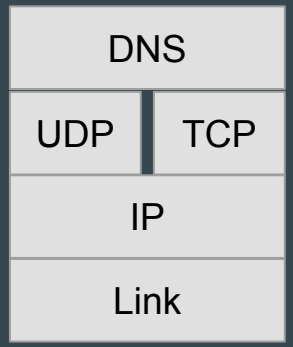
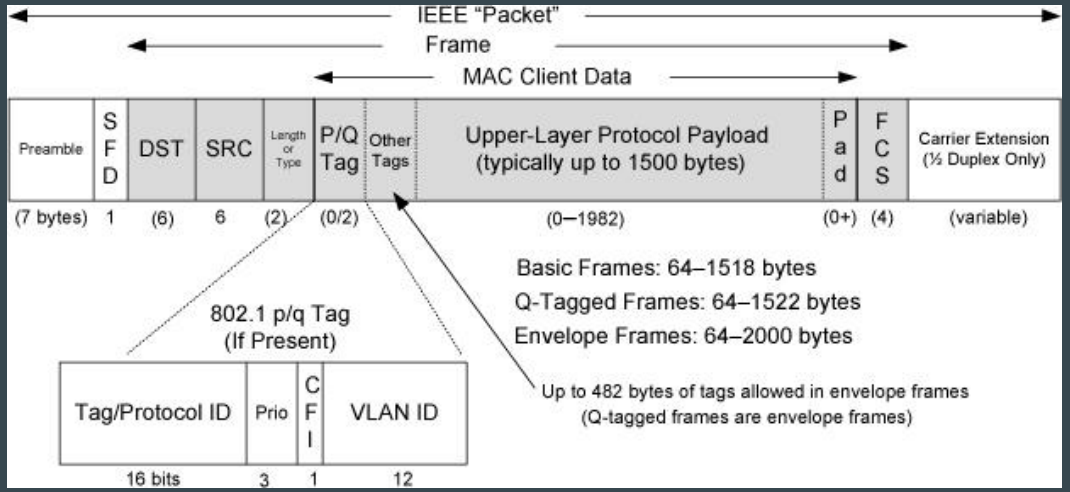
Link Layer

