

Figure 8.9 *Delay in a datagram network*

*Note*

Switching in the Internet is done by   
 using the datagram approach

to packet switching at

the network layer.

8.16

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.*

*Topics discussed in this section:*

Three Phases Efficiency

Delay

Circuit-Switched Technology in WANs

8.18

8.17

Figure 8.10 *Virtual-circuit network*

8.19

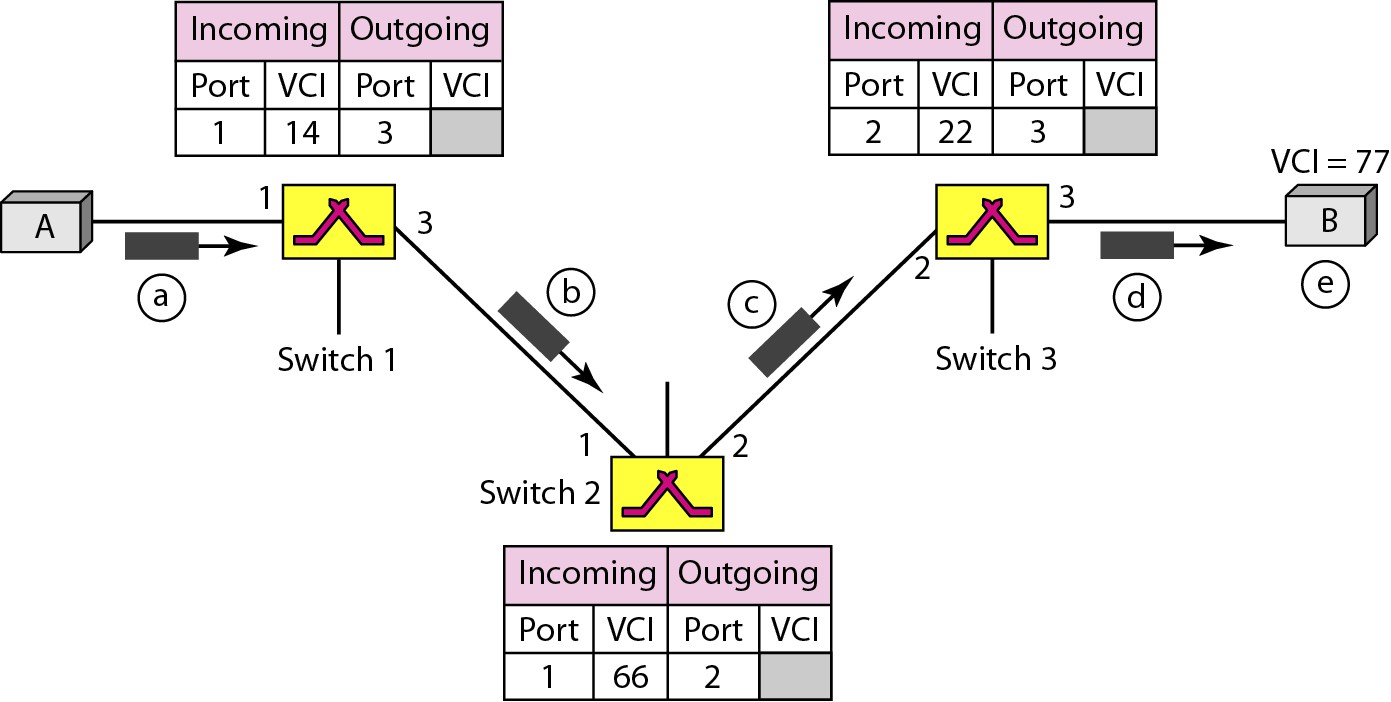
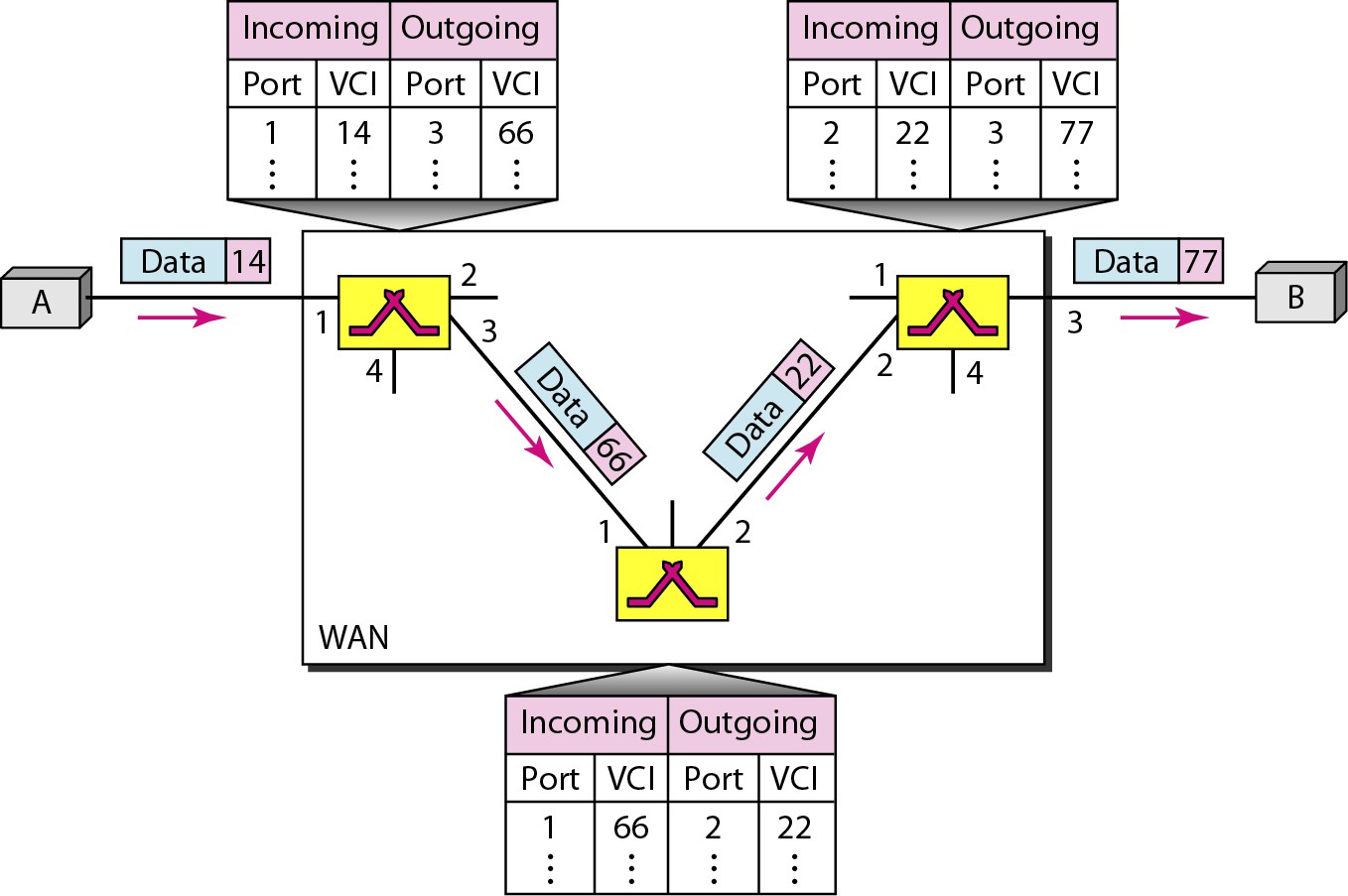
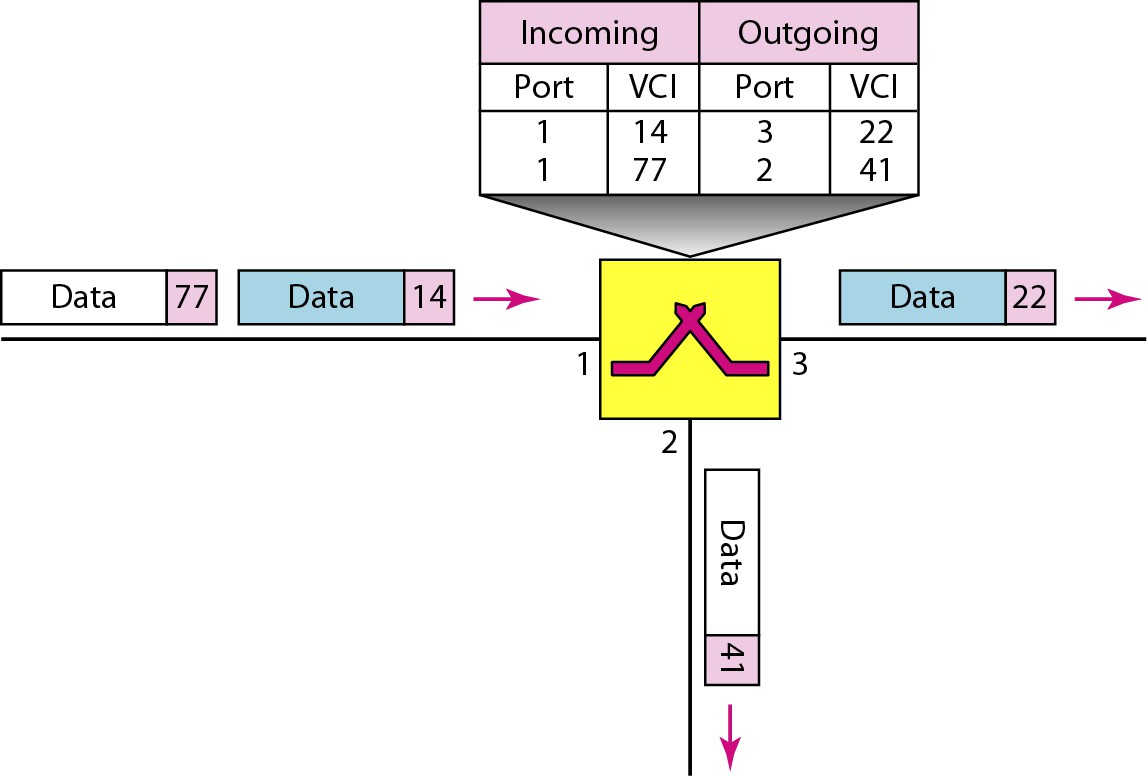
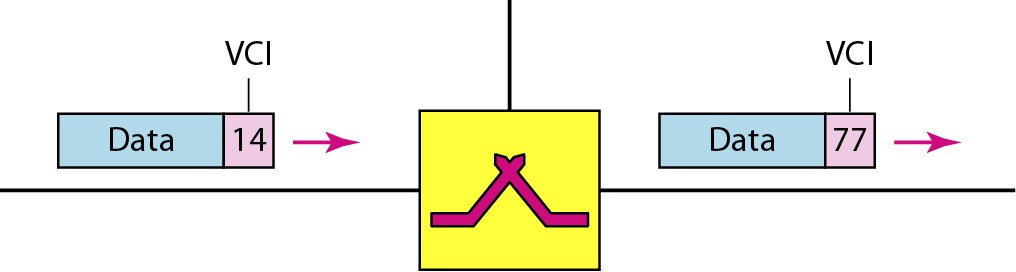


