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Chapter 8: Switching

Figure 8.1 *Switched network*

- 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.

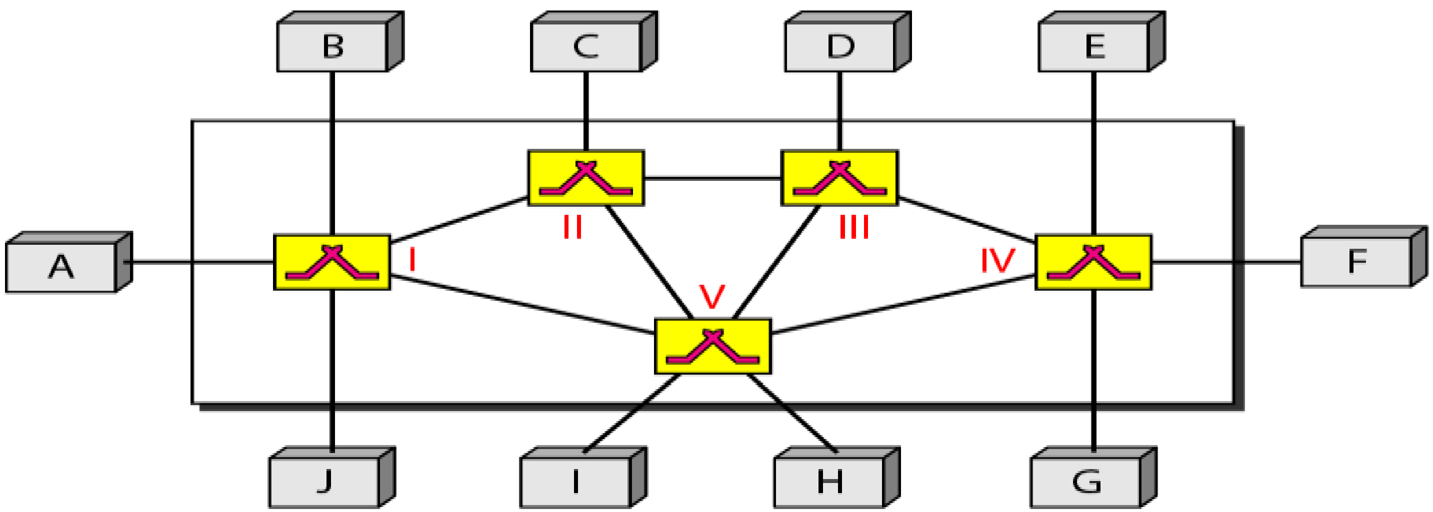
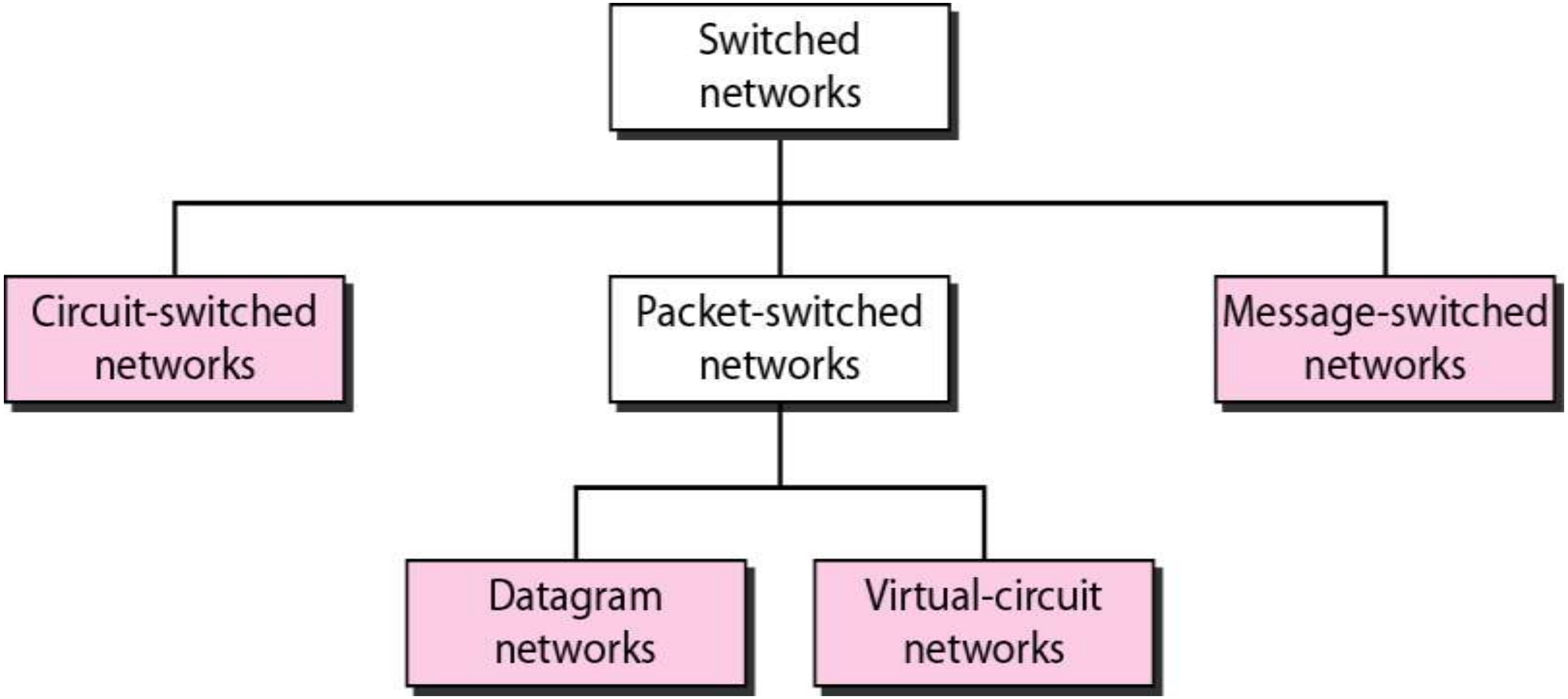


