6.263 Data Communication Networks

Lecture 1: Computer Networks

(some slides are taken from I. Stoica and N. Mckewon)

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Administrative Information

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Grades

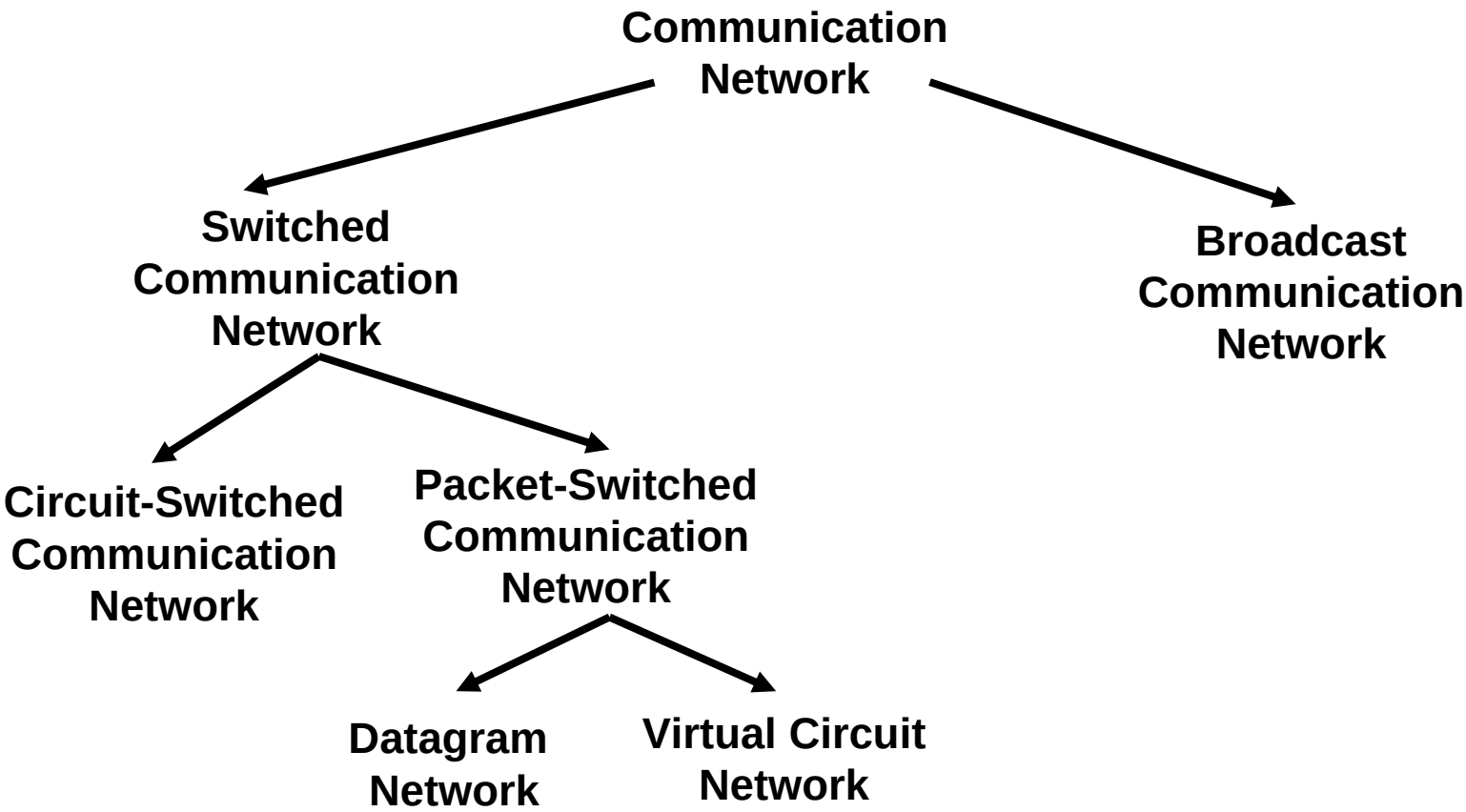
HW (weekly)	10%
Project	30%
Midterm	25%
Final	35%

Syllabus

- Routing & Switching
- Queuing
- Wireless
- Congestion Control
- Compression & Coding
- Network Security

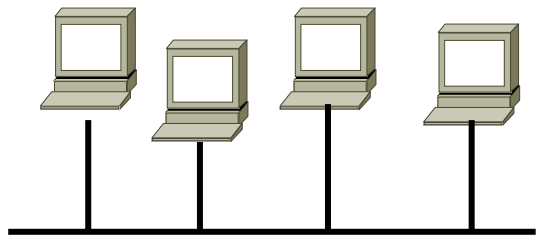
A Taxonomy of Communication Networks

- Communication networks can be classified based on the way in which the nodes exchange information:

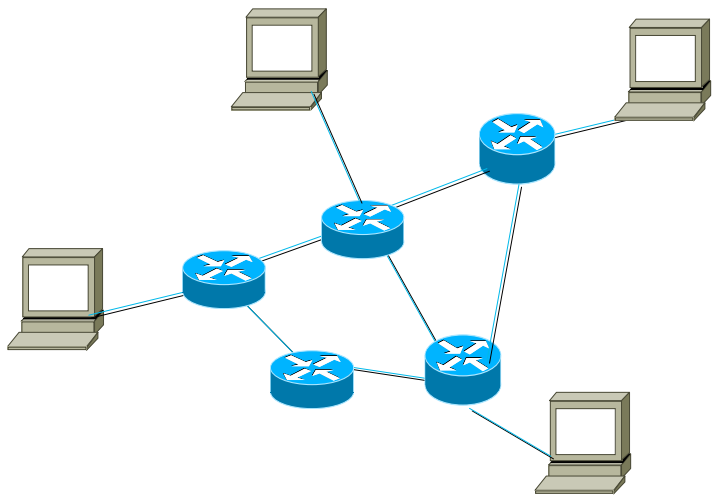


Broadcast vs. Switched Networks

- Broadcast networks
  - Information transmitted by any node is received by every node in the network
    - Ex: Broadcast Ethernet, wireless LANs
  - Need to coordinate the access to the shared medium → MAC
  - Does it scale?



