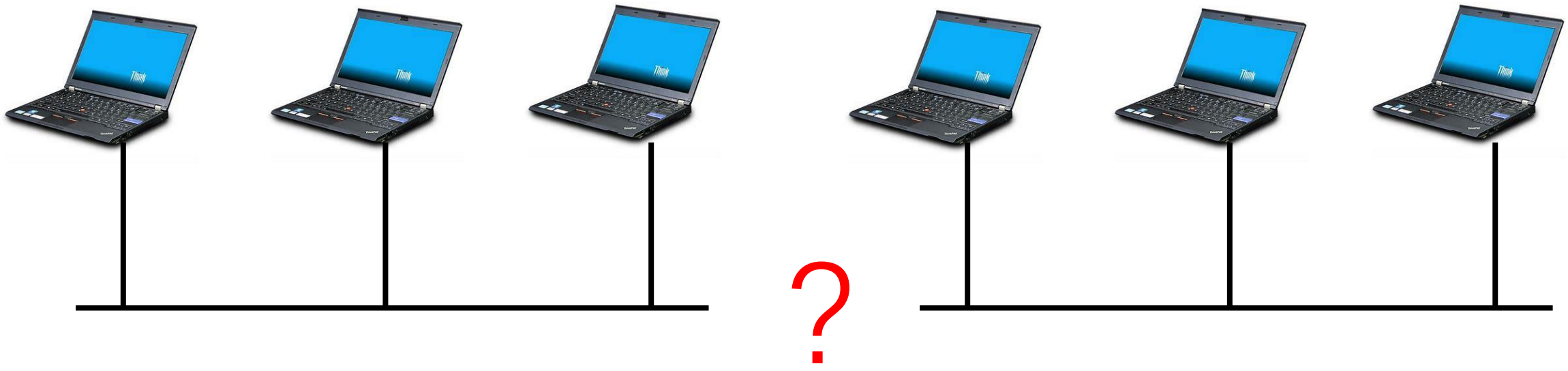
CS120: Computer Networks

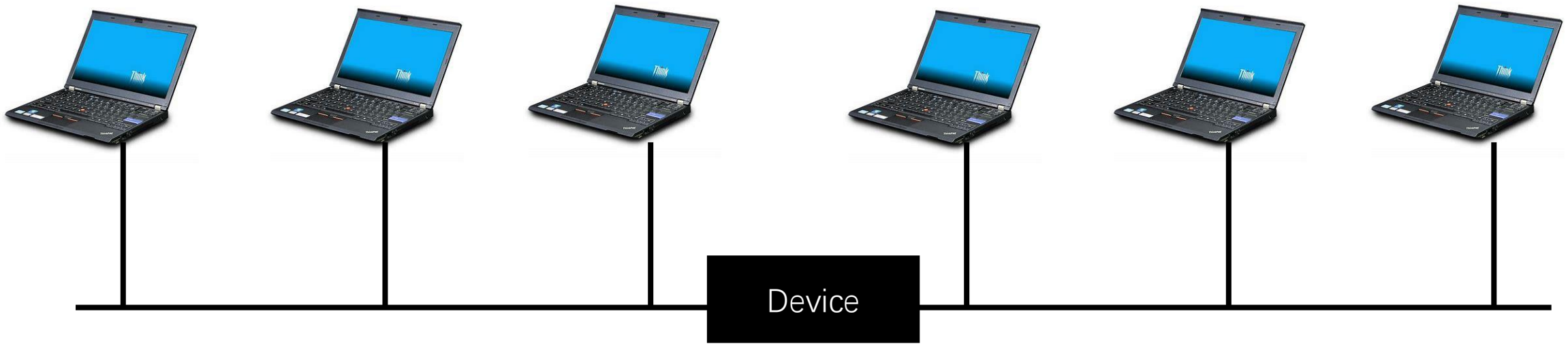
Lecture 8. Switching

Zhice Yang

How to Extend the Ethernet ?



How to Extend the Ethernet ?

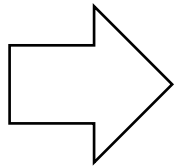


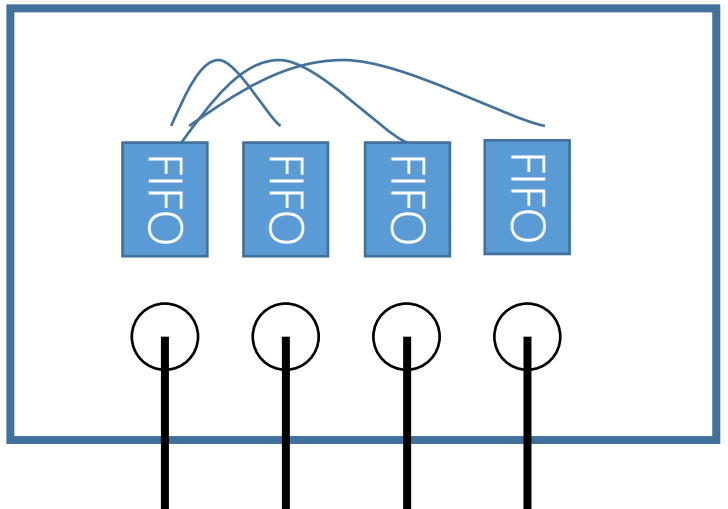
Ethernet Bridge/Switch

Store and Forward

Switch

- A multi-input, multi-output device
  - Function: transfer packets from an input to one or more outputs
  - Ports can be connected to hosts
  - Ports can be connected to other switches

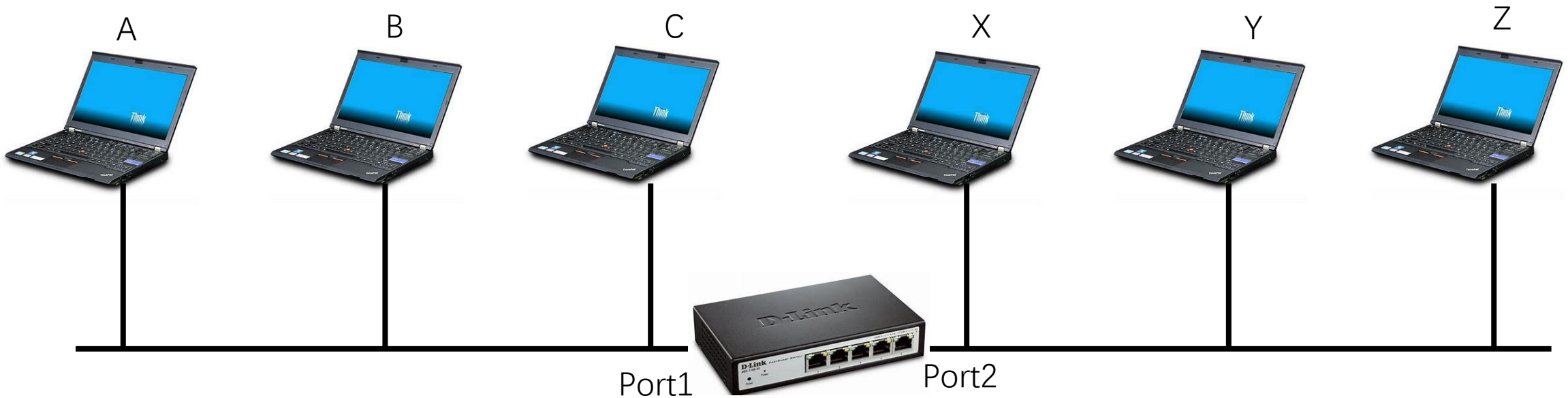




How to Extend the Ethernet ?

- Simplest Strategy
  - Accept LAN frames on input ports and forward them out to **all** other output ports
- Better Strategy
  - Forward them to the output ports that connect to the destination

How to Extend the Ethernet ?



Ethernet Bridge/Switch

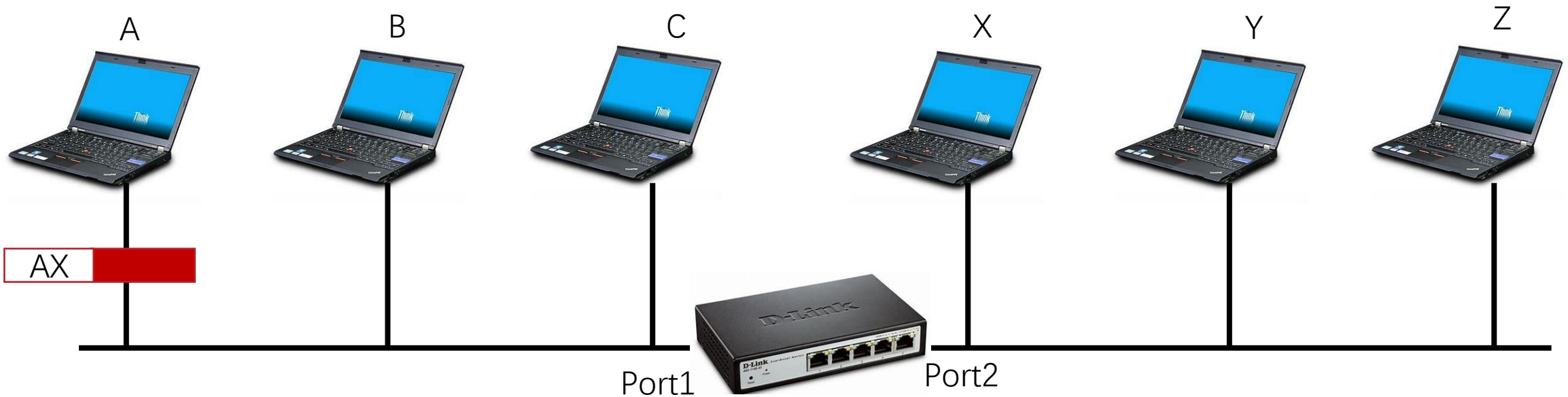
Forward

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

How to Obtain the Forwarding Table

- Strategy
  - If the destination is unknown, forward the frame to all output ports
  - Frames arrived from certain port indicate that the port is connected the network containing the destination host

