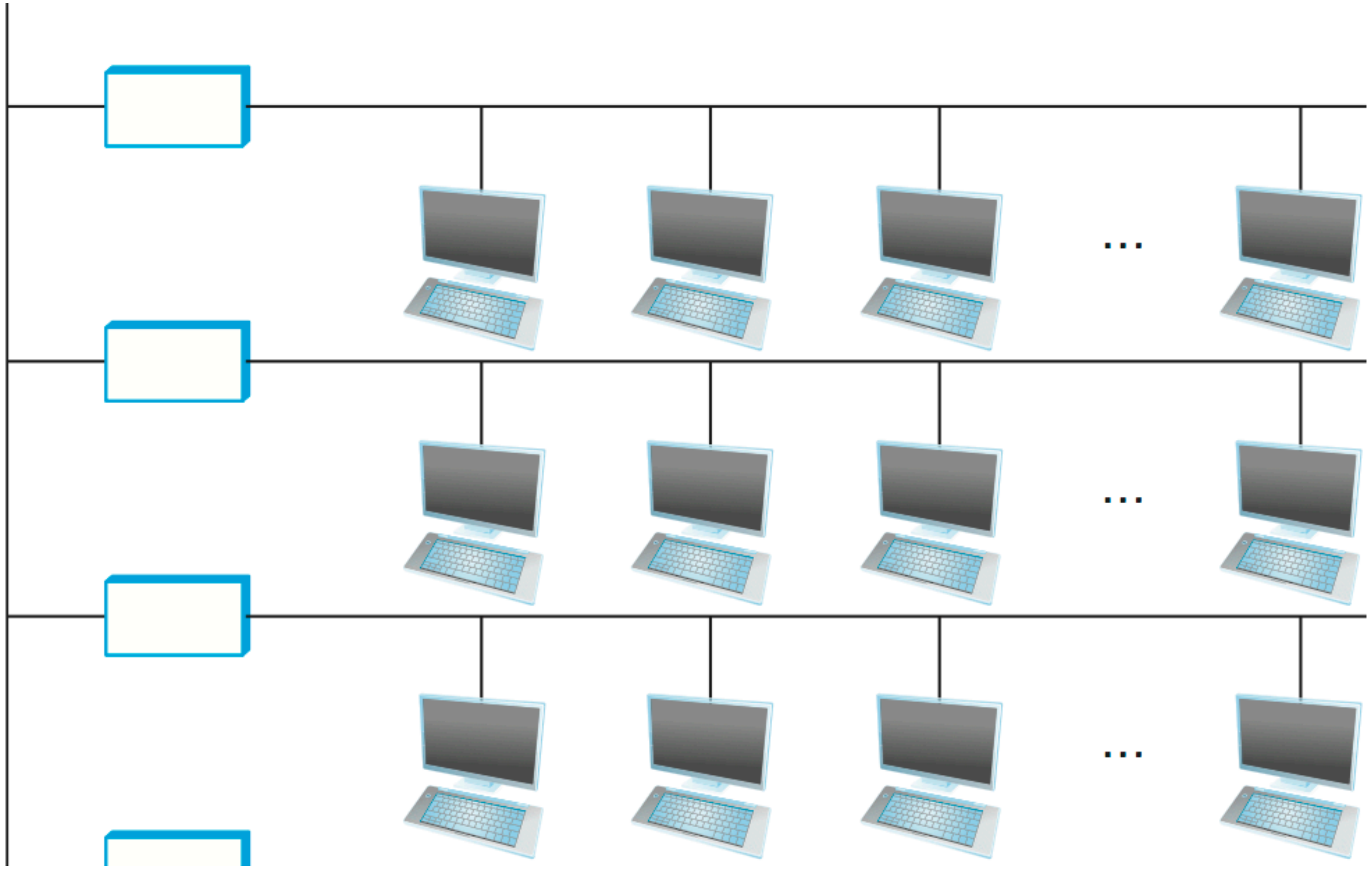
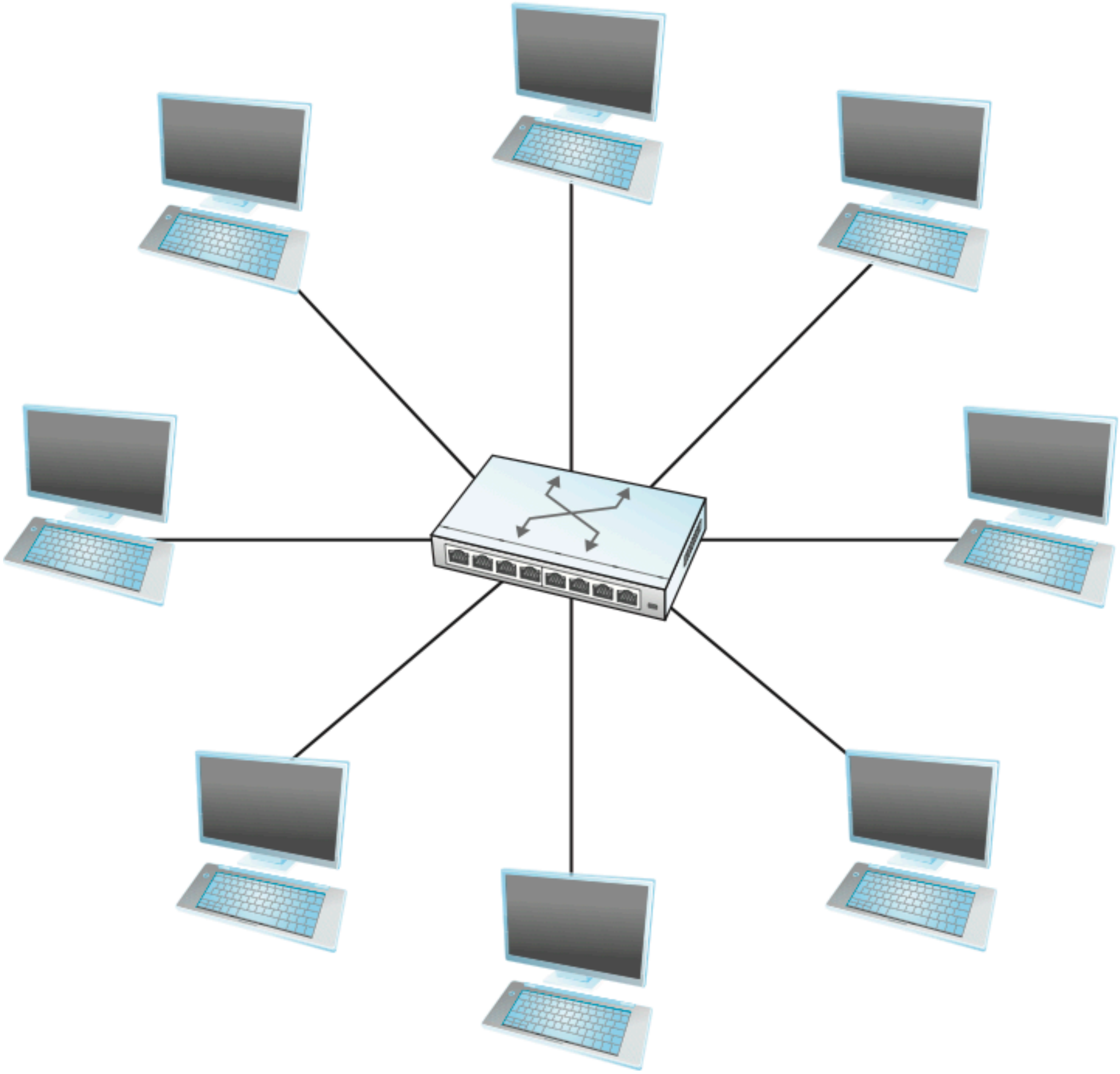
# Switching and Bridging

COS 460 - Fall 2019



# Ethernet as we know it

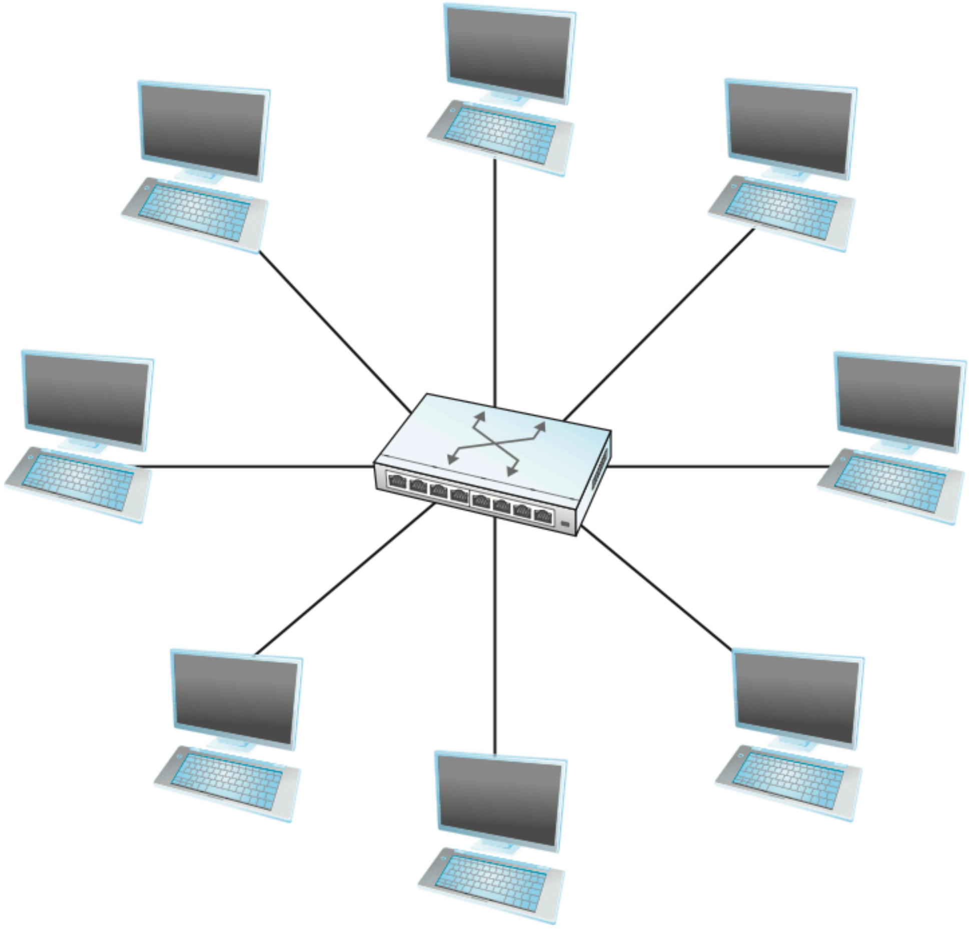
All hosts connected to same “wire”
All hosts see the same signals



