Network Sharing

An Ideal Network Topology Fulfills Three Requirements

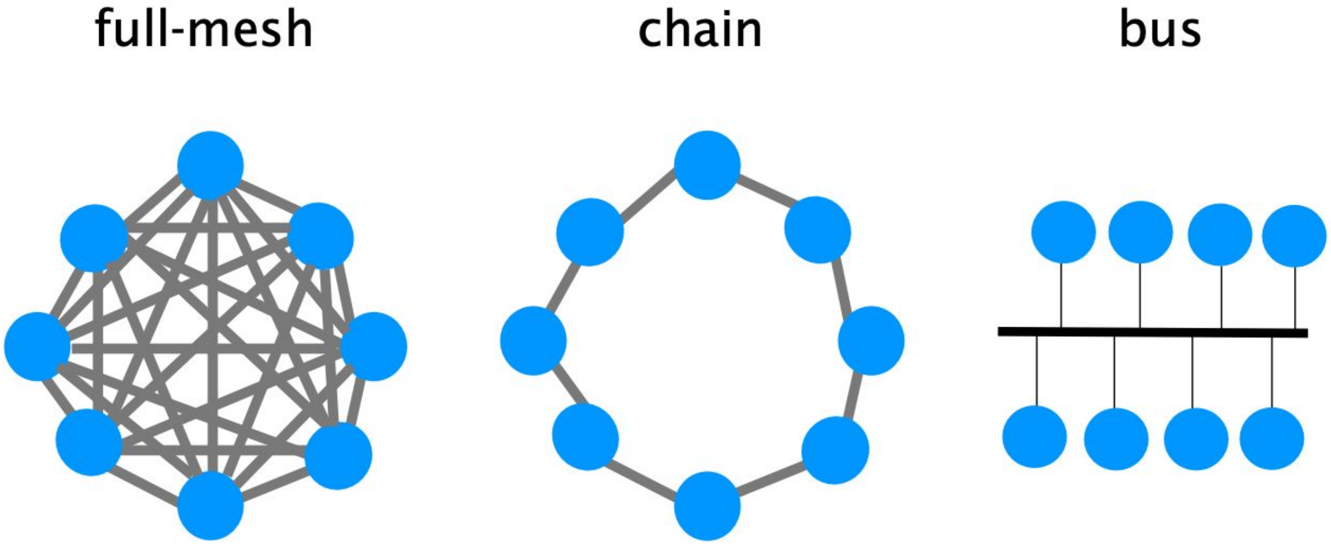
- Resilient to failures
  - >1 path should exist between each node

- Allow sharing (to be feasible and cost-effective)
  - The number of links should be kept low

- Provide adequate capacity
  - Links should not be too small

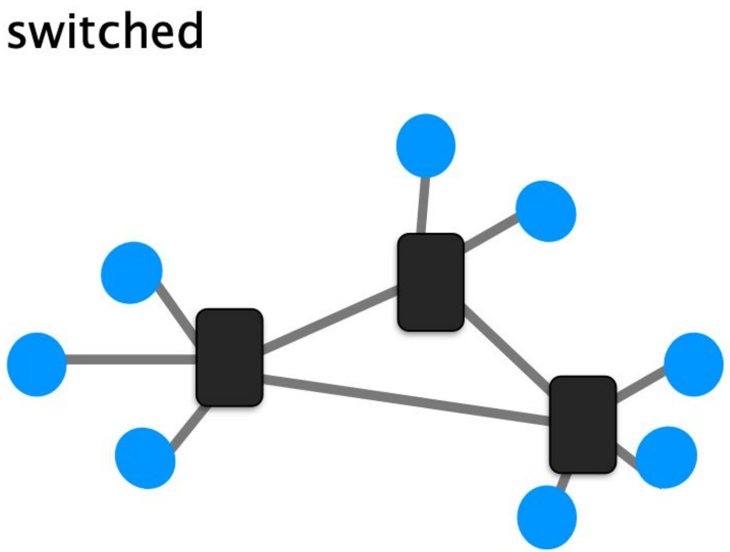
An Ideal Network Topology Fulfills Three Requirements

- Compare these designs in terms of <u>sharing</u>, <u>resiliency</u>, and per-node <u>capacity</u>