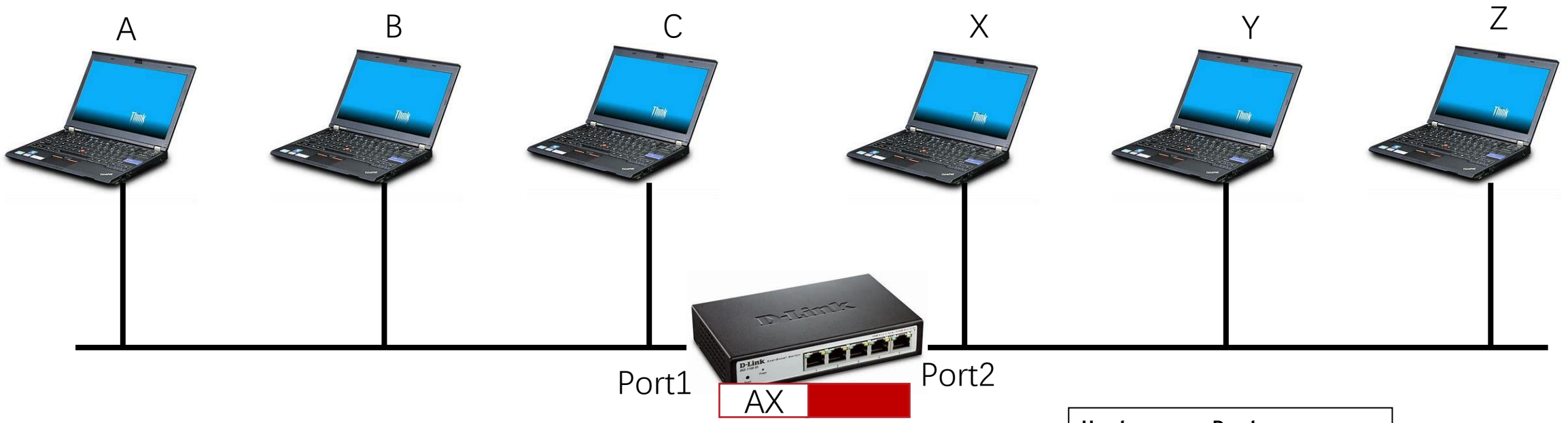
Learning Switch



Ethernet Bridge/Switch

Host	Port
Null	Null

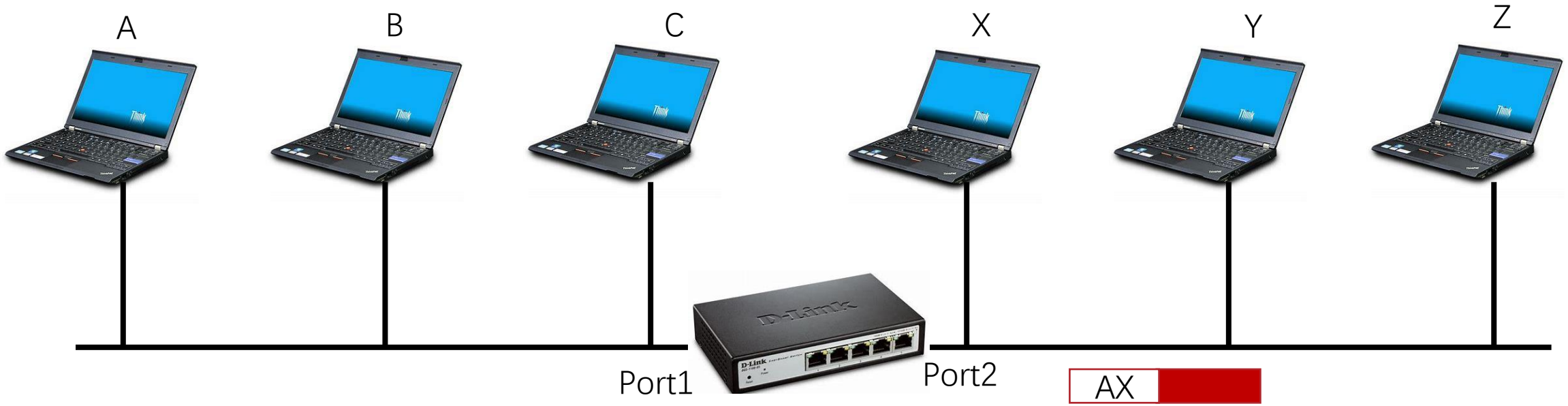
Learning Switch



Ethernet Bridge/Switch

Host	Port
A	1

Learning Switch

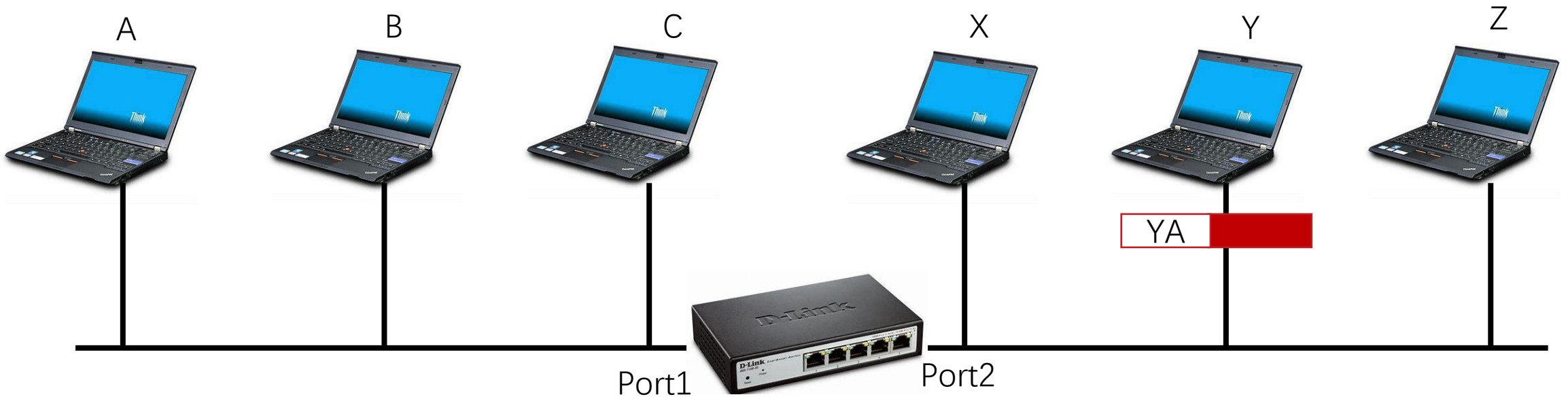


Ethernet Bridge/Switch

AX

Host	Port
A	1

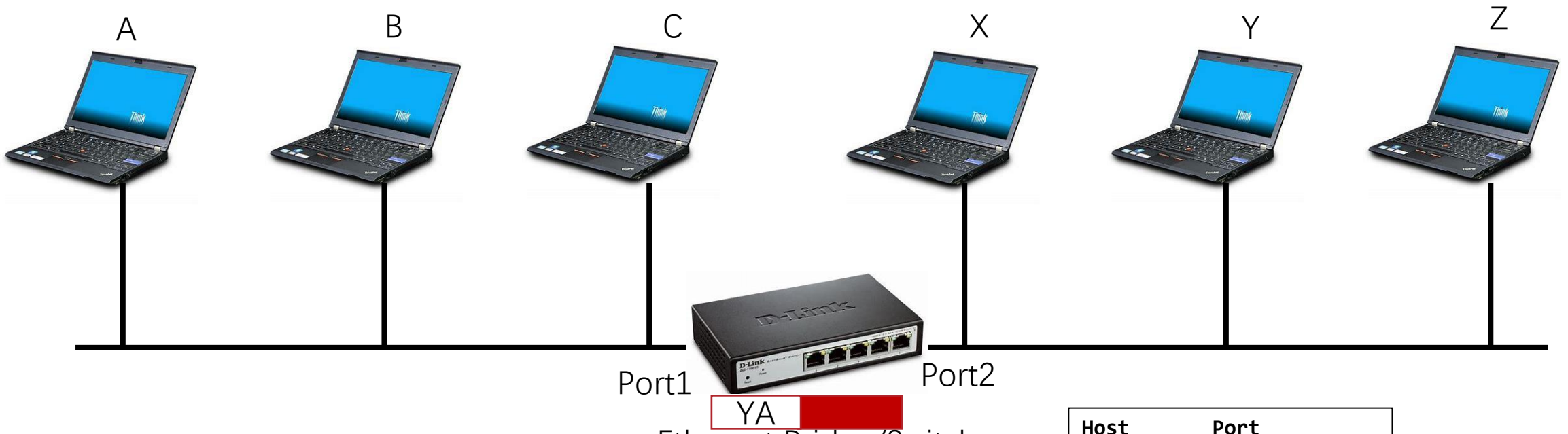
Learning Switch



Ethernet Bridge/Switch

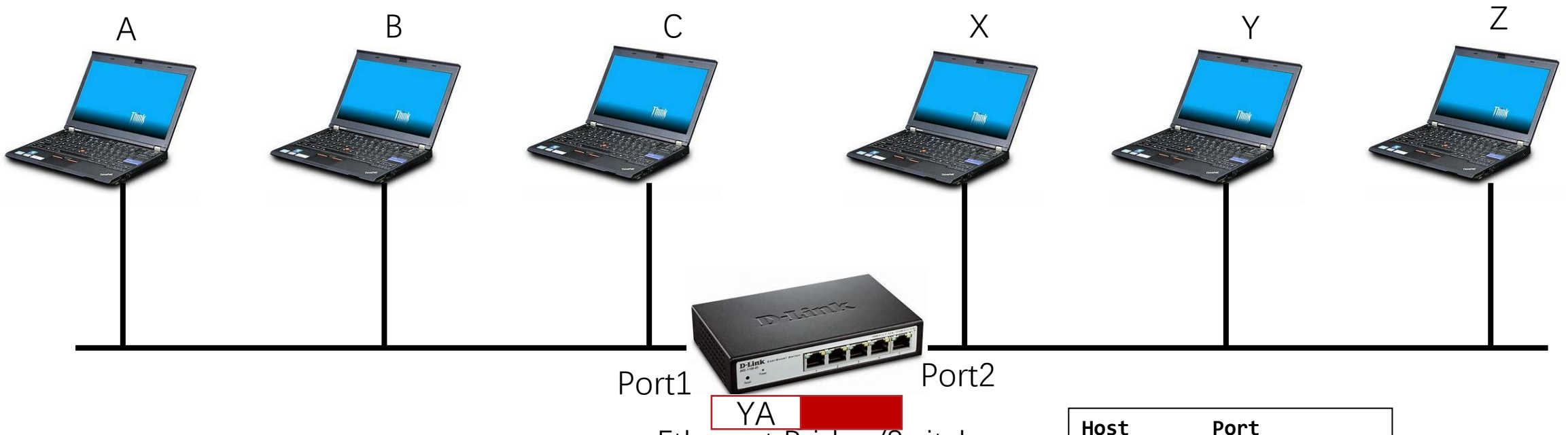
Host	Port
A	1

Learning Switch



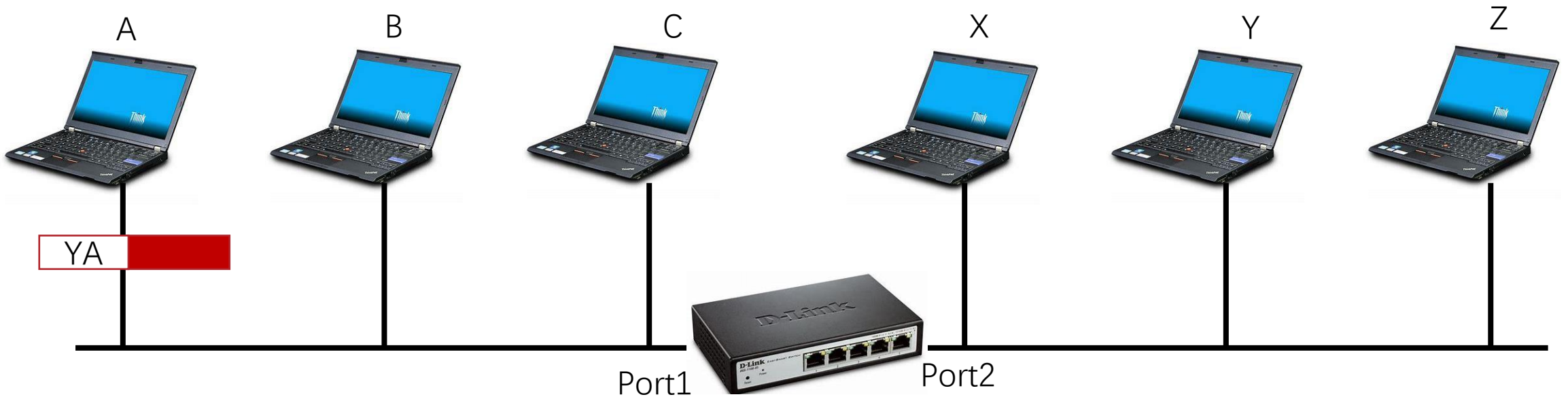
Host	Port
A	1
Y	2

Learning Switch



Host	Port
A	1
Y	2

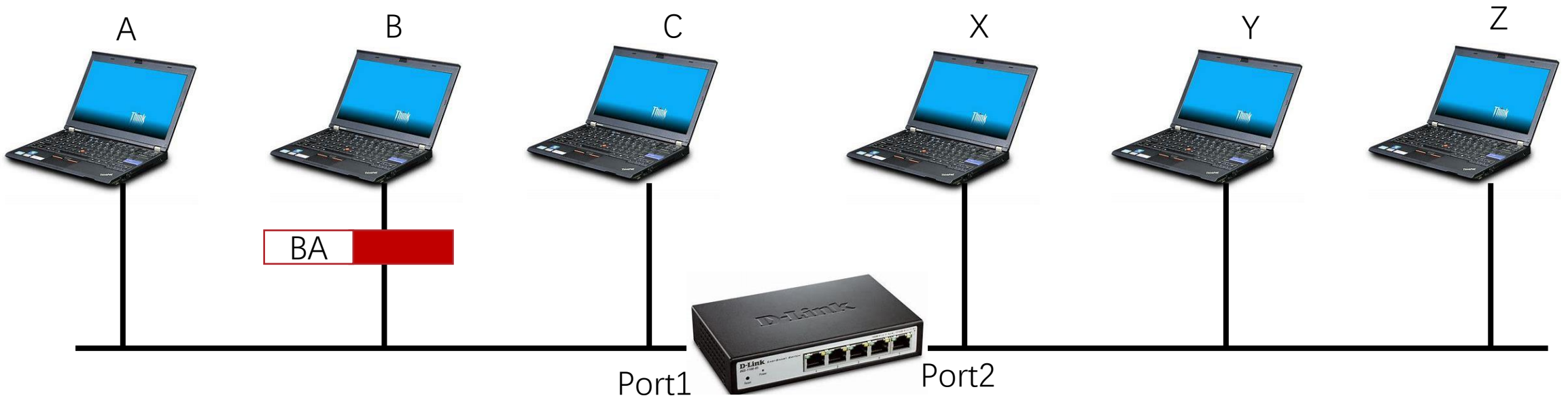
Learning Switch



Ethernet Bridge/Switch

Host	Port
A	1
Y	2

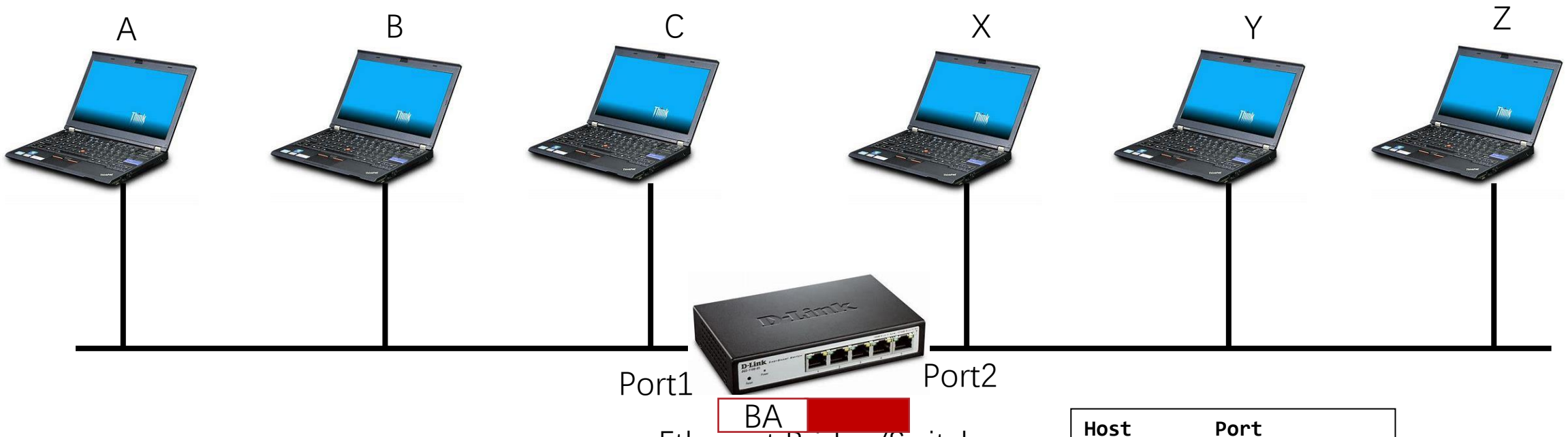
Learning Switch



Ethernet Bridge/Switch

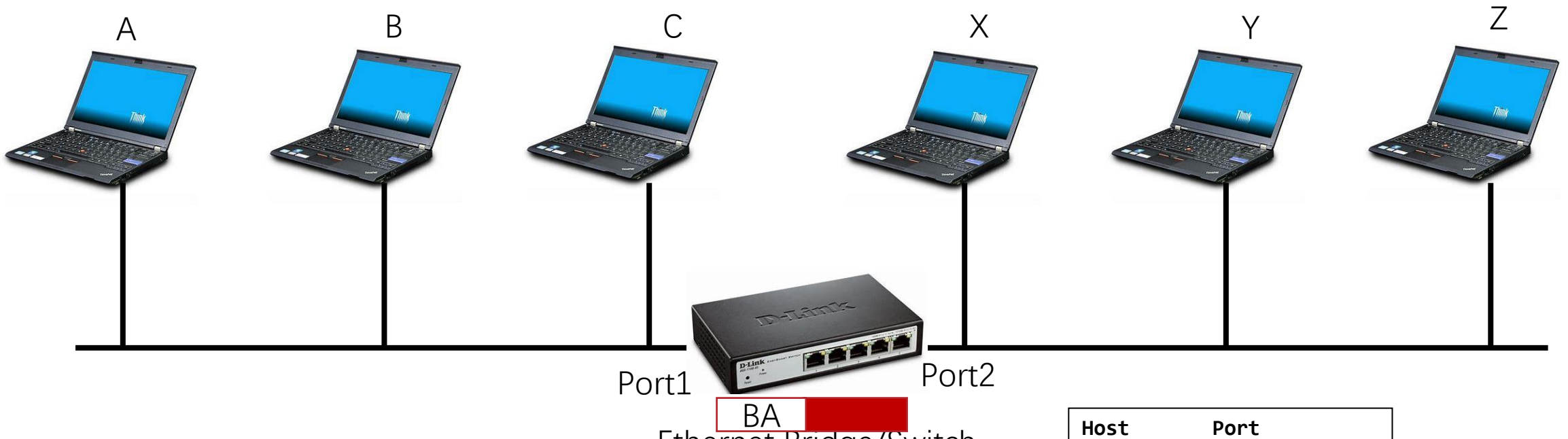
Host	Port
A	1
Y	2

Learning Switch



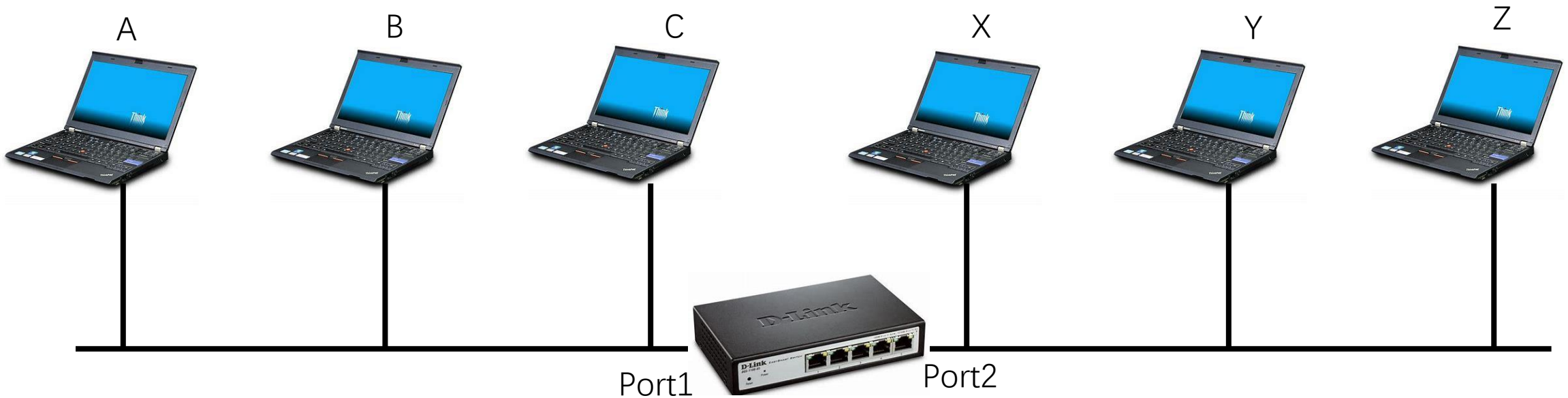
Host	Port
A	1
Y	2
B	1

Learning Switch



Host	Port
A	1
Y	2
B	1

How to Extend the Ethernet ?



Ethernet Bridge/Switch

Forward