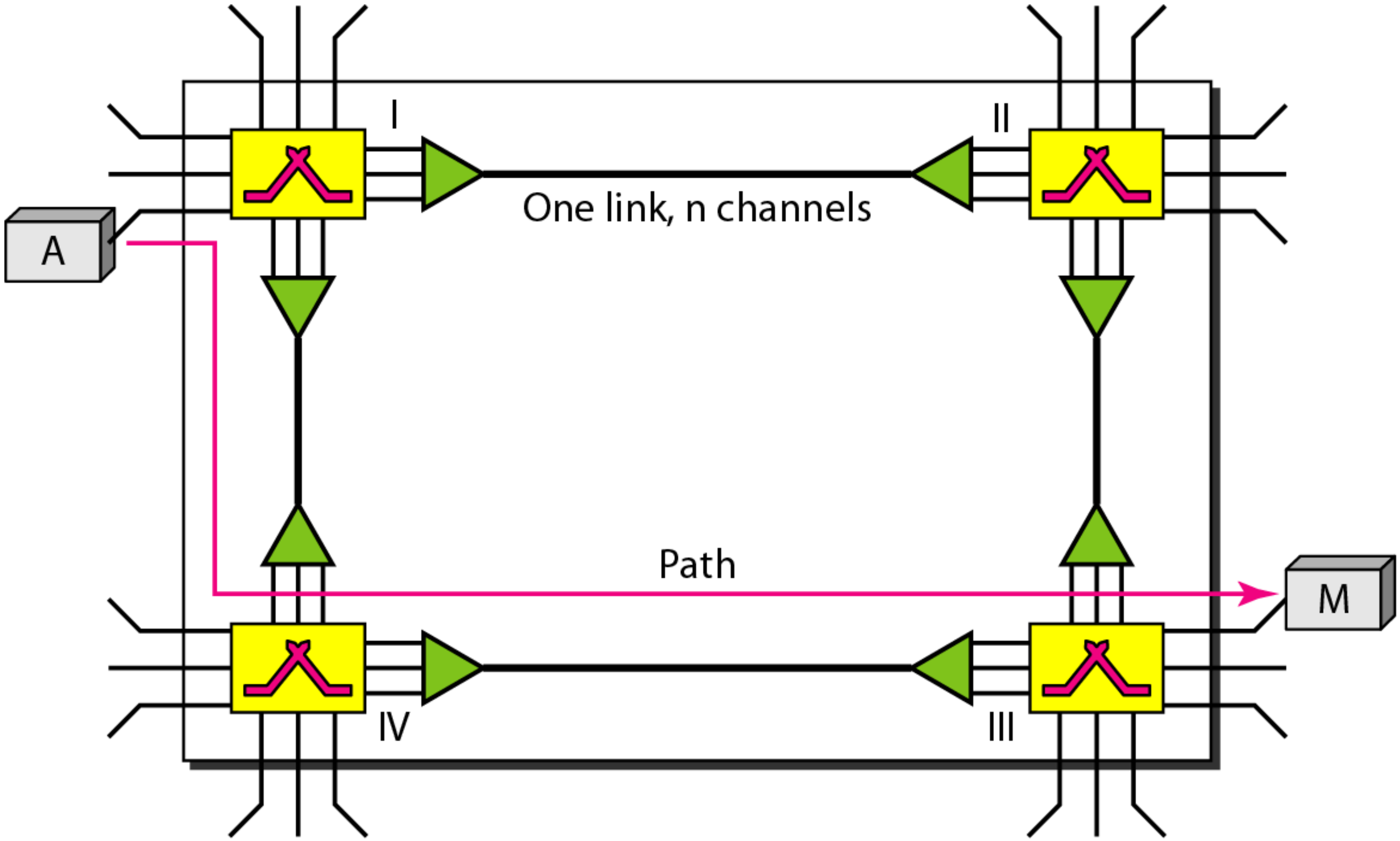
Figure 8.2 *Taxonomy of switched networks*



8-1 CIRCUIT-SWITCHED NETWORKS

- A circuit-switched network 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. However, each connection uses only one dedicated channel on each link. Each link is normally divided into n channels by using FDM or TDM.

Figure 8.3 *A trivial circuit-switched network*



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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. This is called the setup phase.

a circuit (channel) is reserved on each link, and the combination of circuits or channels defines the dedicated path. After the dedicated path made of connected circuits (channels) is established, the data-transfer phase can take place.

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After all data have been transferred, the circuits are torn down called teardown phase.

Features:

- Circuit switching takes place at the physical layer.
- Before starting communication, the stations must make a reservation for the resources to be used during the communication.
- Data transferred between the two stations are not packetized.
- There is no addressing involved during data transfer.