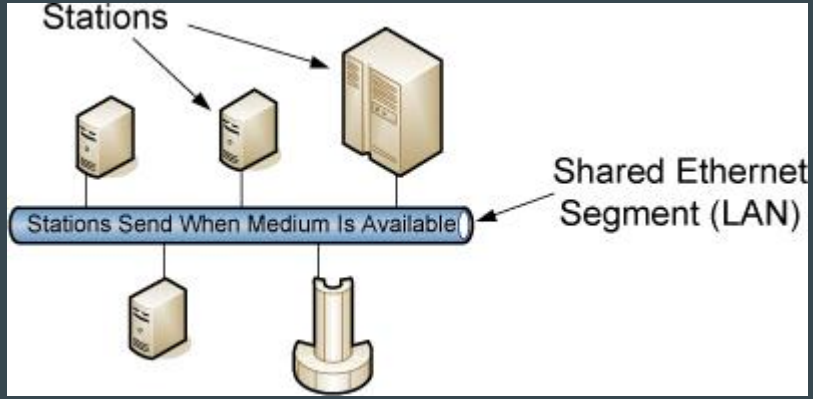
- Chapter 3, Fall & Stevens



Ethernet Frame Format



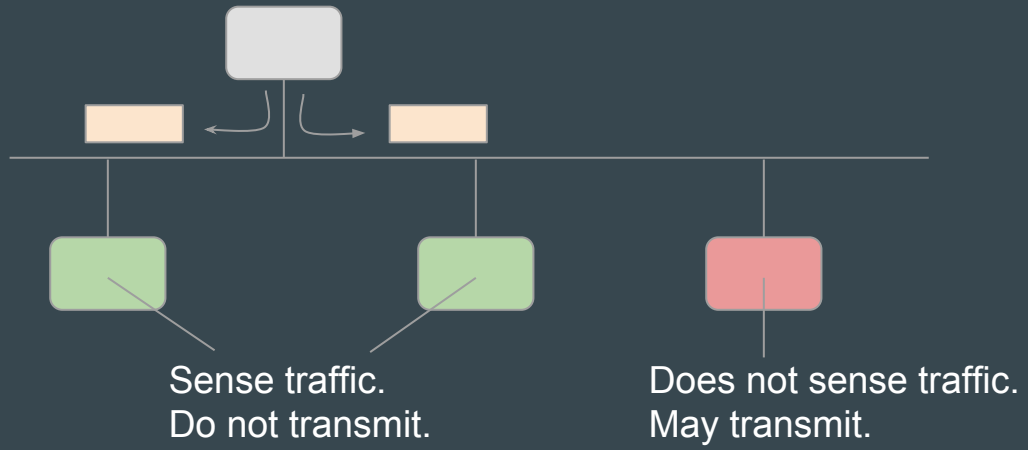
(Shared) Ethernet



CSMA/CD

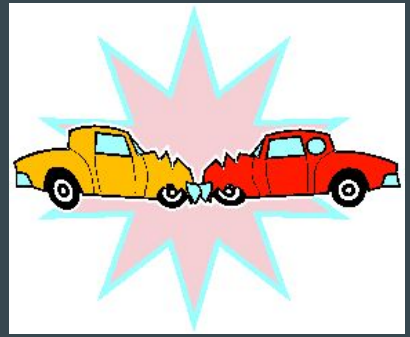
Carrier Sense Multiple Access with Collision Detection

Carrier Sense: do not transmit when you know someone else is.



Collision, Collision Detection

- Collision: > 1 pulse on the bus.
- Detection: hosts check for collision immediately after transmission.
- Minimum frame size (64 bytes) designed with this in mind.

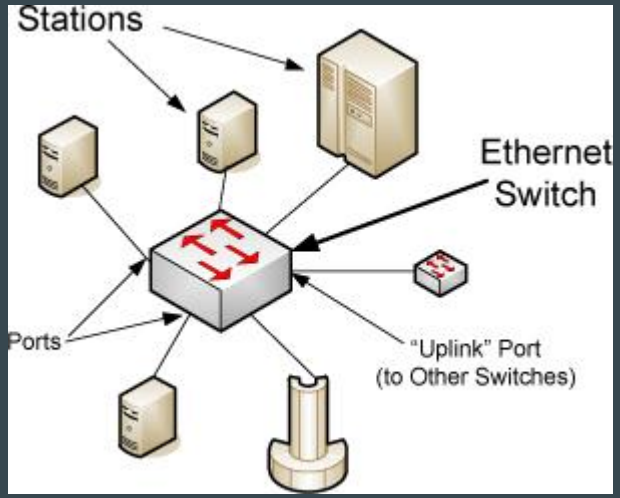


Exponential Back-off

- In attempting to send a frame, *f*, after c^{th} collision
  - Choose a uniform integer, $i \in [0, 2^c - 1]$
  - Delay by $i \times$ “slot time”
  - Usually, $c \in [0, 16]$. Give up after $c = 16$.

Switched Ethernet

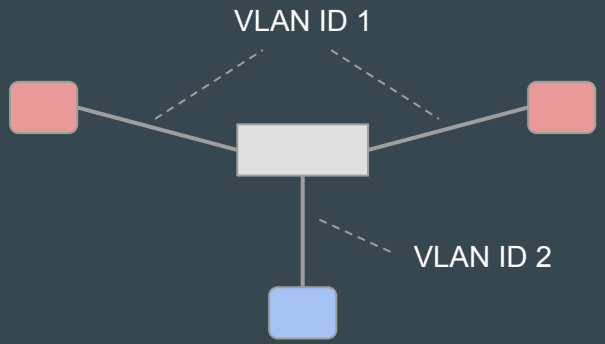
- Switch learns and maintains a table.
- While not yet learned, switch acts as a hub.



