

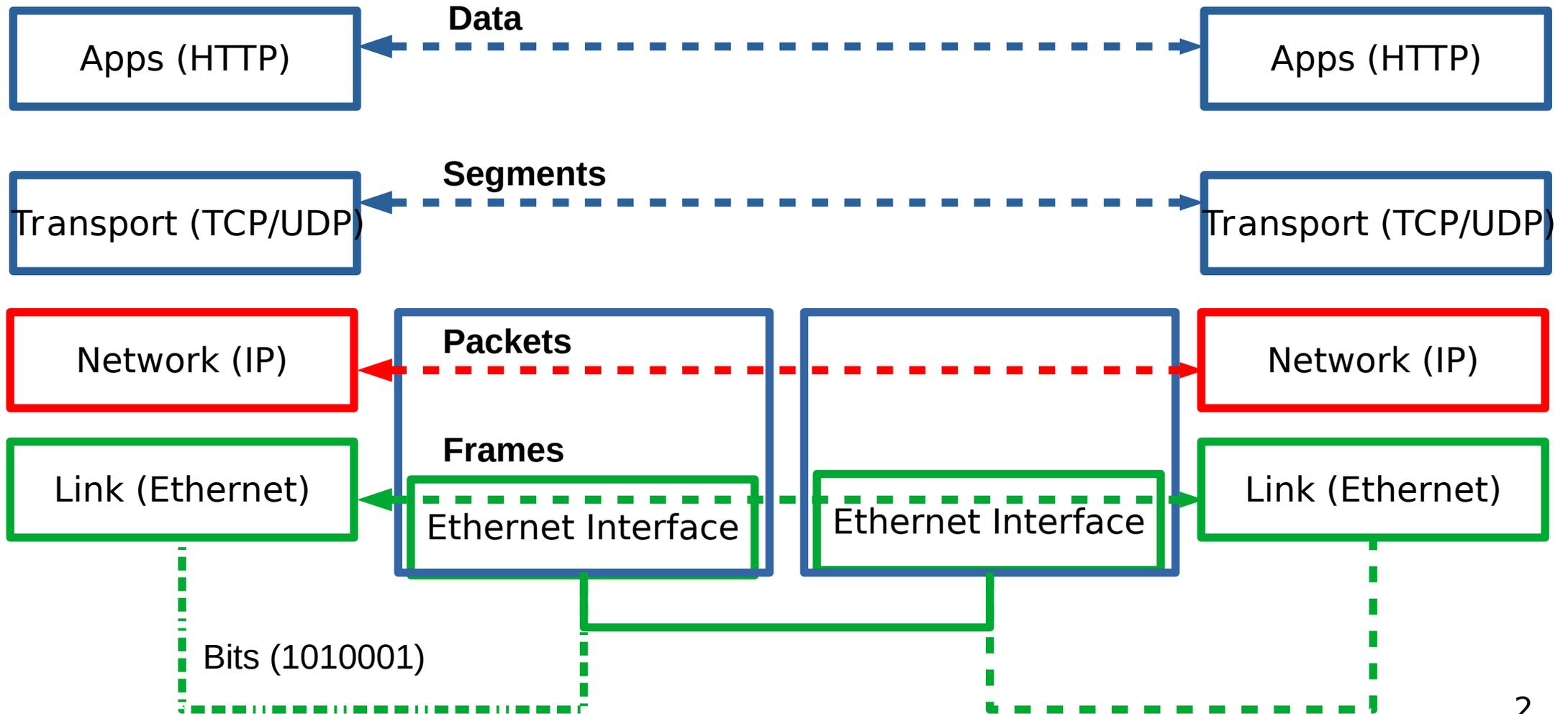
CSC4200/5200 – COMPUTER NETWORKING

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INTERNETWORKING

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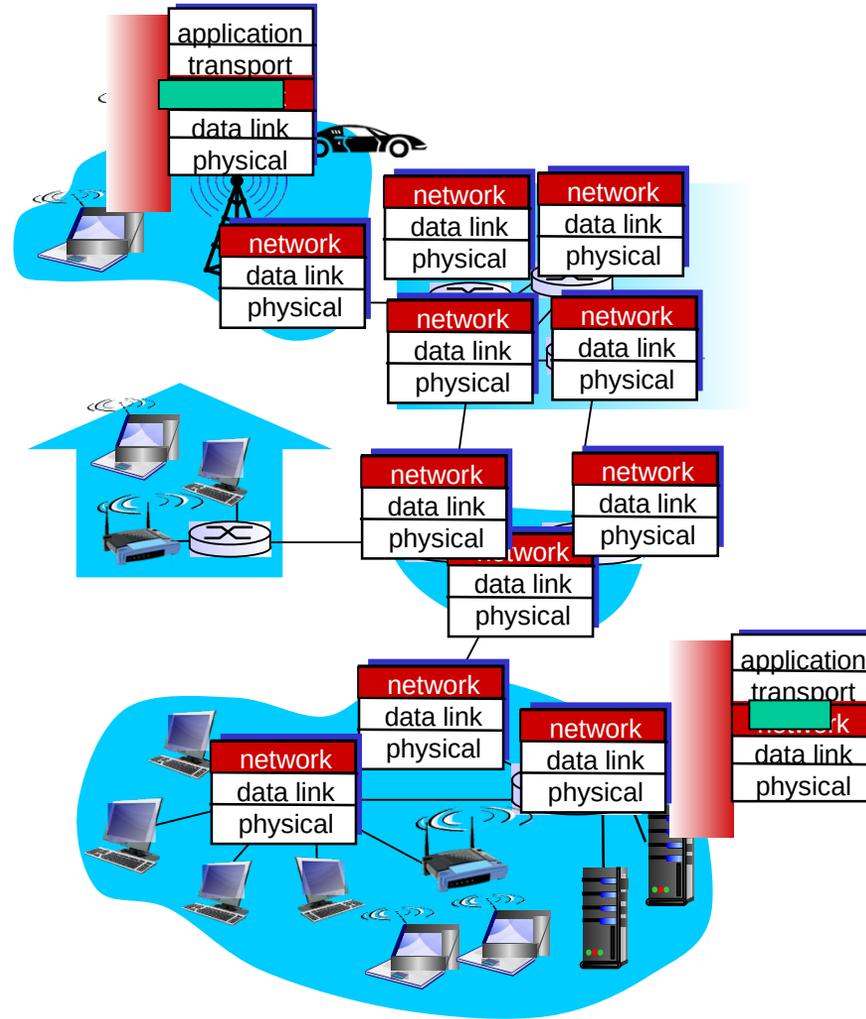




