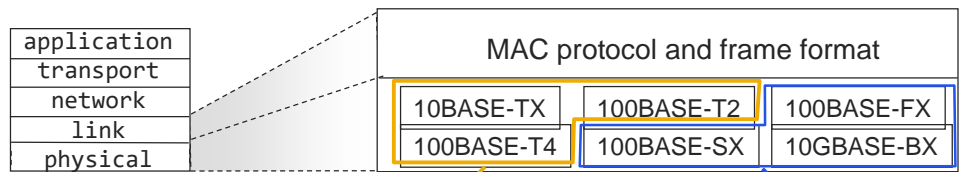
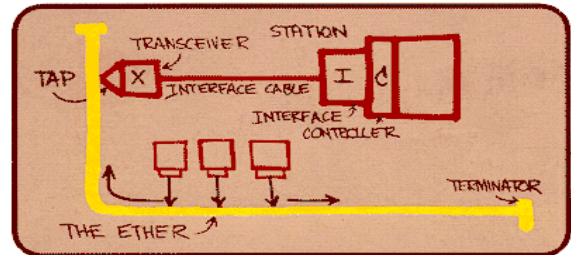


# Ethernet



- “Dominant” wired LAN technology:
  - First widely used LAN technology
  - Simpler, **cheaper** than token LANs and ATM
  - Kept up with speed race:
    - 10 Mbps – 10 Gbps
  - Cheap \$20 for NIC

## Bob Metcalfe's Ethernet sketch



Copper (twisted pair) physical layer

Fiber physical layer

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Mountains & Minds

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# Ethernet



- MTU
  - Standard frame - 1500 bytes
  - Jumbo frame – up to 9000 bytes
- Shared medium cables
- Variants
  - 10BASE-T – two voltages
  - 100BASE-T – three voltages
  - 1000BASE-T – five voltages
  - 1000BASE-X – optical fiber
- Bridges allow mixing of speeds
  - Well-formed packets forwarded to relevant segment
  - Broadcast packets always forwarded

10BASE5



10BASE2



10BASE-T



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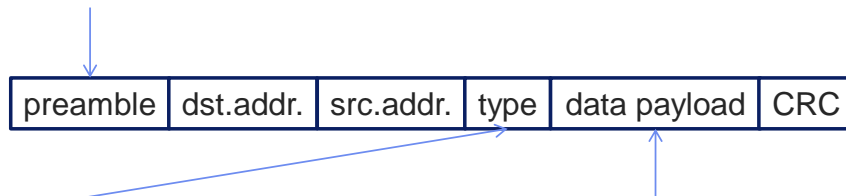
313

# Ethernet frame structure



Preamble:

- 7 bytes with pattern 10101010 followed by one byte with pattern 10101011
- Used to synchronize receiver and sender clock rates



Type (2B) specifies network layer protocol to handle the payload

Sending adapter encapsulates IP datagram (or other network layer protocol packet) in Ethernet frame  
46 – 1500 bytes

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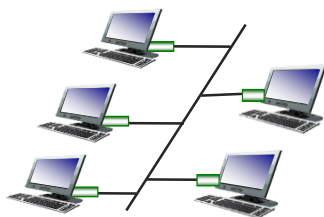
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## Ethernet: physical topology



### Bus

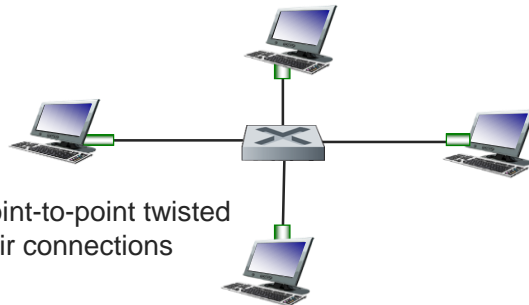
- Popular through mid 90s
- All nodes in same collision domain



Shared coaxial cable

### Star

- Prevails today
- Hub, or switch in the center
- Is this still a broadcast channel?