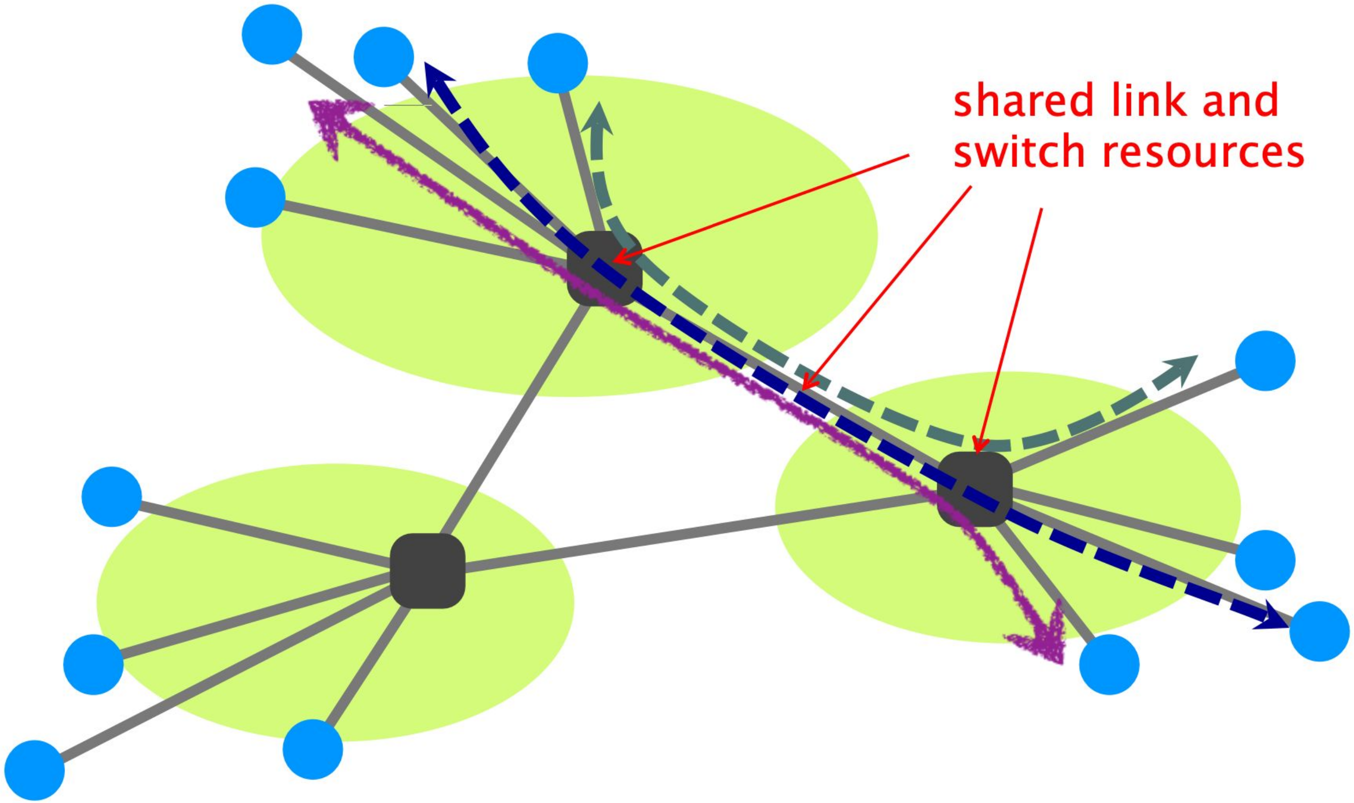


Switched Networks Provide a Reasonable and Flexible Compromise

- Sharing and per-node capacity can be adapted to fit the network needs
- Downside: requires forwarding, routing, and resource allocation



Links and Switches are Shared By Flows



Two Approaches to Shared Links

- Reservation (Circuit switching)
  - Reserve what you need in advance

- On-demand (Packet switching)
  - Send data when needed

Both Use Statistical Multiplexing

- Reservation (Circuit switching)
  - At the flow level

- On-demand (Packet switching)
  - At the packet level

Circuit-Switching (Reservation) vs Packet Switching (On-Demand)