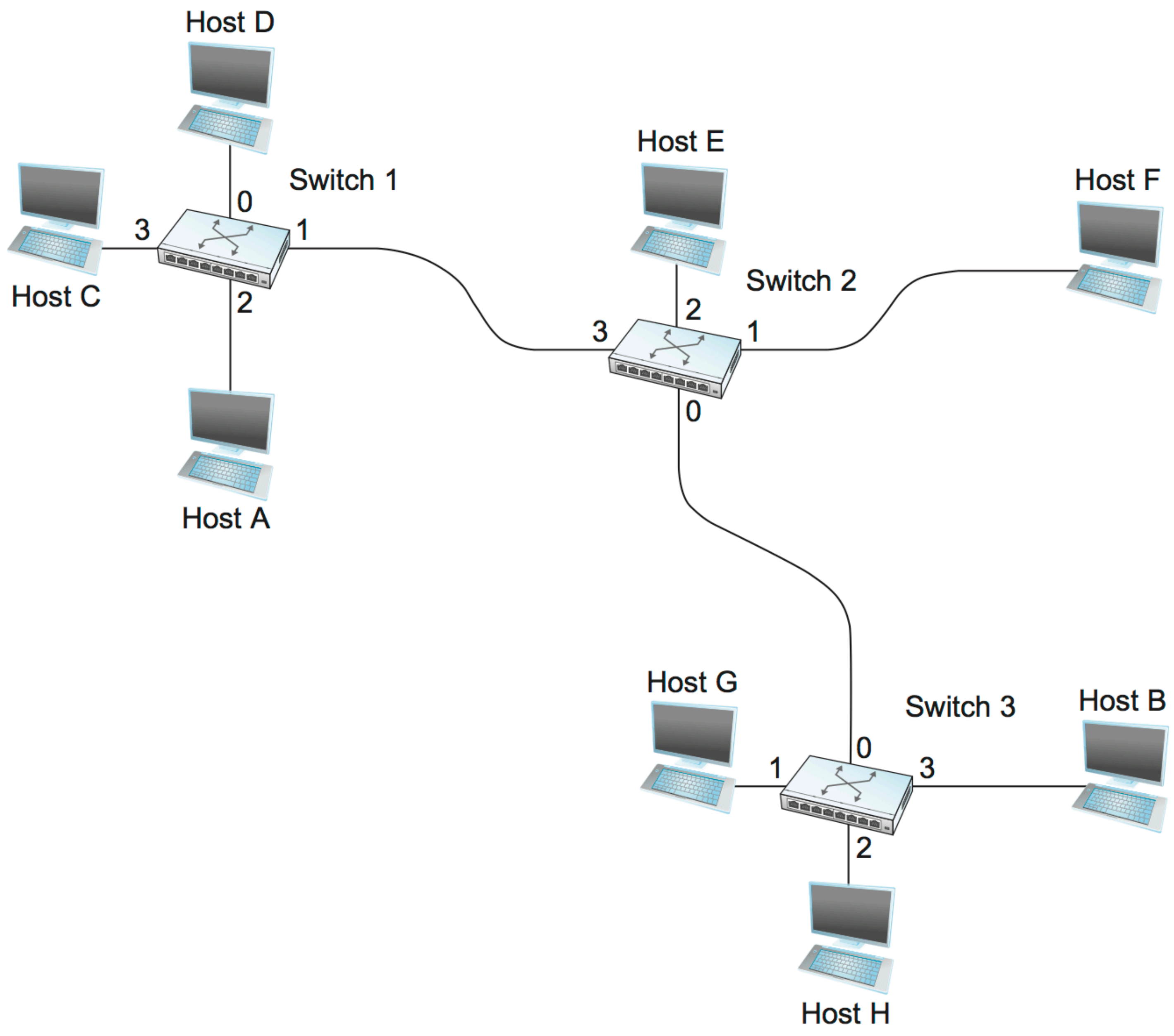
# The Star Topology

Hosts connected to central intelligent “switch”

# The Star Topology



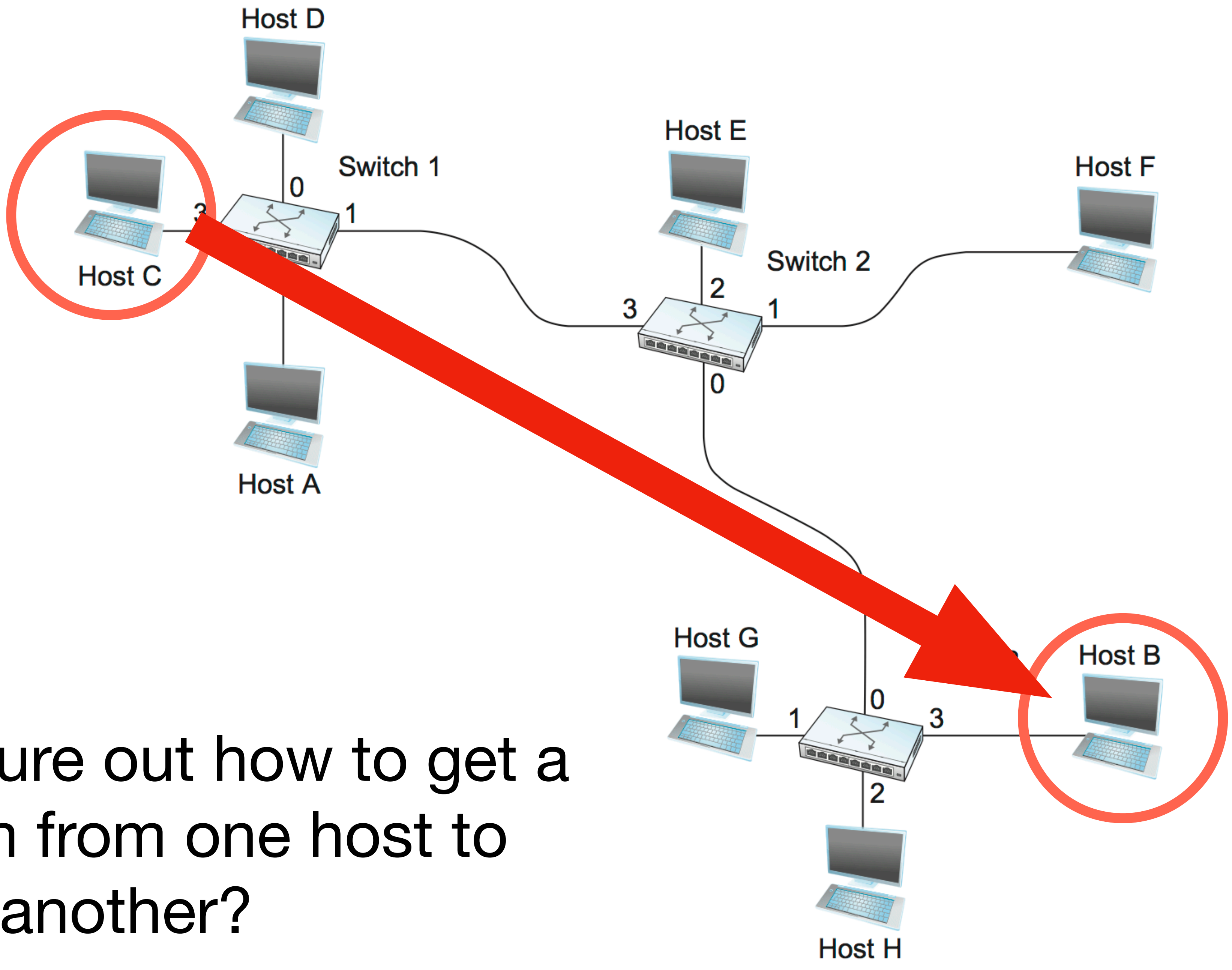
- Fixed number of ***ports***
- Interconnect **hosts** or **switches**
  - …to form larger networks
- No reduction in performance of network*



# The Star Topology

interconnecting networks

# Interconnected Stars



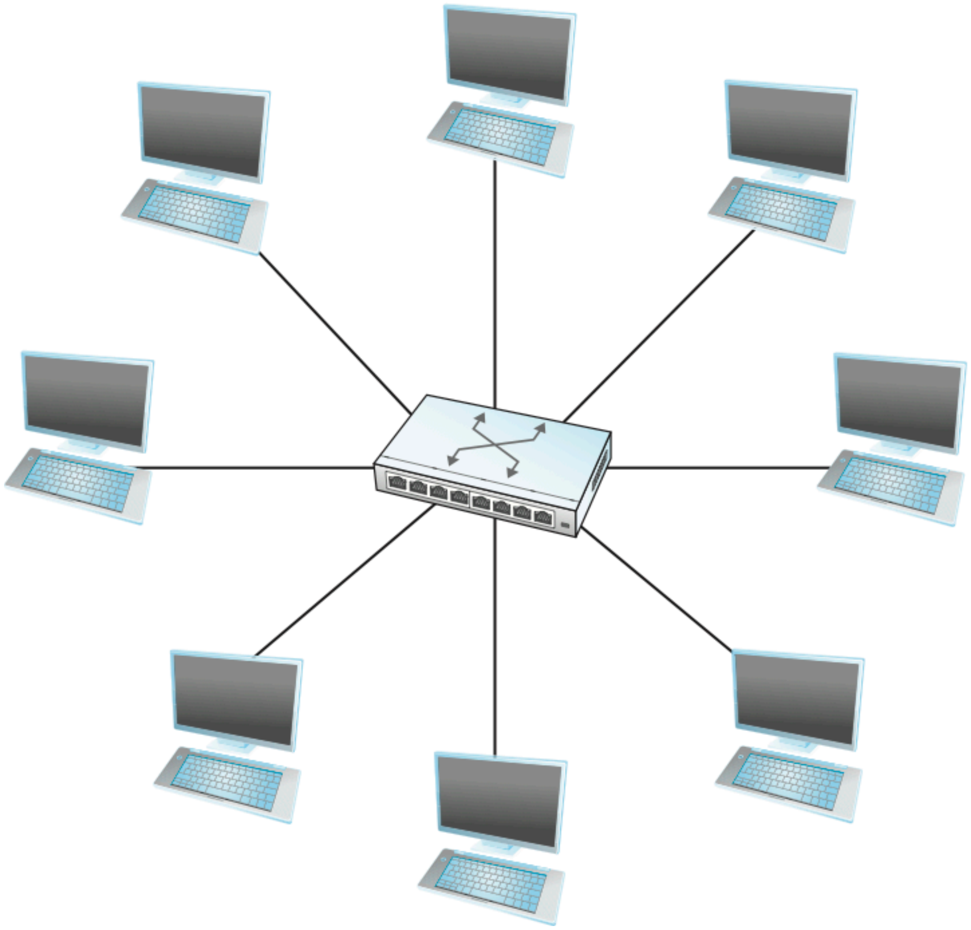
How do figure out how to get a datagram from one host to another?

