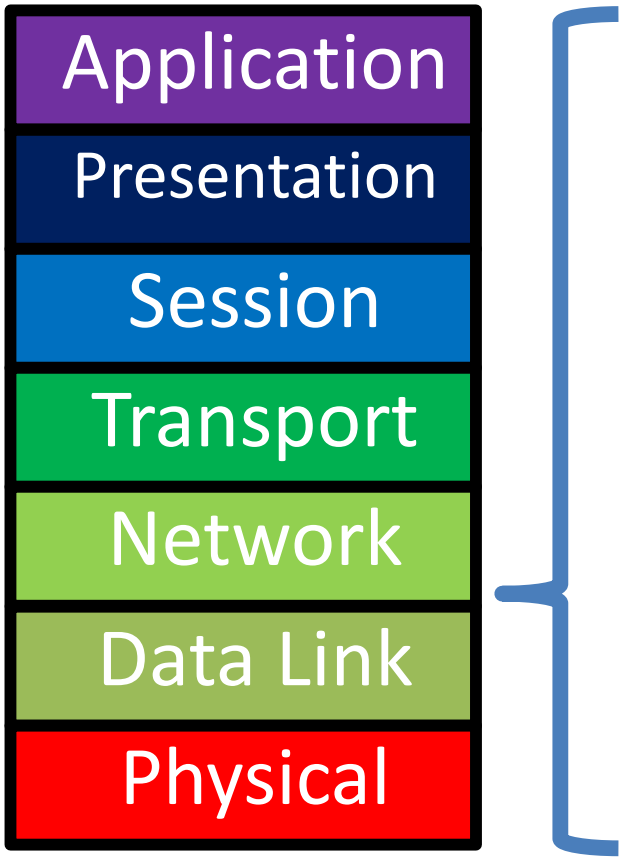
Switching Layer

Just Above the Data Link Layer

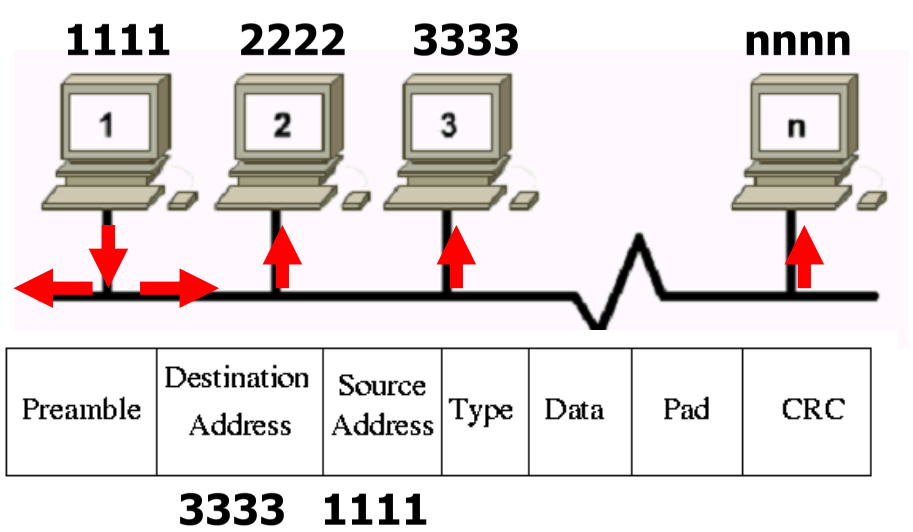


- MAC addressing used in the Data link layer is
- Switching layer?
  - Between the Data link and the Network layer.

Switching occurs within a network

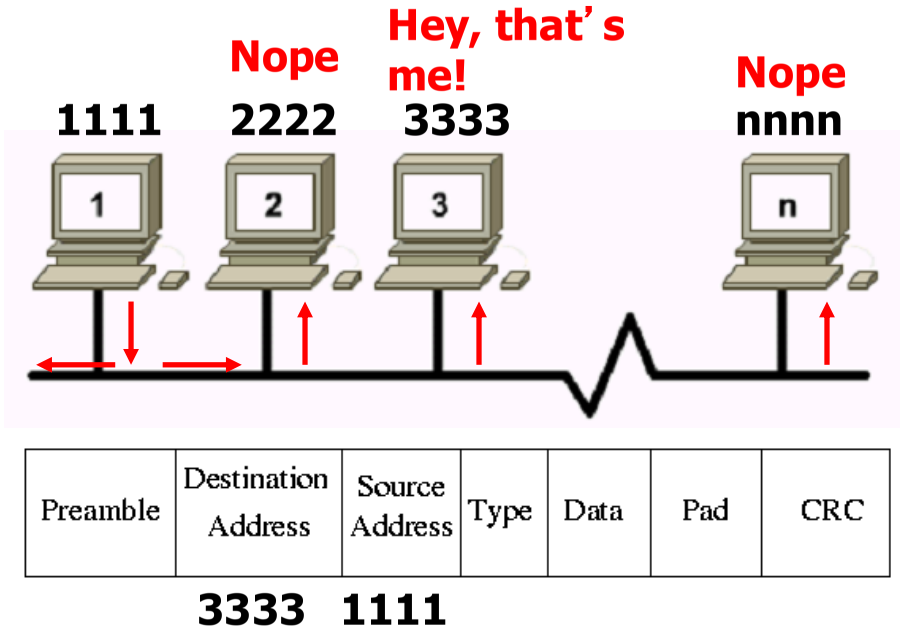
- What does “within a network” mean
  - All nodes in the network share the channel
  - Everyone can hear everyone else
  - Usually there is a router at the end of the domain
- Within the network == Local area network == LAN
- Nodes within the LAN talk using MAC as the address.

LAN Example: Ethernet broadcast



- When an Ethernet frame is sent out on the "bus" all devices on the bus receive it.

Ethernet broadcast: How it happens



- Each NIC card compares its own MAC address with the Destination MAC Address.
- If it matches, it copies in the rest of the frame.
- If it does NOT match, it ignores the rest of the frame.
  - Unless you are running a Sniffer program

Why MAC addresses in LANs?