So far...

- we saw how to build a local network
- How do we interconnect different types of networks to build a large global network?

Why another layer?



Switching

- Switch

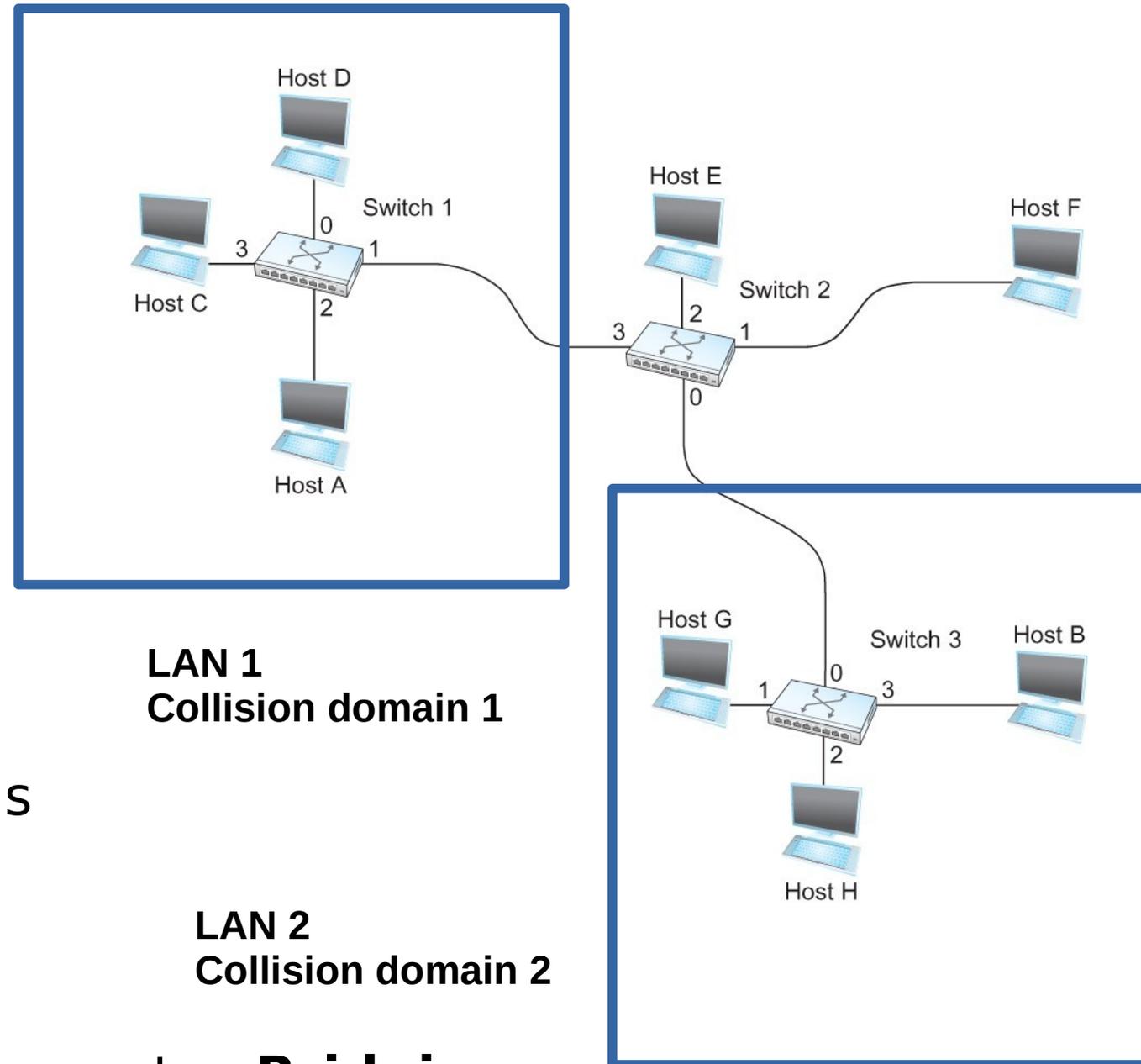
- A mechanism to interconnect links to form a large network