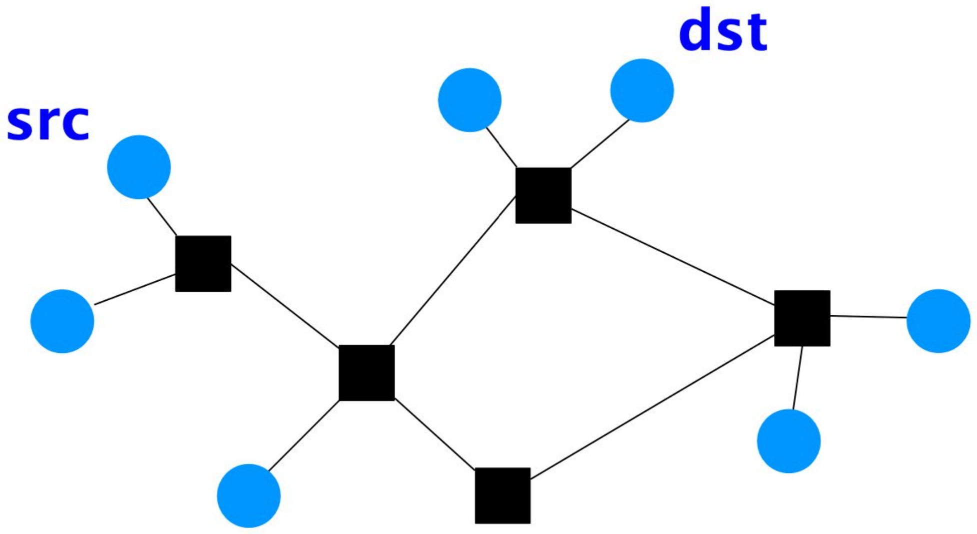
- Every flow has peak rate (P) and average rate (A)
- **Circuit switching must reserve P**, but level of utilization is A/P
    - P=100 Mbps, A=10 Mbps, level of utilization=10%
- Packet switching can usually achieve higher level of utilization
    - depends on degree of sharing and burstiness of flows

Circuit-Switching (Reservation) vs Packet Switching (On-Demand)

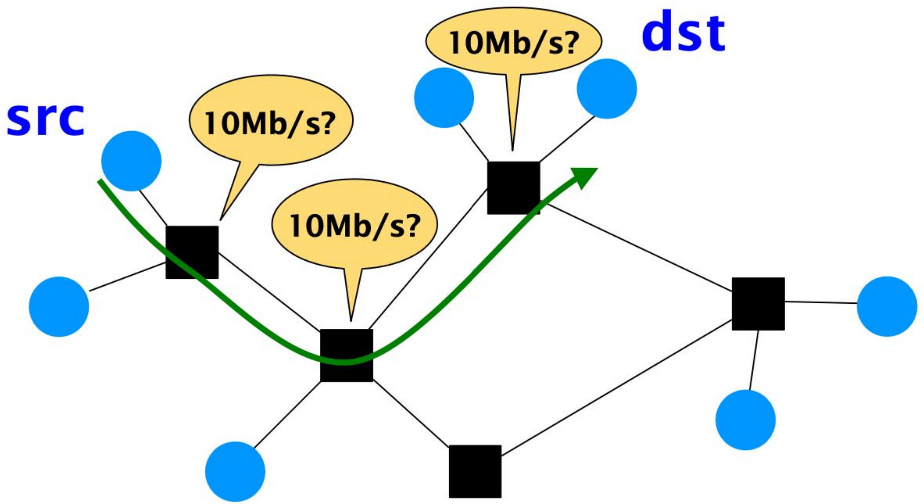
- Circuit switching makes sense when P/A is small
    - voice traffic has a ratio of ~3

- Circuit switching wastes capacity when P/A is big
    - data applications are bursty, ratios >100 are common

