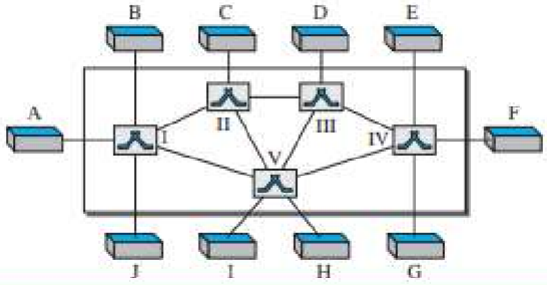
Switching

5.2. INTRODUCTION

A switched network consists of a series of interlinked nodes, called switches. Switches are devices capable of creating temporary connections between two or more devices linked to the switch.

Figure 8.1 *Switched network*

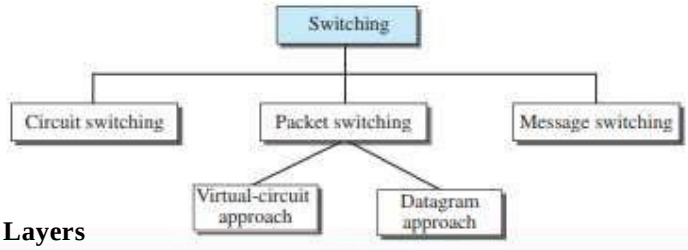


- The above figure is a switching network, the end systems (communicating devices) are labeled A, B, C, D, and so on, and the switches are labeled I, II, III, IV, and V. Each switch is connected to multiple links.

Three Methods of Switching

- Traditionally, three methods of switching have been discussed: circuit switching, packet switching, and message switching.
- Packet switching can further be divided into two subcategories—virtualcircuit approach and datagram approach.

Figure 8.2 *Taxonomy of switched networks*



Switching and TCP/IP Layers

Switching can happen at several layers of the TCP/IP protocol suite.

- Switching at Physical Layer

At the physical layer, we can have only circuit switching. There are no packets exchanged at the physical layer. The switches at the physical layer allow signals to travel in one path or another.

- Switching at Data-Link Layer

  At the data-link layer, we can have packet switching. However, the term packet in this case means frames or cells. Packet switching at the data-link layer is normally done using a virtual-circuit approach.

- Switching at Network Layer

  At the network layer, we can have packet switching. In this case, either a virtual-circuit approach or a datagram approach can be used. Currently the Internet uses a datagram approach.

- Switching at Application Layer

  At the application layer, we can have

  only message switching. The communication at the application layer occurs by exchanging messages.

CIRCUIT-SWITCHED NETWORKS

A circuit-switched network is made of a set of switches connected by physical links, in which each link is divided into n channels.

❑ Circuit switching takes place at the physical layer.

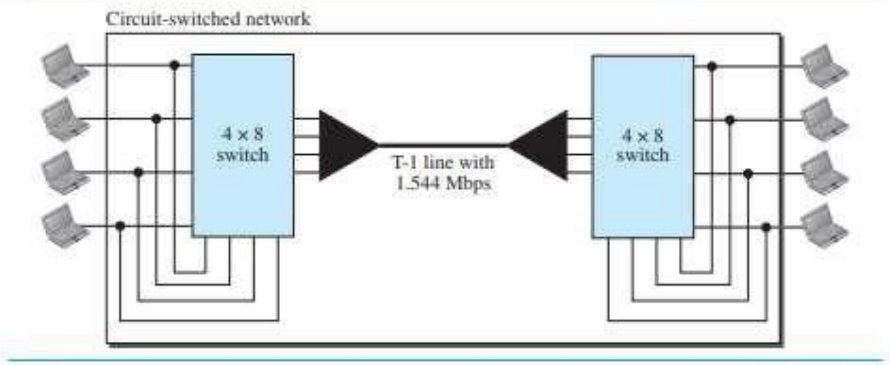
- In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer until the teardown phase.

❑ Before starting communication, the stations must make a reservation for the resources to be used during the communication. These resources, such as channels, switch buffers, switch processing time, and switch input/output ports, must remain dedicated during the entire duration of data transfer until the teardown phase.

❑ Data transferred between the two stations are not packetized. The data are a continuous flow sent by the source station and received by the destination station, although there may be periods ofsilence

❑ There is no addressing involved during data transfer. The switches route the data based on their occupied band (FDM) or time slot (TDM).

Figure 8.5 *Circuit-switched network used in Example 8.2*



Three Phases

- The actual communication in a circuit-switched network requires three phases: connection setup, data transfer, and connection teardown.
- Setup Phase

  Before the two parties can communicate, a dedicated circuit needs to be established. The end systems are normally connected through dedicated lines to the switches. so connectionsetup means creating dedicated channels between the switches.
- Data-Transfer Phase

  After the establishment of the dedicated circuit (channels), the two parties can transfer data.
- Teardown Phase

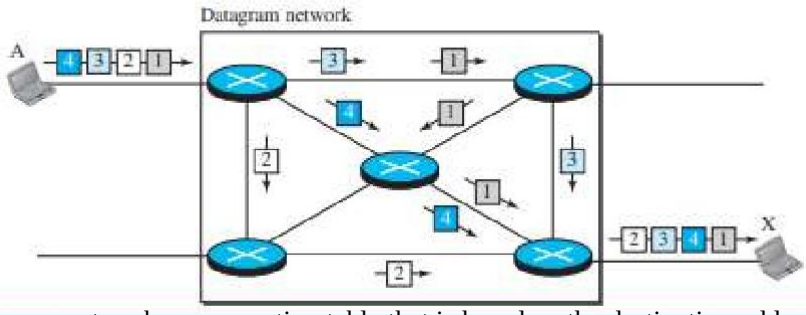
  When one of the parties needs to disconnect, a signal is sent to each switch to release the resources.
- **Efficiency:** Circuit-switched networks are not as efficient as the other two types of networks because resources are allocated during the entire duration of the connection. These resources are unavailable to other connections.
- **Delay** :Although a circuit-switched network normally has low efficiency, the delay in this type of network is minimal. During data transfer the data are not delayed at each switch; the resources are allocated for the entire duration of the connection.

