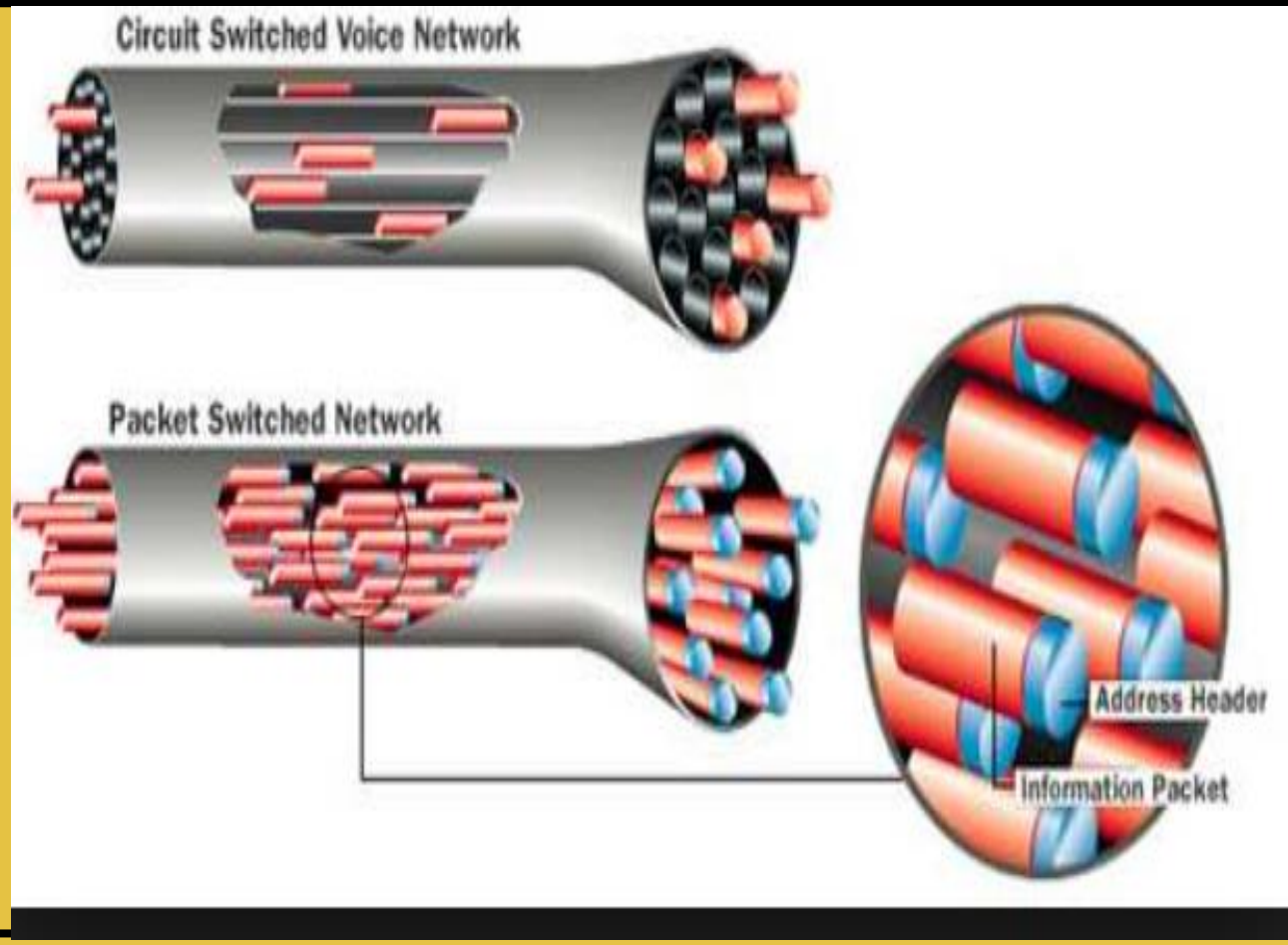
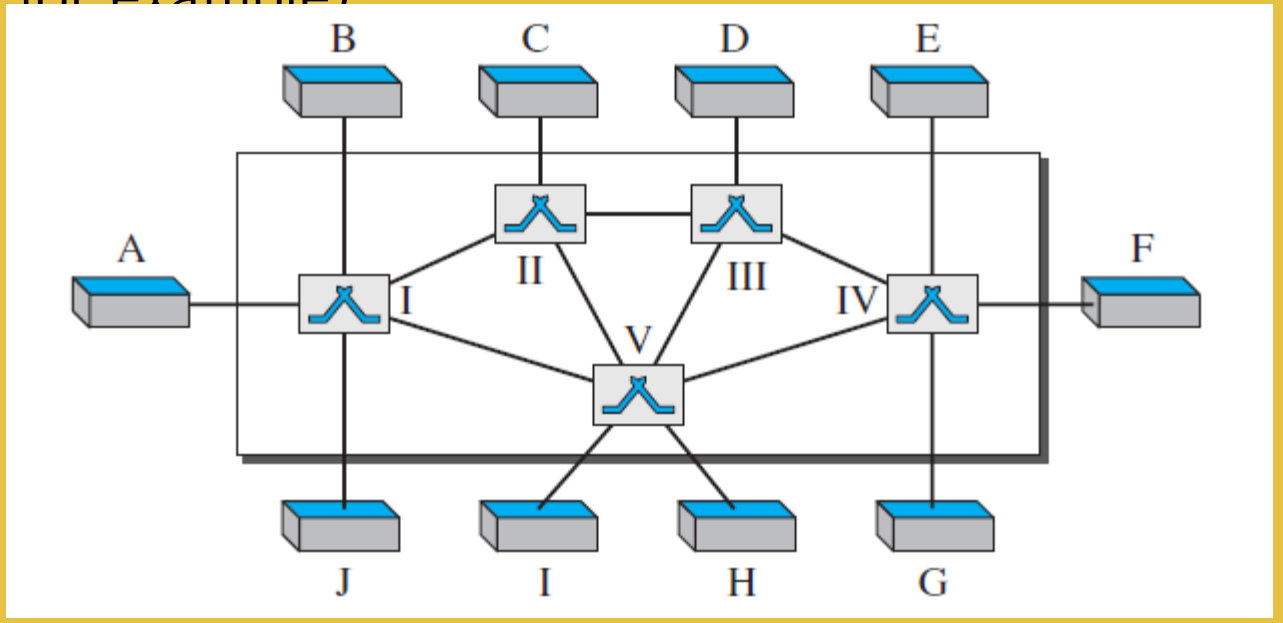
SWITCHING