Point-to-point twisted pair connections

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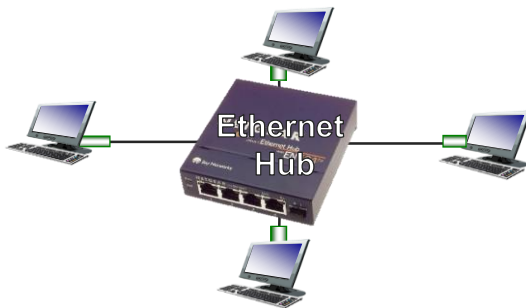
315

# Ethernet hubs versus switches



## Hub

- Packets arriving on one interface are replicated onto the other interfaces
- Not store and forward
  - Collisions are possible
- Hubs boost PHY signal

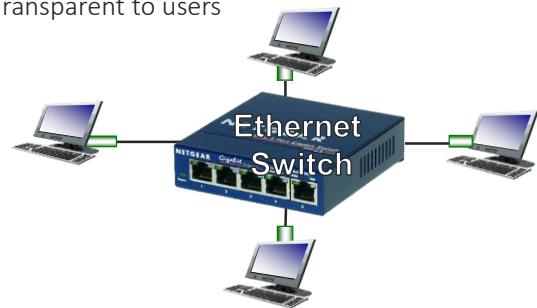


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## Switch

- Packets arriving on an **in** interface are switched onto the appropriate **out** interface
- Store and forward
  - No collisions – full duplex!
  - Different PHY standards and speeds possible on each interface
- Transparent to users



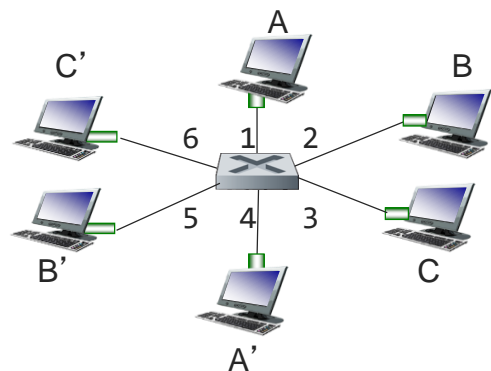
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# Simultaneous transmissions



- Hosts have dedicated, direct connection to switch
- Ethernet protocol used on each incoming link, but no collisions; full duplex
  - Each link is its own collision domain
- Switching: A-to-A' and B-to-B' can transmit simultaneously, without collisions

Switch with six interfaces



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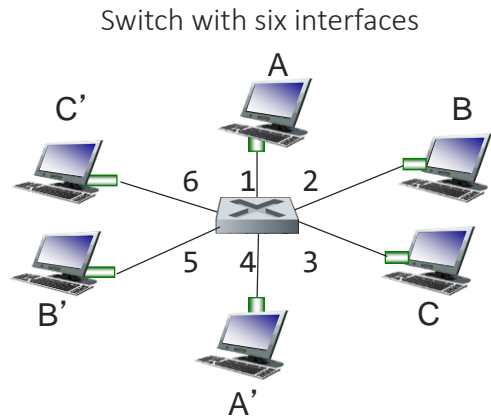
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# Switch forwarding table



- Q: How does the switch know A' is reachable via interface 4, B' reachable via interface 5?
- A: Each switch has a switch table, each entry:
  - <MAC address of host, interface to reach host, time to live>
  - Looks like a routing table!
- Q: When are entries created?