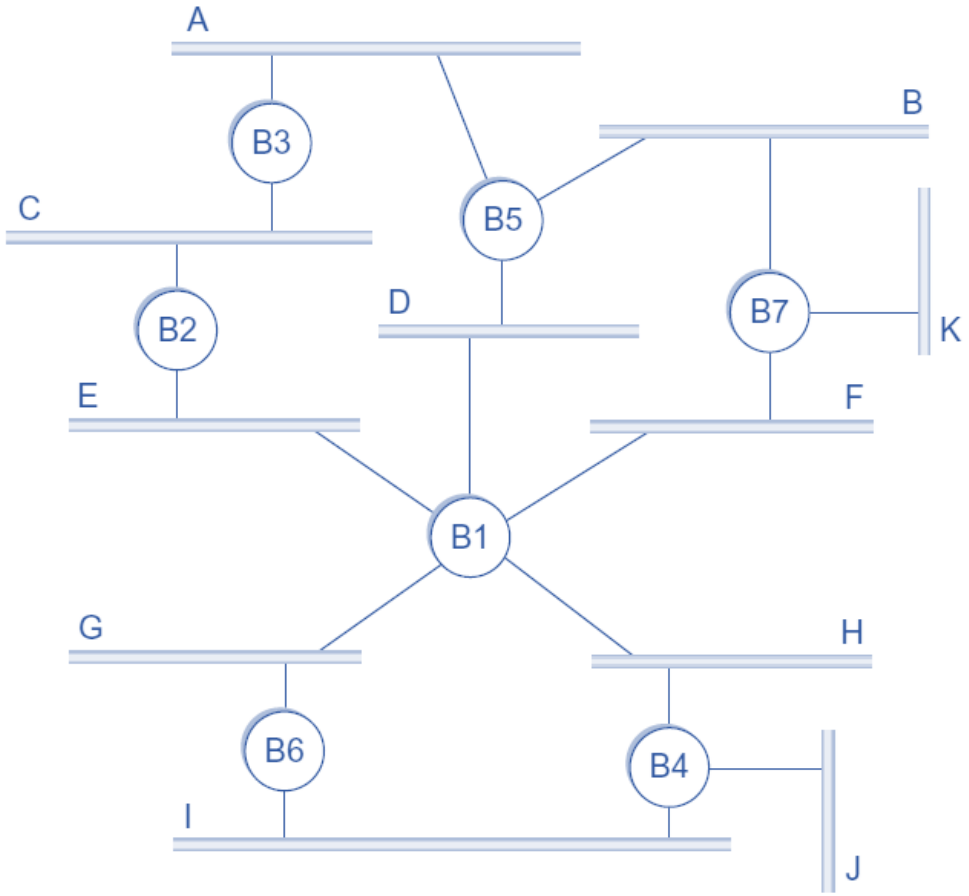
Host	Port
A	1
B	1
C	1
X	2
Y	2
Z	2

Learning Switch

- When packet is received at switch
  - Record incoming port, source address
  - Index forwarding table using destination address
    - if destination exists
      - if destination on port from which packet arrived
        - drop
      - else
        - forward packet on port indicated by entry
    - else
      - forward on all ports except the arriving port

Network with Switches

- A Network of Ethernet

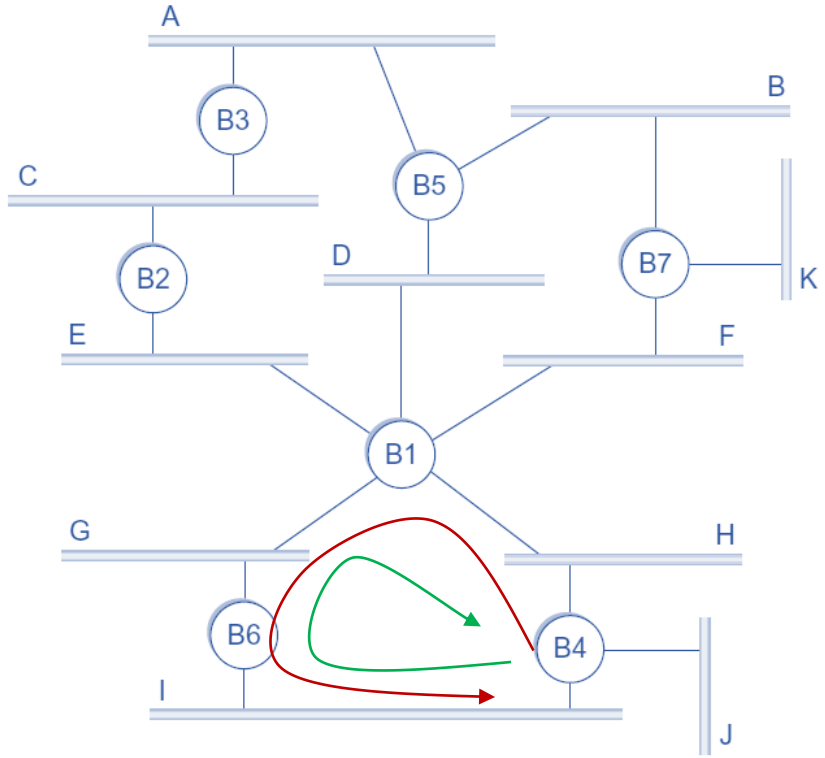


Cycles in Ethernet

- Possible Reasons
  - On purpose: introduce redundancy
    - Cycles in network enable recovery from single link failure
  - Not on purpose: wrong setup
    - e.g., network manager dose not have the entire view of the network
- Problem
  - Broadcast storm

Looped Frames

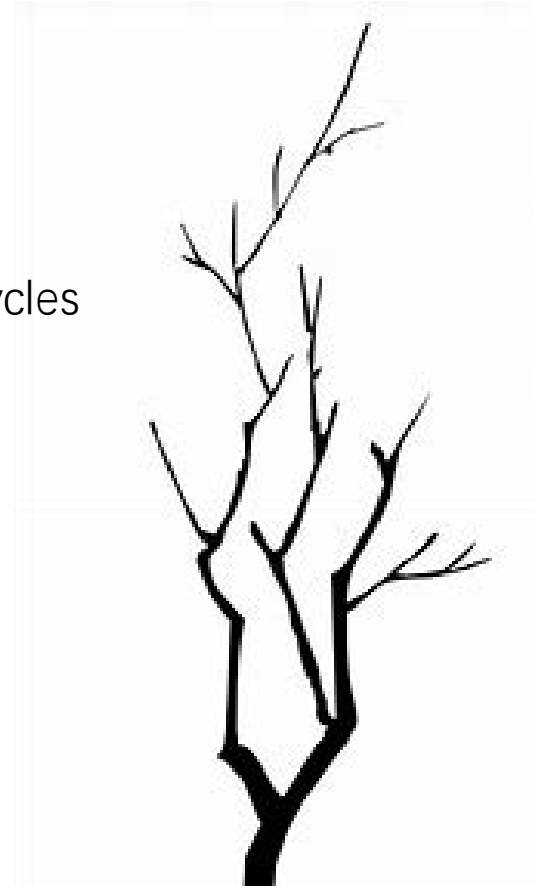
- Network J sends a frame to a host in Network A, but B1,B4,B6 has no entry about the host, then the frame will loop in the network endlessly