Circuit-Switching Uses a Resource Reservation Protocol

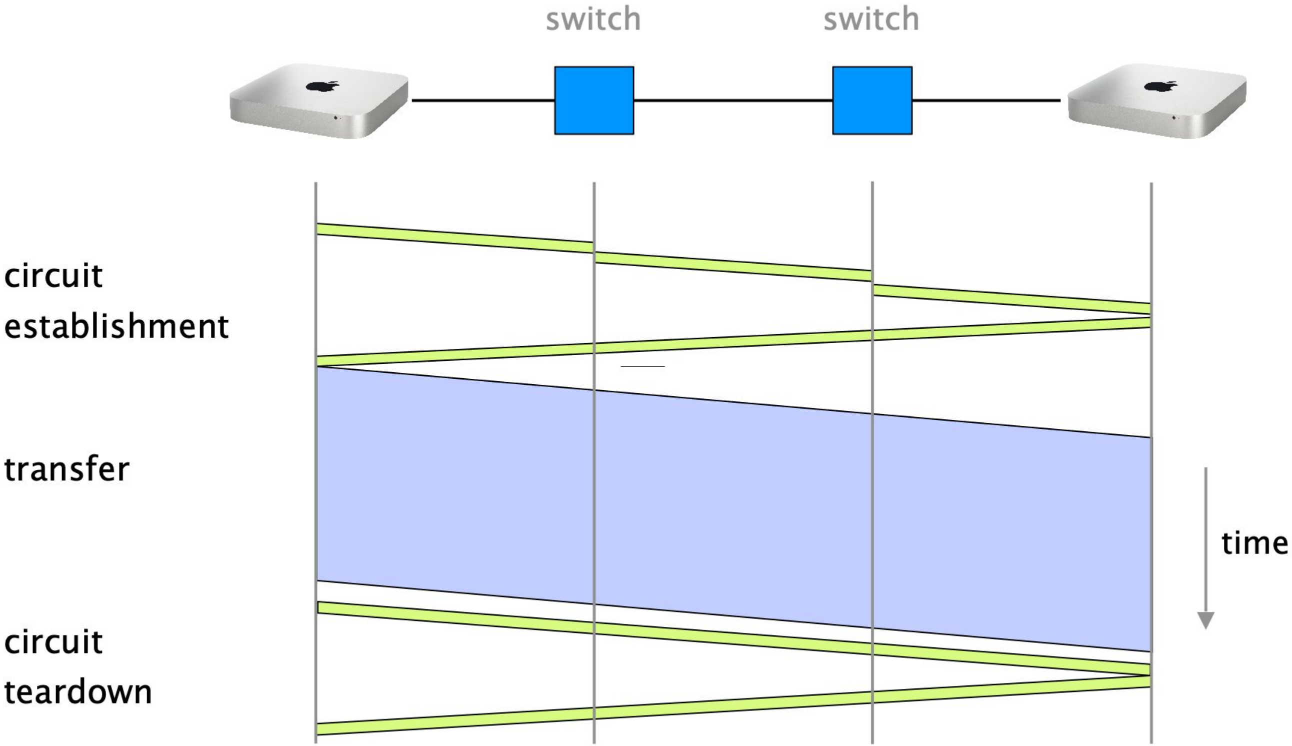


Circuit-Switching Uses a Resource Reservation Protocol



(1) src sends a reservation request for 10Mbps to dst
(2) switches "establish a circuit"
(3) src starts sending data
(4) src sends a "teardown circuit" message

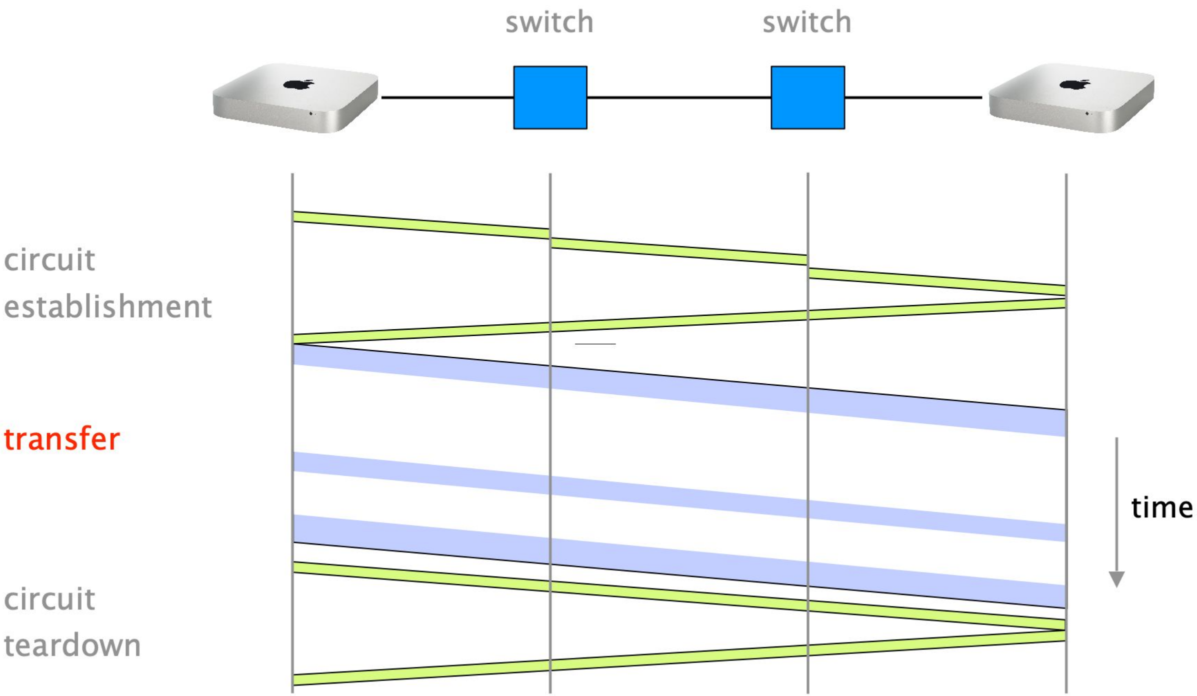
Circuit-Switching Uses a Resource Reservation Protocol