- Forward **frames**

- Separate the collision domains

- Filter packets between LANs

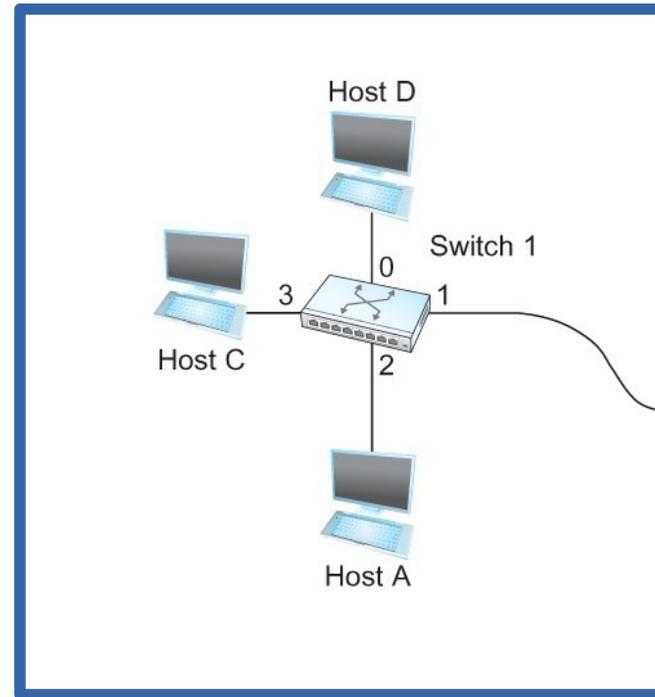
- Connects two or more LAN segments - **Bridging**



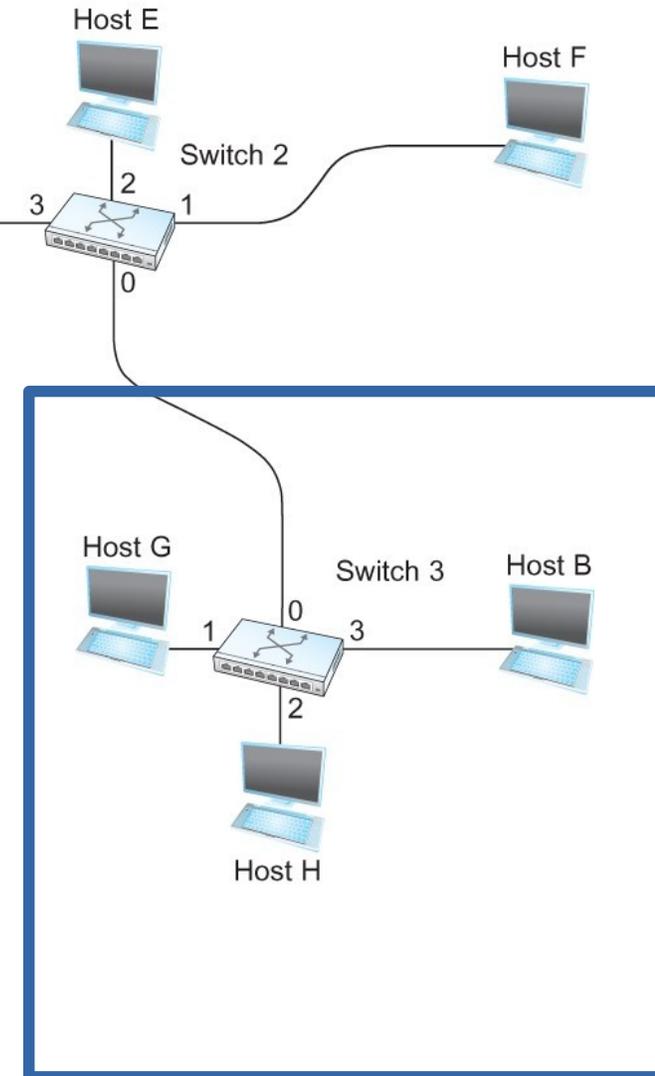
Switches are Self learning!



- No configuration needed
- Send frames to needed segment
- **How do they construct such a table?**



LAN 1
Collision domain 1



LAN 2
Collision domain 2

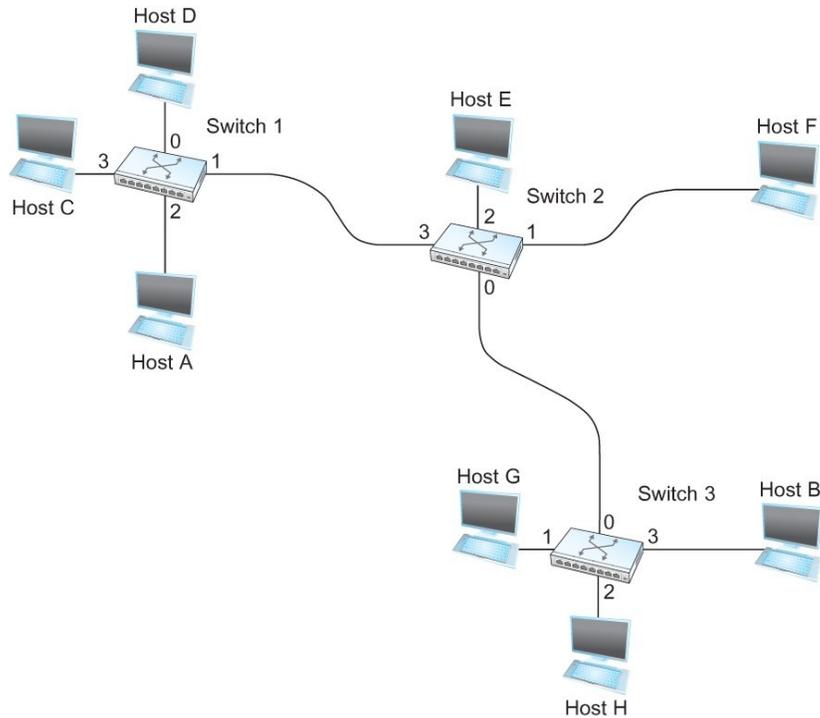
Switches are self learning!

