COMPUTER COMMUNICATION NETWORKS

Prajeesha

Department of Electronics and Communication Engineering

COMPUTER COMMUNICATION NETWORKS

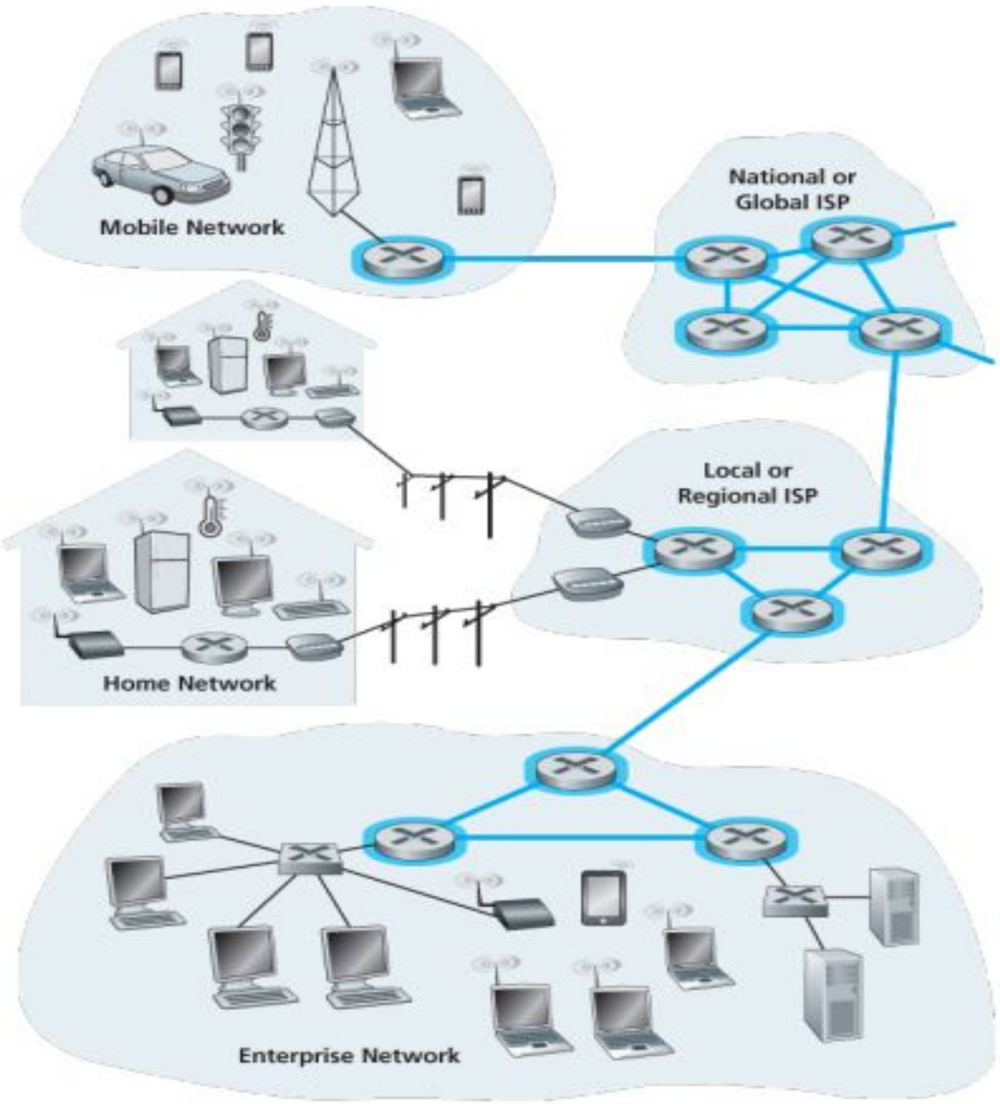
Network Core

Prajeesha

Department of Electronics and Communication Engineering

Network Core

- Network core is also known as **backbone network**
- Network core connects the network edges.
- Topology is mesh of interconnected routers connected by high-speed links.
- Network core is made of interconnection of ISPs.