- Switched networks
  - Links are point-to-point
    - Ex: WANs (Telephony Network, Internet)
  - Routing becomes harder



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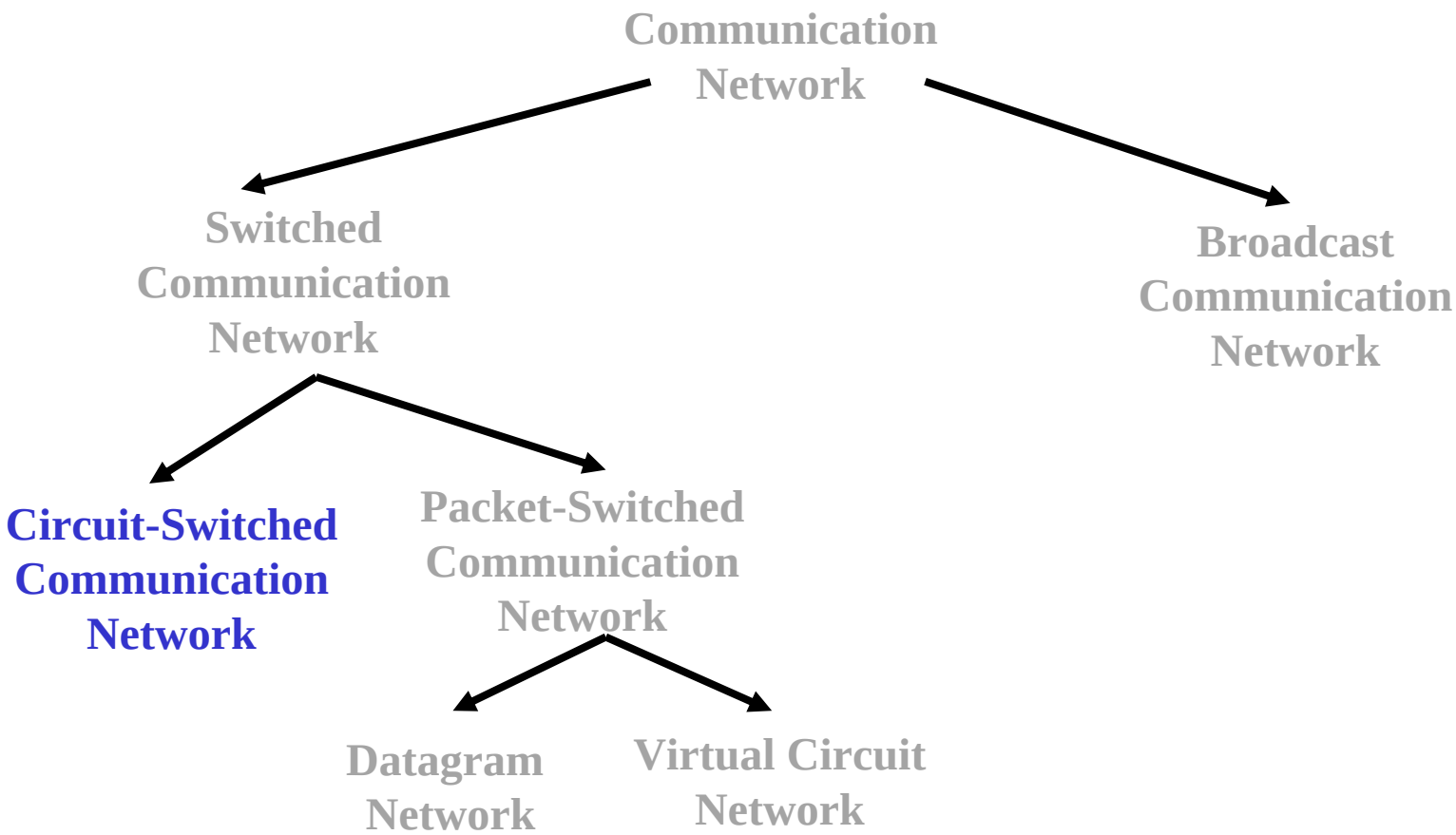


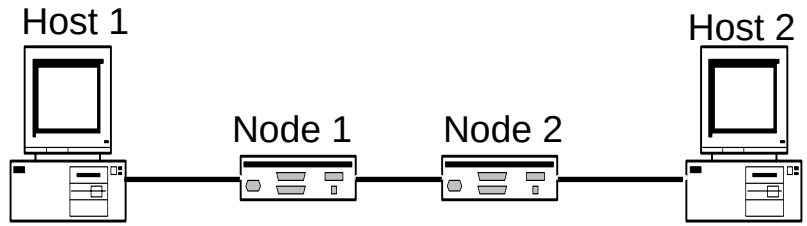
Circuit Switching

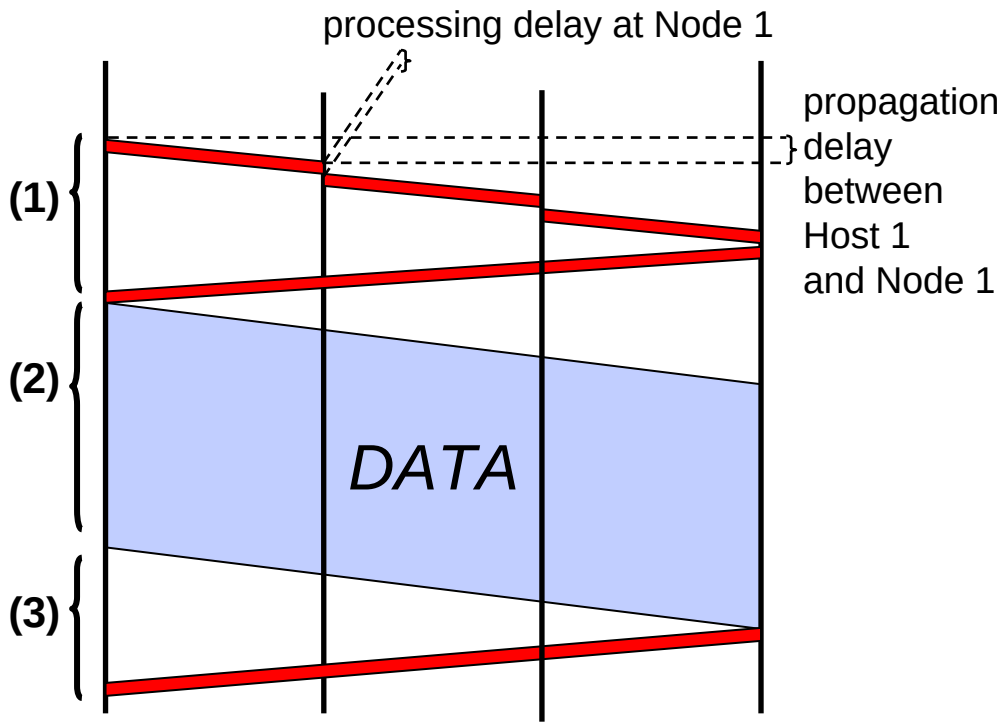
Three phases:

1. Circuit Establishment: allocates certain bandwidth and establish a path
2. Data Transfer
3. Circuit Termination

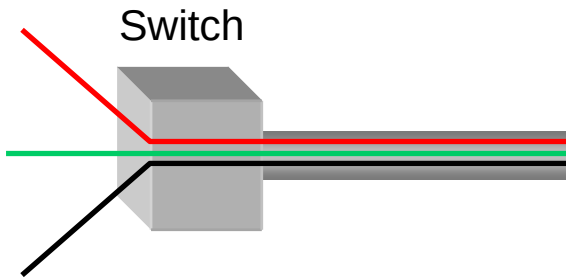
If circuit not available: "Busy signal"

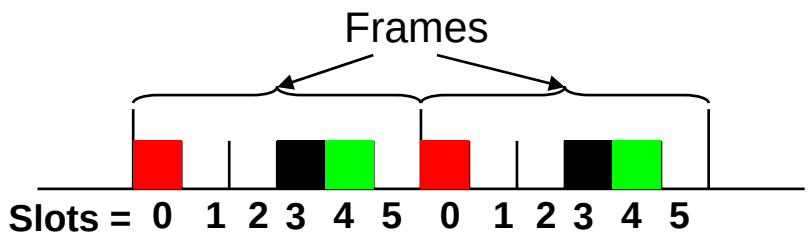
Ex: Telephone networks





Circuit Switching: Multiplexing/Demultiplexing





One way for circuit switching is TDM:

- Time divided into frames and frames divided in slots
- Relative slot position inside a frame determines which conversation the data belongs to
  - E.g., slot 0 belongs to the red conversation
- Needs synchronization between sender and receiver
- If a conversation does not use its circuit the capacity is wasted!

