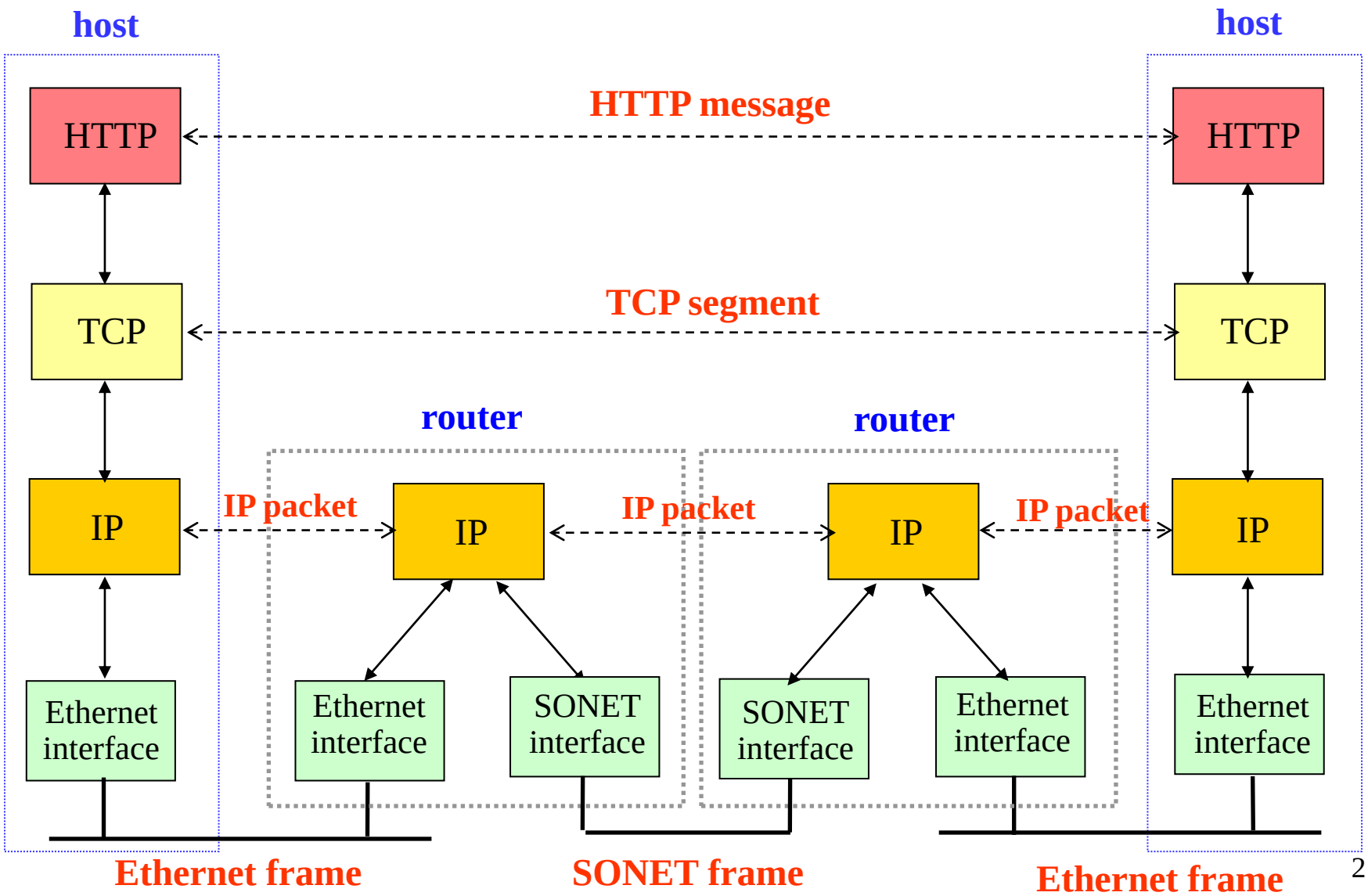
# Hub, Switch and Bridges

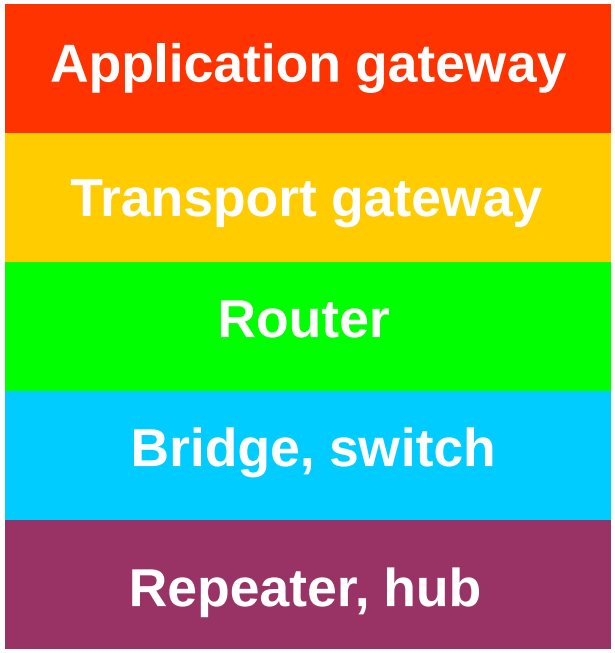

- Devices that shuttle data at different layers
  - Repeaters and hubs
  - Bridges and switches
  - Routers
- Switch protocols and mechanisms
  - Dedicated access and full-duplex transfers
  - Cut-through switching
  - Self learning of the switch table

