Packet Switching

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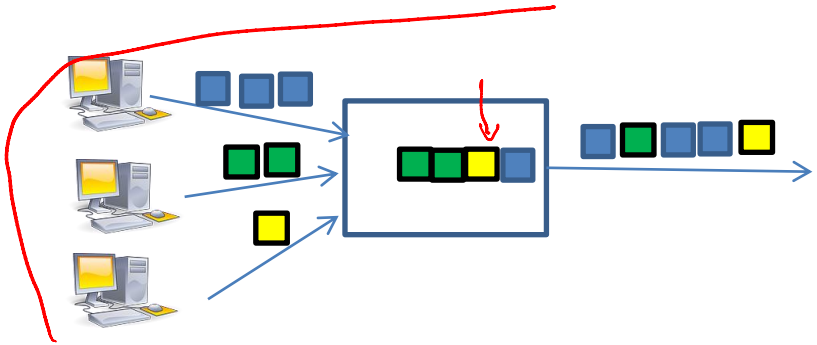
Recap

- Switching as a solution to scale networks
- Circuit Switching: Assign dedicated resources to users
- Packet Switching: Assign resources based on demand
  - Statistical Multiplexing
  - Store and Forward design



Packet Forwarding

- How are packets forwarded to the right port?
  - Packets carry information (in headers)
- Different types of packet switching
  - Datagram
  - Virtual Circuit
  - Source Routing

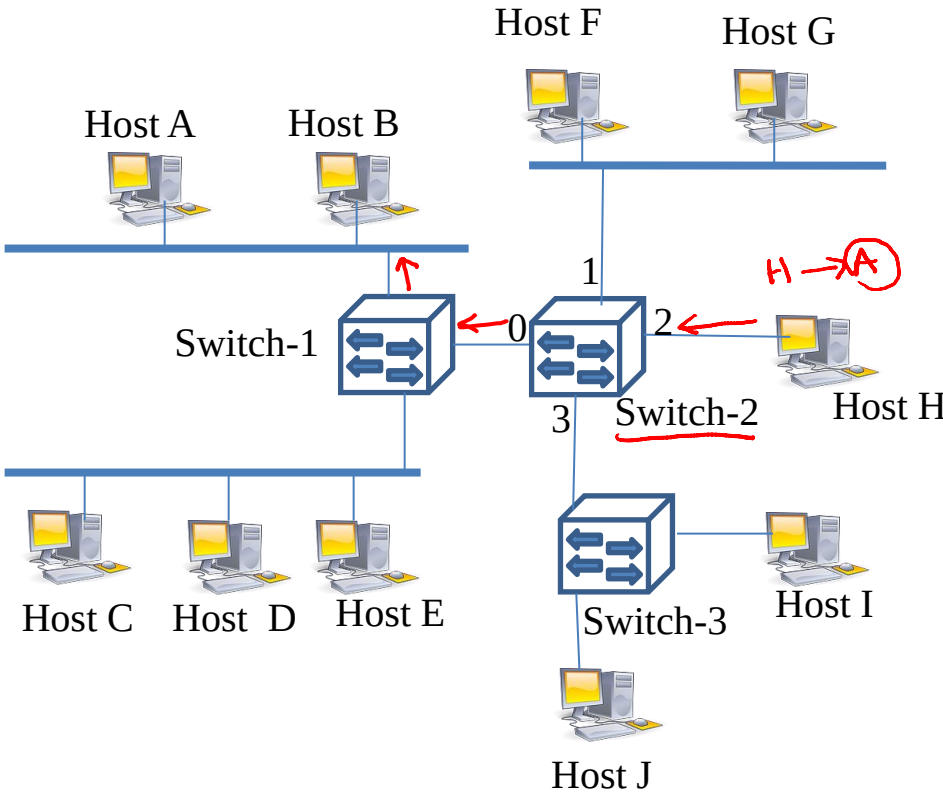
Datagram Switching

- Connection-less approach
- Each packet carries a destination address
  - Sender address also included so that receiver can reply
- Use destination address to determine port
  - Needs a forwarding table (maps addresses to ports)
  - How are forwarding table entries filled?
    - There are specific protocols that run in background (learning bridges, routing protocols) ✓

Example

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

Forwarding Table at Switch-2



Characteristics

- Can send a packet anywhere and at any time (no call set-up delay or per-connection state)
- No guarantees of packet delivery
  - Receiver may be down
- Possibility of reordering
  - Packets can take different routes
- Fault-tolerant
  - Alternate routes possible

Virtual Circuit Switching

1980's 1990's

- Tradeoff between Packet and circuit switching
  - ATM, Frame Relay, X.25 technologies
- Connection-oriented: A virtual connection set up over a packet switching core

store & forward architecture

  - Can reserve resources if needed
  - Virtual circuit identifier (VCI tag) carried inside the header of packets

