Packet Switching

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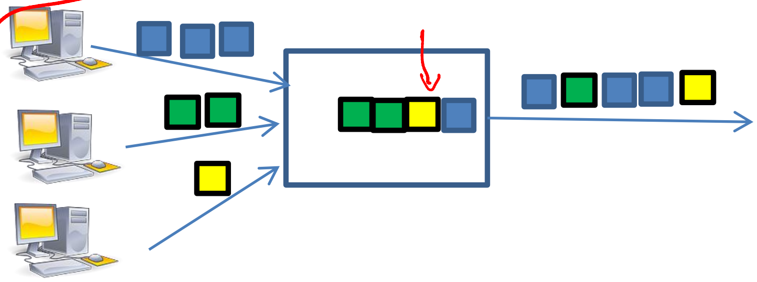
Recap

- Switching as a solution to scale networks

bandwidth

- 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 ✓

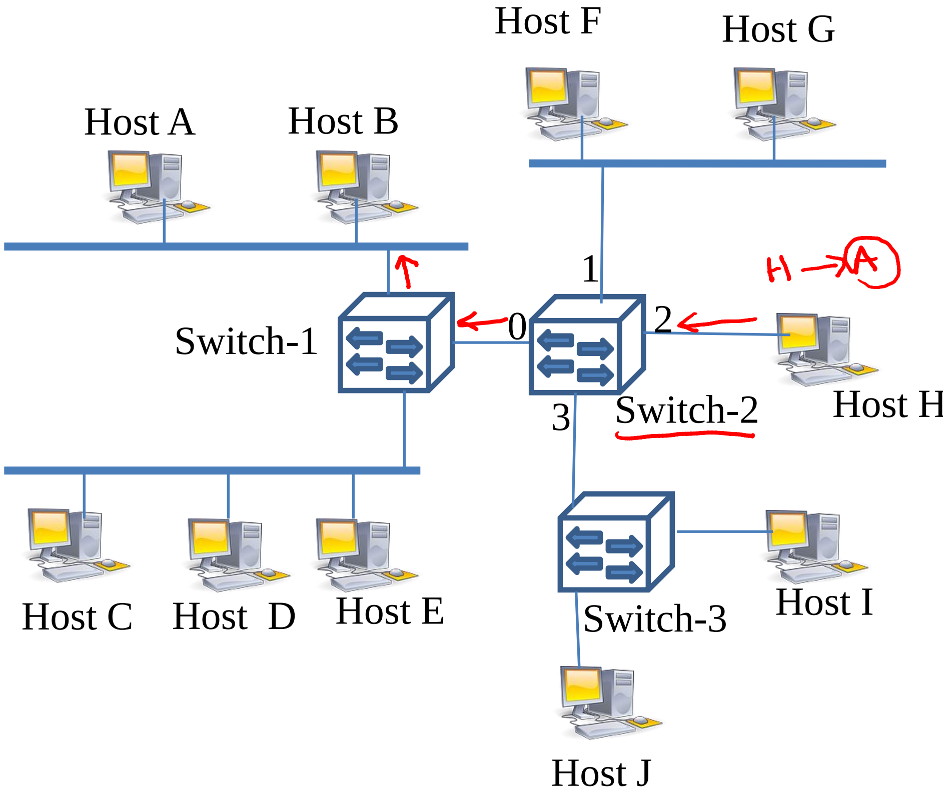
Datagram Switching

- 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

→ info

- Can send a packet anywhere and at any time (no call set-up delay or per-connection state)

A → H
B → C

- 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

it was found that, data gram .... cannot support real time applications like voice and video...because of delay problems

- 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

it do not need a resourse reservation but if we need then we can use it through a connecton oriented approch.

establish a connecction before talikng

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

Connection Setup

- Before sending data, set up connection src & dest
- At each switch between source and destination
  - Based on destination address, create a mapping of incoming VCI/Port to outgoing VCI/Port reserve resources
  - 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

# of bits

global

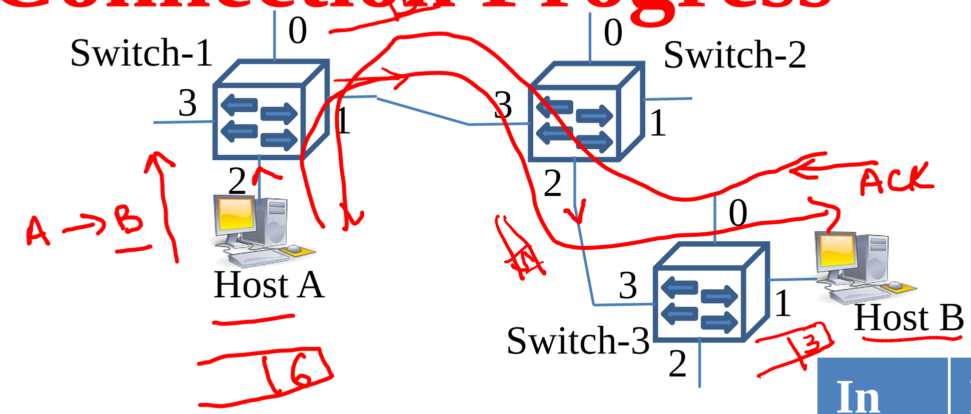
need to be unique among all the hostds

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	~~7~~ 5	1	?



