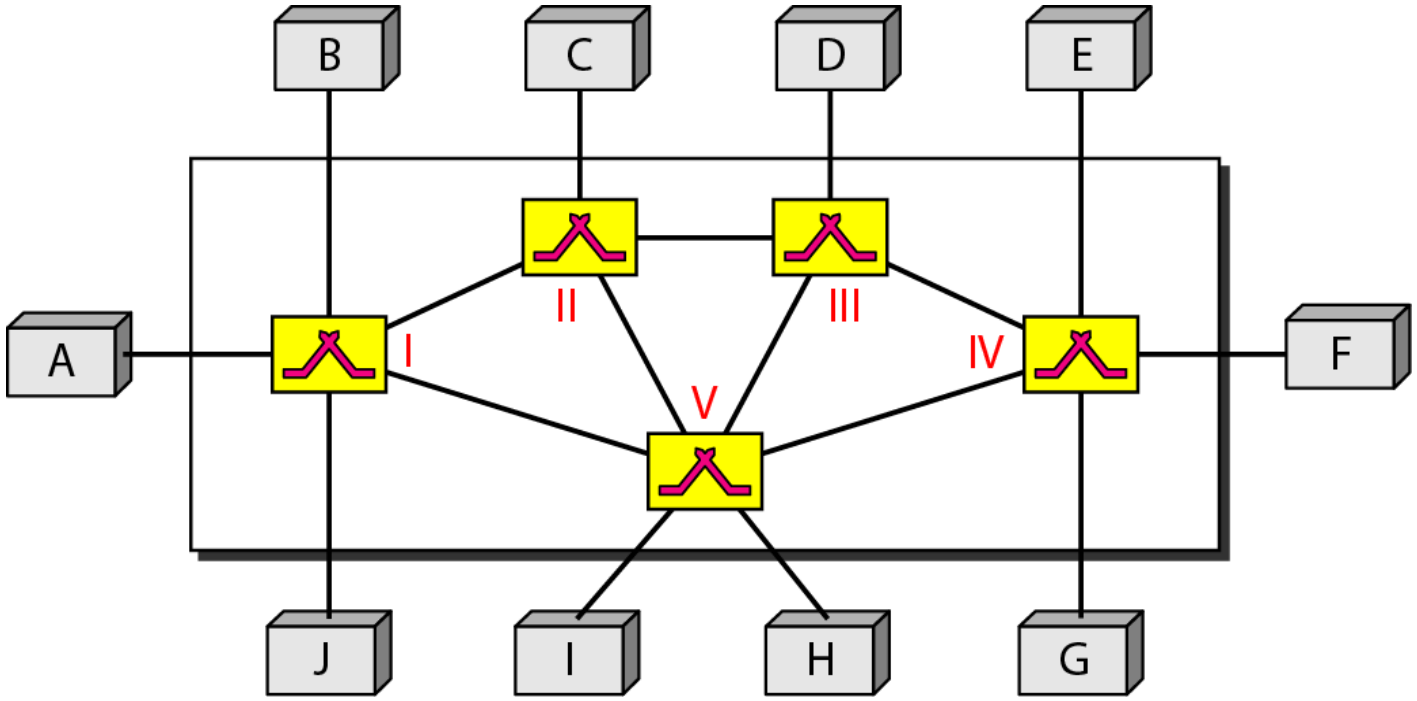
Lecture 6

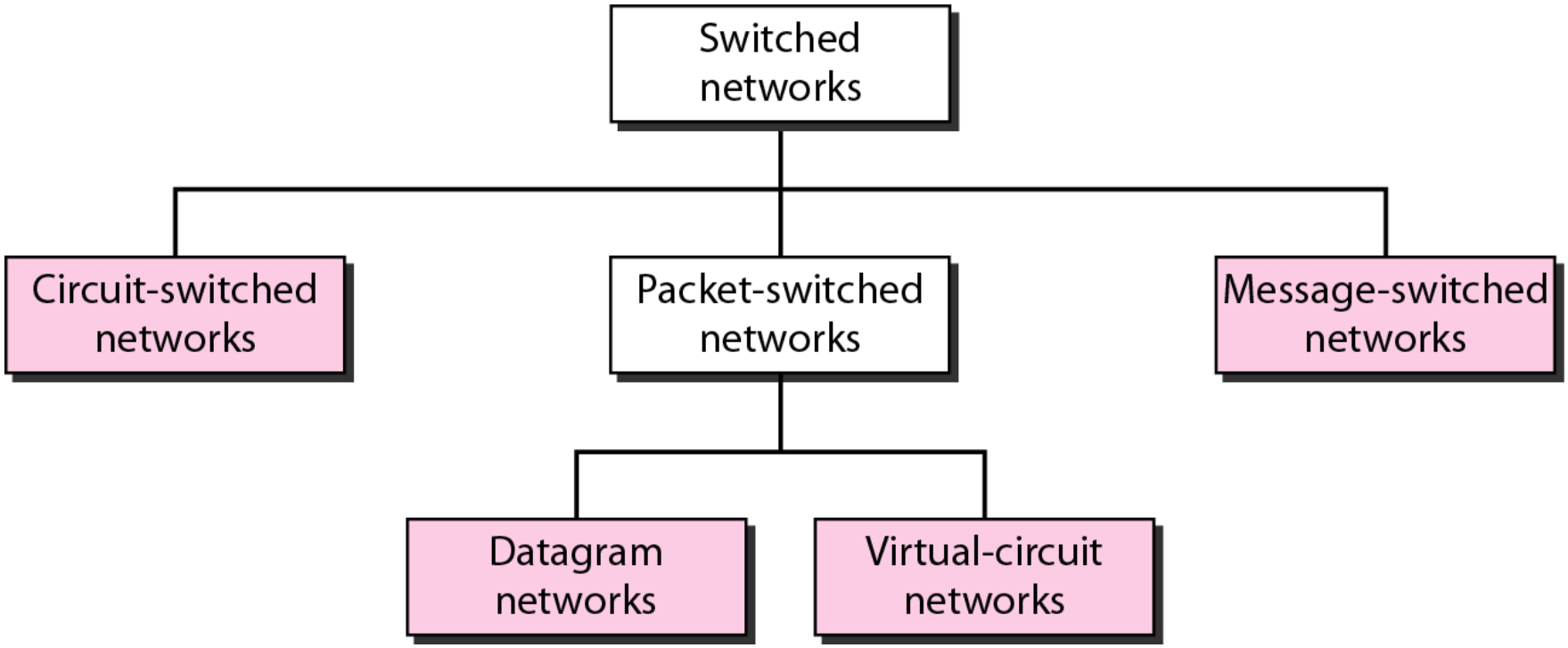
Switching and practical examples of telephone and cable networks

Figure 8.1 *Switched network*



- A mesh or star topology for a large network ?
- A bus topology for a large network ?

Figure 8.2 *Taxonomy of switched networks*



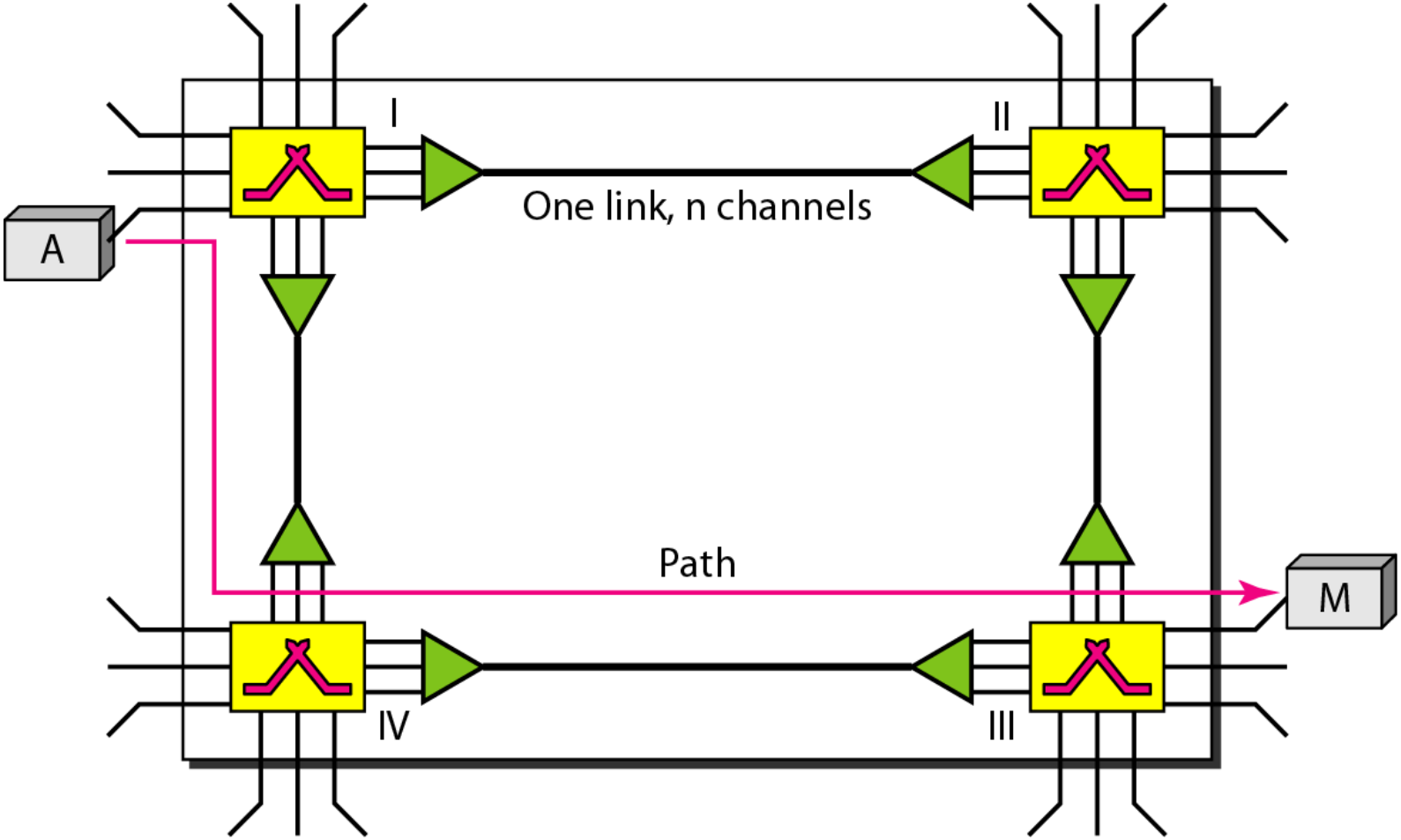
8-1 CIRCUIT-SWITCHED NETWORKS

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.

Three Phases
Efficiency
Delay
Circuit-Switched Technology in Telephone 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.