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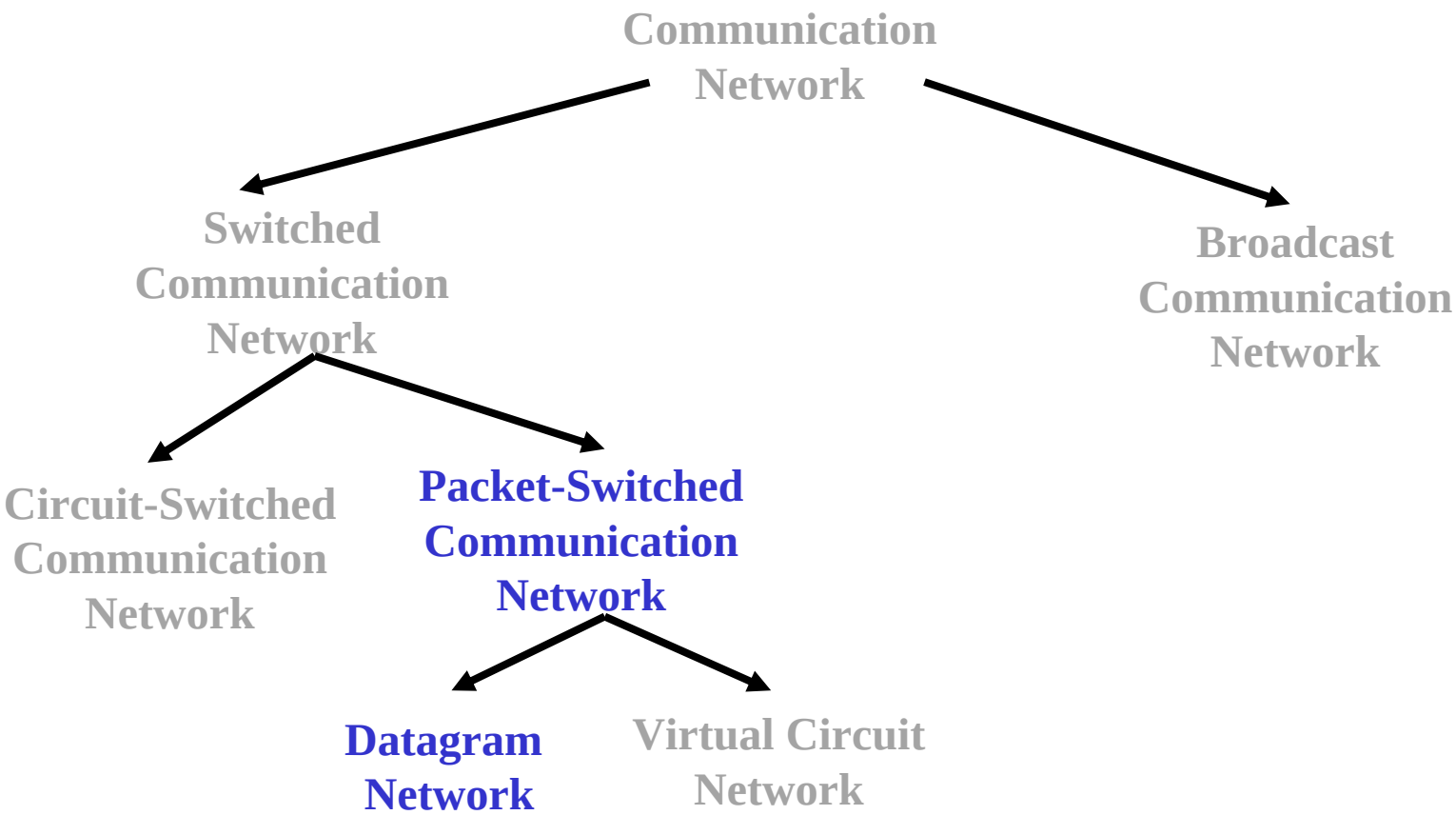
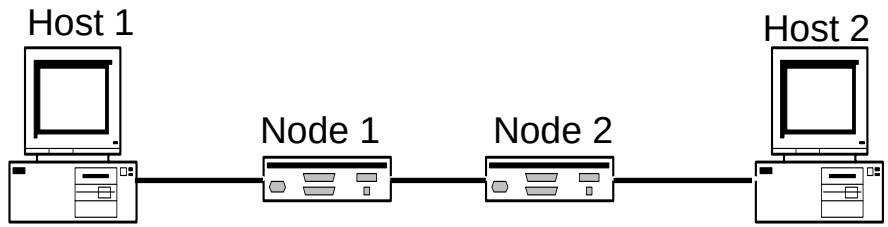
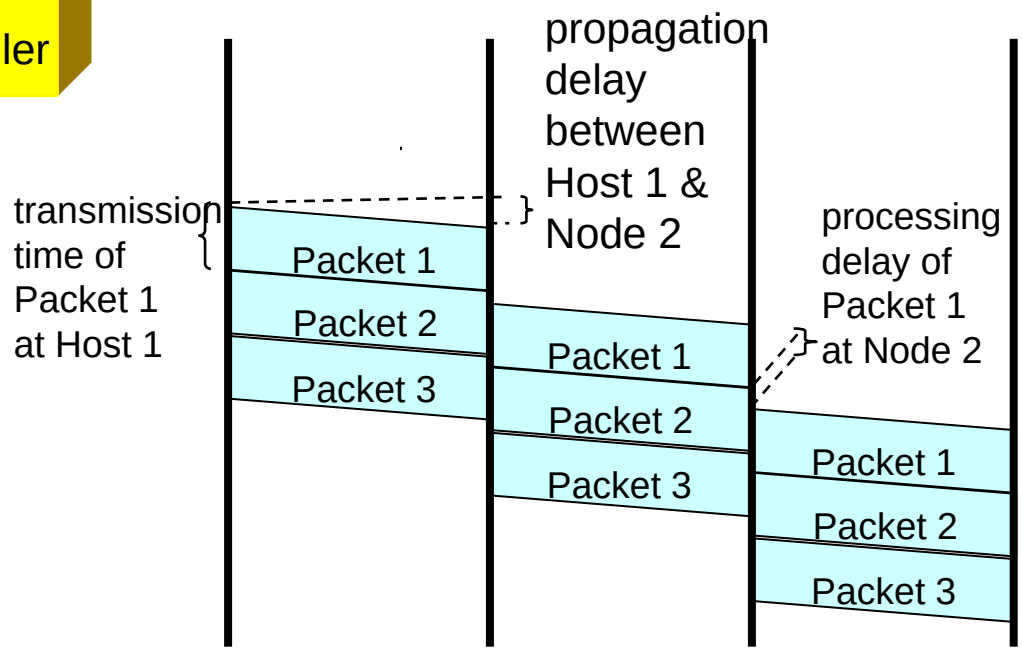


