

CISC 7332X T6  
C13a: Packet Switching

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# Acknowledgements

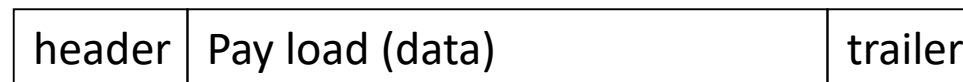
- Some pictures used in this presentation were obtained from the Internet
- The instructor used the following references
  - Larry L. Peterson and Bruce S. Davie, *Computer Networks: A Systems Approach*, 5th Edition, Elsevier, 2011
  - Andrew S. Tanenbaum, *Computer Networks*, 5th Edition, Prentice-Hall, 2010
  - James F. Kurose and Keith W. Ross, *Computer Networking: A Top-Down Approach*, 5th Ed., Addison Wesley, 2009
  - Larry L. Peterson's (<http://www.cs.princeton.edu/~llp/>) Computer Networks class web site

# Design Issues

- Store-and-forward packet switching
- Connectionless service (datagrams)
- Connection-oriented service (virtual circuits and source routing)
- Comparison of virtual-circuits and datagrams
- Source routing

# Packet-switched Networks

- Data are divided and sent using *packets*
  - A packet has a header and trailer which contain control information
    - *e.g., destination and source addresses*
- *Store-and-forward*
  - Each packet is passed from node to node along some path through the network
  - At each node, the entire packet is received, stored briefly, and then forwarded to the next node



A packet

# Switching Approaches

- Datagram switching
  - Connectionless service
- Virtual circuit switching
  - Connection-oriented service
- Source routing

# Datagram Packet Switching

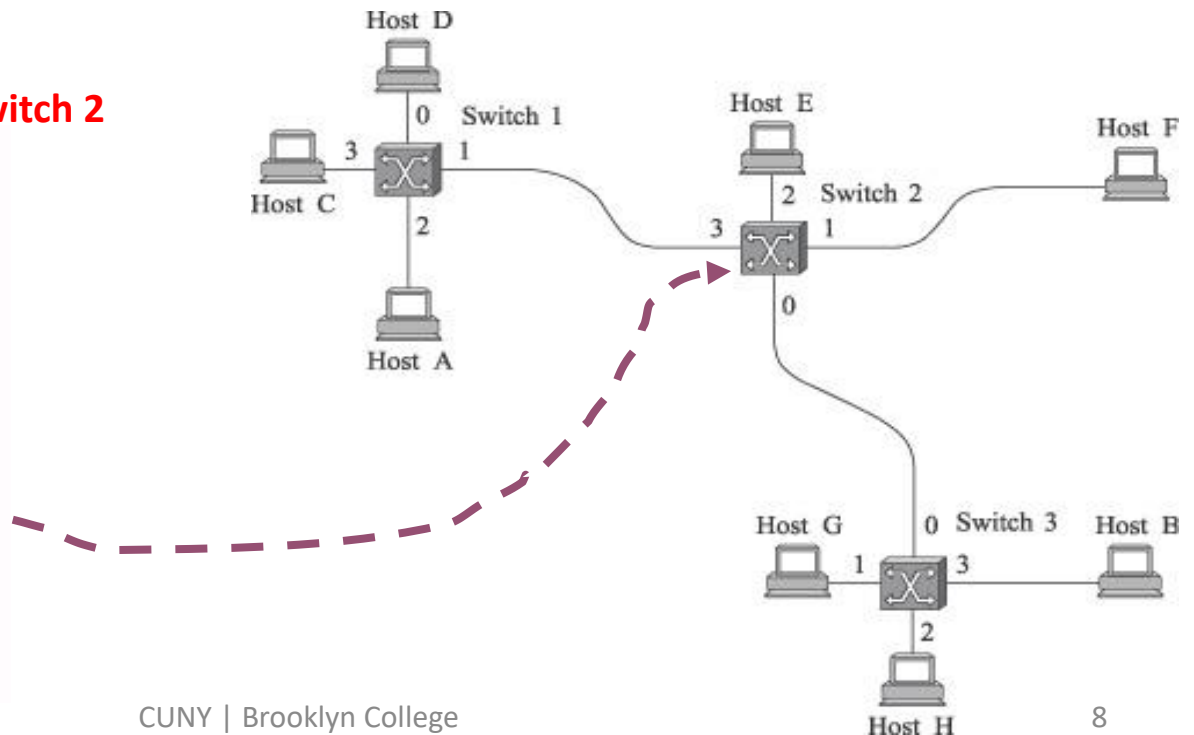
- Network nodes process each packet independently
- Two consecutively-sent packets can take different routes.
- Implications:
  - A sequence of packets can be received in a different order than they were sent
  - Each packet header must contain full address of the destination
- Example of networks using packet switching
  - Extended Ethernet LAN, a data link layer protocol
  - The Internet Protocol, a network layer protocol