*let's just worry about any path right now. later we will talk about routing.*

# Some Switching Options

1. Datagram Switching
2. Virtual Circuit Switching
3. Source Routing

# Datagram Switching



- Run **Ethernet protocol** on each link
- **Broadcast** when needed

# Datagram Switching

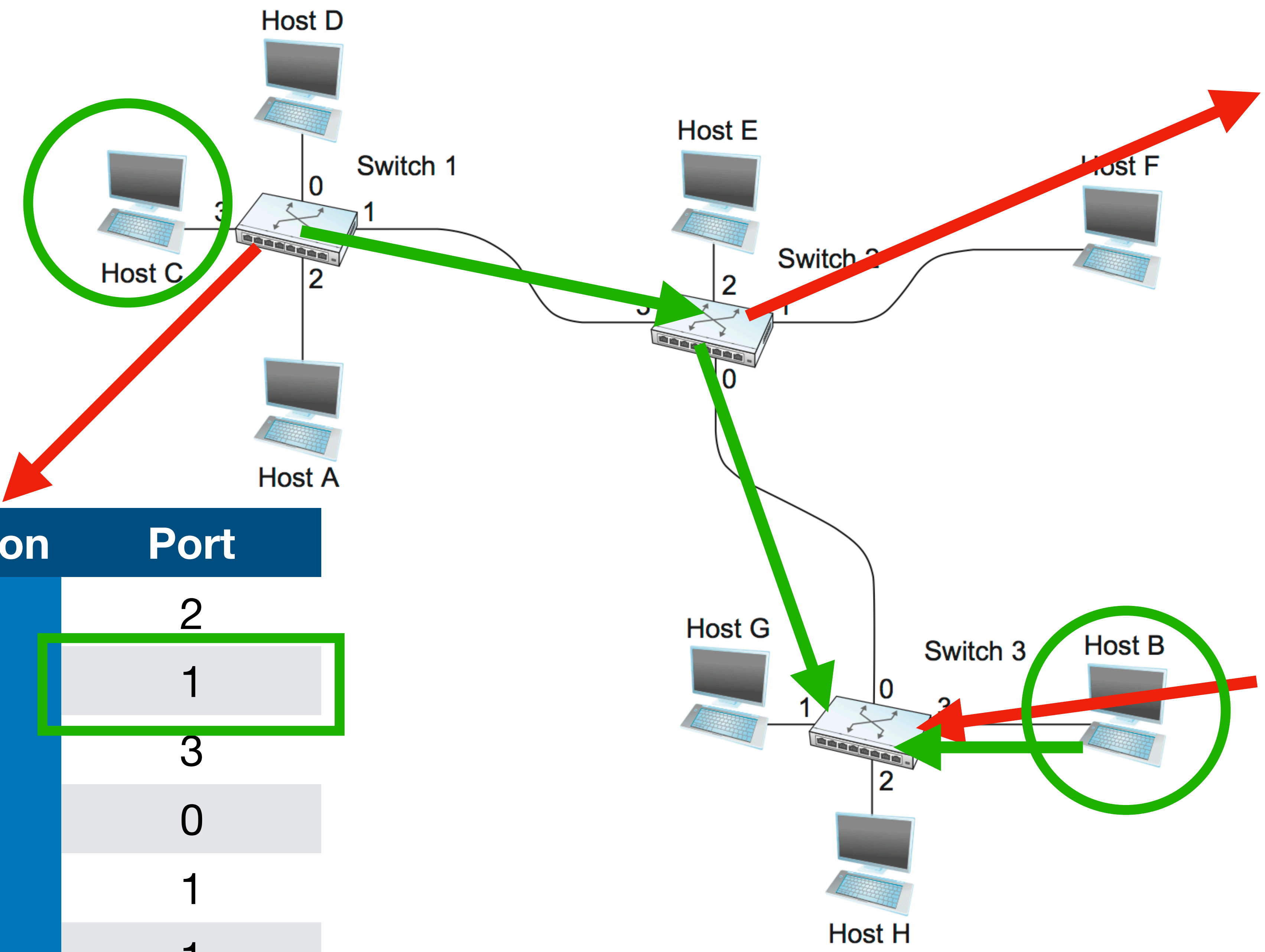
- A host can send a packet **anywhere** at **any time** (*connectionless*)

- When sending, the host does not know if the network can deliver it or not (*unreliable*)

- Each packet is **delivered independently** of all other packets

- Switches and links fail, alternate paths route around problems

# Datagram Forwarding

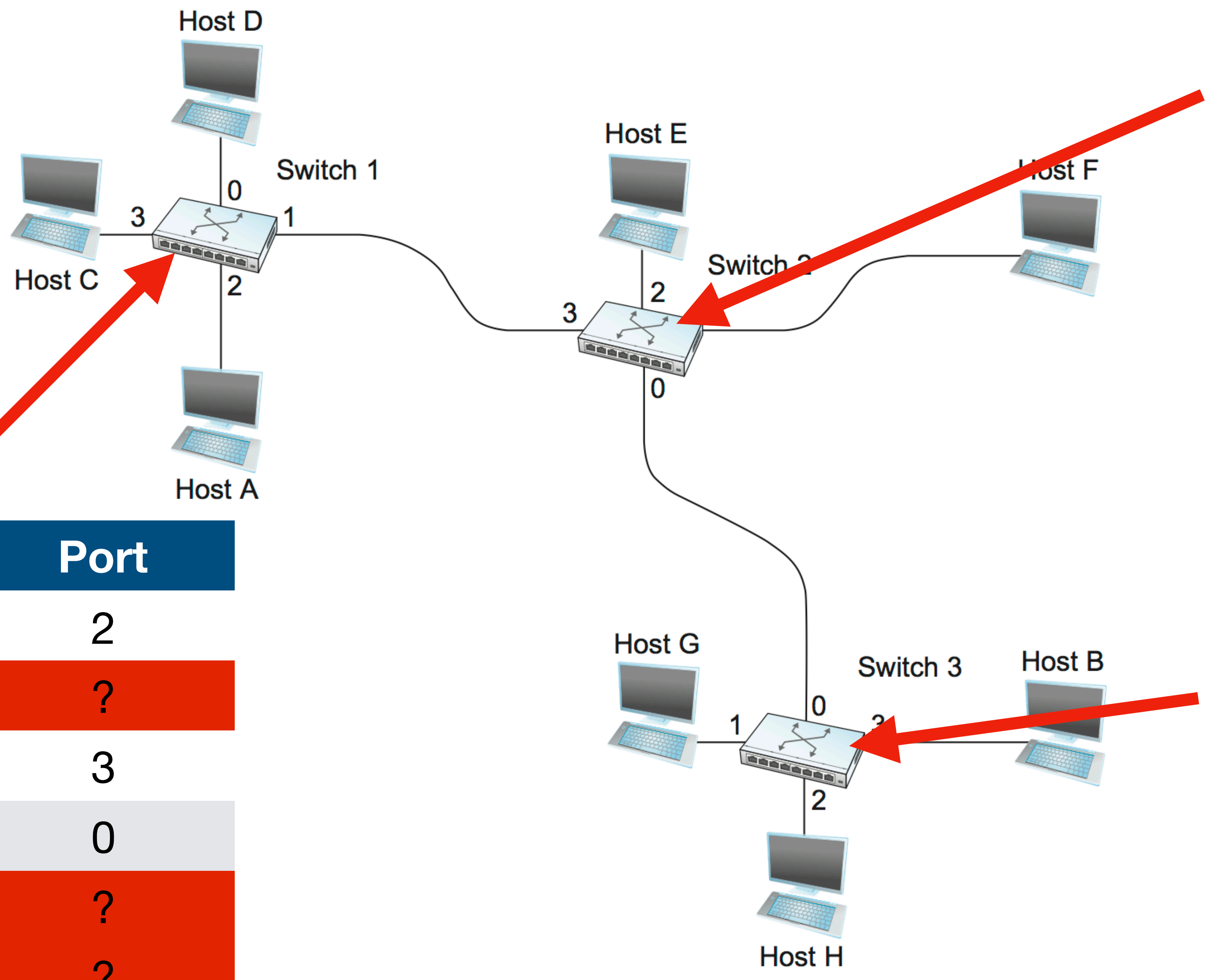


| Destination | Port |
|---|---|
| A | 2 |
| B | 1 |
| C | 3 |
| D | 0 |
| E | 1 |
| F | 1 |
| G | 1 |
| H | 1 |
| ... | ... |

| Destination | Port |
|---|---|
| A | 3 |
| B | 0 |
| C | 3 |
| D | 3 |
| E | 2 |
| F | 1 |
| ... | ... |

| Destination | Port |
|---|---|
| A | 0 |
| B | 3 |
| C | 0 |
| D | 0 |
| E | 0 |
| F | 0 |