Datagram Packet Switching

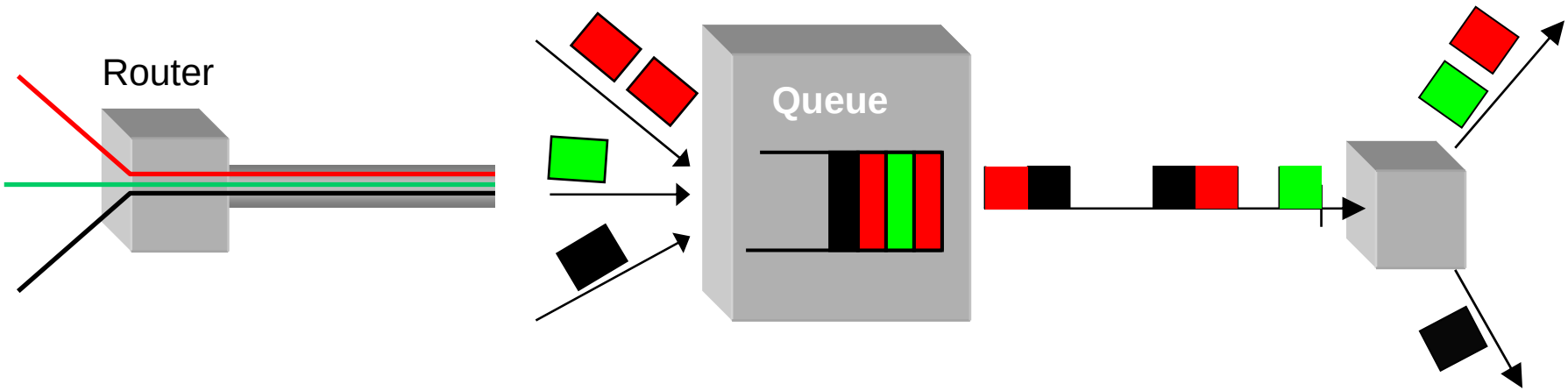
- Data is sent in **Packets** (header and trailer contain control info, e.g., source and destination addresses)



- Per-packet routing
- At each node the entire packet is received, stored, and then forwarded (**Store-and-Forward Networks**)
- No capacity is allocated
- E.g. The Internet



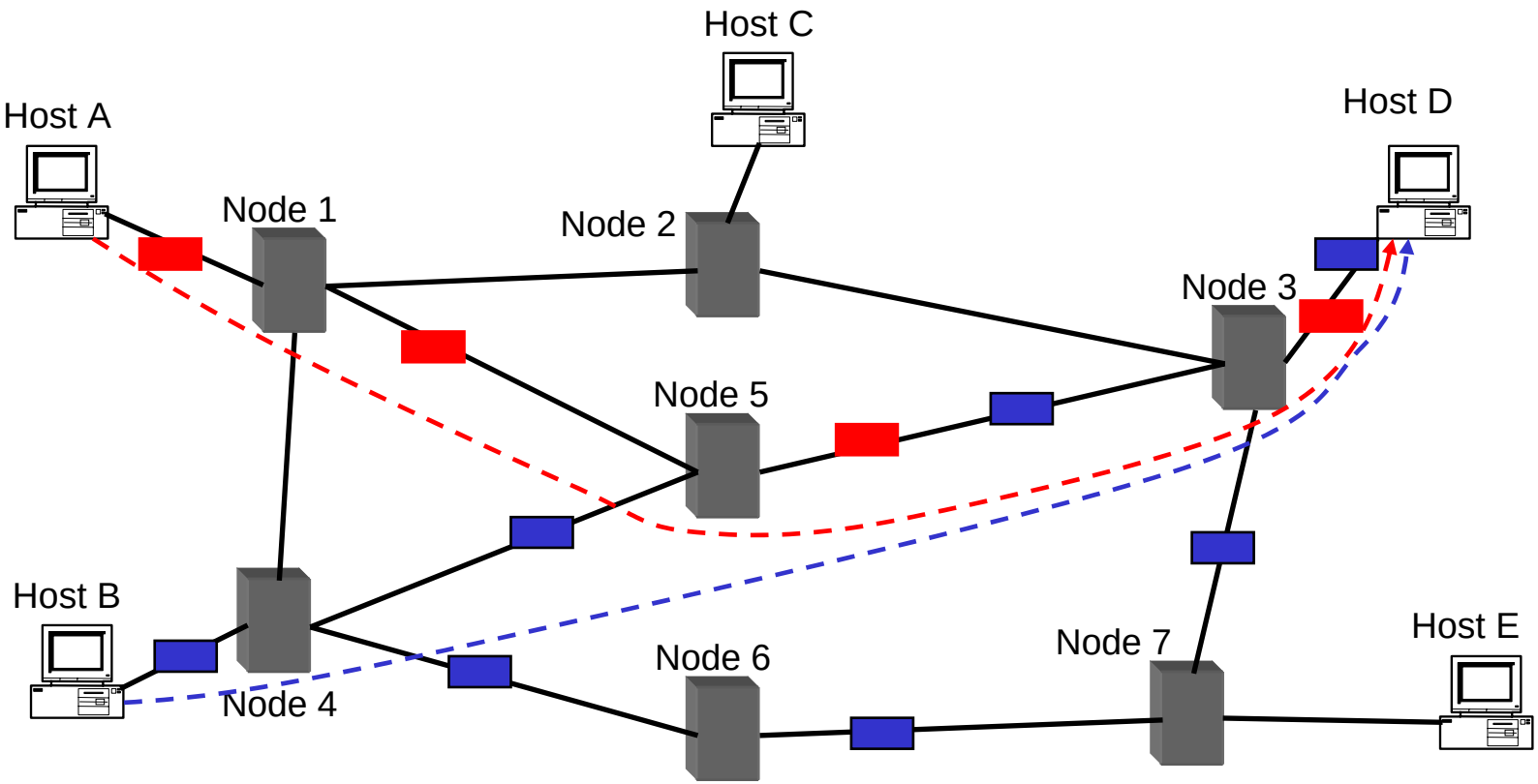
Datagram Packet Switching: Multiplexing/Demultiplexing



- Multiplex using a queue
  - Routers need memory
  - Queuing introduces jitters
- Demultiplex using packet headers