Connection Setup

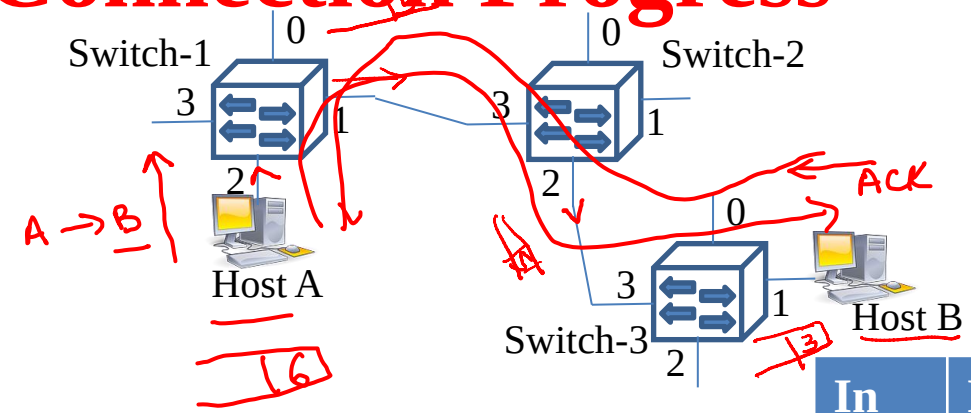
- Before sending data, set up connection
- At each switch between source and destination
  - Based on destination address, create a mapping of incoming VCI/Port to outgoing VCI/Port
  - At a switch, for each connection, VCI on a port is unique (local not global scope)
    - VCI field can be much smaller than address field

Connection Progress

Forwarding Table

Connection Table

In Port	In VCI	Out Port	Out VCI
Switch-1			
2	6	1	?
Switch-2			
3	5	2	?
Switch-3			
3	3	1	?



hardware → speed up switching

In Port	In VCI	Out Port	Out VCI
Switch-1			
2	6	1	5
Switch-2			
3	5	2	3
Switch-3			
3	3	1	3

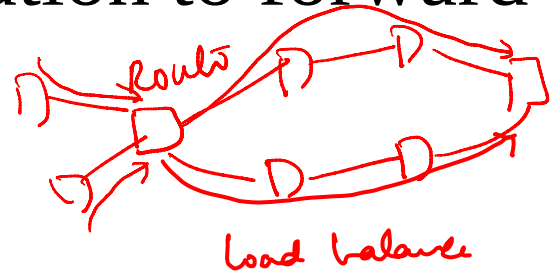
Host B allocated VCI of 3 to identify flow from A
Host B acks connection and specifies chosen VCI
Ack propagate back to A
VCI values populated in the tables
Forwarding of packets is rather straightforward now
Connection torn down after data transfer

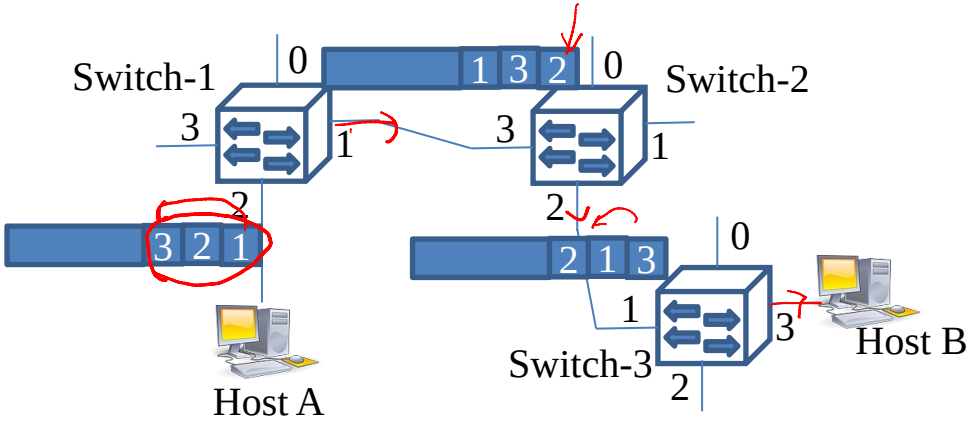
Characteristics

- Resources can be reserved during setup phase
  - Buffer space, link bandwidth
- At least one RTT before one can send data
- Reduced packet overhead per packet
- In case of failure at a switch, old connection needs to be torn down and new connection needs to be established

Source Routing

- Source provides all information to forward the packet
- In practice, rarely used





Characteristics

- Source needs to determine the route (not practical in many situations)
- Variable header length
- Both datagram and virtual circuit networks can support this feature
- Two Categories: “strict” vs “loose”
  - Strict: Full path specified
  - Loose: Subset of nodes specified

Tradeoffs

Metric	Datagram	Pure Circuit	Virtual Circuit
Forwarding Cost	High	None	Low
Bandwidth Utilization	High	Low	Flexible

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Forwarding Cost	High	None	Low
Bandwidth Utilization	High	Low	Flexible
Per-packet overhead	High address	None	Low VCI

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Forwarding Cost	High	None	Low
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Resource reservation	Not possible	Possible	Flexible

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Initial delay	None	High	High

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Initial delay	None	High	High
Reordering	Possible	None	None
Robustness	High	Low	Low

Summary

- Three types of Packet Switching: Difference is in how packets are forwarded
  - Datagram, Virtual Circuit and Source Routing
  - Inherent tradeoffs
- Ahead: Ethernet Switching