# Datagram Switching

- Each switch maintains a forwarding table
- Frame header contains the identifier of destination node
- Forward packets/frames based on the table
  - Example: if frame header indicates its destination is node B, forward to port 0 → done by looking up the table

Forwarding/Routing Table for **Switch 2**

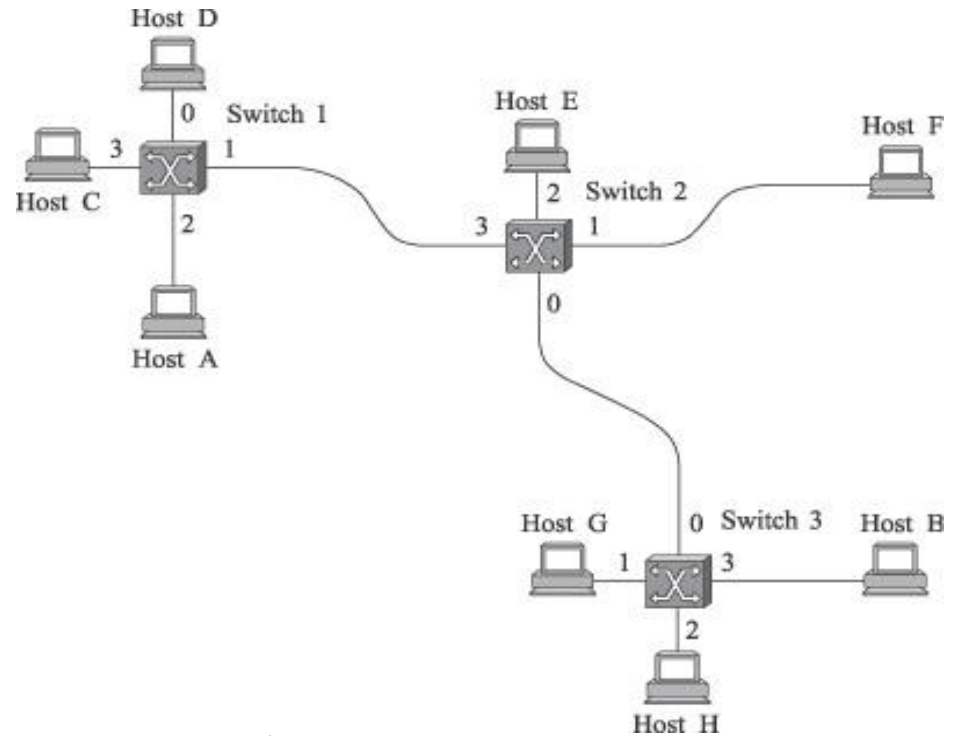
Destination	Port
A	3
B	0
C	3
D	3
E	2
F	1
G	0
H	0



# Quick Exercise C13a-1

Forwarding/Routing Table for Switch 2

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



- Construct the forwarding tables for **other** switches (switches 1 & 3)