- Inspect the source MAC address
 - **What is a mac address?**
- Associate mac address and incoming interface
- Store this association for later use, (for some time)
 - aging-timer

Switching Table



To decide how to forward a packet, a switch consults a *forwarding table*



Destination, Port	

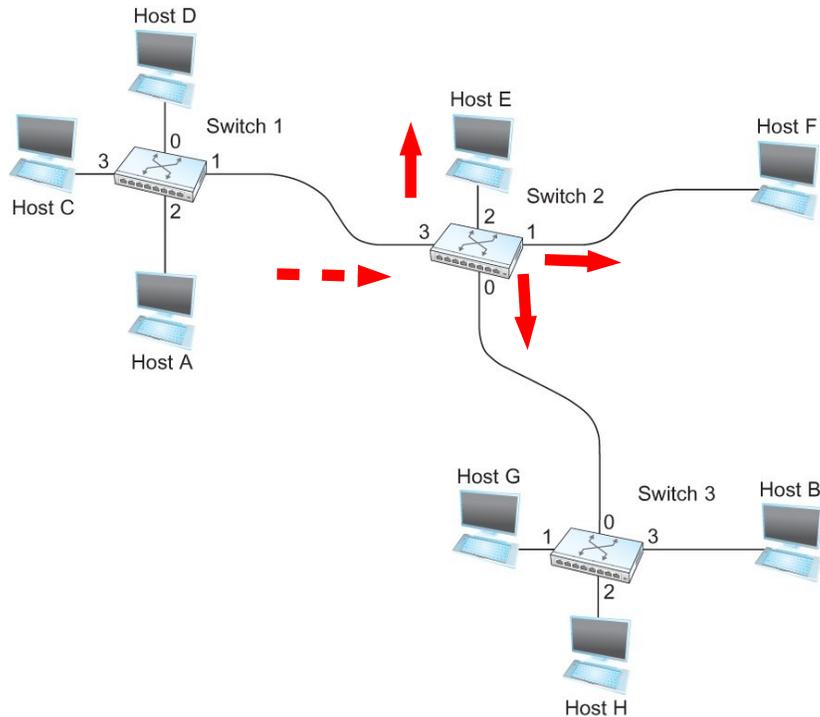
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A	3
B	0
C	3
D	3
E	2
F	1
G	0
H	0

Forwarding Table for Switch 2

Switching Table

Unknown destination → send out on all Interfaces (**flooding**)

• **Skip the incoming interface**



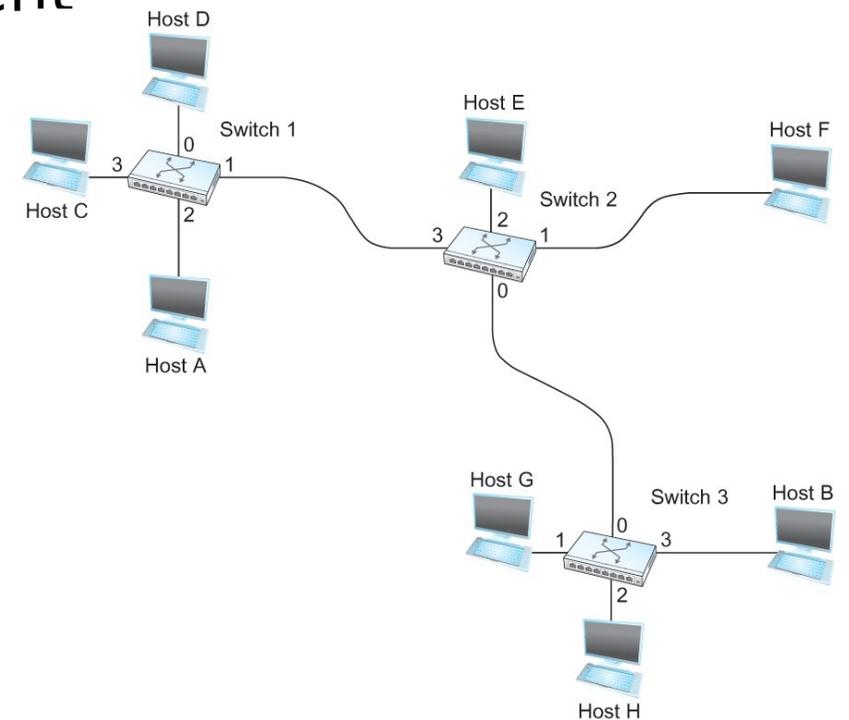
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Forwarding Table for Switch 2