Figure 8.11 *Virtual-circuit identifier* Figure 8.12 *Switch and tables in a virtual-circuit network*

8.20 8.21

Figure 8.13 *Source-to-destination data transfer in a virtual-circuit network* Figure 8.14 *Setup request in a virtual-circuit network*

8.22

8.23

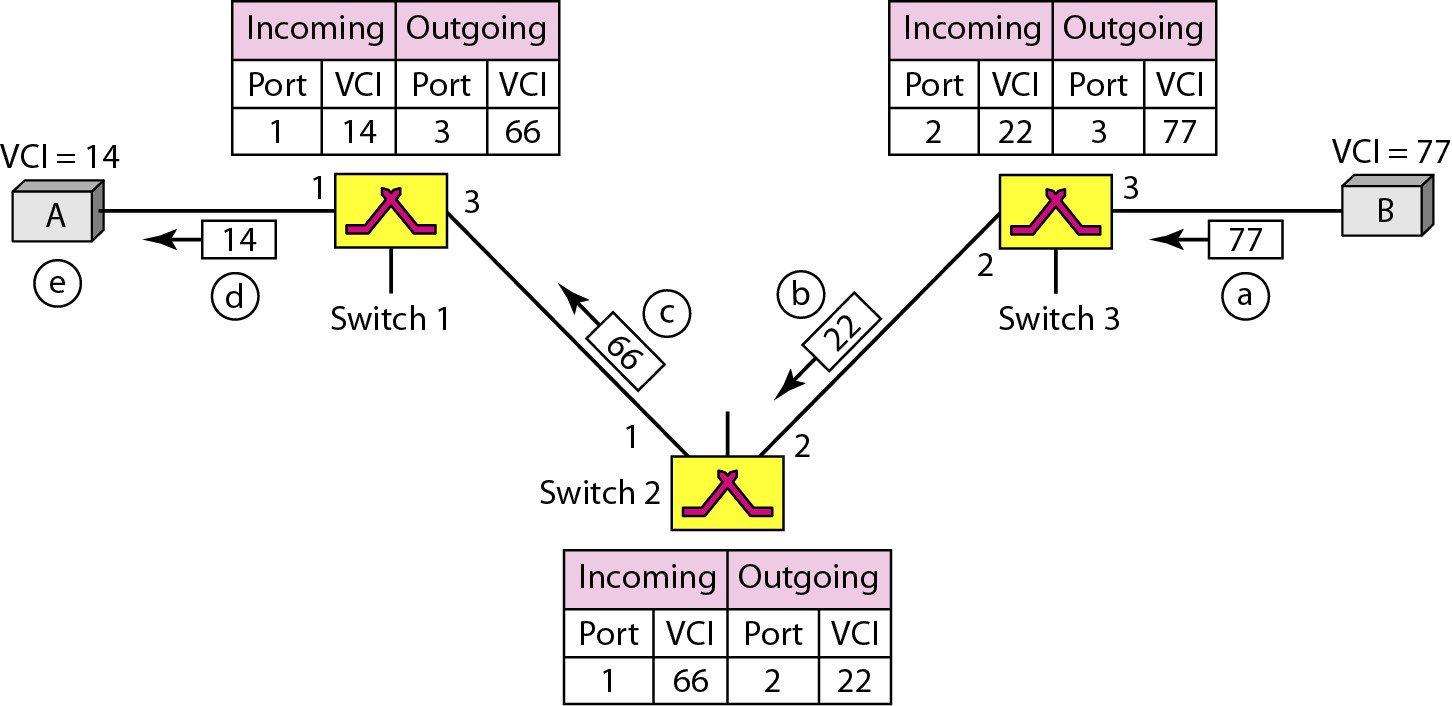


Figure 8.15 *Setup acknowledgment in a virtual-circuit network*

*Note*

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.

8.24 8.25

Figure 8.16 *Delay in a virtual-circuit network*

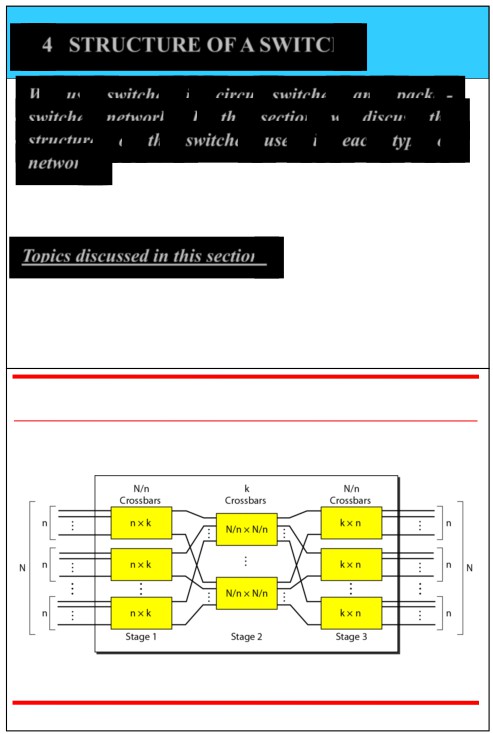
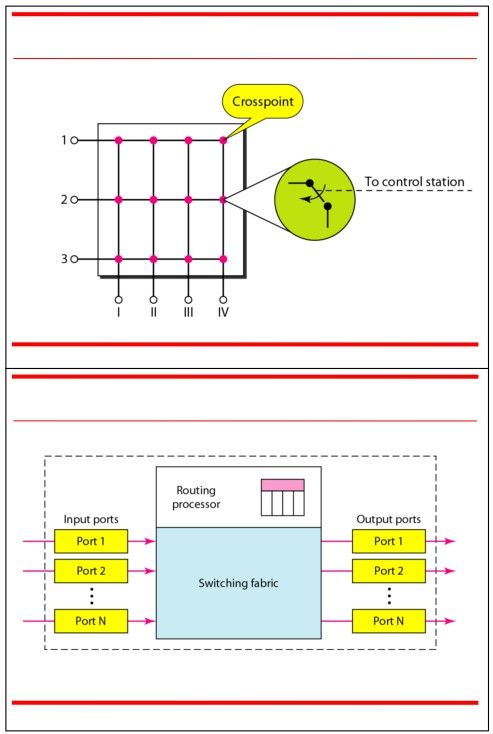
*Note*

Switching at the data link layer in a   
 switched WAN is normally

implemented by using   
virtual-circuit techniques.