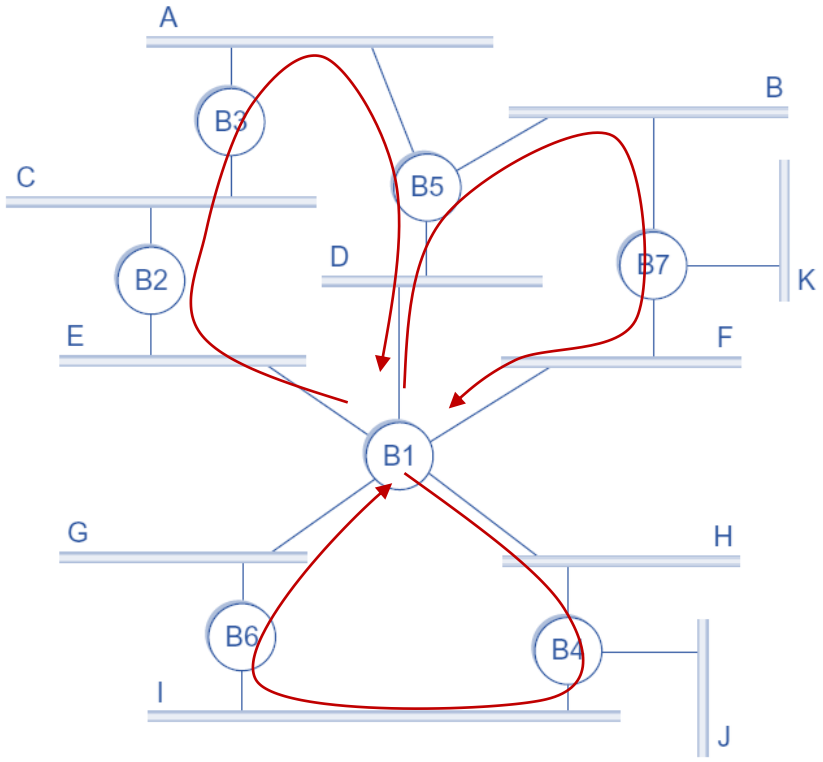


Handling Cycles

- Break the Cycles

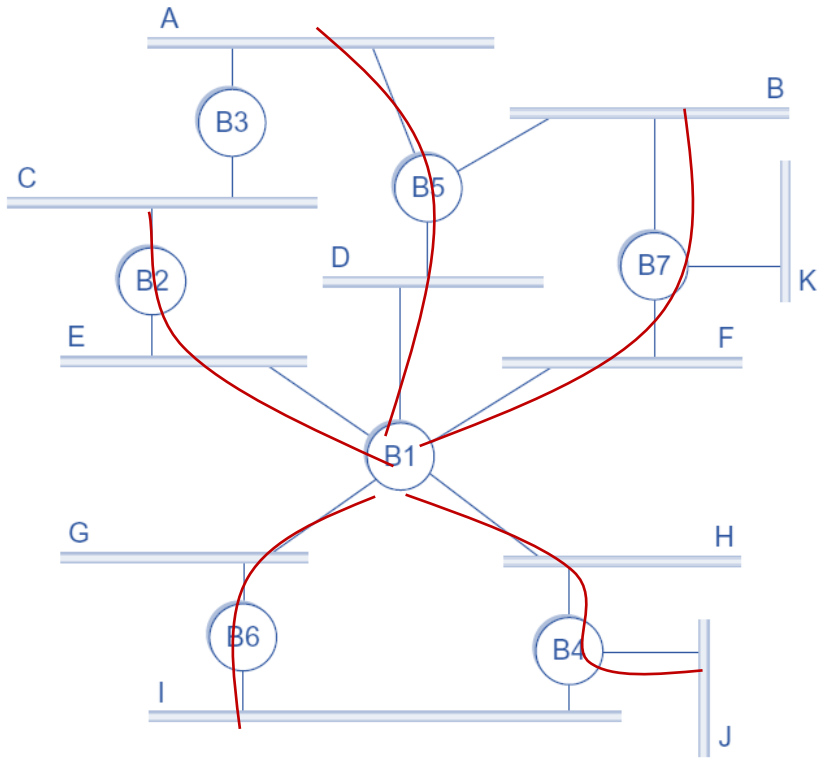
Tree has no cycles



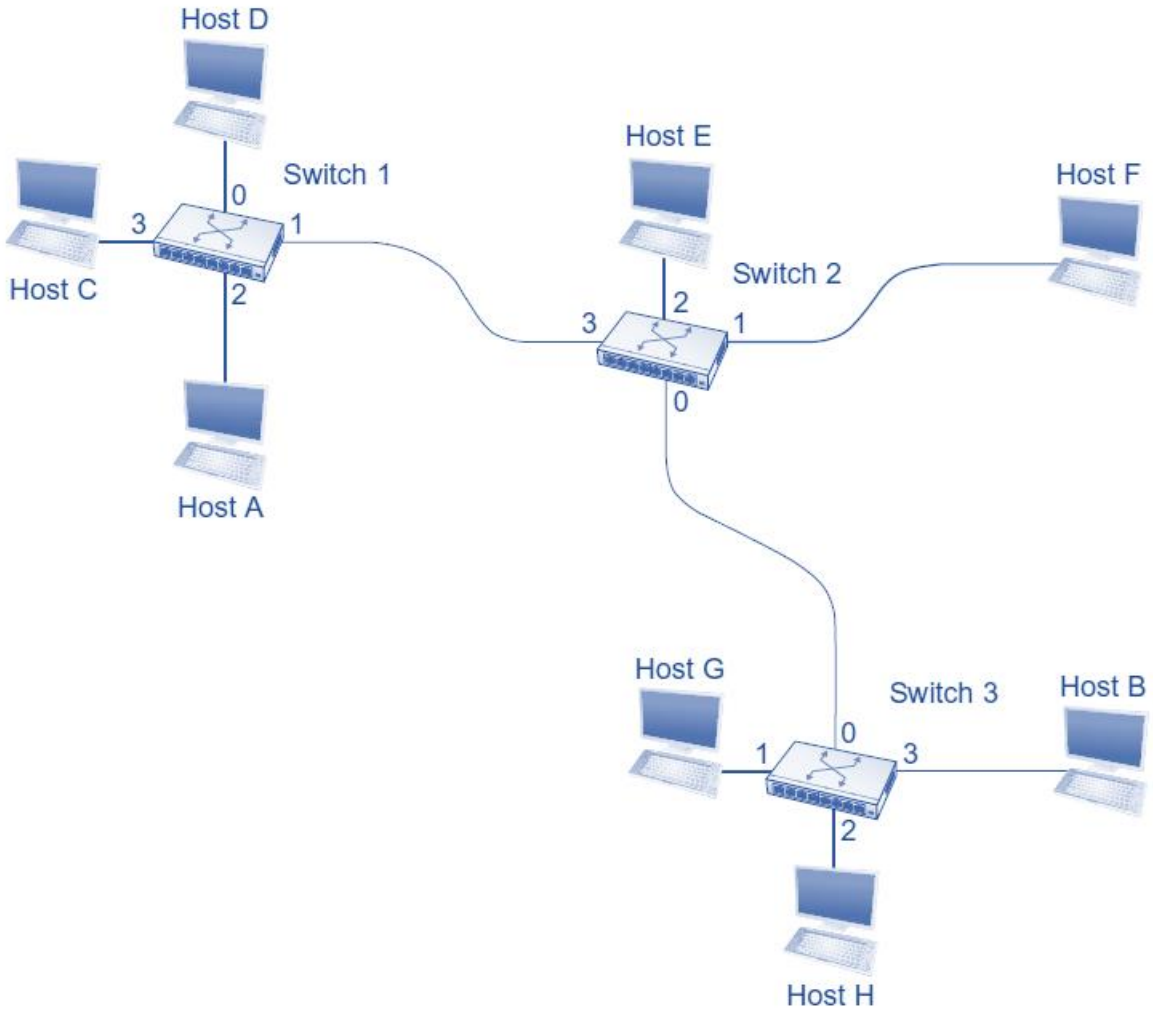


Distributed Spanning Tree Algorithm

- Each switch is a vertex
- Each connected port of a switch is an edge
- Goal: A spanning tree is a sub-graph of this graph that covers all the vertices but contains no cycles
  - Each switch decides the ports over which it is and is not willing to forward frames



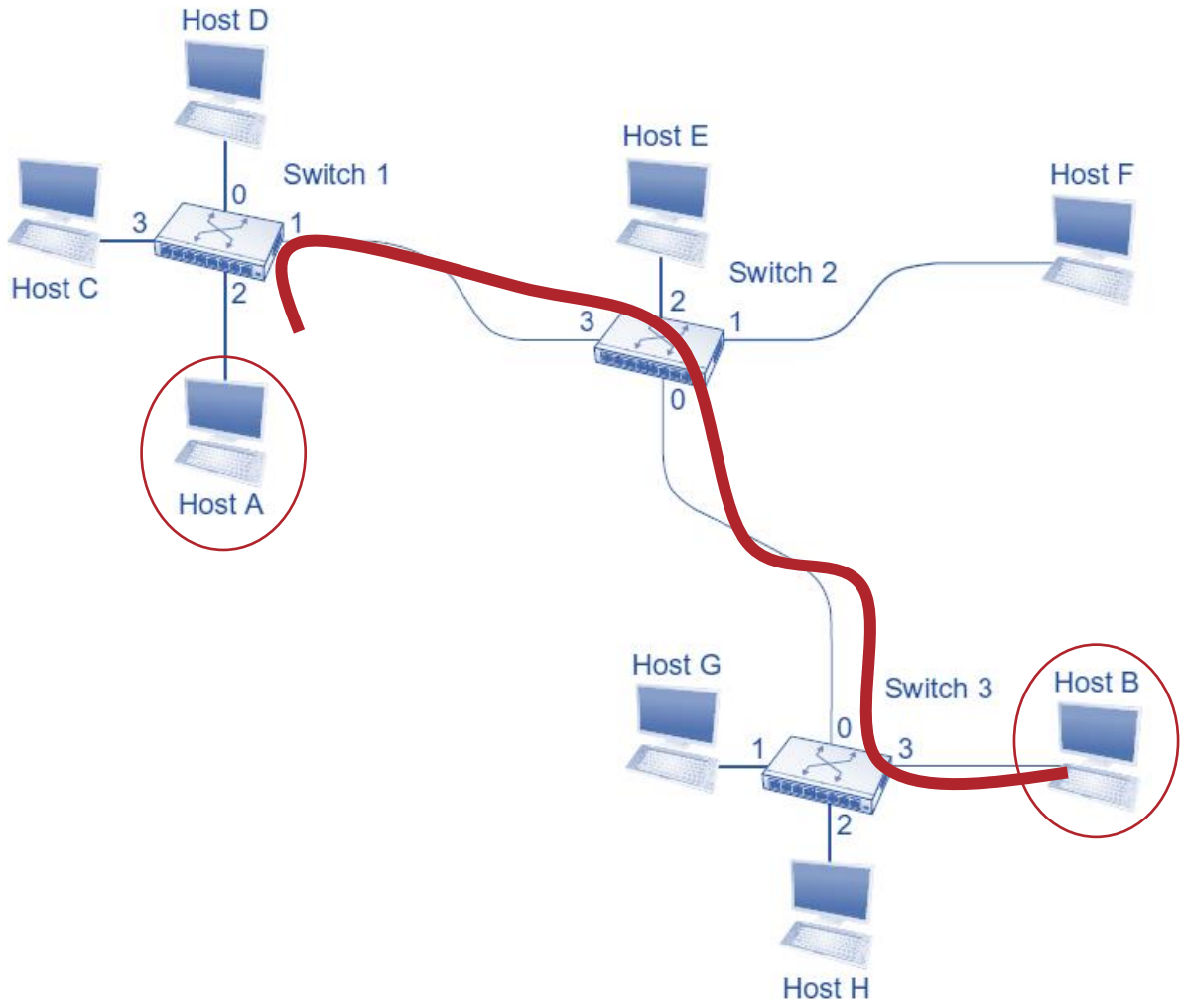
Larger Network with Switches



Switching Methods

- Datagram/Connectionless
  - e.g., Ethernet
- Virtual Circuit (VC)/Connection
  - e.g., X.25, ATM
- Source Routing

