Network Sharing

# An Ideal Network Topology Fulfills Three Requirements

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

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

- 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>
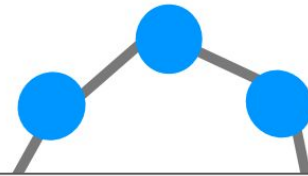
full-mesh

chain
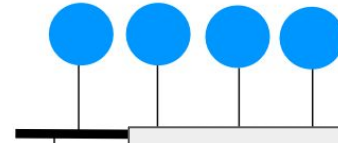
bus

Sharing: BAD

Resiliency: Good

Capacity: Good
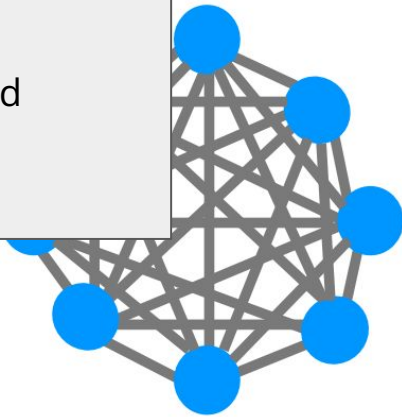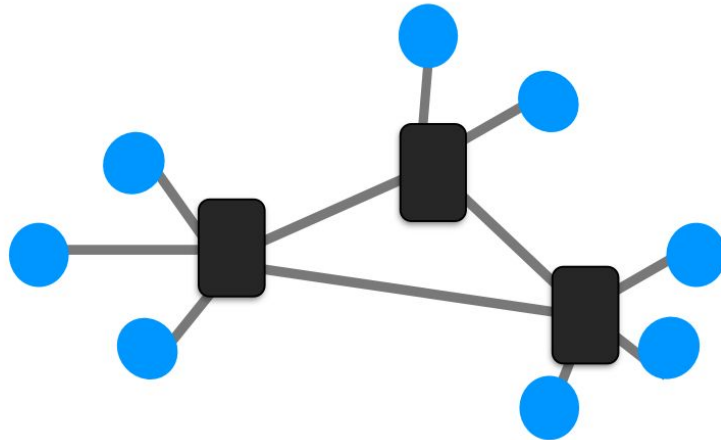
Sharing: Good