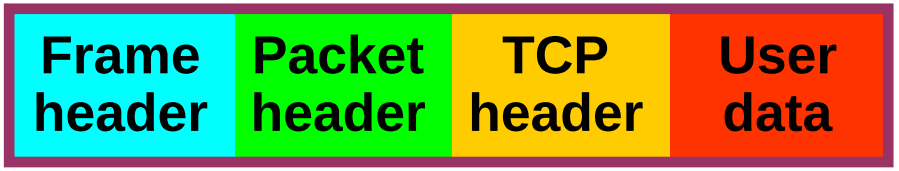
# Message, Segment, Packet, and Frame



# Shuttling Data at Different Layers

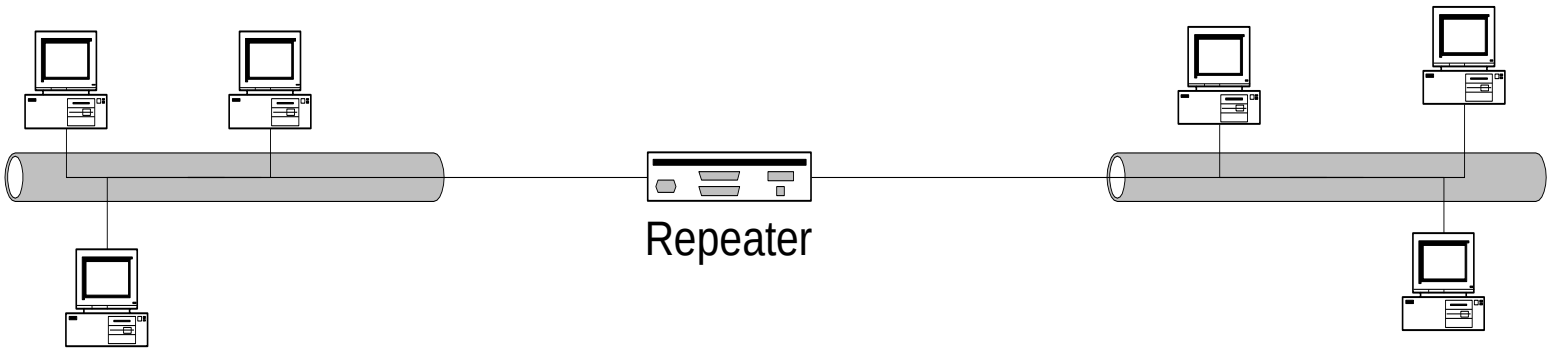
- Different devices switch different things
  - Network layer: packets (routers)
  - Link layer: frames (bridges and switches)
  - Physical layer: electrical signals (repeaters and hubs)