# Forwarding Tables

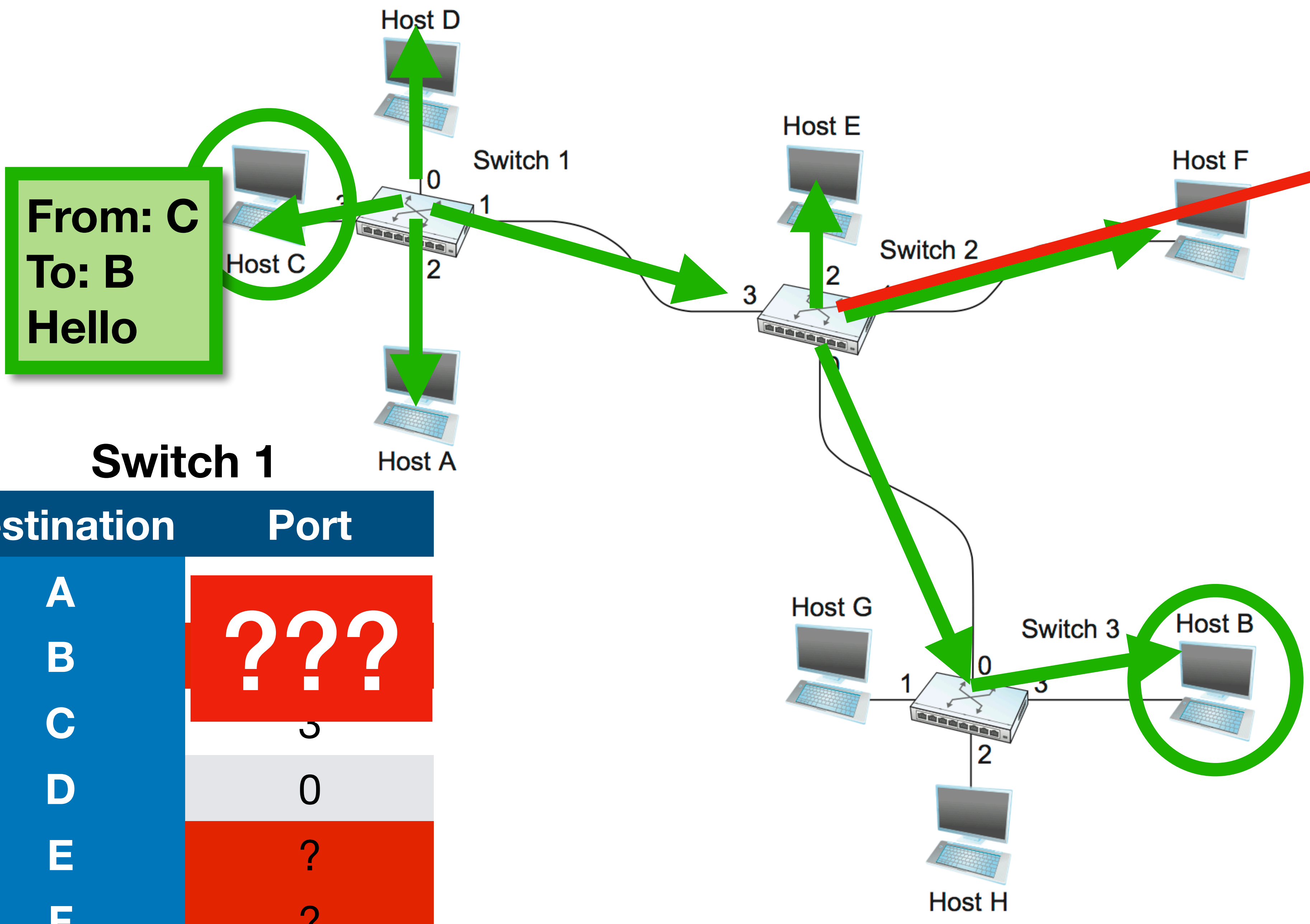


| Destination | Port |
|---|---|
| A | ? |
| B | ? |
| C | ? |
| D | ? |
| E | 2 |
| F | 1 |
| ... | ... |

| Destination | Port |
|---|---|
| A | 2 |
| B | ? |
| C | 3 |
| D | 0 |
| E | ? |
| F | ? |
| G | ? |
| H | ? |
| ... | ... |

| Destination | Port |
|---|---|
| A | ? |
| B | 3 |
| C | ? |
| D | ? |
| E | ? |
| F | ? |

# Forwarding Tables



From: C
To: B
Hello

**Switch 1**

| Destination | Port |
|---|---|
| A | ??? |
| B | |
| C | 3 |
| D | 0 |
| E | ? |
| F | ? |
| G | ? |
| H | ? |
| ... | ... |

**Switch 2**

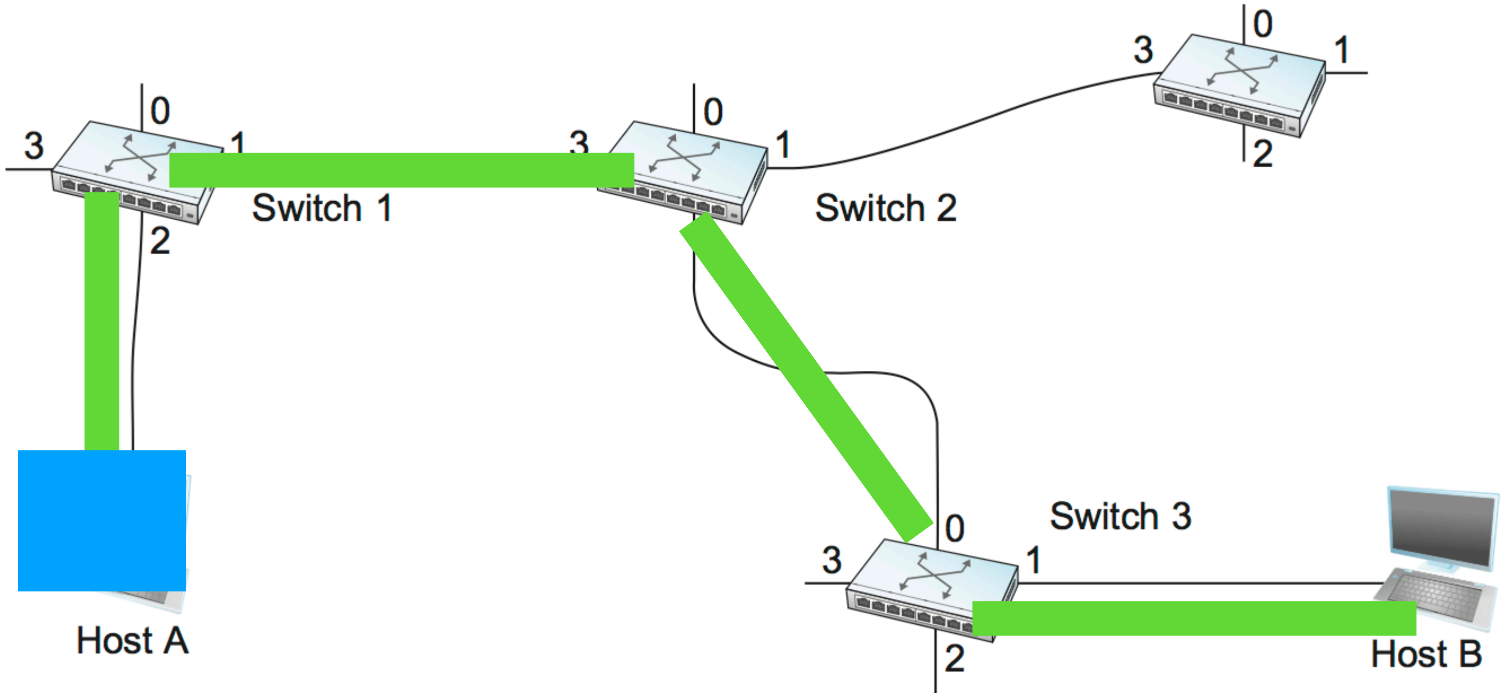
| Destination | Port |
|---|---|
| A | 3 |
| B | ? |
| C | ? |
| D | ? |
| E | 2 |
| F | 1 |
| ... | ... |

**Switch 3**

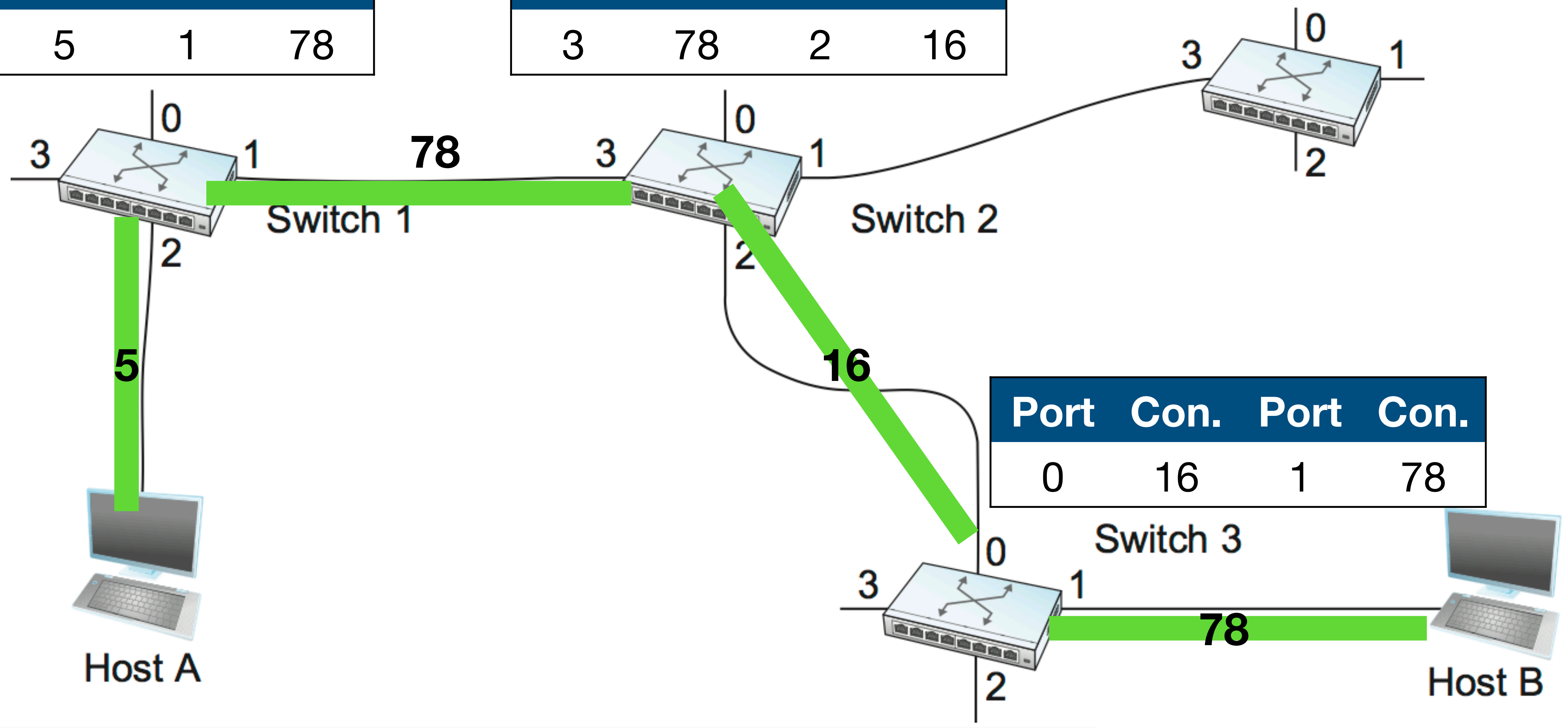
| Destination | Port |
|---|---|
| A | 3 |
| B | 3 |
| C | ? |
| D | ? |
| E | ? |
| F | ? |

# Virtual Circuit Switching

- Set up connection between hosts through network
- Datagrams then go through connection
- Only need addresses to set up connection



# Virtual Circuit Switching



| Port | Con. | Port | Con. |
|---|---|---|---|
| 2 | 5 | 1 | 78 |

| Port | Con. | Port | Con. |
|---|---|---|---|
| 3 | 78 | 2 | 16 |

| Port | Con. | Port | Con. |
|---|---|---|---|
| 0 | 16 | 1 | 78 |

How do we set up the connection?

