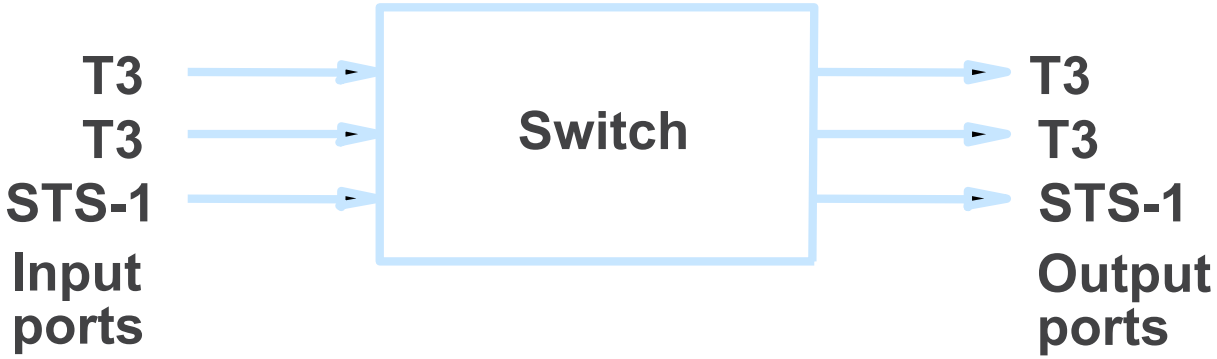
Overview

- Store-and-Forward Switches
  - Direct link network technologies do not scale. You cannot add all the nodes in the world into a single direct link network.
    - If all the nodes in the world were to broadcast, then there is chaos.
    - If all the nodes in the world are in a switched network, then each node will get infinitesimally small quanta
    - If all the nodes in the world were using point-to-point, then we need to run a whole bunch of wires between each node
- Solution: Partition the network into multiple zones and connect each one using a switch. The switch will forward packets from input to output. Only packets that need to be forwarded are sent; local packets are not forwarded

Scalable Networks

- Switch
  - forwards packets from input port to output port
    - Each input/output can use different “direct link network”
  - port selected based on address in packet header



- Advantages
  - cover large geographic area (tolerate latency)
  - support large numbers of hosts (scalable bandwidth)

Design goals

- Switches should increase aggregate throughput
- Switches look inside the packet to decide which output port it should place the packet in
  - Switches look at the destination address
- Switches number input and output ports so that they know where to send the packet
- Switching strategies:
  - Datagram: packet carries enough information, along with forwarding/routing tables
  - Virtual circuit: connection establishment phase
  - Source routing: packet carries the routing table