Datagram



Forwarding Table

Switch1	
Dest	Port
A	2
B	1
C	3
D	0
E	1
F	1
G	1
H	1

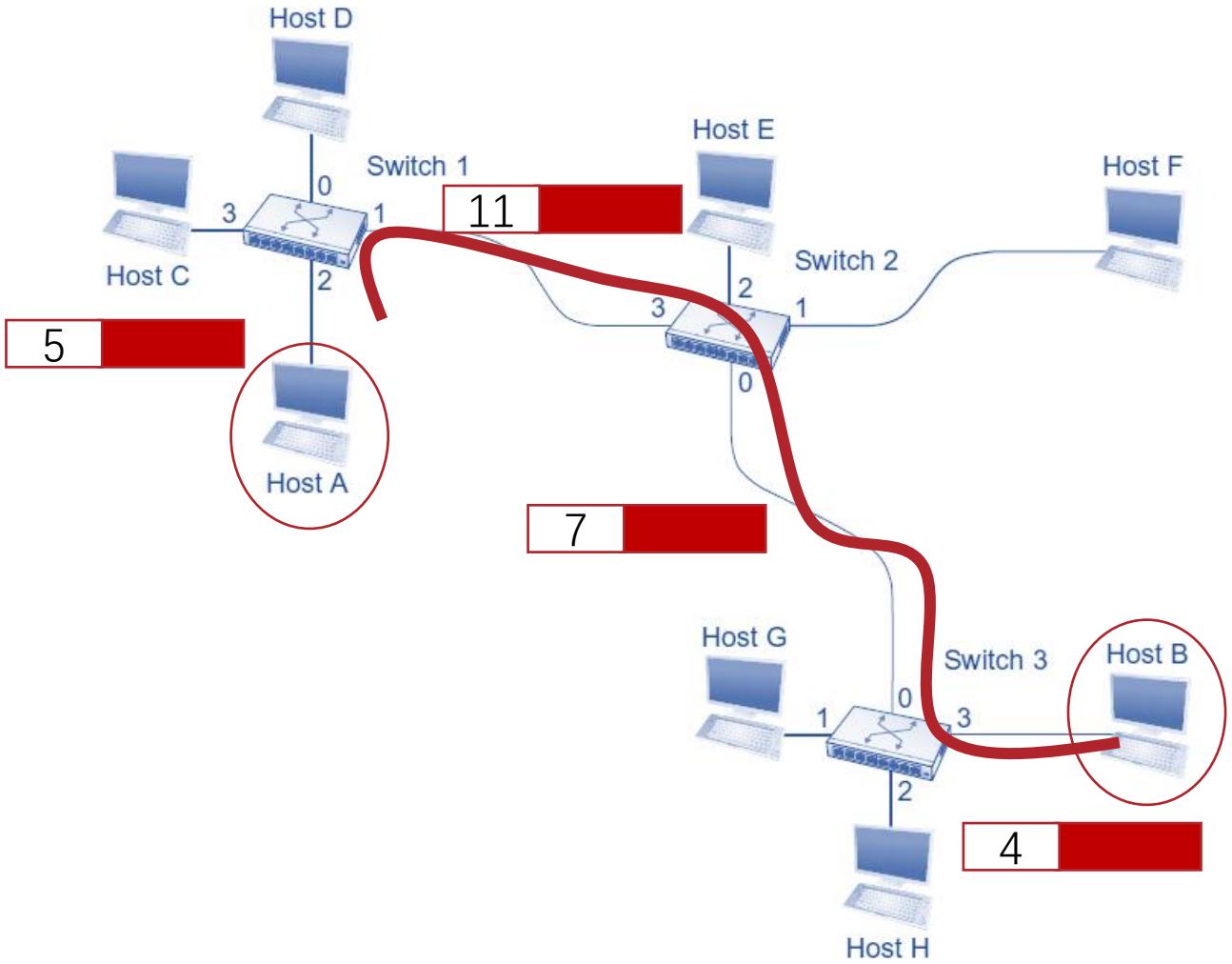
Switch2	
Dest	Port
A	3
B	0
C	3
D	3
E	2
F	1
G	0
H	0

Switch3	
Dest	Port
A	0
B	3
C	0
D	0
E	0
F	0
G	1
H	2

Datagram

- Elastic Service
  - Send at any time
- No Guarantee for
  - Success delivery
  - Performance
    - Delay, Throughput
  - Packet order

Virtual Circuit



Virtual Circuit Table

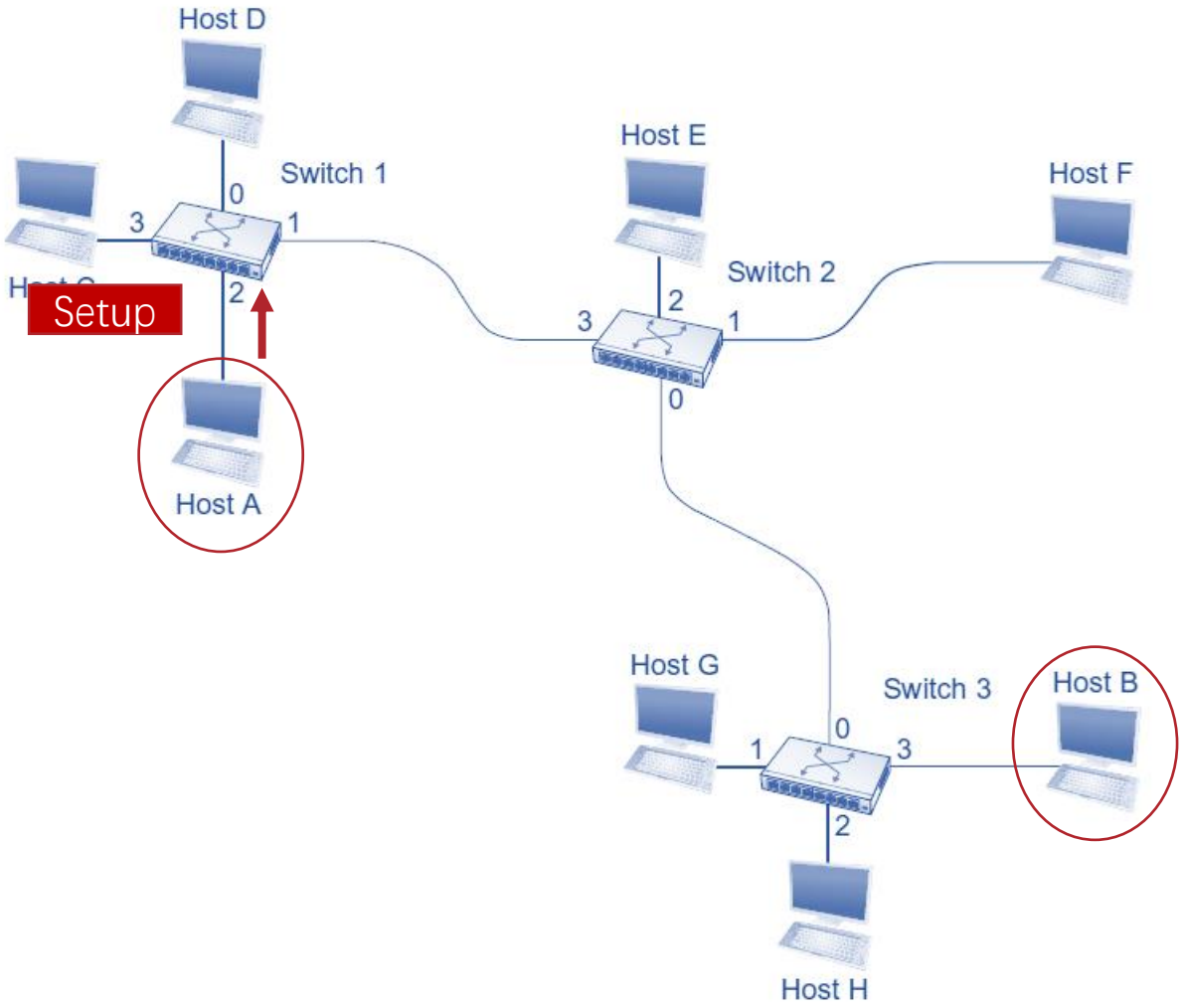
Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5	1	11

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11	0	7

Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7	3	4

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI
To B	5	From A	4

Virtual Circuit



Virtual Circuit Table

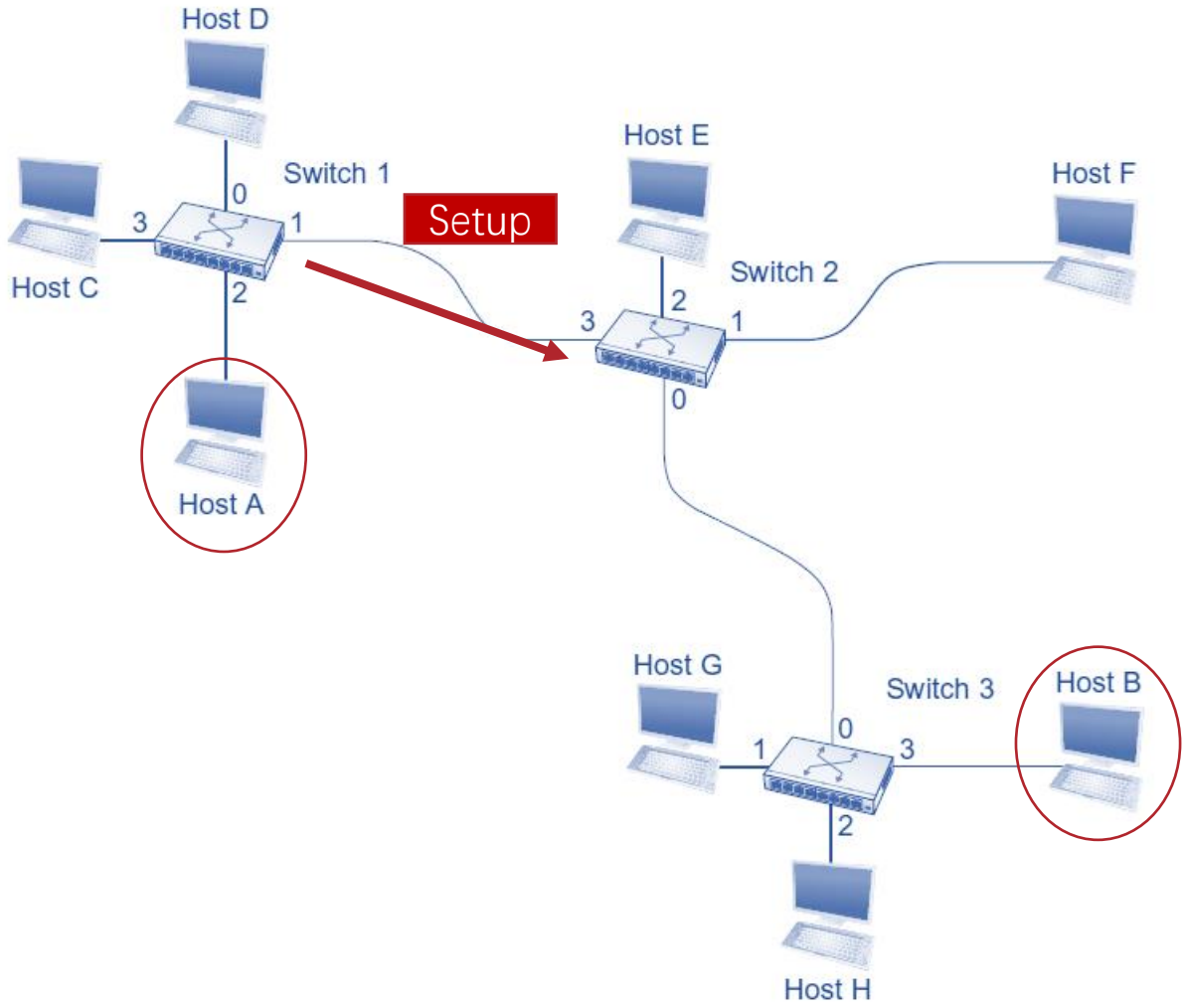
Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5		

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI

Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI

Virtual Circuit

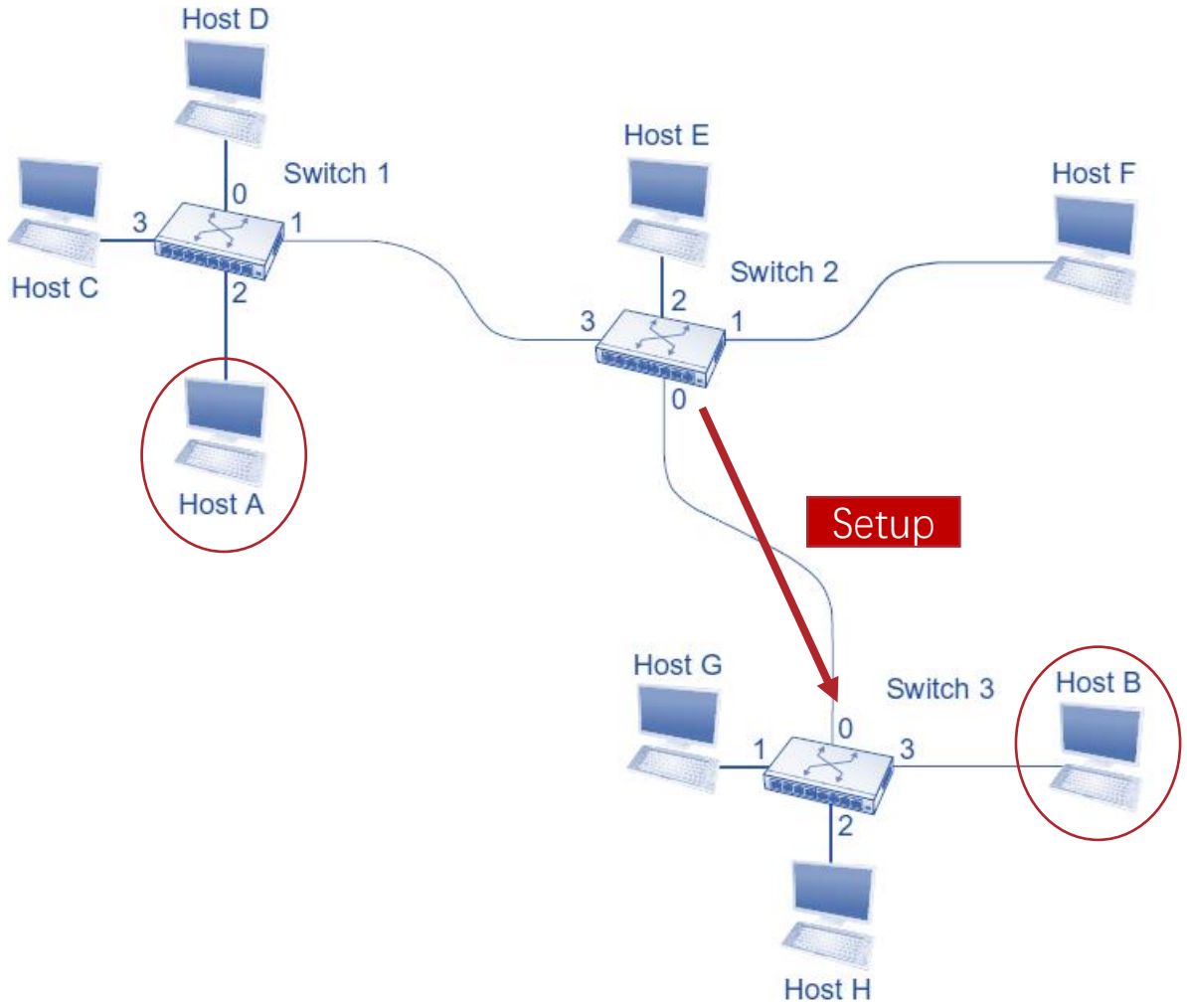


Virtual Circuit Table

Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5		
Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11		
Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI

Virtual Circuit



Virtual Circuit Table

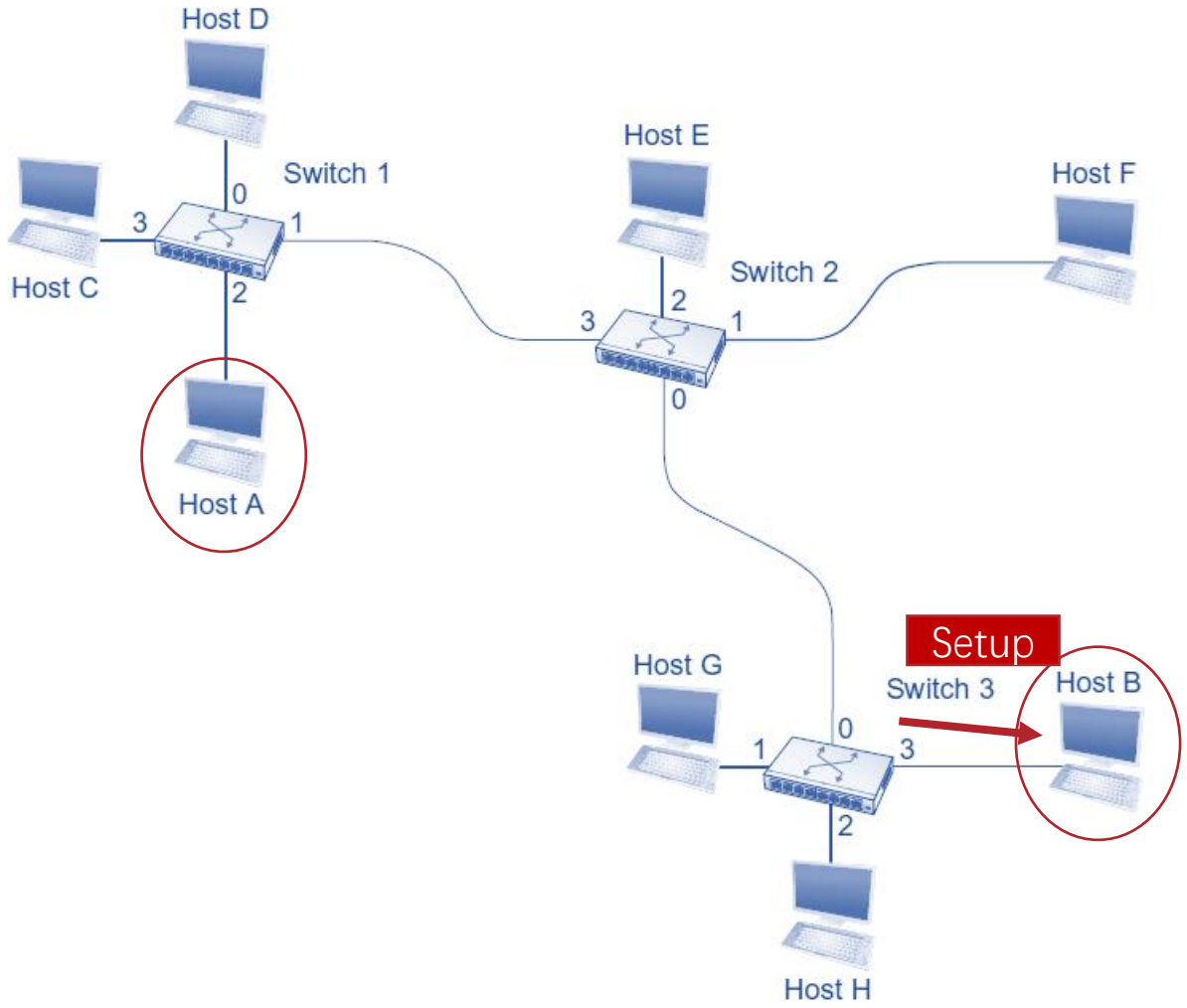
Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5		

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11		

Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7		

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI

Virtual Circuit



Virtual Circuit Table

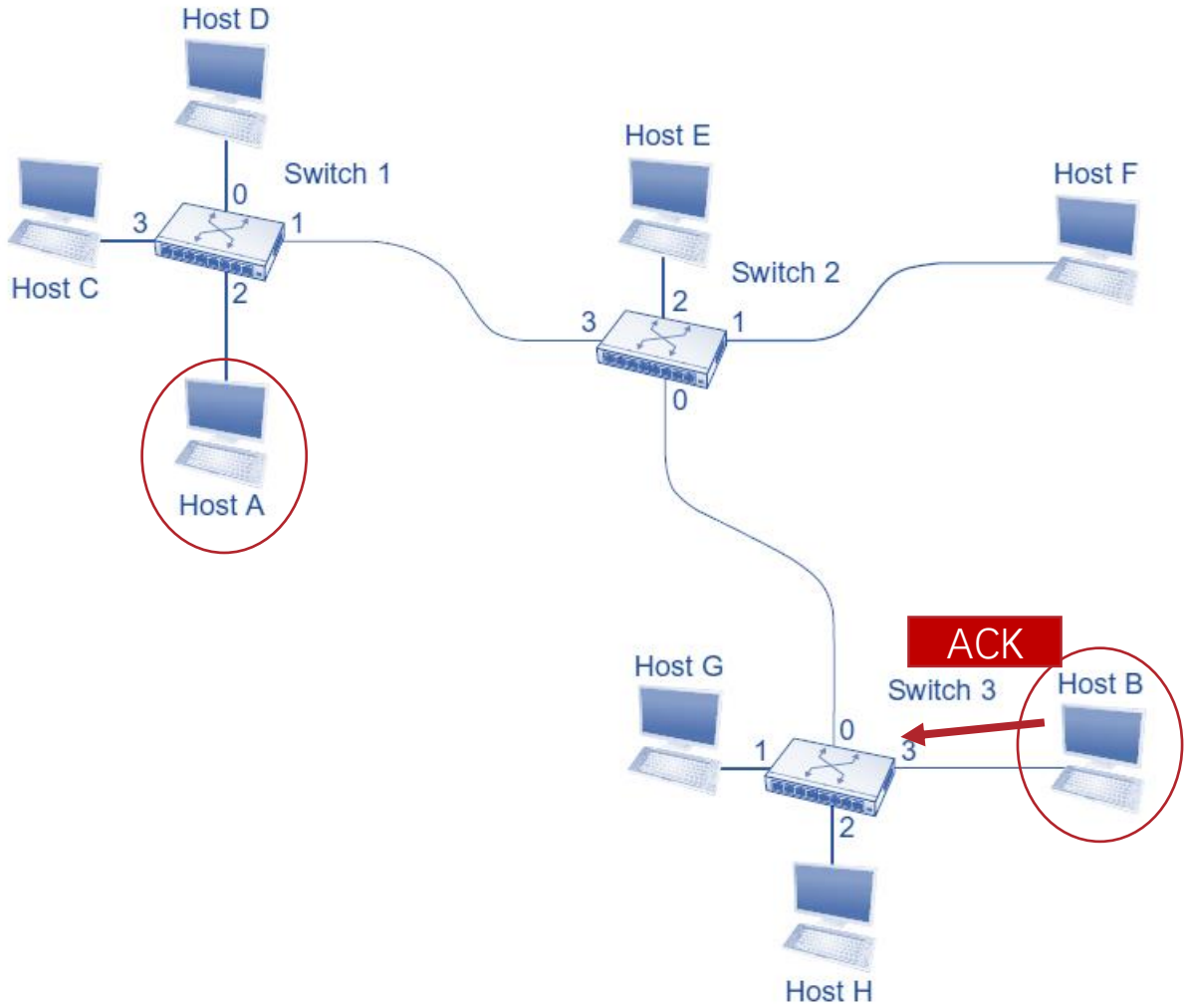
Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5		

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11		

Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7		

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI
		From A	4

Virtual Circuit



Virtual Circuit Table

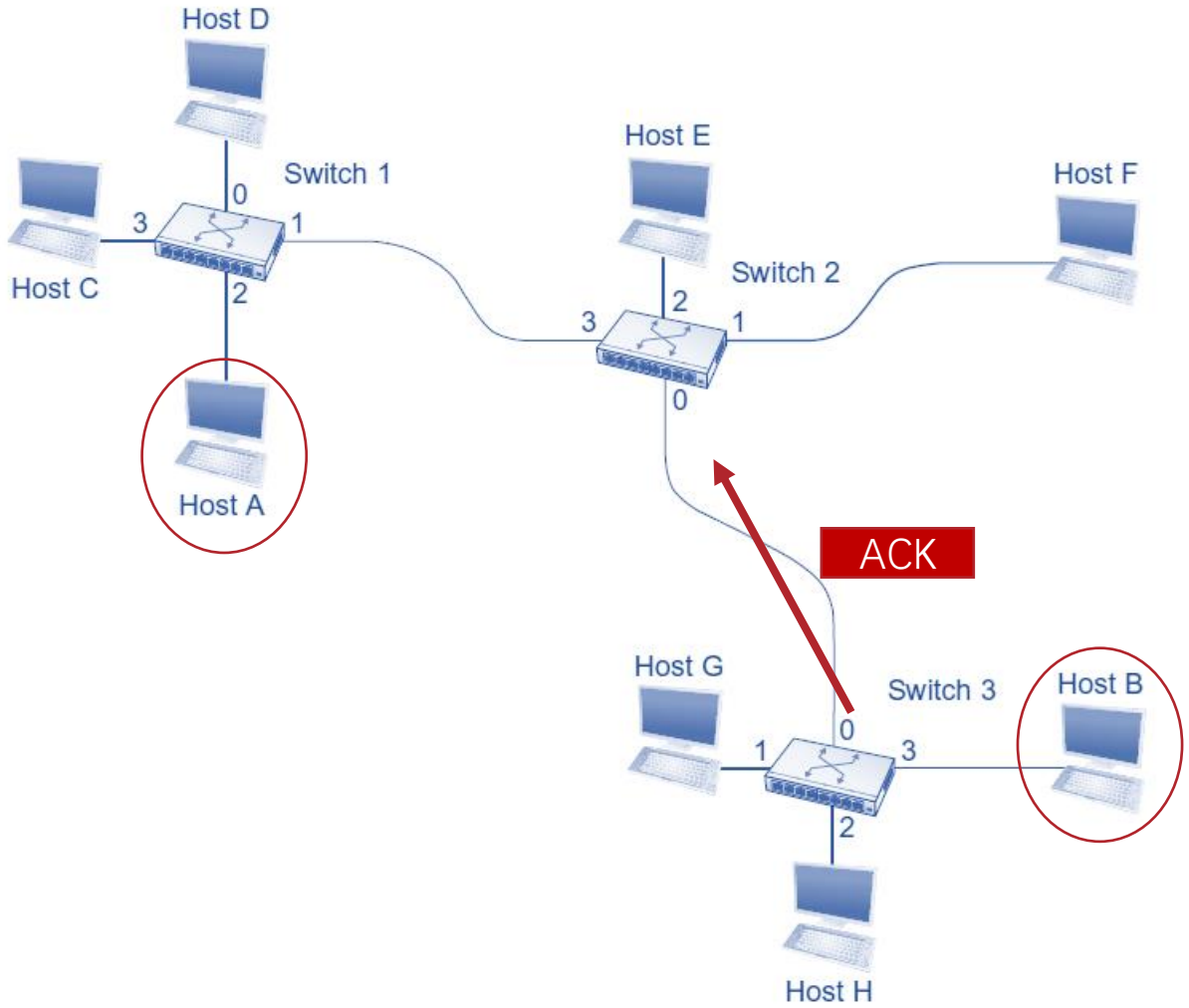
Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5		

