Computer Networks (CN)
EE-353

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Lecture 6 (Chapter 1)

3.1.1. Store-and-Forward Transmission:

- Store-and-forward transmission means that the packet switch must receive the entire packet before it can begin to transmit the first bit of the packet onto the outbound link.
- Total delay (ignoring propagation delay) the entire packet has been received by the destination?
  - 2L/R
- At what time, the destination has received all three packets?
  - 4L/R

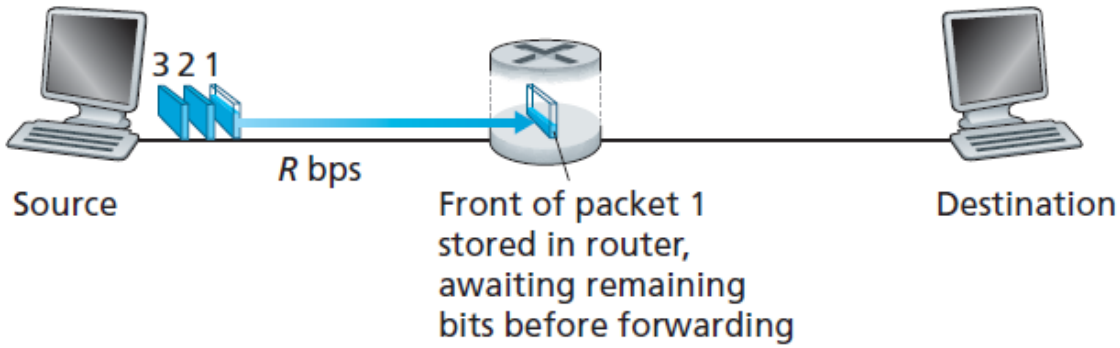


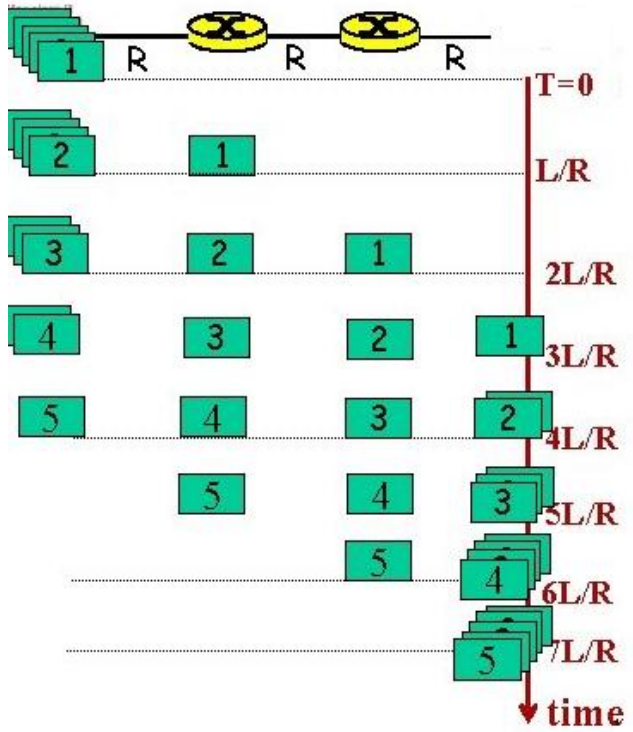
Figure 1.11 ♦ Store-and-forward packet switching

sending one packet from source to destination over a path consisting of *N* links each of rate *R* (thus, there are *N*-1 routers between source and destination), end-to-end delay is