- Static, does not have to be set up by DHCP etc
- Easy to migrate
- Plug and play
- No need to run routing protocols before hand
- Faster

How is data sent in a LAN

- No routing or routing tables
- Packets are broadcast to the network to the correct destination MAC address
- But how do I know the MAC address?
  - Use ARP

Address Resolution Protocol

- Maps IP addresses to MAC addresses
  - All layer 2 addressing is on MAC address
- ARP Request, ARP response, and gratuitous ARP (to update ARP table on hardware changes)

ARP packets

- ARP request: Does anyone know the MAC address from this IP address
  - No IP Header
  - Not part of the Ethernet either
  - Layer 2.5

```
Frame 299 (42 bytes on wire, 42 bytes captured)
Ethernet II, Src: Ibm_43:49:97 (00:11:25:43:49:97), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
Address Resolution Protocol (request)
    Hardware type: Ethernet (0x0001)
    Protocol type: IP (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: request (0x0001)
    [Is gratuitous: False]
    Sender MAC address: Ibm_43:49:97 (00:11:25:43:49:97)
    Sender IP address: 192.168.1.1 (192.168.1.1)
    Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
    Target IP address: 192.168.1.254 (192.168.1.254)
```

ARP response

- ARP response: Yes, this is my IP address and here is my MAC address
- Response is not broadcast, but unicast

```
⊞ Frame 300 (60 bytes on wire, 60 bytes captured)
⊞ Ethernet II, Src: Cisco_35:1a:d0 (00:19:55:35:1a:d0), Dst: Ibm_43:49:97 (00:11:25:43:49:97)
⊟ Address Resolution Protocol (reply)
    Hardware type: Ethernet (0x0001)
    Protocol type: IP (0x0800)
    Hardware size: 6
    Protocol size: 4
    Opcode: reply (0x0002)
    [Is gratuitous: False]
    Sender MAC address: Cisco_35:1a:d0 (00:19:55:35:1a:d0)
    Sender IP address: 192.168.1.254 (192.168.1.254)
    Target MAC address: Ibm_43:49:97 (00:11:25:43:49:97)
    Target IP address: 192.168.1.1 (192.168.1.1)
```

Populating the ARP table

```
C:\>arp -a

Interface: 129.21.152.158 --- 0x10005
  Internet Address      Physical Address      Type
  11.11.11.11           23-34-45-56-67-78     static
  129.21.152.172        00-11-d8-d6-06-91     dynamic
  129.21.152.254        00-00-0c-07-ac-01     dynamic
```

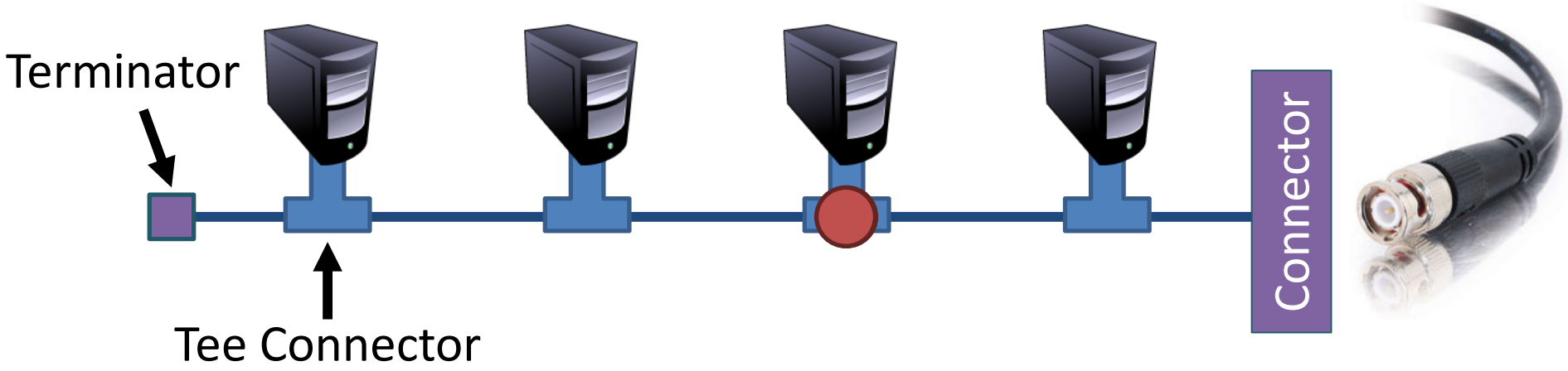
How to extend your LAN?

- A LAN has a constraint that all nodes need to hear all other nodes
- LANs are extended using switches, bridges, hubs, and repeaters.