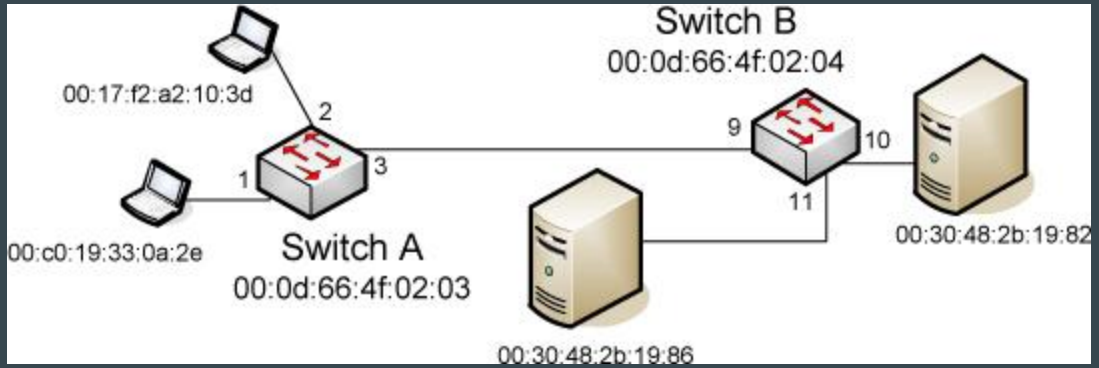
Connected to	*via Port*
c4:8e:f5:68:10:1e	5
2e:8d:11:ee:5e:8a	2
...	...

Virtual LAN (VLAN)

- Hosts connected to same switch may not be on same VLAN.
- One way to do this: switch binds a port to a VLAN ID.
- Traffic allowed to flow within VLAN only - extra column in switching table.



Extended LANs



Switching Table for Extended LAN

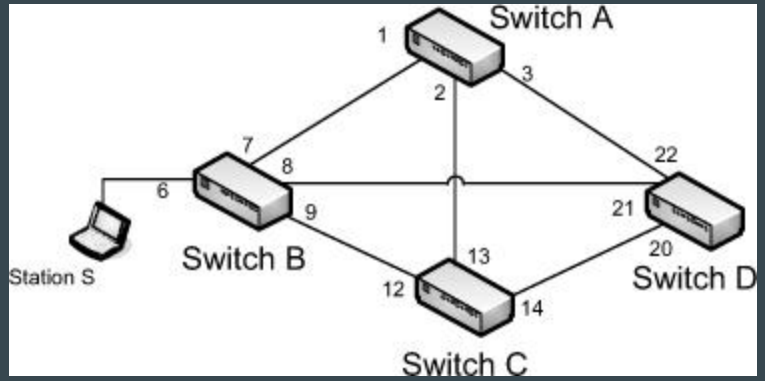
Station	Port
00:17:f2:a2:10:3d	2
00:c0:19:33:0a:2e	1
00:0d:66:4f:02:03	
00:0d:66:4f:02:04	3
00:30:48:2b:19:82	3
00:30:48:2b:19:86	3

Switch A's Database

Station	Port
00:17:f2:a2:10:3d	9
00:c0:19:33:0a:2e	9
00:0d:66:4f:02:03	9
00:0d:66:4f:02:04	
00:30:48:2b:19:82	10
00:30:48:2b:19:86	11