$$d_{\text{end-to-end}} = N\frac{L}{R}$$

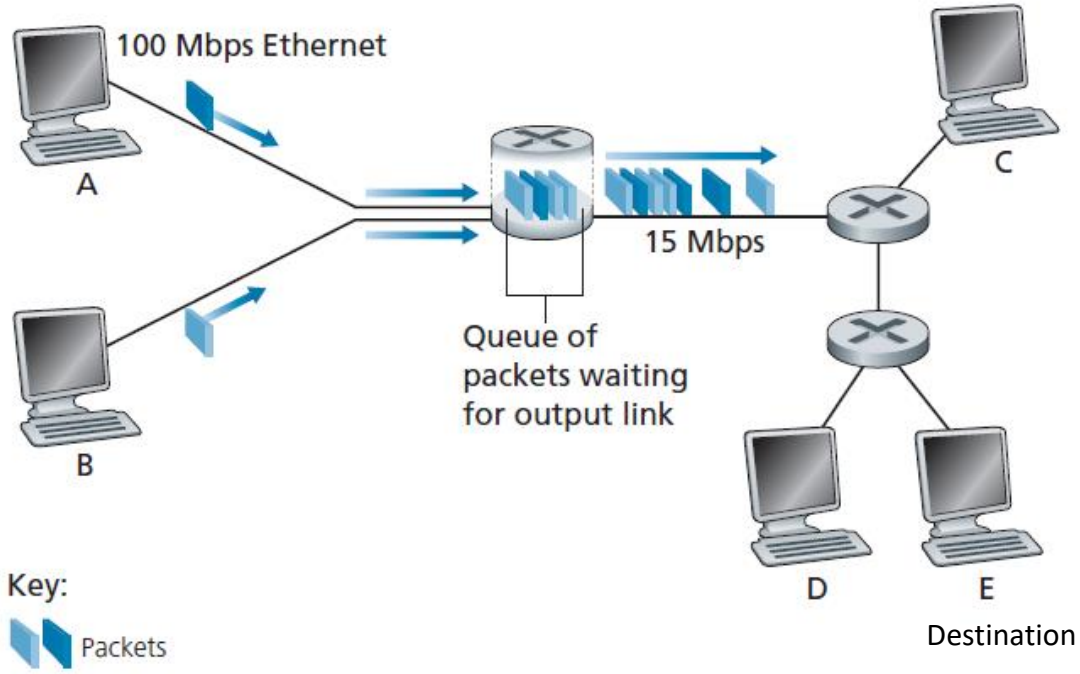
Class Activity:

- Consider five packets, two routers between source and destination, calculate at what time, the destination has received all five packets?
-



3.1.2. Queuing Delays and Packet Loss:

- Each packet switch has multiple links attached to it.
- For each attached link, the packet switch has an **output buffer** (also called an **output queue**), which stores packets that the router is about to send into that link.
- Thus, in addition to the store-and-forward delays, packets suffer output buffer **queuing delays** which are **variable** and **depend on the level of congestion in the network**.
- Since the amount of **buffer space is finite**, an arriving packet may find that the buffer is completely full with other packets waiting for transmission.
- In this case, **packet loss** will occur—either the arriving packet or one of the already-queued packets will be dropped.