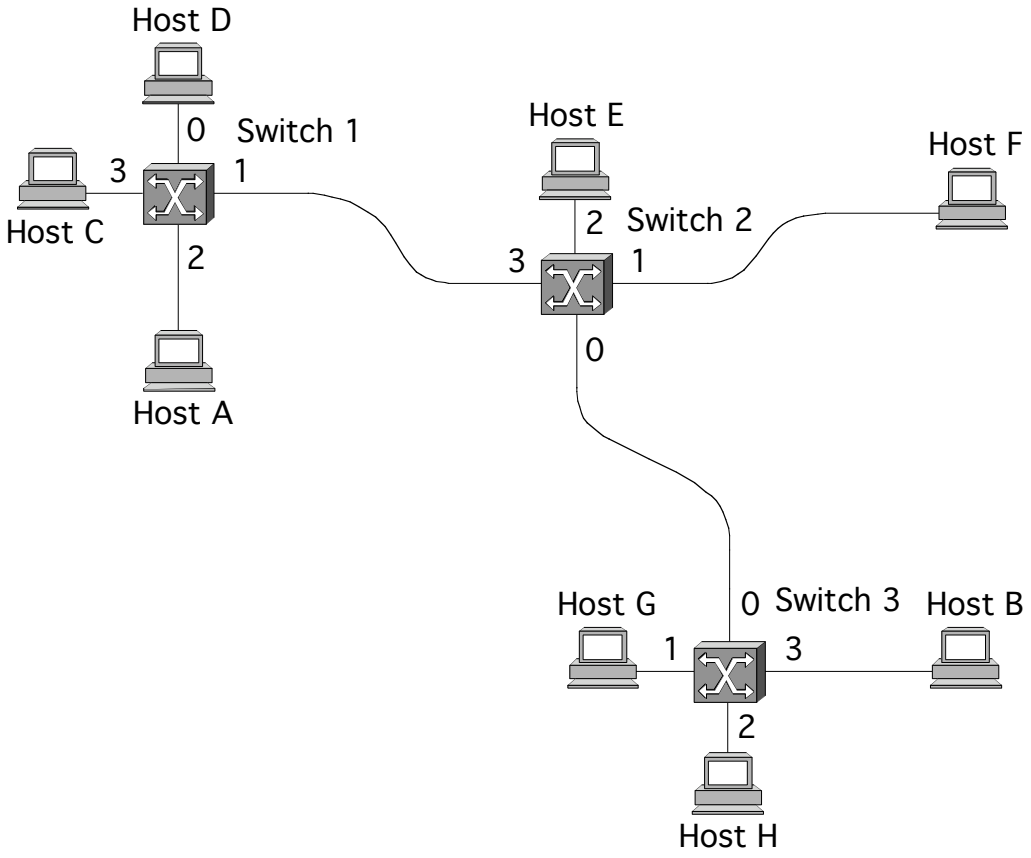
Datagram Switching

- No connection setup phase
- Each packet forwarded independently
- Sometimes called connectionless model

Analogy: postal system

Each switch maintains a forwarding (routing) table

- Routing table for switch 2: A->3, B->0, C->3, D->3….