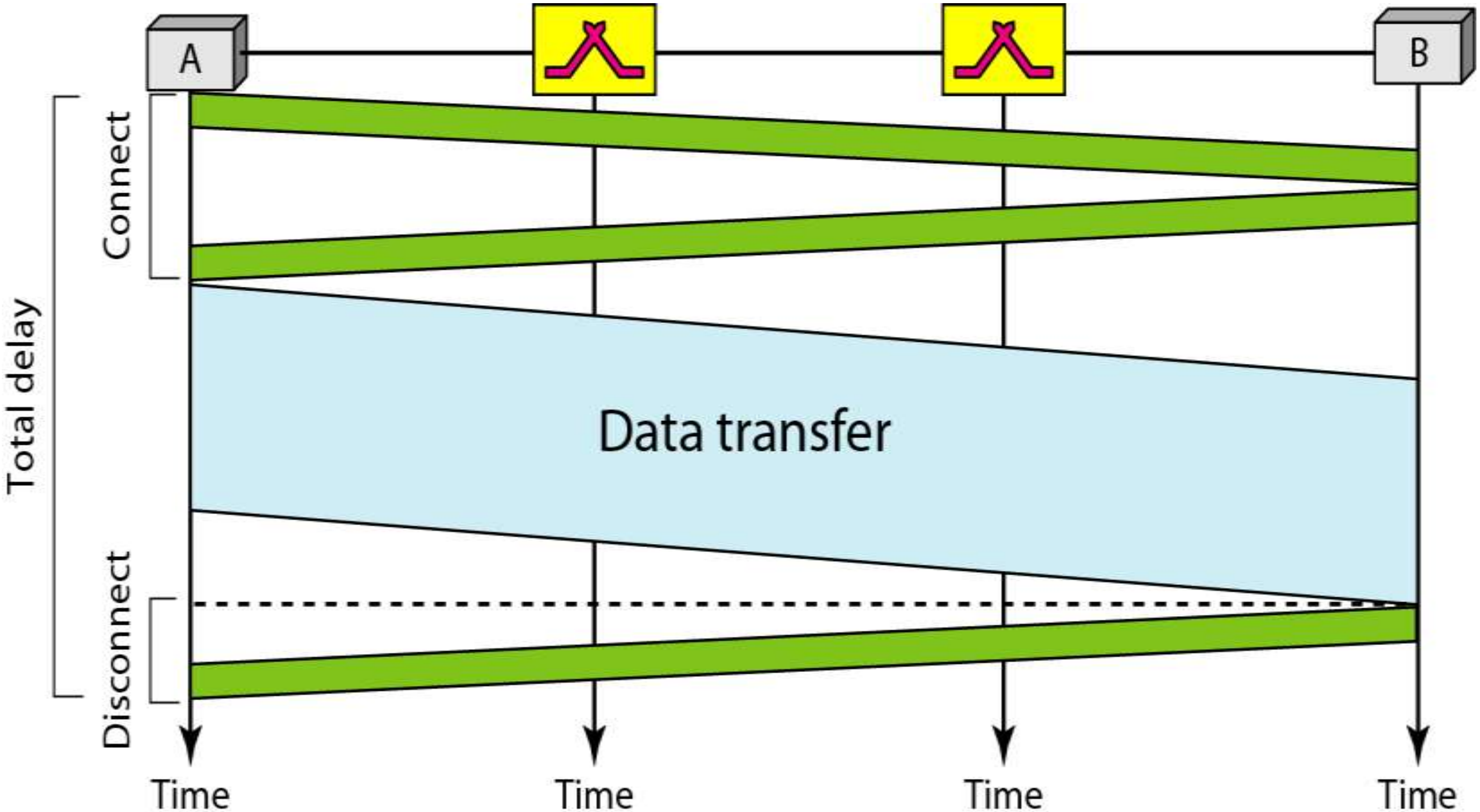
Efficiency

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.

Figure 8.6 *Delay in a circuit-switched network*



8-2 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.
- There is no resource allocation for a packet.
- This lack of reservation may create delay.

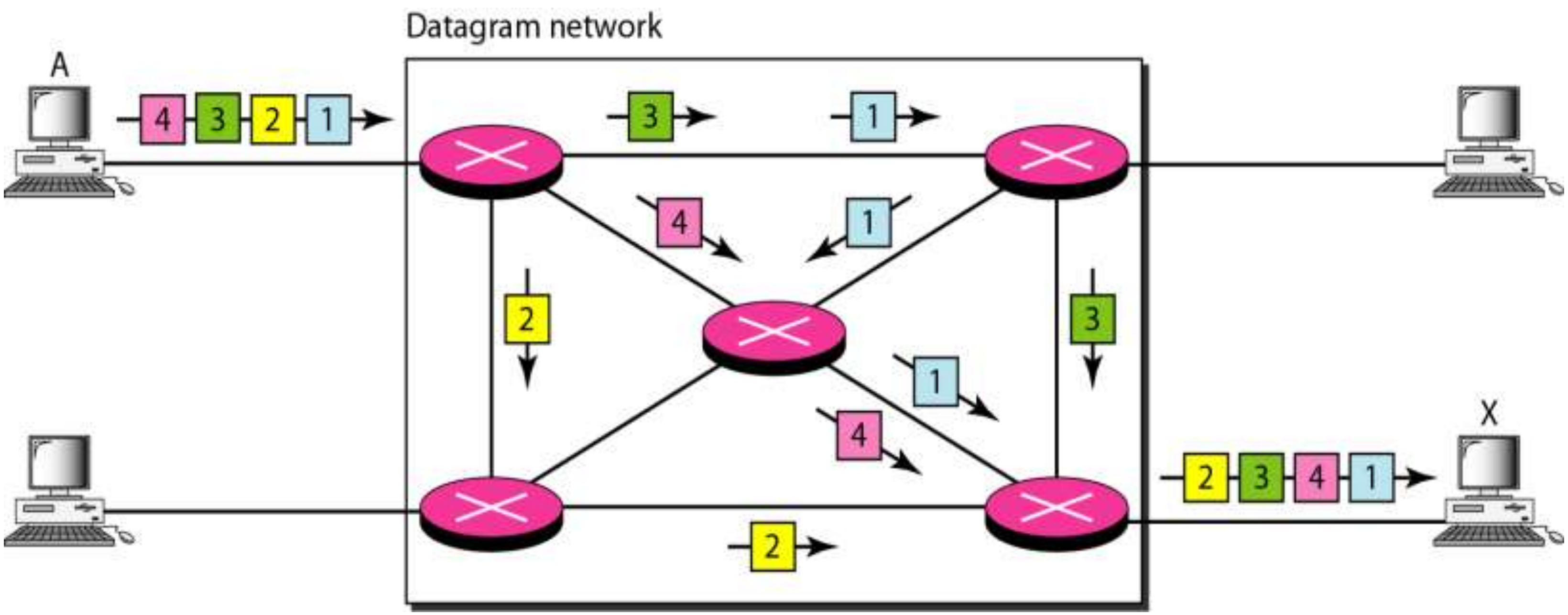
Datagram Networks

In a datagram network, each packet is treated independently of all others. 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, means that the switch (packet switch) does not keep information about the connection state. There are no setup or teardown phases.

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

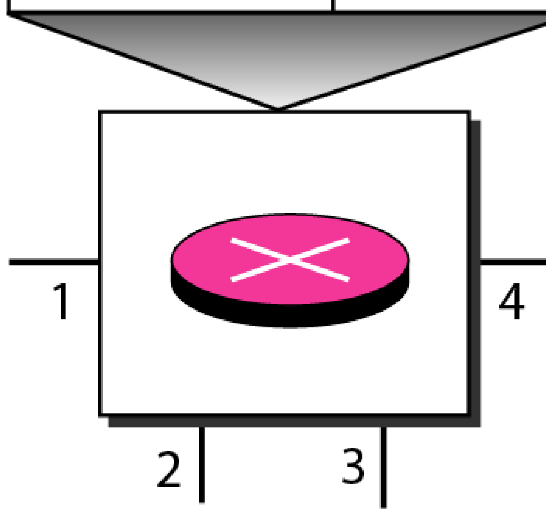


Routing Table

In this type of network, 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.

Figure 8.8 ***Routing table in a datagram network***

Destination address	Output port
1232	1
4150	2
⋮	⋮
9130	3



Destination Address

Every packet in a datagram network carries a header that contains, among other information, the destination address of the packet. When the switch receives the packet, this destination address is examined; the routing table is consulted to find the corresponding port through which the packet should be forwarded.