8.26

8.27



8-4 STRUCTURE OF A SWITCH

*We use switches in circuit-switched and packet-*

*switched networks. In this section, we discuss the*   
*structures of the switches used in each type of*

*network.*

*Topics discussed in this section:*

Structure of Packet Switches

8.28

Figure 8.18 *Multistage switch*

8.30

Figure 8.17 *Crossbar switch with three inputs and four outputs*

8.29

Figure 8.21 *Packet switch components*

8.31

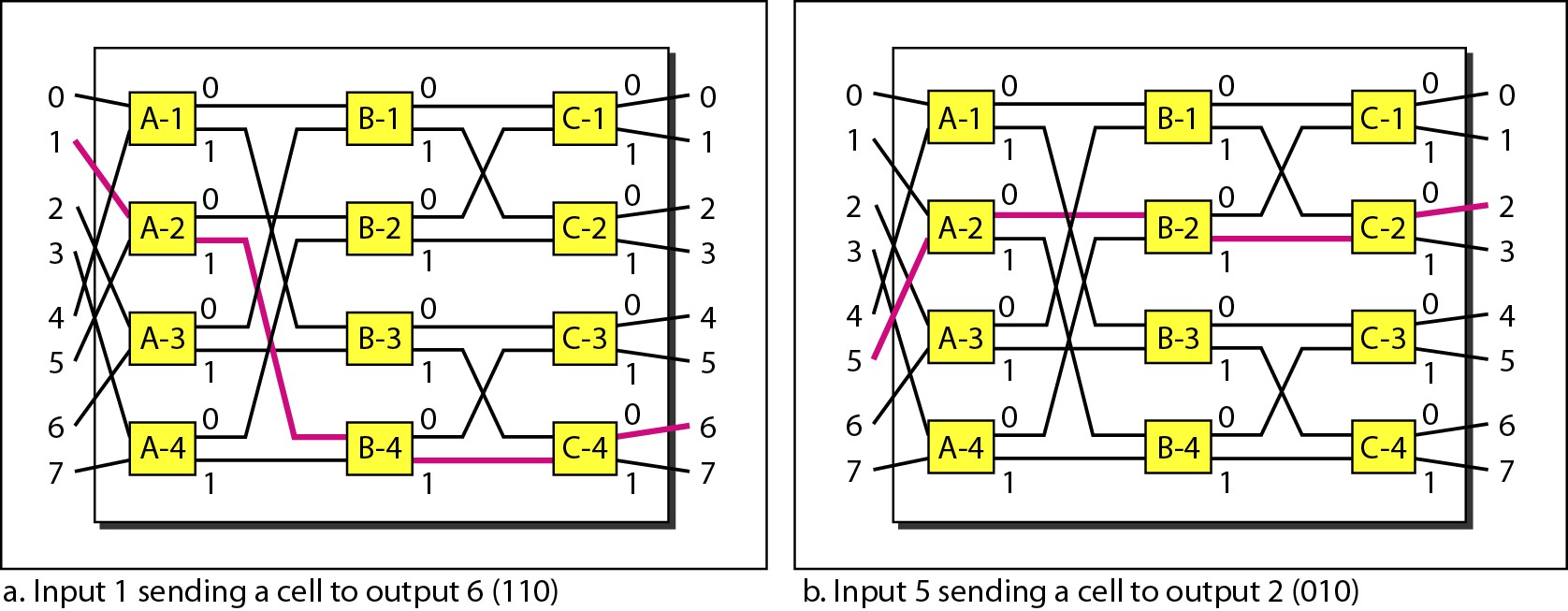
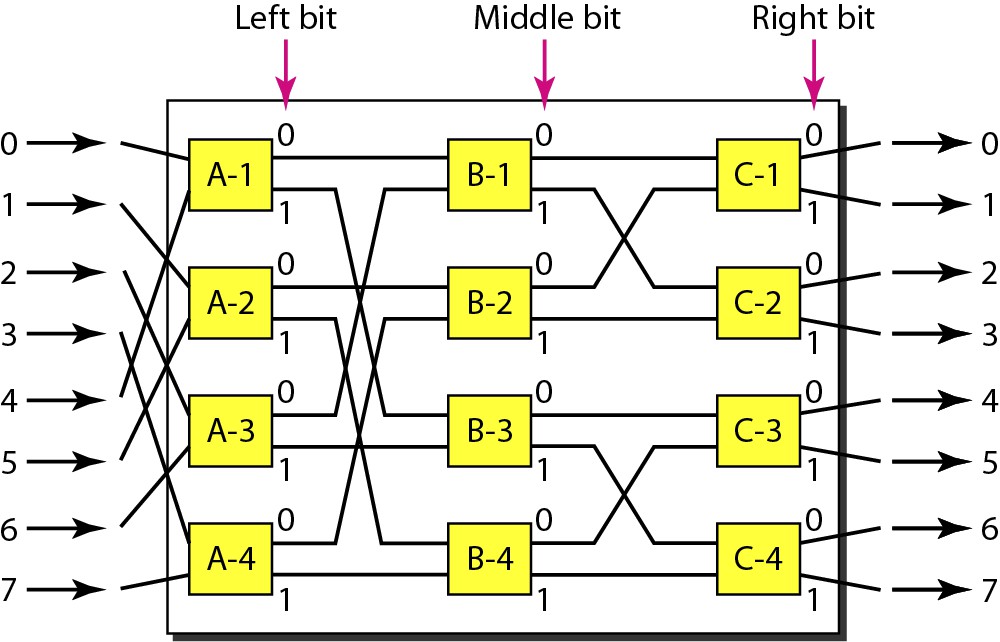
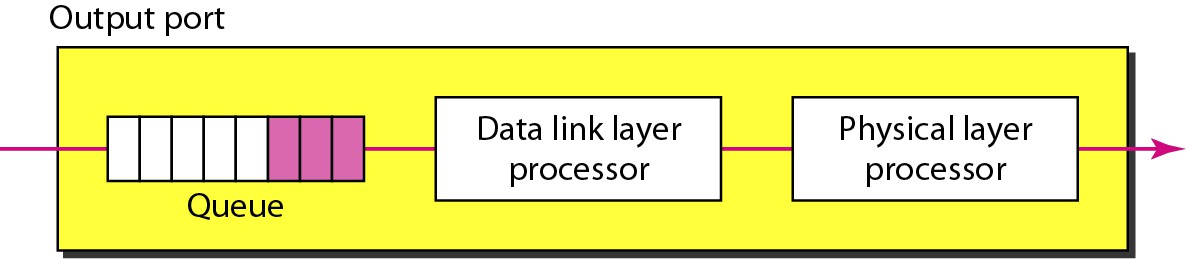
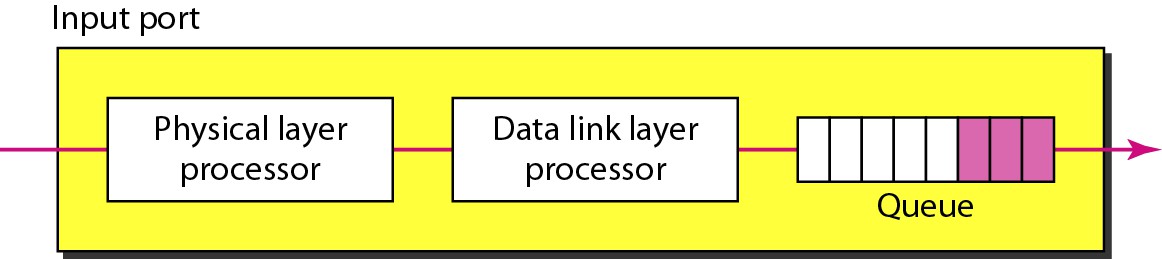


Figure 8.22 *Input port* Figure 8.23 *Output port*

8.32 8.33

Figure 8.24 *A banyan switch* Figure 8.25 *Examples of routing in a banyan switch*

8.34

8.35

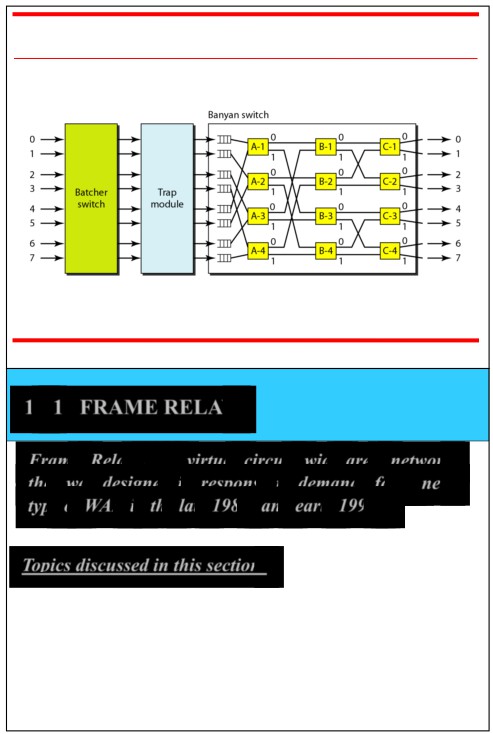
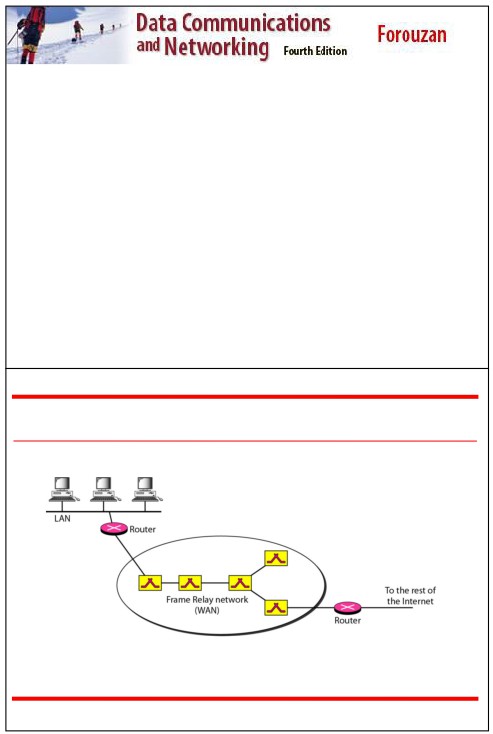


Figure 8.26 *Batcher-banyan switch*

Chapter 18

Virtual-Circuit Networks:

Frame Relay and ATM

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18-1 FRAME RELAY

Figure 18.1 *Frame Relay network*

*Frame Relay is a virtual-circuit wide-area network*   
*that was designed in response to demands for a new*

*type of WAN in the late 1980s and early 1990s.*

*Topics discussed in this section:*

Frame Relay Layers

Extended Address   
FRADs

VOFR

LMI

18.2

18.3

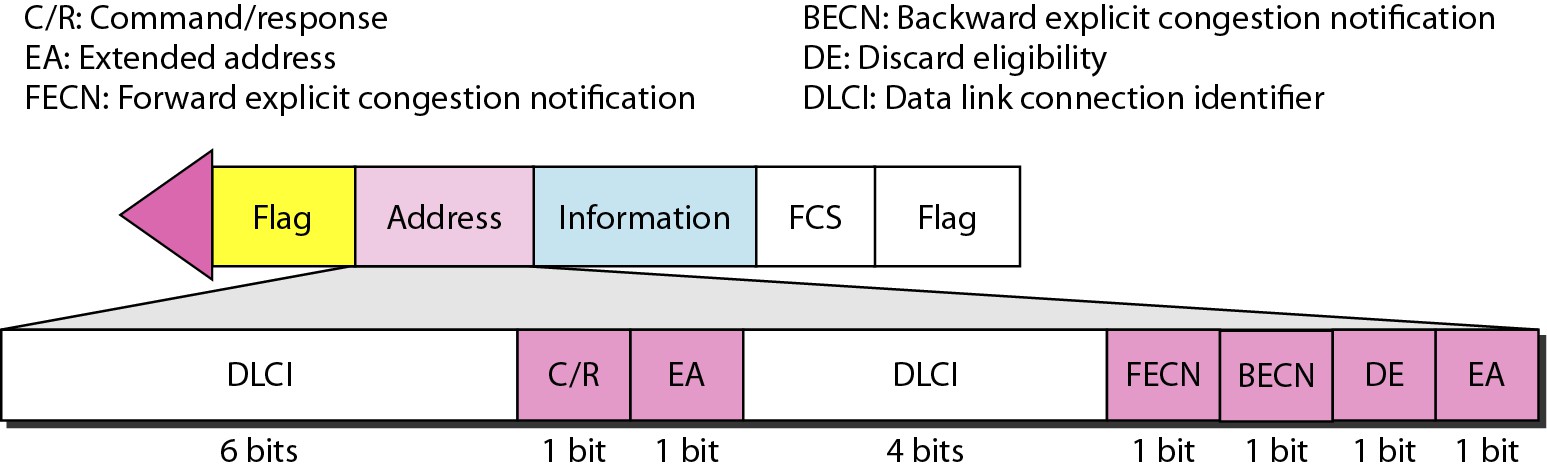
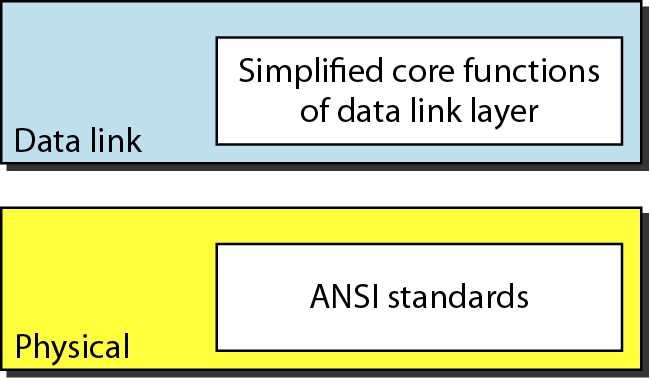


Figure 18.2 *Frame Relay layers*

*Note*

VCIs in Frame Relay are called DLCIs.

18.4 18.5

Figure 18.3 *Frame Relay frame*

*Note*

Frame Relay operates only at the physical and data link layers.

18.6

18.7

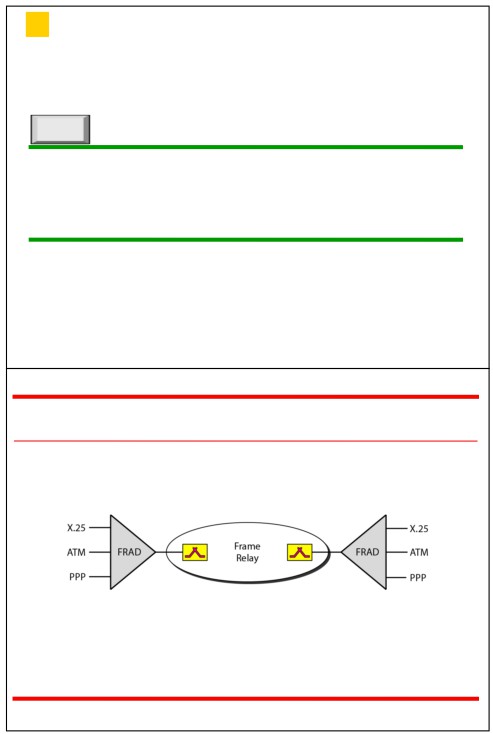
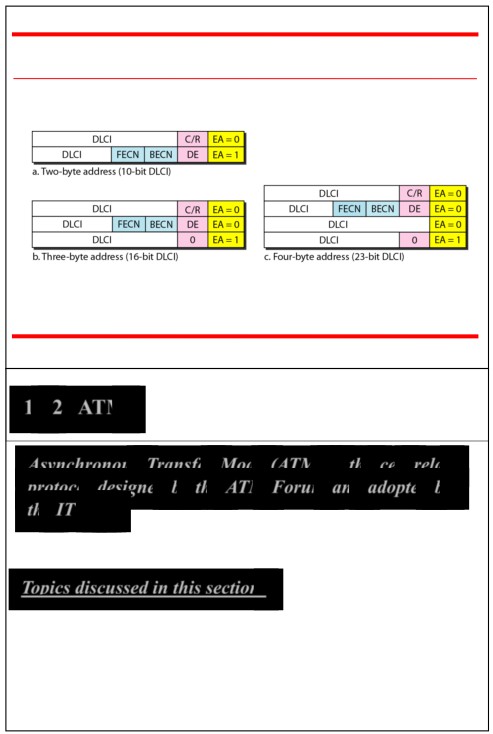


Figure 18.4 *Three address formats*

*Note*

Frame Relay does not provide flow or   
error control; they must be provided

by the upper-layer protocols.

18.8 18.9

18-2 ATM

Figure 18.5 *FRAD*

*Asynchronous Transfer Mode (ATM) is the cell relay*   
*protocol designed by the ATM Forum and adopted by*

*the ITU-T.*

*Topics discussed in this section:*

Problems

Architecture   
Switching   
ATM Layers

18.10 18.11

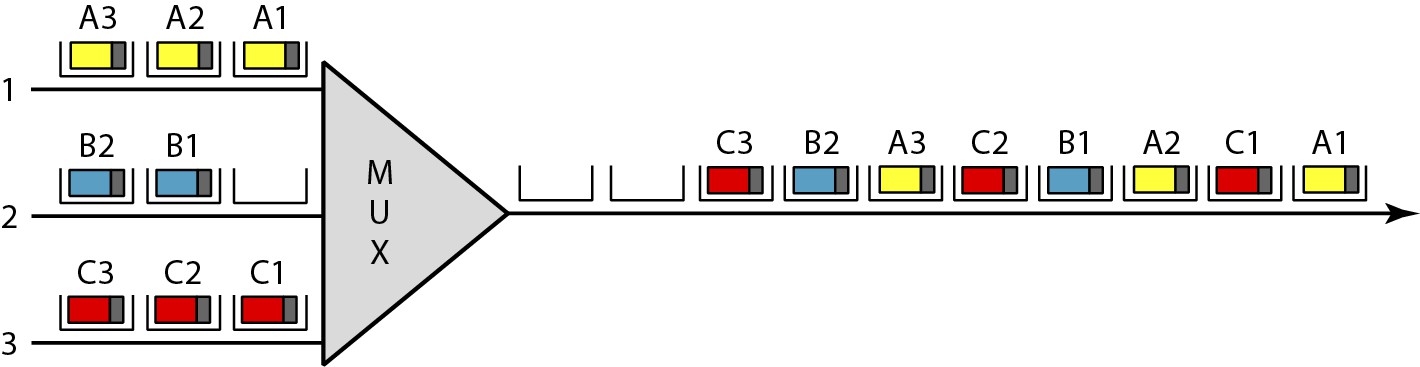
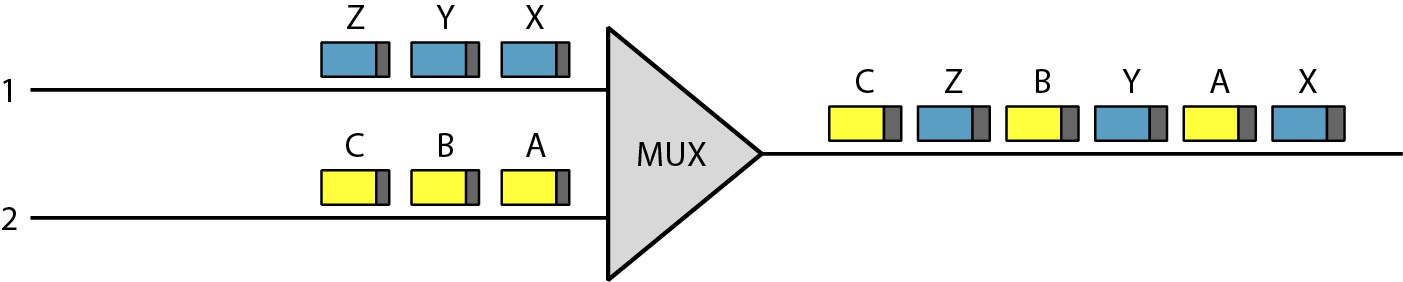
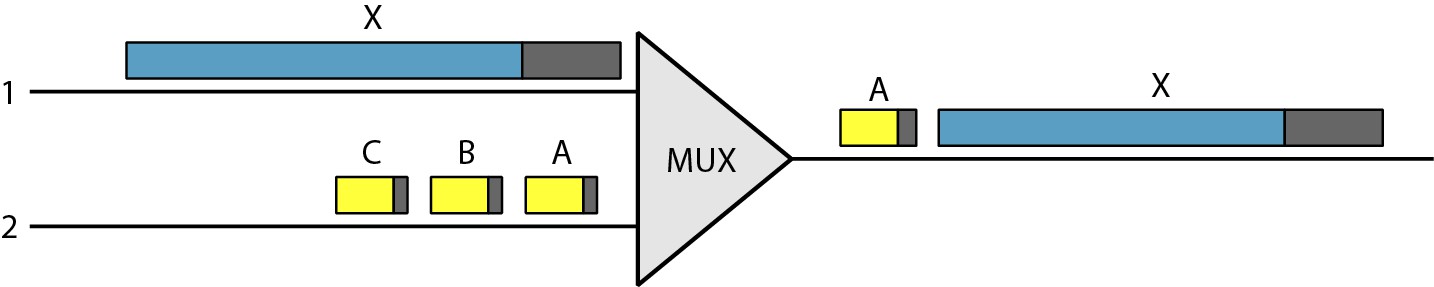