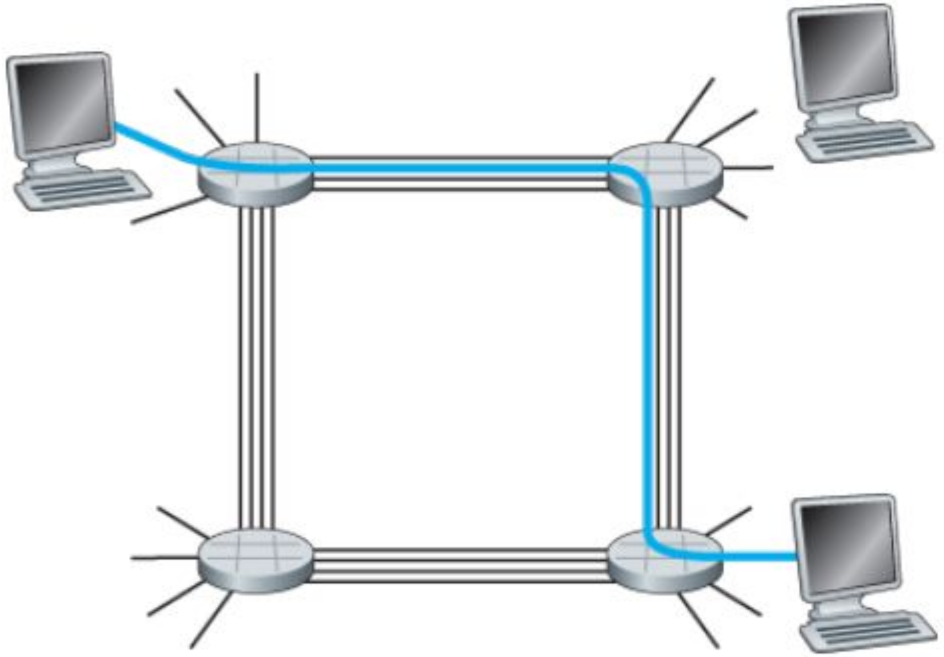
Switching

- It is an important operation in the transfer of data by the routers in the network core
- Each router may be carrying several data flows between different pairs of senders and receivers.
- Data arriving at an input port of a core router is transferred to a designated output port by an action called **switching.**
- Two types of switching can be performed by a core router
  - **Circuit switching** - Dedicated predefined switching
  - **Packet switching** - On-demand switching

Circuit switching

- 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. (e.g. traditional telephone network)

- Before the sender can send the information, the network must establish an end-to-end connection(which may span more than one link) between the sender and the receiver called as **circuit**



Circuit switching (contd.)

- When the network establishes the circuit, it reserves a **constant transmission rate in the network's links** (representing a fraction of each link's transmission capacity) for the duration of the connection.
- Since a given transmission rate has been reserved for this sender-to receiver connection, the sender can transfer the data to the receiver at the **guaranteed constant rate.**
- After the data transfer, the **circuit** is **closed** by releasing the reserved resources at each intermediate router(s).
- **No waiting time** and **no loss of data** at intermediate routers
- **Throughput reduces** with resource sharing
- Examples: TDM, FDM, etc.

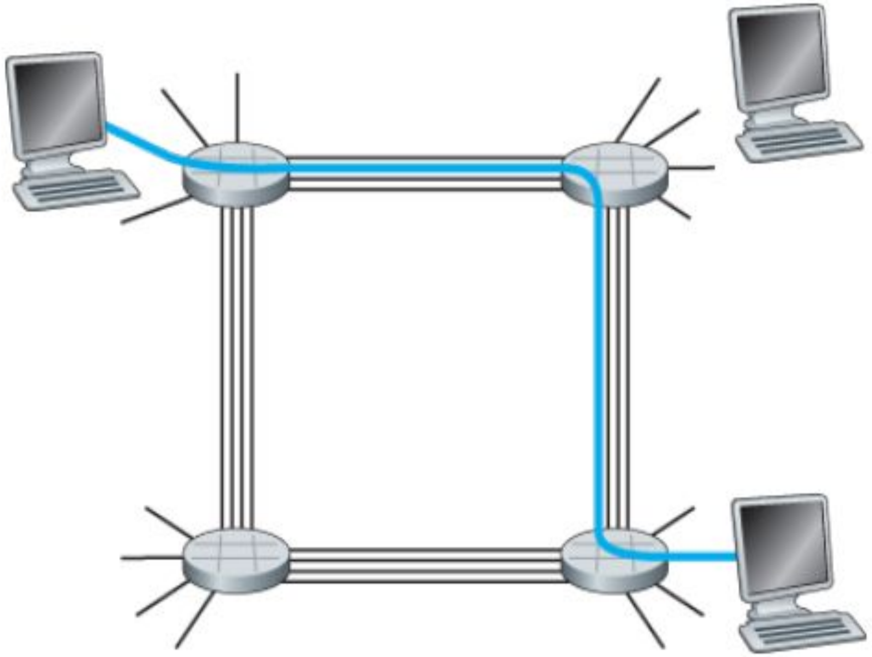
Circuit switching (contd.)

