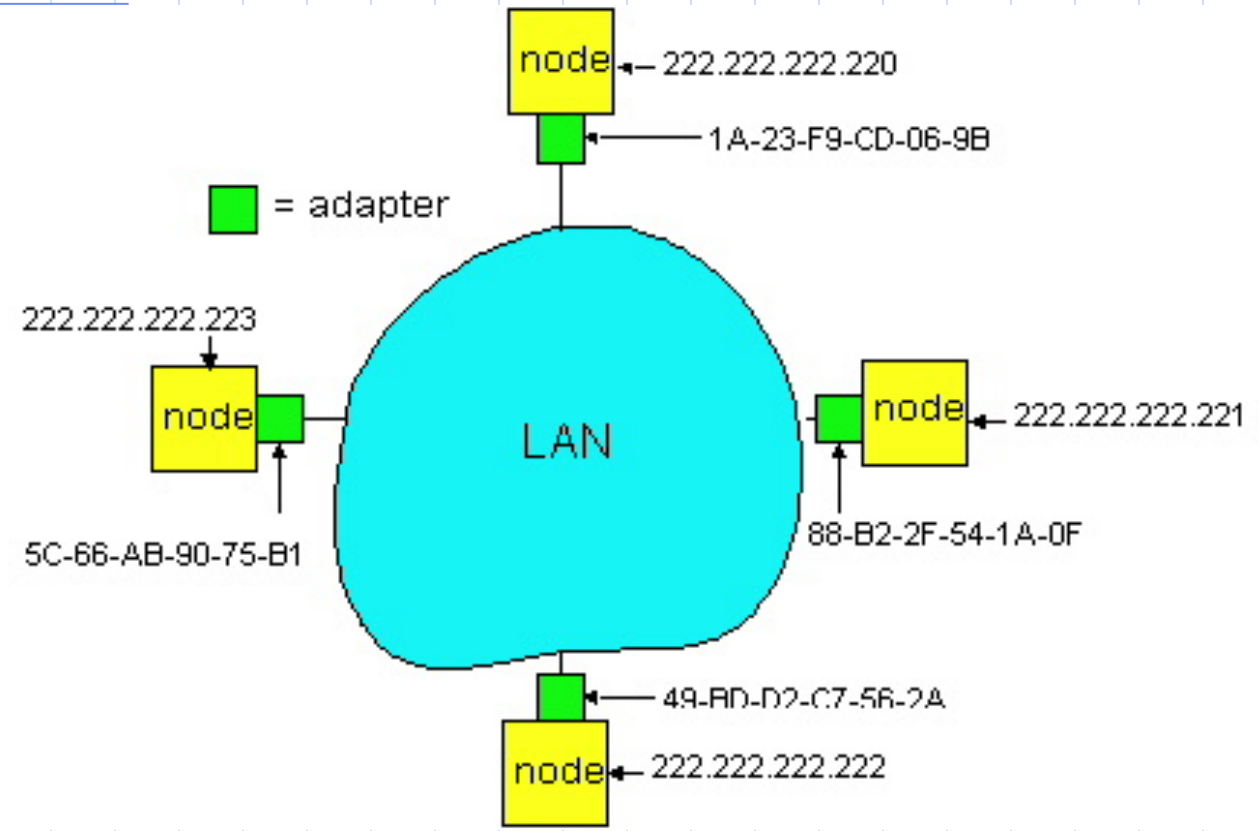
Why MAC addresses ?