# Virtual Circuit Setup

- Signaling protocol, out of band data between switches
- Host embeds global unique address of destination
- Broadcast like through switches to find destination
- Circuit set up on return path confirmations

# Virtual Circuit Switching

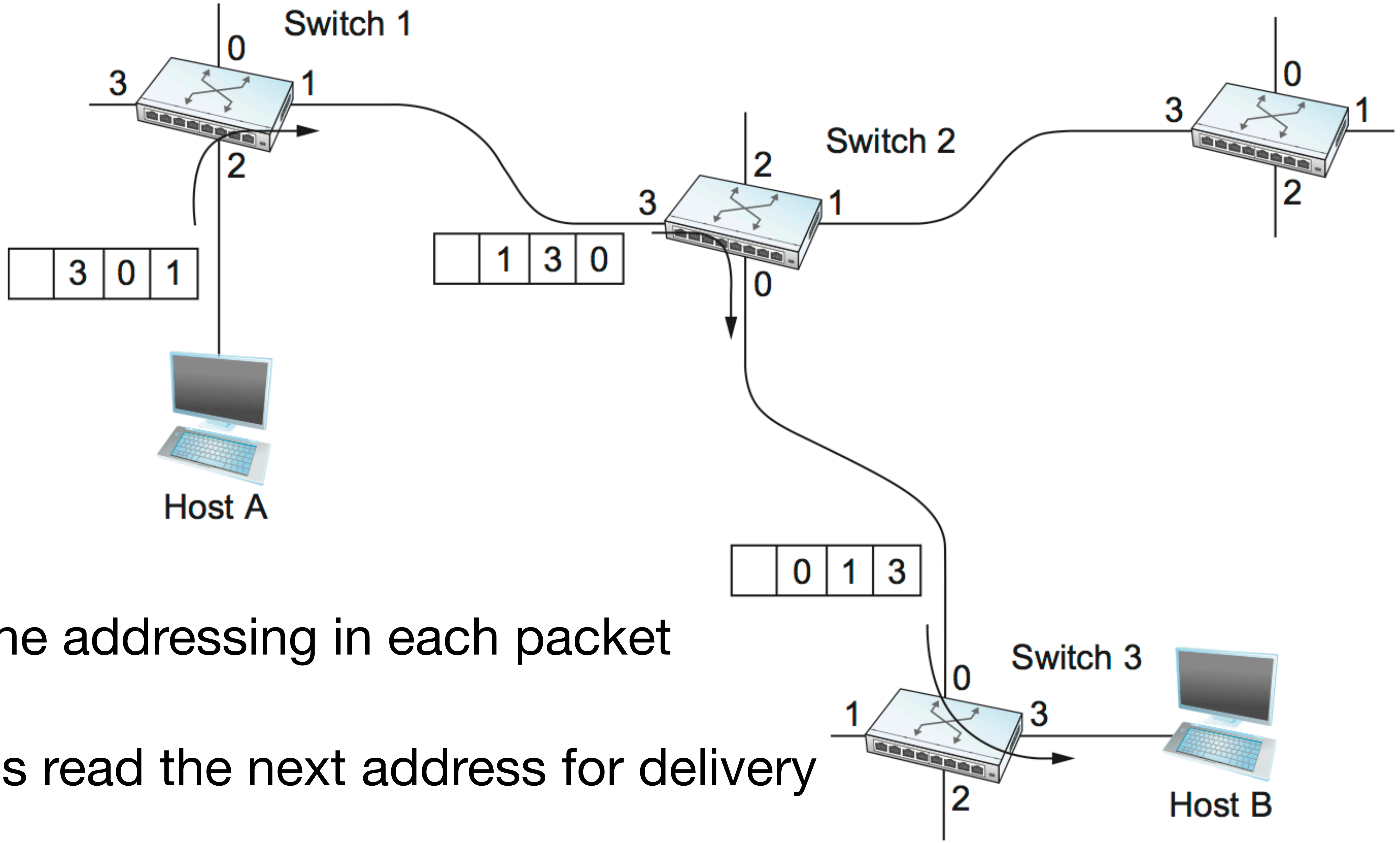
**Pros:**

- Less overhead on individual packets (less addressing)
- Less variability in delivery time across network
- Lots of knowledge about the network after setup (times, buffers, etc.)
- Quality of Service (QoS) easier* to implement

**Cons:**

- At least 1 x RTT to setup connection
- If switch or link fails, need to make new connection
- Convoluted out-of-band setup and signaling needed.

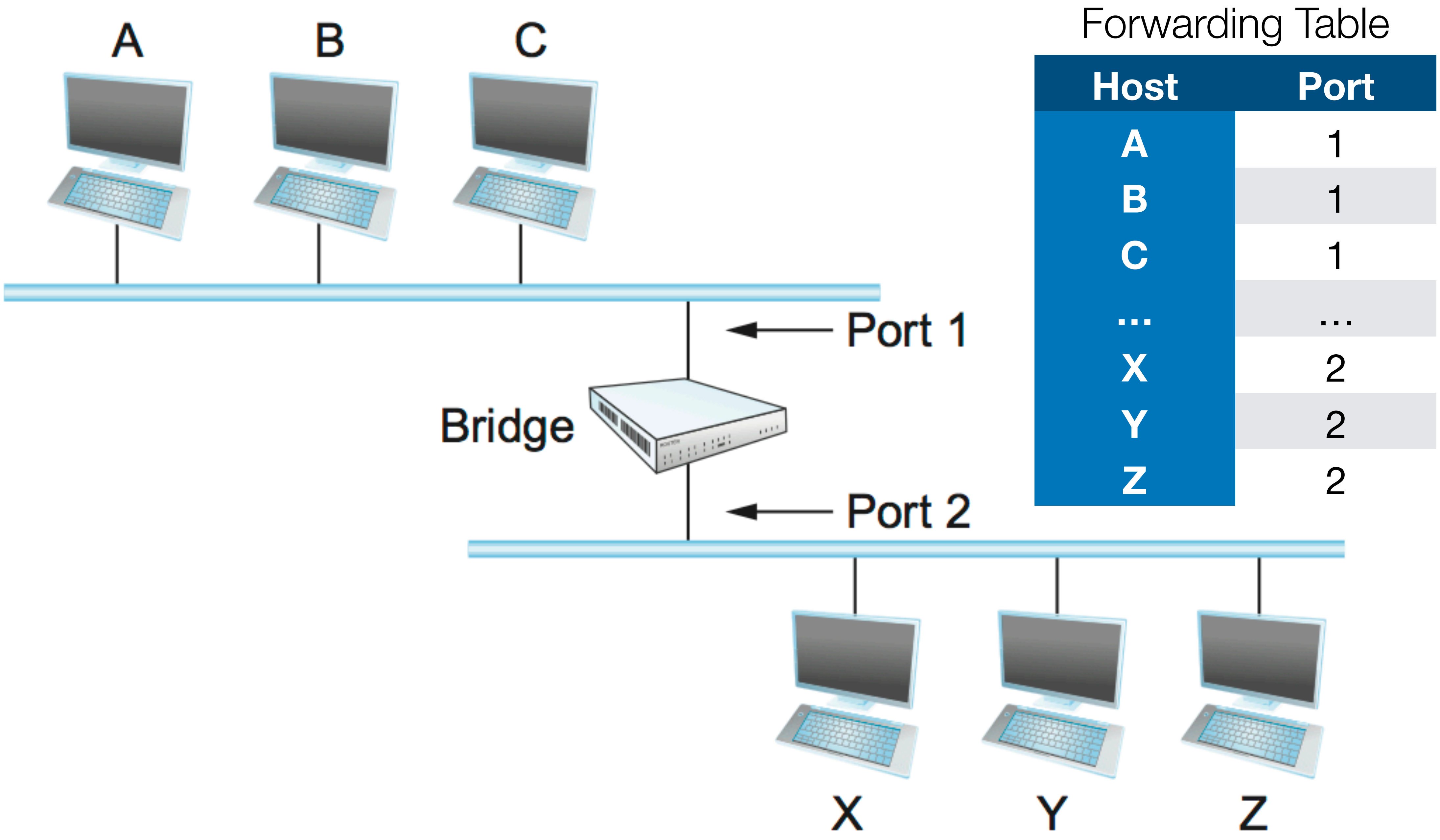
# Source Routing



- Put all the addressing in each packet
- Switches read the next address for delivery
- “Rotate” the address field to create return path

# Bridges and L2 Switches

- Learning Bridges
- Spanning Tree Algorithm
- Broadcast and Multicast
- Limitations