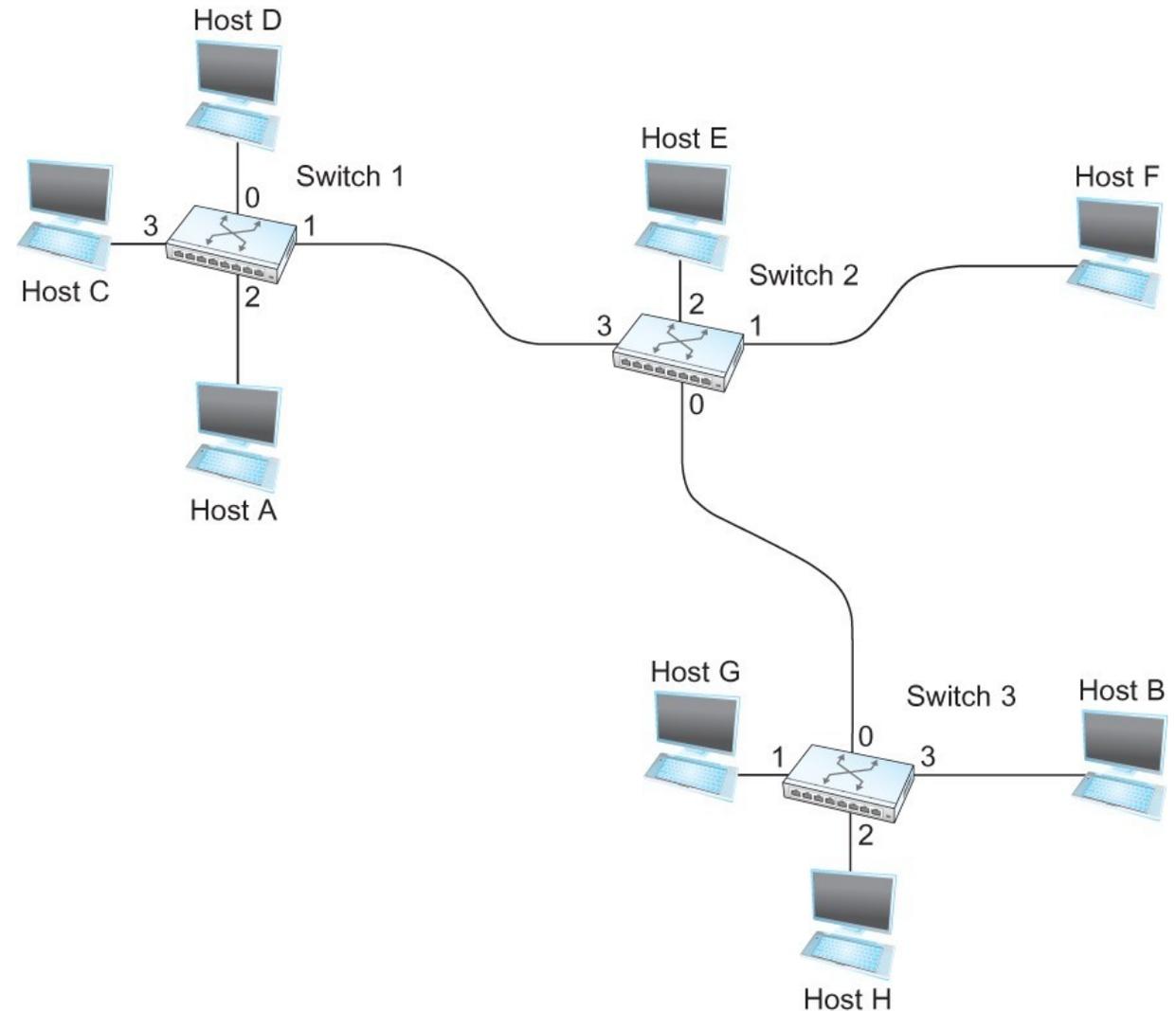
Switching Table Algorithm

- Create the table first!
 - **For each packet**
 - If destination address in arriving segment
 - Drop
 - If destination is in another segment
 - Forward
 - If destination unknown
 - Flood!

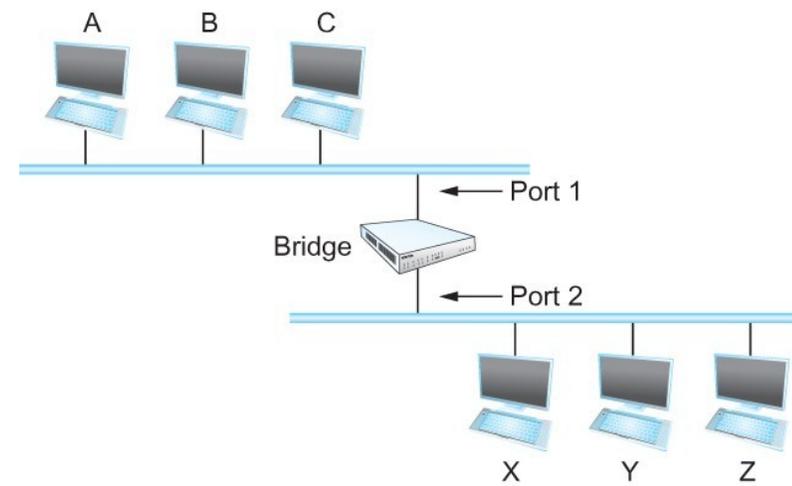


Switching Table Algorithm

- **Send frame from C to F**
- Switch 1 →
 - Notes C is on Interface 3
 - Floods
- Switch 2 →
 - Notes C is on Interface 3
 - Floods
- Host F replies
 - Switch 2 notes F is on Interface 1
 - Sends back over Interface 3
- Switch 1 notes F is on Interface 1
 - Sends back over Interface 3
 - Host c receives frame



Bridges



▢ Bridges and LAN Switches

- Class of switches that is used to forward packets between shared-media LANs such as Ethernets