Switch B's Database

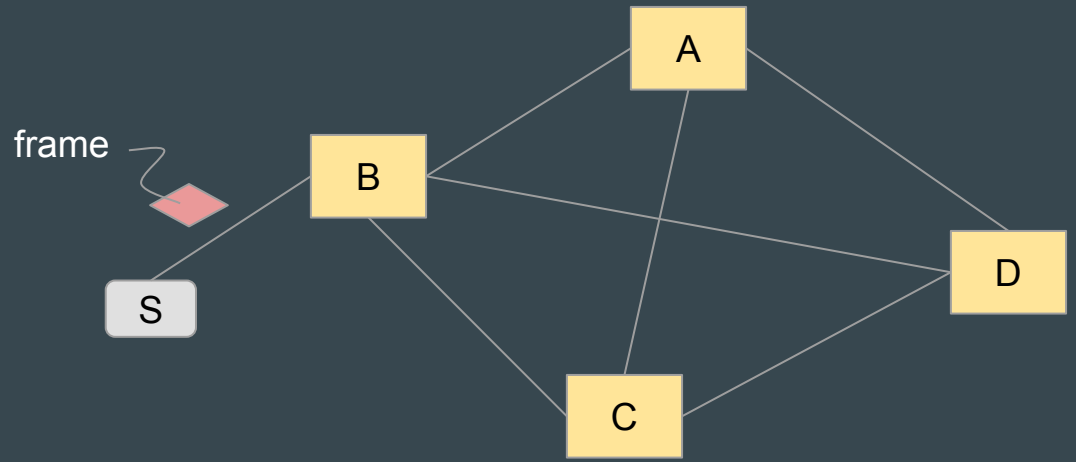
Spanning Tree Protocol (STP) - motivation



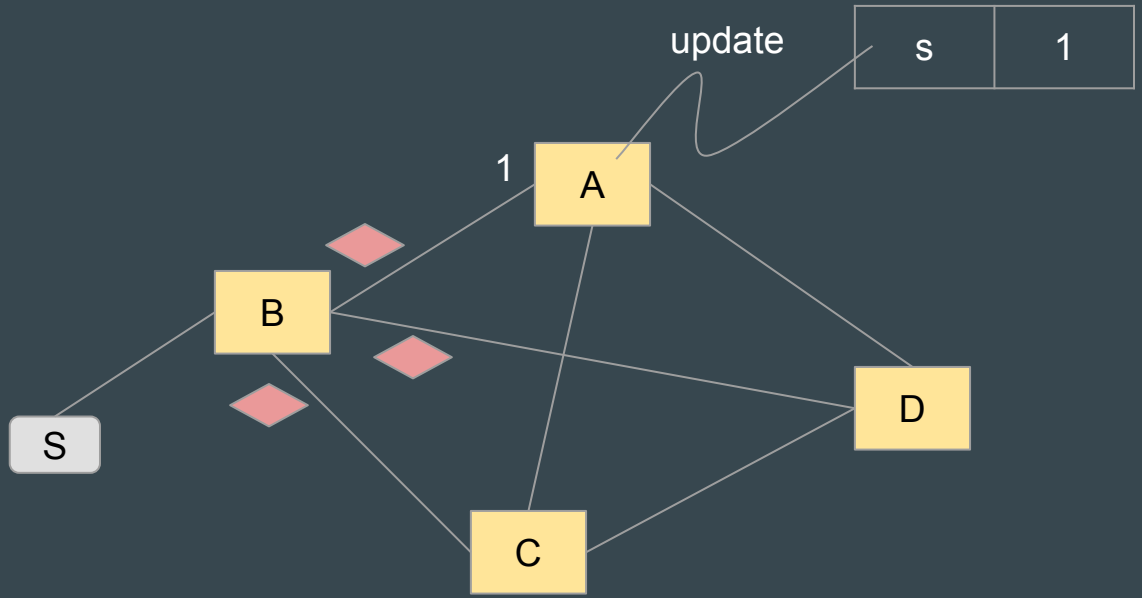
- What could go wrong?

STP - motivation, contd.