Figure 8.3 *A trivial circuit-switched network*

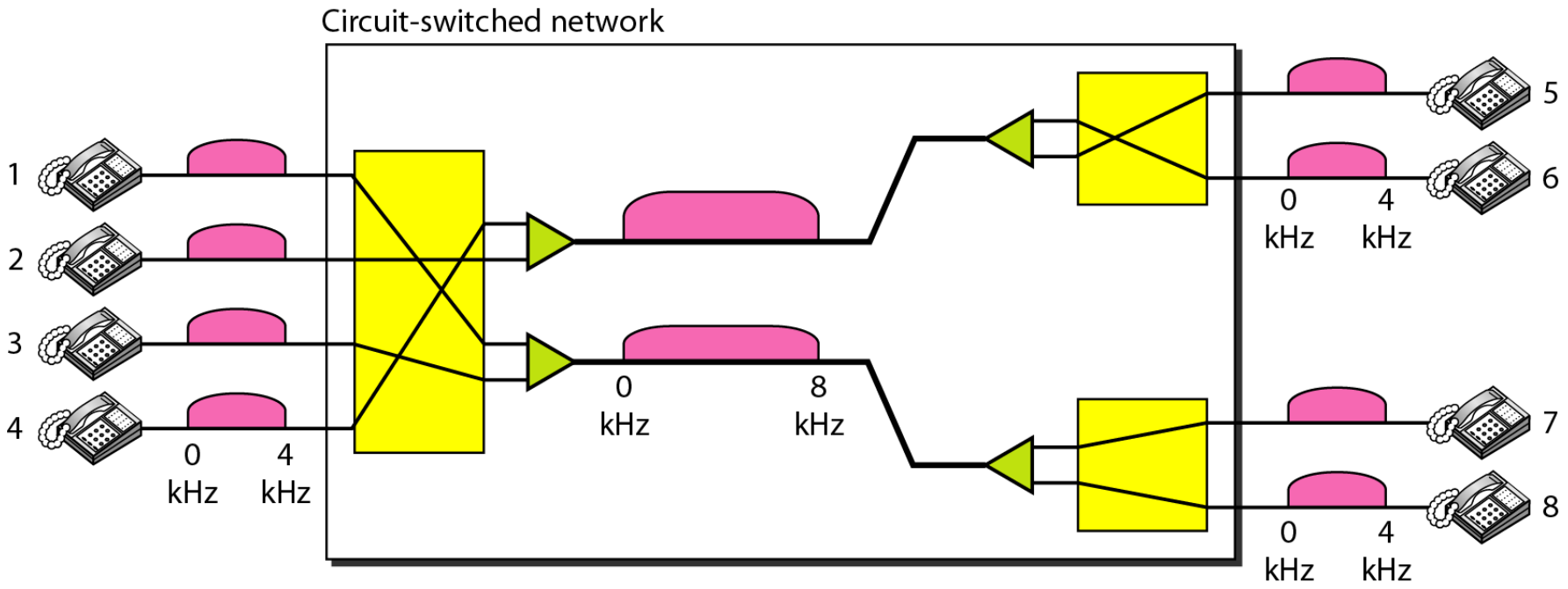


In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer until the teardown phase.

Example 8.1

As a trivial example, let us use a circuit-switched network to connect eight 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. Figure 8.4 shows the situation. Telephone 1 is connected to telephone 7; 2 to 5; 3 to 8; and 4 to 6. Of course the situation may change when new connections are made. The switch controls the connections.

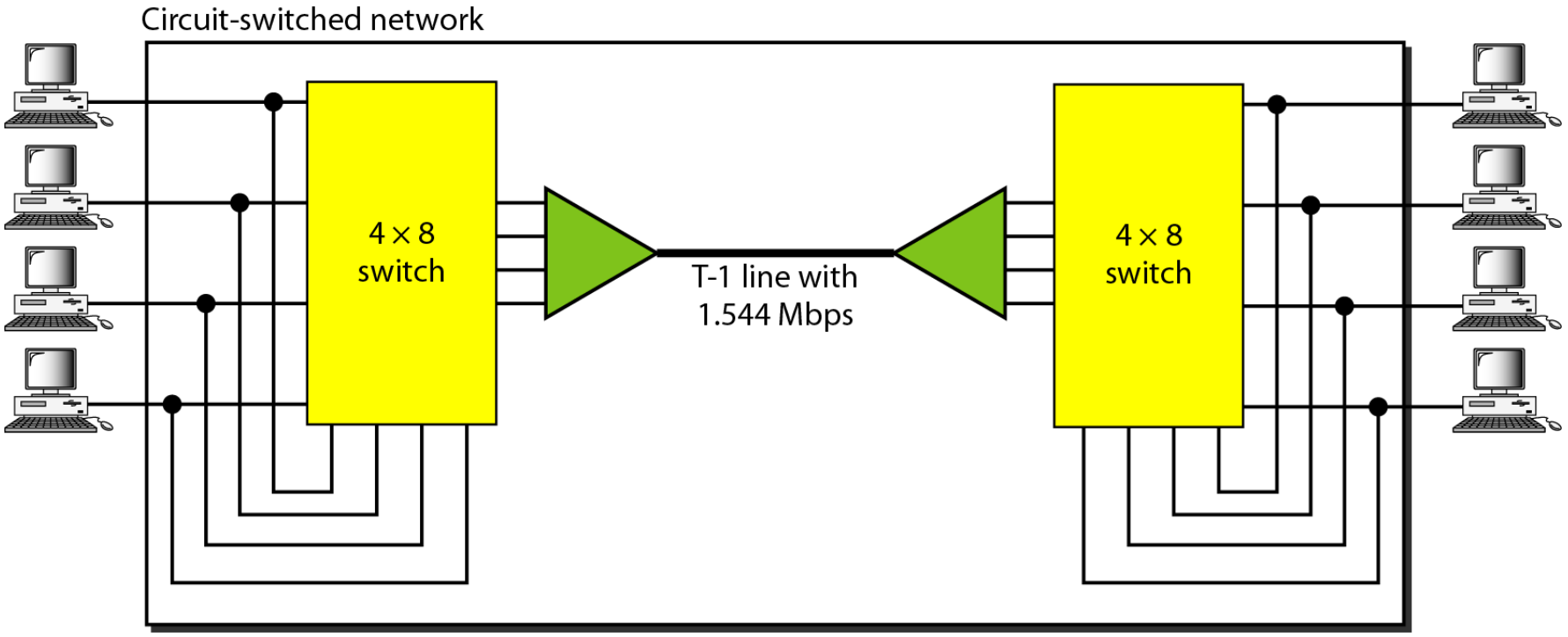
Figure 8.4 *Circuit-switched network used in Example 8.1*



Example 8.2

As another example, consider a circuit-switched network that connects computers in two 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 × 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. Figure 8.5 shows the situation.

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

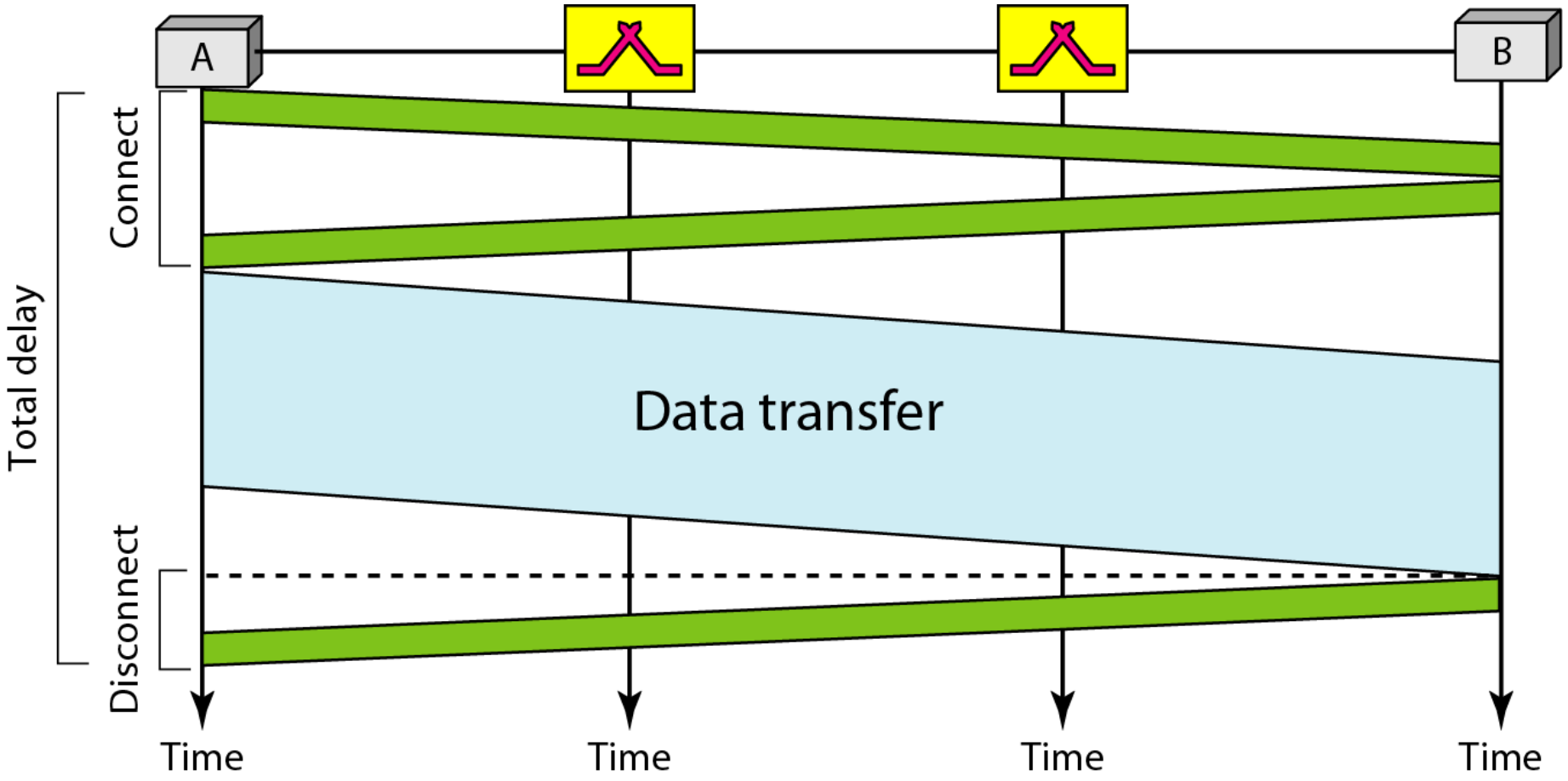


Circuit Switching (Phases and Efficiency)

- Setup Phase
- Data Transfer Phase
- Teardown Phase

- Efficiency of circuit switching is low, as resources allocation is fixed and no sharing is allowed

Figure 8.6 *Delay in a circuit-switched network*



Switching at the physical layer in the traditional telephone network uses the circuit-switching approach.

Example of old days telephone connections

8-2 DATAGRAM NETWORKS

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.

Routing Table
Efficiency
Delay
Datagram Networks in the Internet

In a packet-switched network, there is no resource reservation; resources are allocated on demand.