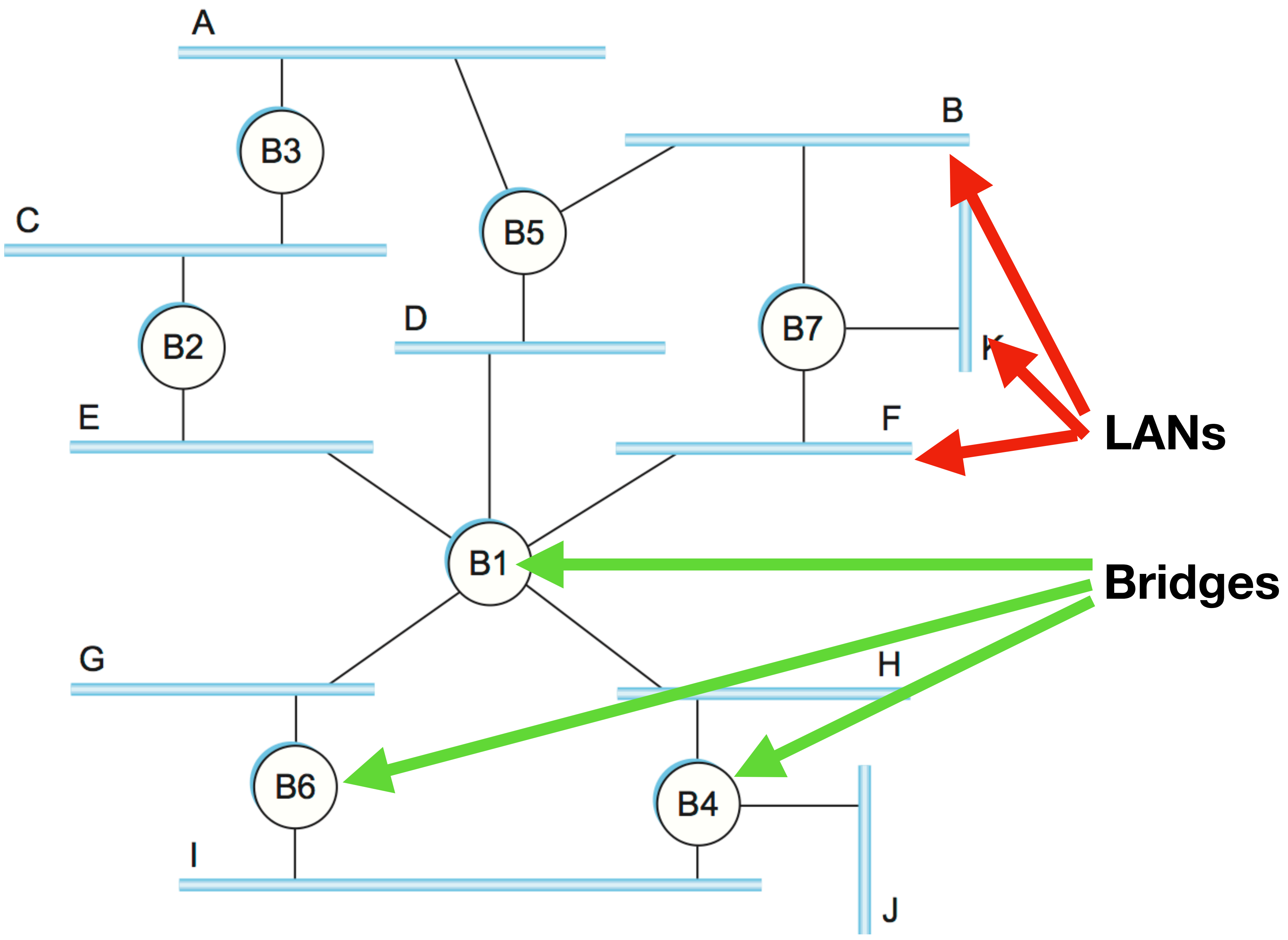


Forwarding Table

| Host | Port |
|---|---|
| A | 1 |
| B | 1 |
| C | 1 |
| ... | ... |
| X | 2 |
| Y | 2 |
| Z | 2 |

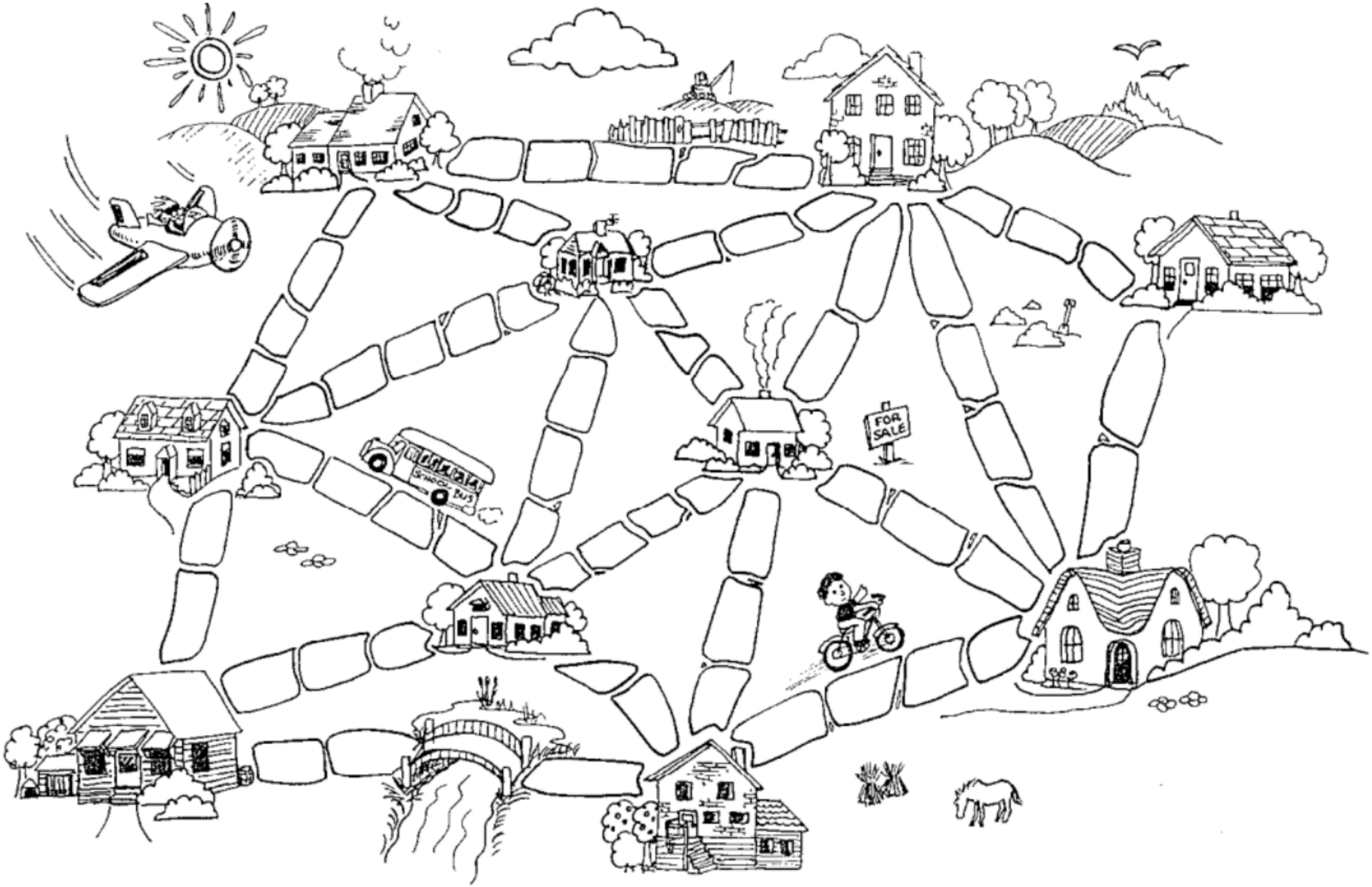
# Learning Bridge

Same as we saw earlier, listen to the source addresses on each port (*promiscuously*)



# More Complex Connections

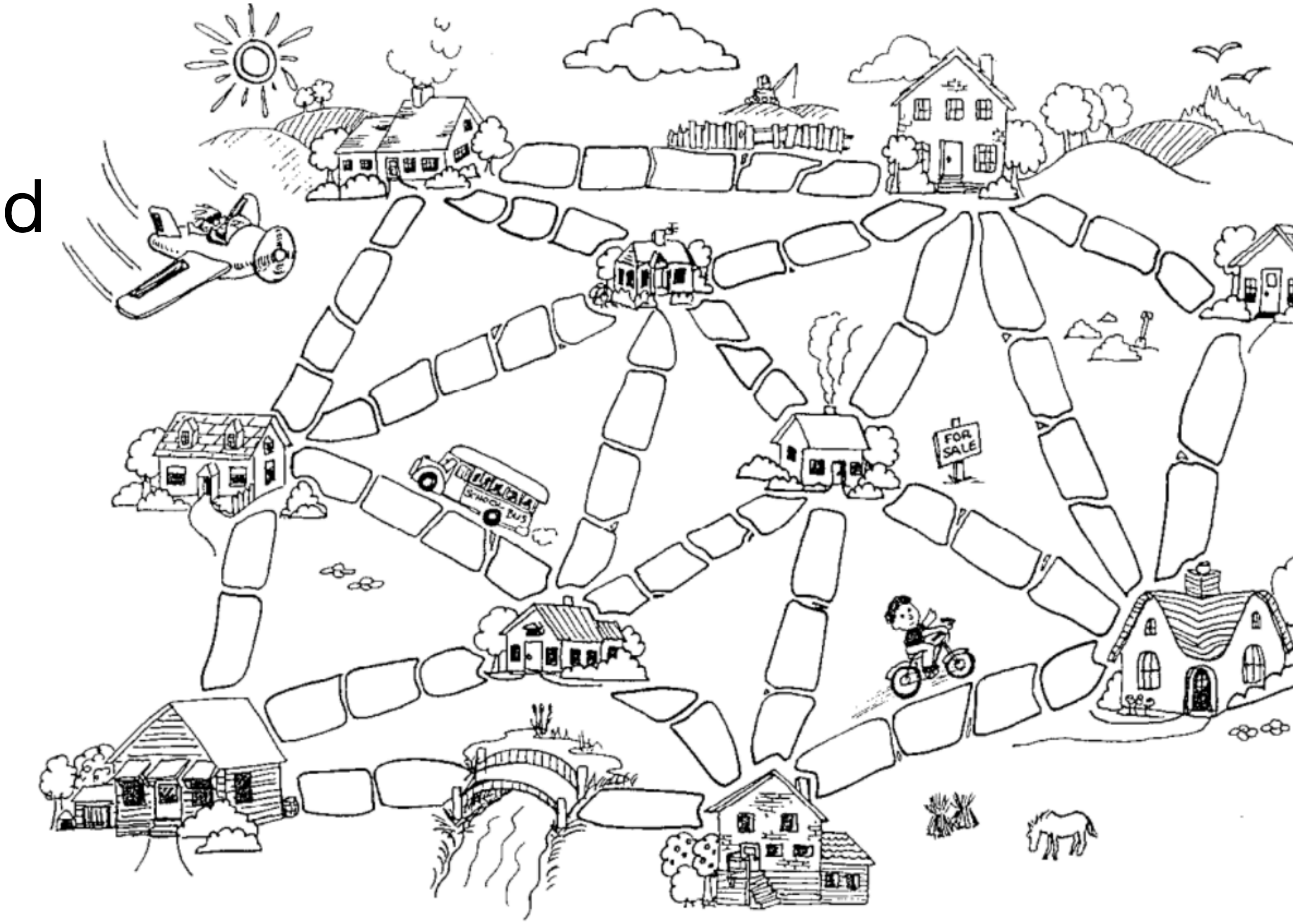
When the extended LAN has a **loop** in it, our previous strategies may have delivery problems



Which roads should we pave to get complete yet least expensive connectivity?