Resiliency: Bad

Capacity: Okay

Sharing: Good
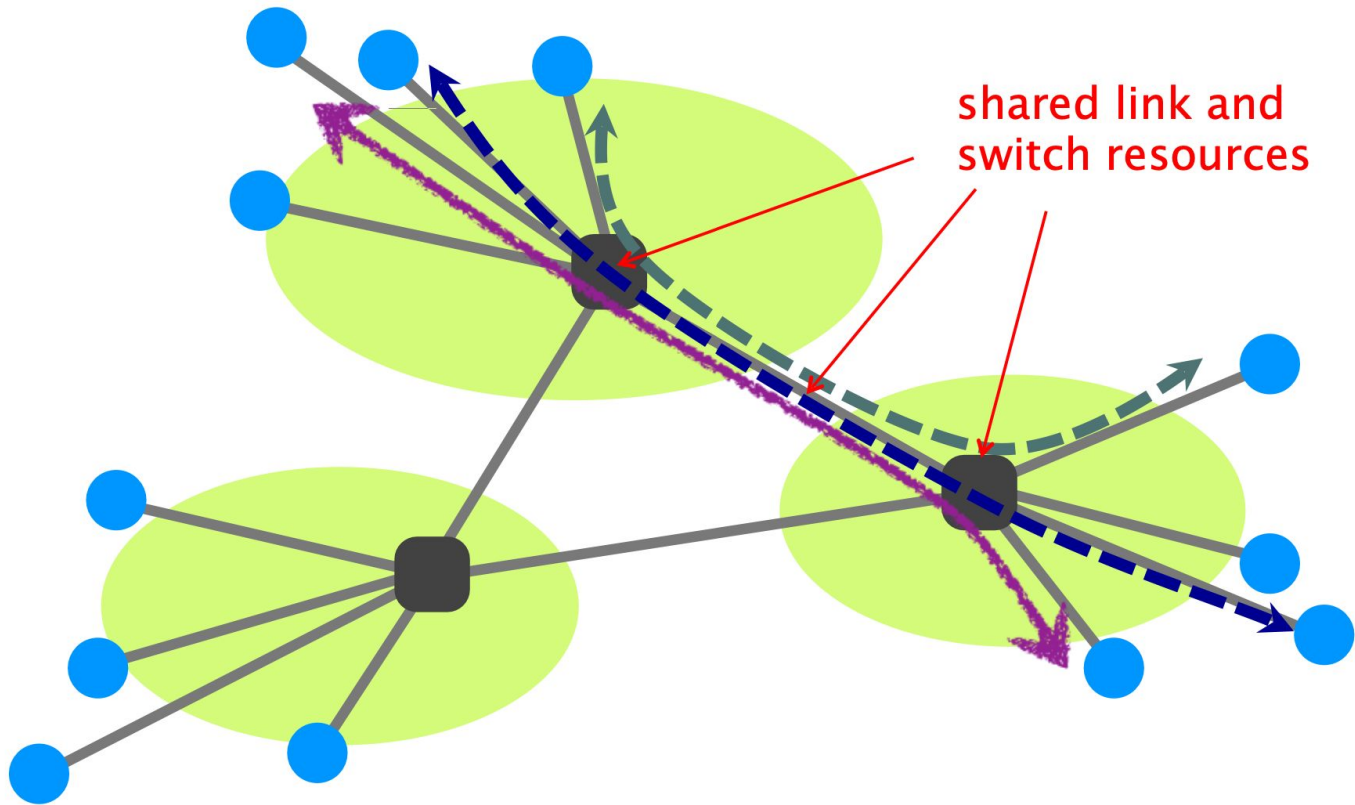
Resiliency: BAD

Capacity: Bad

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

switched

Links and Switches are Shared By Flows

shared link and
switch resources

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
    - Examples?
        - Telephone trunk lines

- On-demand (Packet switching)
    - At the packet level
    - Examples?
   - Basically the entire Internet