Datagram Packet Switching

Packets in a flow may not follow the same path (depends on routing as we will see later)



Some Differences Between Datagram & Circuit Switching

Circuit-switching	Datagram-Switching
Guaranteed capacity	No guarantees (best effort)
Capacity is wasted if data is bursty	More efficient
Before sending data establishes a path	Send data immediately
All data in a single flow follows one path	Different packets might follow different paths
No Reordering of data	Packets may be reordered

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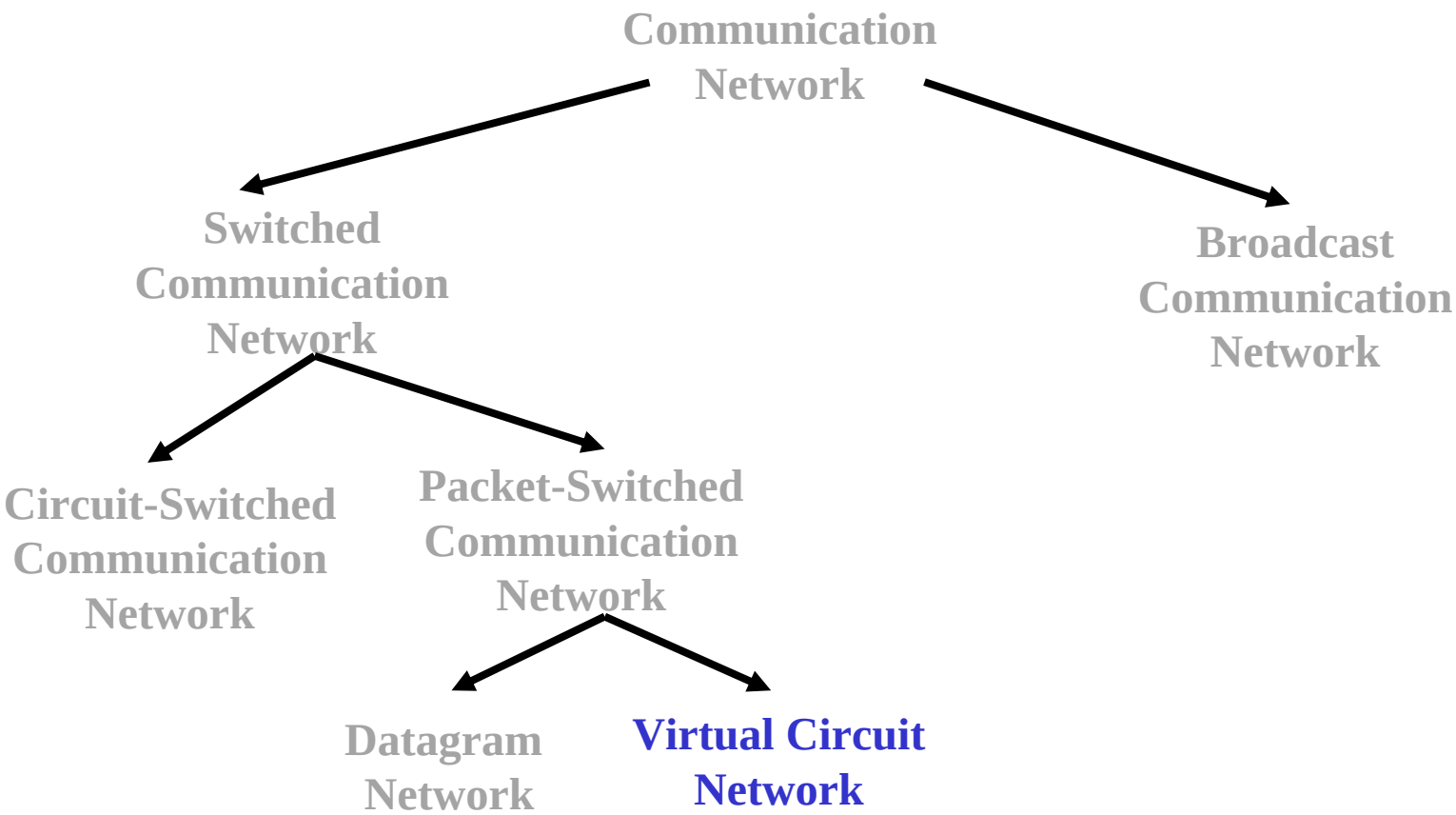
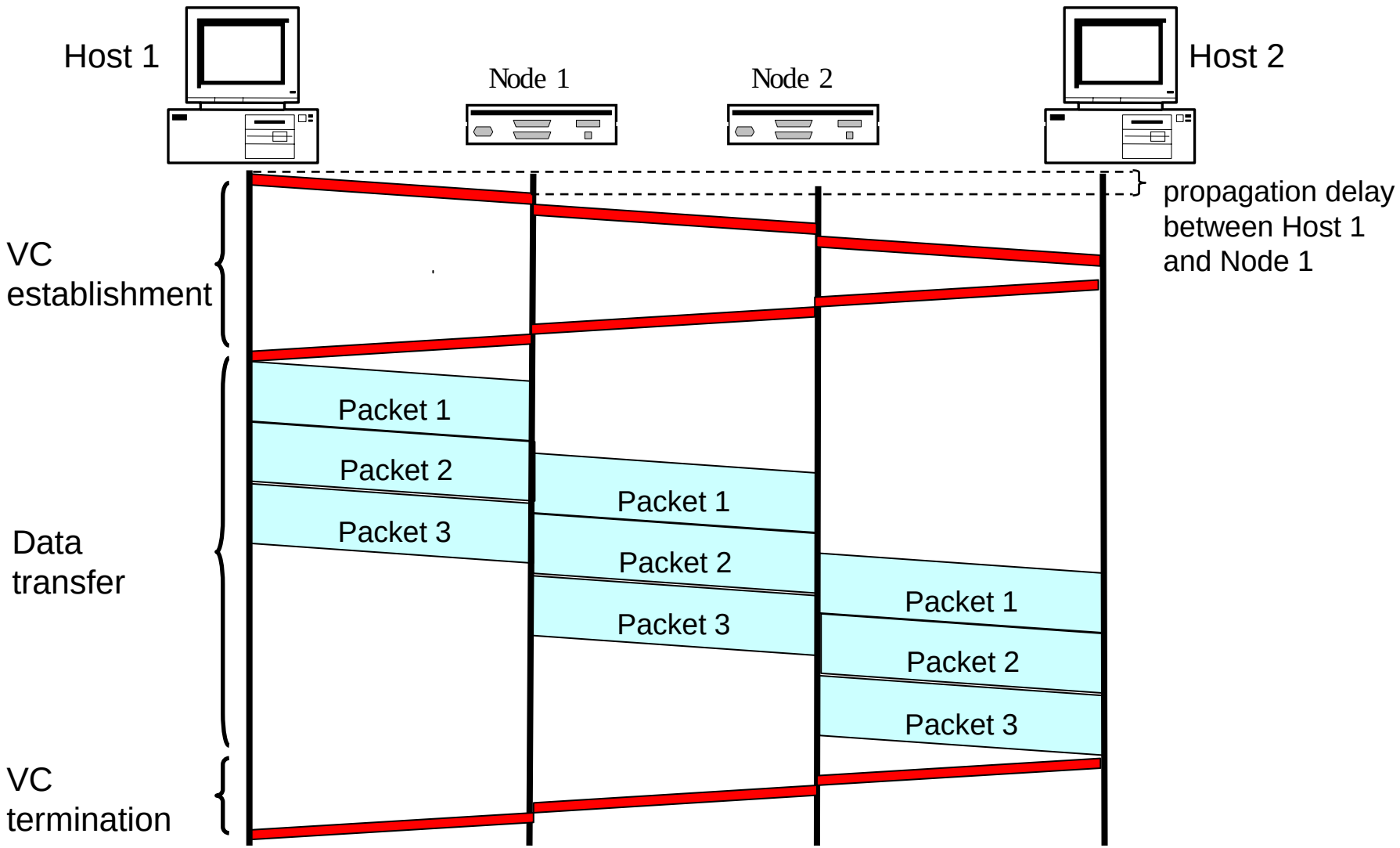