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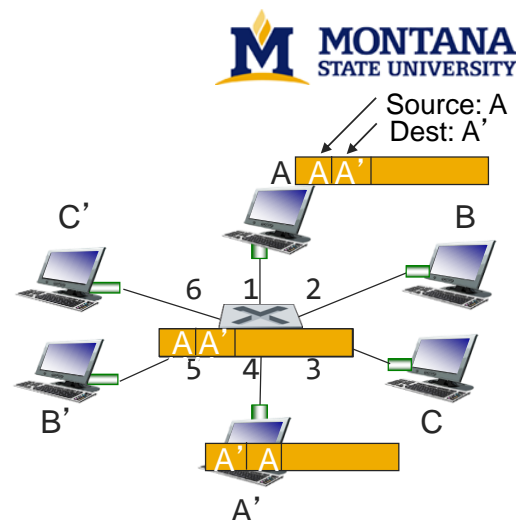
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## An Example

- When frame received at switch:
  - Record MAC address of sending host
  - Look for dest. MAC in switch table
  - if dest. MAC found:
    - if dest. on interface from which frame arrived: drop frame
    - else forward frame on interface from table
    - else flood
- Frame destination, A', location unknown:
  - Flood frame on all other interfaces
- Destination A location known
  - Selectively send over just one link

Why?



MAC addr	interface	TTL
A	1	60
A'	4	60

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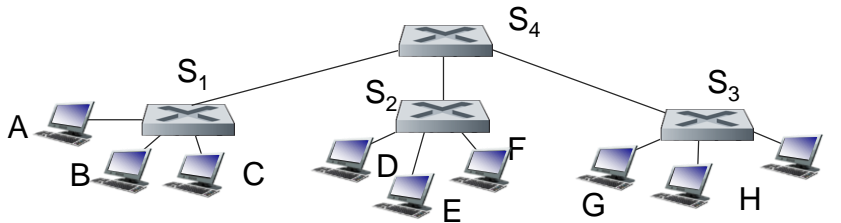
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## Interconnecting switches



- Switches can be connected together



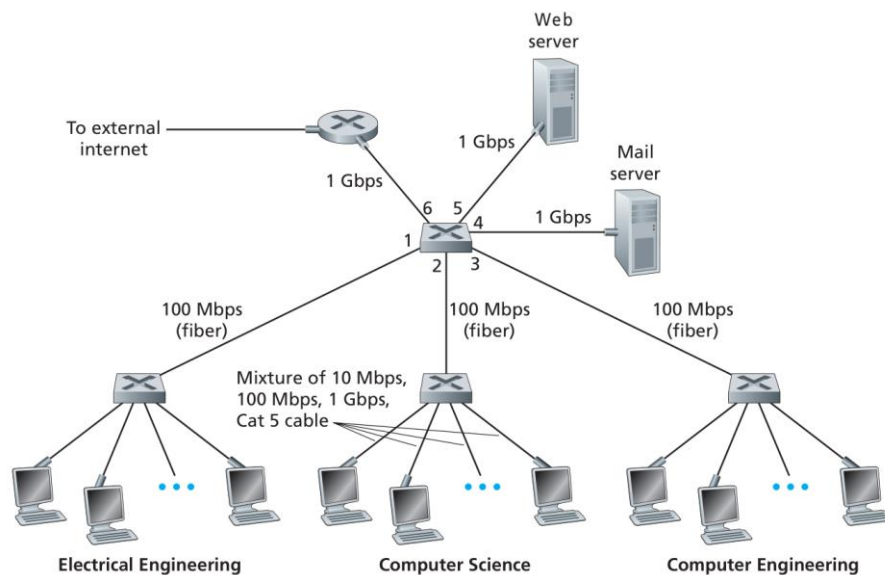
- Q: sending from A to G - how does S1 know to forward frame destined to G via S4 and S3?
- A: self learning! (works exactly the same as in single-switch case!)

