Introduction: WANs and Routing

- LANs are limited in distance although a LAN can be extended using techniques such as a repeater or a bridge.
- LAN's, even extended LANs, can not handle arbitrarily many computers.
  - Shared medium does not scale
  - LAN protocols typically do not scale
- Need other technologies for larger networks.

Characterizations of Networks

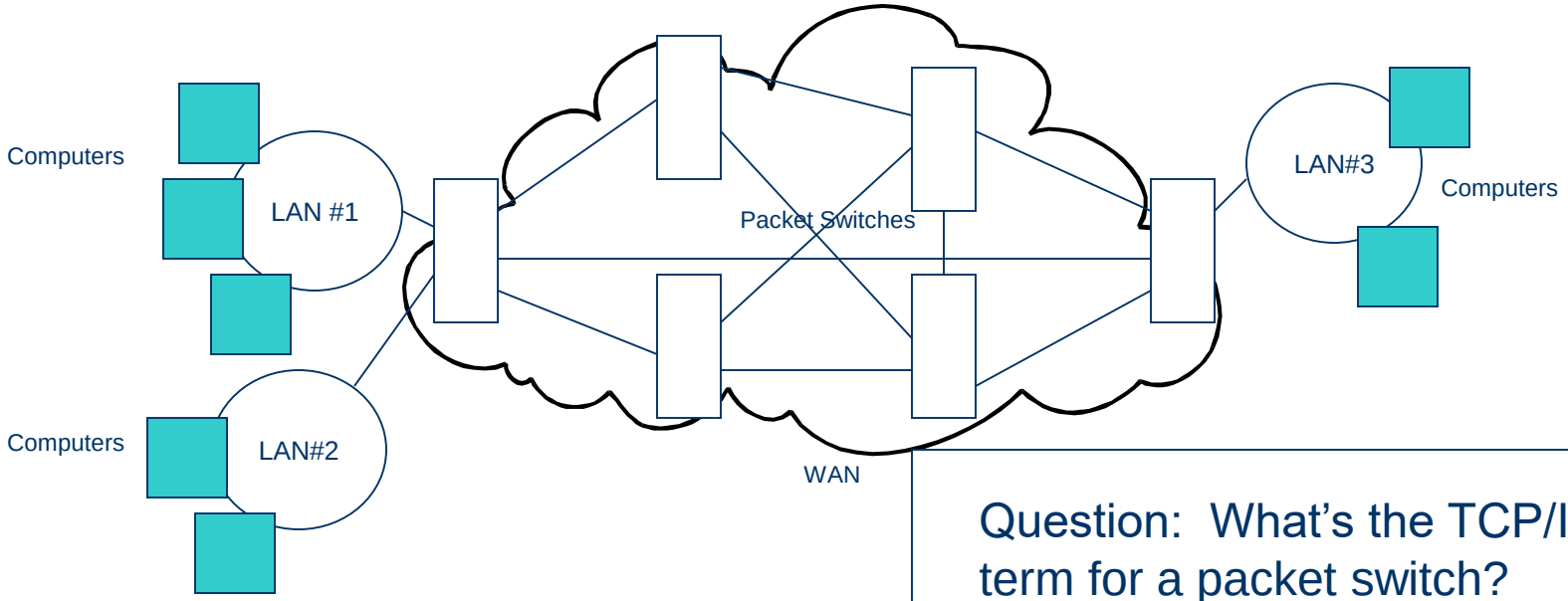
- *Local Area Network* (WAN) - single building
- *Metropolitan Area Network* (MAN) - single city
- *Wide Area network* (WAN) - country, continent, planet

Packet Switches

- To span long distances or many computers, network must replace *shared medium* with *packet switches.*
  - Each switch moves *packets* from one connection to another (rather than entire frames like a repeater or a bridge).
  - A small computer with network interfaces, memory and program dedicated to packet switching function.