- 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



ARP- Address Resolution Protocol



FF-FF-FF-FF-FF-FF – broadcast address

ARP Tables

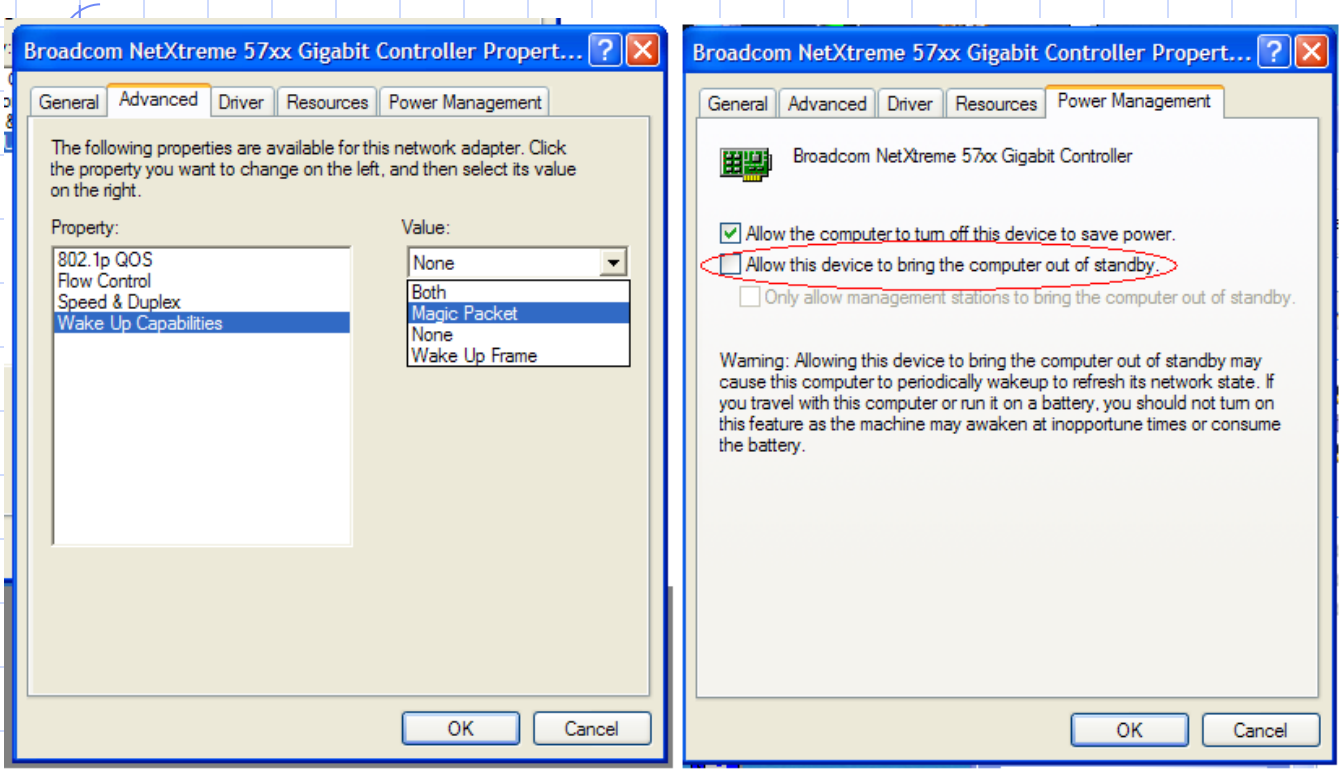
IP address	LAN address	TTL
222.222.222.221	88-B2-2F-54-1A-0F	13:45:00
222.222.222.223	5C-66-AB-90-75-B1	13:52:00

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)