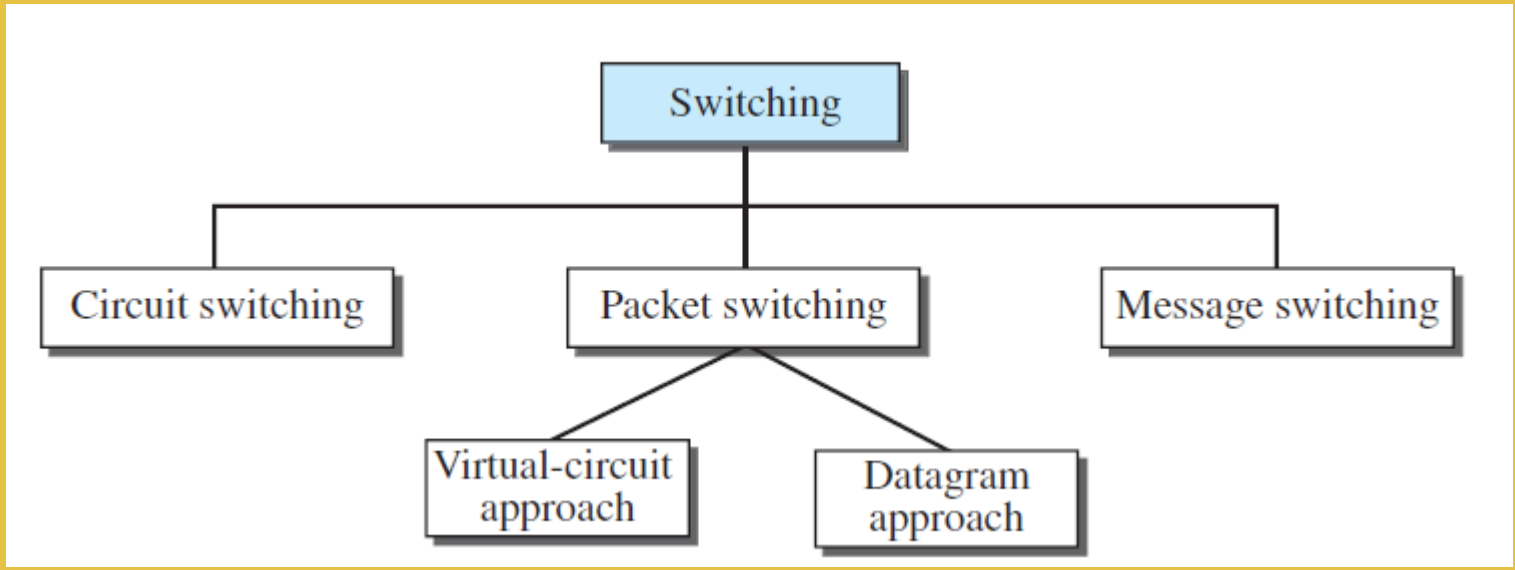

Circuit Switched Voice Network
Packet Switched Network
Address Header
Information Packet

Switching

- 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.
- In a switched network, some of these nodes are connected to the end systems (computers or telephones, for example).
- Others are used only for routing.



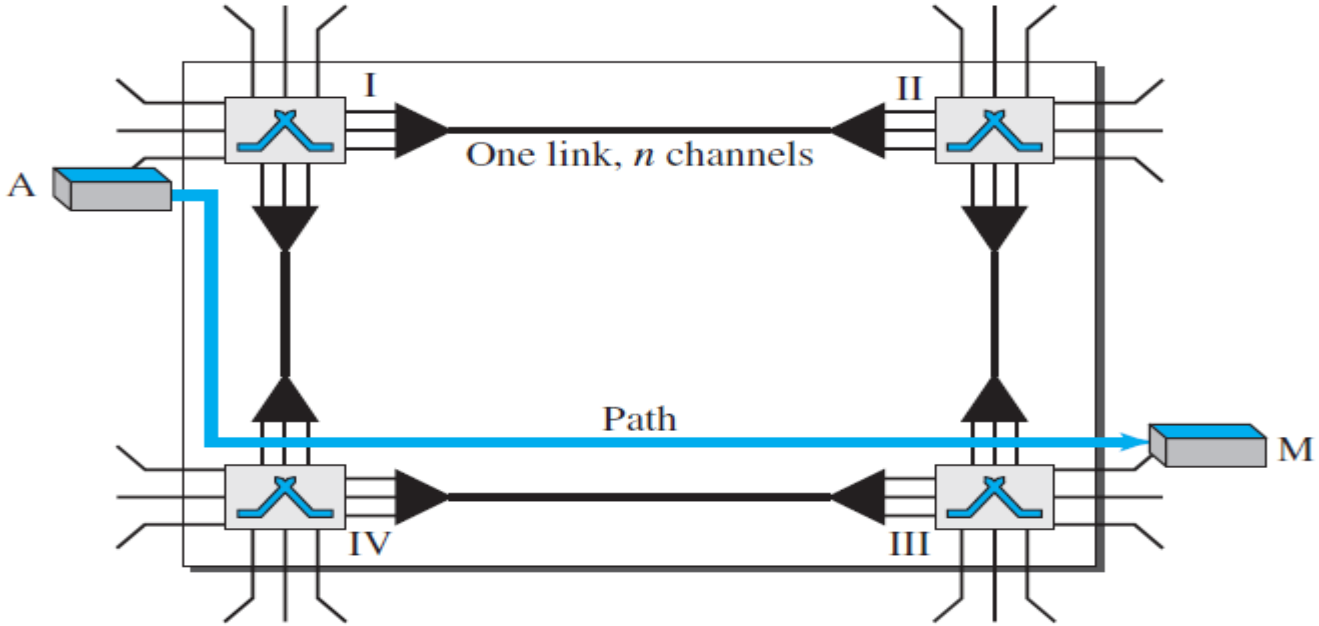
Three Methods of Switching



Switching and TCP/IP Layers	
Physical Layer	Circuit switching
Data-Link Layer	Packet switching
Network Layer	Packet switching
Application Layer	Message switching

Circuit-switched networks

- Consists of a set of switches connected by physical links.
- A connection between two stations is a dedicated path made of one or more links.
- Each link is normally divided into n channels by using fdm or tdm



- Circuit-switched network with four switches and four links
- Each link is divided into n = 3

Circuit-switching

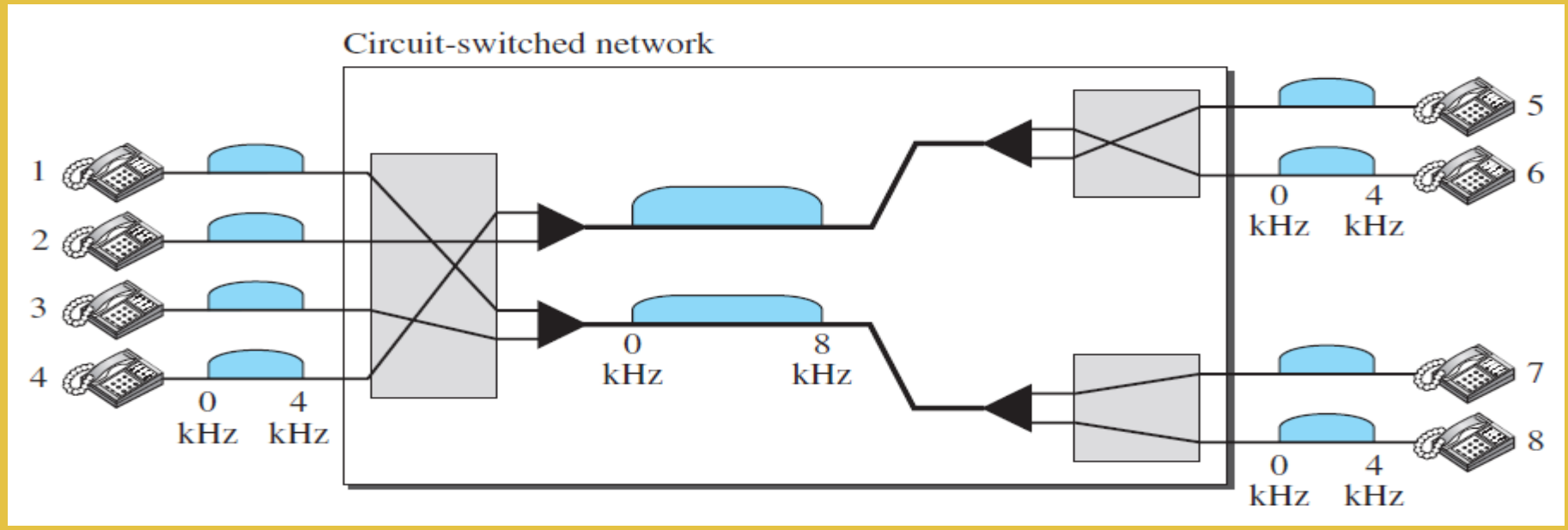
- Setup phase :when end system A needs to communicate with end system M, system A needs to request a connection to M that must be accepted by all switches as well as by M itself.
- A circuit (channel) is reserved on each link, and the combination of circuits or channels defines the dedicated path.
- Data-transfer: after the dedicated path made of connected circuits (channels) is established, the data-transfer phase can take place.
- After all data have been transferred, the circuits are torn down.