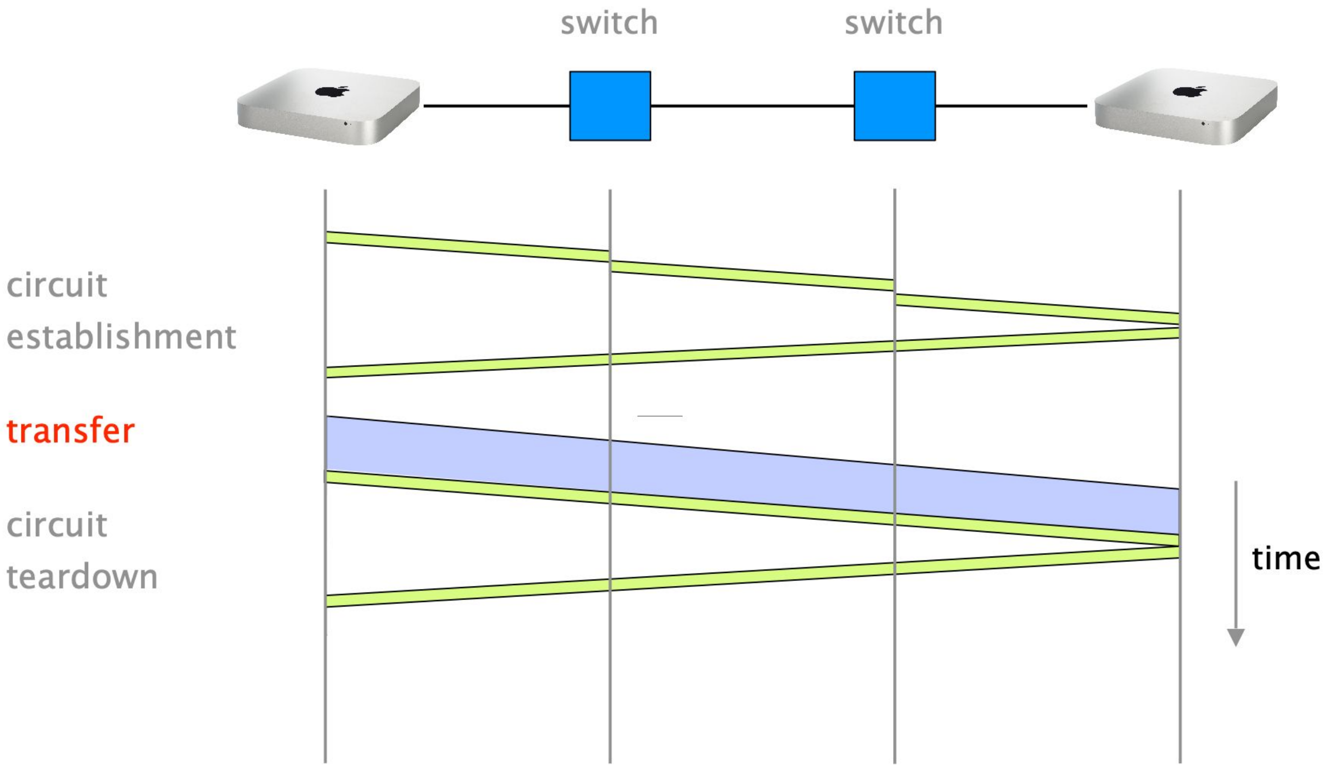
Circuit-Switching Uses a Resource Reservation Protocol