# Spanning Tree

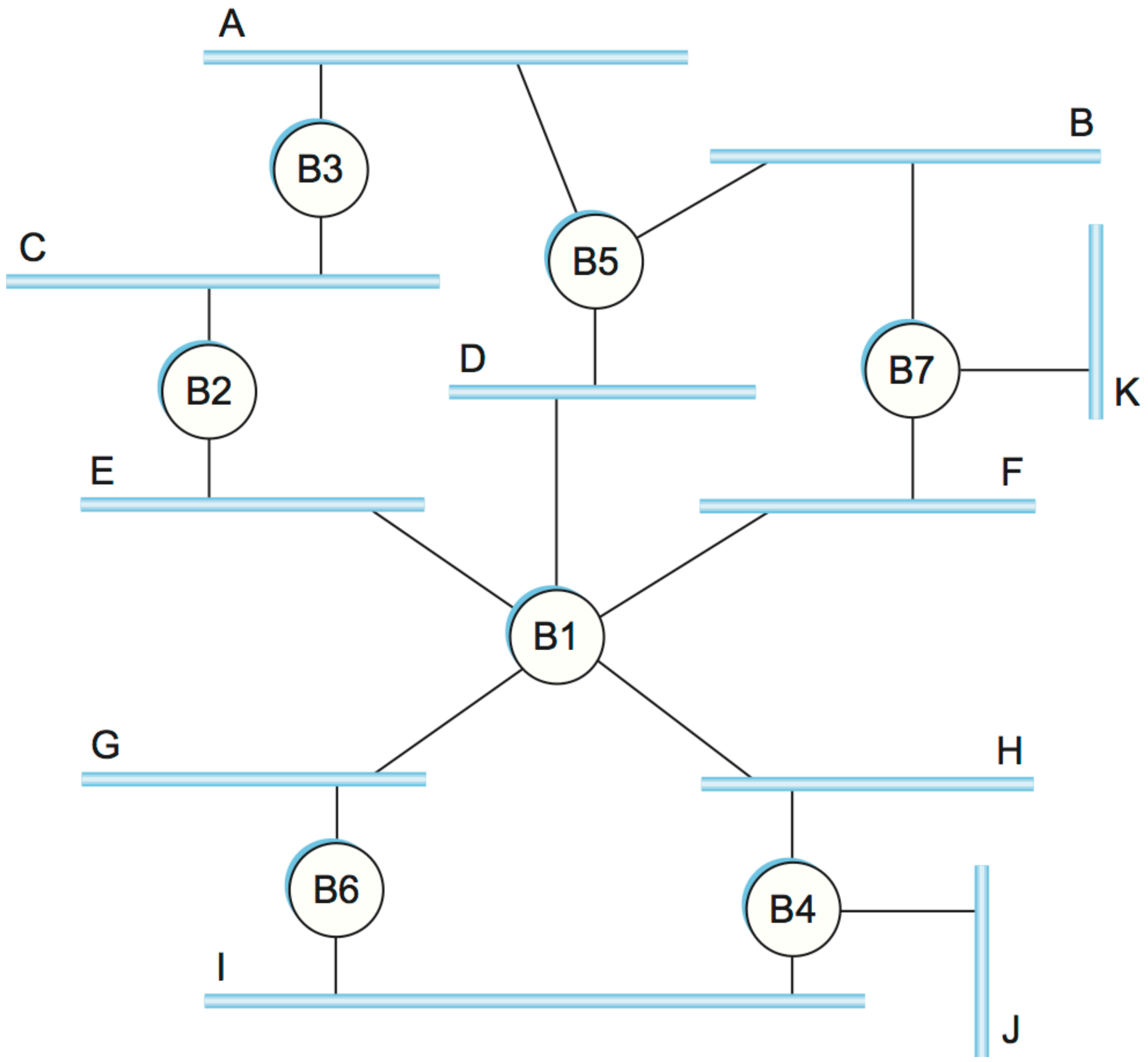
- Which connections would you choose to build to keep total cost down?
- Can you come up with a strategy or process to solve this problem? …for any network?



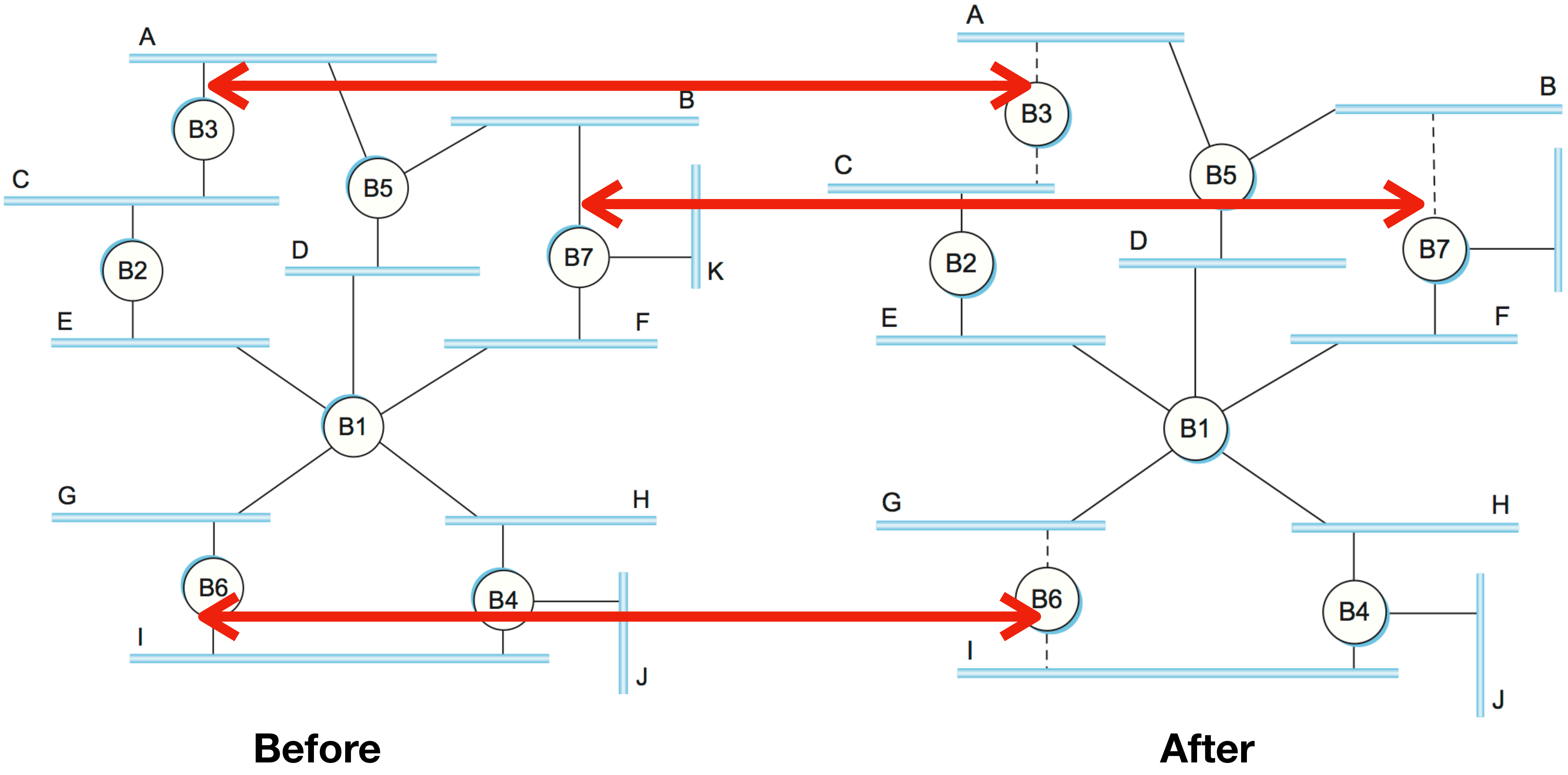
# Spanning Tree

**The Big Idea**

- Bridges **select ports** they will forward packets
- These ports will cover the network **without loops**
- Some switches will **disable** ports to prevent loops
- **Distributed Algorithm**, all bridges run it independently