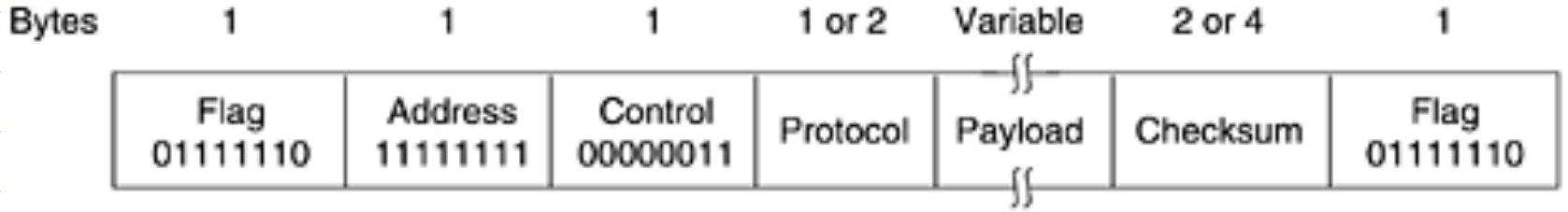
Linux – **ethtool** –s *wol g* eth0

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

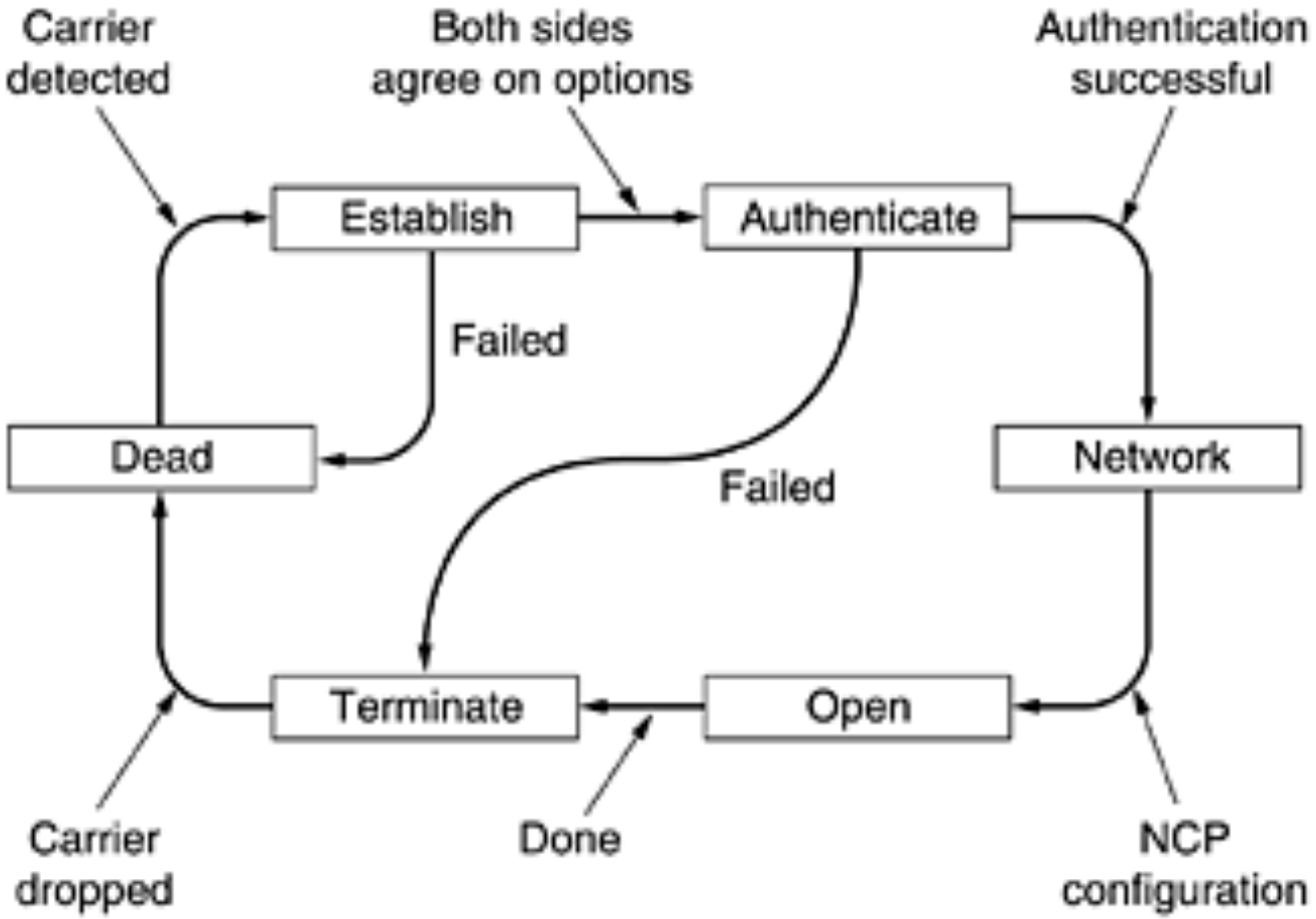


Protocol

bit 0=1 Negotiators: LCP, NCP

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

PPP


Carrier detected
Both sides agree on options
Authentication successful
Establish
Authenticate
Failed
Dead
Failed
Network
Terminate
Open
Carrier dropped
Done
NCP configuration