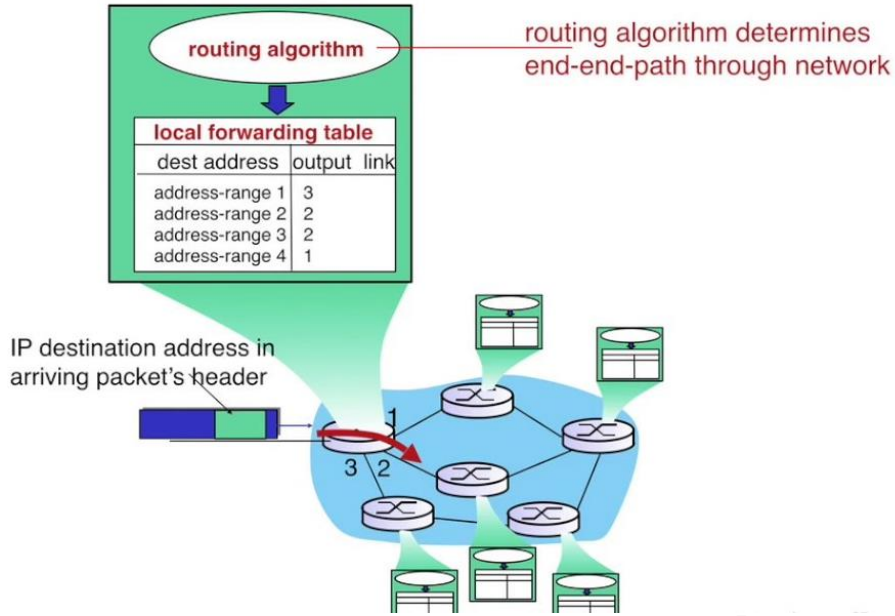


Queues are part of packet-switched networks

3.1.3. Forwarding Tables and Routing Protocols:

- How does the router determine which link it should forward the packet onto?
- Each router has a **forwarding table** that maps destination addresses (or portions of the destination addresses) to that router's outbound links. (end-to-end routing process)

- End-to-end routing is analogous to a car driver who does not use maps but instead prefers to ask for directions.
- Suppose you're driving to SEECS/CR-10
  - Route to NUST
  - NUST Gate
  - Gate to SEECS
  - SEECS to UG Block
  - CR-10
- What are routers in the above example?
- How do forwarding tables get set?
  - Internet has a number of special **routing protocols**
  - used to automatically set the forwarding tables.



3.2. Circuit Switching:

- In **circuit-switched networks**, the resources needed along a path (buffers, link transmission rate) to provide for communication between the end systems are ***reserved*** for the **duration of the communication session** between the end systems.
- Traditional telephone networks are examples of circuit-switched networks.
  - network must establish a connection
  - *a bona fide* connection for which the switches on the path between the sender and receiver maintain connection state, this connection is called a **circuit**.
  - Each link (having four circuits) can support four simultaneous connections.
  - The connection gets one fourth of the link's total transmission capacity for the duration of the connection.
- **Multiplexing in circuit-switched network**: A circuit in a link is implemented with either **frequency-division multiplexing (FDM)** or **time-division multiplexing (TDM)**.

A dedicated **end-to-end** connection between two hosts

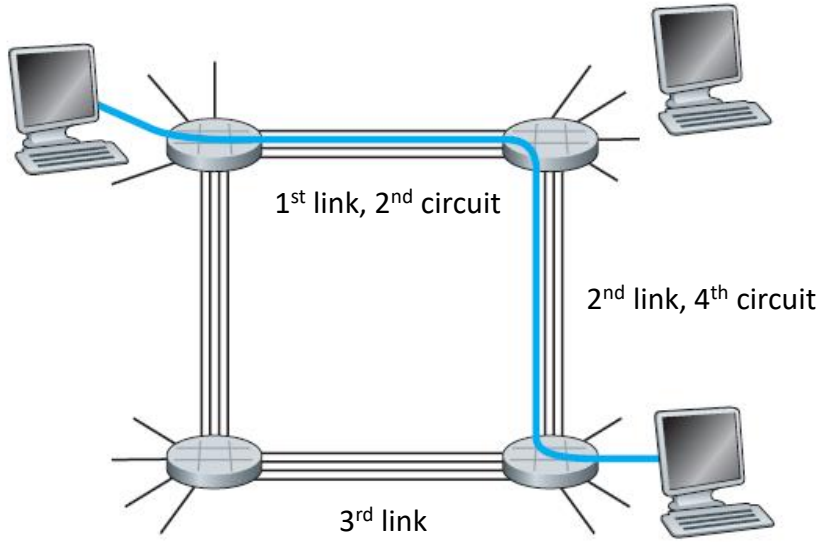


Figure 1.13 ♦ A simple circuit-switched network consisting of four switches and four links

Same scenario for packet-switched networks no reservation (wait in a buffer, suffer delay)