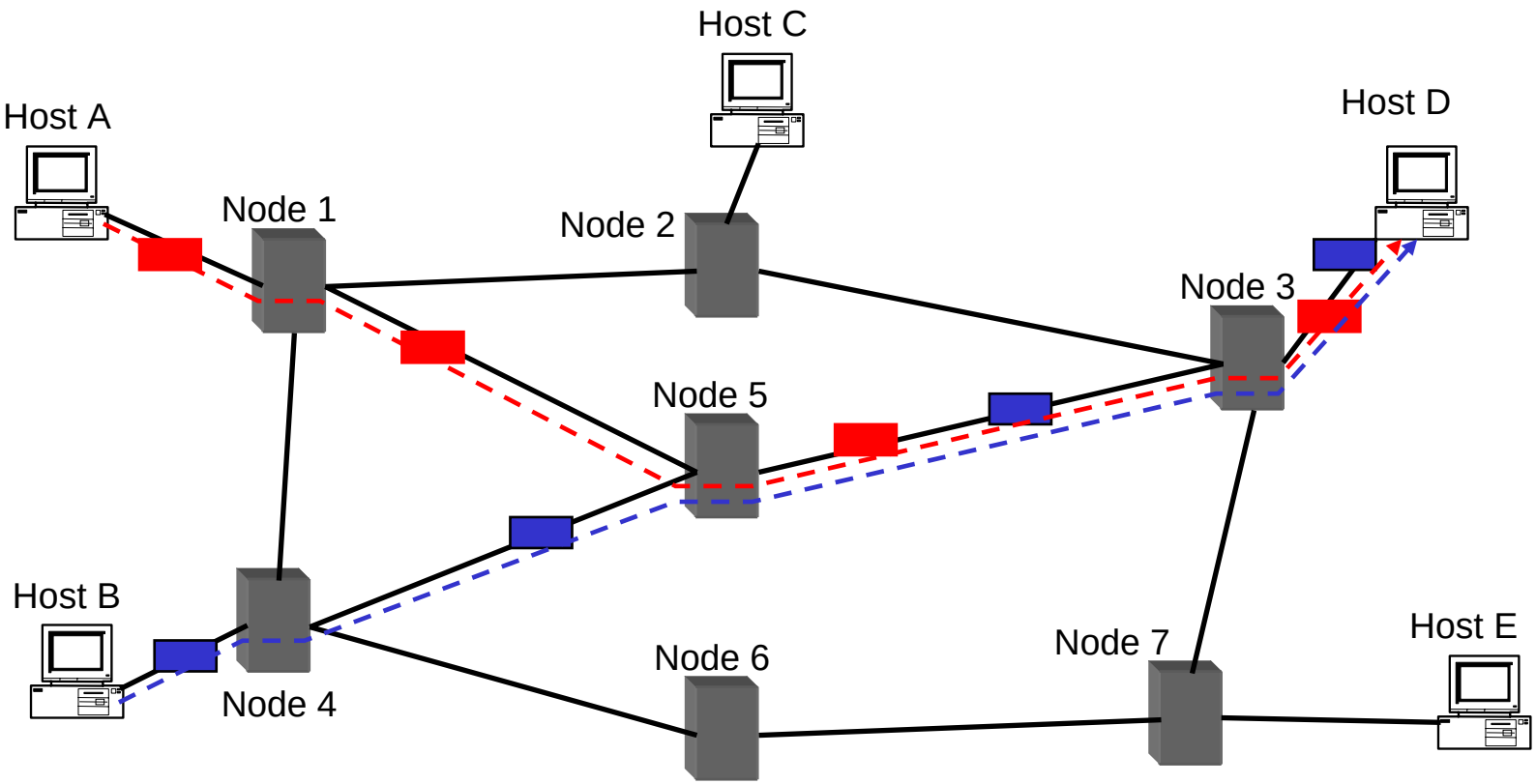
Virtual-Circuit Packet Switching

- Hybrid of circuit switching and packet switching
  - Data is transmitted as packets
  - All packets from one packet stream are sent along a pre-established path (i.e., a virtual circuit)
- No capacity guarantees, but guarantees no reordering of packets
- E. g., ATM networks

Timing of Virtual-Circuit Packet Switching



Virtual Circuits guarantees all packets in a flow follow one path



In Reality

- The Internet is a datagram network
- But part of the Internet use circuit-switching (Phone links) or virtual circuit (ATM)
- The Internet works by abstracting an ATM region or a circuit-switched region as a single link

Routing: How to deliver packets from source to destination?

Addressing

- A network is a graph
- Each node should have an address
  - E.g., IP addresses, Phone numbers

How can we deliver packets?

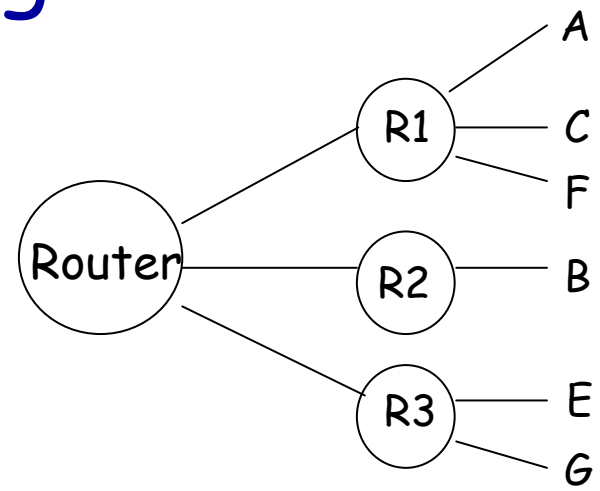
- We need to send packets form source to destination
  - Hierarchical Addressing
  - Source Routing
  - Virtual Circuit
  - Routing & forwarding are both done by the routers

Internet Routing

(see BG-5.2.3 for Algs.)