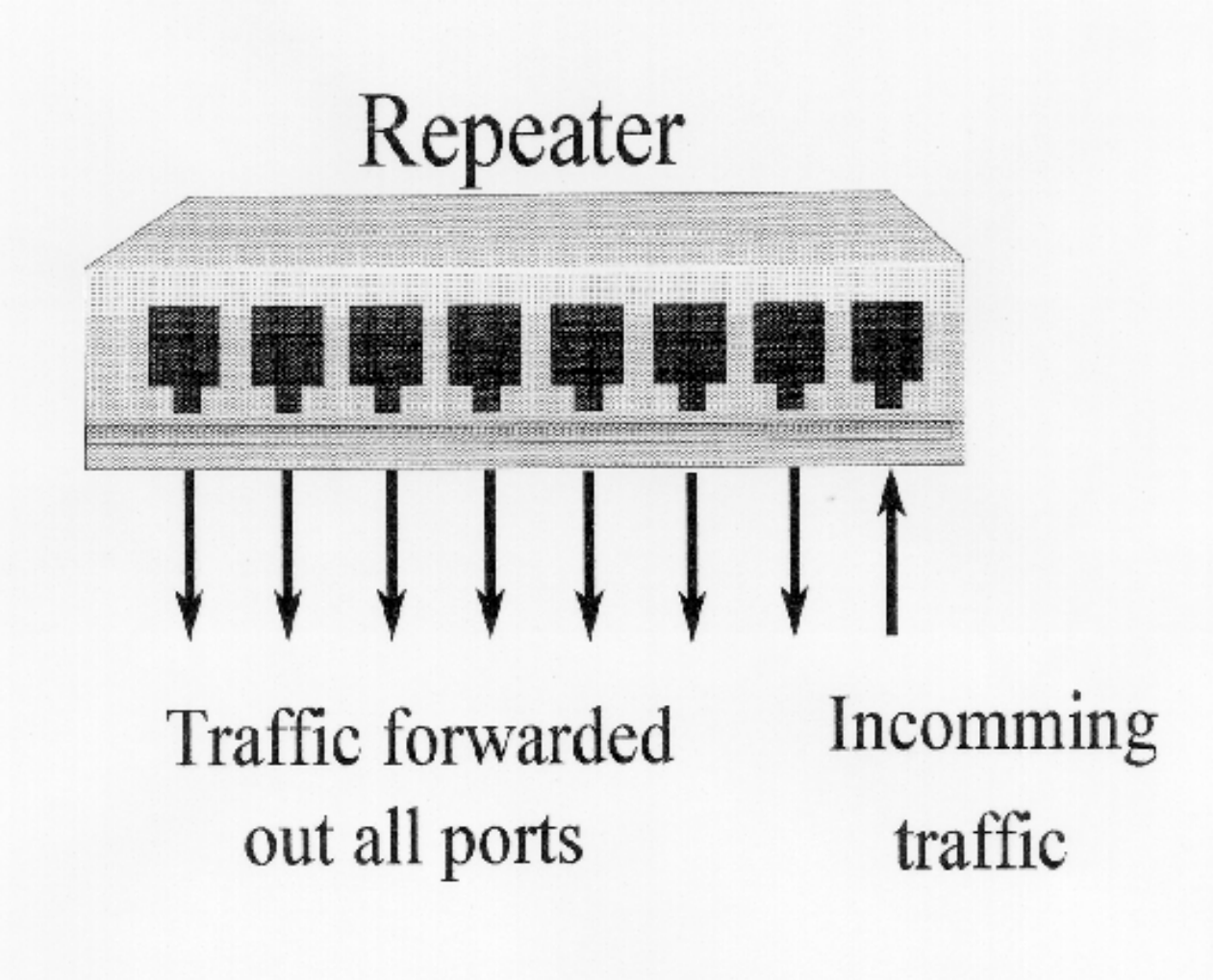
Switches, Bridges, Hubs, Repeaters

- All hardware
- Ethernet networks used to be built using **repeaters**.
- Repeaters performed poorly as too many devices shared the same segment, so network engineers added bridges
- As networks grew in size and complexity, the **bridge evolved into the modern switch**, allowing segmentation of the network.
- Today's networks typically are built using **switches and routers**, often with the routing and switching function in the same device.