Circuit-switching

- Circuit switching takes place at the physical layer.
- Reservation for the resources: channels (bandwidth in FDM and time slots in TDM), 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
- There is no addressing involved during data transfer

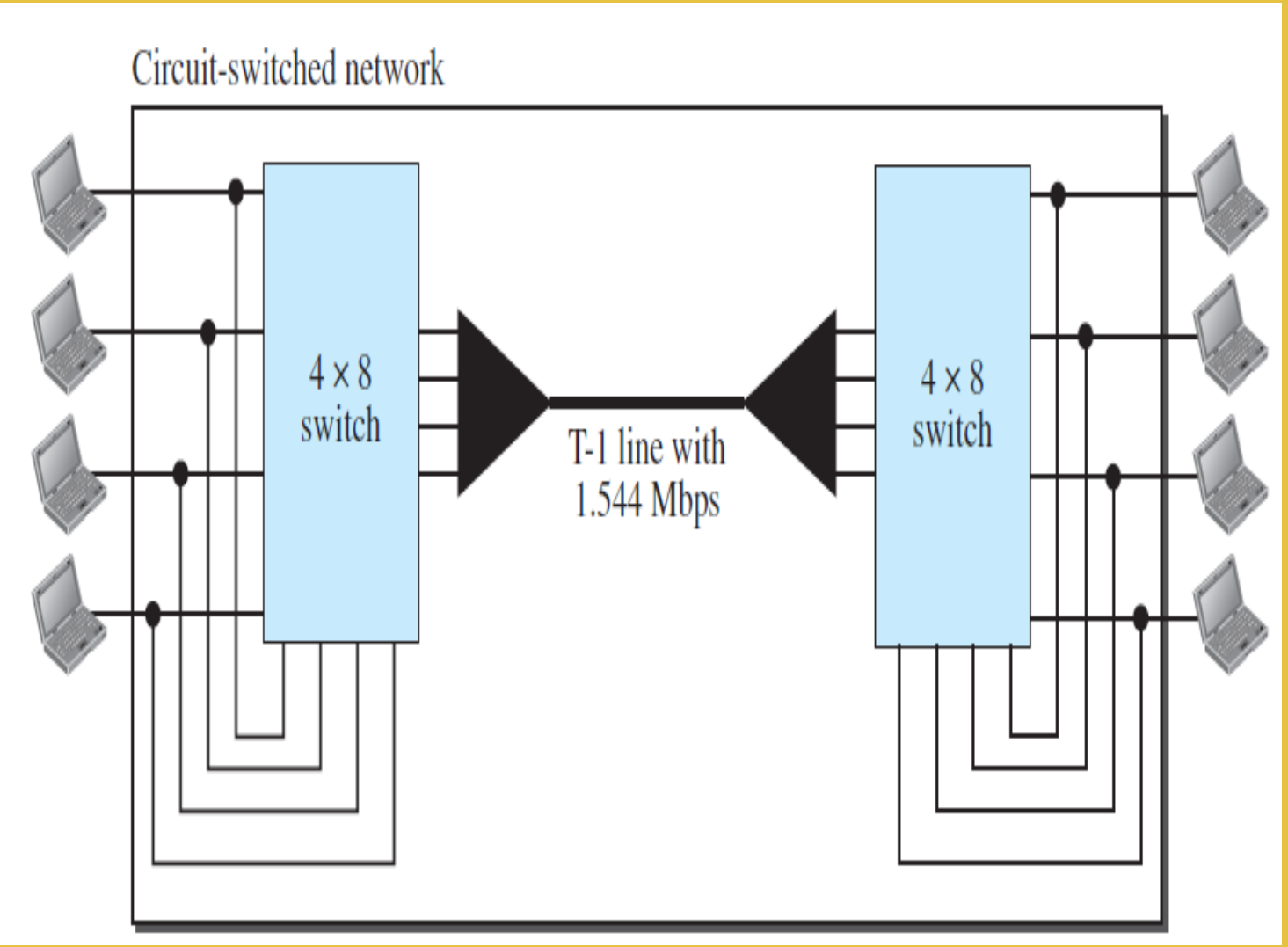
Circuit-switched network

- Let us use a circuit-switched network to connect 8 telephones in a small area. Communication is through 4-khz voice channels. We assume that each link uses FDM to connect a maximum of two voice channels. The bandwidth of each link is then 8 khz.
- Telephone 1 is connected to telephone 7; 2 to 5; 3 to 8; and 4 to 6.
- The switch controls the connections.



Circuit-switched network

- Consider a circuit-switched network that connects computers in 2 remote offices of a private company.
- The offices are connected using a t-1 line leased from a communication service provider.
- There are two 4 x 8 (4 inputs and 8 outputs) switches in this network.
- For each switch, four output ports are folded into the input ports to allow communication between computers in the same office.
- Four other output ports allow communication between the two offices.



Three Phases : *Setup Phase*

Circuit-switched network requires three phases: connection setup, data transfer, and connection teardown

- Dedicated circuit (combination of channels in links) needs to be established. The end systems are normally connected through dedicated lines to the switches
- When system A needs to connect to system M, it sends a setup request that includes the address of system M, to switch I. Switch I finds a channel between itself and switch IV
- Switch I then sends the request to switch IV, which finds a dedicated channel between itself and switch III. Switch III informs system M of system a's intention at this time.
- An acknowledgment from system M needs to be sent to A. Only after system A receives this acknowledgment is the connection established.
- End-to-end addressing is required for creating a connection between the two end systems.
- The addresses of the computers assigned by the administrator in a TDM network, or telephone numbers in an FDM network.

Three Phases

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

Resources are allocated during the entire duration of the connection → unavailable to other connections.