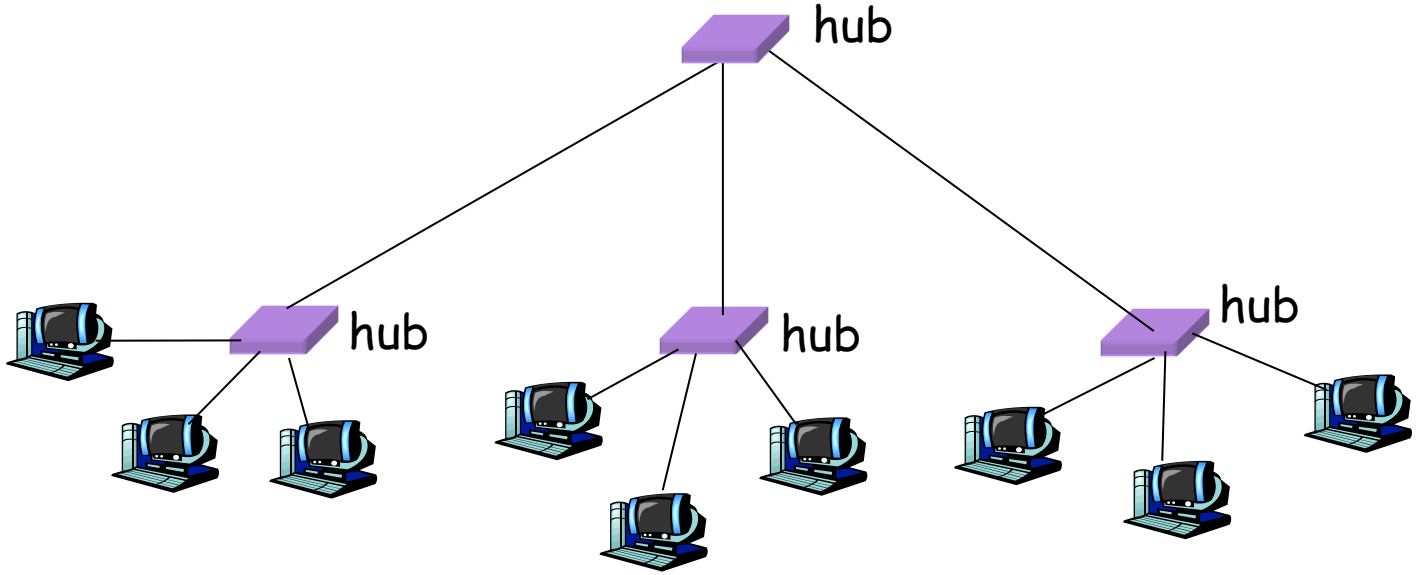
# Physical Layer: Repeaters

- Distance limitation in local-area networks
  - Electrical signal becomes weaker as it travels
  - Imposes a limit on the length of a LAN
- Repeaters join LANs together
  - Analog electronic device
  - Continuously monitors electrical signals on each LAN
  - Transmits an amplified copy



# Physical Layer: Hubs

- Joins multiple input lines electrically
  - Designed to hold multiple line cards
  - Do not necessarily amplify the signal
- Very similar to repeaters
  - Also operates at the physical layer

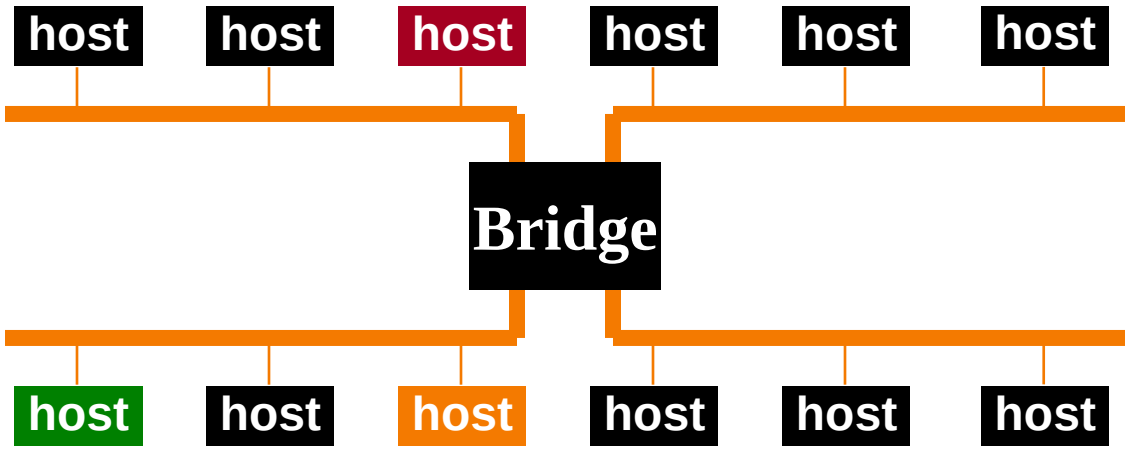


# Limitations of Repeaters and Hubs


- Broadcasting
  - Each bit is sent everywhere
- Cannot support multiple LAN technologies
  - Does not buffer or interpret frames
  - So, can't interconnect between different rates or formats
  - E.g., 10 Mbps Ethernet and 100 Mbps Ethernet
- Limitations on maximum nodes and distances
  - Shared medium imposes length limits (see next lecture)
  - E.g., cannot go beyond 2500 meters on Ethernet