PACKET SWITCHING

- In data communications, we need to send messages from one end system to another. If the message is going to pass through a packet-switched network, it needs to be divided into packets of fixed or variable size. The size of the packet is determined by the network and the governing protocol.

- In a packet-switched network, there is no resource reservation; resources are allocated on demand.
- We can have two types of packet-switched networks: datagram networks and virtual circuit networks.
- **Datagram Networks**
  - ❖ In a datagram network, each packet is treated independently of all others. Even if a packet is part of a multipacket transmission, the network treats it as though it existed alone. Packets in this approach are referred to as datagrams.
  - ❖ Datagram switching is normally done at the network layer.
  - ❖ The datagram networks are sometimes referred to as connectionless networks. The term connectionless here means that the switch (packet switch) does not keep information about the connection state. There are no setup or teardown phases. Each packet is treated the same by a switch regardless of its source or destination.

Figure 8.7 *A datagram network with four switches (routers)*



- ❖ A switch in a datagram network uses a routing table that is based on the destination address.
- ❖ The routing tables are dynamic and are updated periodically. The destination addresses andthe corresponding forwarding output ports are recorded in the tables.
- ❖ Every packet in a datagram network carries a header that contains, among other information, the destination address of the packet.
- ❖ The destination address in the header of a packet in a datagram network remains the same during the entire journey of the packet.
- ❖ **Efficiency** :The efficiency of a datagram network is better than that of a circuit-switched network; resources are allocated only when there are packets to be transferred. If a source sends a packet and there is a delay of a few minutes before another packet can be sent, the resources can be reallocated during these minutes for other packets from other sources.

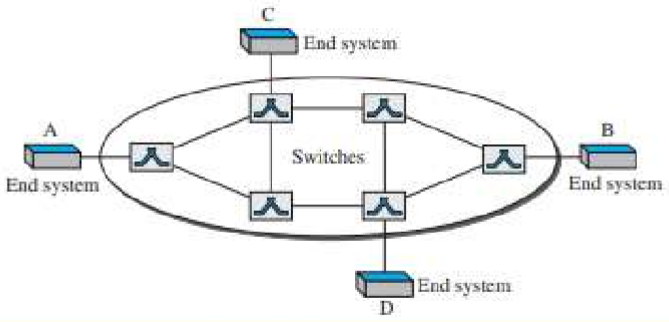
- **Delay**: There may be greater delay in a datagram network than in a virtual-circuit network. Although there are no setup and teardown phases, each packet may experience a wait at a switch before it is forwarded.

Virtual-Circuit Networks

A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both.

1. Virtual-Circuit Networks has setup and teardown phases in addition to the data transfer phase.
2. Resources can be allocated during the setup phase, or on demand.
3. Data are packetized and each packet carries an address in the header. However, the address in the header has local jurisdiction (it defines what the next switch should be and the channel on which the packet is being carried), not end-to-end jurisdiction.
4. All packets follow the same path established during the connection.
5. A virtual-circuit network is normally implemented in the data-link layer, while a circuit-switched network is implemented in the physical layer and a datagram network in the network layer.

Figure 8.10 *Virtual-circuit network*



- **Addressing**In a virtual-circuit network, two types of addressing are involved: global and local (virtual-circuit identifier).
  - **Global Addressing** A source or a destination needs to have a global address—an address that can be unique in the scope of the network.
  - **Virtual-Circuit Identifier** The identifier that is actually used for data transfer is called the virtual-circuit identifier (VCI) or the label. A VCI, unlike a global address, is a small number that has only switch scope; it is used by a frame between two switches. When a frame arrives at a switch, it has a VCI; when it leaves, it has a different VCI.
- Three Phases
  - The three phases in a virtual-circuit network: setup, data transfer, and teardown.

- **Data-Transfer Phase**
  - To transfer a frame from a source to its destination, all switches need to have a table entry for this virtual circuit. The table, in its simplest form, has four columns.
  - The data-transfer phase is active until the source sends all its frames to the destination. The procedure at the switch is the same for each frame of a message. The process creates a virtual circuit, not a real circuit, between the source and destination.
- **Setup Phase**
  - In the setup phase, a switch creates an entry for a virtual circuit. For example, suppose source A needs to create a virtual circuit to B. Two steps are required: the setup request and the acknowledgment.
  - Initially A setup request frame is sent from the source to the destination. After the entries in the switching tables gets completed A special frame, called the acknowledgment frame id generated
- **Teardown Phase**
  - In this phase, source A, after sending all frames to B, sends a special frame called a teardown request. Destination B responds with a teardown confirmation frame. All switches delete the corresponding entry from their tables.

- In virtual-circuit switching, all packets belonging to the same source and destination travel the same path, but the packets may arrive at the destination with different delays if resource allocation is on demand.
- Switching at the data-link layer in a switched WAN is normally implemented by using virtual-circuit techniques.