In order for Host A to communicate with Host B, the network must first reserve one circuit on each of two links.

In this example, the dedicated end-to-end connection uses the second circuit in the first link and the third circuit in the second link.

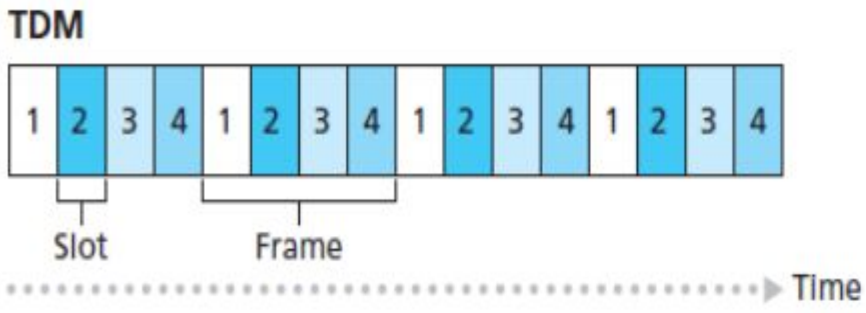
Because each link has four circuits, for each link used by the end-to-end connection, the connection gets one fourth of the link's total transmission capacity for the duration of the connection.

(e.g. If each link between adjacent switches has a transmission rate of 1 Mbps, then each end-to-end circuit-switch connection gets 250 kbps of dedicated transmission rate)



Multiplexing in Circuit Switched Networks

A circuit in a link is implemented with either **frequency-division multiplexing** (FDM) or **time-division multiplexing** (TDM)

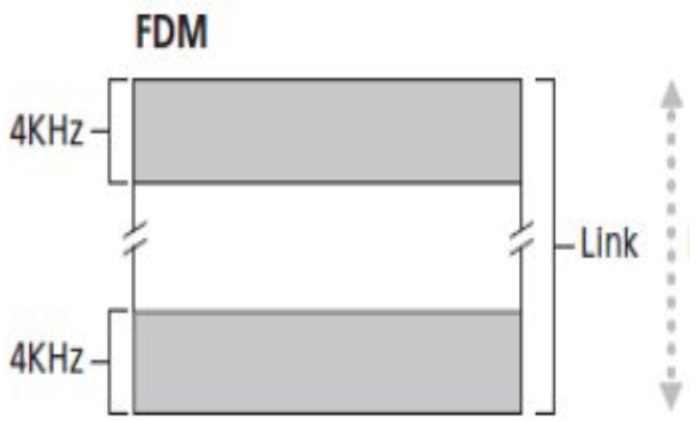


Time division multiplexing (TDM)

- Time is divided into **frames** and frames into **slots**
- Slots in a frame are reserved for the **transmitting hosts**
- Each slot ends with a **guard time** to prevent **ISI**
- Duration of frame, slot, guard time are fixed

Circuit Switching - Frequency division multiplexing (FDM)

- Bandwidth is divided into **channels**
- All channels reserved for transmitting hosts in a **fixed slot time**
- **Channel reservation** done slot-by-slot-basis
- Channels separated by **guard band** to prevent **adjacent channel interference**