Figure 18.6 *Multiplexing using different frame sizes*

*Note*

A cell network uses the cell as the basic

unit of data exchange.

A cell is defined as a small, fixed-size   
 block of information.

18.12 18.13

Figure 18.7 *Multiplexing using cells* Figure 18.8 *ATM multiplexing*

18.14

18.15

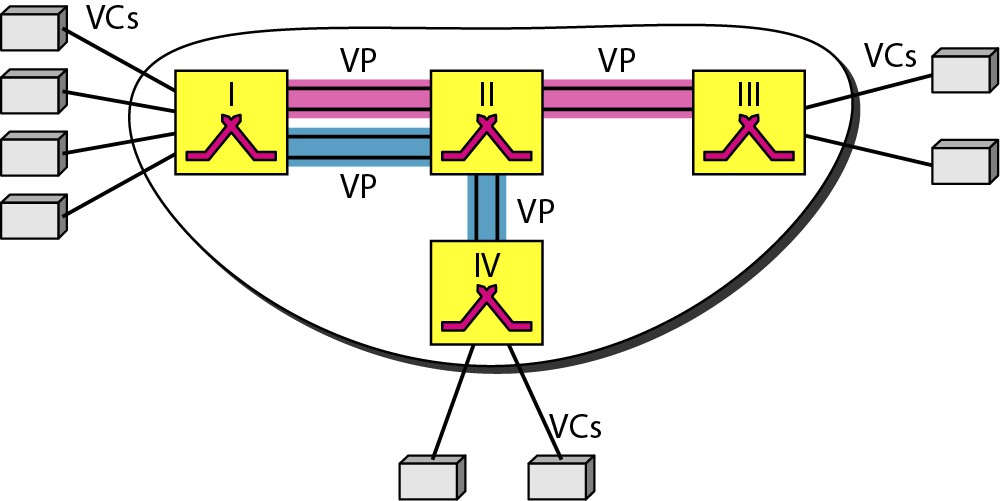
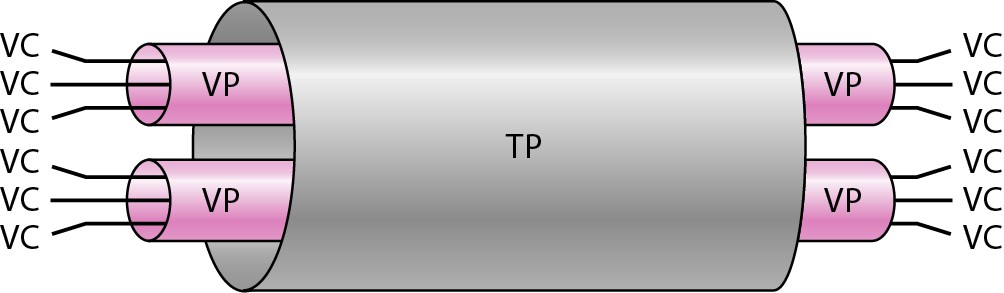


Figure 18.9 *Architecture of an ATM network* Figure 18.10 *TP, VPs, and VCs*

18.16 18.17

Figure 18.11 *Example of VPs and VCs*

*Note*

Note that a virtual connection is defined   
 by a pair of numbers:

the VPI and the VCI.

18.18

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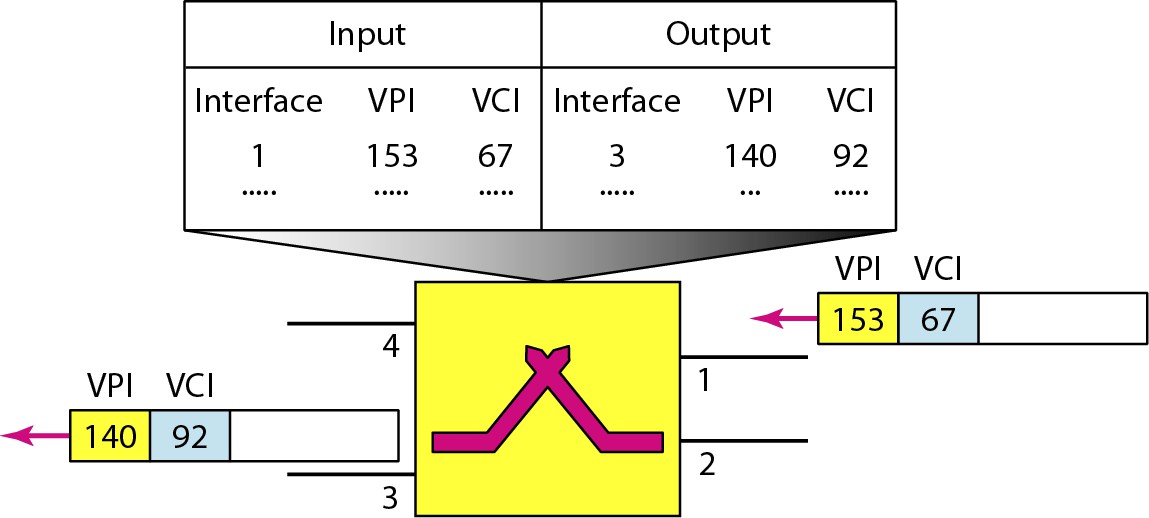
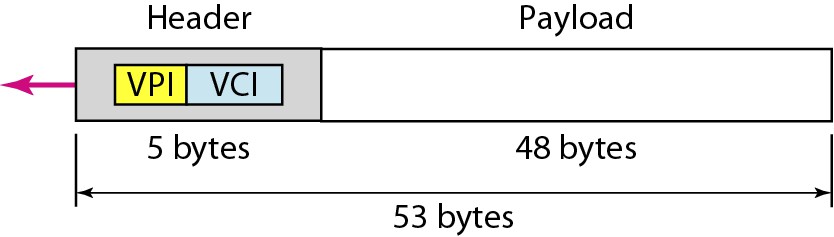
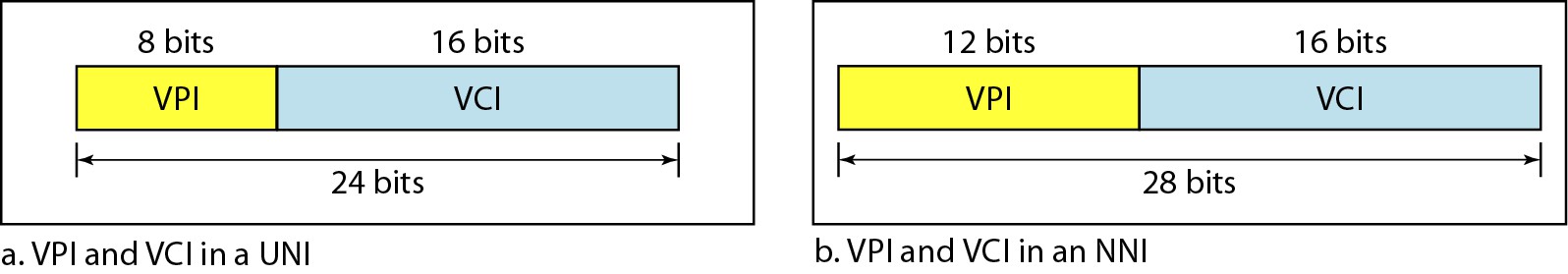
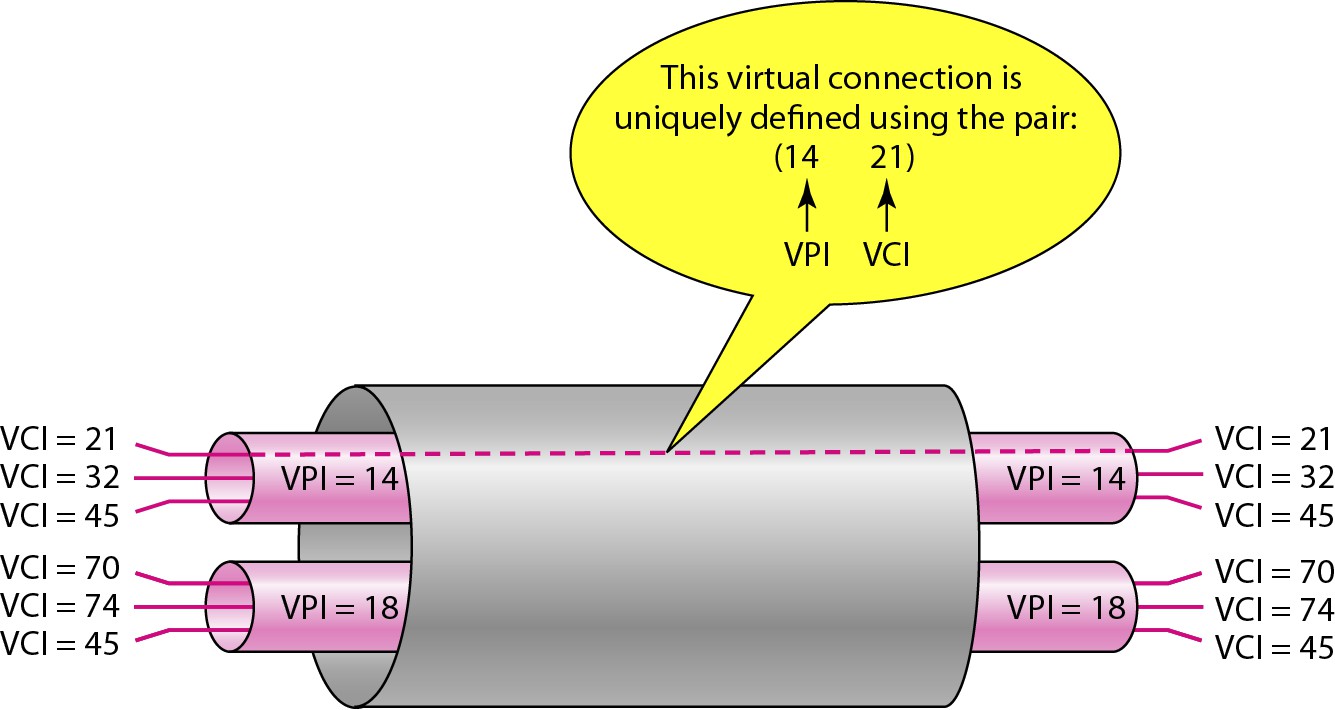