Only efficient if the circuit is utilized once established

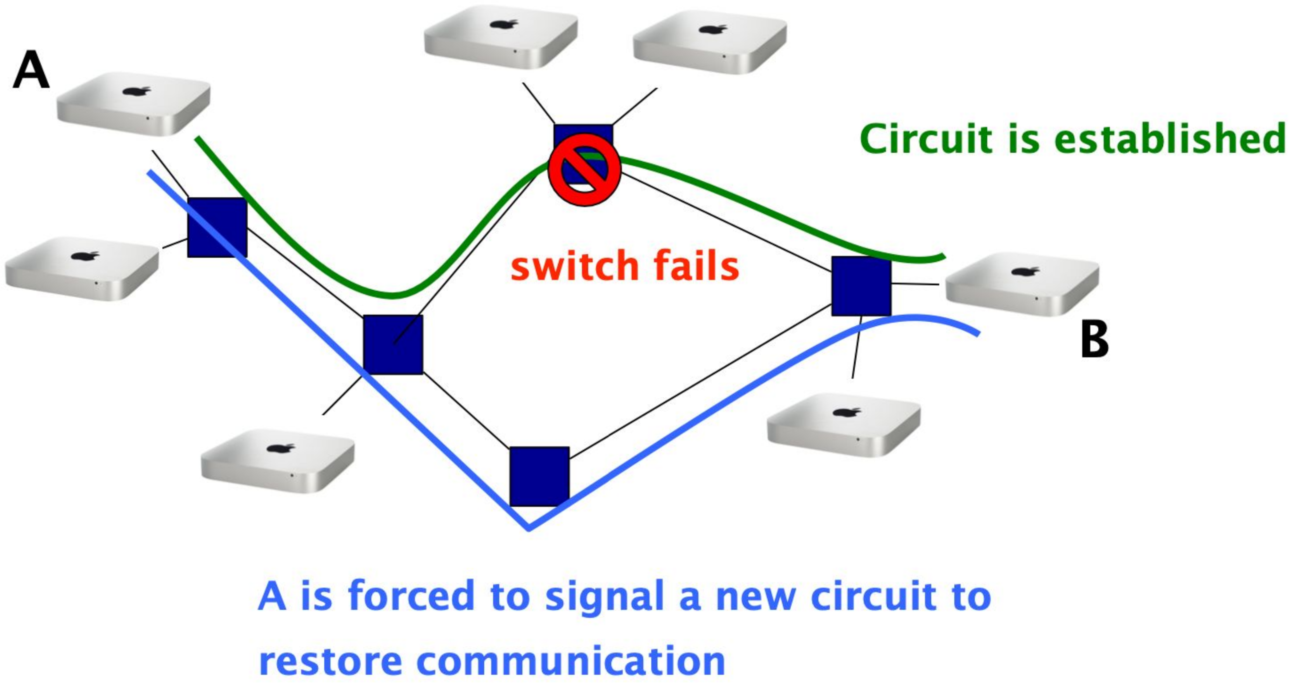
Low Efficiency - Bursty Traffic



Low Efficiency - Short-Lived Circuit



Circuit Switching Doesn't Route Around Failures



Pros and Cons of Circuit Switching

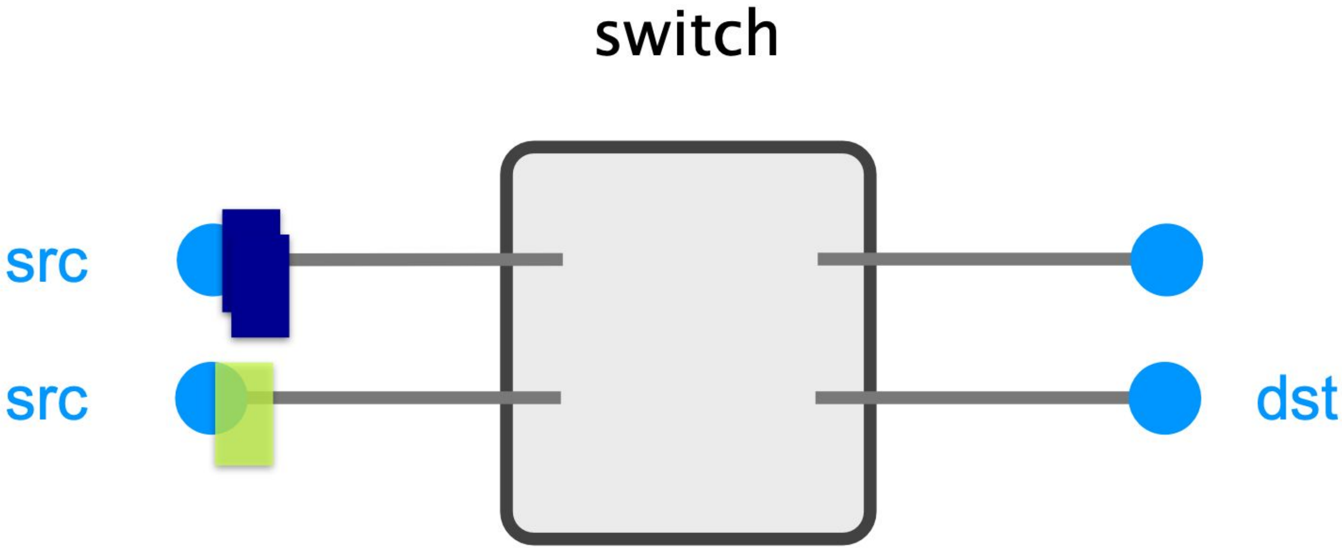
Pros

- Predictable performance
- Simple and fast switching once circuit established

Cons

- Inefficient if traffic is bursty or short lived
- Complex circuit setup / teardown
- Requires new circuit upon failure