- the delay in this type of network is minimal

Delay in a circuit-switched network

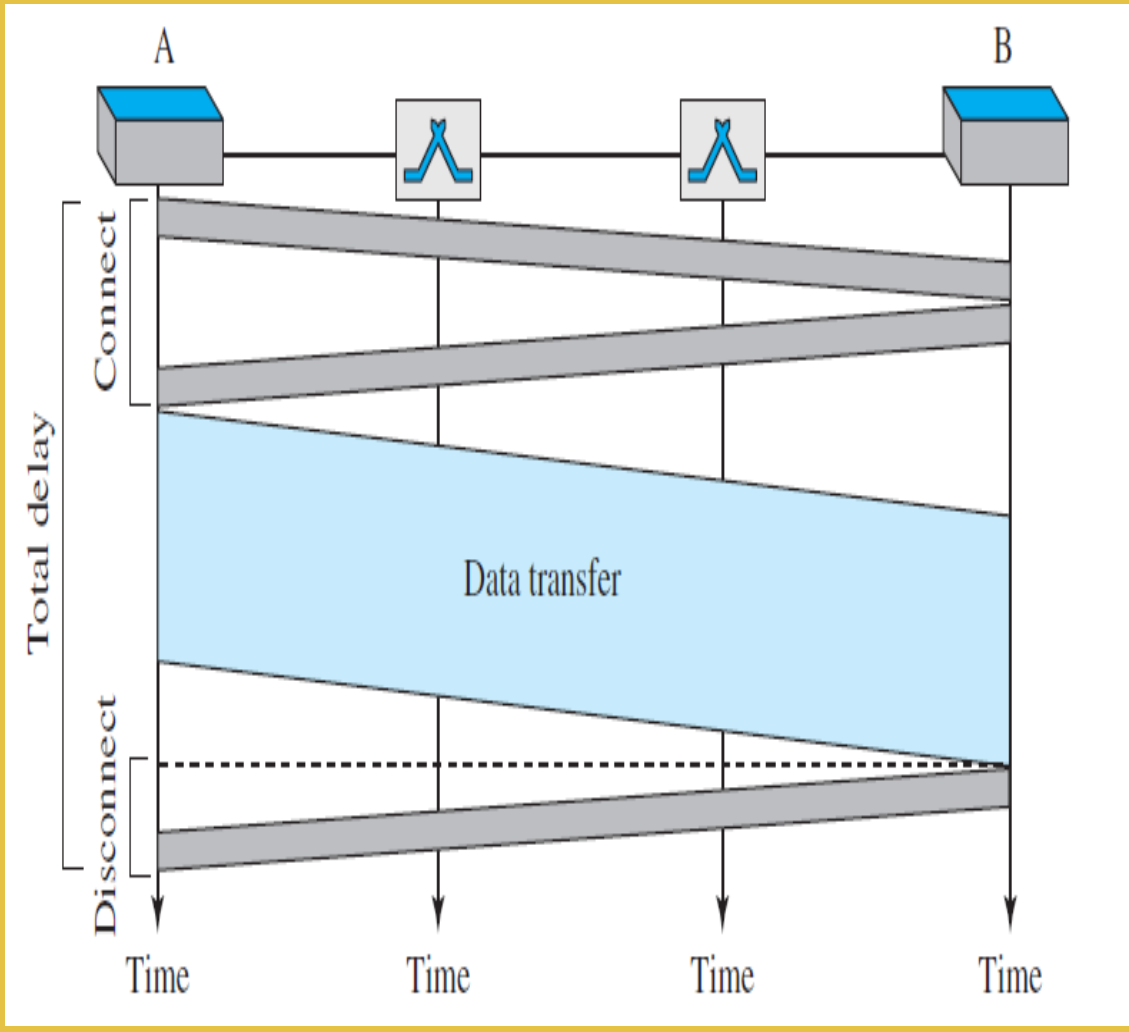
- There is no waiting time at each switch.

- Total delay =the time needed to create the connection,+ transfer data + disconnect circuit.

- Setup delay =propagation time of the source computer request (slope of the first gray box) + request signal transfer time (height of the first gray box) + propagation time of the acknowledgment from the destination computer (slope of the second gray box) + signal transfer time of the acknowledgment (height of the second gray box).

- The delay due to data txr = propagation time (slope of the colored box) + data transfer time (height of the colored box).

- The third box shows the time needed to teardown the circuit.

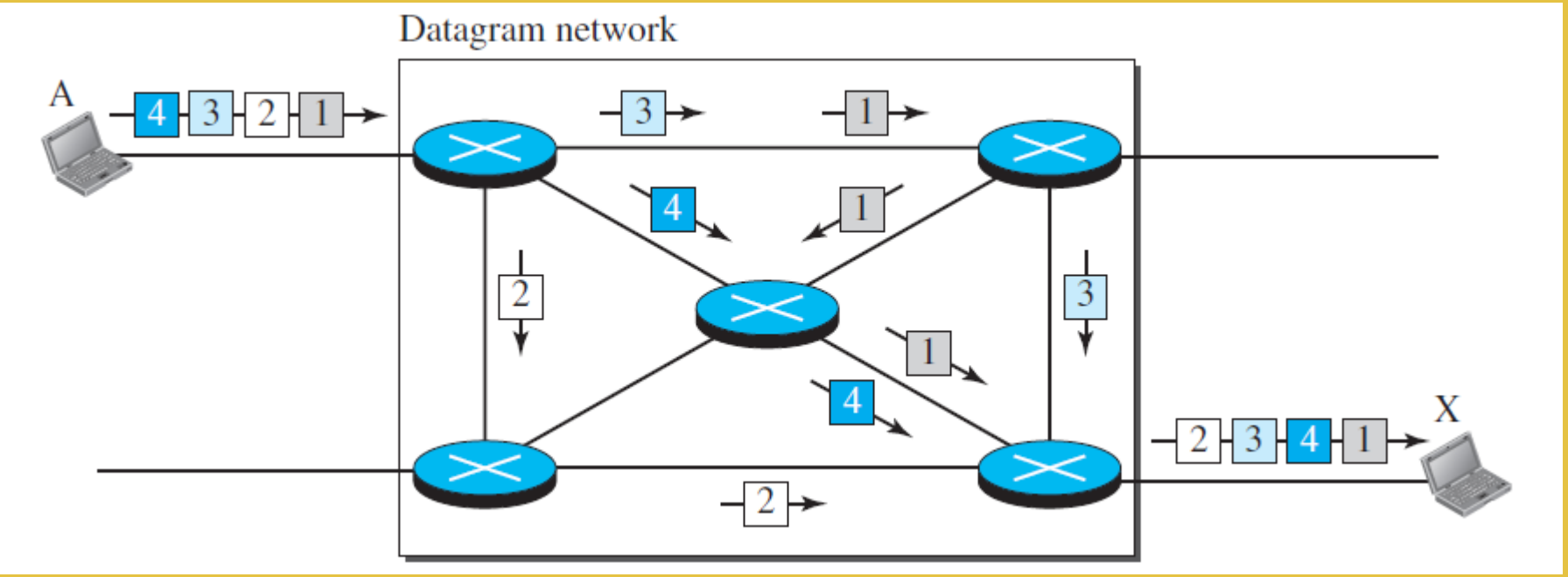


Packet Switching

- 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 packet switching, there is no resource allocation for a packet → no reserved bandwidth on the links, and there is no scheduled processing time for each packet.
- Resources are allocated on demand. The allocation is done on a first come, first-served basis.
- When a switch receives a packet, no matter what the source or destination is, the packet must wait if there are other packets being processed.

Datagram Networks

- Each packet is treated independently of all others. Packets called as datagrams
- Datagram switching is done at the network layer.