# Datagram Switching: Discussion

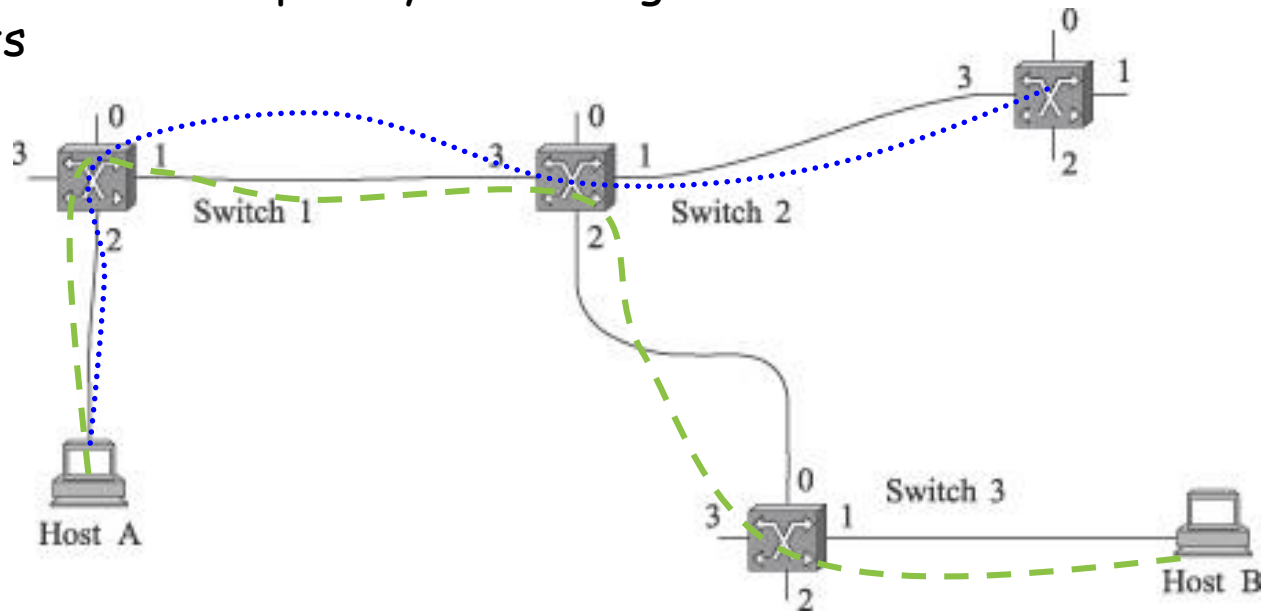
- Each node maintains a forwarding table
- No connection setup
- Hosts/switches sends/forwards packets independently
- Hosts/switches do not know if the network can deliver a packet to its destination
- A switch/link failure might not be catastrophic
  - Find an alternate route and update forwarding table

# Virtual Circuit Switching

- Connection-oriented model
  - Connection setup → establish “virtual circuit (VC)”
  - Data transfer → subsequent packets follow same circuit
  - Tear down VC
- Each switch maintains a VC table
  - An entry (row) in VC table must have
    - VCI: identify connection at this switch within a link → a different VCI will be used for outgoing packets
    - Incoming interface, e.g., a port for receiving packets
    - Outgoing interface, e.g., a port for forwarding packets
- Frame header contains VC number (VCI value) of next link along a VC

# Virtual Circuit Switching: Example

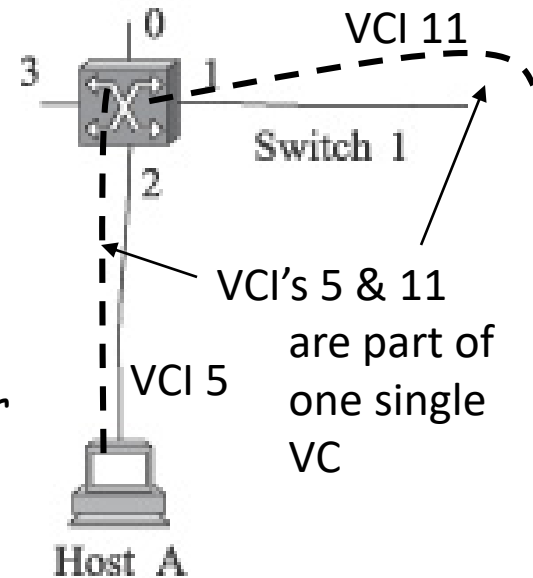
- Example: host A → host B
  - Switches needed? Switches 1, 2, and 3
  - Network do not explicitly maintain global information about virtual circuits