Efficiency

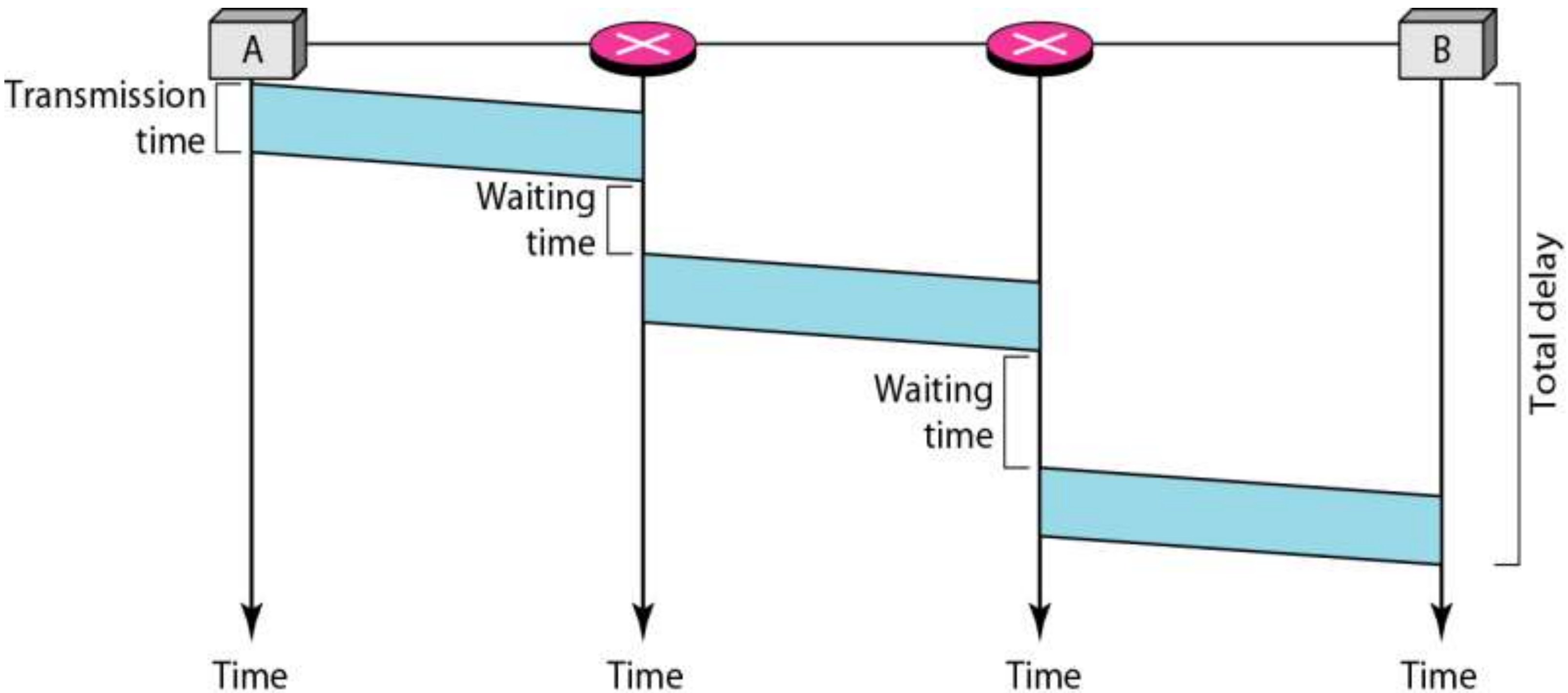
The efficiency of a datagram network is better than that of a circuit-switched network; resources are allocated only when there are packets to be transferred.

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. In addition, since not all packets in a message necessarily travel through the same switches, the delay is not uniform for the packets of a message.