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

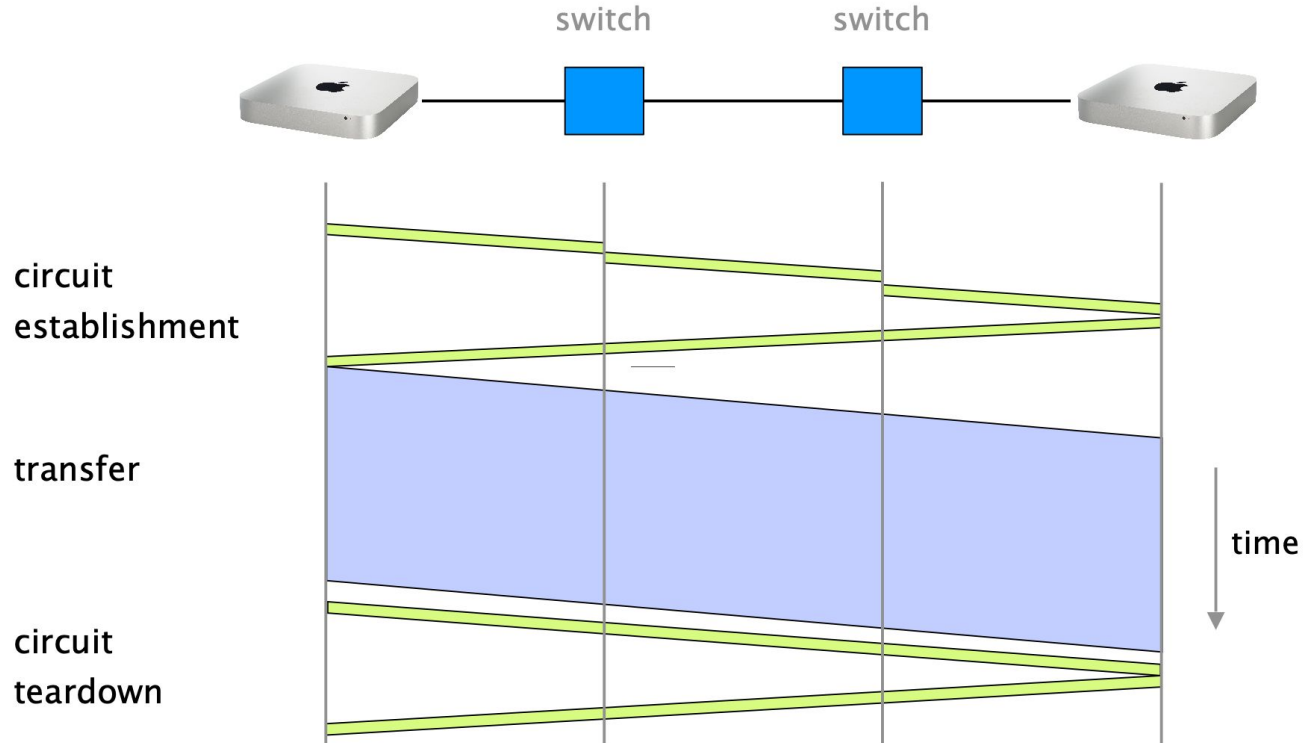# Circuit-Switching Uses a Resource Reservation Protocol
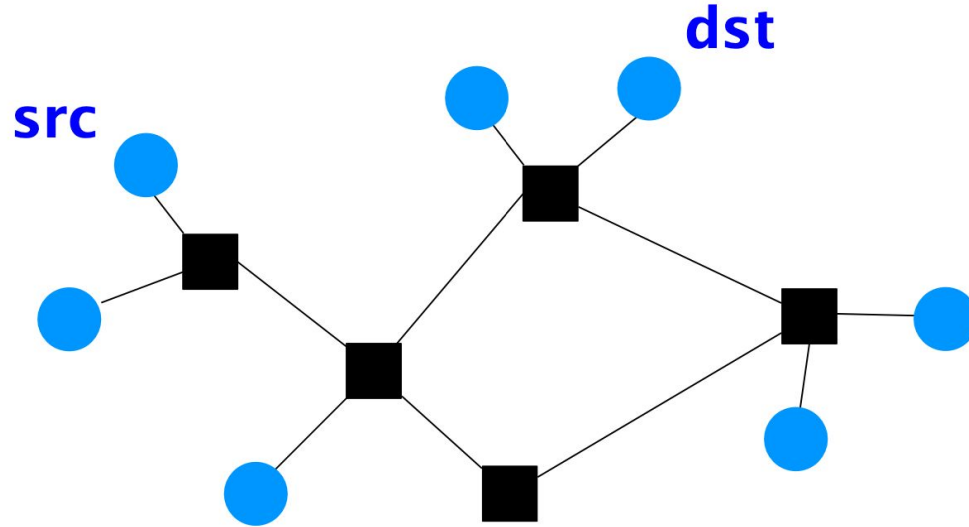
Circuit-Switching Uses a Resource Reservation Protocol
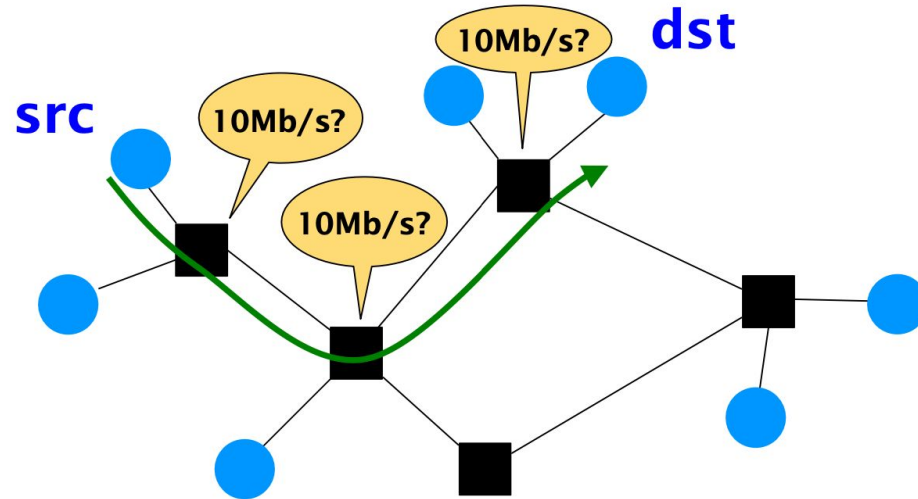
(1) src sends a reservation request for 10Mbps to dst
(2) switches "establish a circuit"
(3) src starts sending data
(4) src sends a "teardown circuit" message