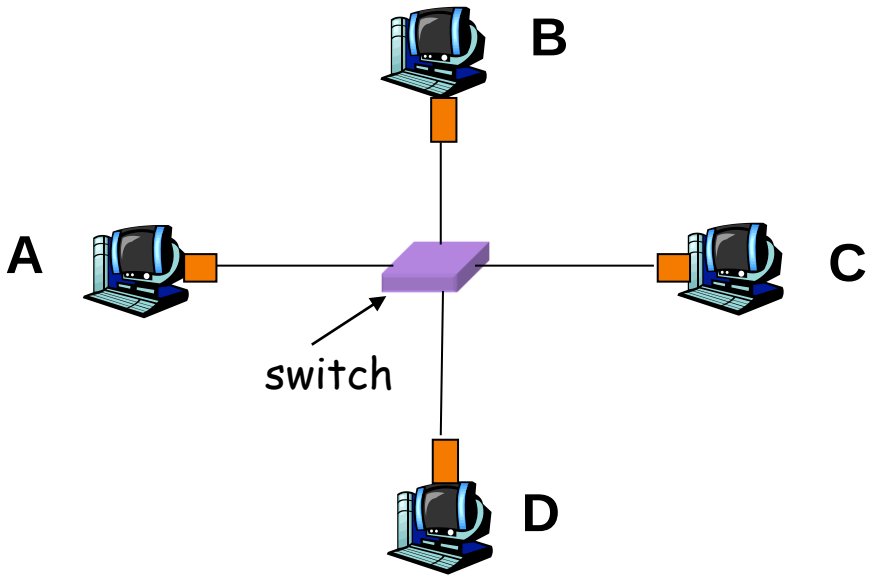
# Link Layer: Bridges

- Connects two or more LANs at the link layer
  - Extracts destination address from the frame
  - Looks up the destination in a table
  - Forwards the frame to the appropriate LAN segment
- Each segment can carry its own traffic



# Link Layer: Switches

- Typically connects individual computers
  - A switch is essentially the same as a bridge
  - … though typically used to connect hosts, not LANs
- Like bridges, support concurrent communication
  - Host A can talk to C, while B talks to D