Figure 18.12 *Connection identifiers* Figure 18.13 *Virtual connection identifiers in UNIs and NNIs*

18.20 18.21

Figure 18.14 *An ATM cell* Figure 18.15 *Routing with a switch*

18.22

18.23

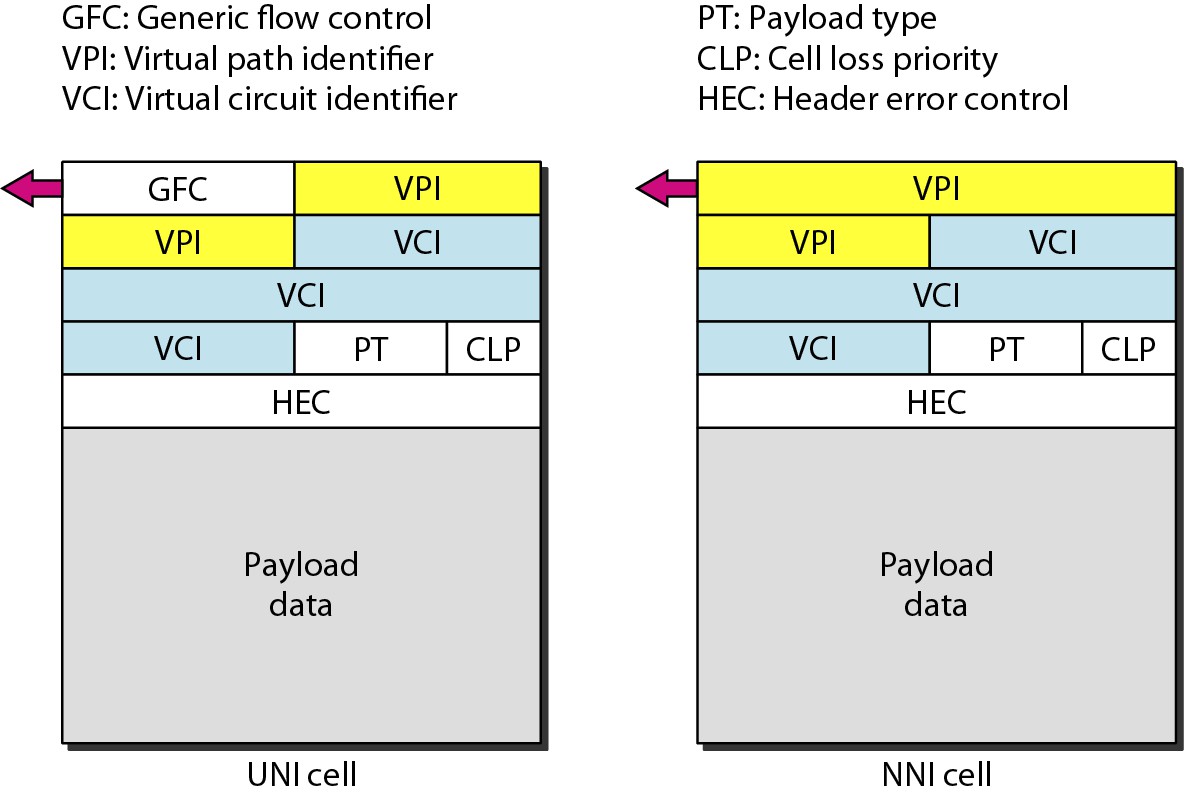
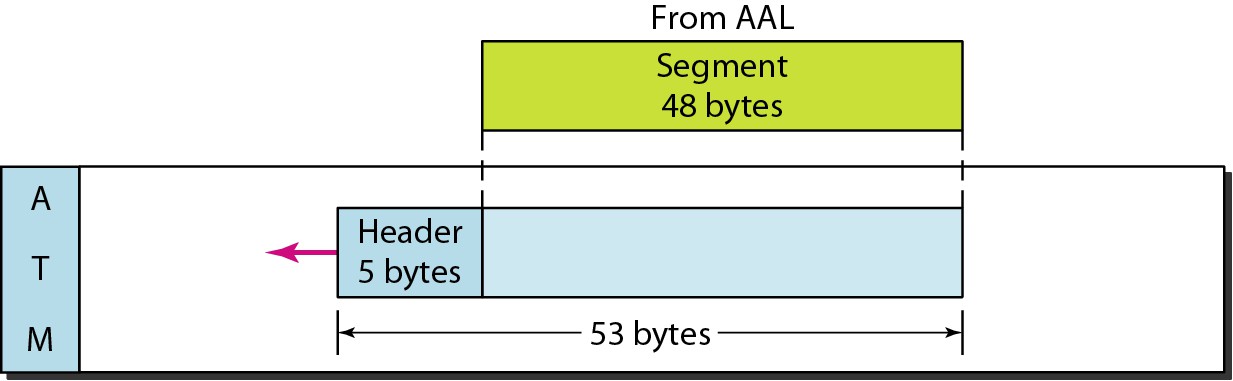
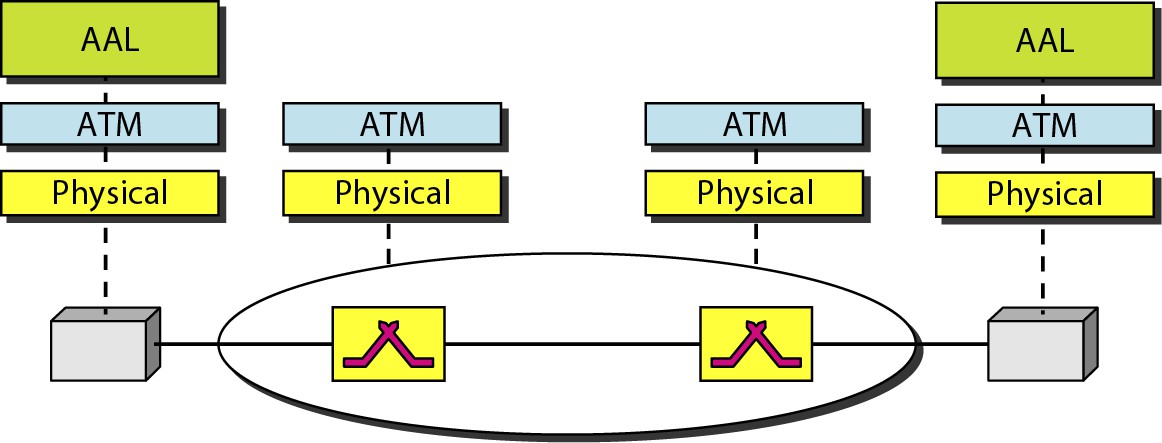
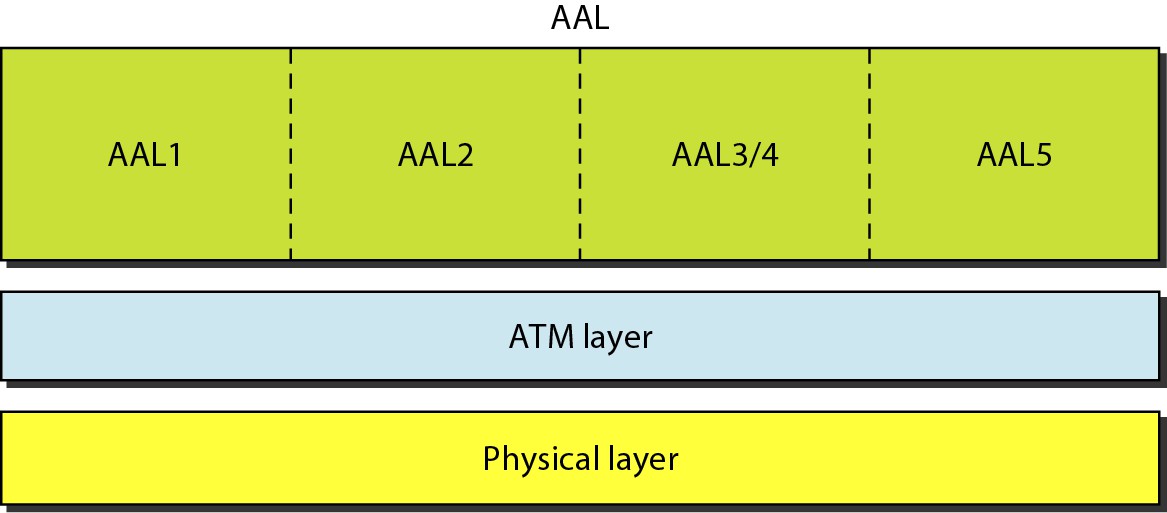