Figure 8.9 *Delay in a datagram network*



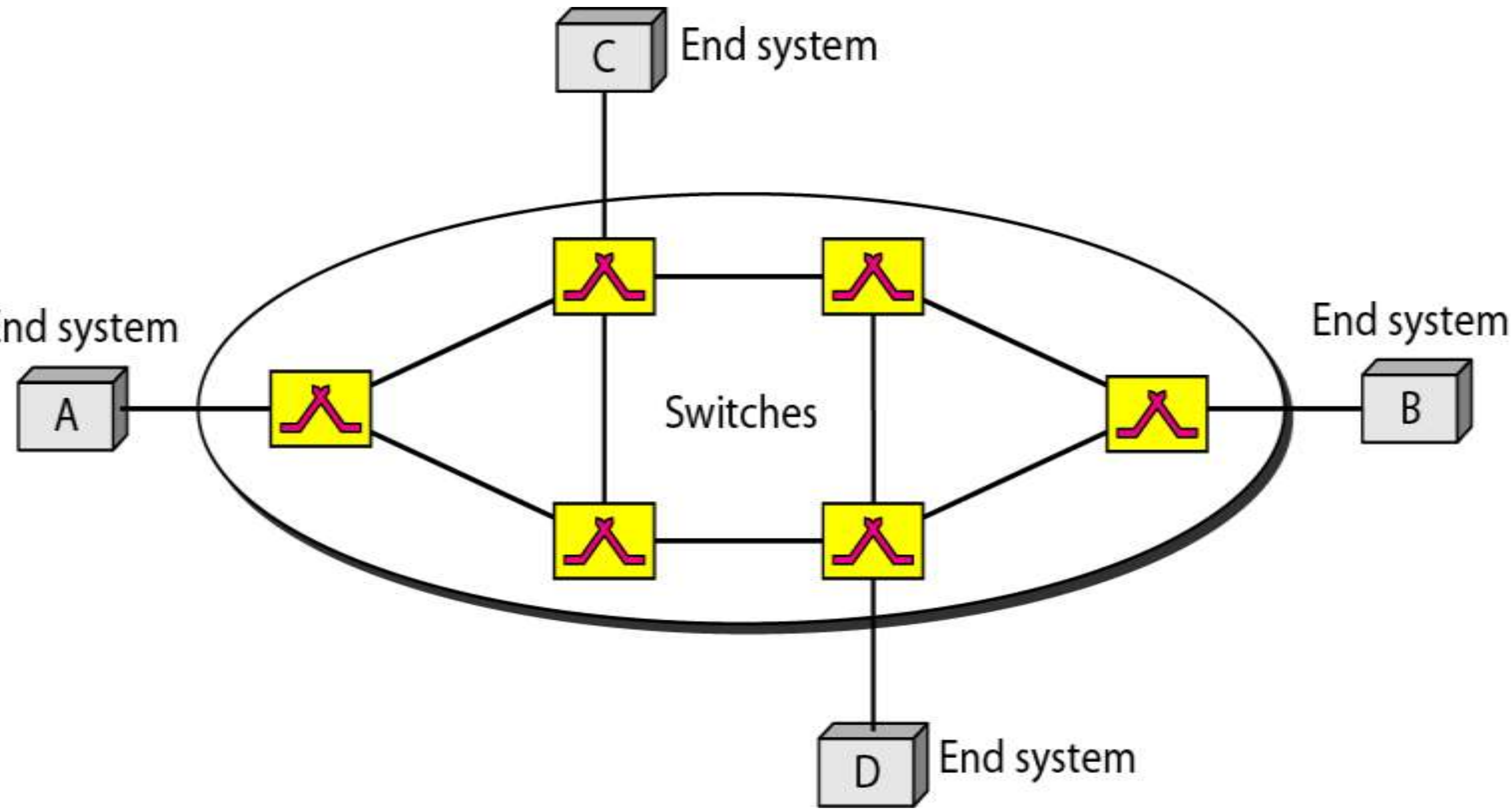
8-3 VIRTUAL-CIRCUIT NETWORKS

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

Continue..

- There are setup, teardown and data transfer phase.
- Resources can be allocated during the setup phase or on demand.
- Data are packetized and each packet carries an address in the header.
- All packets follow the same path established during the connection.
- A virtual-circuit network is normally implemented in the data-link layer.

Figure 8.10 *Virtual-circuit network*



Addressing

In a virtual-circuit network, two types of addressing are involved: global and local

Global Addressing:

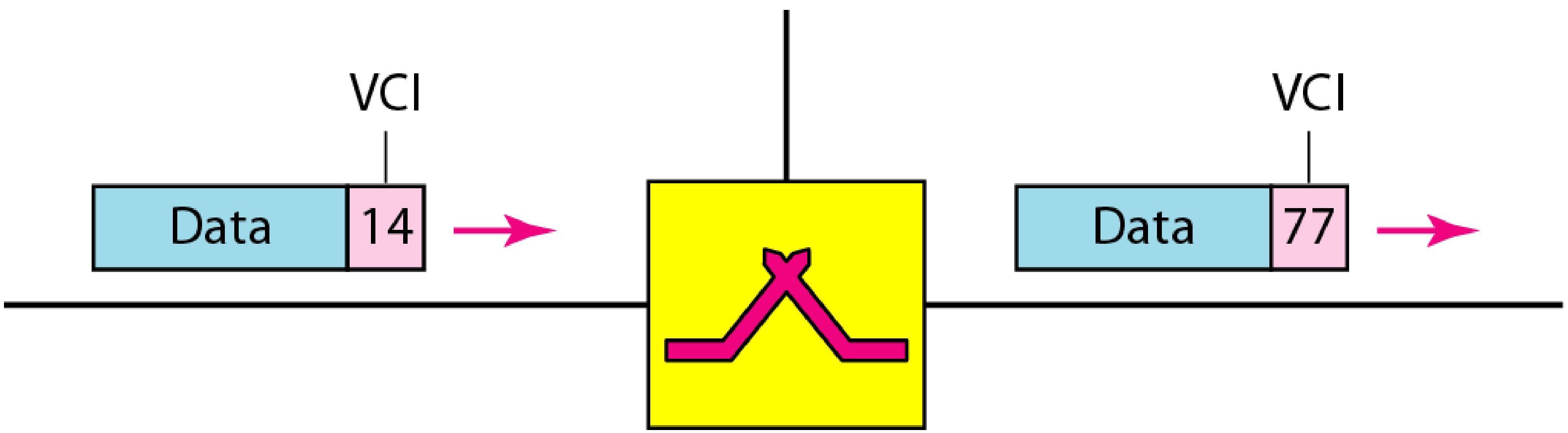
A source or a destination needs to have a global address—an address that can be unique in the scope of the network or internationally if the network is part of an international network.

global address in virtual-circuit networks is used only to create a virtual-circuit identifier.

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

As in a circuit-switched network, a source and destination need to go through 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.