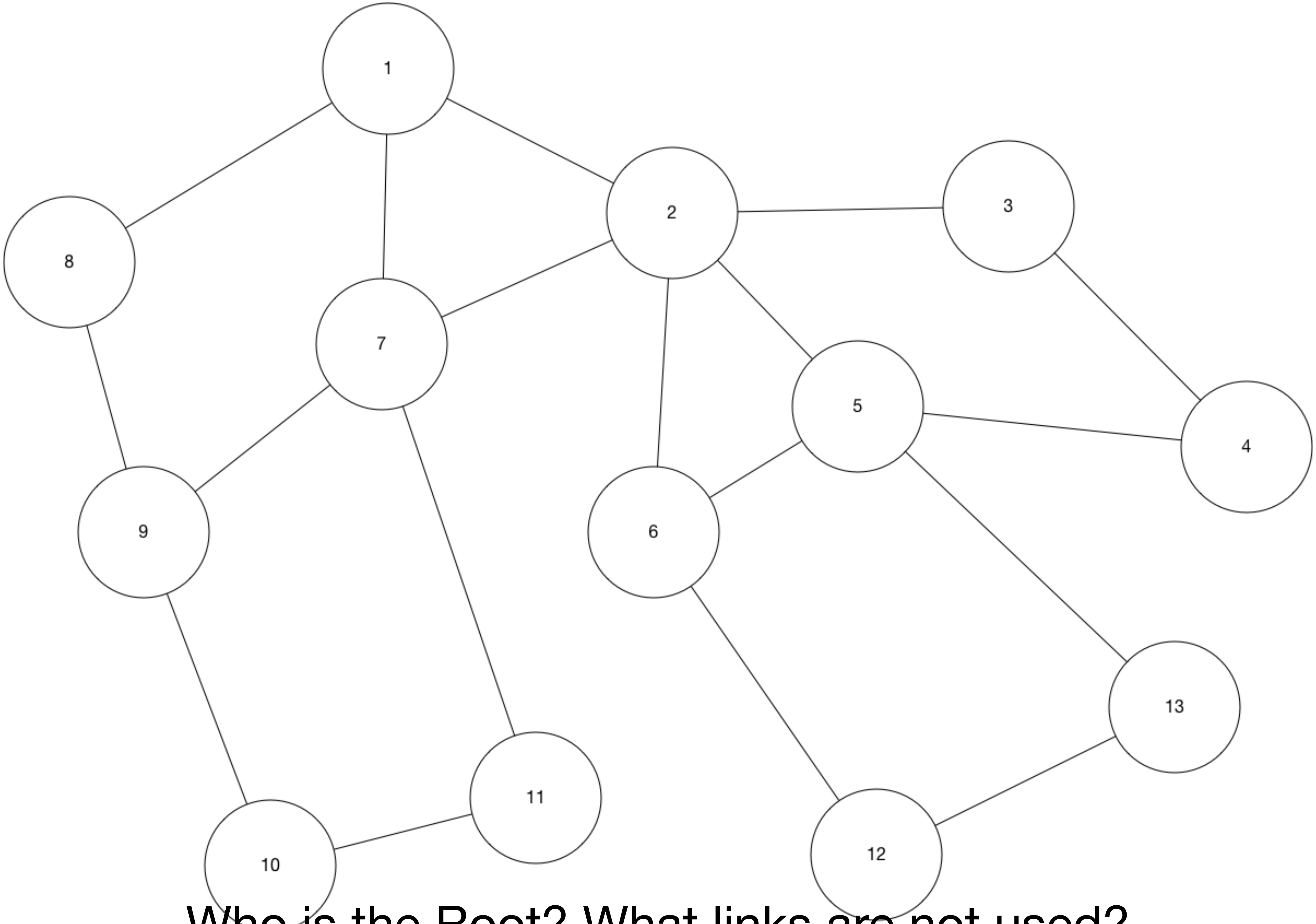


# Spanning Tree Result

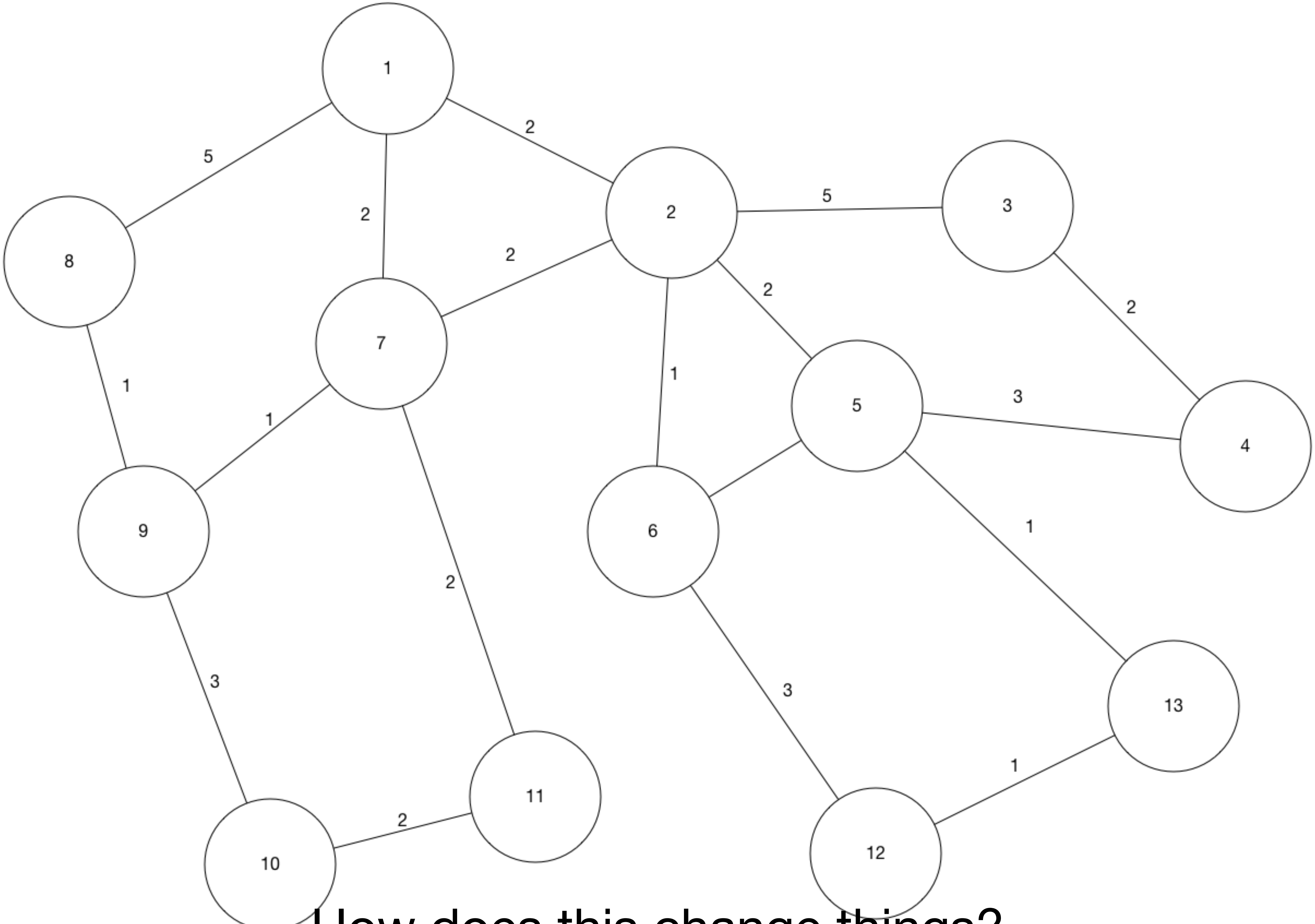


# Spanning Tree Algorithm

- Exchange Configuration Messages on all ports <BridgeID, RootID, Distance>
  - My Bridge Identifier
  - Bridge I think is the root bridge
  - Distance (in hops) from me to root
- Pretend I'm the root bridge and send out configuration <me, me, 0>
- Record best configuration messages on each port
  - Root ID is smaller than the what I think is the Root ID
  - Root ID is the same but shorter distance
  - Root ID and distance are the same but sending bridge ID is smaller
- If new configuration is better than old one
  - Discard old one
  - Stop generating own configuration messages
  - Send out new configuration adding one (1) to distance field



Who is the Root? What links are not used?



How does this change things?

# Broadcast & Multicast

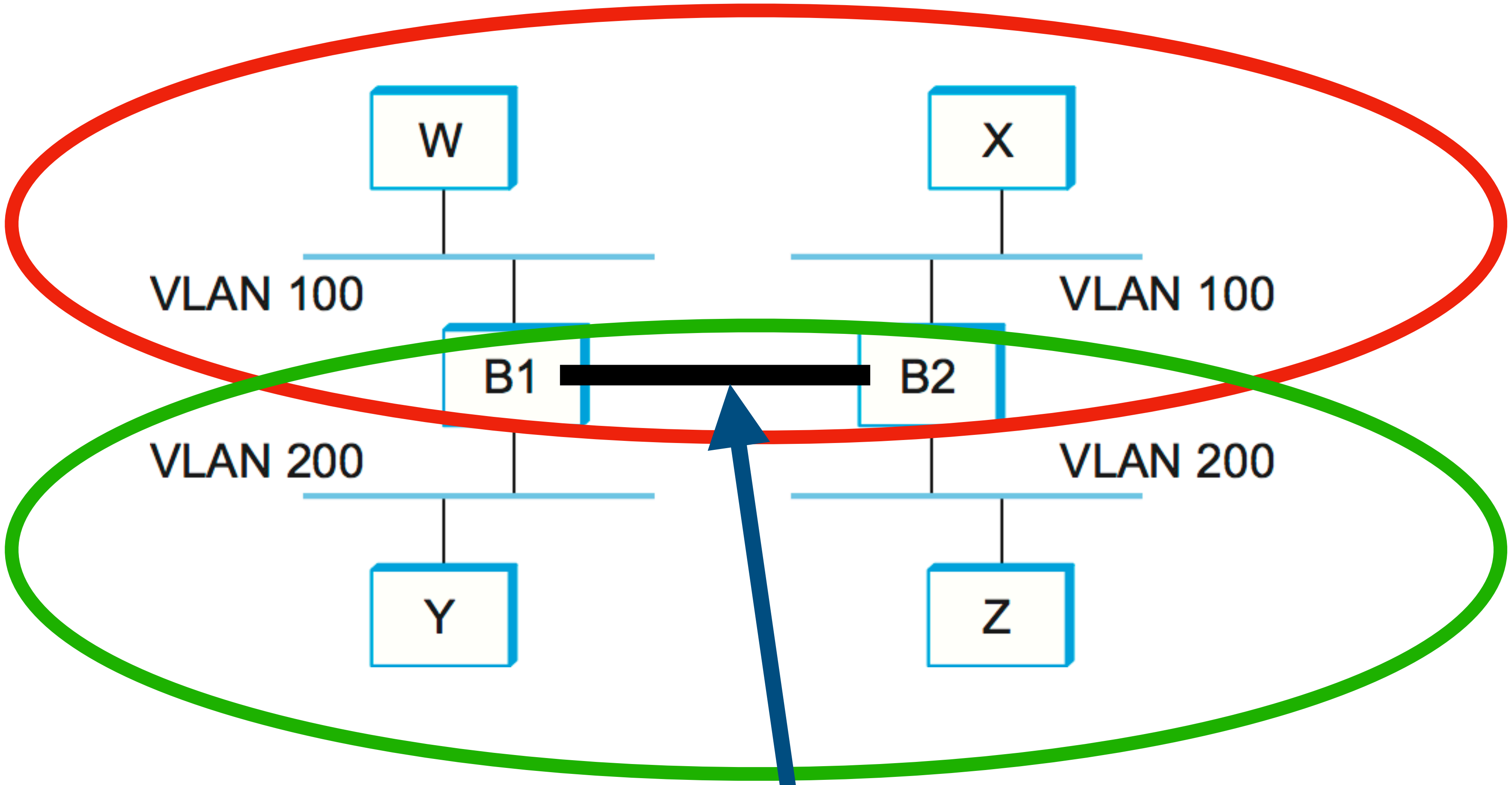
- **Broadcast** — forward out other ports (simple)

- **Multicast** — forward out other ports (simple)
  - A bridge *could* however be intelligent about it and pay attention to hosts on LANs that subscribe to multicast addresses

# Limitations

- Spanning Tree **does not scale well** beyond “tens of” bridges (linear)
- Broadcasting of frames across large network eats up bandwidth
    - Virtual LANs (VLANs) offer a solution to this

# Virtual LANs



Packets on this link are "tagged" with the VLAN ID

# fin

- **Switching Options**
  - Datagram (connectionless)
  - Circuit Switched (connection-oriented)
  - Source Routing
- **Bridges**
  - Learning
  - Spanning Tree Algorithm
  - Limitations and Virtual LANs