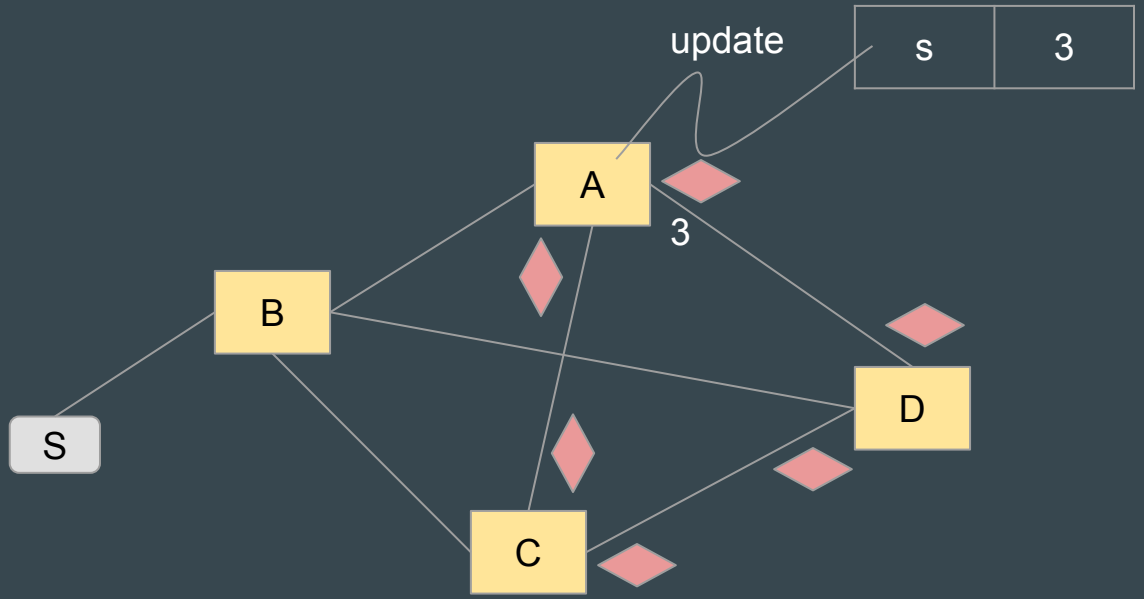
- Assume A, B, C, D just switched on.



STP - motivation, contd.



STP - motivation, contd.



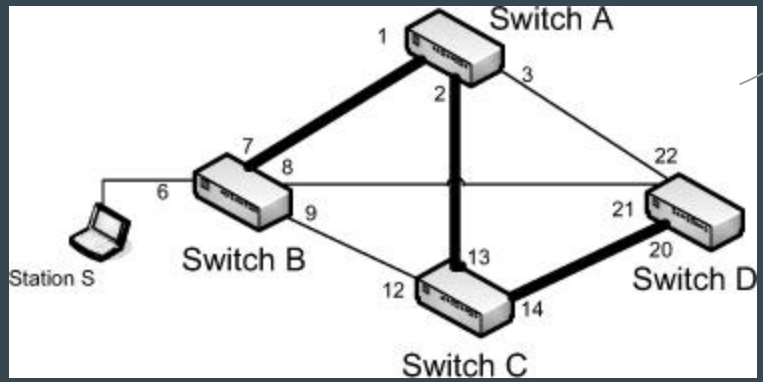
STP - motivation, contd.

So two problems:

- Broadcast storm
- Oscillation of switching tables

A solution

- Switches first agree on a Spanning Tree.
- Spanning Tree Protocol (STP).
- Given an undirected connected graph G, a spanning tree T of G is a connected acyclic subgraph.

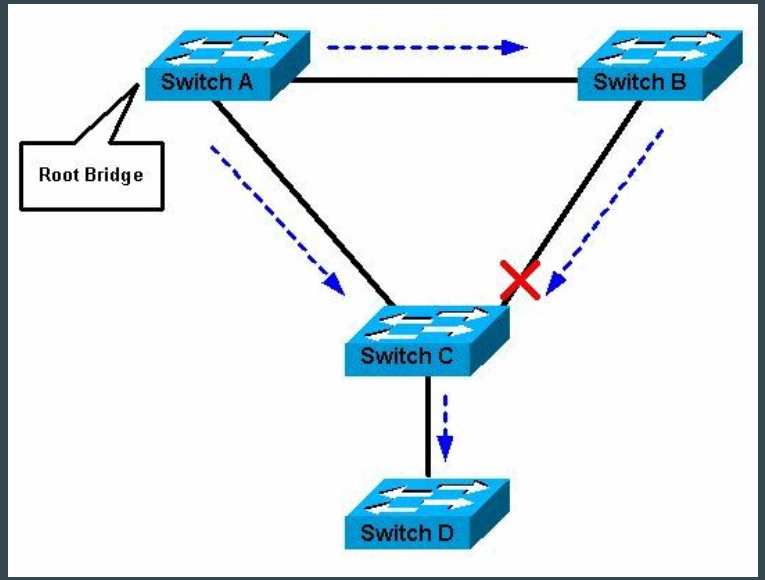


E.g., Switch B will forward packets on ports 6 and 7 only.