- Known as LAN switches
- Referred to as Bridges

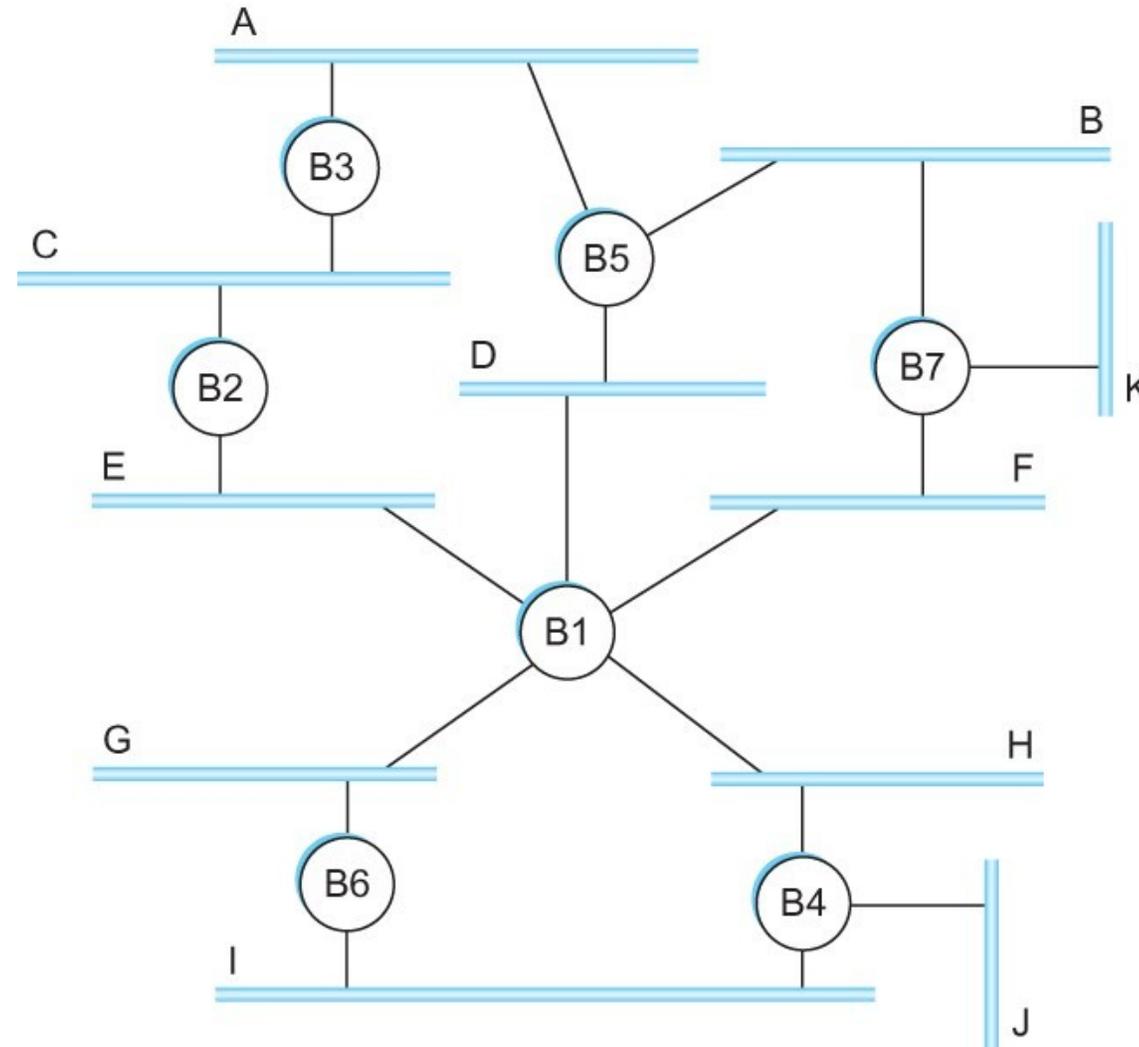
▢ Suppose you have a pair of Ethernets that you want to interconnect

- One approach is put a repeater in between them, physical limitations

▢ An alternative would be to put a node between the two Ethernets and have the node forward frames from one Ethernet to the other

- This node is called a **Bridge**
- A collection of LANs connected by one or more bridges is usually said to form an **Extended LAN**

Flooding over bridges causes forwarding loops

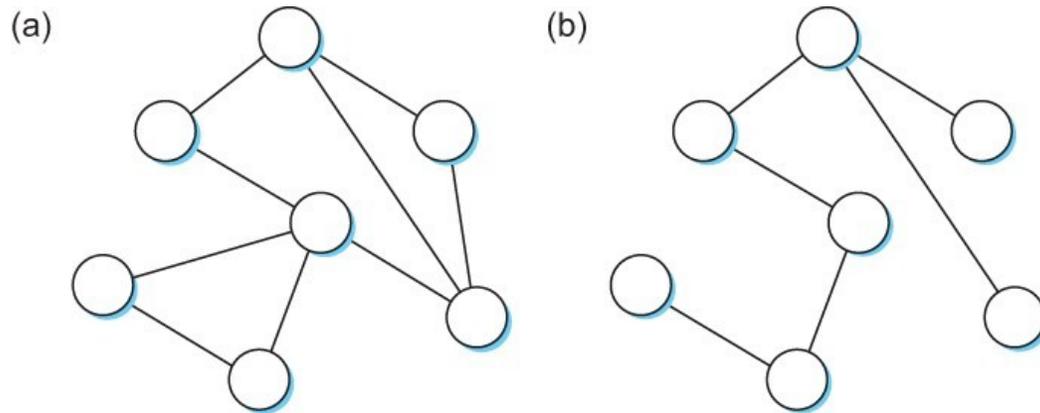


Spot the loop
Why?

Solution? Spanning Tree

Think of the extended LAN as being represented by a graph that possibly has loops (cycles)

- A spanning tree is a sub-graph of this graph that covers all the vertices but contains no cycles
- Spanning tree keeps all the vertices of the original graph but throws out some of the edges