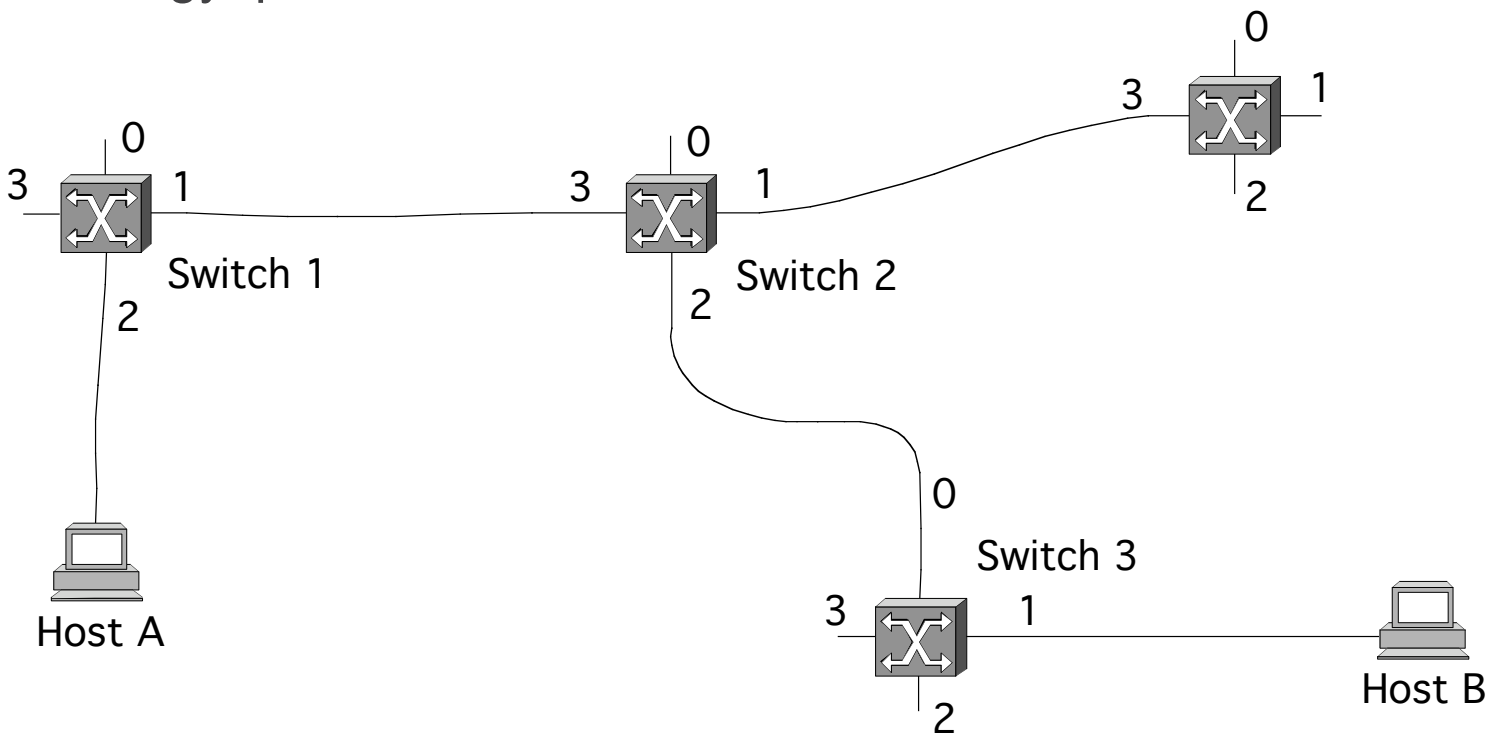
Datagram Model

- There is no round trip time delay waiting for connection setup; a host can send data as soon as it is ready
- Source host has no way of knowing if the network is capable of delivering a packet or if the destination host is even up.
- Since packets are treated independently, it is possible to route around link and node failures