Two planned virtual circuits in dashed/dotted lines

# Virtual Circuit Switching: Example: VC Table

- Setup phase (could be performed manually for a network administrator) → permanent VC → Establish VC table for each switch
- Example: Switch 1
  - When host A sends out a frame, it places the VCI (i.e. 5) of next link into the frame header
  - Switch 1 looks up an entry based on both incoming interface (i.e., 2) and the VCI (i.e., 5) in the frame header to determine outgoing port (i.e., 1) and VCI (i.e., 11)
  - The scope of VCI values is links
    - Unused VCI value on the link (Host A to Switch 1)
    - VCI can be duplicated on different link



Virtual circuit table entry for **switch 1**

Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5	1	11

# Virtual Circuit Switching: Example: VC Table

Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5	1	11

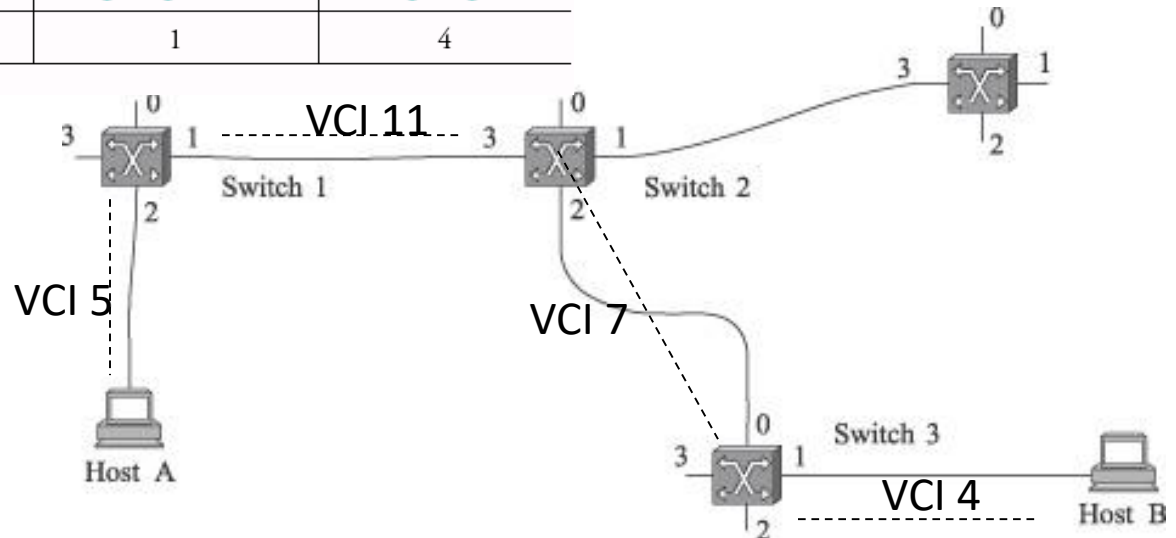
Virtual circuit table entry for switch 1

Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11	2	7

VC table entry at switch 2

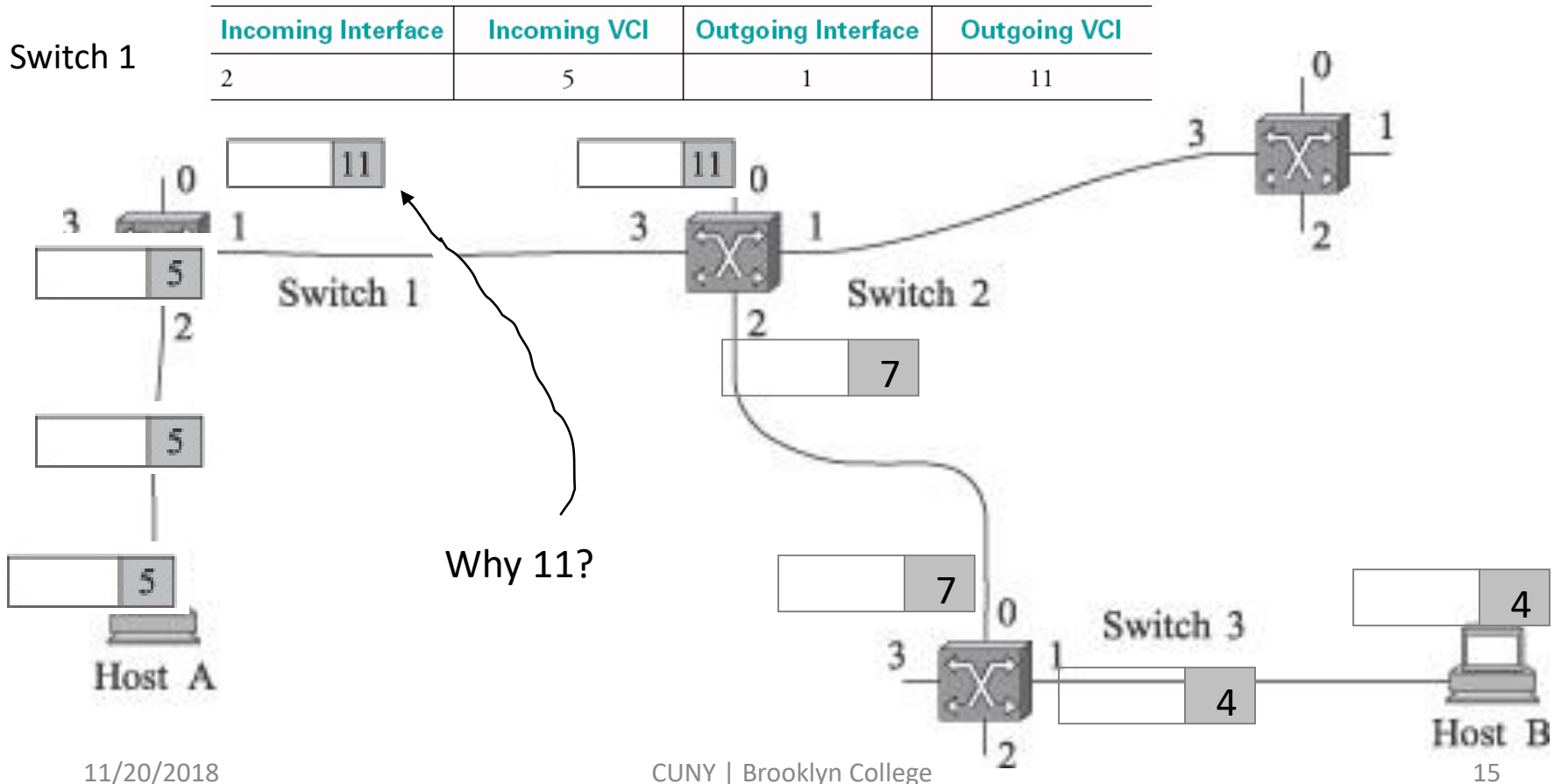
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7	1	4