First connection is established, then msg is send

hardware → speed up switching

~~looking up forwarding table is tedious~~

In Port	In VCI	Out Port	Out VCI
Switch-1			
2	6	1	5 ✓
Switch-2			
3	5	2	~~7~~ 5
Switch-3			
3	~~7~~ 5	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

  Queue

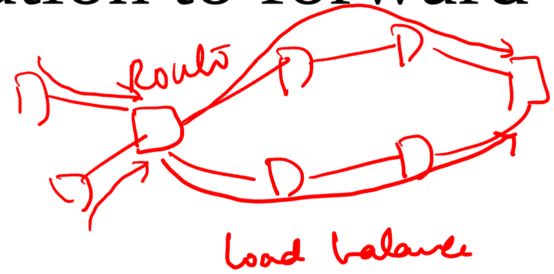
  - Buffer space, link bandwidth
- At least one RTT before one can send data

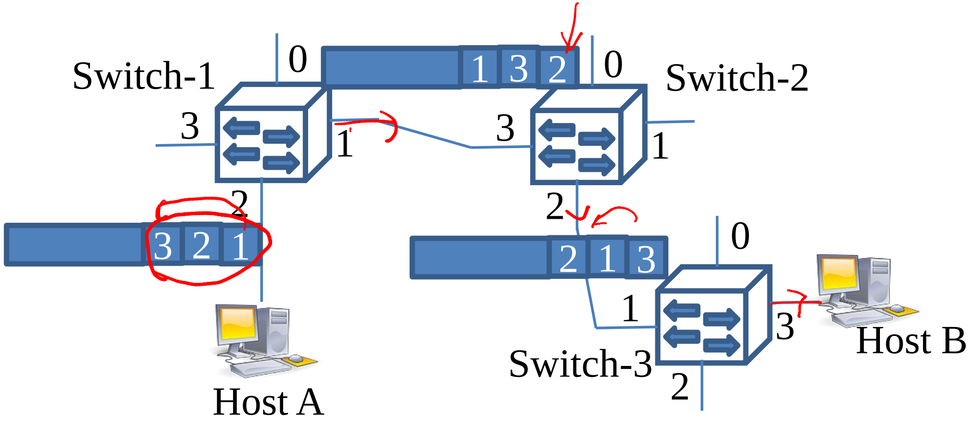
  VCI
- Reduced packet overhead per packet
- In case of failure at a switch, old connection needs to be torn down and new connection needs to be established

Source Routing

Host

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



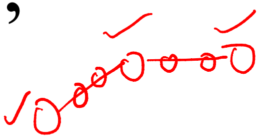


Characteristics

- Source needs to determine the route (not practical in many situations)
- Variable header length

destination

- Both datagram and virtual circuit networks can support this feature
- Two Categories: "strict" vs "loose"
  - Strict: Full path specified
  - Loose: Subset of nodes specified



Forwarding decision

Tradeoffs

local [connection table

Metric	Datagram	Pure Circuit	Virtual Circuit
Forwarding Cost	High	None	Low can be implemented in hardware... so fast
Bandwidth Utilization	High	Low	Flexible

Tradeoffs

Metric	Datagram	Pure Circuit	Virtual Circuit
Forwarding Cost	High	None	Low
Bandwidth Utilization	High	Low	Flexible
Per-packet overhead	High address	None	Low VCI

Tradeoffs

Metric	Datagram	Pure Circuit	Virtual Circuit
Forwarding Cost	High	None	Low
Bandwidth Utilization	High	Low	Flexible
Per-packet overhead	High	None	Low
Resource reservation	Not possible	Possible	Flexible

Tradeoffs

Metric	Datagram	Pure Circuit	Virtual Circuit
Forwarding Cost	High	None	Low
Bandwidth Utilization	High	Low	Flexible
Per-packet overhead	High	None	Low
Resource reservation	Not possible	Possible	Flexible
Initial delay	None	High	High

Tradeoffs

Metric	Datagram	Pure Circuit	Virtual Circuit
Forwarding Cost	High	None	Low
Bandwidth Utilization	High	Low	Flexible
Per-packet overhead	High	None	Low
Resource reservation	Not possible	Possible	Flexible
Initial delay	None	High here also first connection needs to be established	High
Reordering	Possible	None	None here we just pin the whole path... so re ordring is not possible

Tradeoffs

Metric	Datagram	Pure Circuit	Virtual Circuit
Forwarding Cost	High	None	Low
Bandwidth Utilization	High	Low	Flexible
Per-packet overhead	High	None	Low
Resource reservation	Not possible	Possible	Flexible
Initial delay	None	High	High
Reordering	Possible	None	None
Robustness	High because it can always find an alternating path	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