Figure 18.16 *ATM layers* Figure 18.17 *ATM layers in endpoint devices and switches*

18.24 18.25

Figure 18.18 *ATM layer* Figure 18.19 *ATM headers*

18.26

18.27

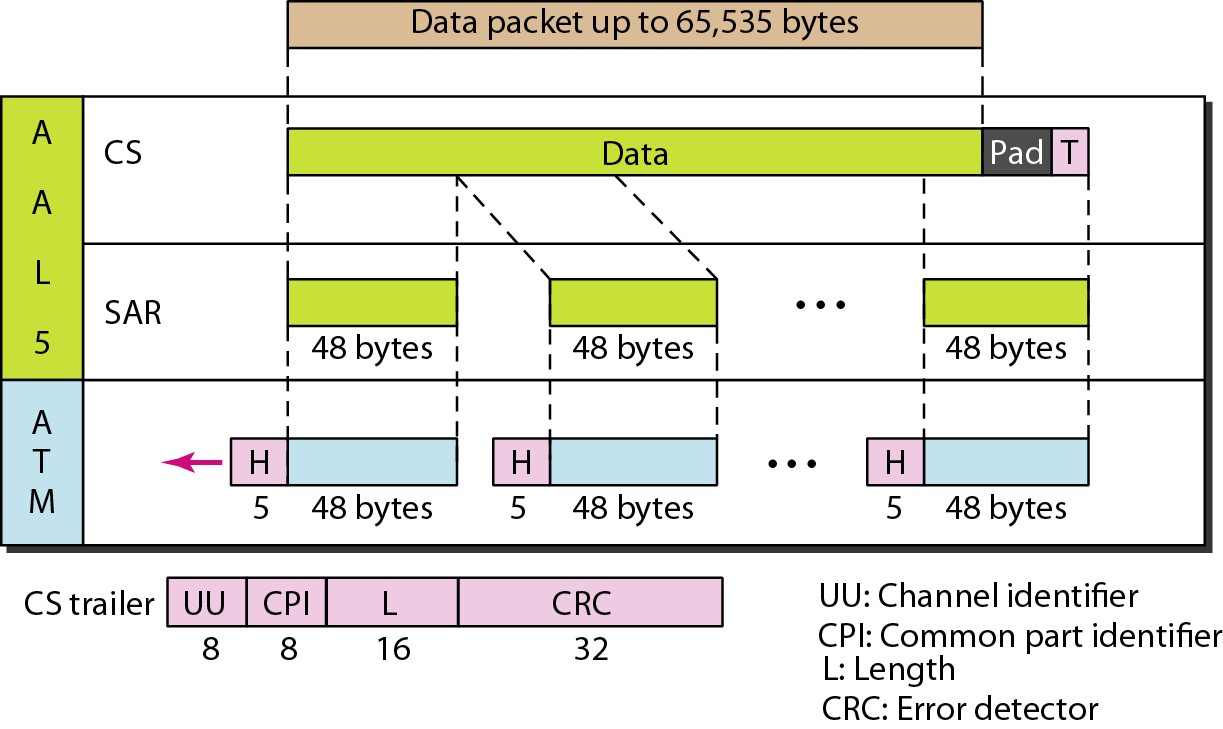
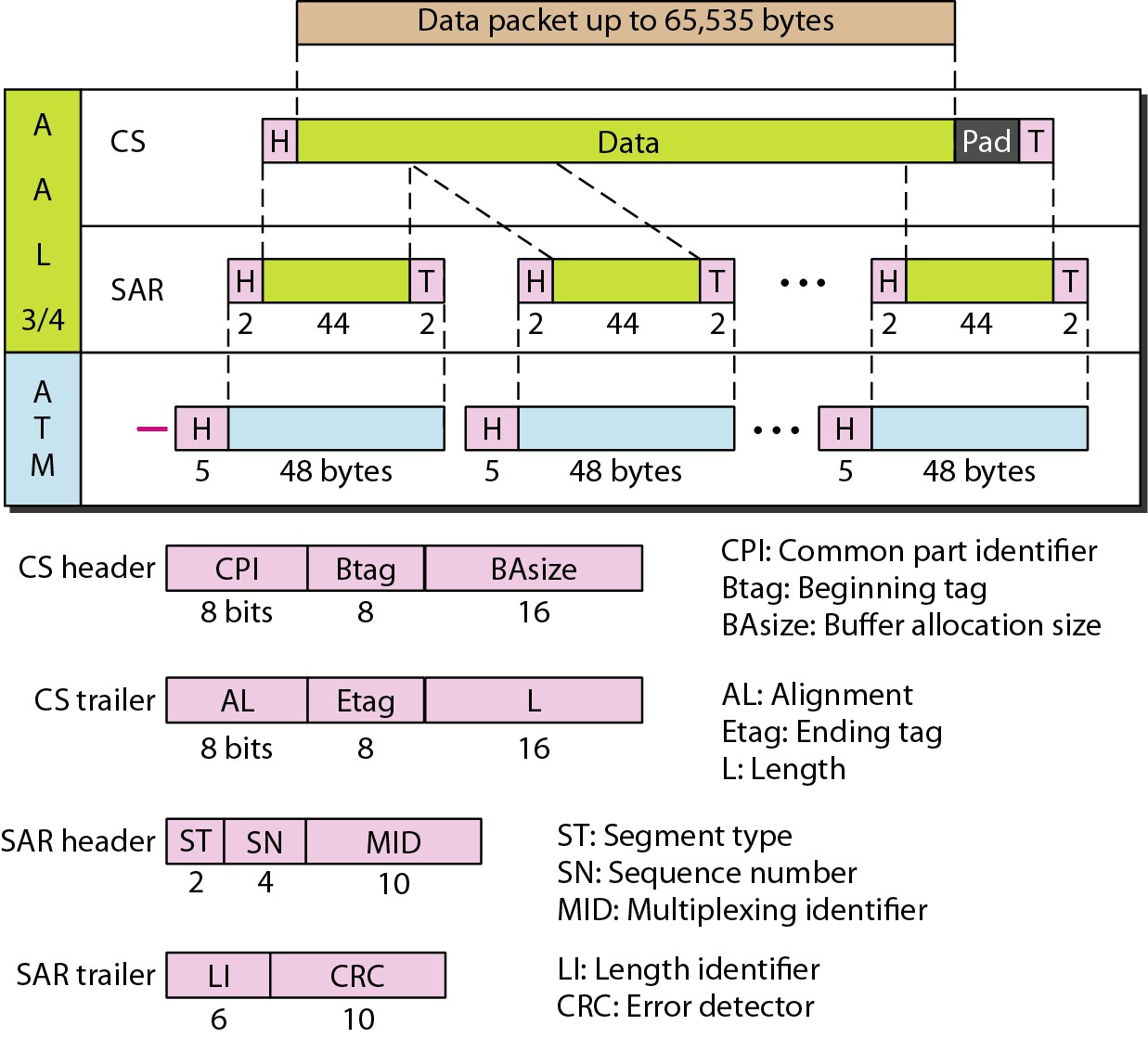
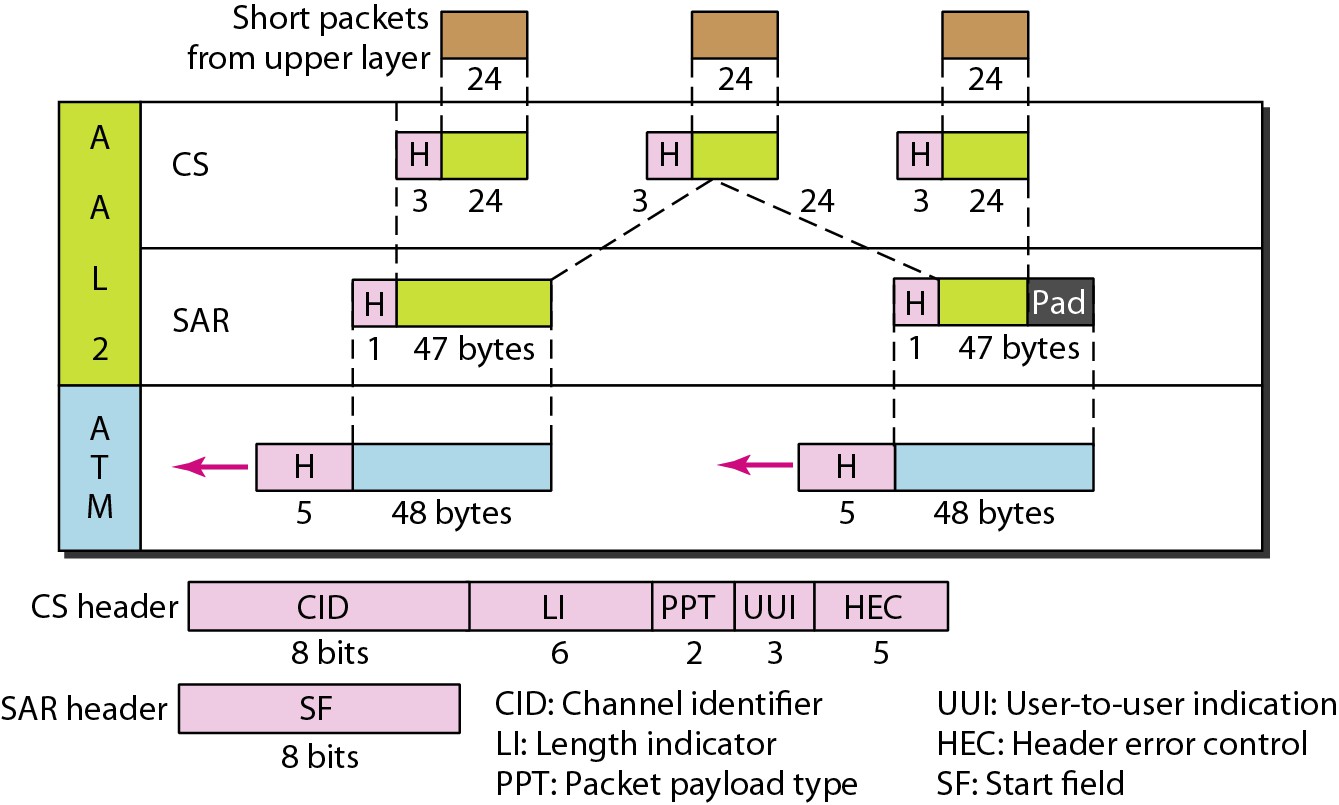
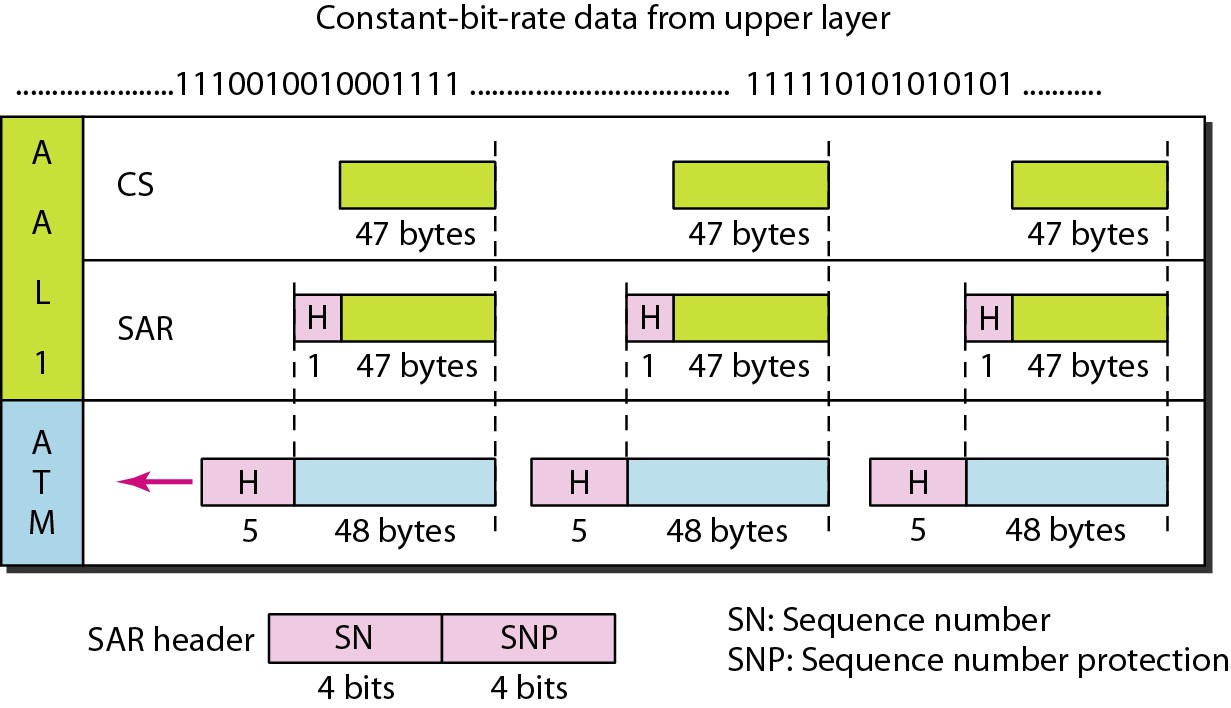