- Since every packet must carry the full address of the destination, the overhead per packet is higher than for the connection-oriented model

Virtual Circuit Switching

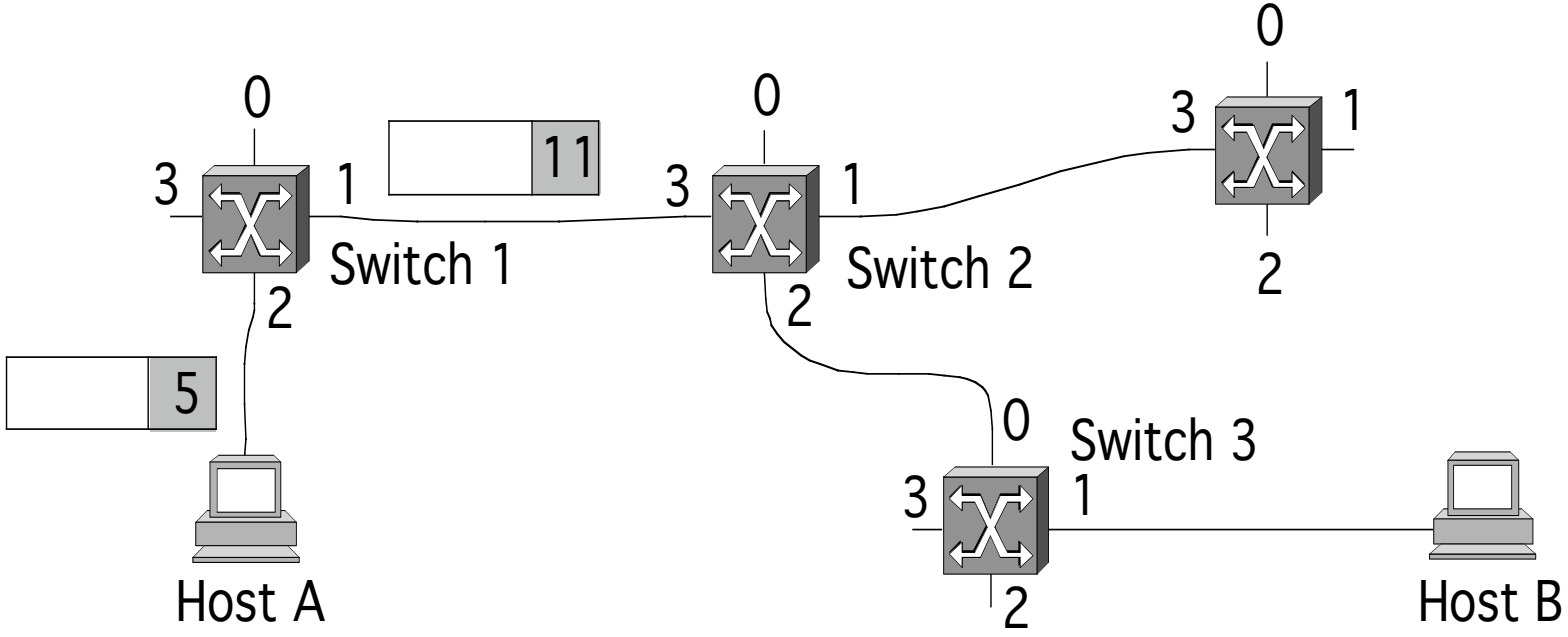
- Explicit connection setup (and tear-down) phase
- Subsequence packets follow same circuit
- Sometimes called connection-oriented model