- Packets are proceesed on first-come, first-served bases.

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

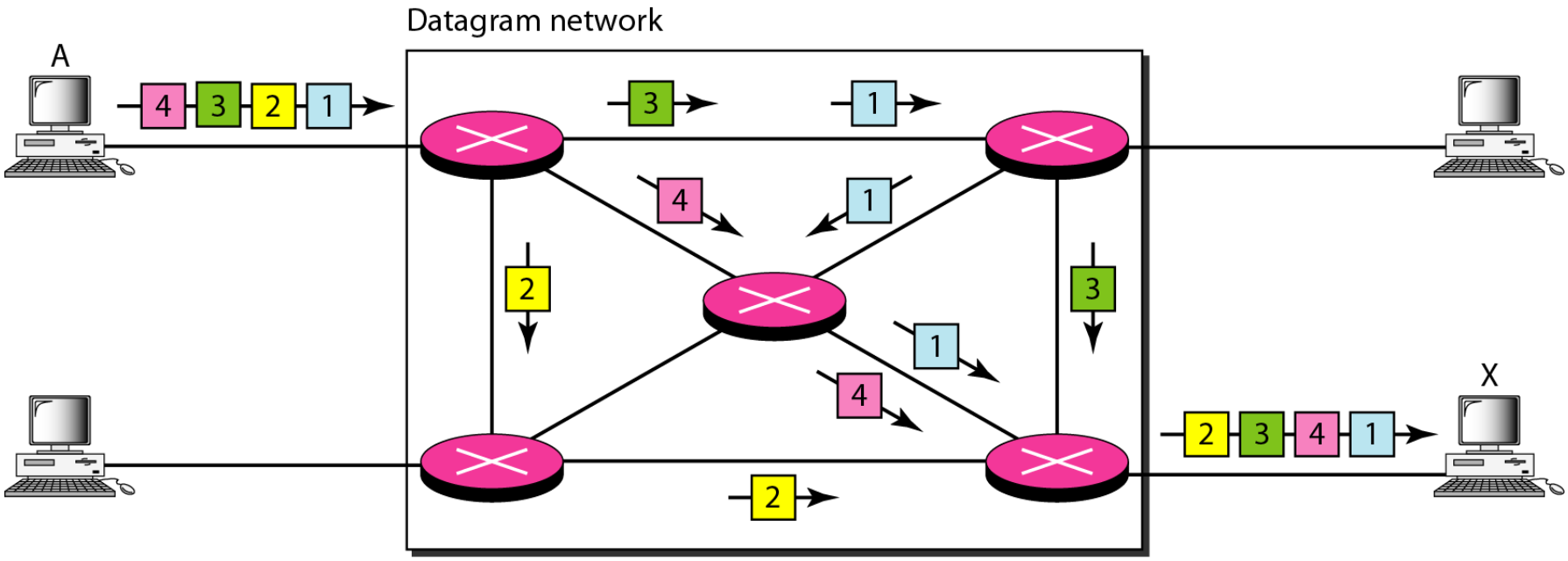
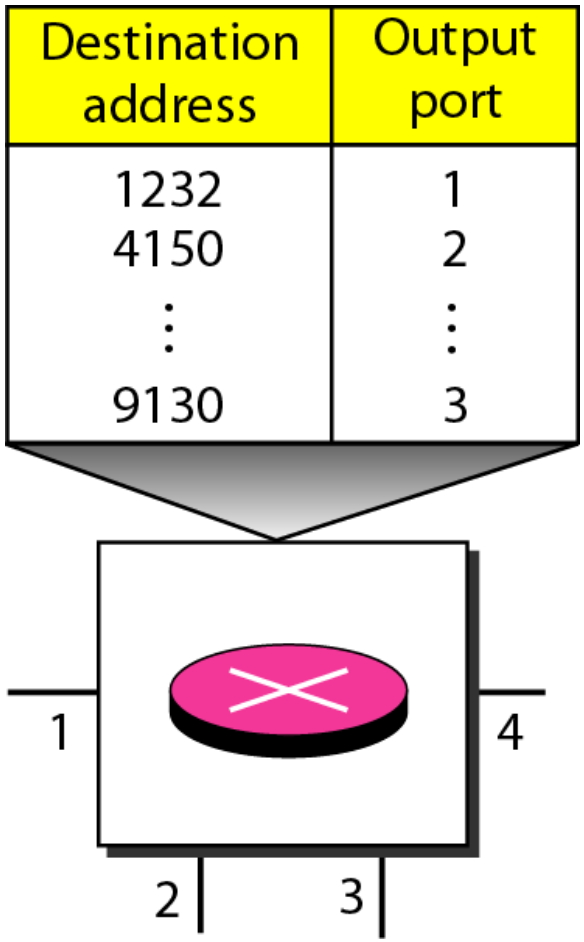


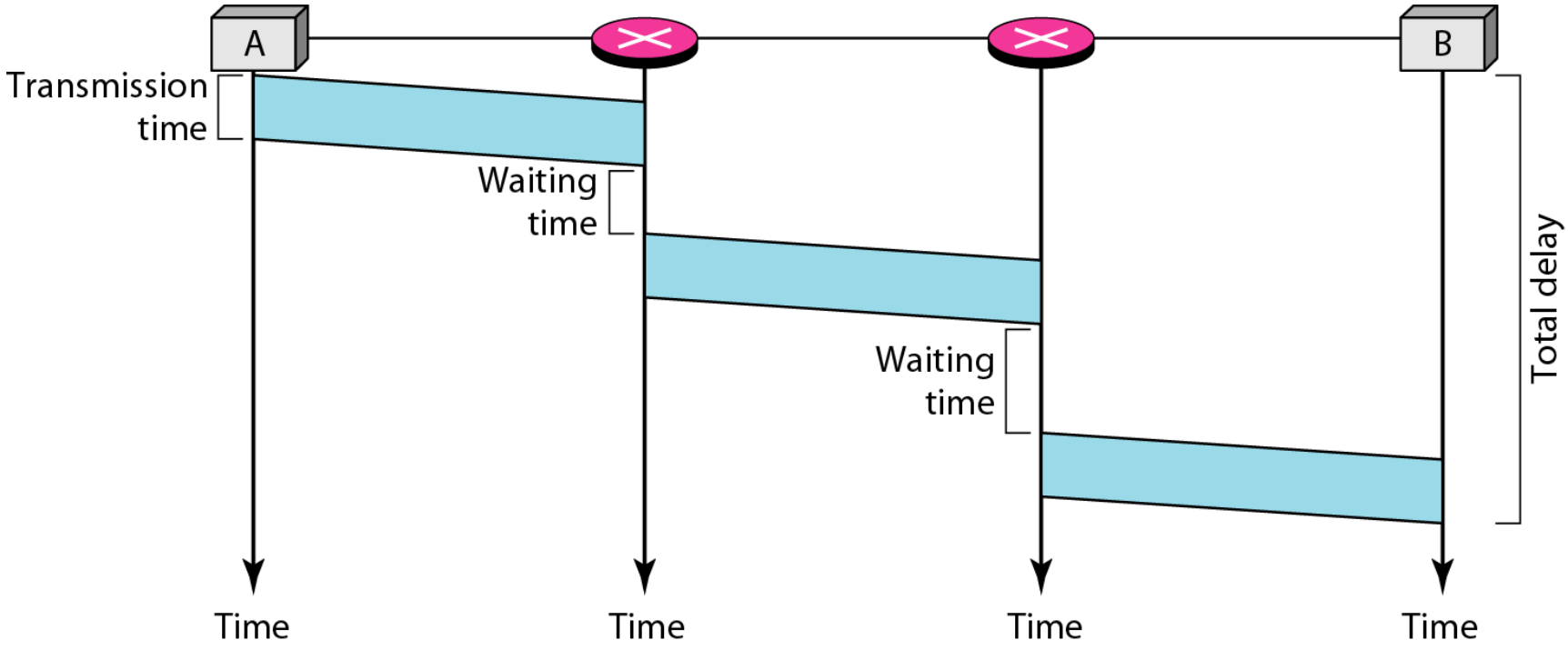
Figure 8.8 *Routing table in a datagram network*



A switch in a datagram network uses a routing table that is based on the destination address.

The destination address (Logical Address) in the header of a packet in a datagram network remains the same during the entire journey of the packet.

Figure 8.9 *Delay in a datagram network*



Switching in the Internet is done by using the datagram approach at the network layer.

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.