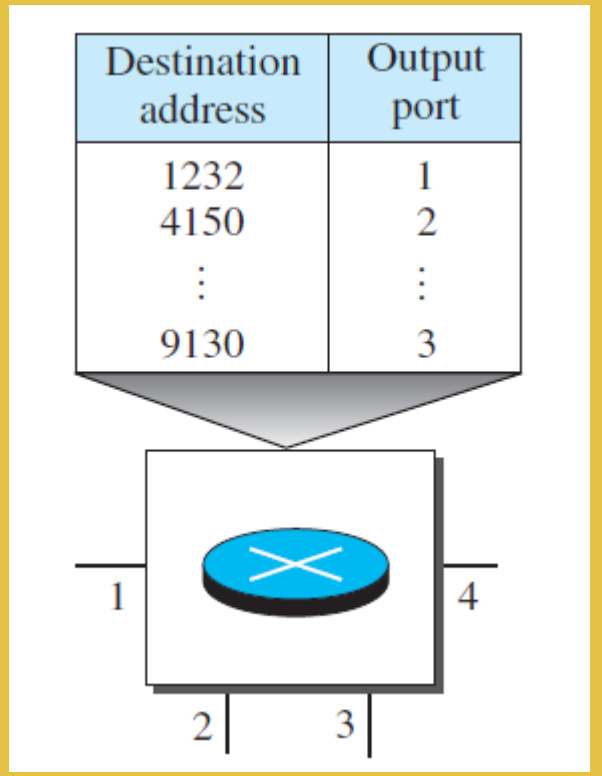
- Datagram approach is used to deliver four packets from station A to station X.
- The switches in a datagram network are referred to as **routers.**

Datagram Networks

- Packets may also be lost or dropped because of a lack of resources.
- It is the responsibility of an upper-layer protocol to reorder the datagrams or ask for lost datagrams before passing them on to the application.
- Datagram networks : connectionless networks.
- 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.

Routing Table

- Each switch (or packet switch) has a routing table which is based on the destination address.
- The routing tables are dynamic and are updated periodically.
- The destination addresses and the corresponding forwarding output ports are recorded in the tables.

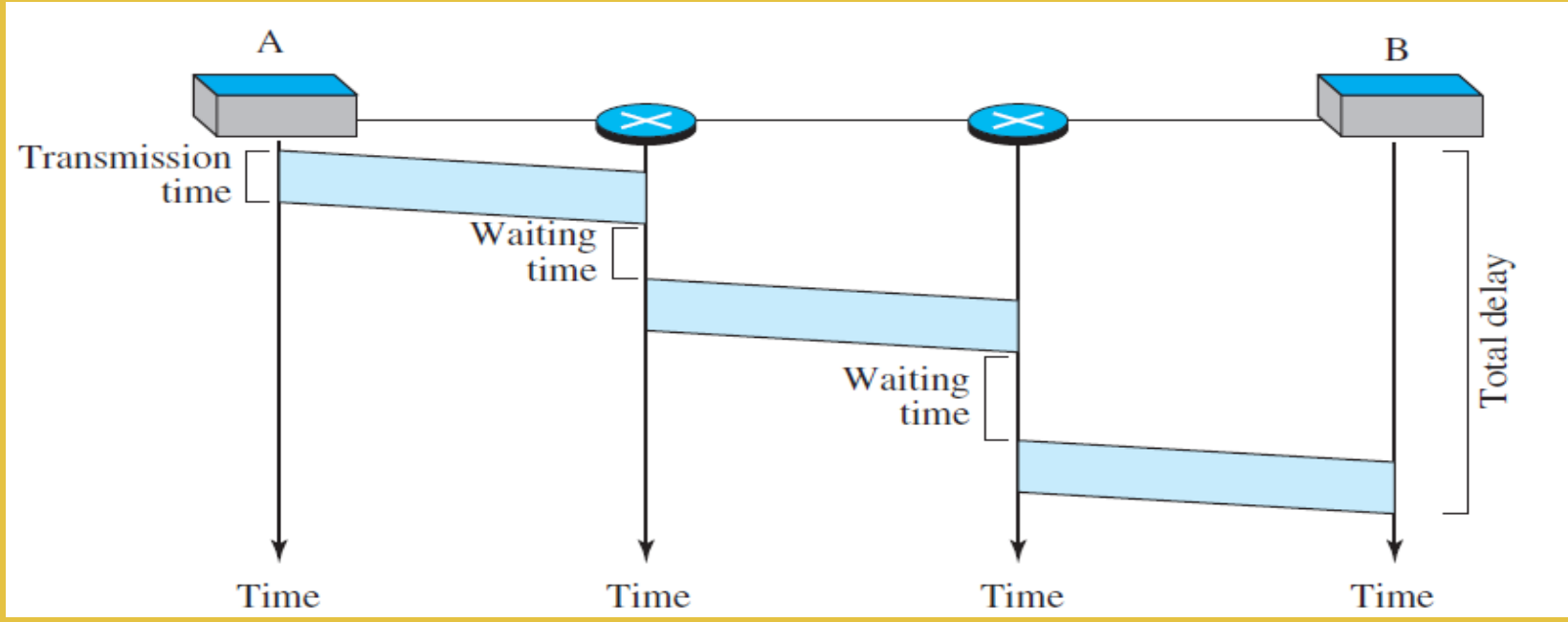


Efficiency

- 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.
- Greater delay in a datagram network and not uniform for the packets

Total delay = 3T + 3τ + w1 + w2

- three transmission times (3T), three propagation delays (slopes 3τ of the lines), and two waiting times (w1 + w2)