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## Institutional network



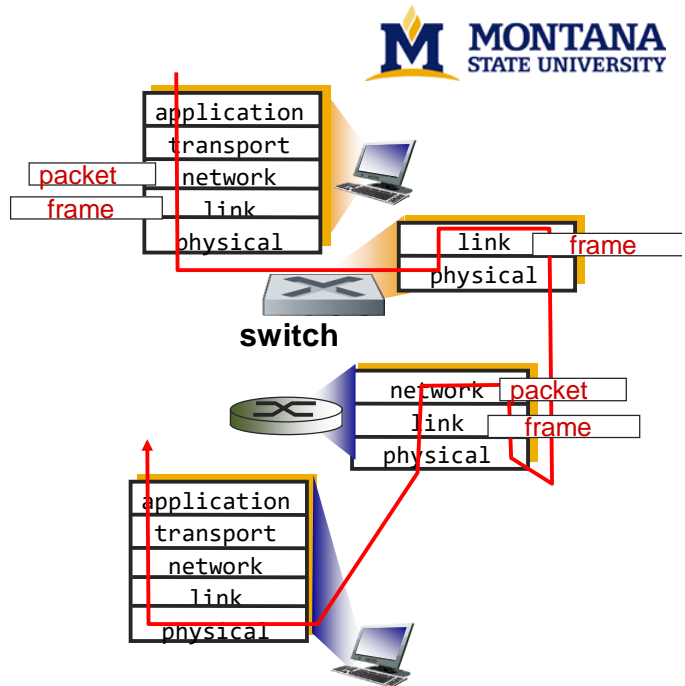
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# Switches vs. routers

- Both are store-and-forward:
  - Routers: network-layer devices (examine network-layer headers)
  - Switches: link-layer devices (examine link-layer headers)
- Both have forwarding tables:
  - Routers: compute tables using routing algorithms, IP addresses
  - Switches: learn forwarding table using flooding, MAC addresses
- What about:
  - Path reliability?
  - Forwarding speed?
  - Network scalability?



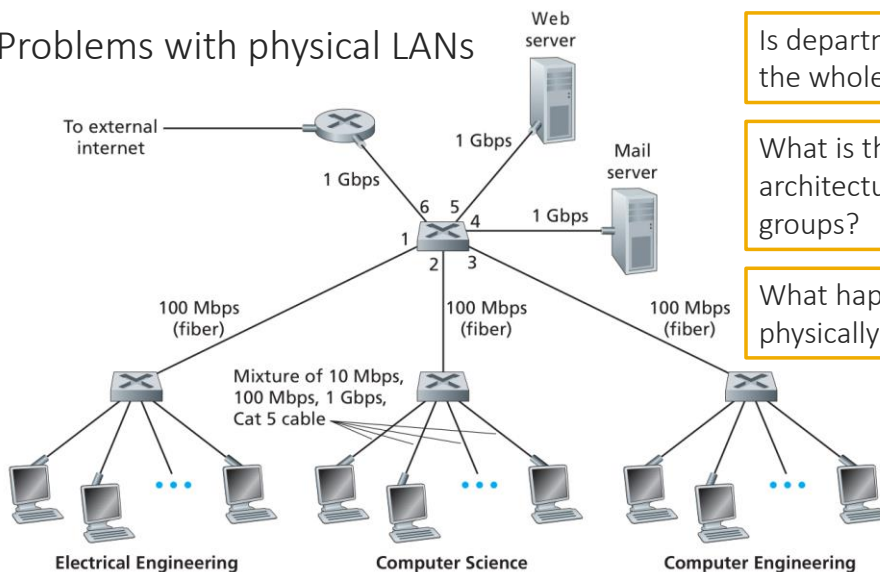
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# Virtual LANs (VLANs)

## Problems with physical LANs



Is departmental traffic broadcast to the whole network?

What is the downside of this architecture if we have many small groups?

What happens when a user physically moves between groups?