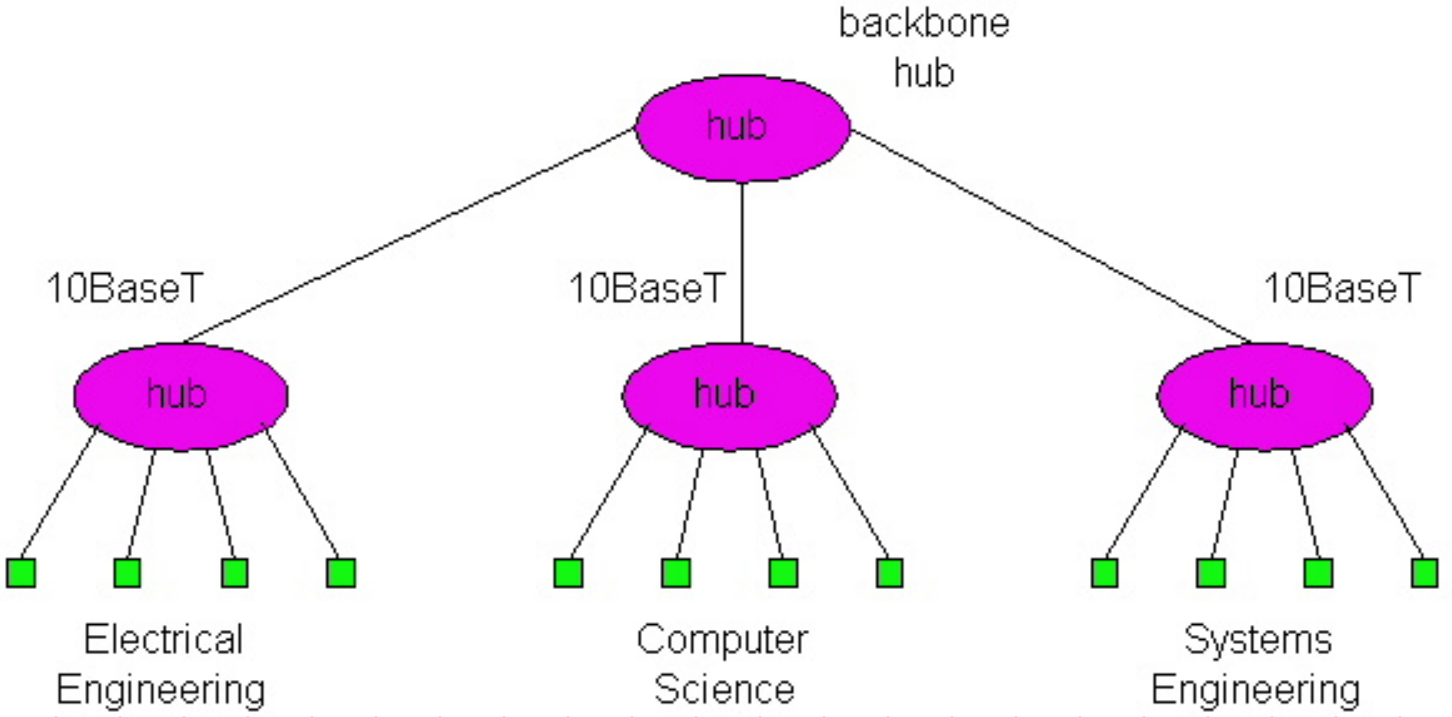
LCP Frame Types

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)