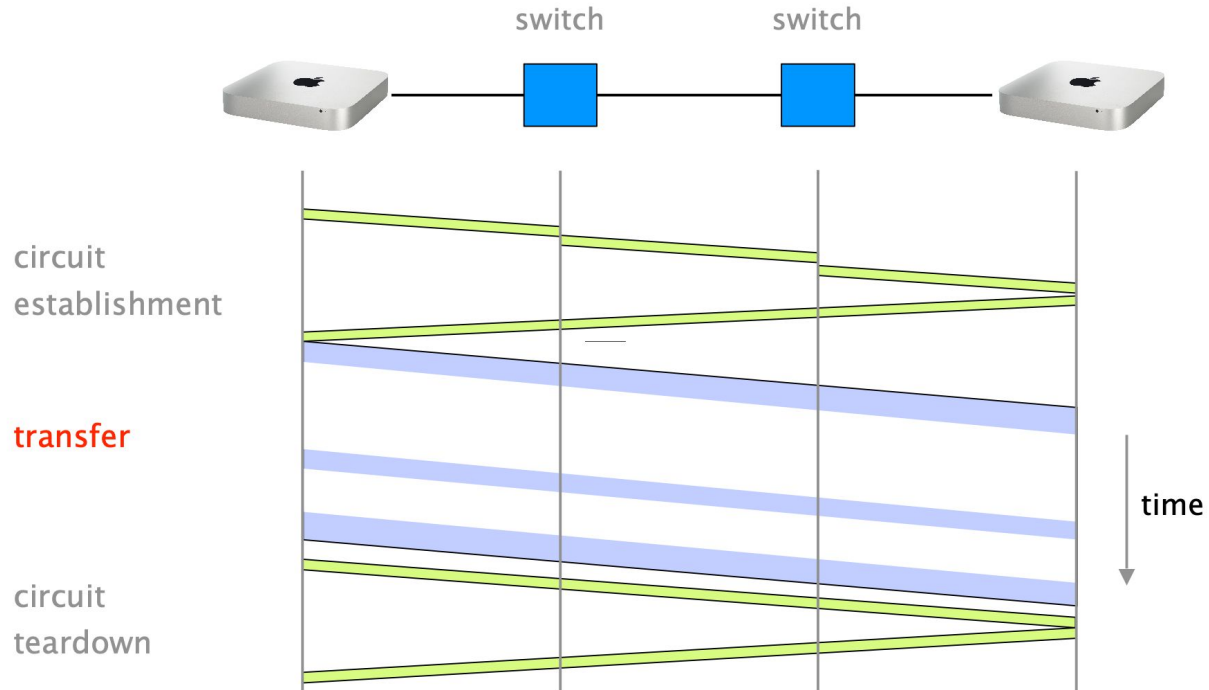# Circuit-Switching Uses a Resource Reservation Protocol