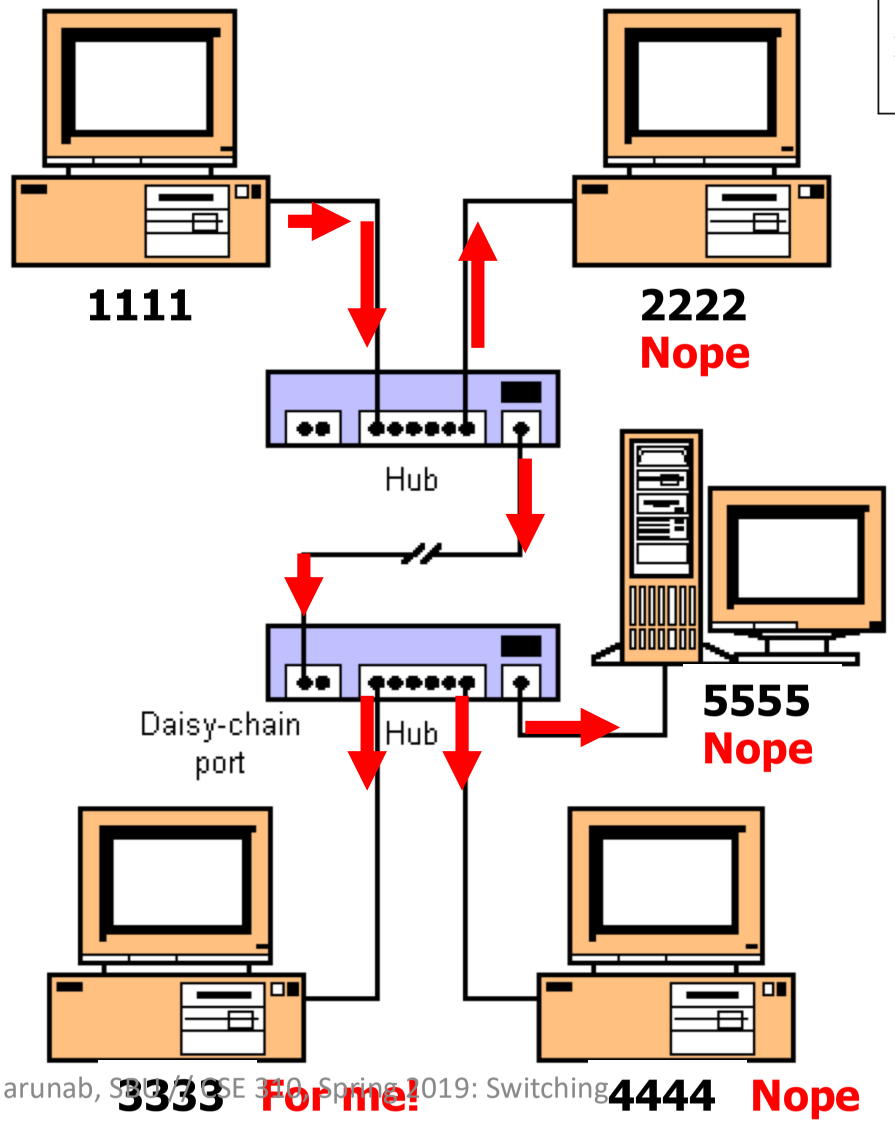
Connectors



- A Hub is a repeater with a single input and multiple output



Ethernet frames via a hub



Preamble	Destination Address	Source Address	Type	Data	Pad	CRC

3333 **1111**

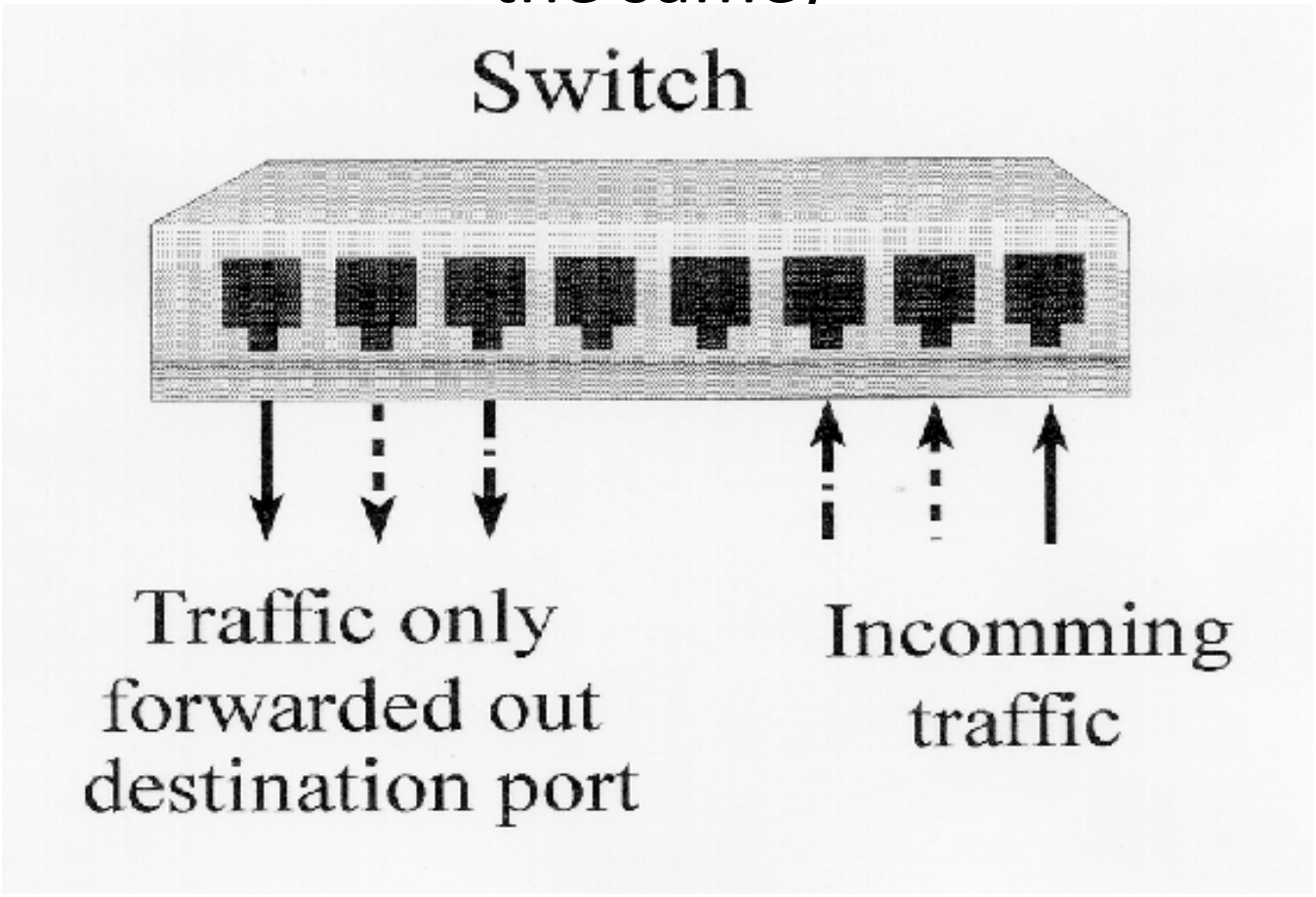
- The hub **floods** on all ports except the incoming port.
- Hub is a layer 1 device, does NOT look at layer 2 addresses.

- Disadvantage: It is a single **collision domain**.
- Also wastes bandwidth

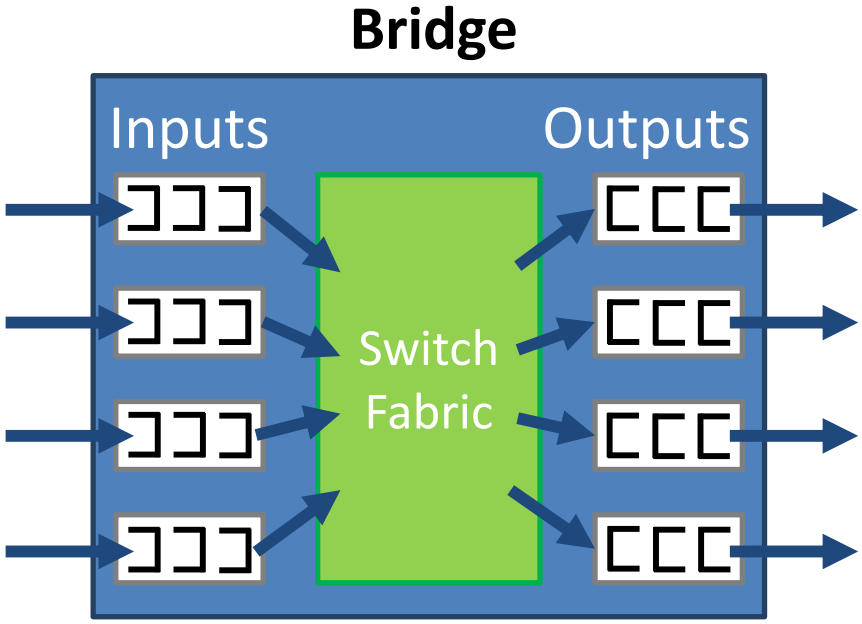
Hubs

- Advantages
  - Simple and Cheap
  - Fast
- Disadvantages
  - Single collision domain
  - Waster bandwidth

Switches and Bridges (for our purposes they are the same)