Addressing
Three Phases
Efficiency
Delay
Circuit-Switched Technology in WANs

Figure 8.10 *Virtual-circuit network*

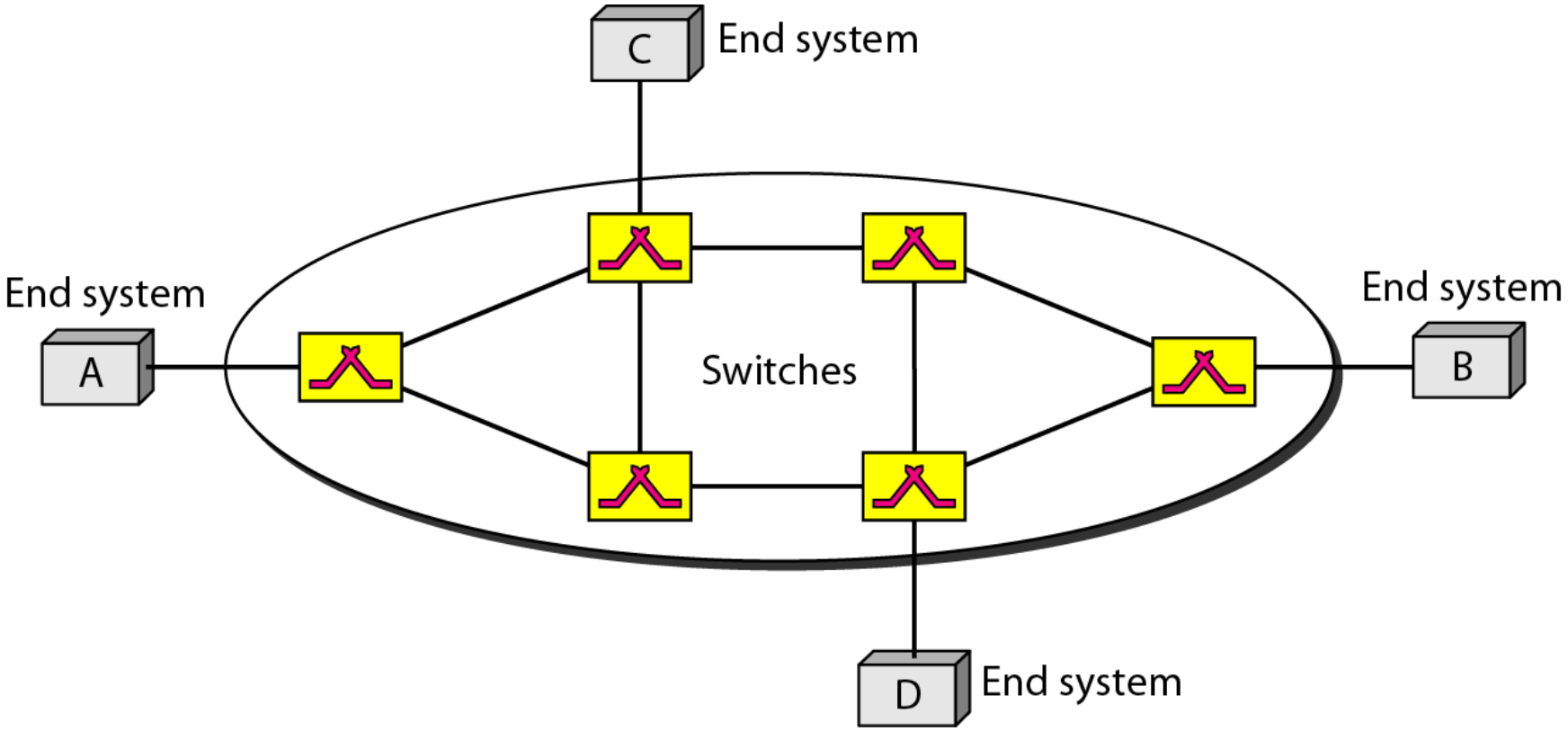


Figure 8.11 *Virtual-circuit identifier*

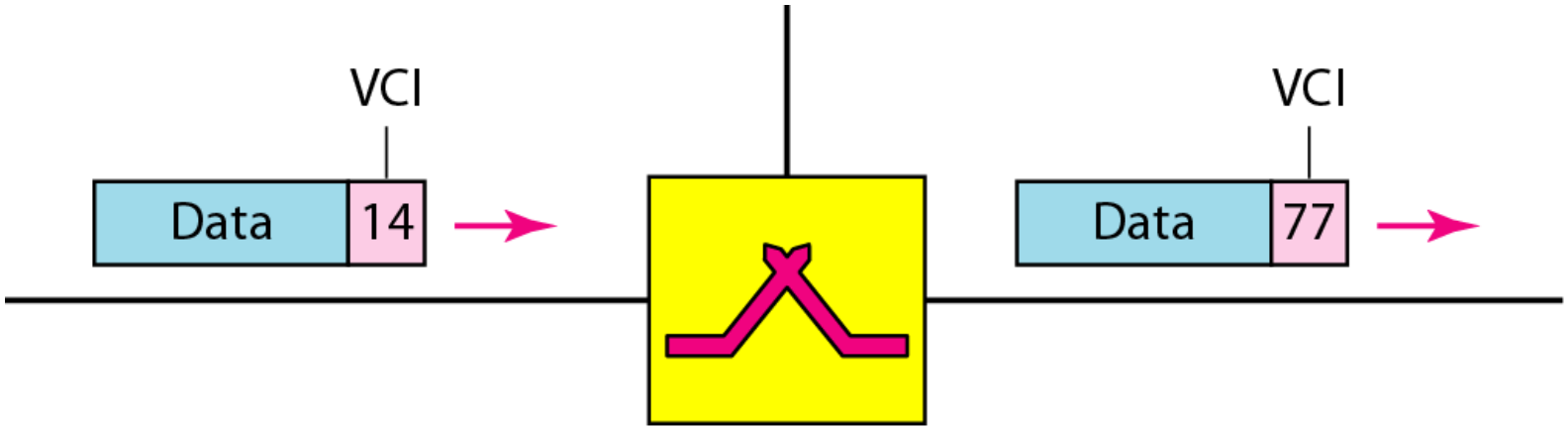


Figure 8.12 *Switch and tables in a virtual-circuit network*

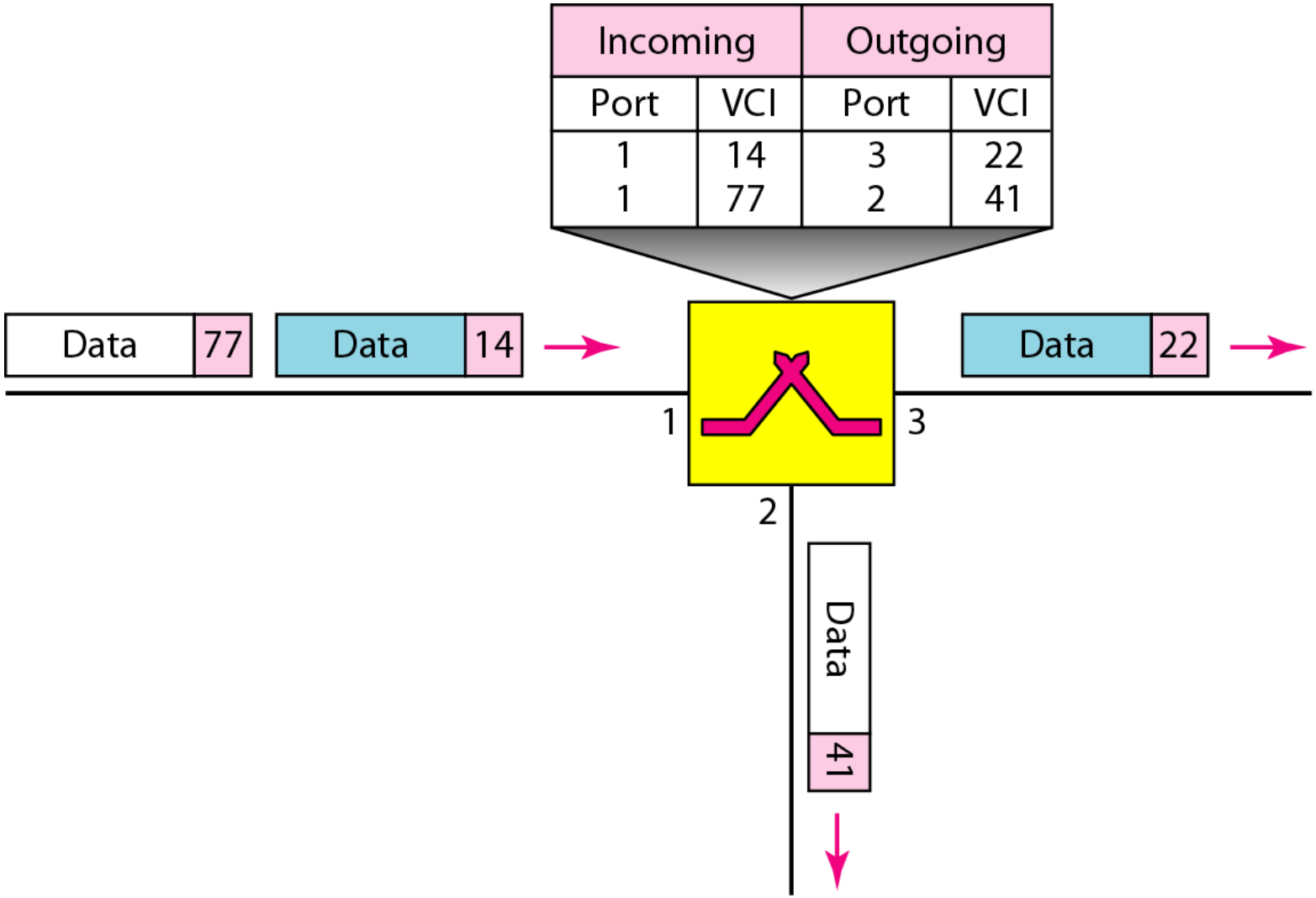