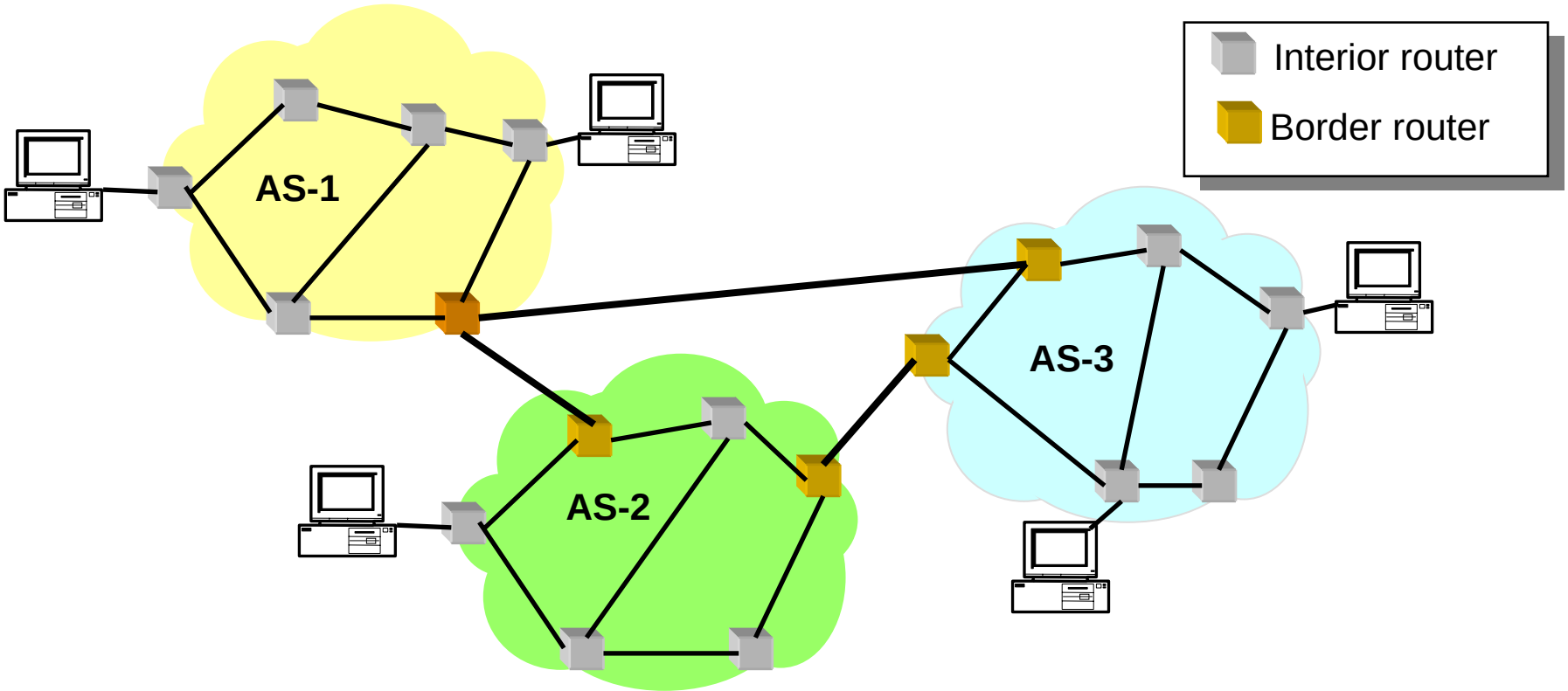
Forwarding

- What's the difference between routing and forwarding?
  - Routing is finding the path
  - Forwarding is the action of sending the packet to the next-hop toward its destination
- Each router has a forwarding table
  - Forwarding tables are created by a routing protocol
- Forwarding:
  - For every packet, we need to look up the next hop toward its destination in the table
- Forwarding needs to be fast



Dest. Addr	Next-hop
A	R1
B	R2
C	R1
E	R3
F	R1
G	R3

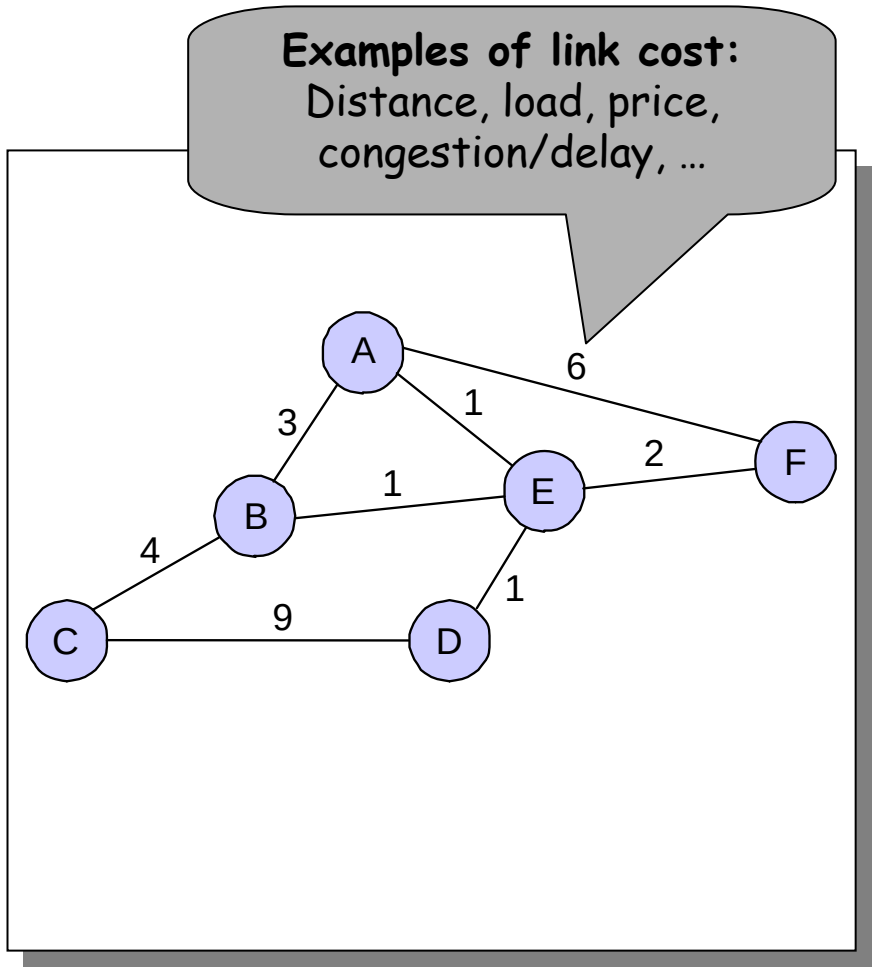
Picture of the Internet



- Internet: A collection of ASes
- Routing:
  - Intra-Domain Routing
  - Inter-Domain Routing