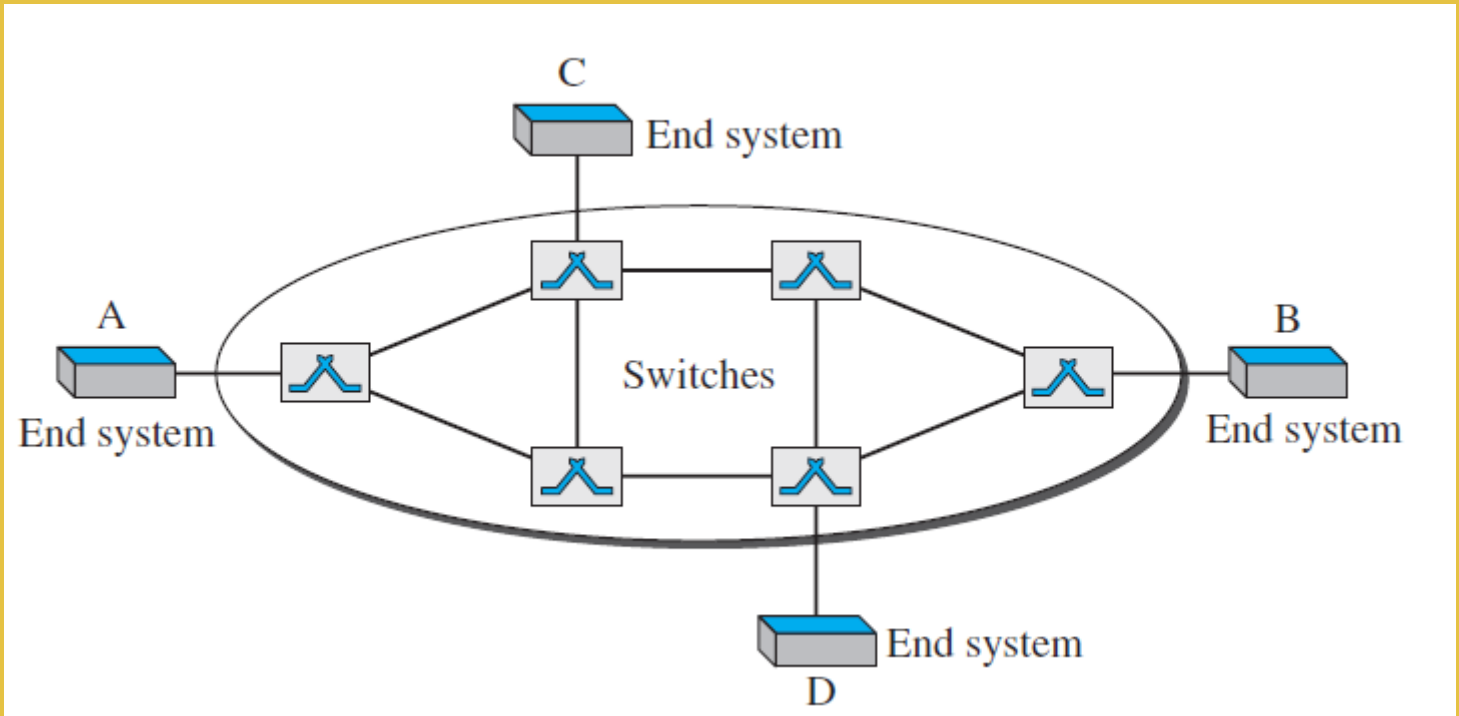


Virtual-Circuit Networks

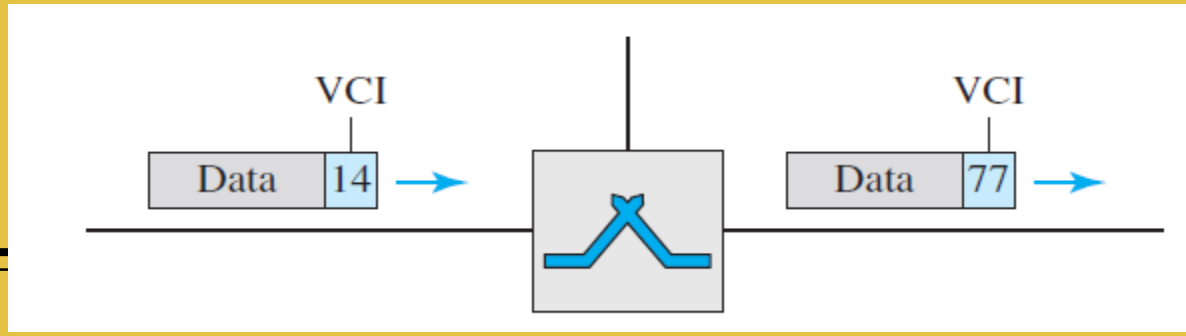
A cross between a circuit-switched network and a datagram network.

1. There are setup and teardown phases in addition to the data transfer phase.
2. Resources can be allocated during the setup phase, or on demand, as in a datagram network.
3. Data are packetized and each packet carries an address in the header. However, the address in the header has local jurisdiction, not end-to-end jurisdiction.
4. All packets follow the same path established during the connection.
5. VCN is 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.

Virtual-Circuit Networks



Addressing



- 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 or internationally if the network is part of an international network.
- A global address in virtual-circuit networks is used only to create a virtual-circuit identifier, as discussed next.

Virtual-Circuit Identifier

- The identifier that is actually used for data transfer → virtual-circuit identifier (VCI) or label.
- A VCI, 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.

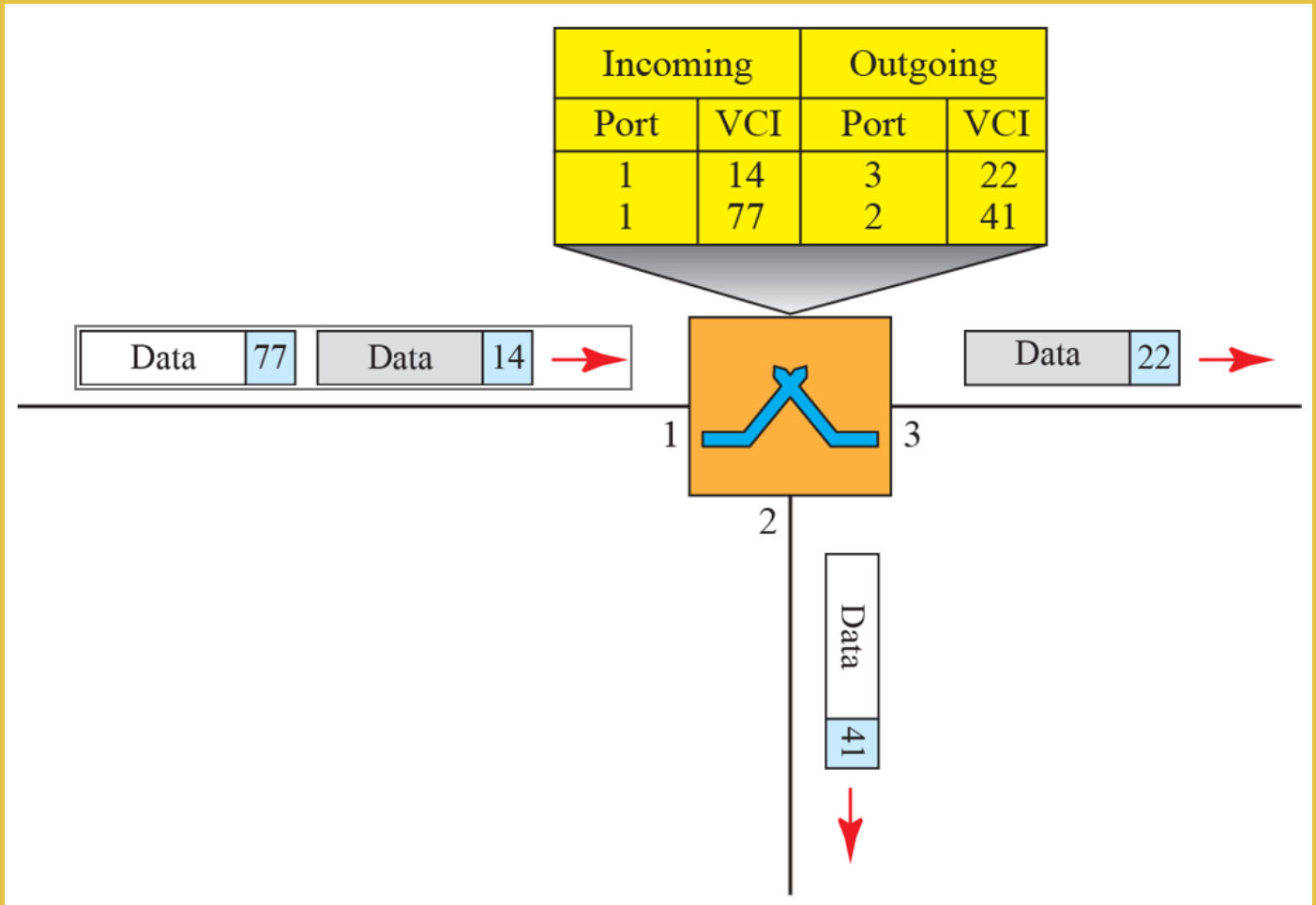
Three Phases

- In the setup phase, the source and destination use their global addresses to help switches make table entries for the connection.
- In the teardown phase, the source and destination inform the switches to delete the corresponding entry.
- Data transfer occurs between these two phases.