VC table entry at switch 3



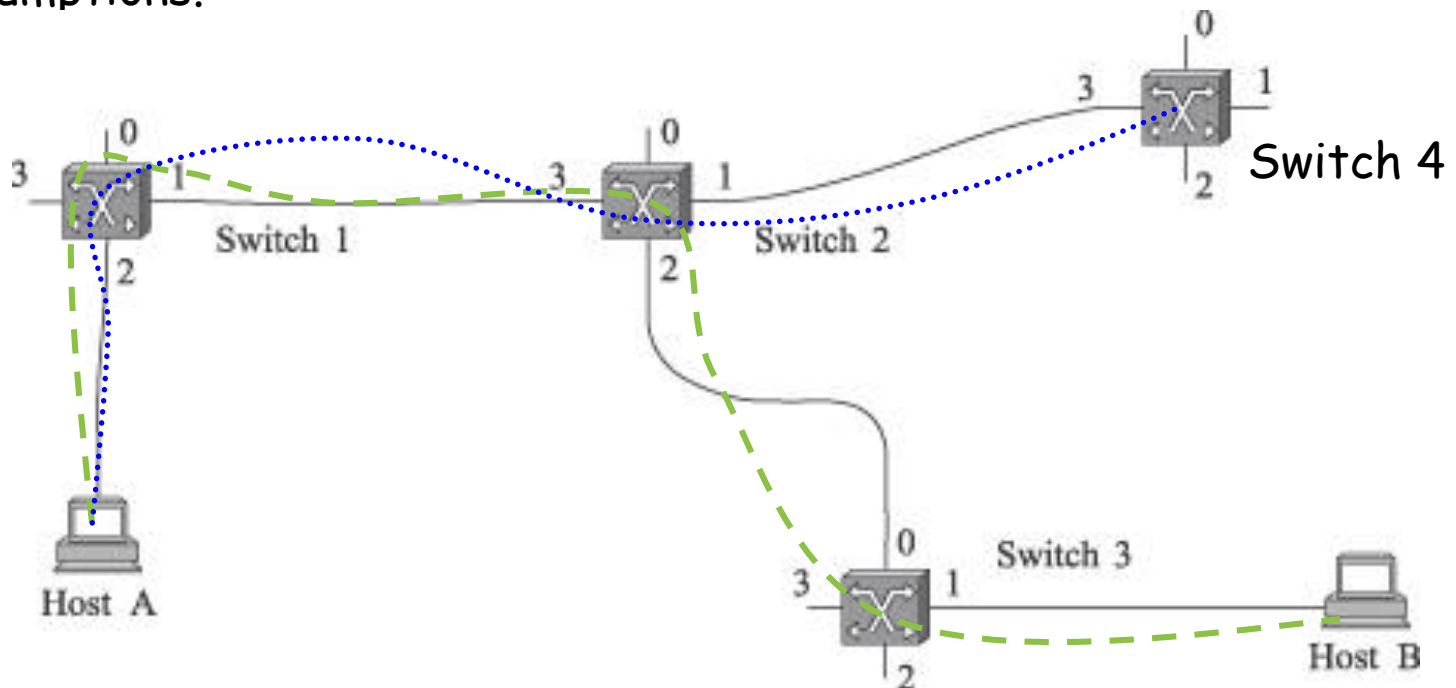
# Virtual Circuit Switching: Example

- Host A sends a frame to host B



# Quick Exercise C13a-2

- Construct Virtual Circuit (VC) table entry for all the switches on the Virtual Circuit for both Virtual Circuits (dash or dotted lines)
- List VC tables for switches 1, 2, 3, and 4. You may make necessary assumptions.



# Virtual Circuit Switching: Connection Setup

- Connection setup
  - Permanent virtual circuit (PVC): manual configured → unmanageable for great number of nodes
  - Switched virtual circuit (SVC): automatically configured via signaling
    - A process similar to datagram model



# Virtual Circuit: Discussion

- Connection setup takes 1 RTT minimally
- VCI number typically needs less memory space. Per-packet overhead is less than that of the datagram model
- Need VC re-setup in case of a connection failure
- Possible to allocate network resources during VC setup

# Comparison of Virtual-Circuits & Datagrams

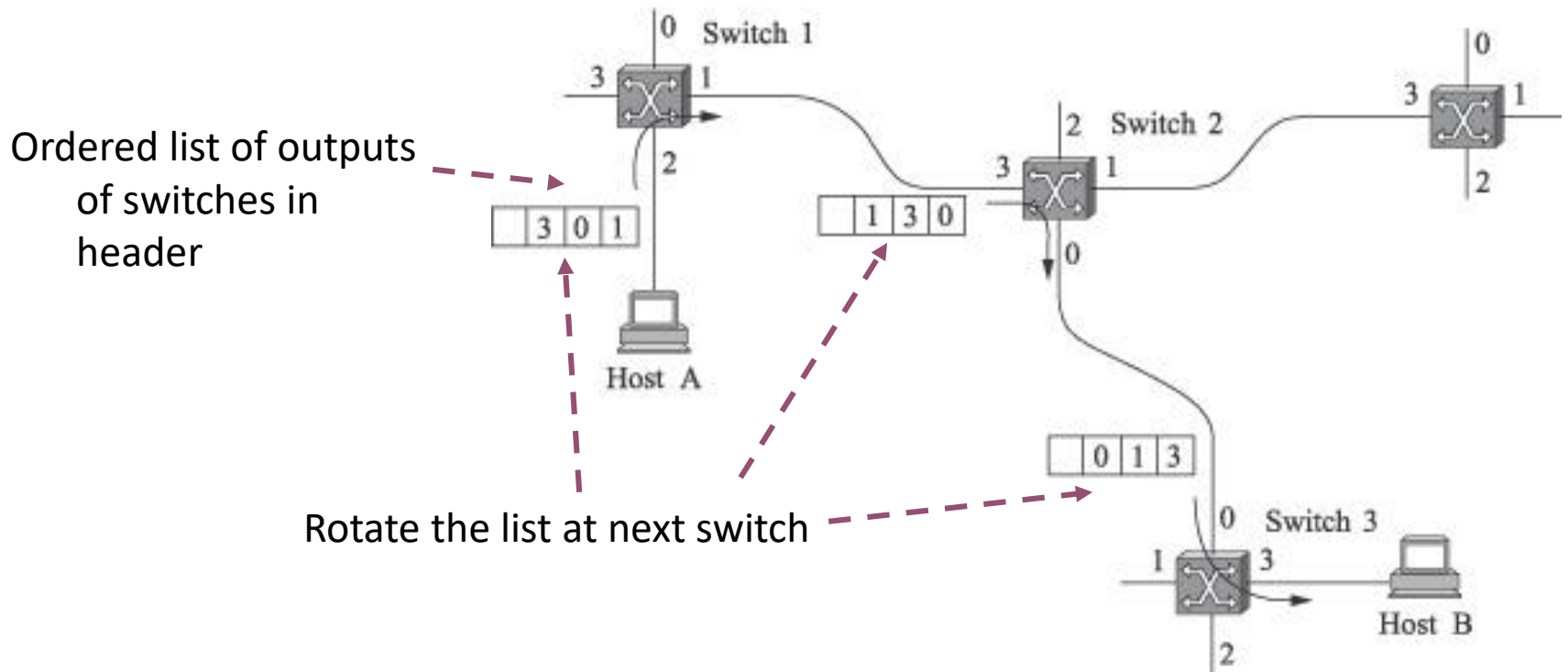
Issue	Datagram network	Virtual-circuit network
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