Figure 8.13 *Source-to-destination data transfer in a virtual-circuit network*

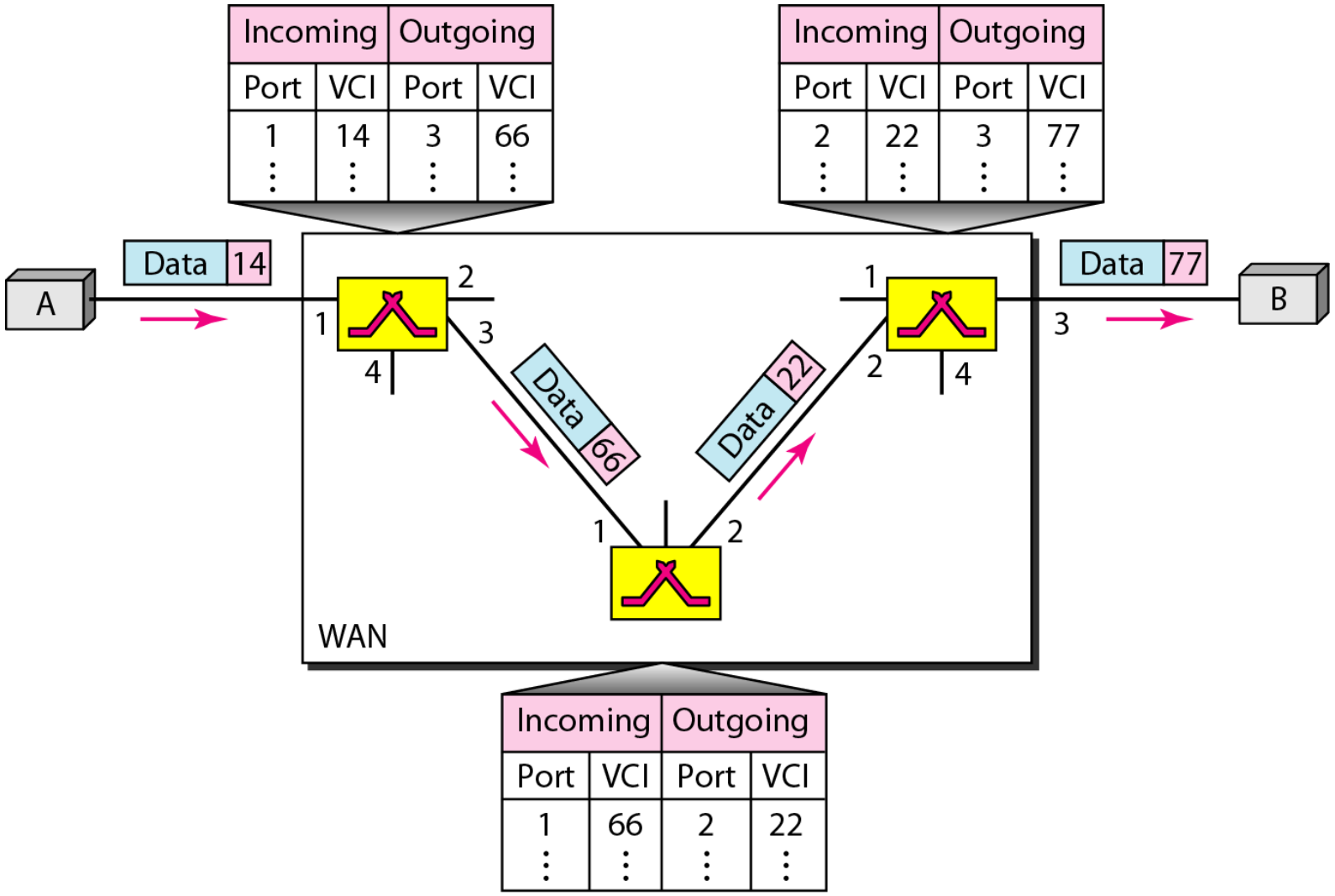


Figure 8.14 *Setup request in a virtual-circuit network*

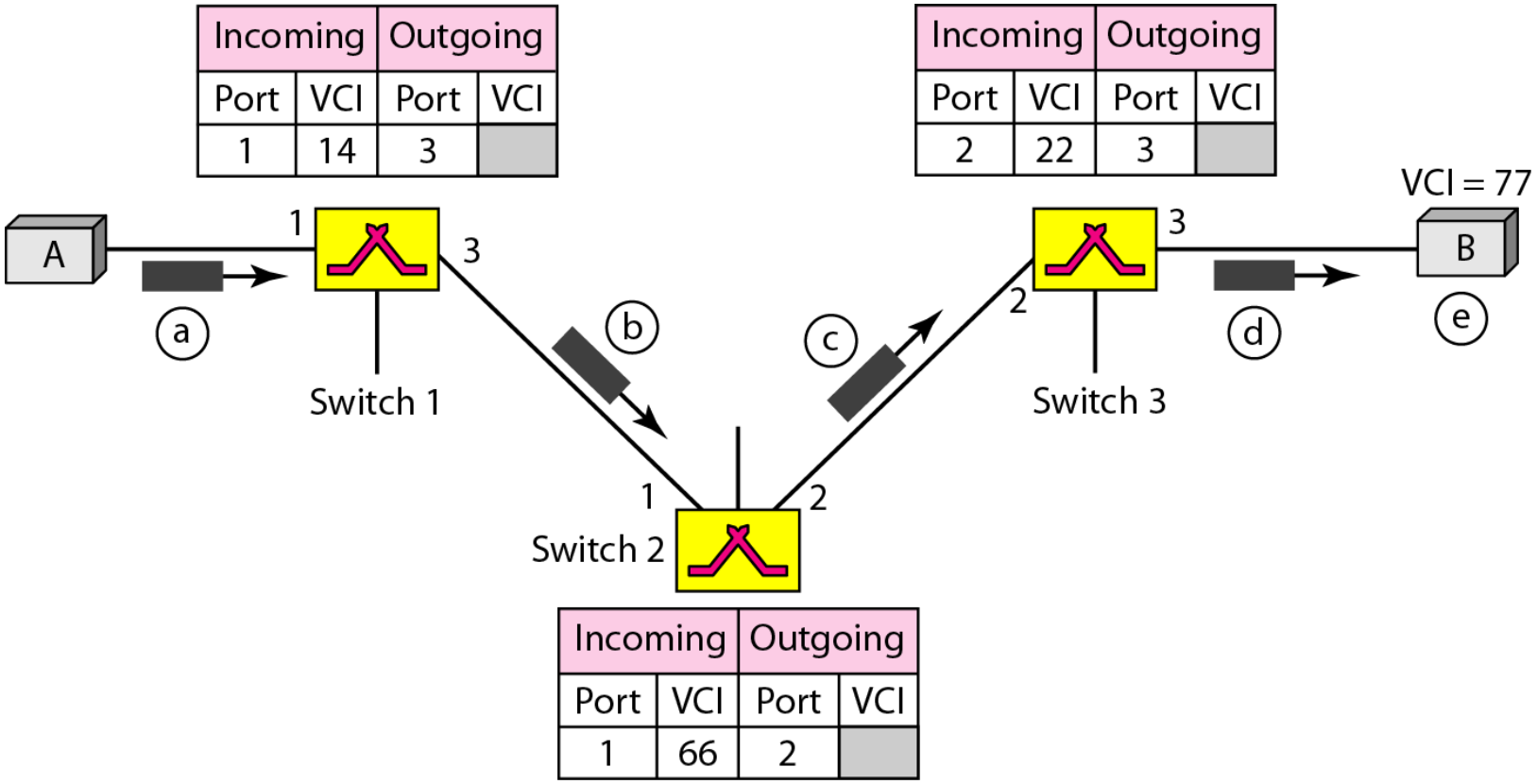
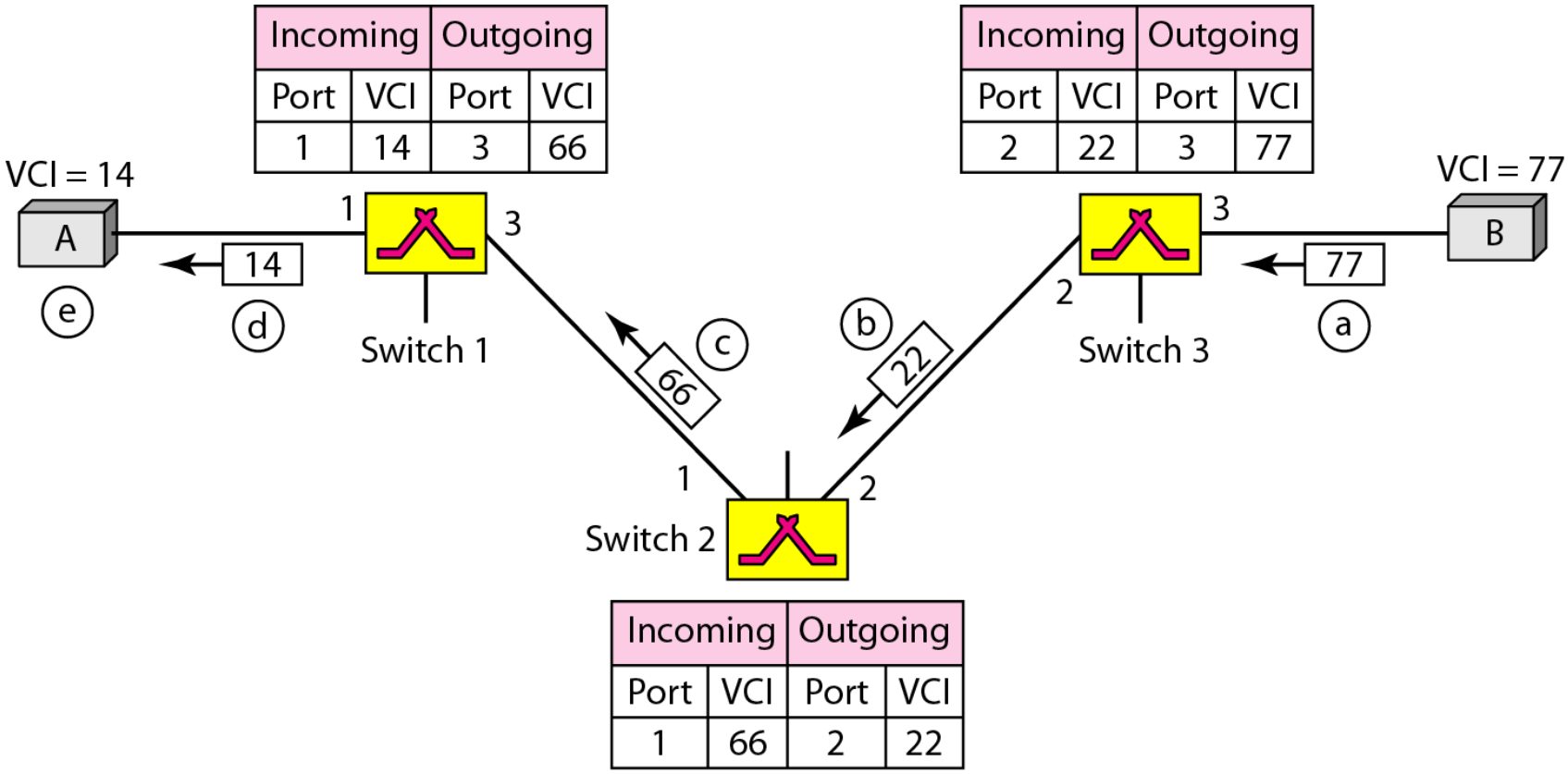
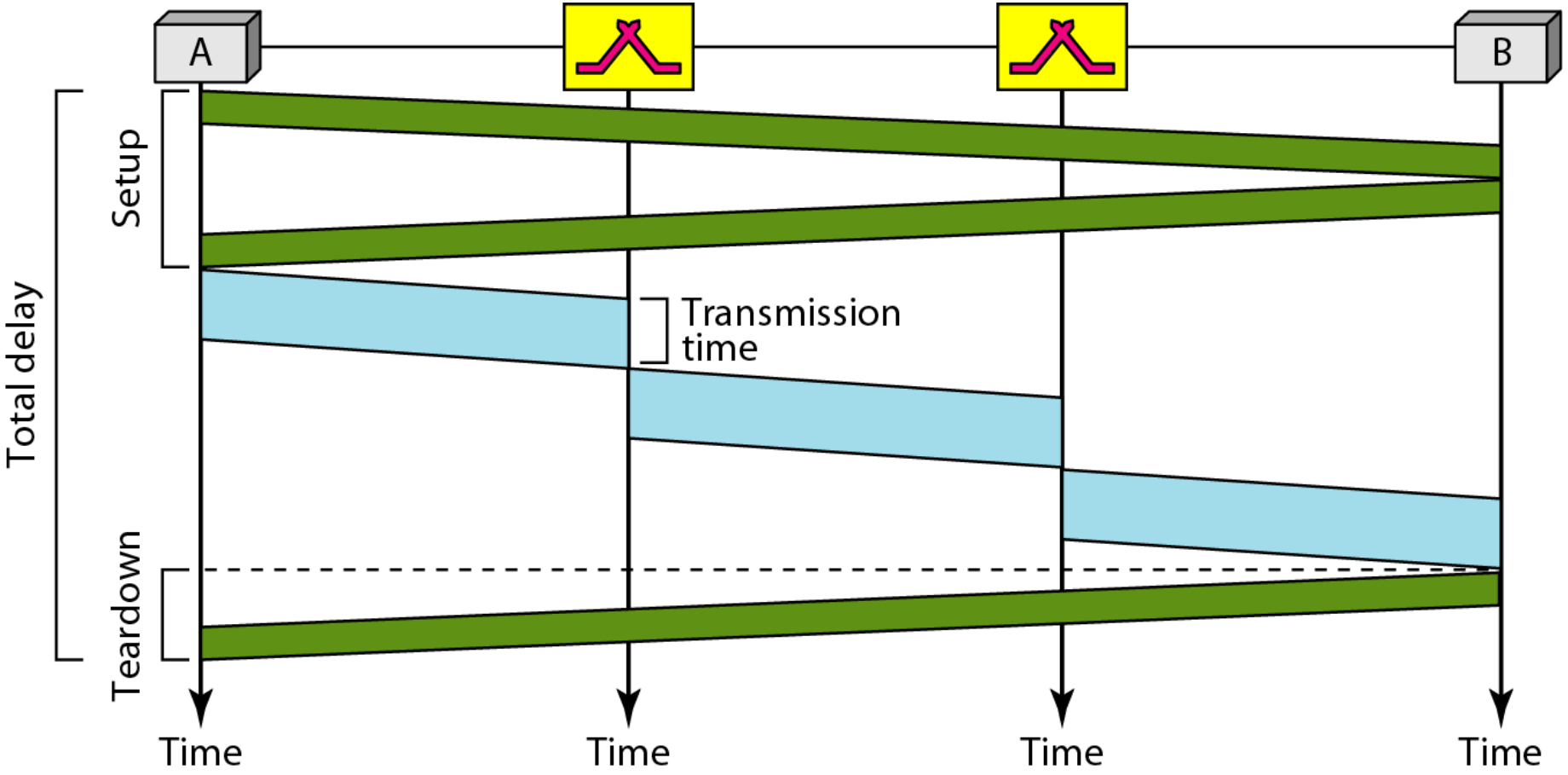


Figure 8.15 *Setup acknowledgment in a virtual-circuit network*



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.