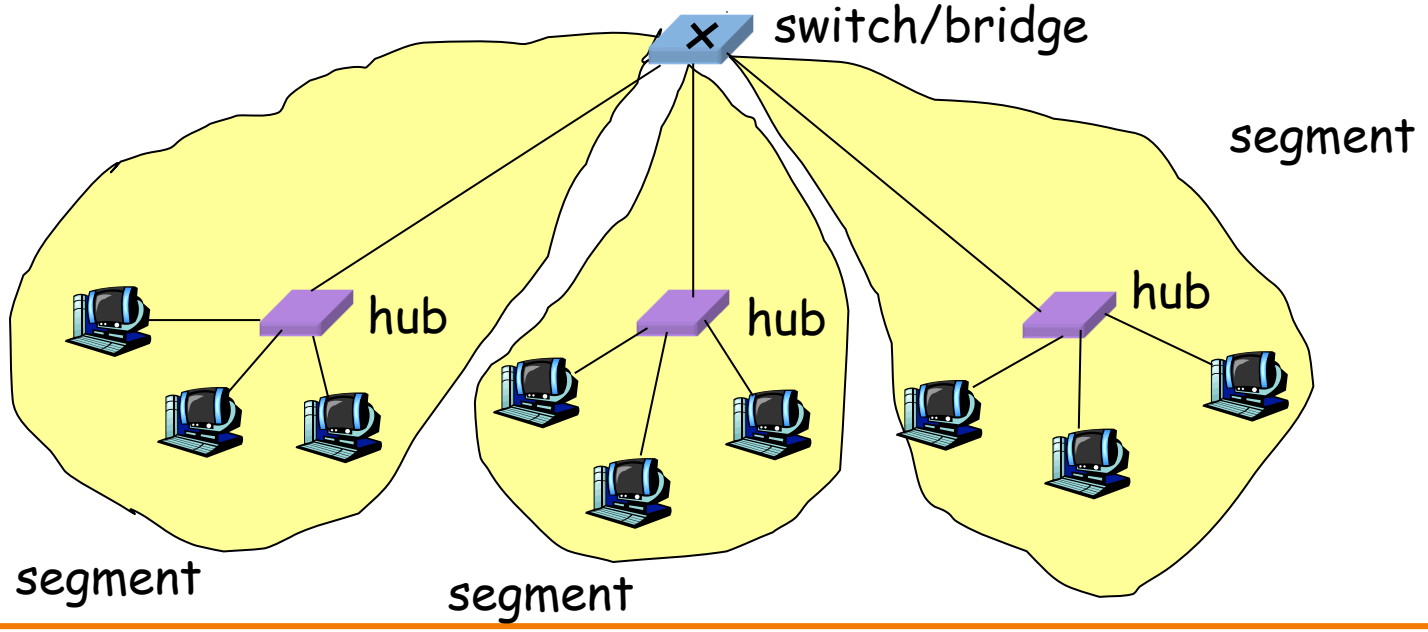


# Dedicated Access and Full Duplex


- Dedicated access
  - Host has direct connection to the switch
  - … rather than a shared LAN connection
- Full duplex
  - Each  connection can send in both directions
  - Host sending to switch, and host receiving from switch
  - E.g., in 10BaseT and 100Base T
- Completely supports concurrent transmissions
  - Each connection is a bidirectional point-to-point link

# Bridges/Switches: Traffic Isolation

- Switch breaks subnet into LAN segments
- Switch filters packets
  - Frame only forwarded to the necessary segments
  - Segments can support separate transmissions



# Advantages Over Hubs/Repeaters

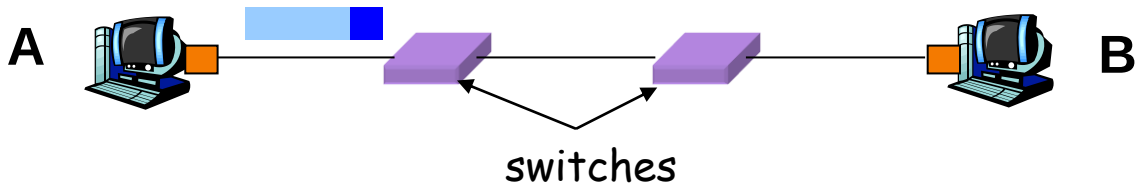

- Only forwards frames as needed
  - Filters frames to avoid unnecessary load on segments
  - Sends frames only to segments that need to see them
- Extends the geographic span of the network
  - Separate segments allow longer distances
- Improves privacy by limiting scope of frames
  - Hosts can “snoop” the traffic traversing their segment
  - … but not all the rest of the traffic
- Can join segments using different technologies

# Disadvantages Over Hubs/Repeaters


- Delay in forwarding frames
  - Bridge/switch must receive and parse the frame
  - … and perform a look-up to decide where to forward
  - Storing and forwarding the packet introduces delay
  - Solution: cut-through switching
- Need to learn where to forward frames
  - Bridge/switch needs to construct a forwarding table
  - Ideally, without intervention from network administrators
  - Solution: self-learning
- Higher cost
  - More complicated devices that cost more money

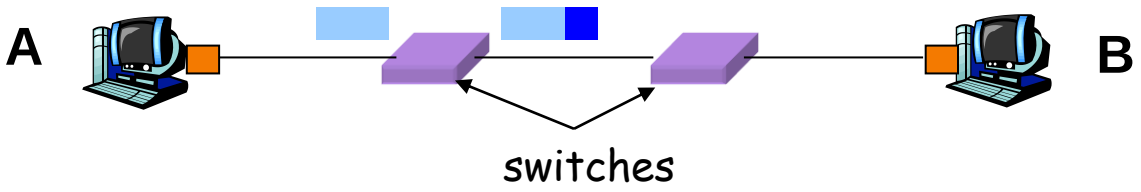
# Motivation For Cut-Through Switching


- Buffering a frame takes time
  - Suppose L is the length of the frame
  - And R is the transmission rate of the links
  - Then, receiving the frame takes L/R time units
- Buffering delay can be a high fraction of total delay
  - Propagation delay is small over short distances
  - Making buffering delay a large fraction of total
  - Analogy: large group walking through NYC