Packet Switching: Data is Sent Using Independent Packets

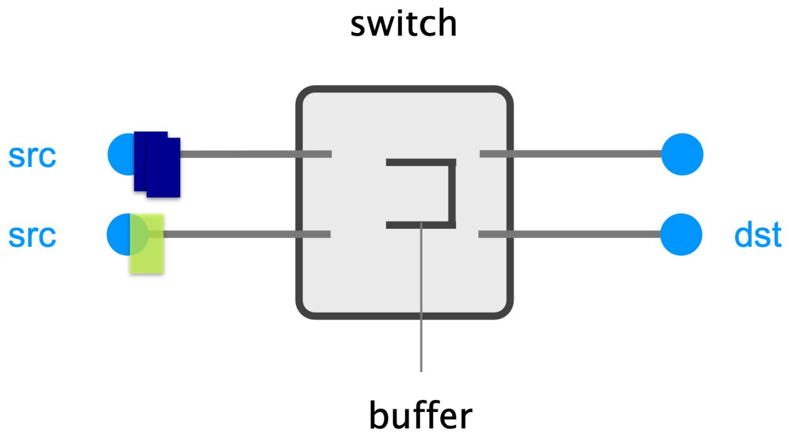


Each packet contains a destination (dst)

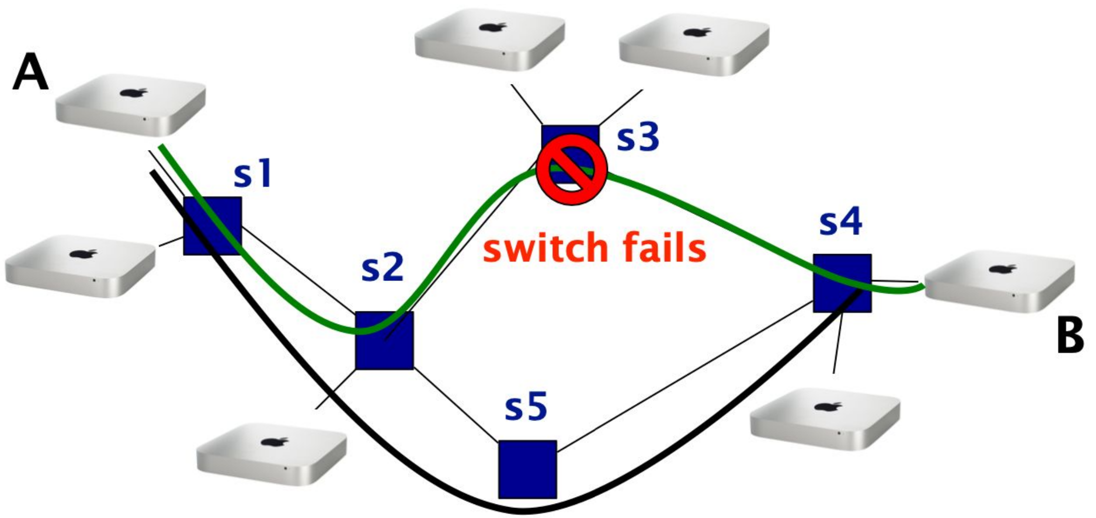
Packet Switching: Data is Sent Using Independent Packets

With no coordination, packets can “collide”

To absorb transient overload, packet switching relies on buffers



Packet Switching Routes Around Failure



route recomputed on the fly by s2

Pros and Cons of Packet Switching

Pros

- Efficient use of resources

- Simple to implement

- Route around problems

Cons

- Unpredictable performance

- Requires buffer management and congestion control

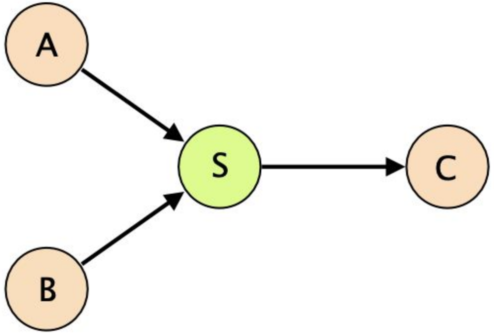
Packet Switching Wins

Almost all systems use packet switching
(even telecom is moving towards it).

Circuit Switching vs Packet Switching

A and B are sending data towards C. All the links in the network have a bandwidth of 10 Mbps. For circuit switching, assume that circuit establishment and teardown each take 50 ms.

- How long does it take if node A is sending a 50 Mbit file to C using packet switching? B sends nothing.
- How long does it take if node B is sending a 50 Mbit file to C using circuit switching? A sends nothing.



Assume now that A and B are using packet switching and are each sending a 50 Mbit file to C at the same time.

- What will happen if the switch has no buffer?