# Source Routing

- Source host knows network topology to deliver a packet/frame
- Source host places output ports of each switch along the route into the frame header

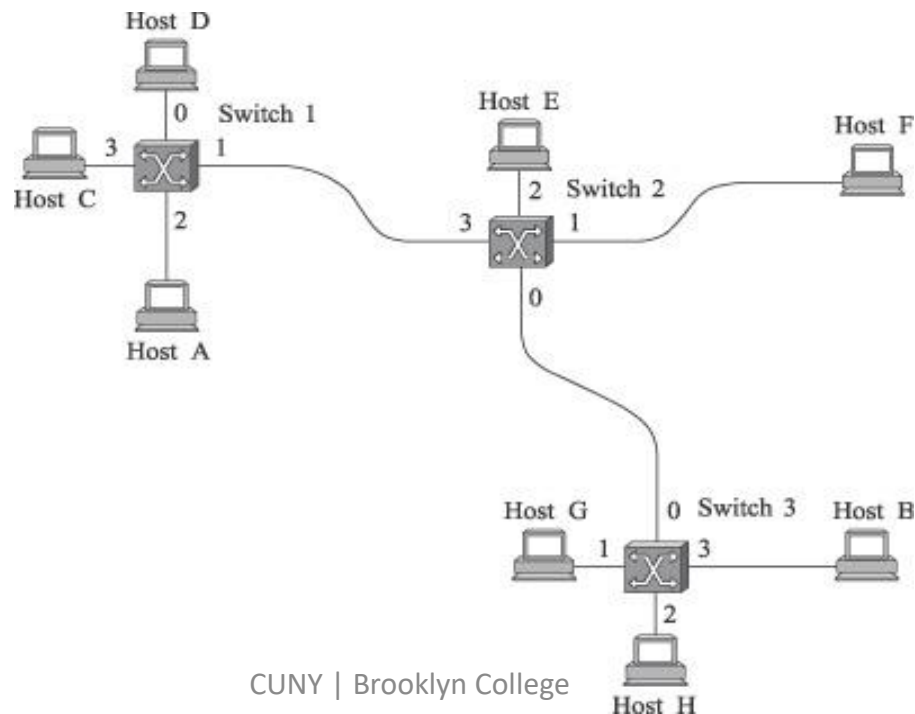
# Source Routing: Example

- Example: Host A sends a frame to host B



# Quick Exercise C13a-3

- Assume source routing presented in previous slide is used, show headers of a frame leaves from Host H and arrives at Host D at each switches along the path



# Questions?

- Packet switching
- Datagram switching
  - *Example in practice?*
    - *Ethernet and learning bridge*
- Virtual circuit switching
- Source routing