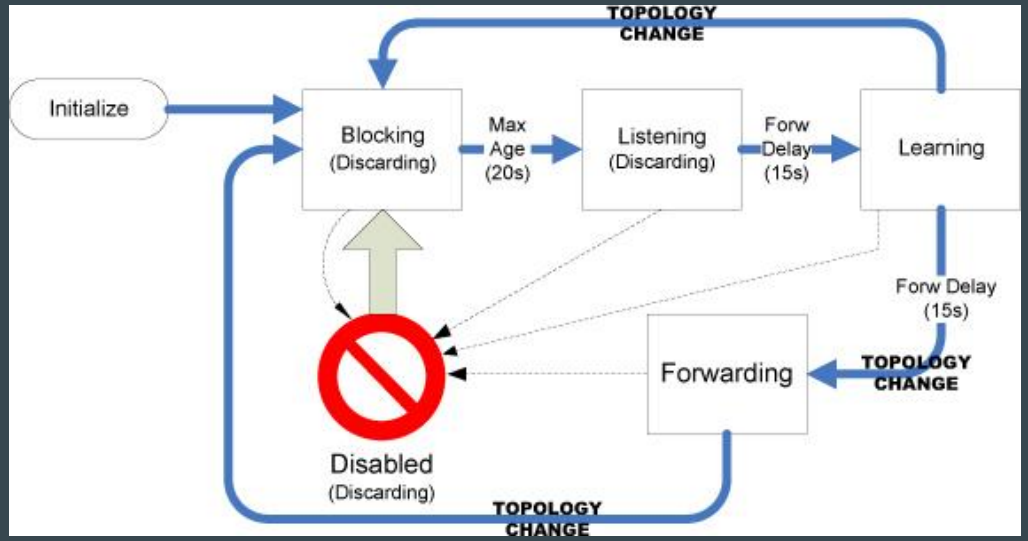
How STP works

- Special frames: Bridge Protocol Data Units (BPDUs).
- A rooted tree is built.

How STP works, contd.



State Machine for each Port



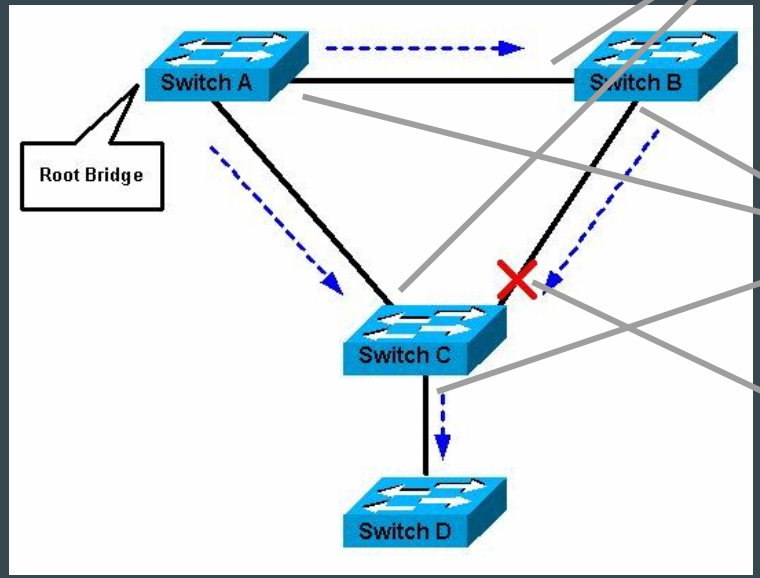
Use of the state machine (1)

- *Blocking* state - not allowed to transmit, only receive BPDUs.
- *Listening* - allowed to receive and transmit BPDUs.
- *Learning* - allowed to Learn switching table.
- *Forwarding* - (finally) allowed to forward data frame.