Figure 8.16 *Delay in a virtual-circuit network*



Switching at the data link layer in a switched WAN is normally implemented by using virtual-circuit techniques.

- Eg. of switched WANs – Frame Relay and ATM networks

Telephone and Cable Networks for Data Transmission

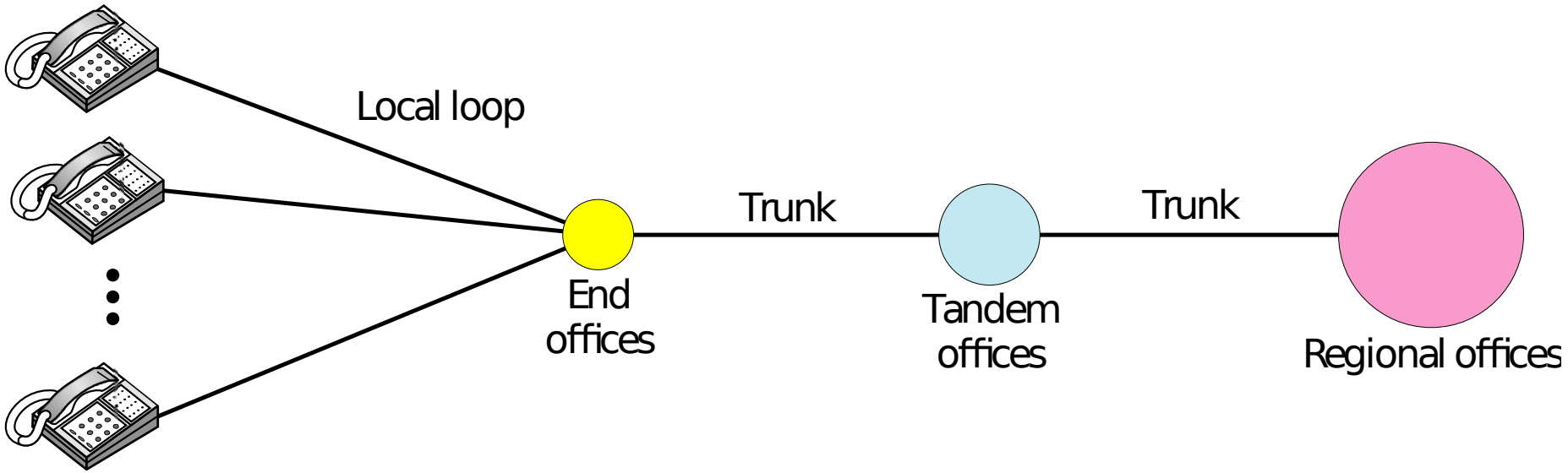
9-1 TELEPHONE NETWORK

Telephone networks use circuit switching. The telephone network had its beginnings in the late 1800s. The entire network, which is referred to as the plain old telephone system (POTS), was originally an analog system using analog signals to transmit voice.

Topics discussed in this section:

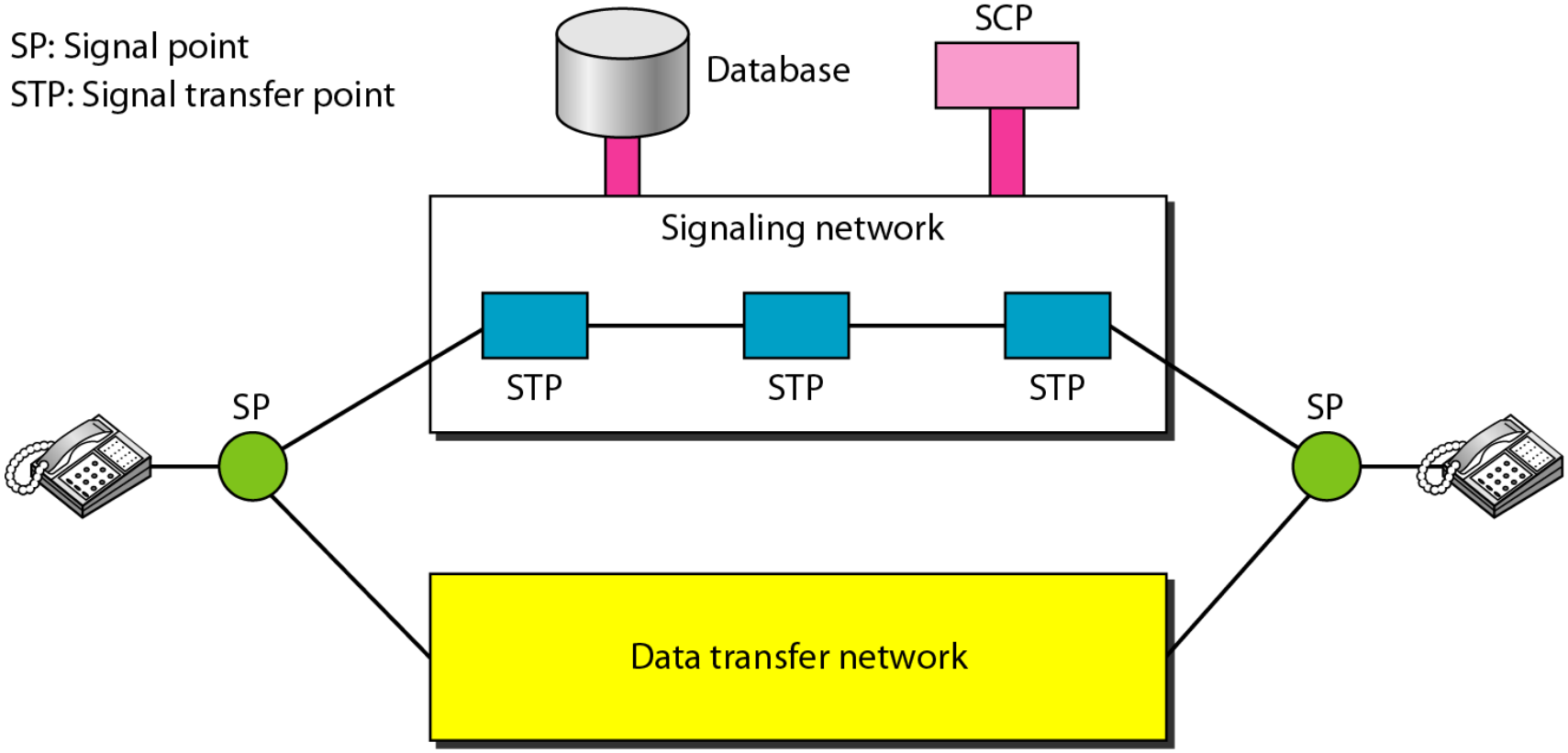
Major Components
LATAs
Signaling
Services Provided by Telephone Networks

Figure 9.1 *A telephone system*



The tasks of data transfer and signaling are separated in modern telephone networks: data transfer is done by one network, signaling by another.

Figure 9.4 *Data transfer and signaling networks*

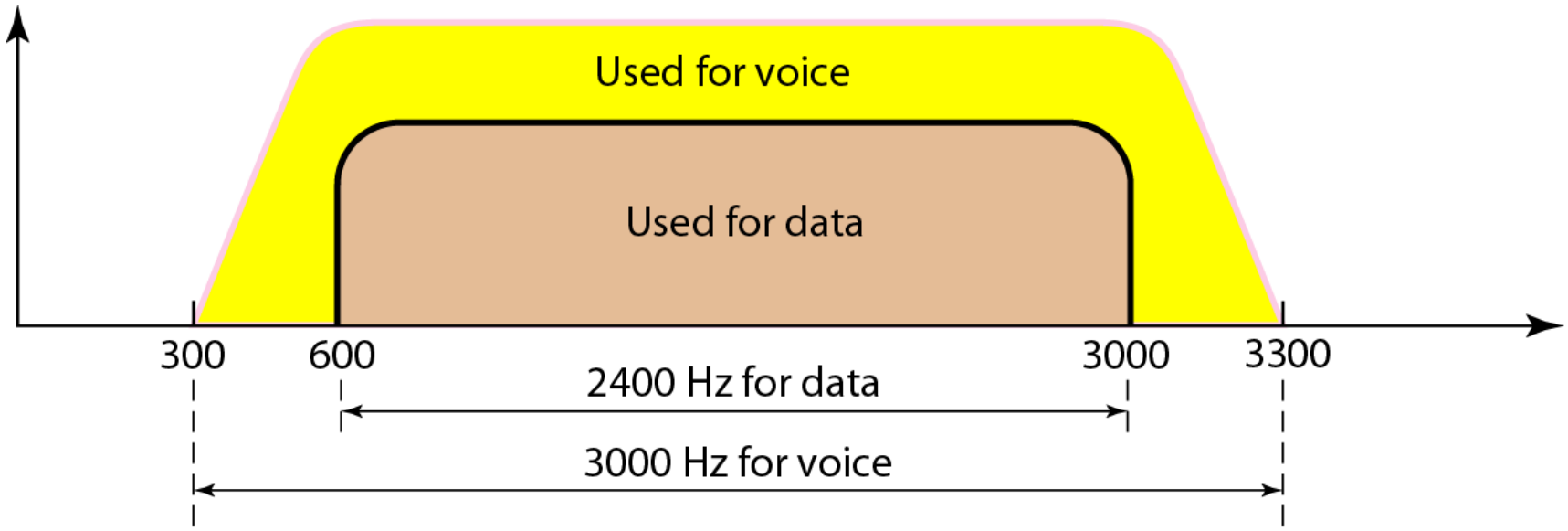


9-2 DIAL-UP MODEMS

Traditional telephone lines can carry frequencies between 300 and 3300 Hz, giving them a bandwidth of 3000 Hz. All this range is used for transmitting voice, where a great deal of interference and distortion can be accepted without loss of intelligibility.