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, has four columns.

Switch and tables in a VCN



- A frame arriving at port 1 with a VCI of 14.
- When the frame arrives, the switch looks in its table to find port 1 and a vci of 14.
- When it is found, the switch knows to change the vci to 22 and send out the frame from port 3.

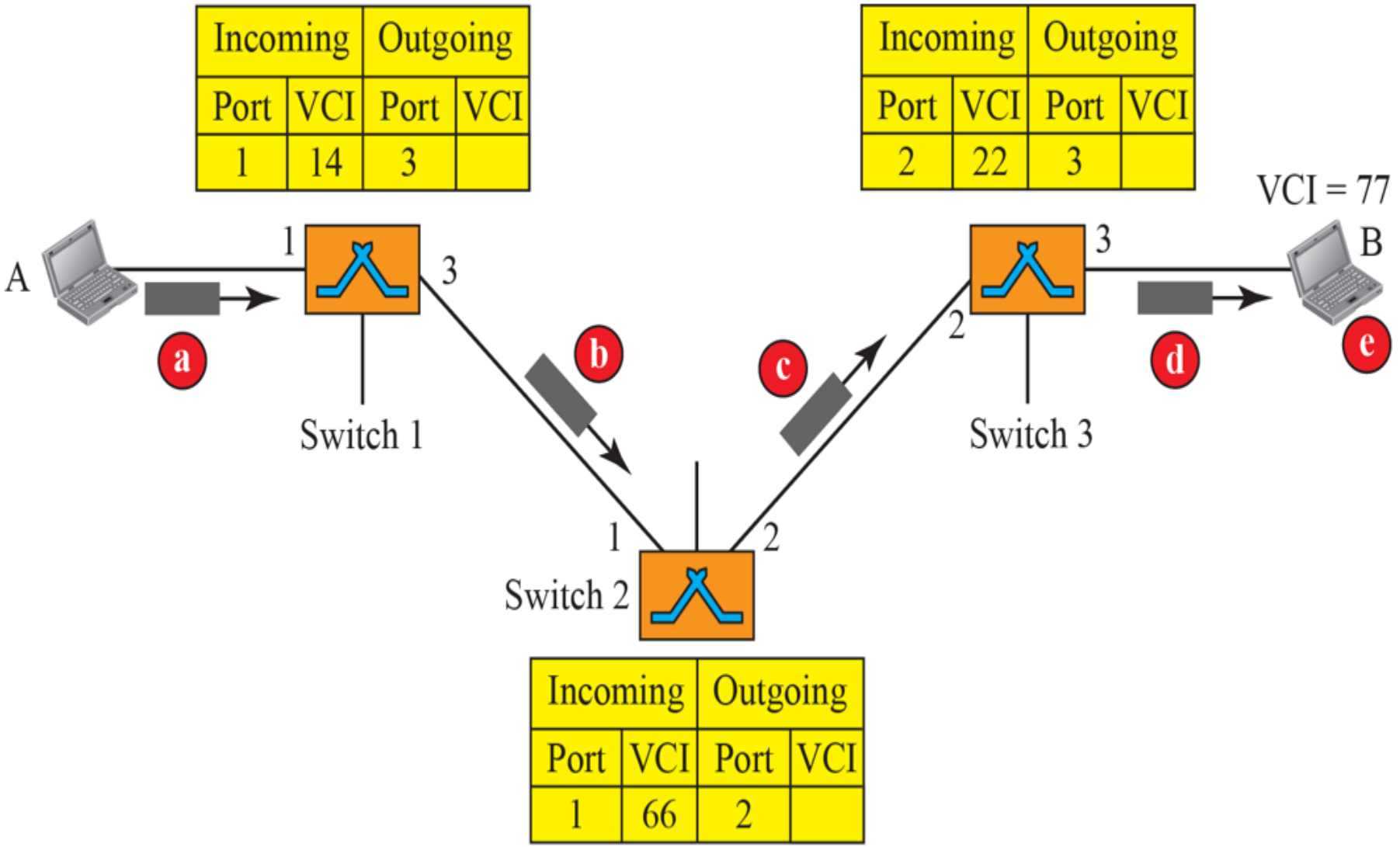
Three Phases

Setup phase

- A switch creates an entry for a virtual circuit.
- Suppose source a needs to create a virtual circuit to b. Two steps are required: the setup request and the acknowledgment

Setup request

- A setup request frame is sent from the source to the destination.



Setup Request

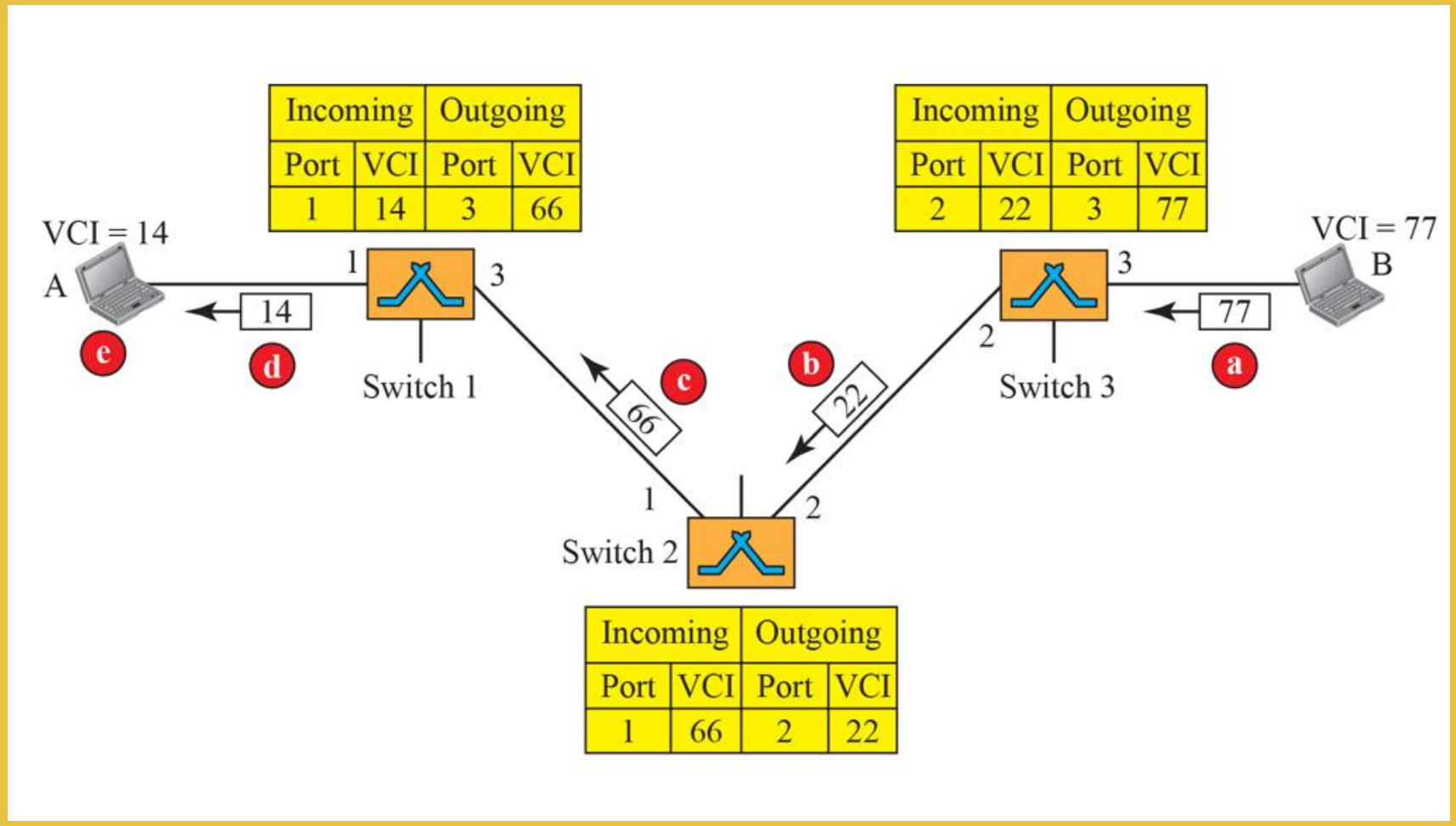
- a. Source A sends a setup frame to switch 1.
- b. Switch 1 receives the setup request frame. It knows that a frame going from A to B goes out through port 3.
  - The switch, in the setup phase, acts as a packet switch; it has a routing table which is different from the switching table.
  - The switch creates an entry in its table for this virtual circuit, but it is only able to fill three of the four columns.
  - The switch assigns the incoming port (1) and chooses an available incoming VCI (14) and the outgoing port (3). It does not yet know the outgoing VCI, which will be found during the acknowledgment step.
  - The switch then forwards the frame through port 3 to switch 2.