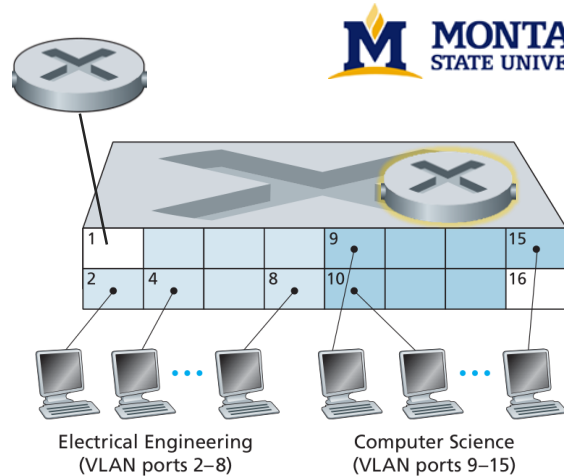
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## Virtual LANs (VLANs)

- Multiple VLANs defined over a single switch
- Network manager assigns groups of ports to different subnets
- Each group of ports acts as an independent switch
  - Own broadcast domain
  - Own switching table
- How to send data between EE and CS departments?
  - Have a separate router
  - Built-in router



- Benefits:
  - No longer broadcasting to the whole network. Why?
  - No separate switch for each subnet
  - Easy to move users between groups. How?

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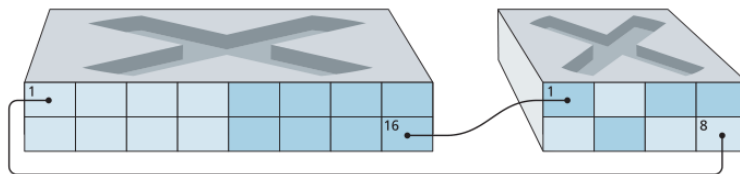
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## VLAN trunking



How to set up a subnet that spans multiple buildings?



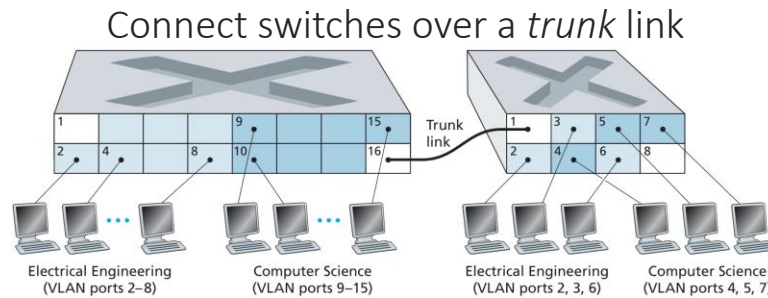
But now we need a cable spanning the buildings for each subnet

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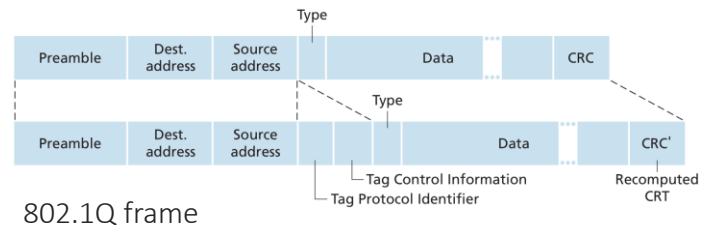
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# VLAN trunking



How to direct a frame from a trunk line to the correct broadcast domain?

VLAN tag {  
 TPID – fixed 81-00 – Why?  
 TCI – 12-bit VLAN ID and 3 bit priority



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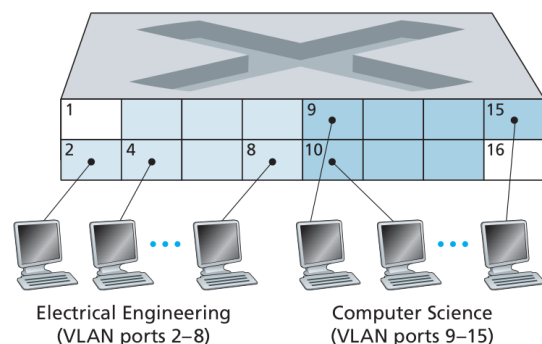
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## Virtual LANs (VLANs)



- Port-based VLANs
  - Network manager assigns groups of ports to different subnets
- MAC-based VLANs
  - MAC addresses assigned to different groups (regardless of the port to which they connect)
- Network-protocol VLANs
  - IPv4, and IPv6 traffic could be sent to different VLANs



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