Figure 8.12 *Switch and tables in a virtual-circuit network*

Incoming		Outgoing	
Port	VCI	Port	VCI
1	14	3	22
1	77	2	41

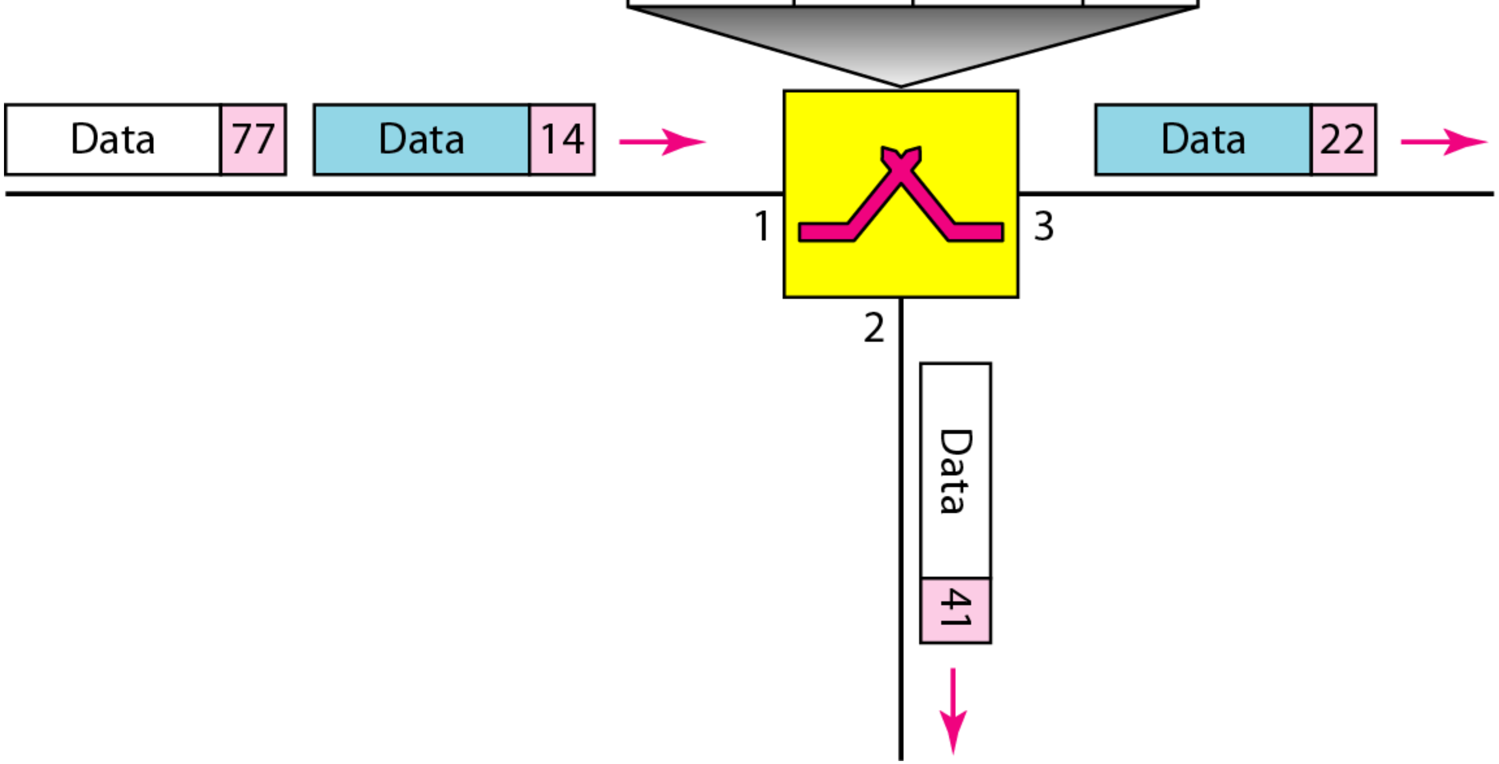


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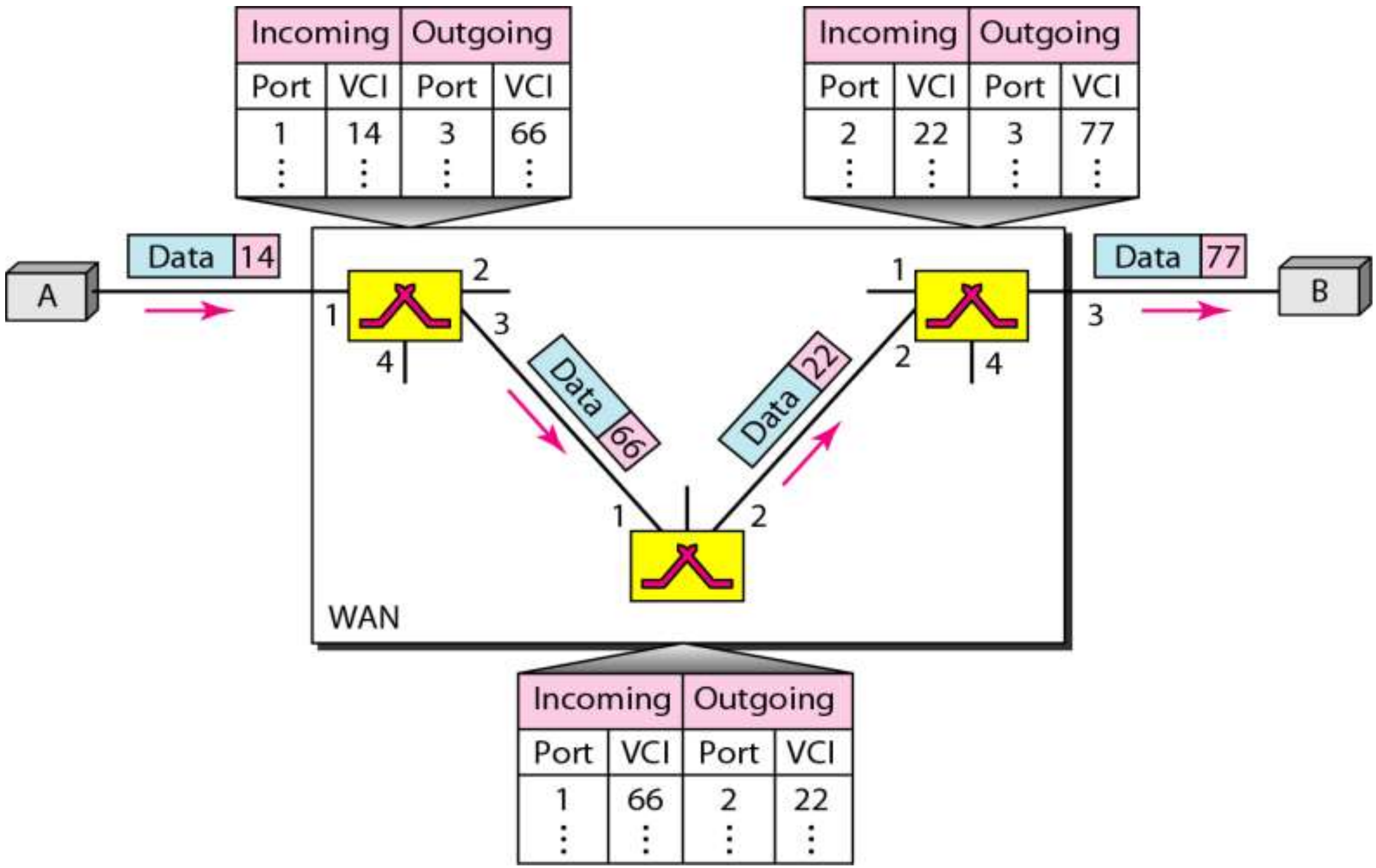
Figure 8.13 ***Source-to-destination data transfer in a virtual-circuit network***



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.