Setup Request

- c. Switch 2 receives the setup request frame.
- d. Switch 3 receives the setup request frame. Again, three columns are completed: incoming port (2), incoming VCI (22), and outgoing port (3).
- e. Destination B receives the setup frame, and if it is ready to receive frames from A, it assigns a VCI to the incoming frames that come from A, in this case 77.
- This VCI lets the destination know that the frames come from A, and not other sources.

Acknowledgment

- A special frame, called the acknowledgment frame, completes the entries in the switching tables



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.

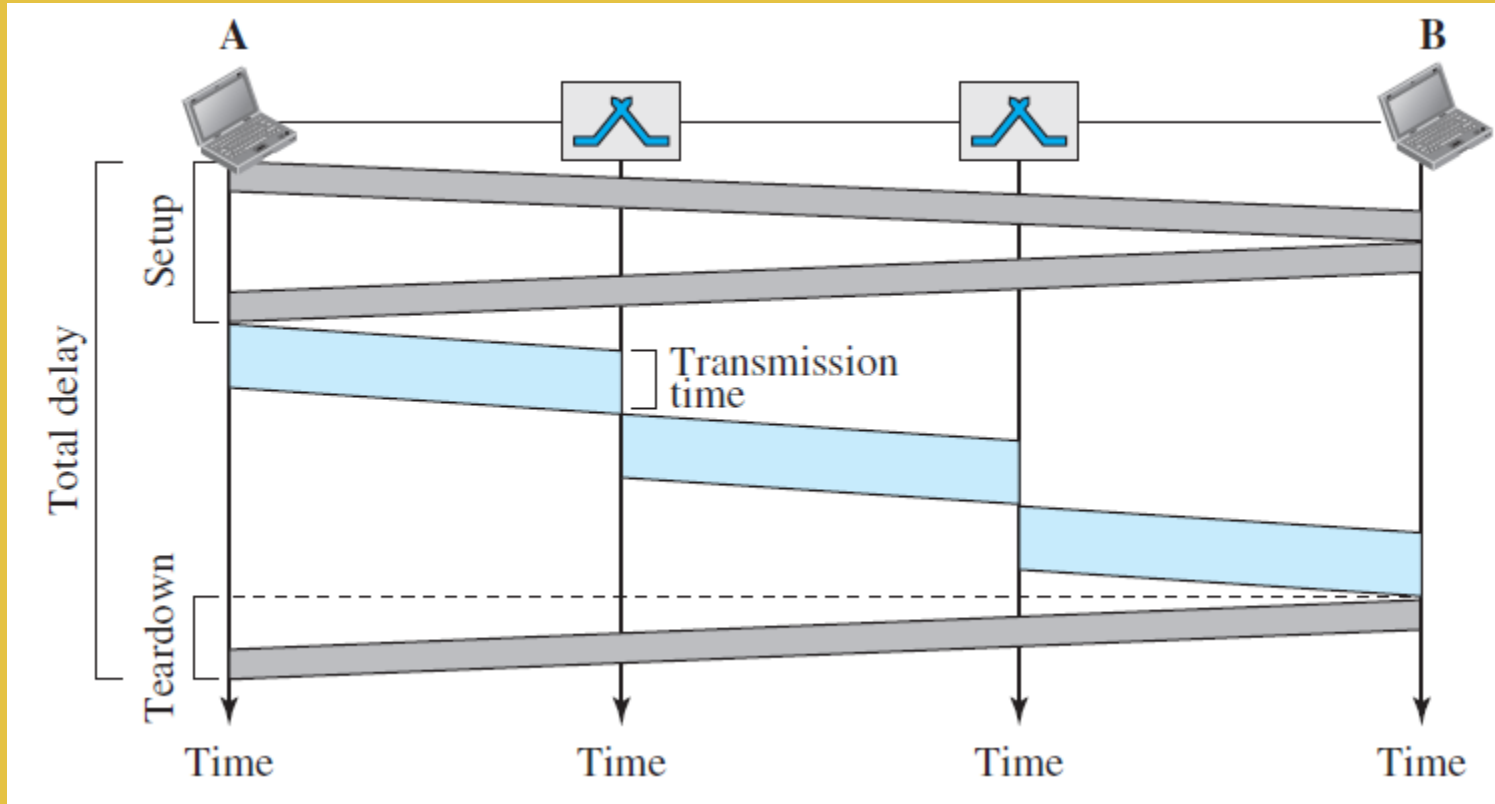
Efficiency

- Resource reservation in a virtual-circuit network can be made during the setup or can be on demand during the data-transfer phase.
- In the first case, the delay for each packet is the same; in the second case, each packet may encounter different delays.
- Advantage: the source can check the availability of the resources, without actually reserving it.
- 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.

Delay in Virtual-Circuit Networks

- There is a one-time delay for setup and a one-time delay for teardown.
- If resources are allocated during the setup phase, there is no wait time for individual packets.
- The packet is traveling through two switches (routers).
- There are three transmission times (3T), three propagation times (3τ), data transfer depicted by the sloping lines, a setup delay and a teardown delay

Total delay = 3T + 3τ + setup delay + teardown delay



Summary

- A switched network consists of a series of interlinked nodes, called switches
- Packet-switched networks can also be divided into two subcategories: virtual-circuit networks and datagram networks.
- A circuit-switched network is made of a set of switches connected by physical links
  - the resources remain dedicated for the entire duration
- In packet switching, there is no resource allocation for a packet
  - Resources are allocated on demand

Test your Understanding

- What are the two approaches to packet switching?

- What is the role of the address field in a packet traveling through a datagram network?