- Analogy: phone call



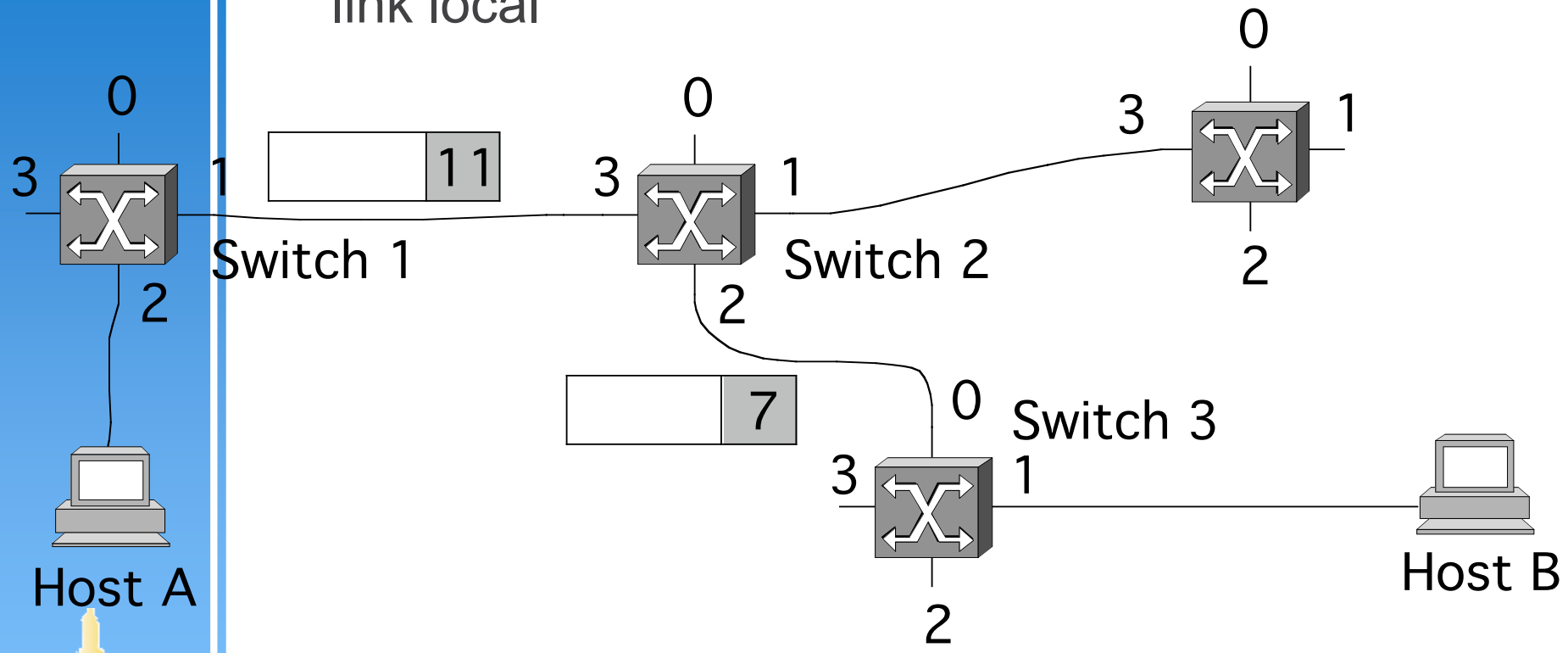
Message from Host A to Host B

- Each switch maintains a VC table
  - Incoming port 2, Incoming VC 5, Outgoing Interface 1, Outgoing VC 11