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11		

Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7	3	4

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI
		From A	4

Virtual Circuit



Virtual Circuit Table

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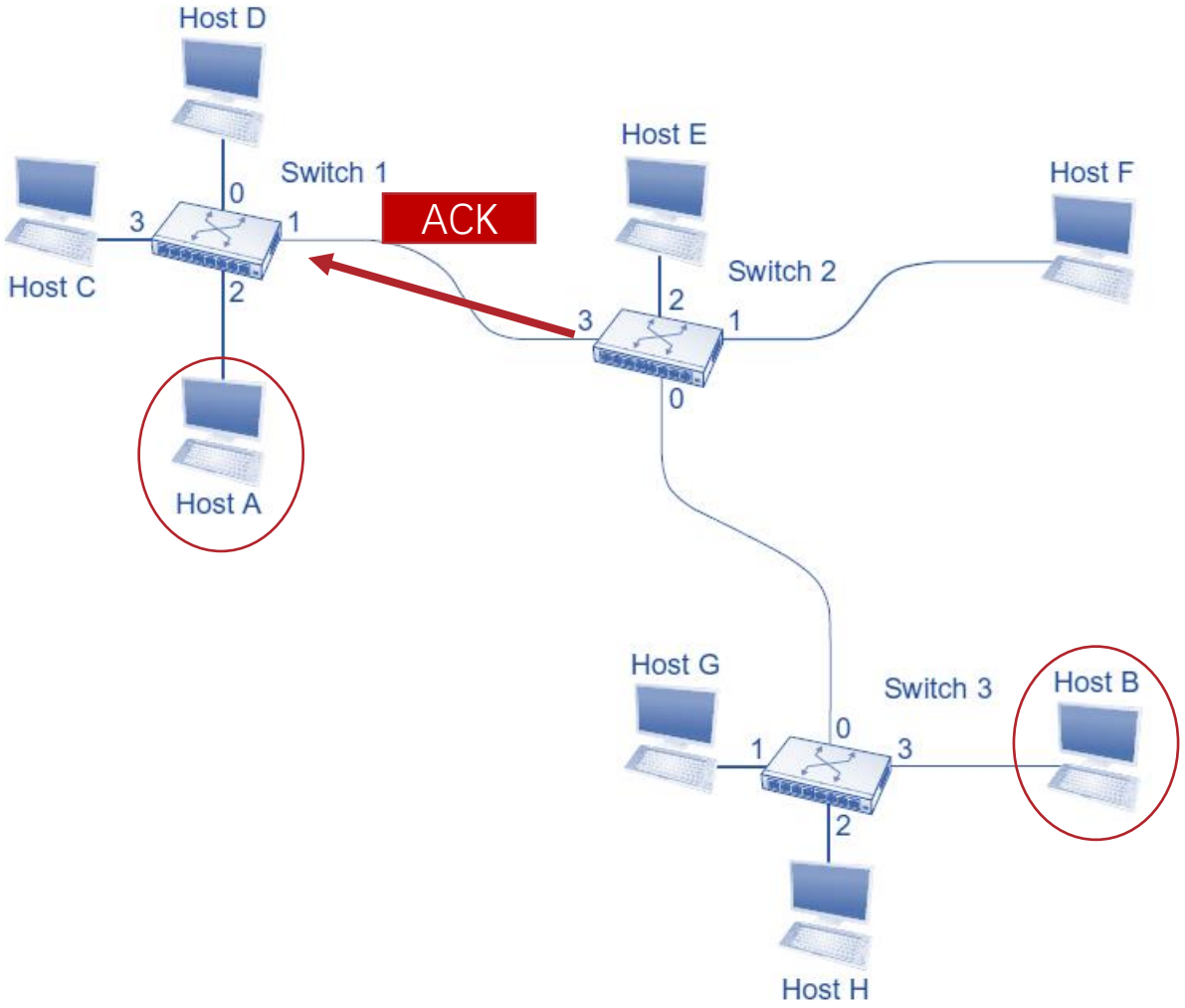
2	5		

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11	0	7

Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7	3	4

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI
		From A	4

Virtual Circuit



Virtual Circuit Table

Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
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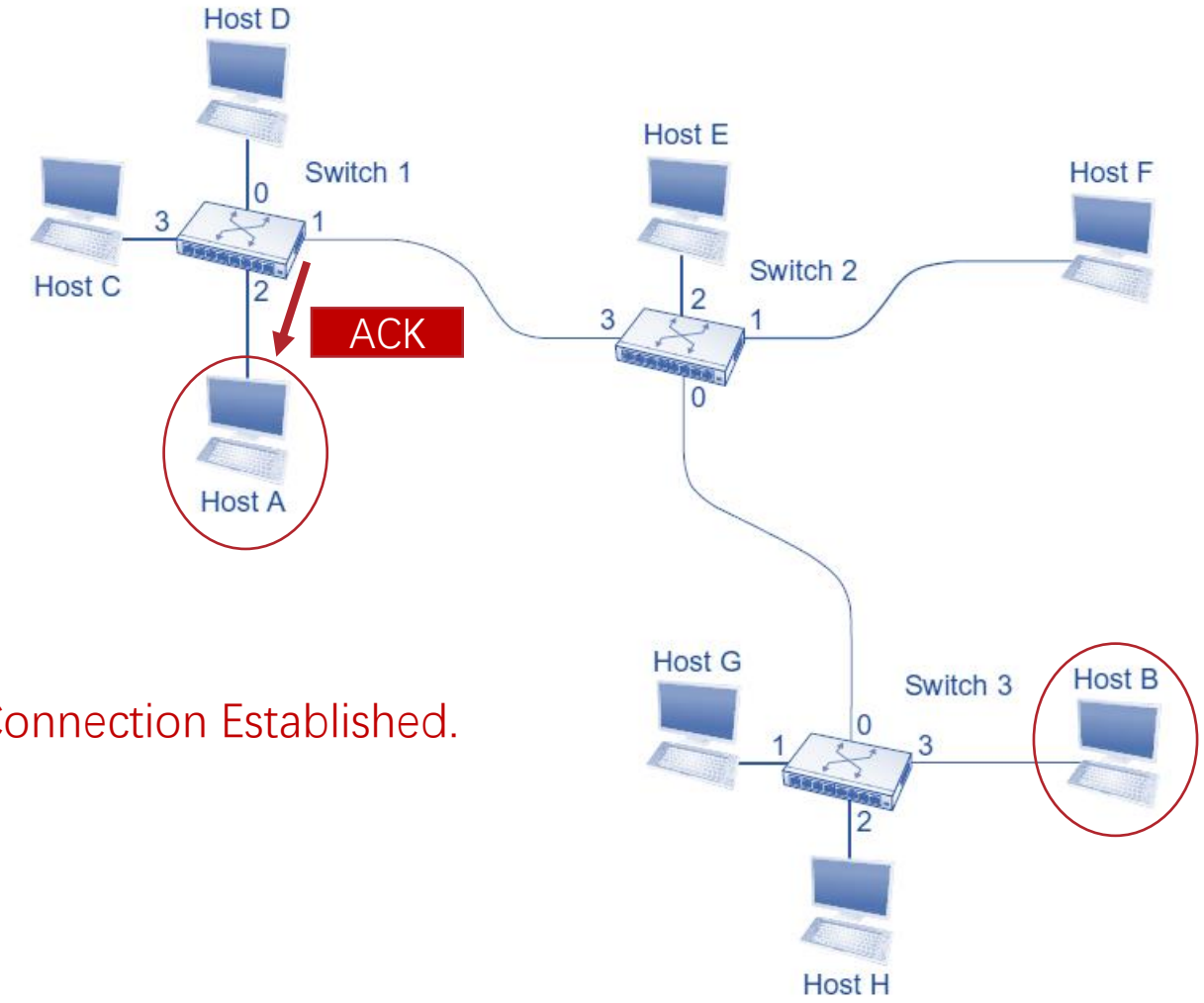
Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11	0	7

Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7	3	4

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI
		From A	4

Virtual Circuit



Connection Established.

Virtual Circuit Table

Switch1			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
2	5	1	11

Switch2			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
3	11	0	7

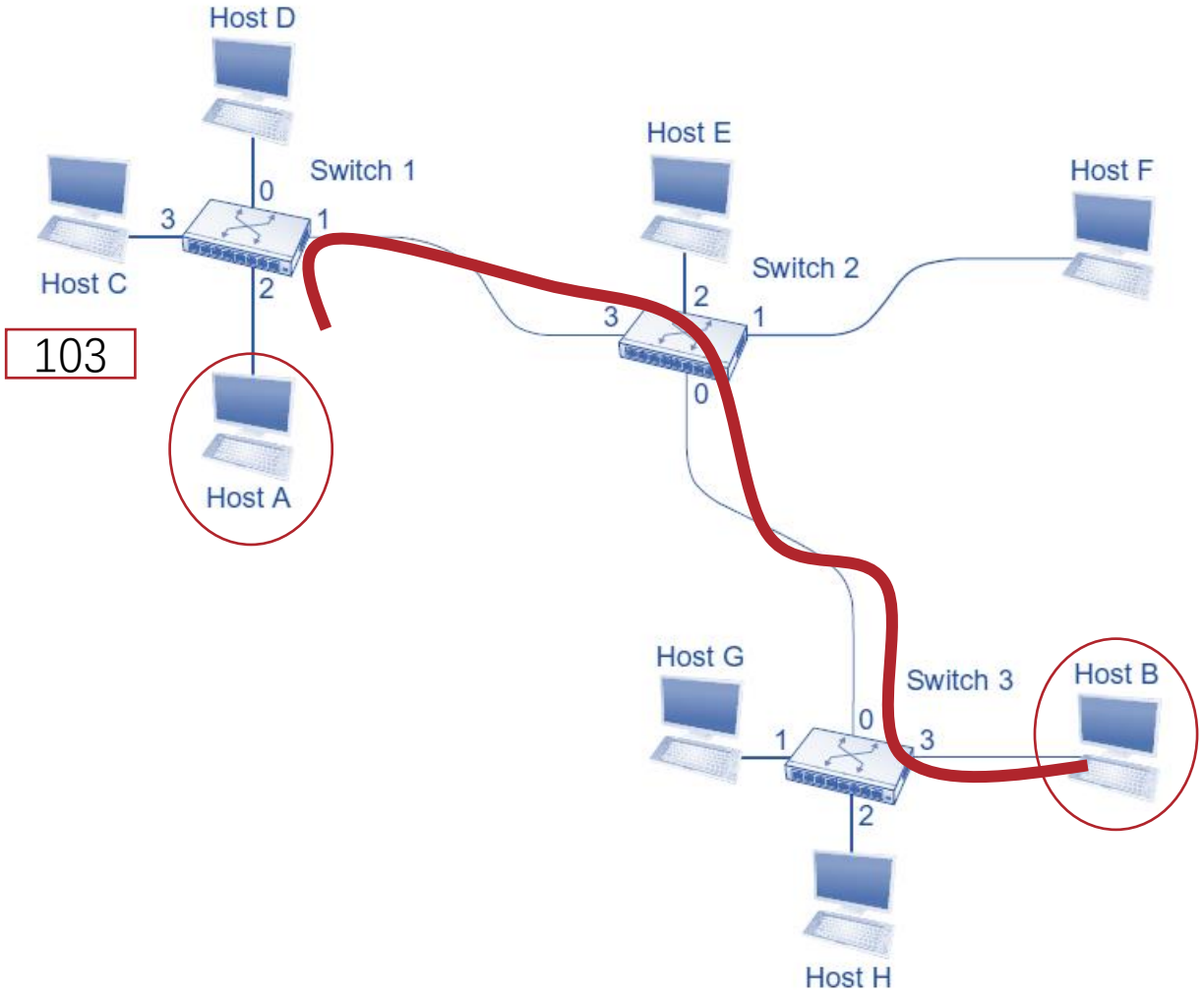
Switch3			
Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
0	7	3	4

Host A		Host B	
Destination	Outgoing VCI	Source	Incoming VCI
To B	5	From A	4

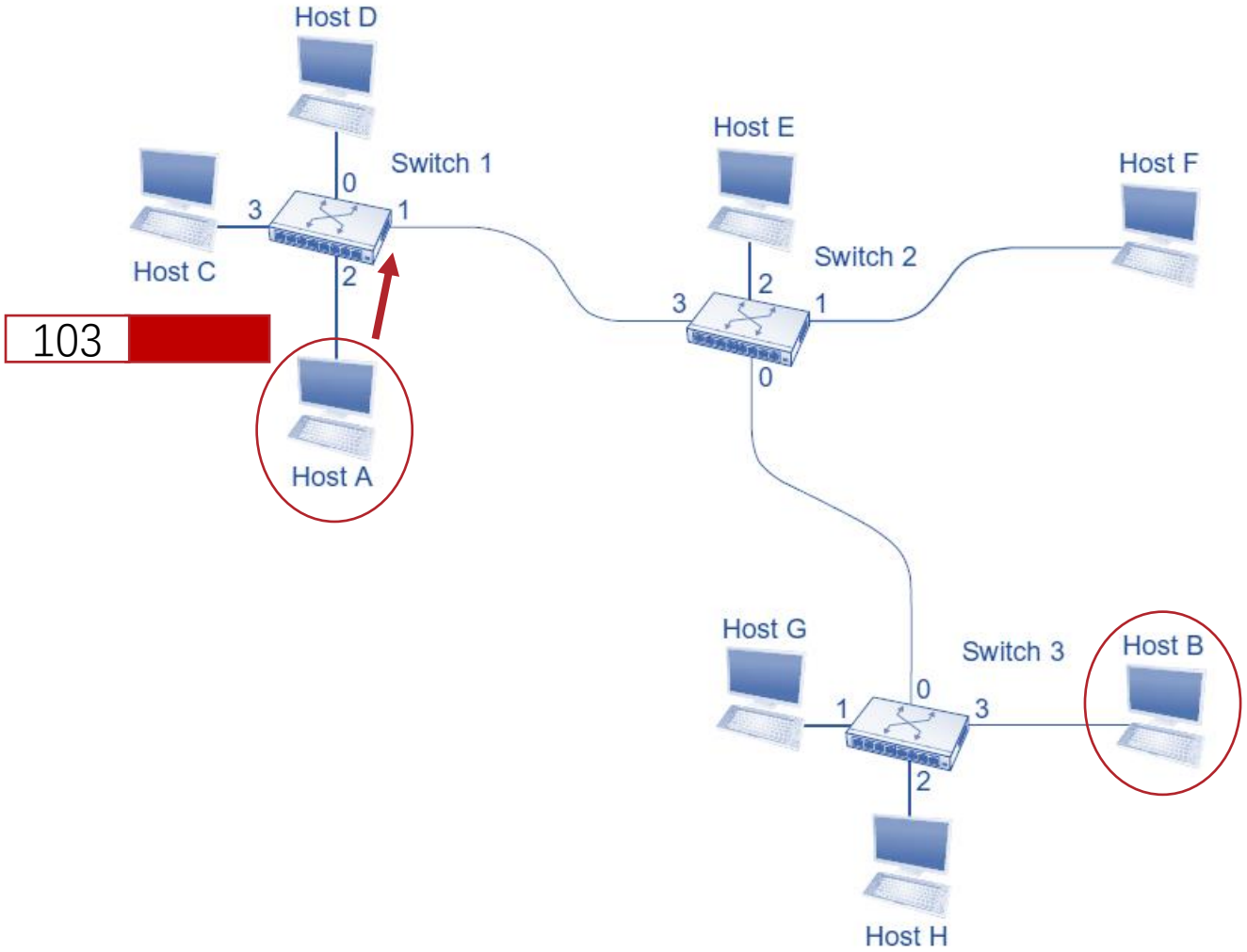
Virtual Circuit

- Reservation Service
  - Reserve Before Sending
- Guaranteed Service
  - Bitrate, Delay, etc.
  - Performance
    - Through reserving buffer, connection bandwidth, etc.