Modem Standards

Figure 9.6 *Telephone line bandwidth*



9-3 DIGITAL SUBSCRIBER LINE

After traditional modems reached their peak data rate, telephone companies developed another technology, DSL, to provide higher-speed access to the Internet. Digital subscriber line (DSL) technology is one of the most promising for supporting high-speed digital communication over the existing local loops.

ADSL
ADSL Lite
HDSL
SDSL
VDSL

ADSL is an asymmetric communication technology designed for residential users; it is not suitable for businesses.

- Asummetric communication because it provide high speed down-stream capabilities and low speed up-stream capabilities

Figure 9.11 *Bandwidth division in ADSL*

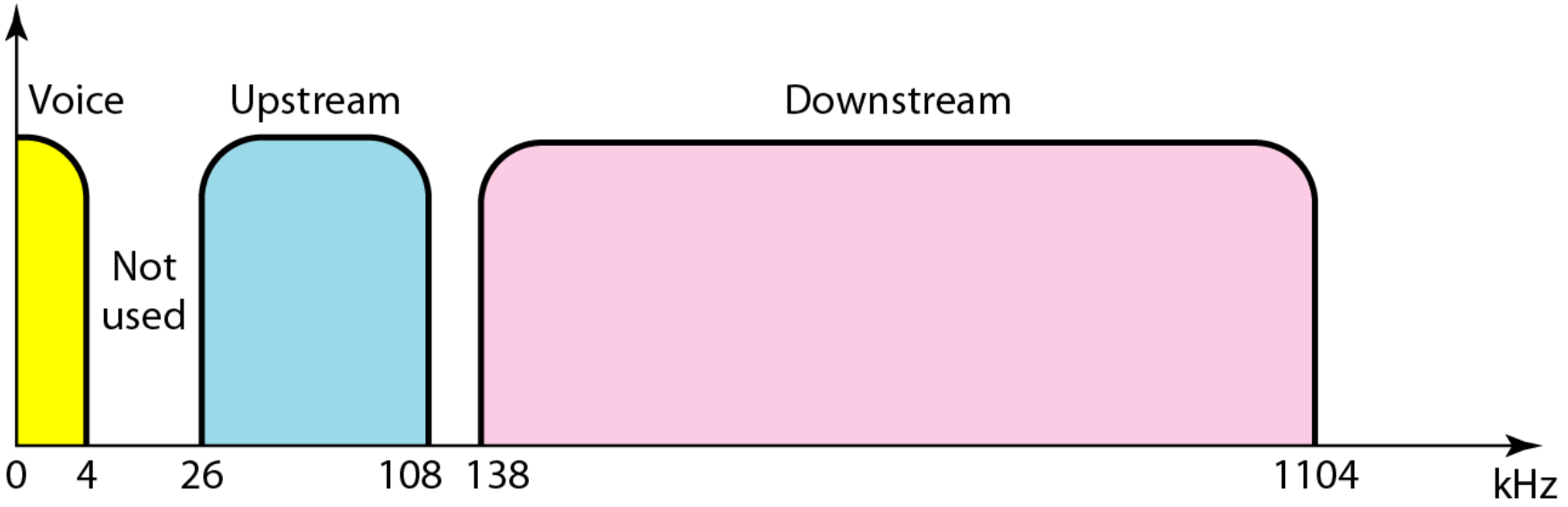


Figure 9.12 *ADSL modem*

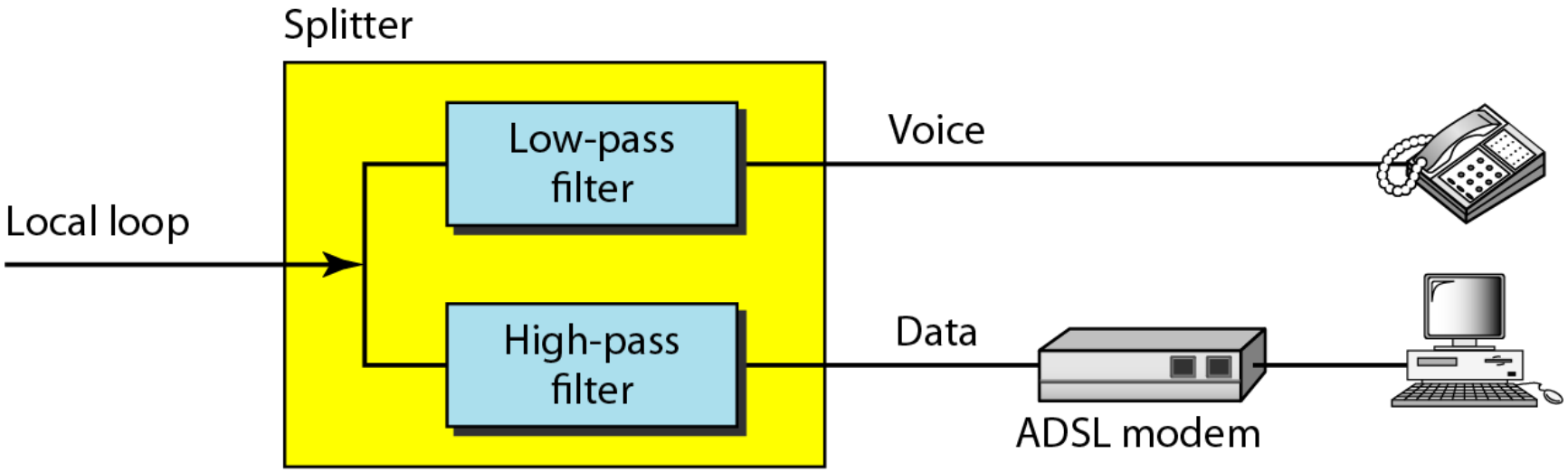
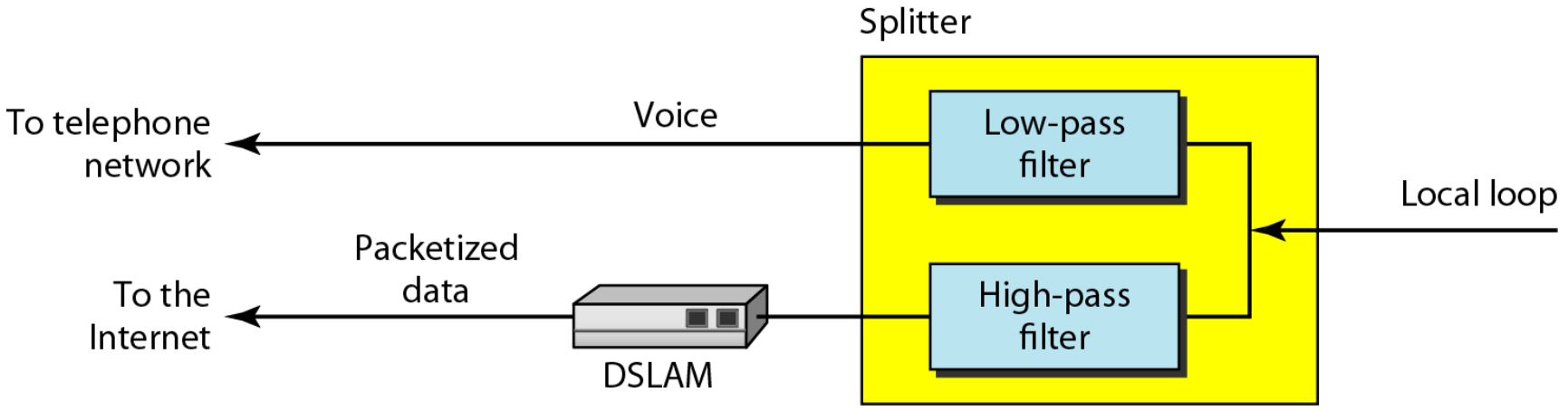


Figure 9.13 *DSLAM (Digital subscriber line access multiplexex)*



- HDSL (High-bit-rate digital subscriber line)
- SDSL (Symmetric digital subscriber line)
- VDSL (Very high-bit-rate digital subscriber line)

Table 9.2 ***Summary of DSL technologies***

Technology	*Downstream Rate*	*Upstream Rate*	*Distance (ft)*	*Twisted Pairs*	*Line Code*
ADSL	1.5–6.1 Mbps	16–640 kbps	12,000	1	DMT
ADSL Lite	1.5 Mbps	500 kbps	18,000	1	DMT
HDSL	1.5–2.0 Mbps	1.5–2.0 Mbps	12,000	2	2B1Q
SDSL	768 kbps	768 kbps	12,000	1	2B1Q
VDSL	25–55 Mbps	3.2 Mbps	3000–10,000	1	DMT

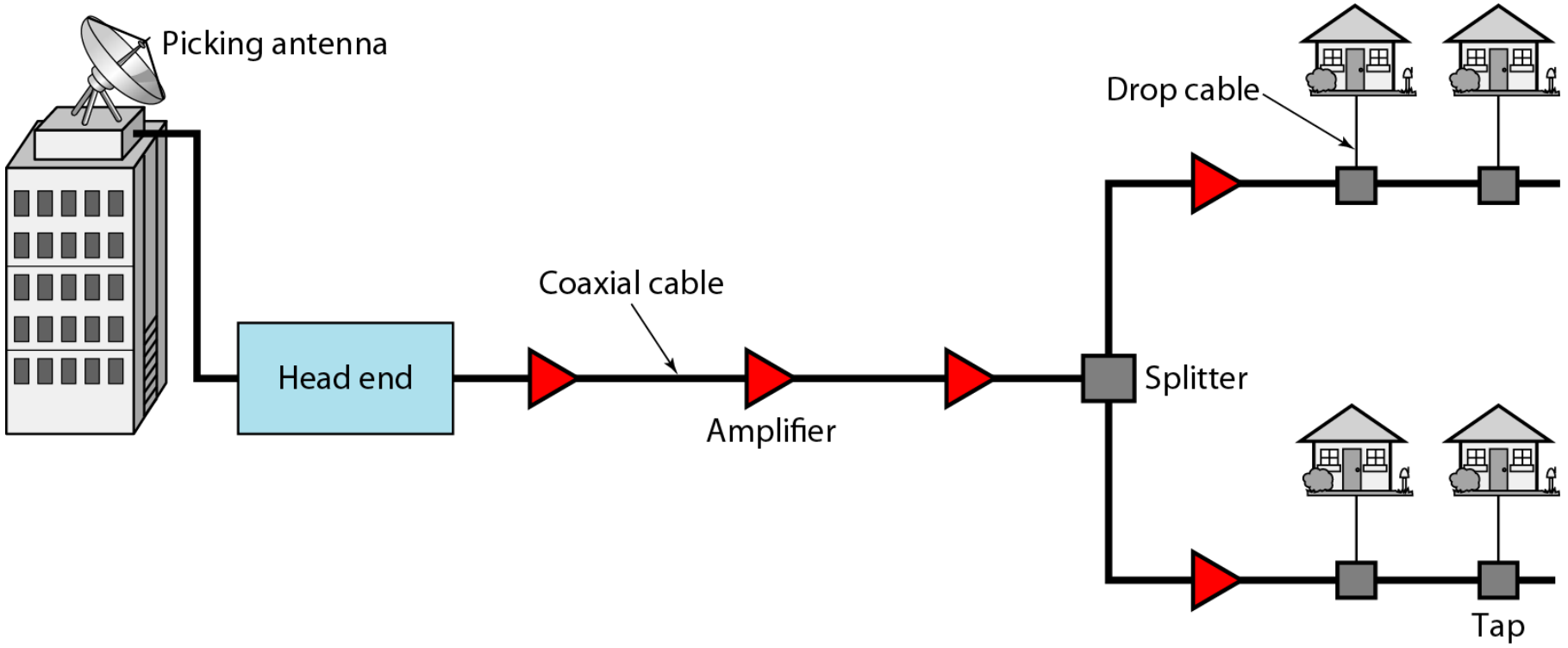
9-4 CABLE TV NETWORKS

*The **cable TV network** started as a video service provider, but it has moved to the business of Internet access. In this section, we discuss cable TV networks per se; in Section 9.5 we discuss how this network can be used to provide high-speed access to the Internet.*