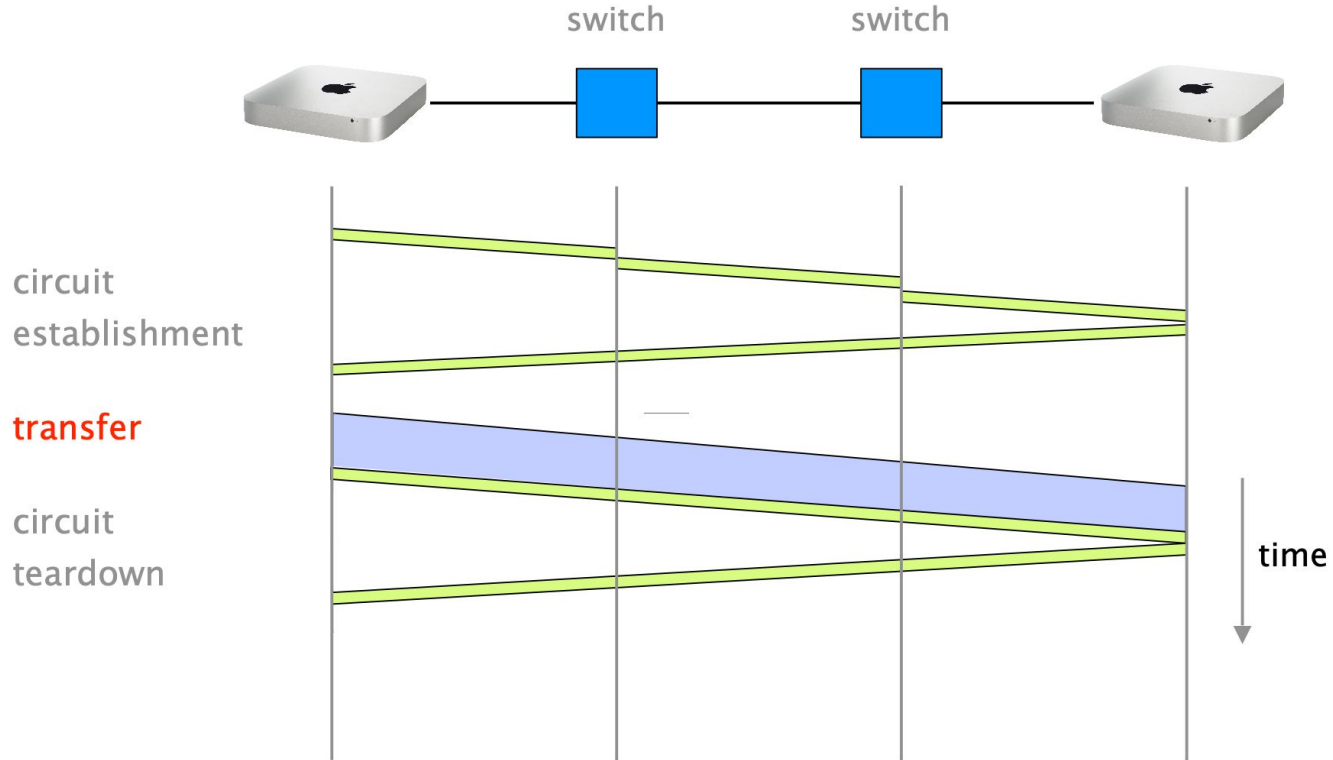# Circuit-Switching Uses a Resource Reservation Protocol

Only efficient if the circuit is utilized once established
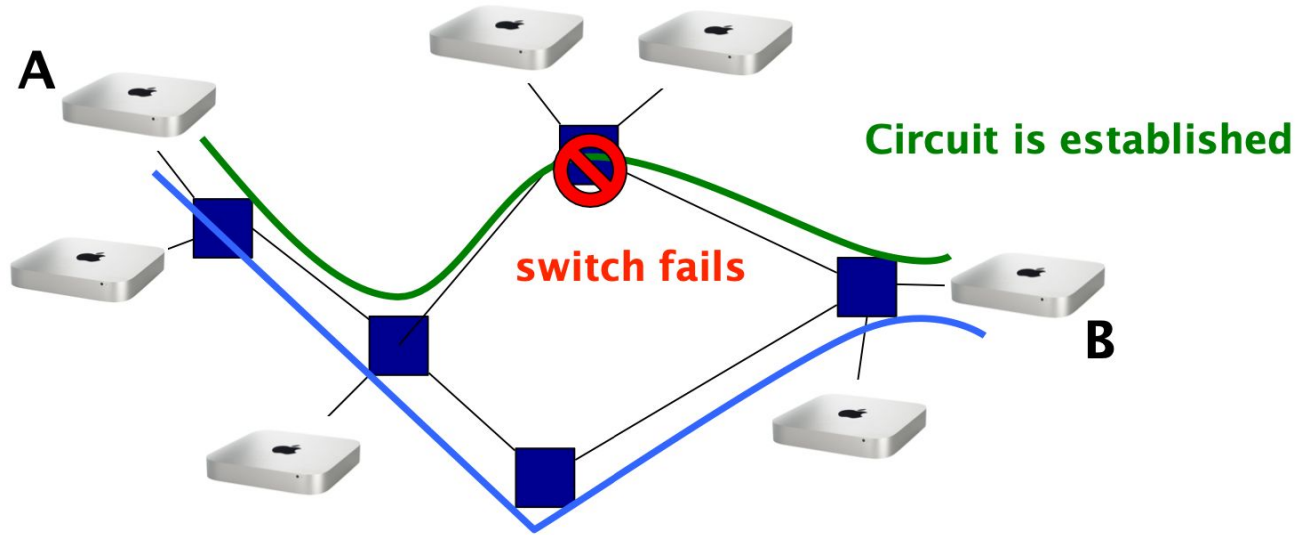
Examples of inefficient circuit scenarios?