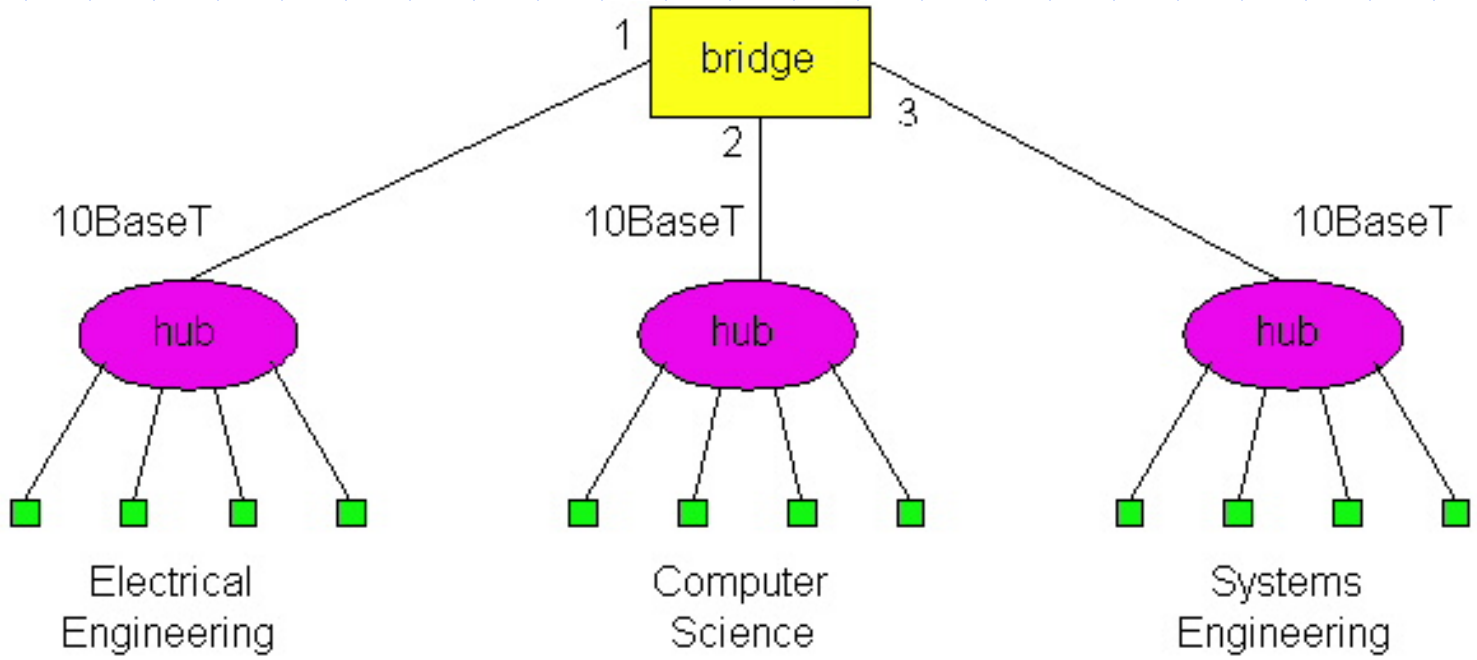
Network Equipment

- Network adapters
- Hubs
- Bridges
- Switches

Hubs


backbone
hub
hub
10BaseT
10BaseT
10BaseT
hub
hub
hub
Electrical
Engineering
Computer
Science
Systems
Engineering