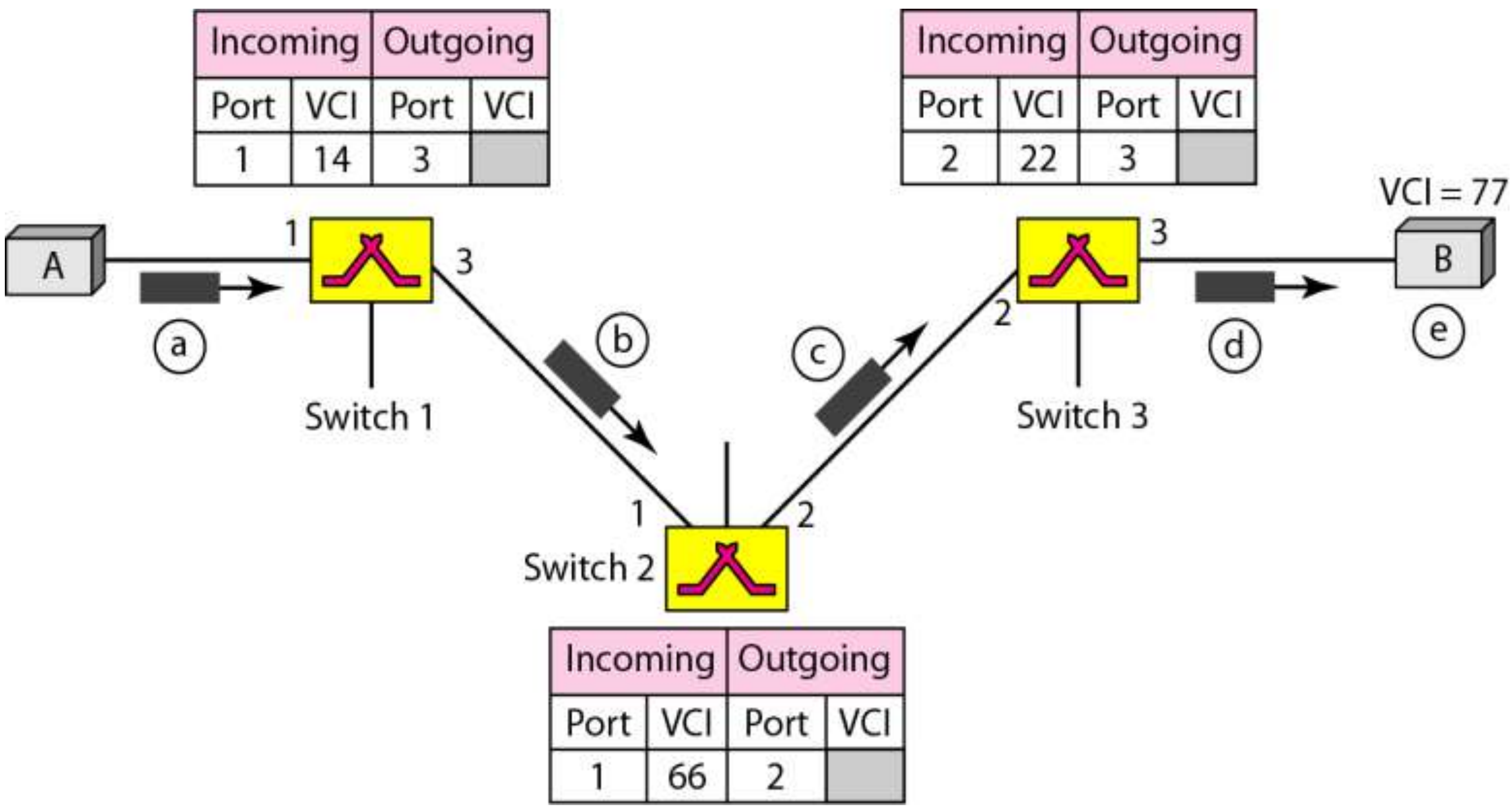
Setup Request

- Source A sends a setup frame to switch 1.
- Switch 1 receives the setup request frame. It knows that a frame going from A to B goes out through port 3. 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.

Continue..

- Switch 2 receives the setup request frame. three columns of the table are completed: in this case, incoming port (1), incoming VCI (66), and outgoing port (2).
- Switch 3 receives the setup request frame. Again, three columns are completed: incoming port (2), incoming VCI (22), and outgoing port (3).
- 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.

Figure 8.14 *Setup request in a virtual-circuit network*



Acknowledgment

- A special frame, called the acknowledgment frame, completes the entries in the switching tables.
- The destination sends an acknowledgment to switch 3. The acknowledgment carries the global source and destination addresses so the switch knows which entry in the table is to be completed. The frame also carries VCI 77, which is the incoming VCI for destination B, but the outgoing VCI for switch 3.
- Switch 3 sends an acknowledgment to switch 2 that contains its incoming VCI in the table, chosen in the previous step. Switch 2 uses this as the outgoing VCI in the table.

Continue..

- Switch 2 sends an acknowledgment to switch 1 that contains its incoming VCI in the table, chosen in the previous step. Switch 1 uses this as the outgoing VCI in the table.
- Finally switch 1 sends an acknowledgment to source A that contains its incoming VCI in the table, chosen in the previous step.
- The source uses this as the outgoing VCI for the data frames to be sent to destination B.