Defensive mindset. To avoid loops.

Use of state machine (2)

Each port converges to a *role*.

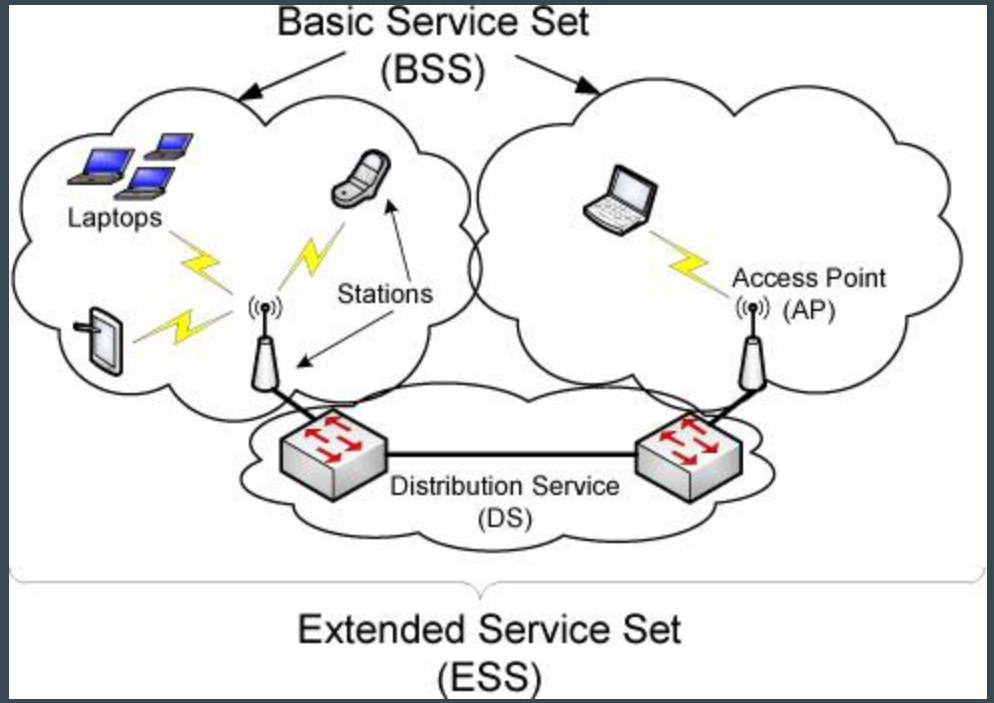


Root Port

Designated Port

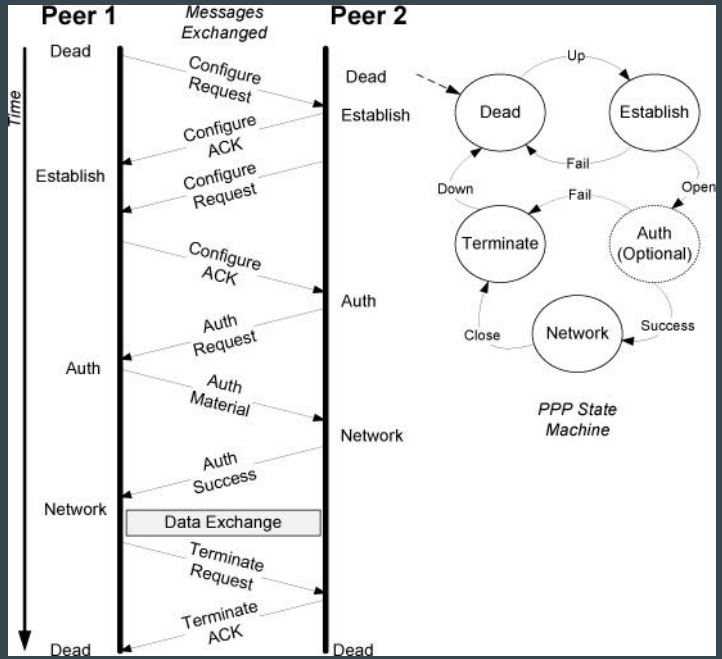
Blocked Port

Wireless LAN - WiFi

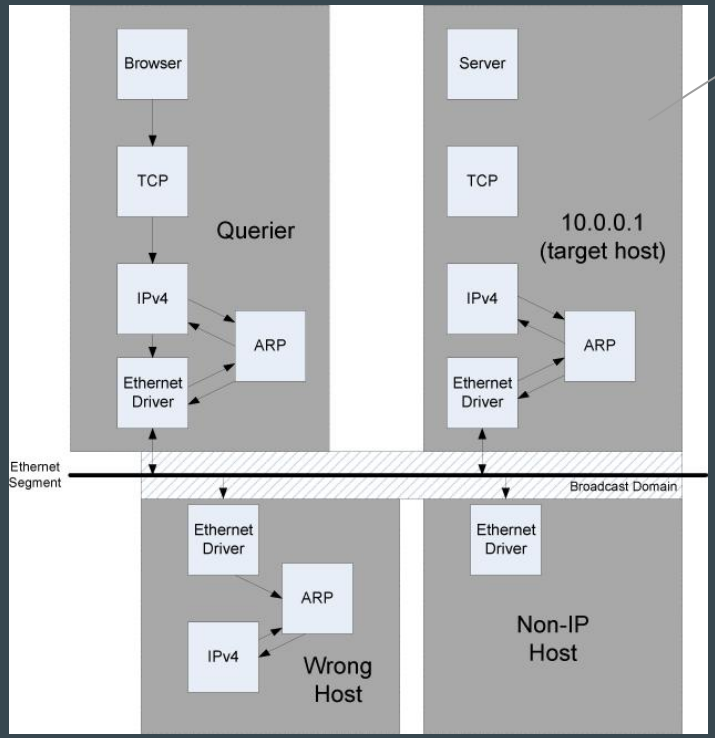


Lower-layer protocols can be complex