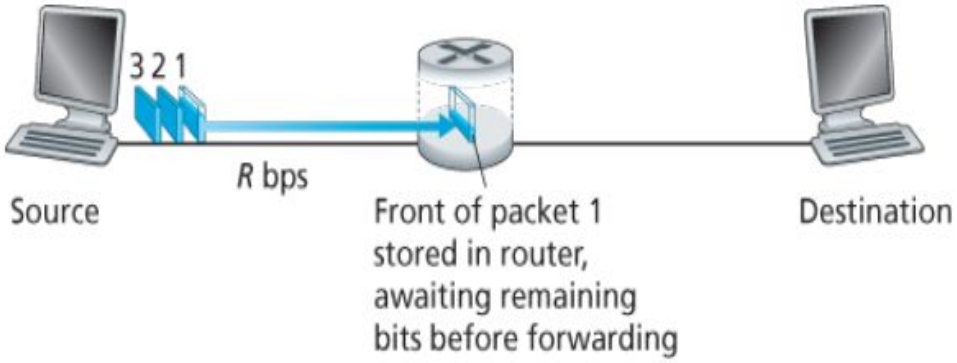


Packet switching

- To send a message from a source end system to a destination end system, the source breaks long messages into smaller chunks of data known as **packets.**
- Between source and destination, each packet travels through communication links and packet switches **(routers and link-layer switches).**
- Packets are transmitted over each communication link at a **rate equal to the full transmission rate of the link.**
- Ex: If a source end system or a packet switch is sending a packet of **L bits** over a link with transmission rate **R bits/sec**, then the **time to transmit the packet is L /R seconds.**

Store and Forward Transmission- Packet switching

- The packet switch must receive the entire packet before it can begin to transmit the first bit of the packet onto the outbound link.
- If the router employs **store-and-forwarding,** it cannot transmit the bits it has received; instead it must first **buffer (i.e., "store")** the packet's bits.
- Only after the router has received all of the packet's bits can it begin to **transmit (i.e., "forward")** the packet onto **the outbound link.**



For sending one packet of length L 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 = NL/R

Queuing Delays

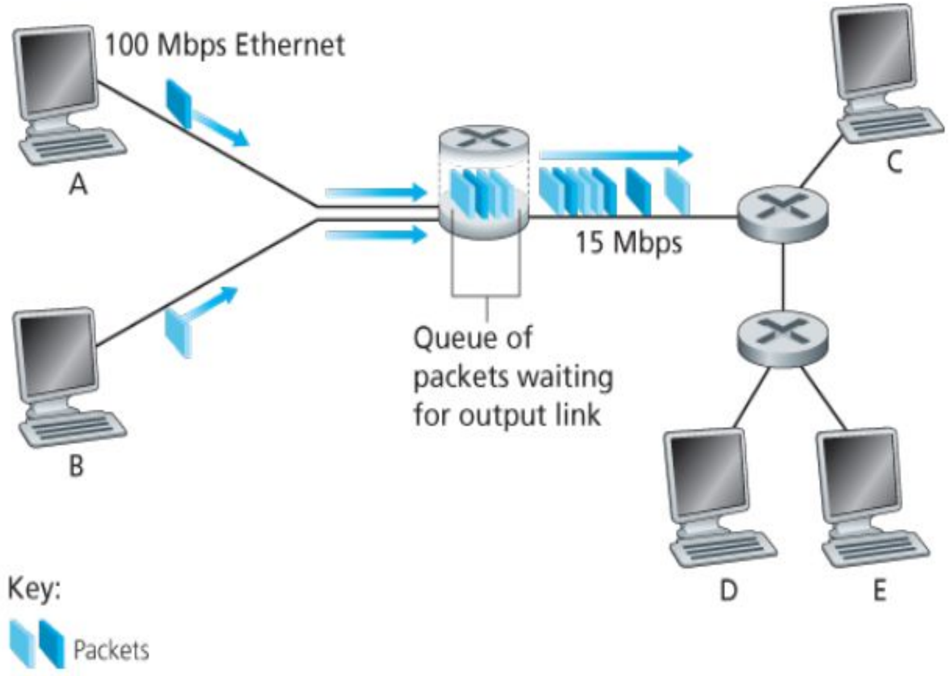
- In addition to the store-and-forward delays, packets suffer output buffer **queuing delays**.
- The output buffers play a key role in packet switching.
- If an arriving packet needs to be transmitted onto a link but finds the link busy with the transmission of another packet, the arriving packet must wait in the **output buffer** (also called an **output queue**).
- **Queuing delays** are variable and depend on the level of congestion in the network.