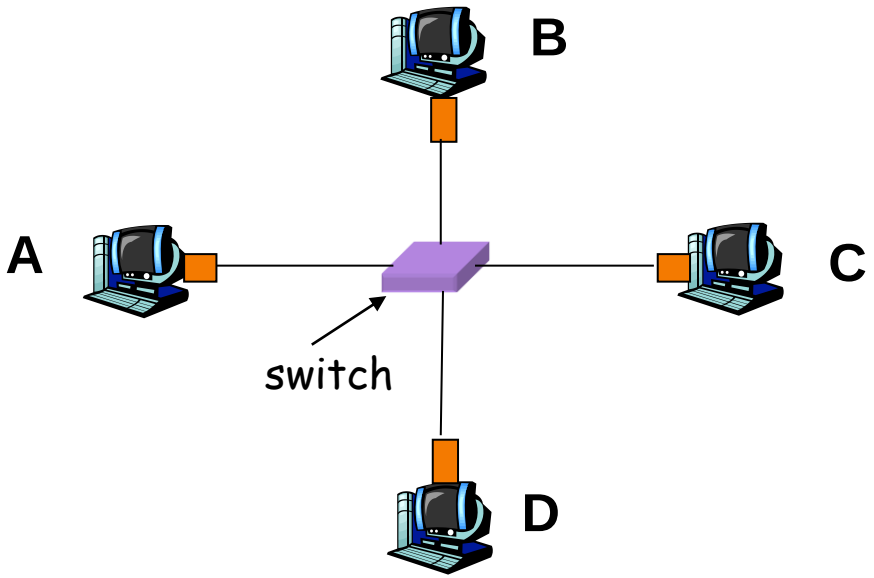
# Cut-Through Switching

- Start transmitting as soon as possible
  - Inspect the frame header and do the look-up
  - If outgoing link is idle, start forwarding the frame
- Overlapping transmissions
  - Transmit the head of the packet via the outgoing link
  - … while still receiving the tail via the incoming link



# Motivation For Self Learning

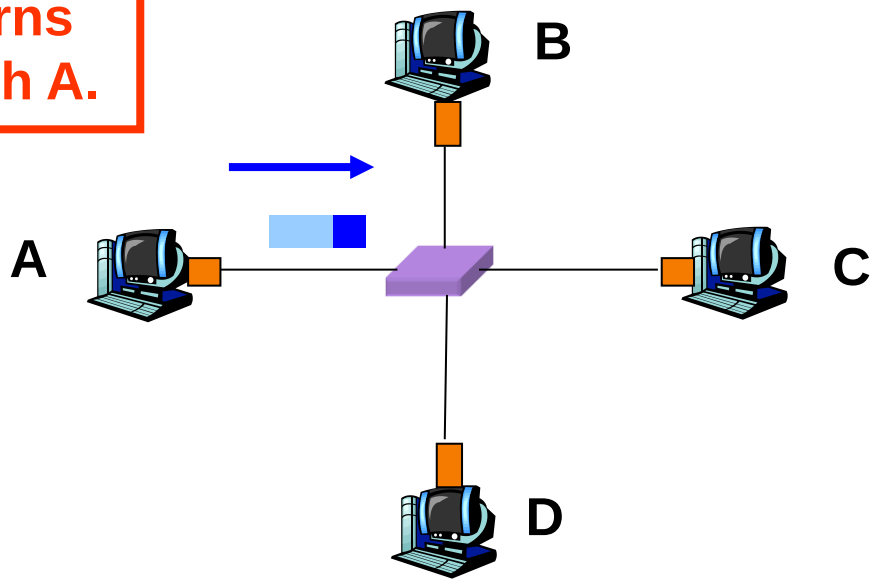
- Switches forward frames selectively
  - Forward frames only on segments that need them
- Switch table
  - Maps destination MAC address to outgoing interface
  - Goal: construct the switch table automatically



# Self Learning: Building the Table

- When a frame arrives
  - Inspect the *source* MAC address
  - Associate the address with the *incoming* interface
  - Store the mapping in the switch table
  - Use a time-to-live field to eventually forget the mapping

**Switch learns how to reach A.**



# Switch Filtering/Forwarding


When switch receives a frame:

index switch table using MAC dest address

**if** entry found for destination
**then{**

**if** dest on segment from which frame arrived
**then** drop the frame

**else** forward the frame on interface indicated

**}**

**else** flood

forward on all but the interface on which the frame arrived

# Comparing Hubs, Switches, Routers


| | Hub/ Repeater | Bridge/ Switch | Router |
|---|---|---|---|
| Traffic isolation | no | yes | yes |
| Plug and Play | yes | yes | no |
| Efficient routing | no | no | yes |
| Cut through | yes | yes | no |