E.g., Link Control Protocol for Point-to-Point links

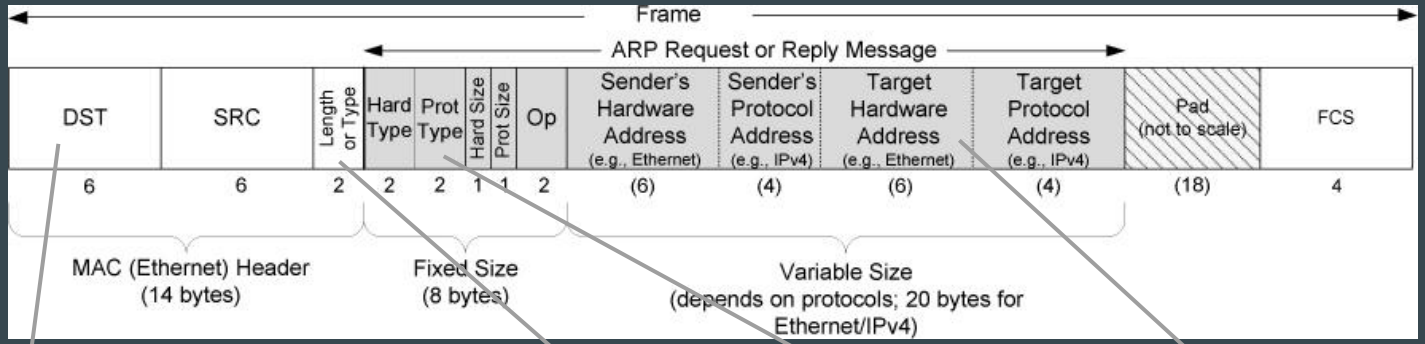


Address Resolution Protocol (ARP) - Chapter 4



May be a router, instead

ARP Frame encapsulated in Ethernet Frame



DST = link-layer broadcast address in a request. Unicast in a response.

ARP = 0x0806

IP = 0x0800

0's in request