Bridges

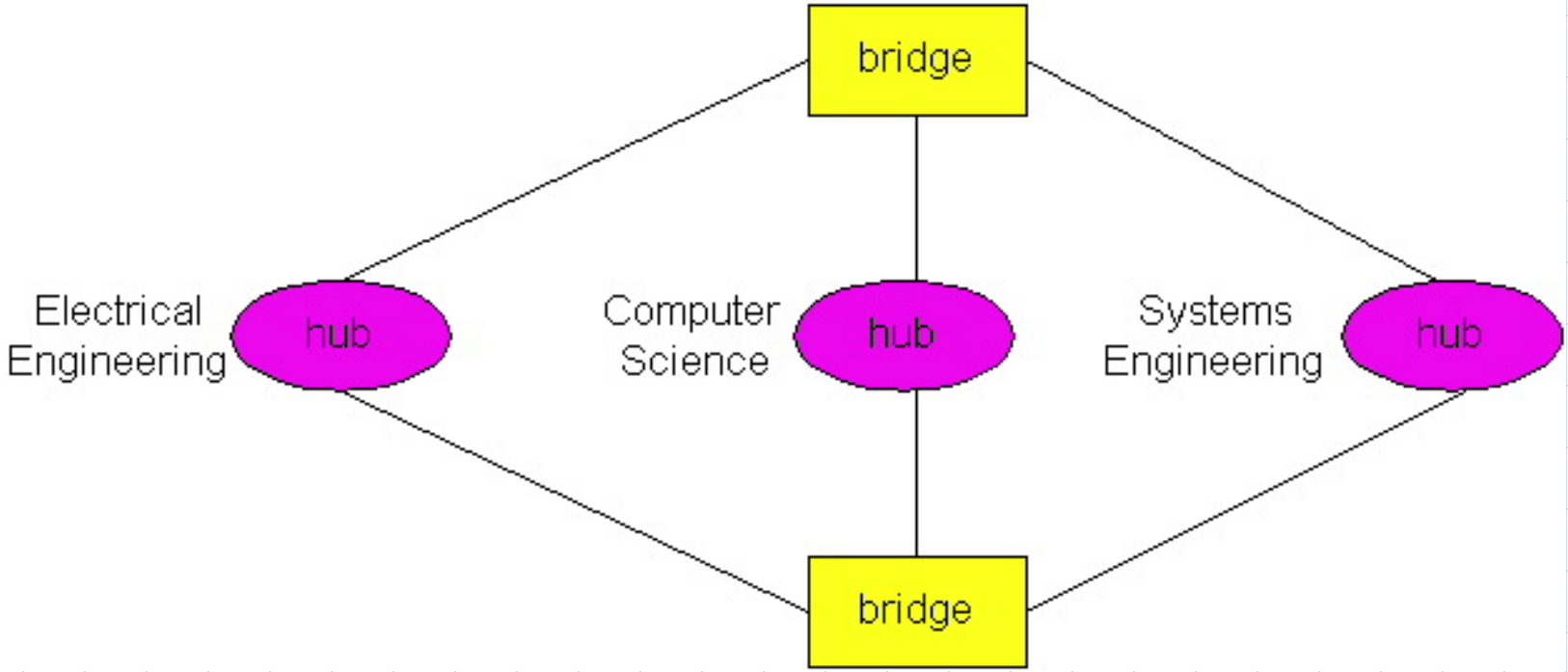

1
bridge
2
3
10BaseT
10BaseT
10BaseT
hub
hub
hub
Electrical Engineering
Computer Science
Systems Engineering