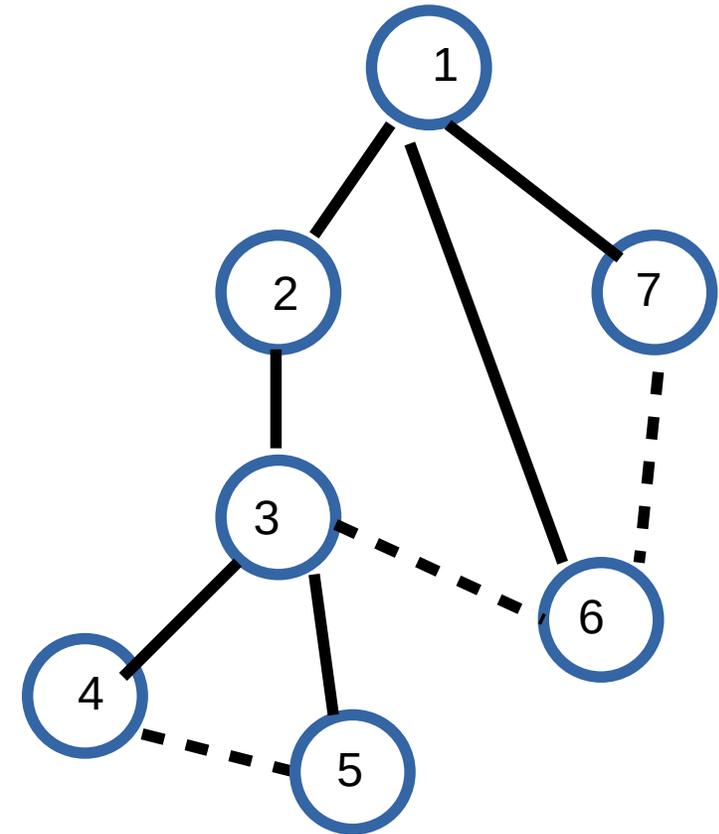
Example of (a) a cyclic graph; (b) a corresponding spanning tree.

How do we create a spanning tree?

- Properties: No loops
- How?
 - Selectively flood
 - Distributed algorithm, no coordination!
 - Automatic reconciliation when failure occurs

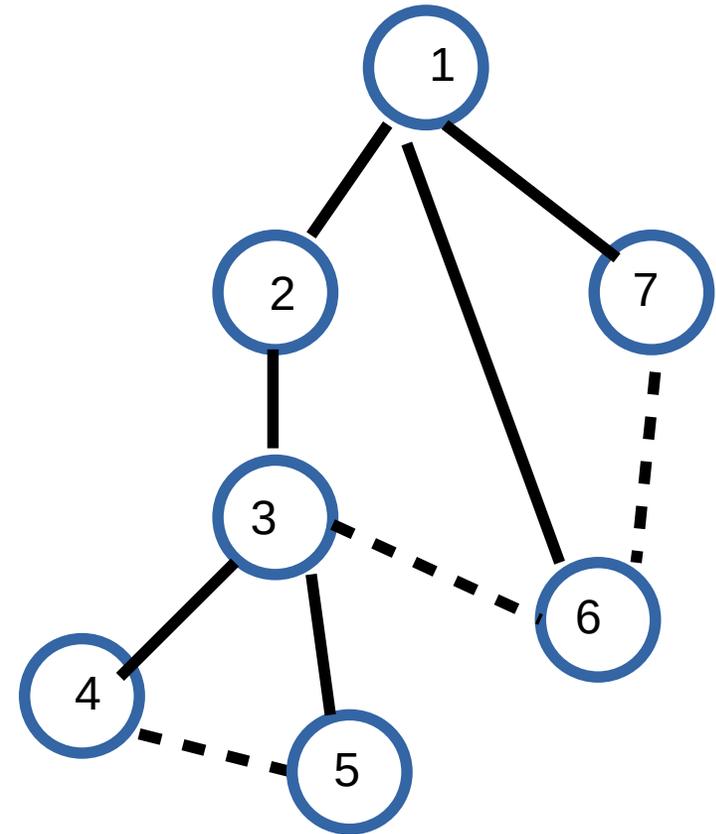
How do we create a spanning tree?

- **Message (Y, d, X) - (to, distance, from)**
- 4 thinks it's the root
- Sends (4, 0, 4) to 3 and 5
- Receives (3,0,3) from 3
 - Sets it to as the root since $3 < 4$
- Receives (3,1,5) from 5
 - Sees that this is a longer path to 3
 - 2 hops vs direct path (1 hop)
 - Removes 4-5 link from the tree



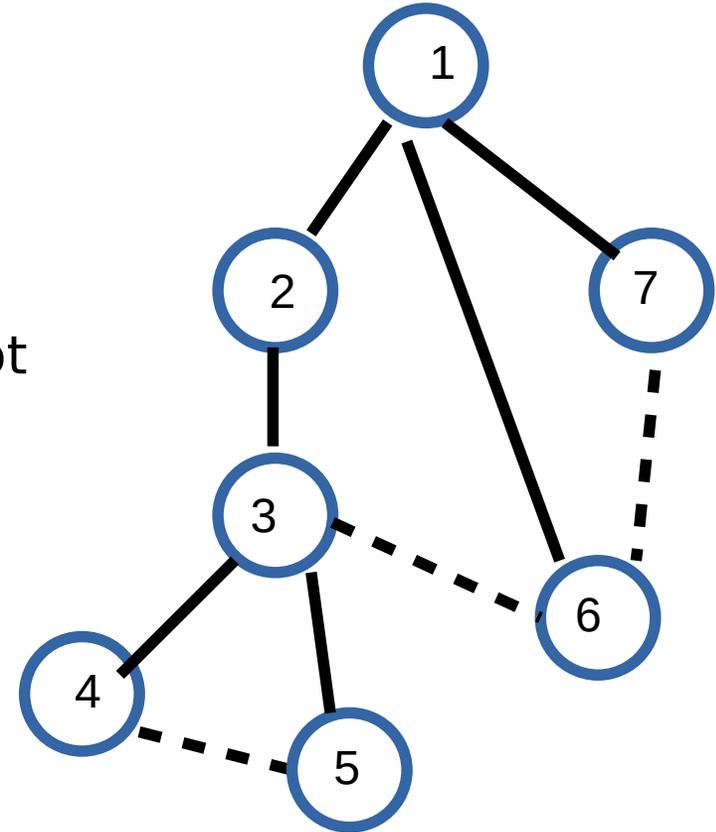
What does 4 do when it hears from 2?