Bridge Internals

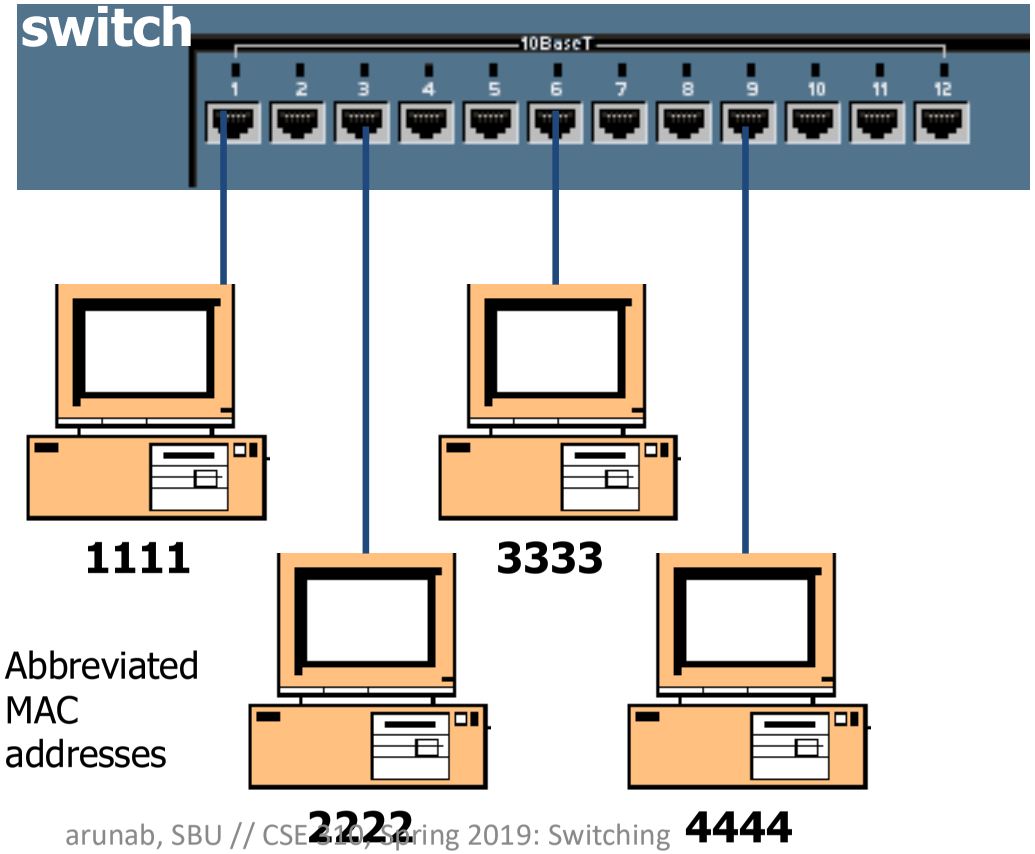


- Smarter than a hub
- Either knows which port to send, or floods

Switches

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC

3333 **1111**



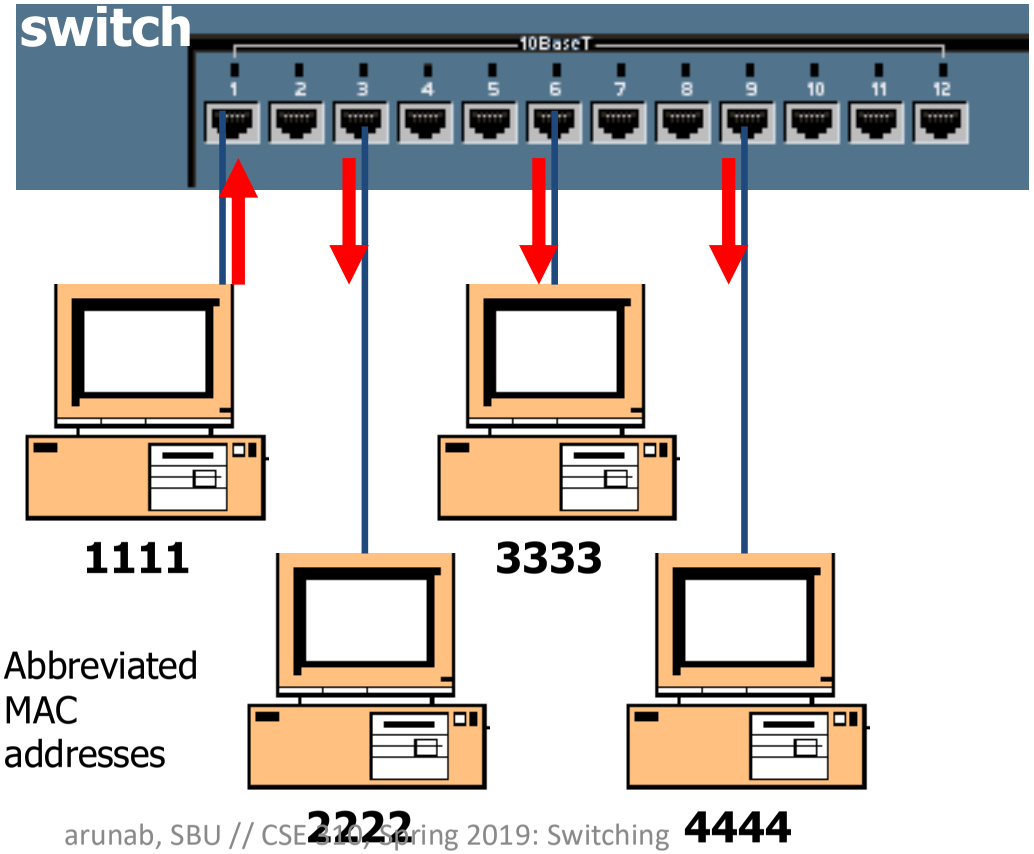
- A switch has a source address table to cache learnt MAC address
- If it finds a match in the table, it sends the frame in the port.
- If not, it **floods the frame** out all ports.