Circuit Switching vs Packet Switching

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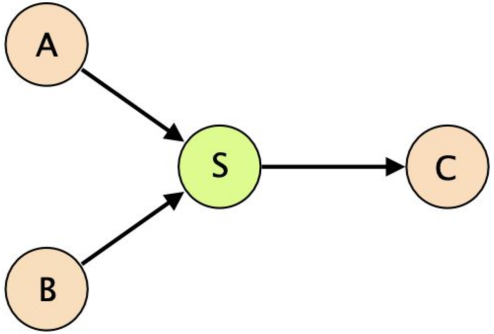


- How long does it take if node A is sending a 50 Mbit file to C using packet switching? B sends nothing.
  Answer: 5s

- How long does it take if node B is sending a 50 Mbit file to C using circuit switching? A sends nothing.
  Answer: 5.1s

Assume now that A and B are using packet switching and are each sending a 50 Mbit file to C at the same time.

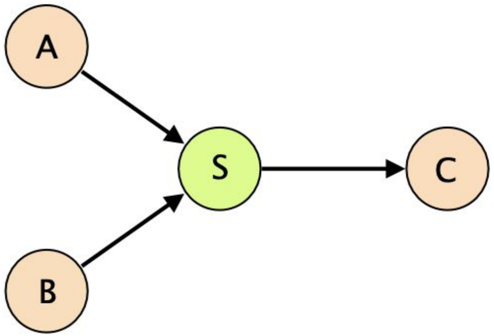
- What will happen if the switch has no buffer?
  Answer: Some packets are dropped

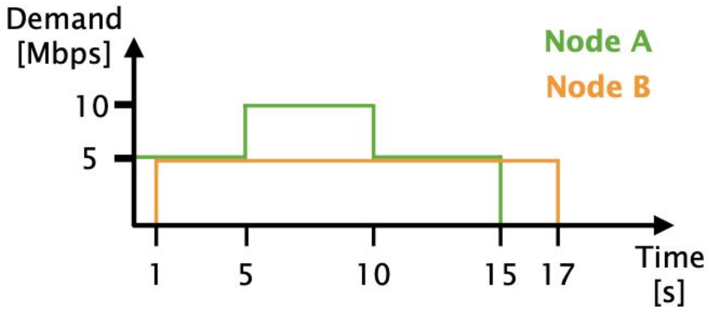
Circuit Switching vs Packet Switching

Assume that A and B have to send data with a demand according to the diagram on the right.

- How long does it take to send all data if A and B use circuit switching (reserving for the peak demand)?

- How long does it take to send all data if A and B use packet switching (you can assume an unlimited buffer size on S)?





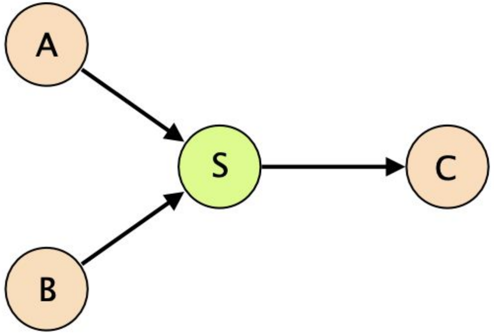
Demand distributions for node A and B.

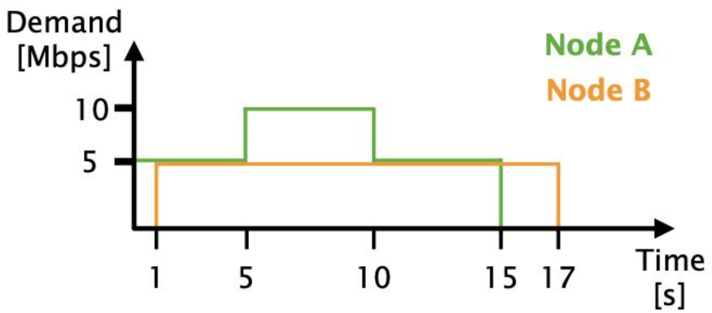
Circuit Switching vs Packet Switching

Assume that A and B have to send data with a demand according to the diagram on the right.

- How long does it take to send all data if A and B use circuit switching (reserving for the peak demand)?
  Answer: First, node A reserves 10Mbps bandwidth. During this time, node B cannot establish its circuit.
  0.05 + 15 + 0.05 + 0.05 + 16 + 0.05 = 31.2 s

- How long does it take to send all data if A and B use packet switching (you can assume an unlimited buffer size on S)?
  Answer: Both nodes start to send packets immediately. From 5 to 10 s, packets are buffered. Assuming the switch always uses the full link bandwidth towards C:
  1 + 14 + 2 + 1.5 = 18.5 s





Demand distributions for node A and B.