- **Message (Y, d, X) - (to, distance, from)**
- 2 hears (1, 0, 1) from 1
- 2 sends (1, 1, 2) to 3
- 3 sends (1, 2, 3) to 5 and 4
- 4 receives (1, 2, 3) from 3
- 4 receives (1, 3, 5) from 5
- Sets 1 as root (id=1 is < id=4)
- Prunes the 4-5 path since it is 4 hops compared to 3 hops via 3



Failure and Downsides

- Even after the system has stabilized, the root continues to send messages periodically
 - Other bridges continue to forward these messages
- When a bridge fails, the downstream bridges will not receive the configuration messages
 - After waiting a specified period of time, they will once again claim to be the root and the algorithm starts again
- No load balancing

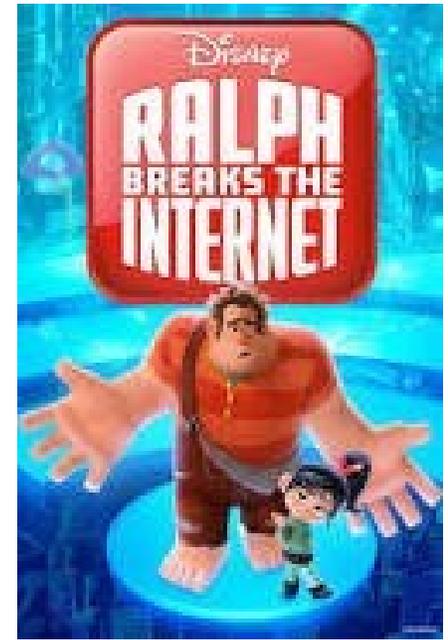


Virtual LAN (VLANs)

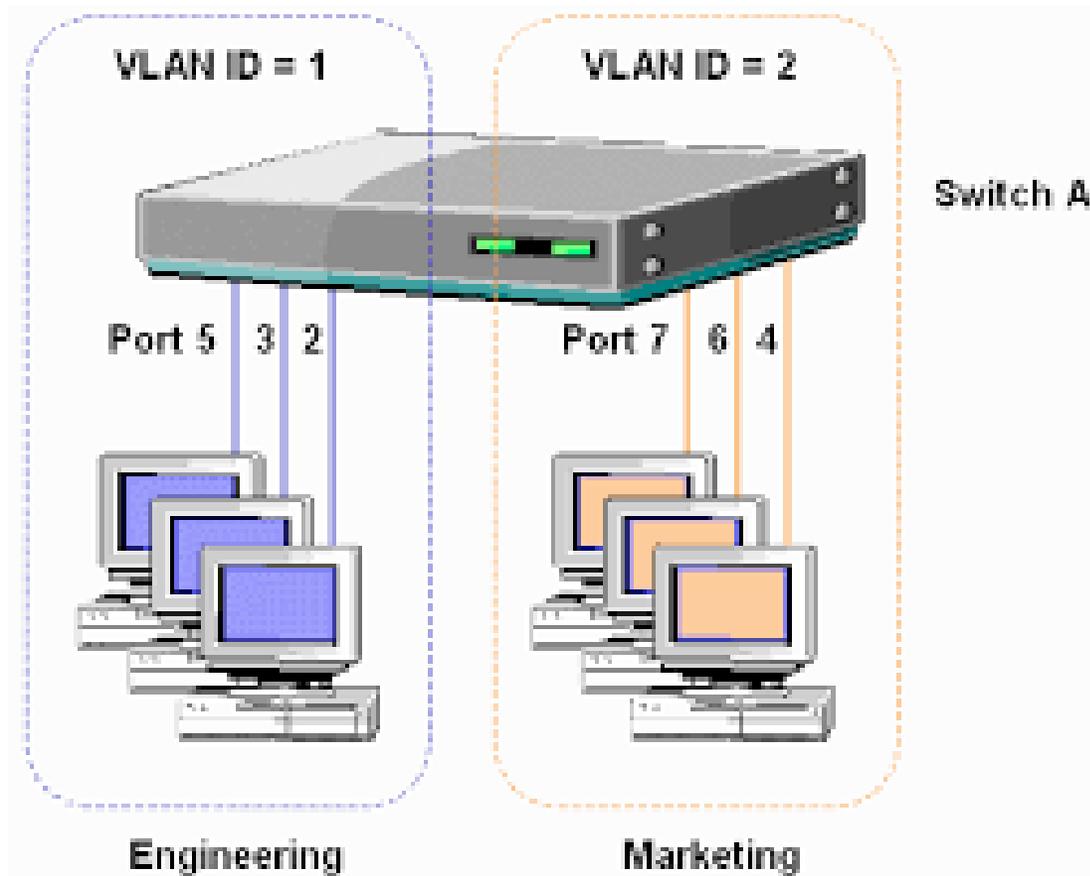
- LANs are on the same Ethernet segments
- Does not scale very well – too many wires
- How can we put multiple people in different locations on the same Ethernet segment (LAN)?
- How do we create multiple LANs over the same wire?

Why separate at all?

- LANs are on the same Ethernet segments! Security.
- Isolation – sensitive traffic vs normal traffic
- Containment of traffic – your for loop broke the internet
- How do we create multiple LANs over the same wire?



VLANs



- Switches specify which VLAN is accessible over which interface
- Each interface can have a VLAN color
- Each Mac address can have a interface color
- Add VLAN tag to the Ethernet header

Reading Assignment

Switching Basics – Chapter 3.1

- <https://book.systemsapproach.org/internetworking/switching.html#switching-basics>
 - *Up to (but not including) Virtual Circuit Switching*
 - 20 minutes read
-
- Switched Ethernet, learning bridges, spanning tree algorithm, VLANs – Chapter 3.2
 - <https://book.systemsapproach.org/internetworking/ethernet.html#switched-ethernet>
 - 30-40 minutes read