Bridge Forwarding and Filtering

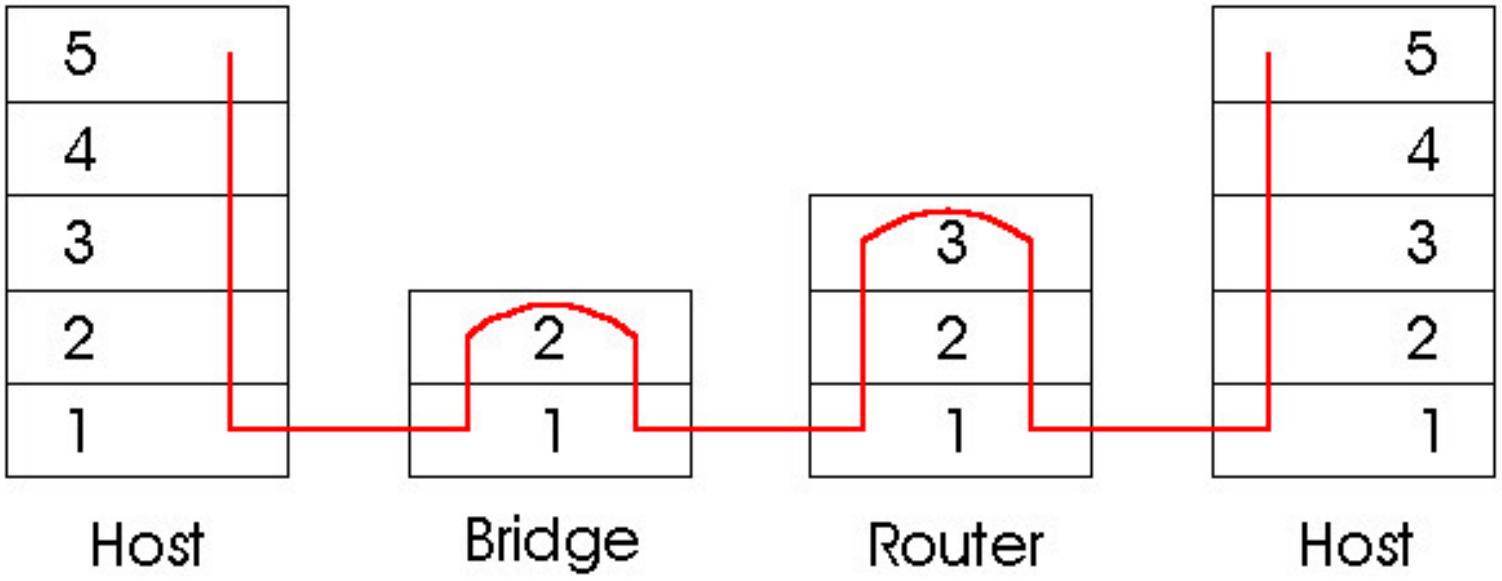
Address	Interface	Time
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
…	…	…

- Self learning components
- Similar to NICs but no MAC Address

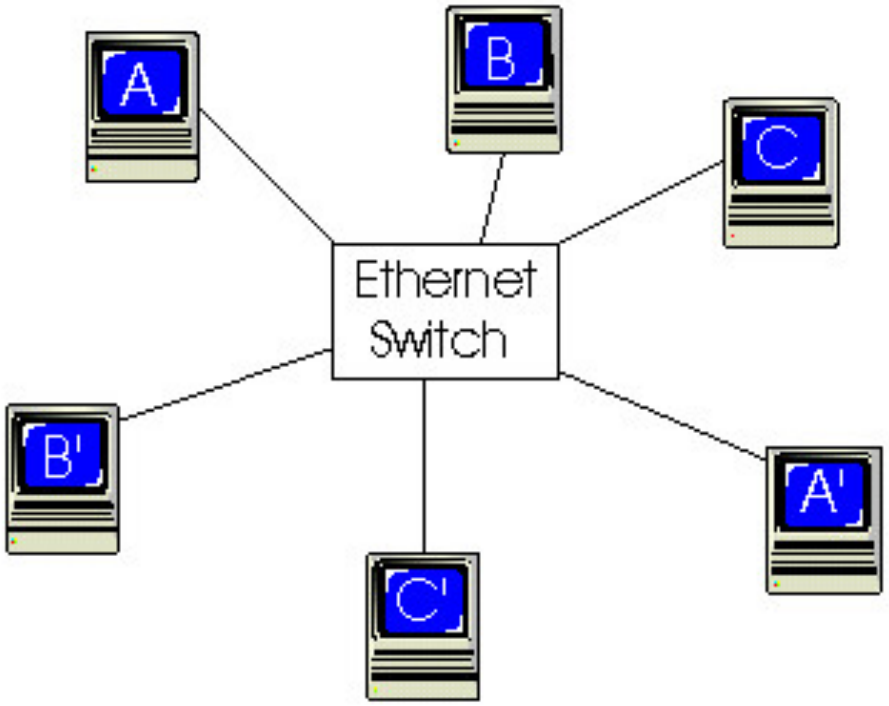
Spanning Tree



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*