Message from Host A to Host B

- Virtual circuit numbers are unique per link - I.e., link local

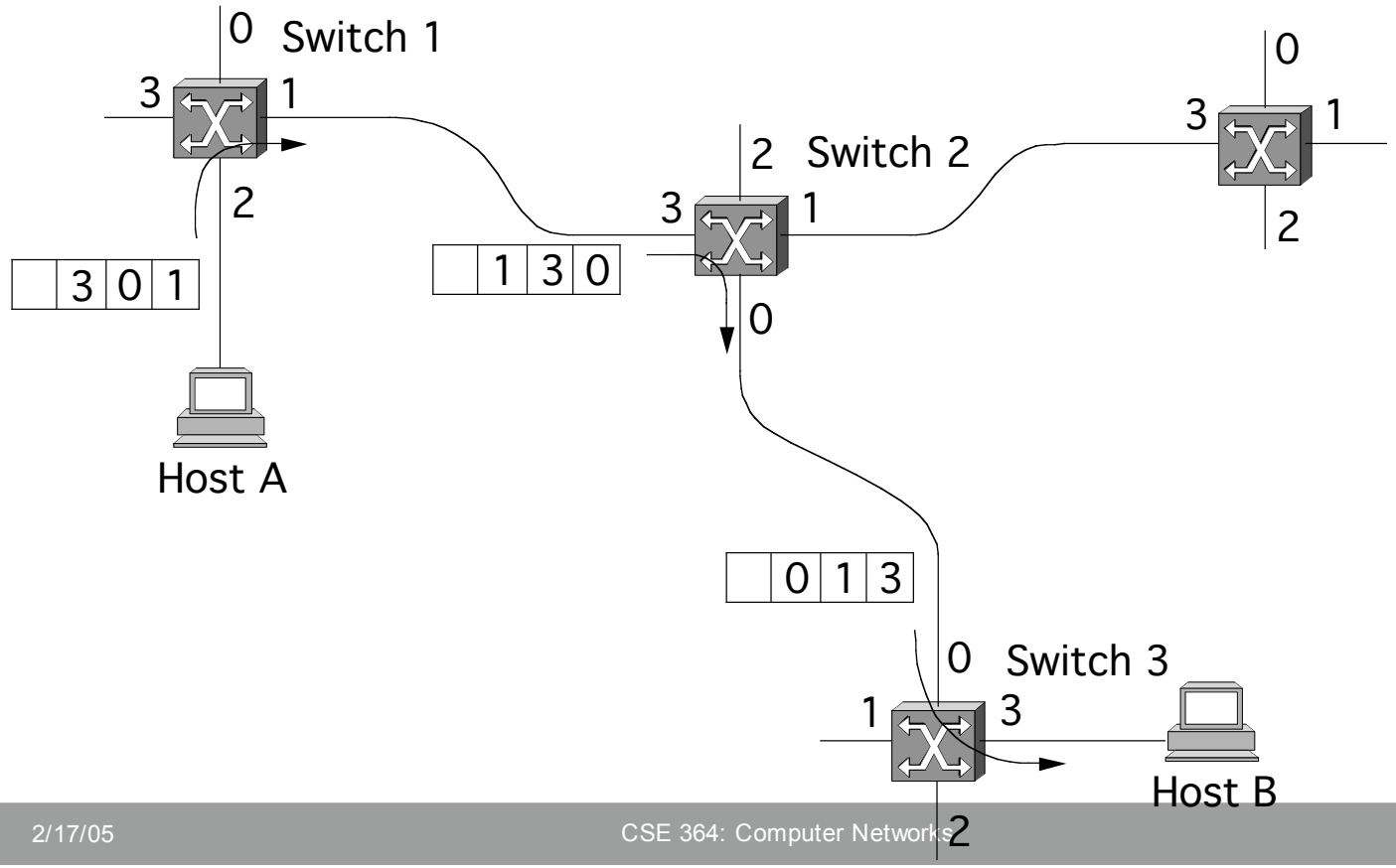


Virtual Circuit Model

- Typically wait full RTT for connection setup before sending first data packet.
- While the connection request contains the full address for destination, each data packet contains only a small identifier, making the per-packet header overhead small.
- If a switch or a link in a connection fails, the connection is broken and a new one needs to be established.
- Connection setup provides an opportunity to reserve resources.

Source Routing

- Each packet carries the routing information
  - Source host knows the exact route
  - Doesn't scale, but reduces state in switch
- Node rotate the address