Learning bridges

Source Address Table

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

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	3333	1111				



- Add both the source and the destination port info

Learning bridges

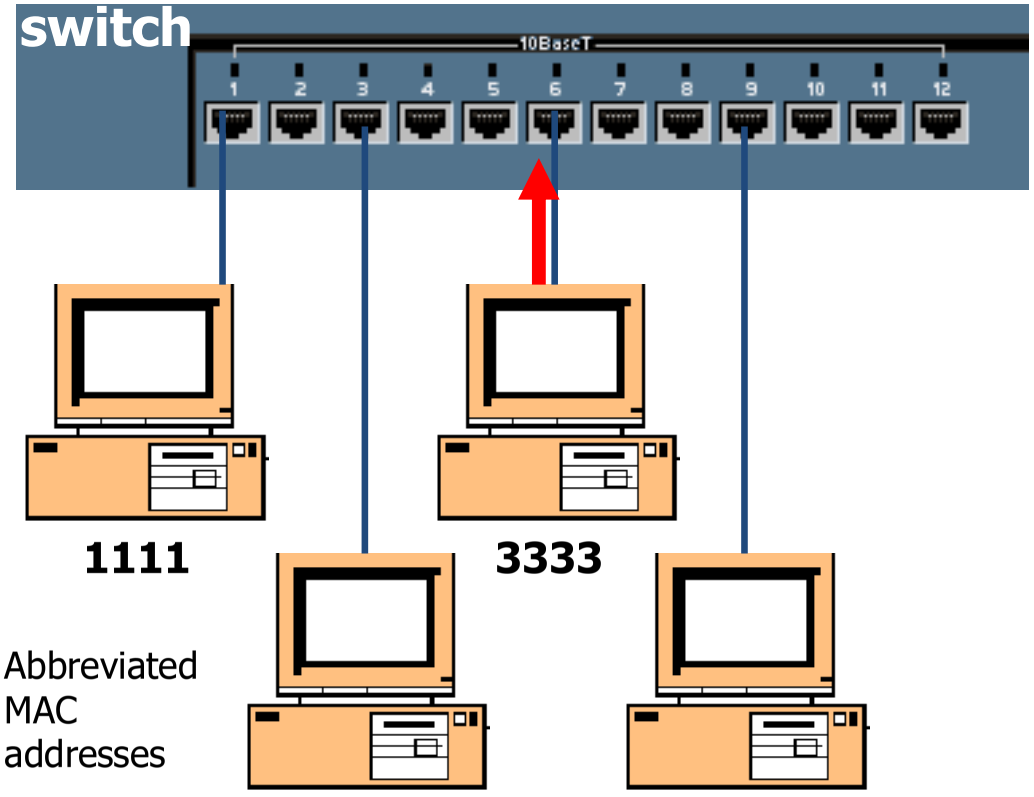
Source Address Table

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

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC

1111 3333

- Add both the source and the destination port info

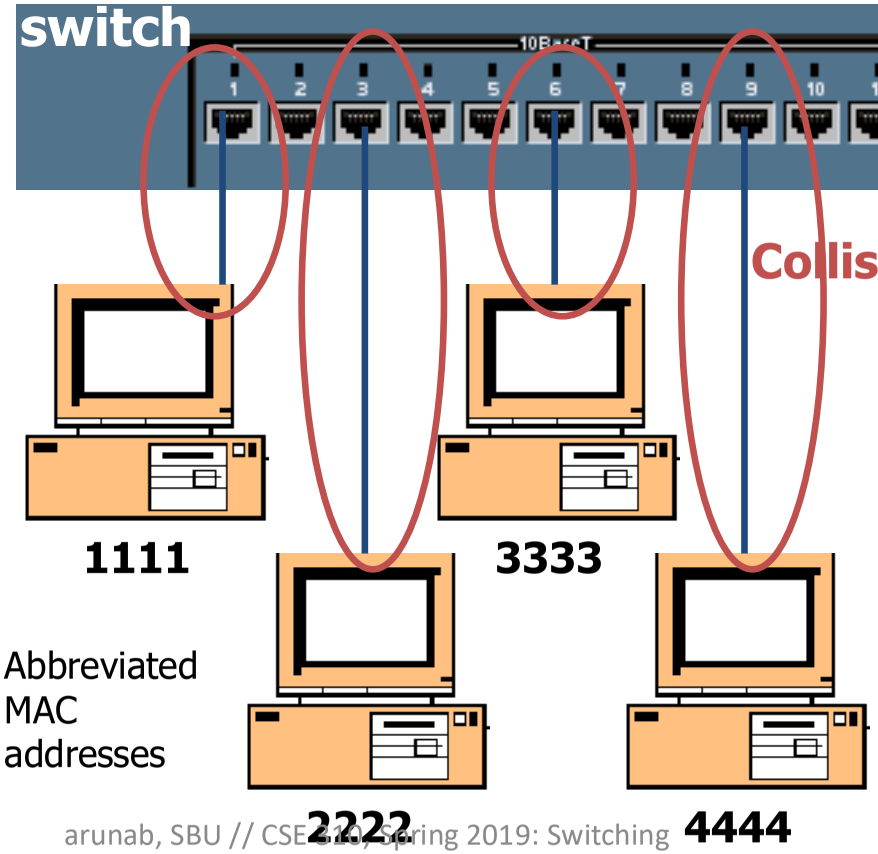


Collision Domains

Source Address Table

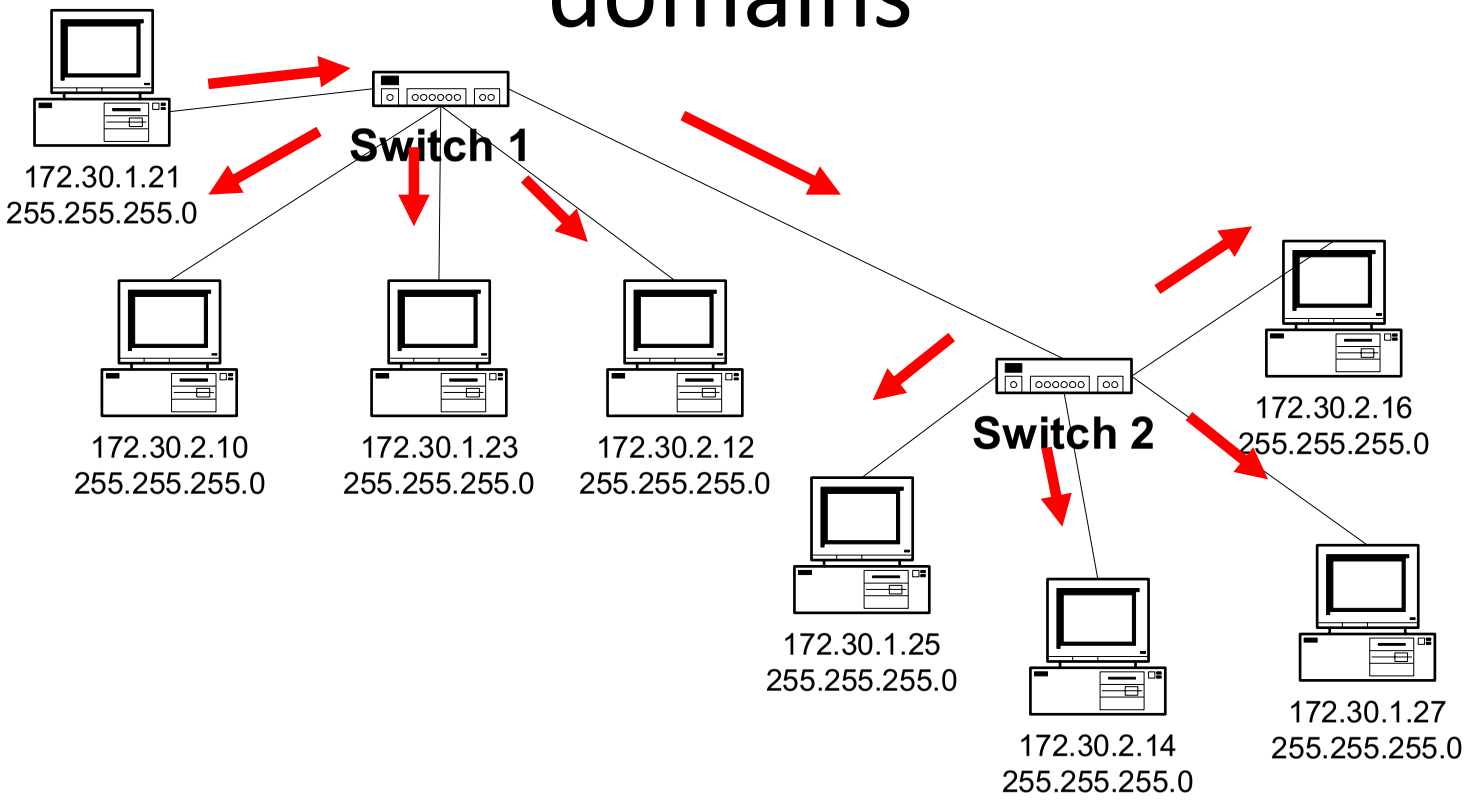
Port	Source MAC Add.	Port	Source MAC Add.
1	1111	6	3333