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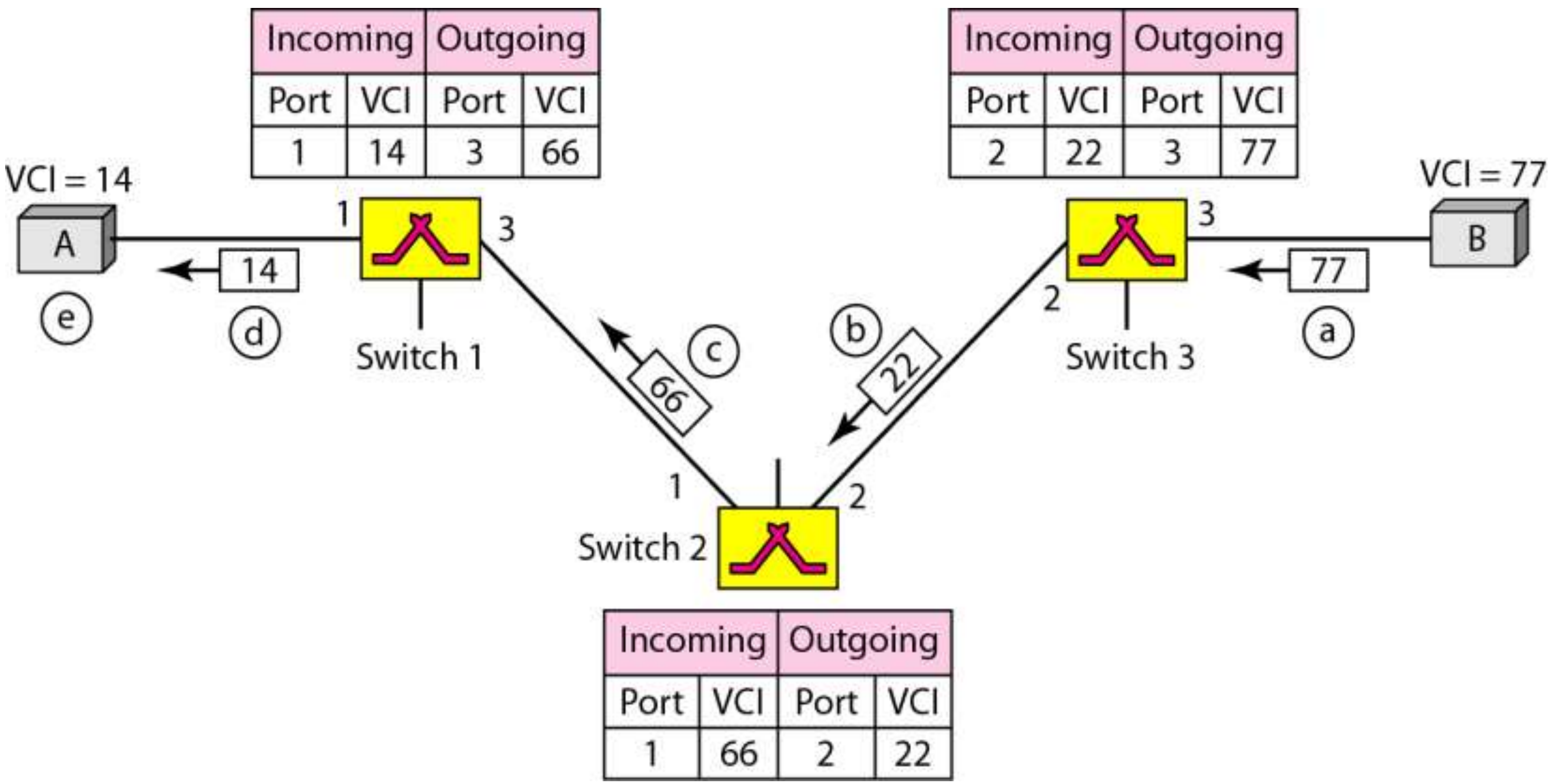
Figure 8.15 *Setup acknowledgment in a virtual-circuit network*



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.

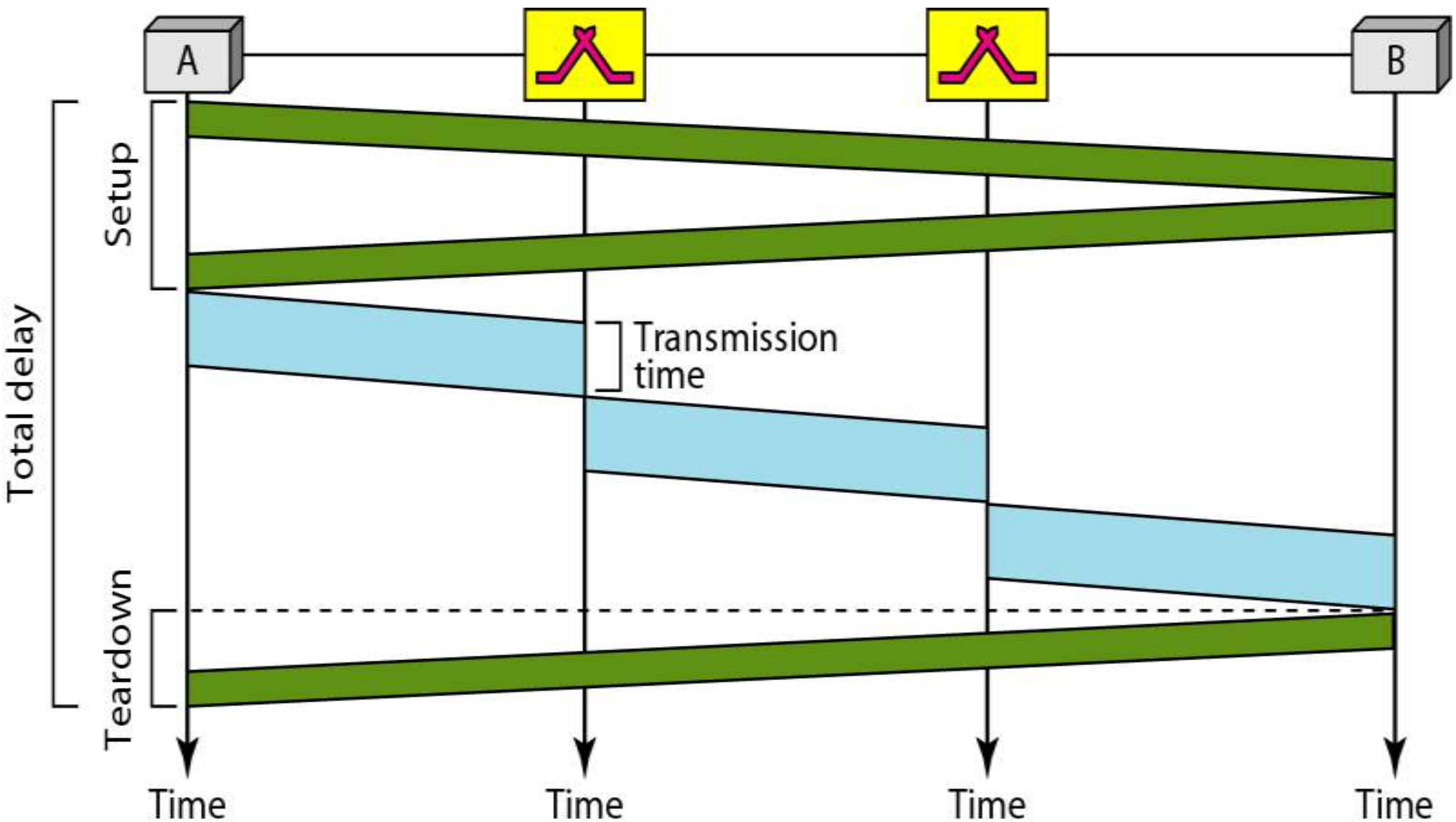
Efficiency

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.
There is one big advantage in a virtual-circuit network even if resource allocation is on demand. The source can check the availability of the resources, without actually reserving it.

Delay in Virtual-Circuit Networks

In a virtual-circuit network, 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.

Figure 8.16 *Delay in a virtual-circuit network*



References

- Data Communications and Networking, Behrouz A. Forouzan, Fifth Edition, TMH, 2013.