Low Efficiency - Bursty Traffic

Low Efficiency - Short-Lived Circuit

switch   switch

circuit
establishment

transfer

circuit
teardown

time

Circuit Switching Doesn't Route Around Failures

A

Circuit is established

switch fails

B

A is forced to signal a new circuit to restore communication
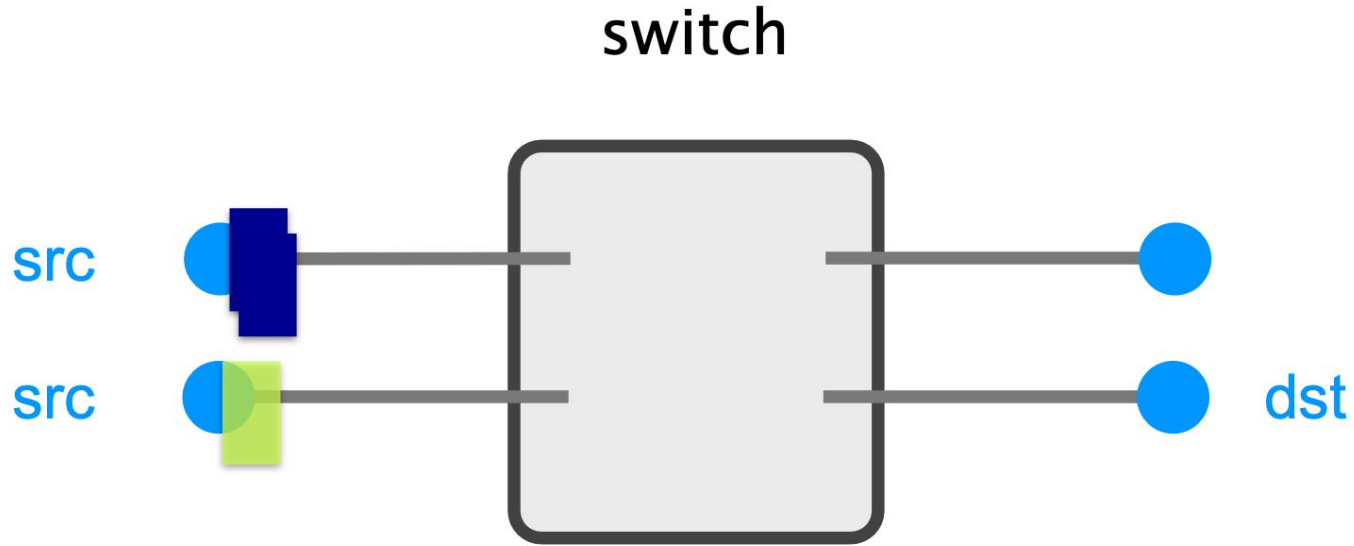
Pros and Cons of Circuit Switching

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

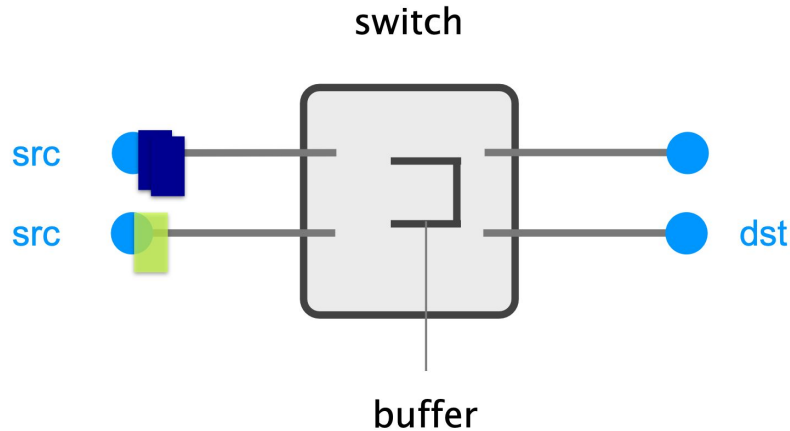# Packet Switching: Data is Sent Using Independent Packets