Traditional Cable Networks

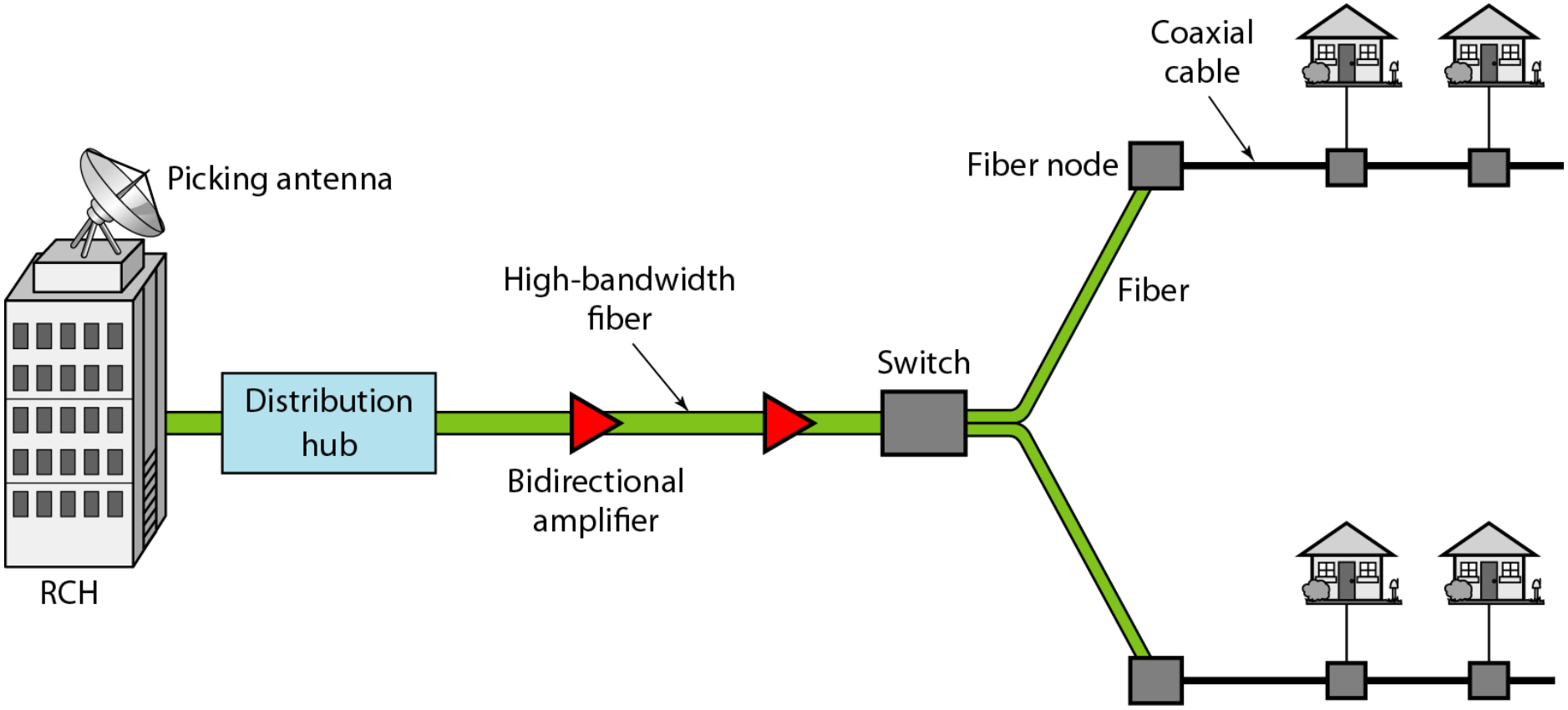
Hybrid Fiber-Coaxial (HFC) Network

Figure 9.14 *Traditional cable TV network*



Communication in the traditional cable TV network is unidirectional.

Figure 9.15 *Hybrid fiber-coaxial (HFC) network*



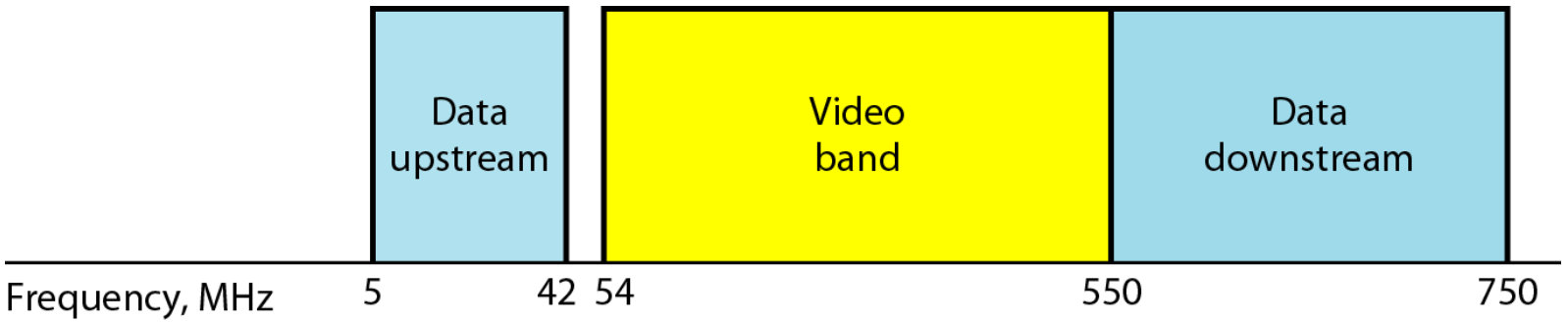
Communication in an HFC cable TV network can be bidirectional.

9-5 CABLE TV FOR DATA TRANSFER

Cable companies are now competing with telephone companies for the residential customer who wants high-speed data transfer. In this section, we briefly discuss this technology.

Bandwidth
Sharing

Figure 9.16 *Division of coaxial cable band by CATV*



- **The theoretical downstream data rate is 30 Mbps.**
- **The theoretical upstream data rate is 12 Mbps.**

Figure 9.17 *Cable modem (CM)*

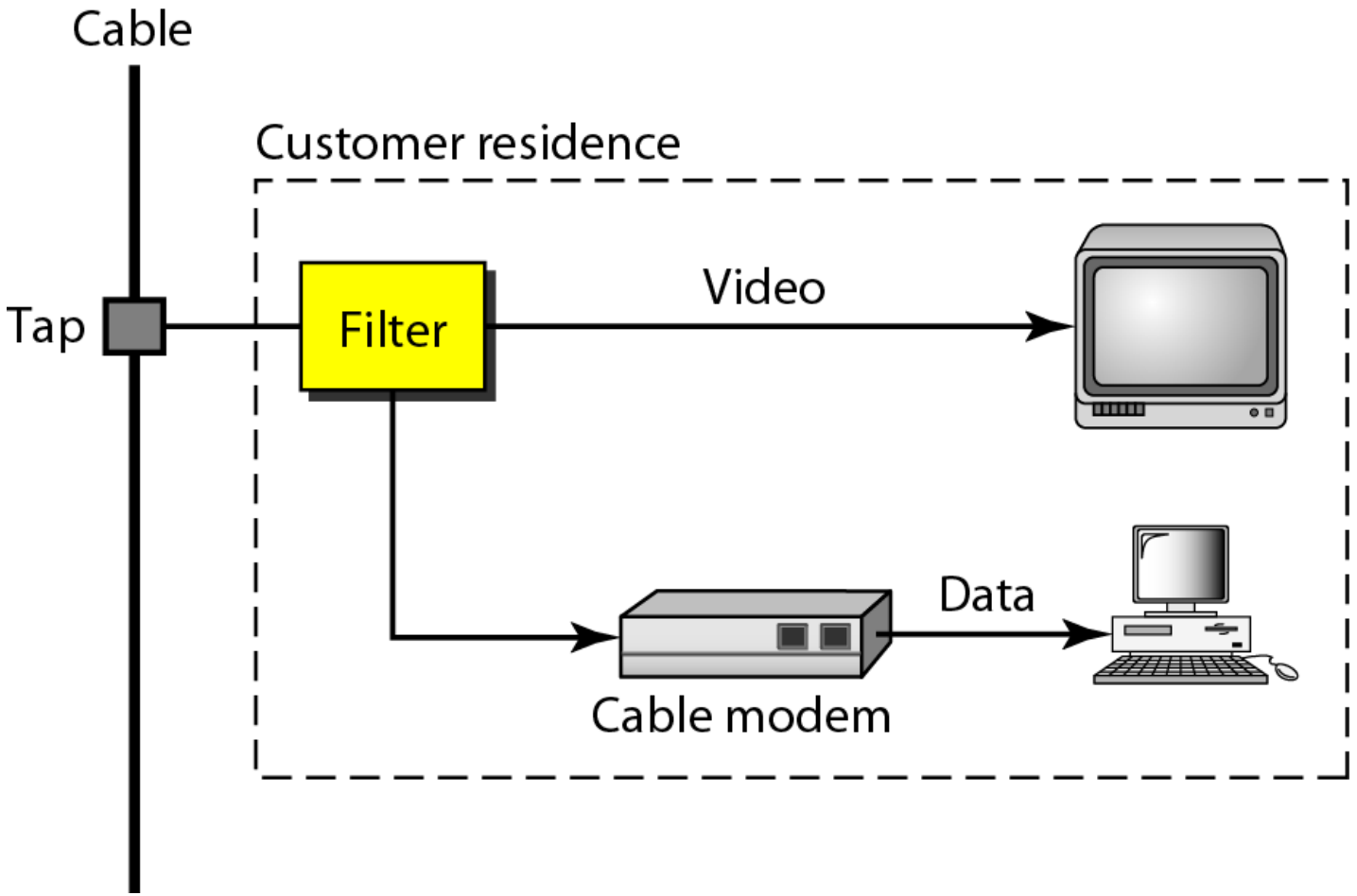


Figure 9.18 *Cable modem transmission system (CMTS)*