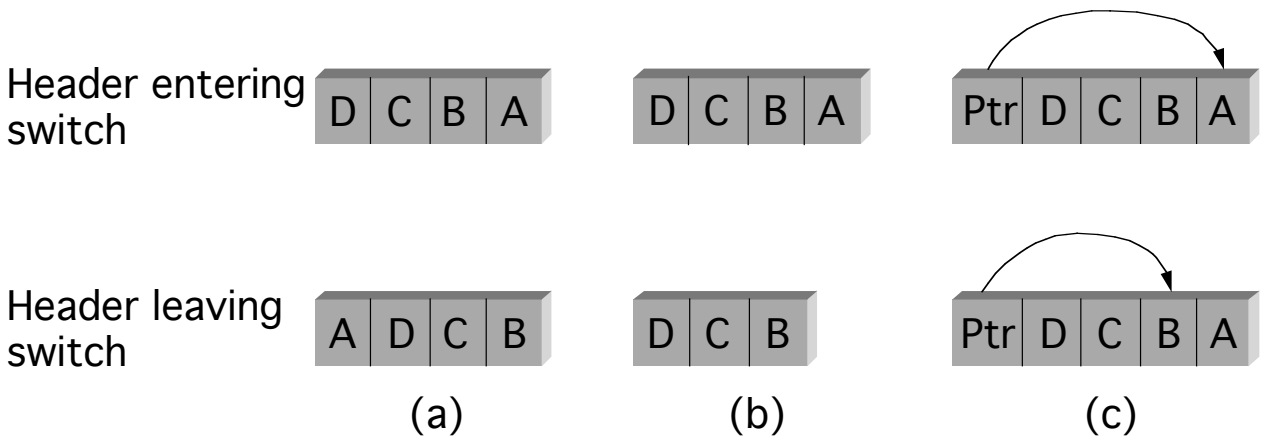


Maintaining the source route

A. rotation of route
   - We will know the reverse path

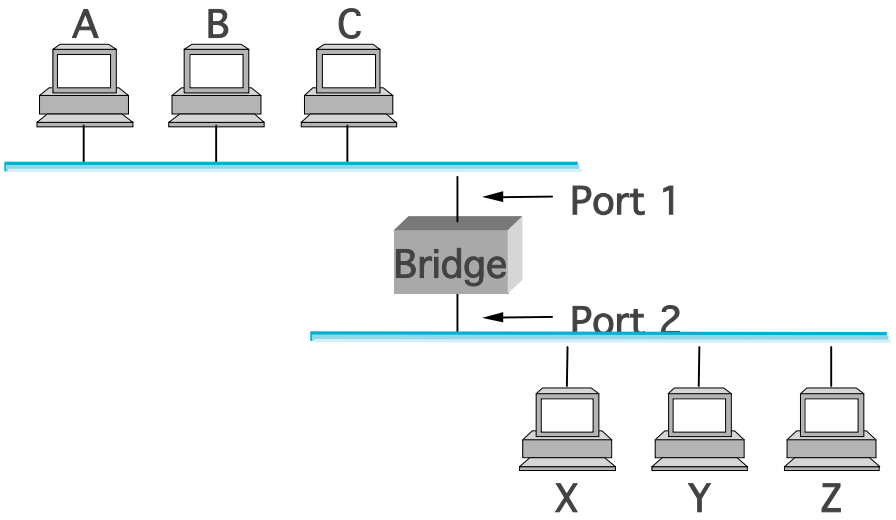
B. Stripping
   - Packets become smaller

C. Pointer
   - Each router updates the pointer



Bridges and Extended LANs

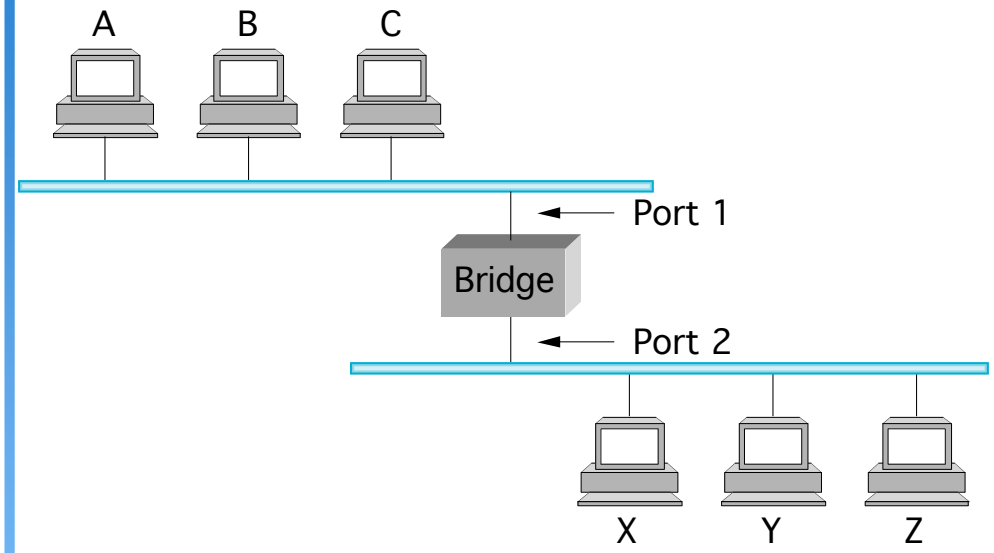
- LANs have physical limitations (e.g., 2500m)
- Connect two or more LANs with a bridge
  - accept and forward strategy
  - level 2 connection (does not add packet header)



- Ethernet Switch = Bridge on Steroids

Learning Bridges

- Do not forward when unnecessary
- Maintain forwarding table



Host	Port
A	1
B	1
C	1
X	2
Y	2
Z	2

- Learn table entries based on source address
- Table is an optimization; need not be complete
- Always forward broadcast frames

Lab setup

- Gateway13-18 are connected to a 8-port Gigabit switch. Itanium servers are connected to a 5 port gigabit switch. The uplink from the 5 port switch is connected to the 8-port switch. The uplink from the 8-port switch is connected to another switch which is connected to ND