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	1111	3333				



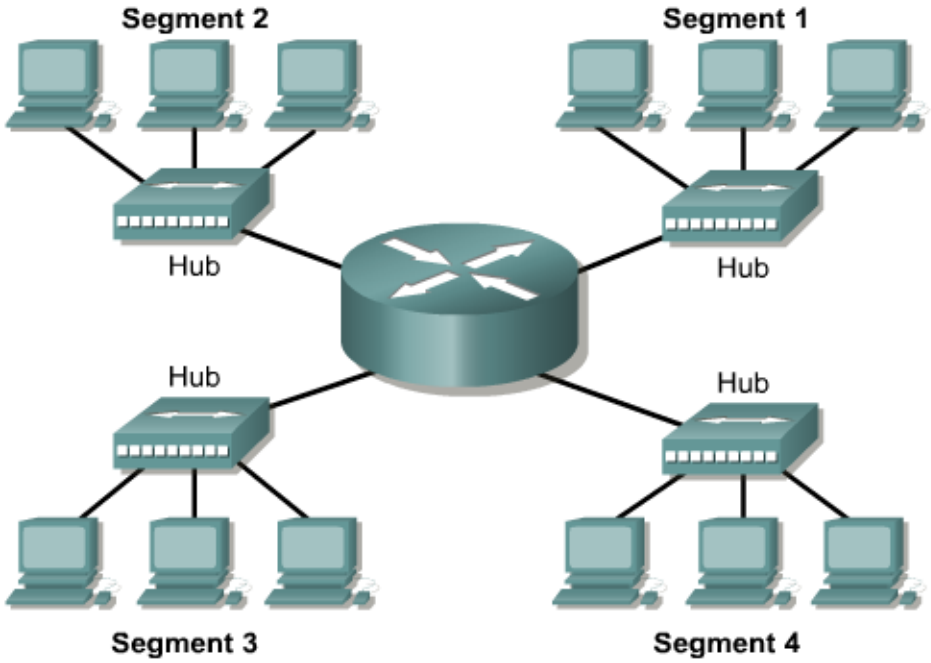
- What is the collision domain?
- When there is only one device on a switch port, the collision domain is only between the PC and the switch.

But, switch do not isolate broadcast domains

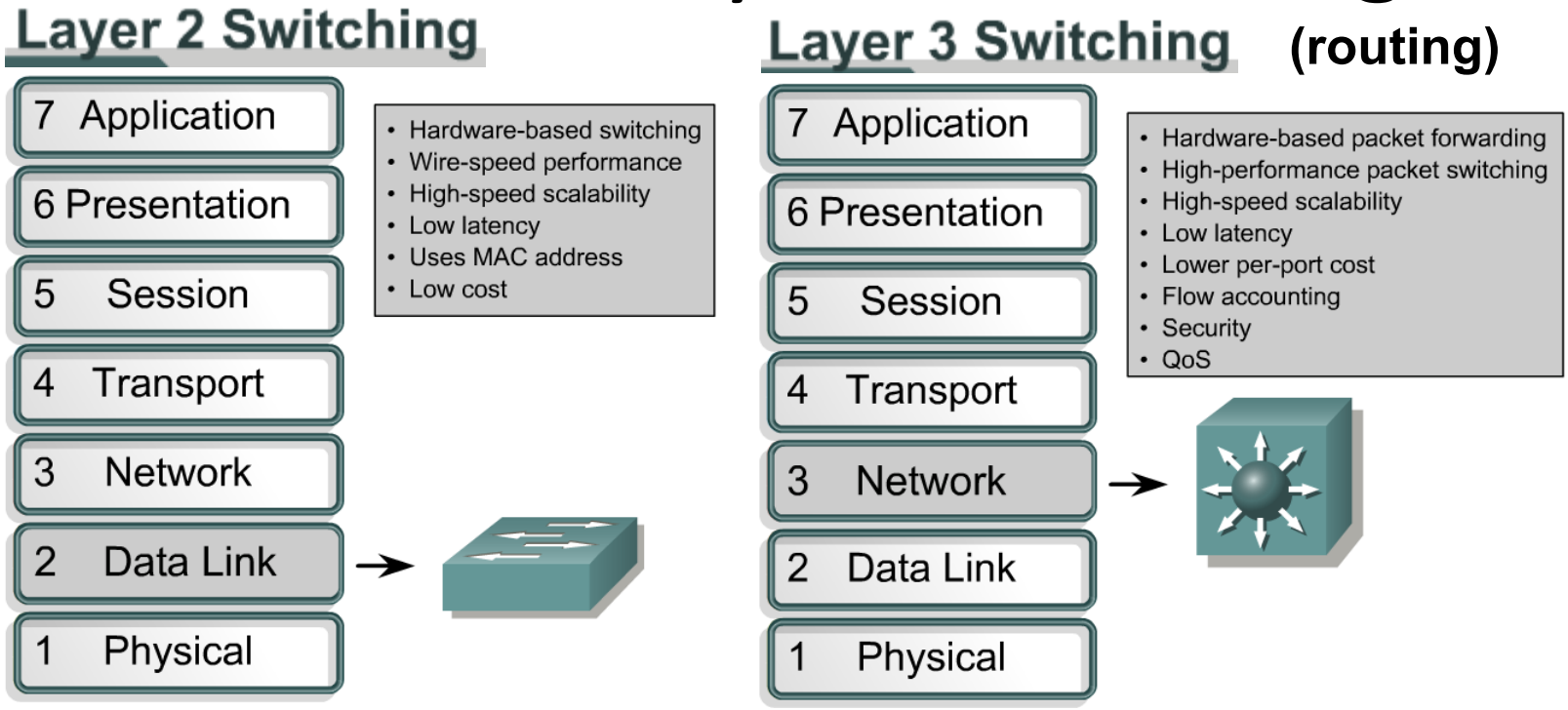


- Hosts connected to the switch are in the same broadcast domain.
- A broadcast from one node will still be seen by all the other nodes connected through the LAN switch.