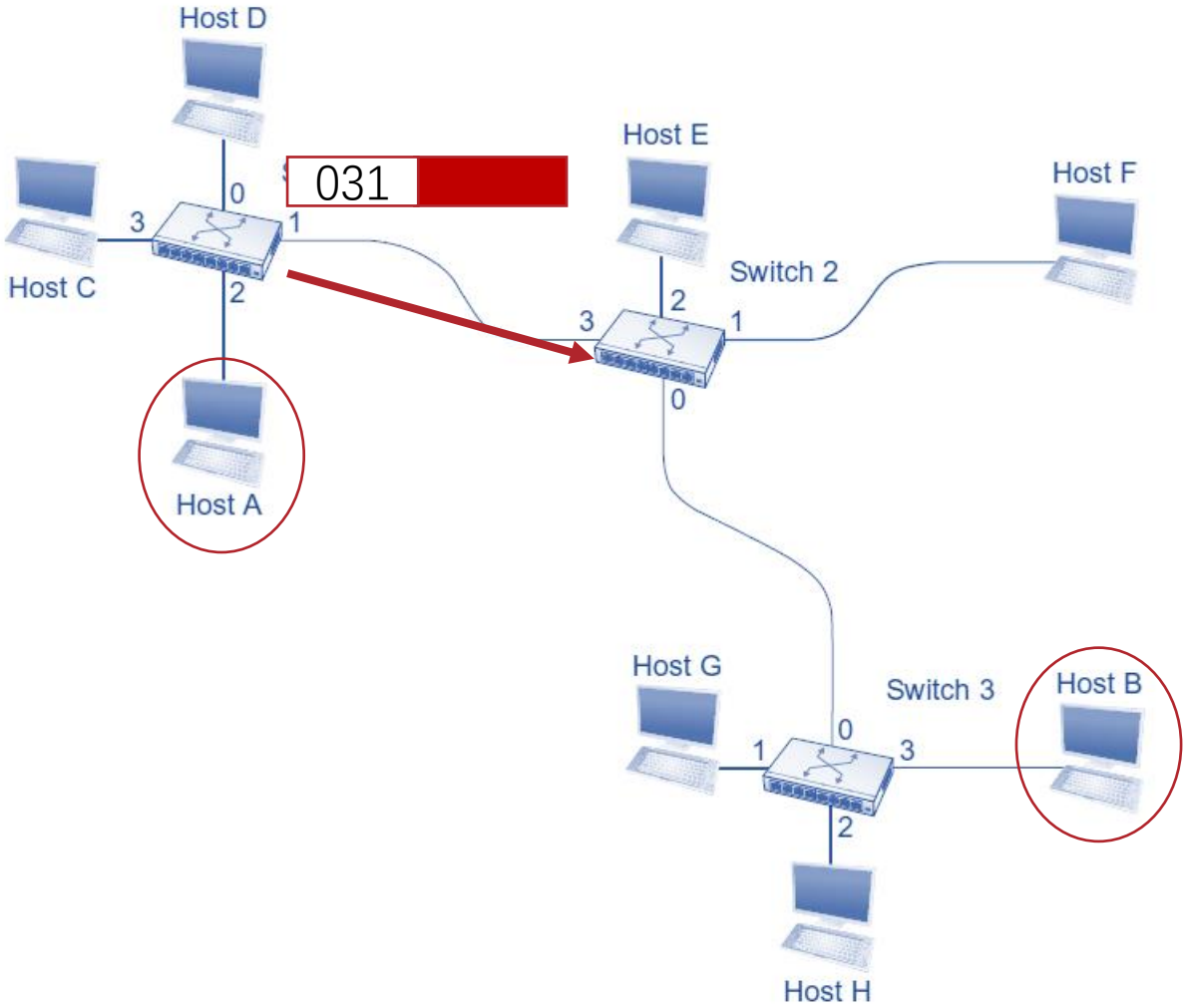
Source Routing



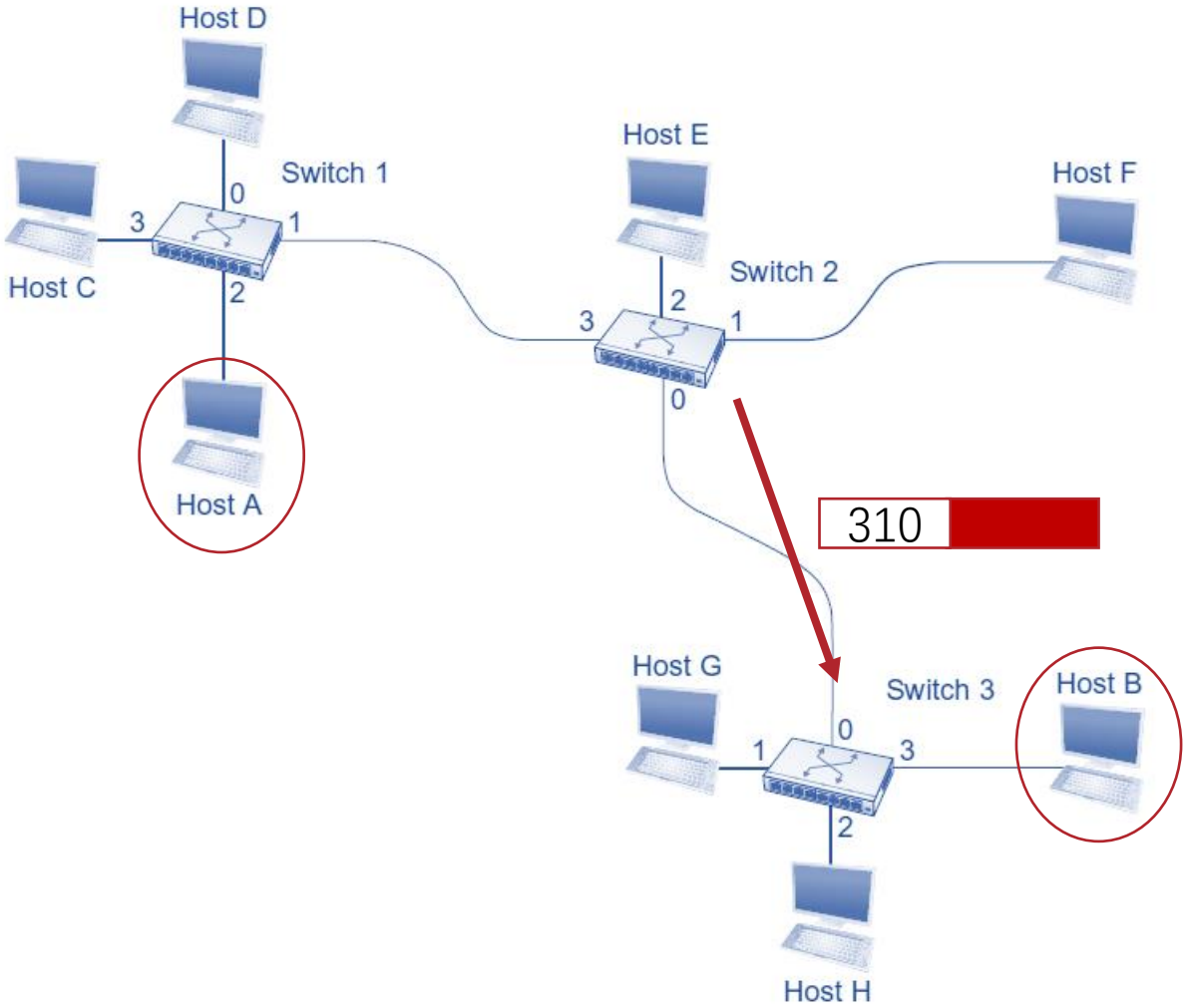
Source Routing



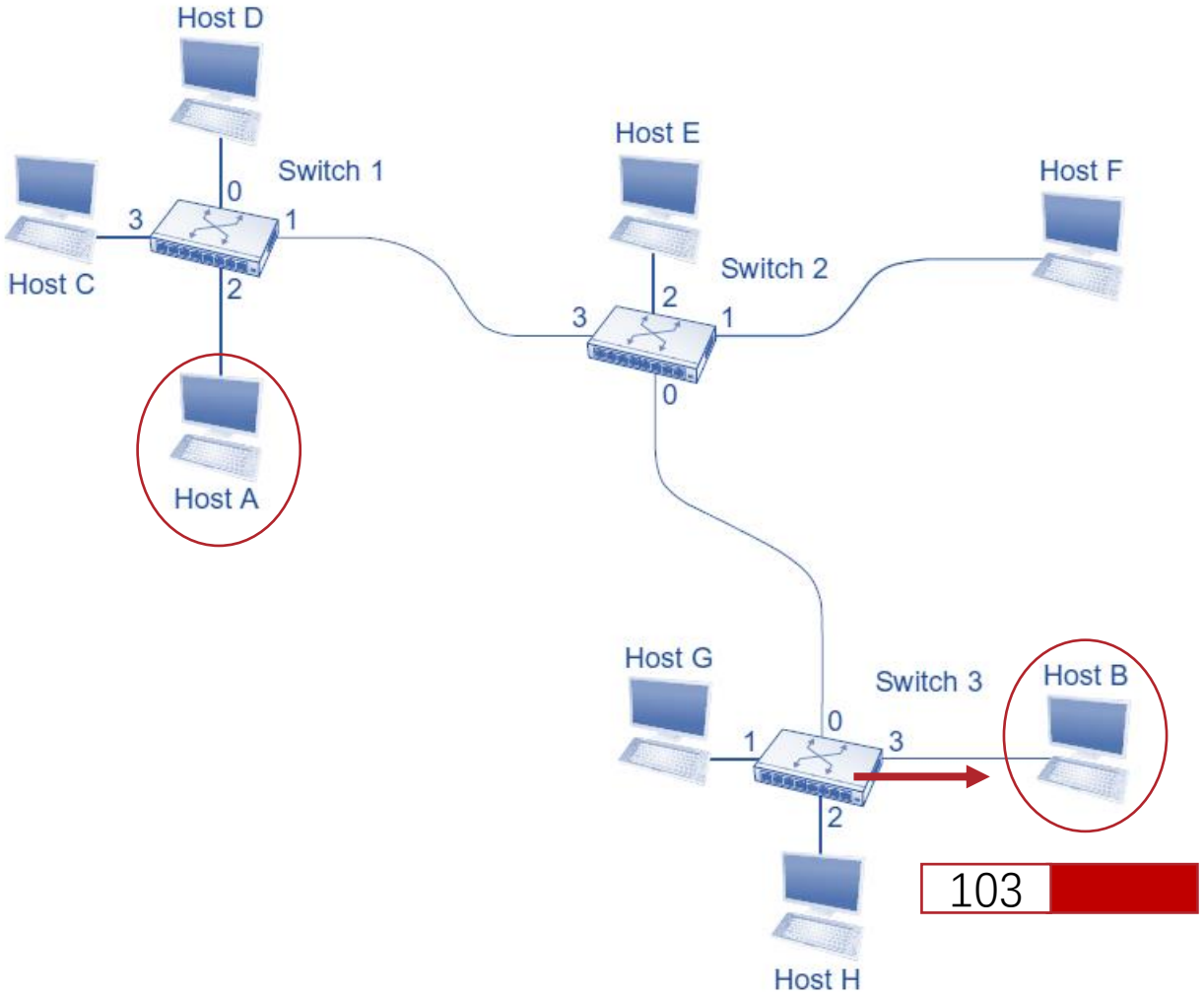
Source Routing



Source Routing



Source Routing



Reference

- Textbook 3.1