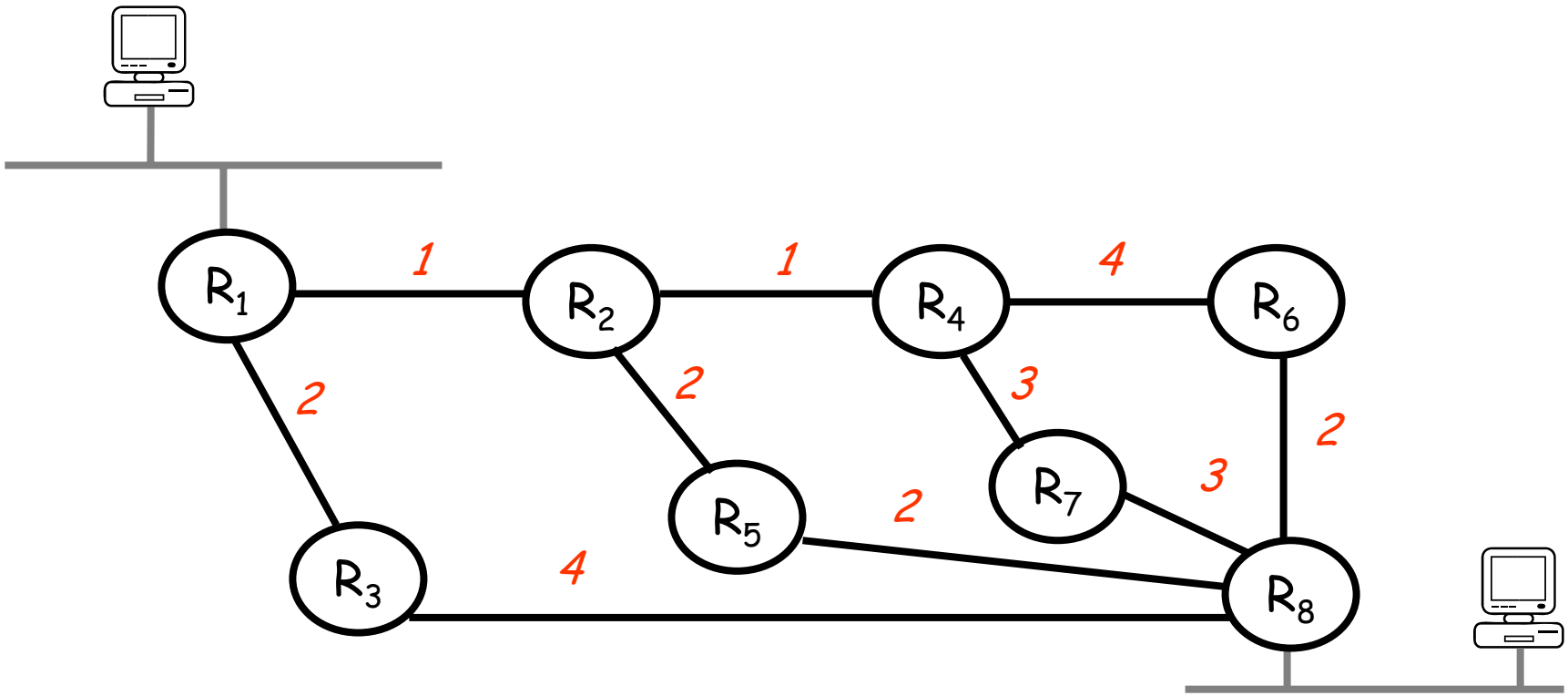
Intra-Domain Routing Algorithms

- Routing algorithms view the network as a graph
  - A node is a router or a whole network region
- Problem: find minimum cost path between two nodes (Shortest path)
  - »
- Factors
  - Semi-dynamic topology (deal with link failures)
  - Dynamic load
  - Policy

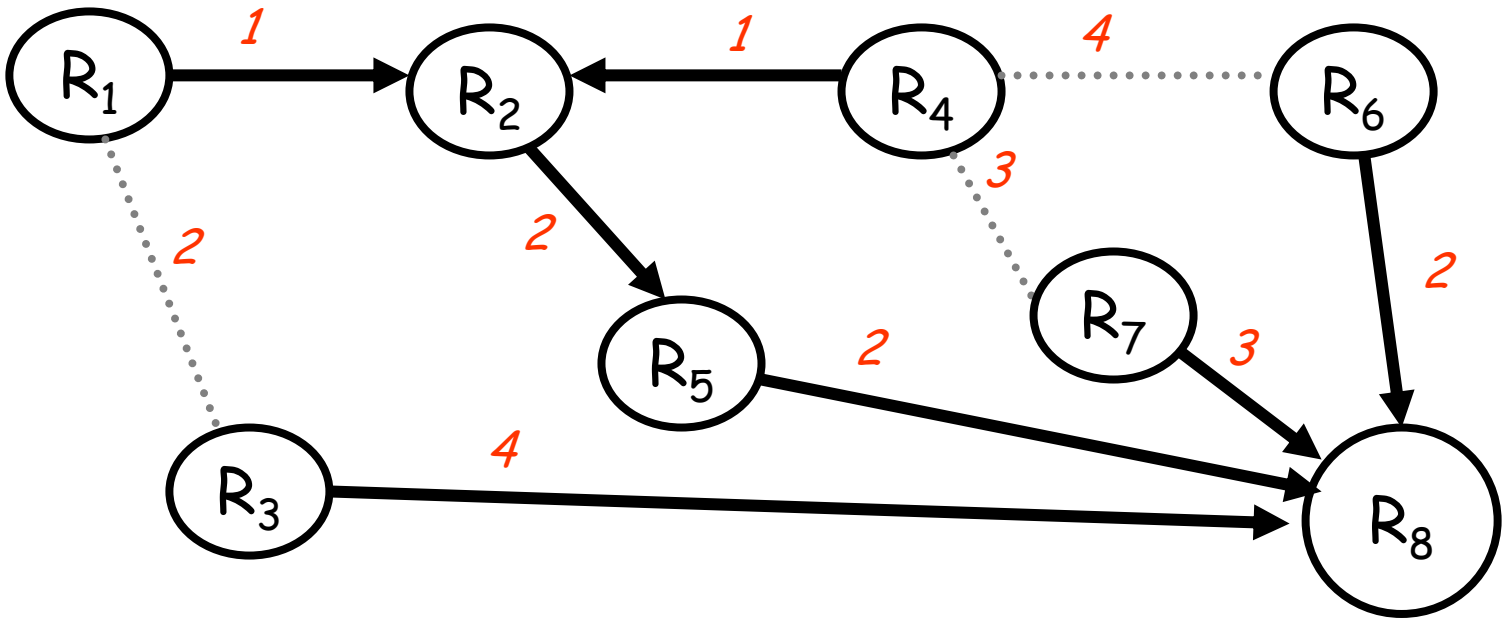


Problem: Shortest Path Routing

Objective: Determine the route from (R_1, …, R_7) to R_8 that minimizes the cost.



Solution is simple by inspection... (in this case)



The shortest paths from all sources to a destination (e.g., R_8) is the spanning tree routed at that destination.