Packet Switches

- Packets switches may connect to computers and to other packet switches
- Technology details depend on desired speed
- Packet switches linked together form a Wide Area Network (WAN).

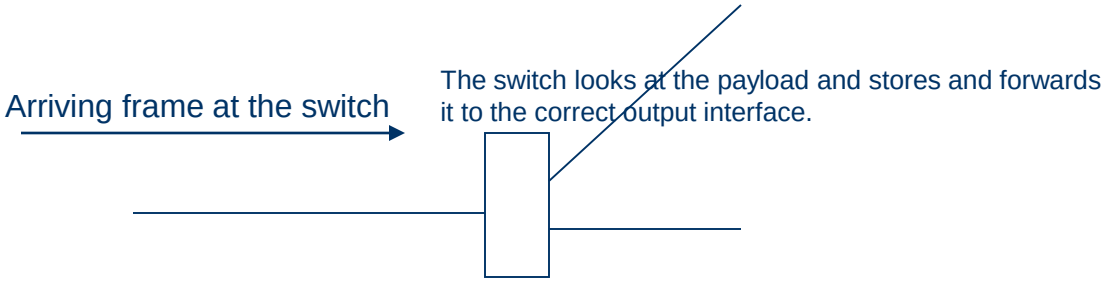


Question: What's the TCP/IP term for a packet switch?

Store and Forward

- Data delivery from one computer to another is accomplished through *store-and-forward* technology
  - Packet switch *stores* incoming packet
  - ... and *forwards* the packet to another switch or computer
- Packet switch has internal memory
  - Can hold packet if outgoing connection is busy
  - Packets for each connection held on queue

Frame src/dst address
Frame payload (i.e., the packet)
- •Sender's address and port
- •Receiver's address and port
- •Type of packet (TCP/UDP/ICMP)
- •TCP/UDP/ICMP header and data

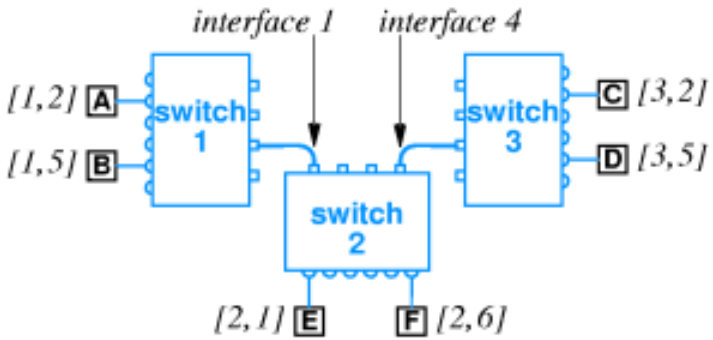


Next-Hop Forwarding

- Packet switch must choose outgoing connection for forwarding
  - If destination is local computer, packet switch forwards to the local network.
  - If destination is attached another switch, this packet switch forwards to the *next hop* by transmitting the packet over the correct output interface.
- Choice based on destination address in packet or, as in our example, based on the destination MAC address.

Choosing the Next-Hop

- Packet switch doesn't keep complete information about all possible destination, instead it just keeps next the hop information.
- So, for each packet, packet switch looks up destination in table and forwards the packet to the next hop.
- Example below: Figure b is the forwarding table for switch 2.



(a)

destination	next hop
[1,2]	interface 1
[1,5]	interface 1
[3,2]	interface 4
[3,5]	interface 4
[2,1]	computer E
[2,6]	computer F

(b)

In this example, the switch is forwarding based on the MAC address. Each WAN port has a hierarchical physical address: address(i,j) where I identifies the switch and j identifies the interface in the switch. We will see how this works in TCP/IP.

Routing

- Process of forwarding is a component of *routing.*
- Information is kept in a forwarding or *routing table.*
- Routing protocols are used to populate the routing tables with correct information.
- Note that many entries have same next hop.
- FYI: Internet routing tables have > 100000 entries!!