Packet Loss

- 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.

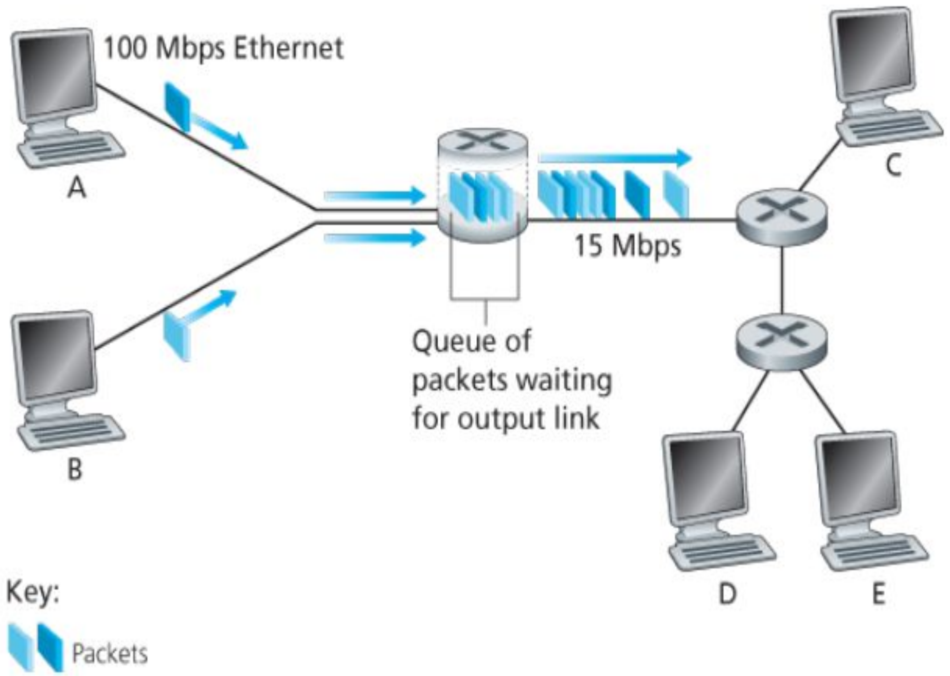
Packet switching (Ex:)

- Suppose Hosts A and B are sending packets to Host E.
- Hosts A and B first send their packets along 100 Mbps Ethernet links to the first router.
- The router then directs these packets to the 15 Mbps link.
- If, during a short interval of time, the arrival rate of packets to the router exceeds 15 Mbps, **congestion** will occur at the router as packets queue in the link's output buffer before being transmitted onto the link.



Forwarding Tables and Routing Protocols

- Each router has a **forwarding table** that maps destination addresses (or portions of the destination addresses) to that router's outbound links.
- When a packet arrives at a router, the router examines the **IP address** and searches its forwarding table, using this destination address, to find the appropriate outbound link.
- The **router** then directs the packet to this **outbound link**.



Performance analysis in packet switched networks

- Performance of a packet switched network is measured in terms of end-to-end delay, throughput, packet loss, jitter, etc.
- Performance is often generalized for any packet traversing the network core.
- Performance is measured statistically(i.e., mean, standard deviation, etc.)
- Performance depends on network size, link rates and switching speed of the routers.

Packet Switching Vs Circuit Switching

Circuit Switching	Packet Switching
Circuit switching requires a dedicated path before sending data from source to destination.	Packet switching does not require any dedicated path to send data from source to destination.
It reserves the entire bandwidth in advance.	It does not reserve bandwidth in advance
No store and forward transmission	It supports store and forward transmission
Each packet follows the same route	A packet can follow any route
Call setup is required	No call setup is required
Bandwidth wastage	No bandwidth wastage

THANK YOU

Prajeesha

Department of Electronics and Communication Engineering