switch
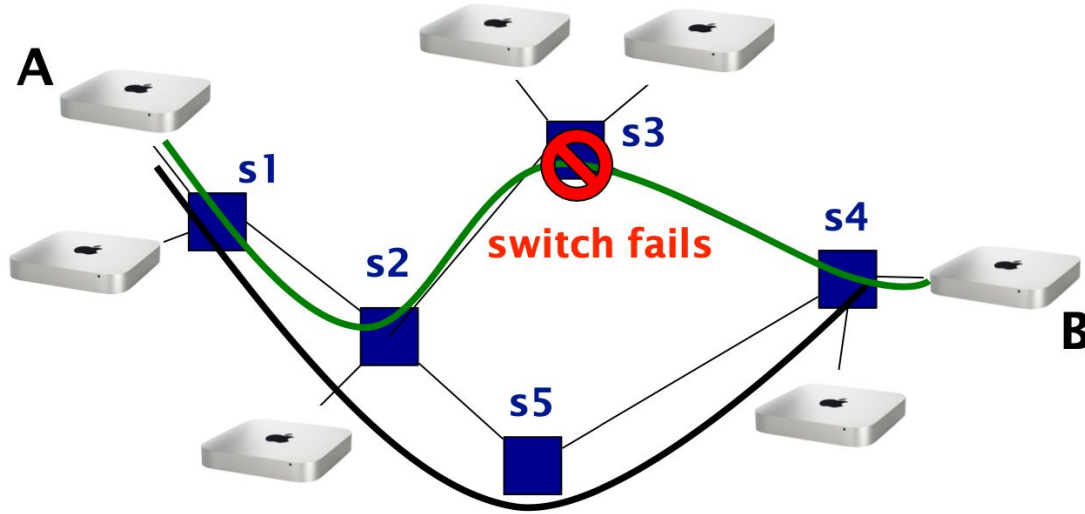

Each packet contains a destination (dst)

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

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
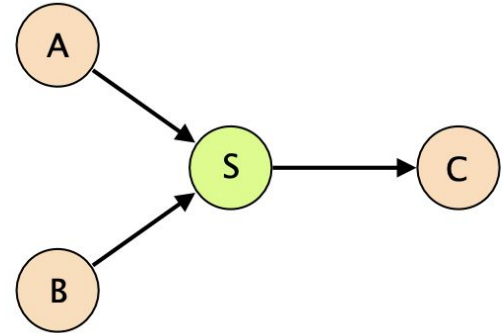(even telecom is moving towards it).

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
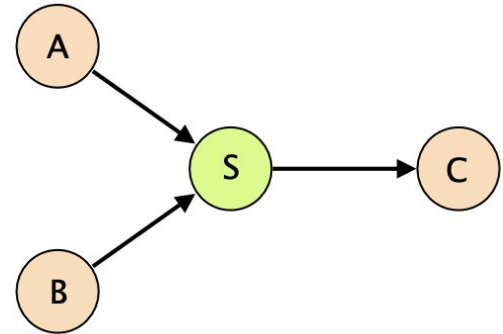
Circuit Switching vs Packet Switching

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)?
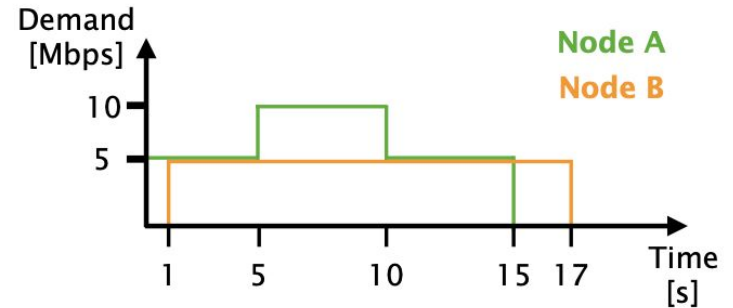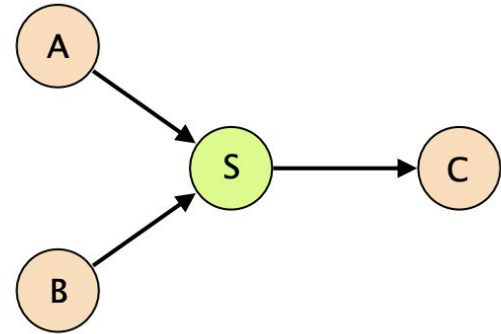
Demand distributions for node A and B.