Layer 3 routers isolate broadcast domains



Layer 2 and layer 3 switching



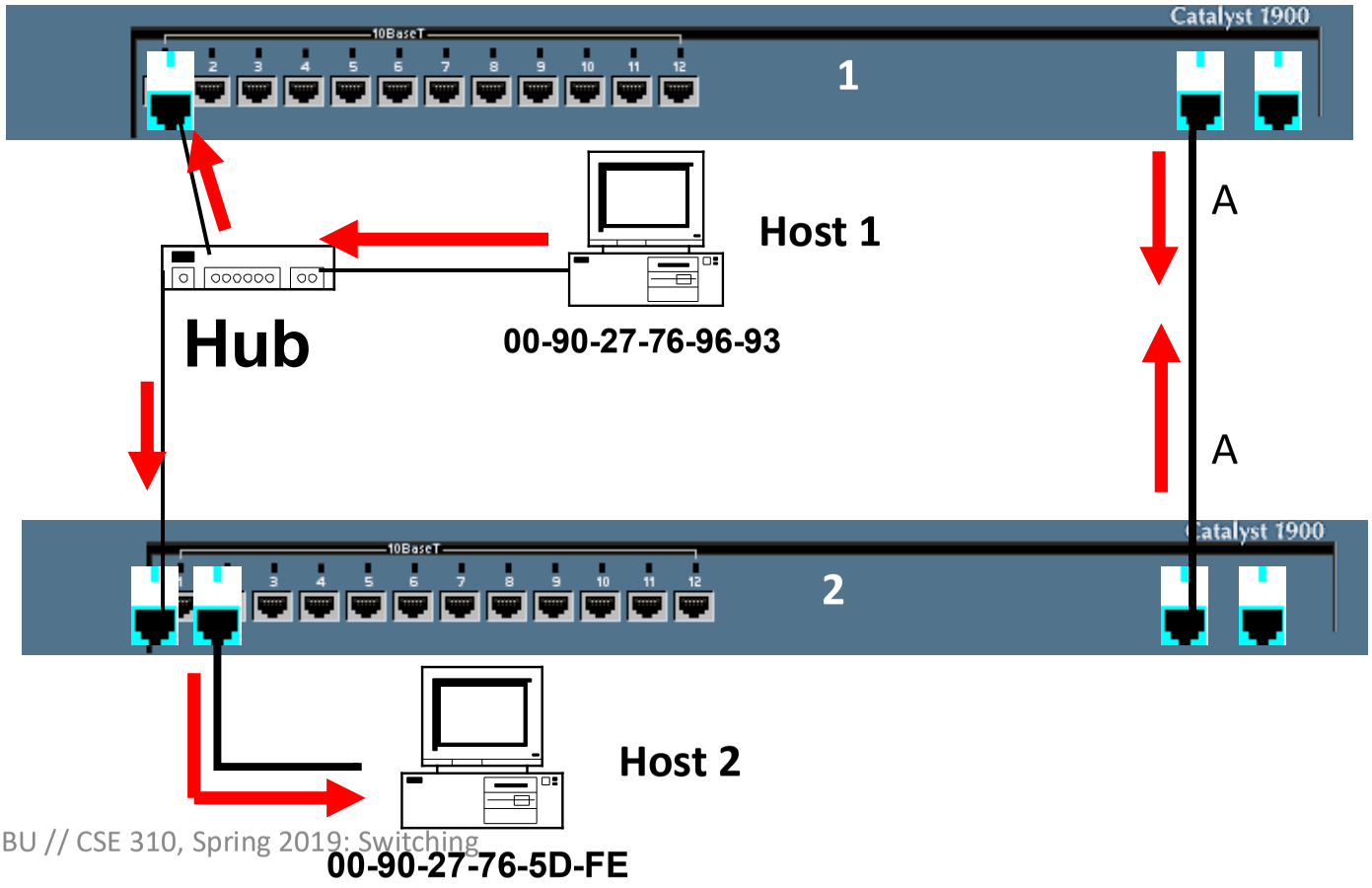
- A layer 3 switch is a layer 2 switch that includes a routing process, i.e. does routing.

Spanning Tree Protocol

Problem: Loops.

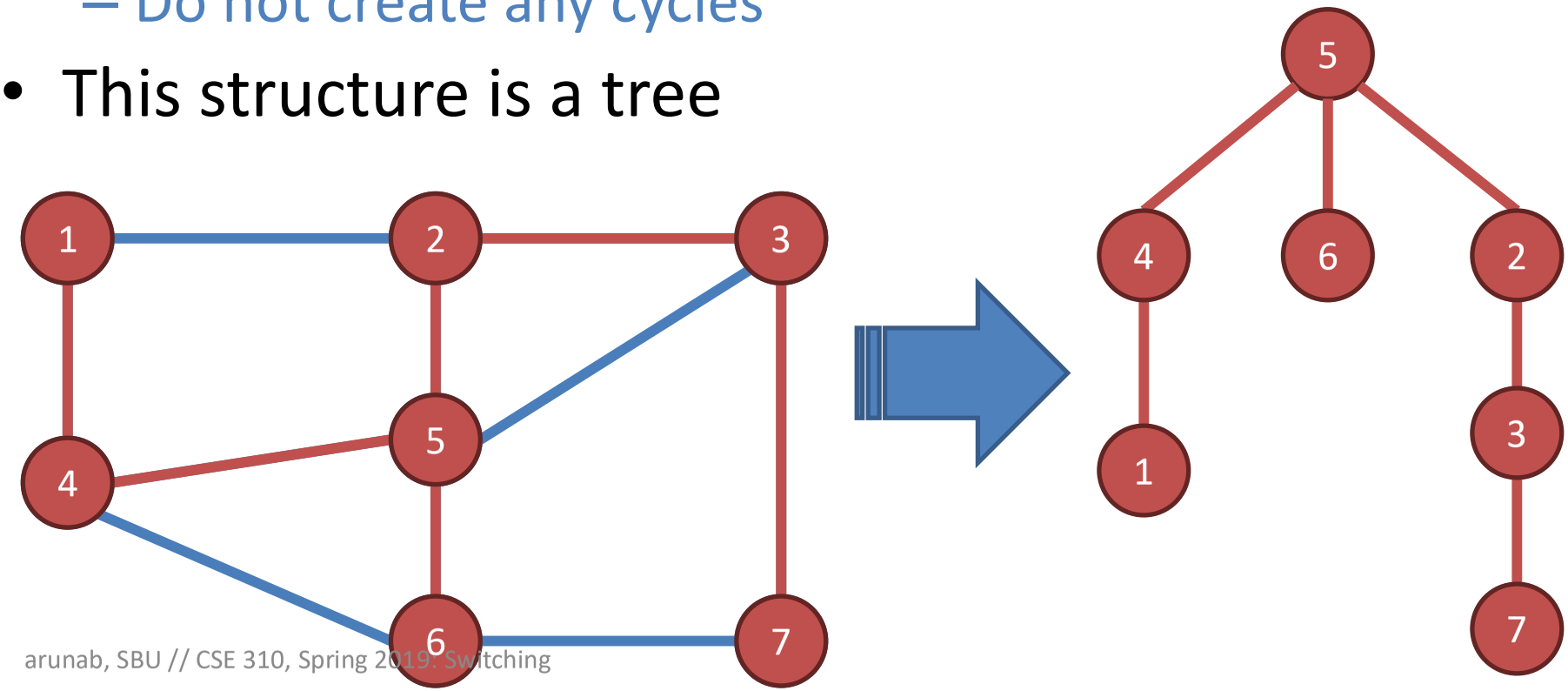
Host 1 sends out a layer 2 broadcast frame, like an ARP Request causing broadcast storms

Solution: Spanning Tree Protocol



Spanning Tree Definition

- A subset of edges in a graph that:
  - Span all nodes
  - Do not create any cycles
- This structure is a tree



Algorhyme by Radia Perlman

I think I shall never see
A graph more lovely than a tree.

A tree whose crucial property
Is loop-free connectivity

A tree that must be sure to span
So packets can reach every LAN.

First the root must be elected.
By ID is is elected.

Least-cost paths from root are
traced.
In the tree, these paths are placed.

A mesh is made by folks like me,
Then bridges find a spanning tree.