Figure 18.20 *AAL1* Figure 18.21 *AAL2*

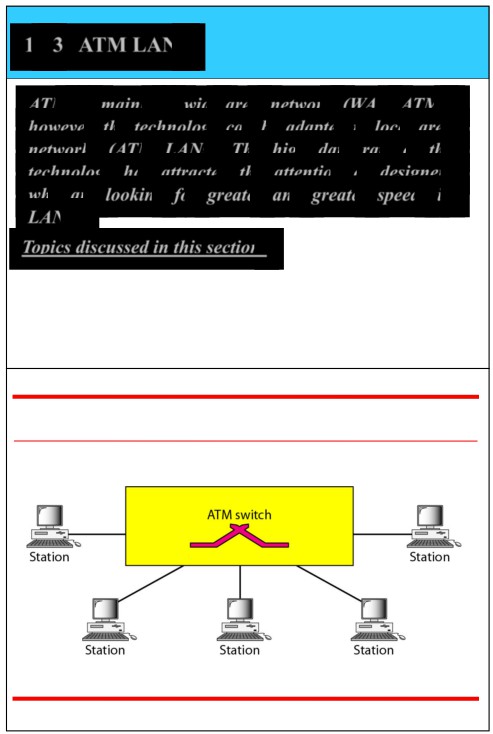
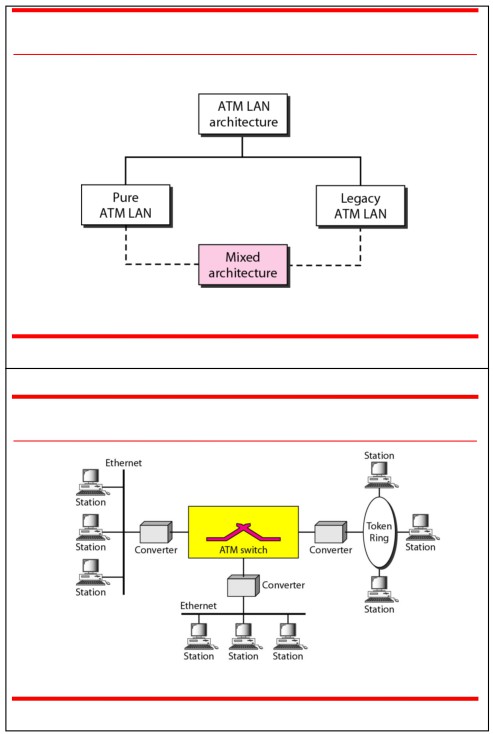
18.28 18.29

Figure 18.22 *AAL3/4*

Figure 18.23 *AAL5*

18.30

18.31



18-3 ATM LANs

*ATM is mainly a wide-area network (WAN ATM);*   
*however, the technology can be adapted to local-area*   
*networks (ATM LANs). The high data rate of the*   
*technology has attracted the attention of designers*   
*who are looking for greater and greater speeds in*   
*LANs.*

*Topics discussed in this section:*

LAN Emulation (LANE) Client/Server Model

Mixed Architecture with Client/Server

18.32

Figure 18.25 *Pure ATM LAN*

18.34

Figure 18.24 *ATM LANs*

18.33

Figure 18.26 *Legacy ATM LAN*

18.35

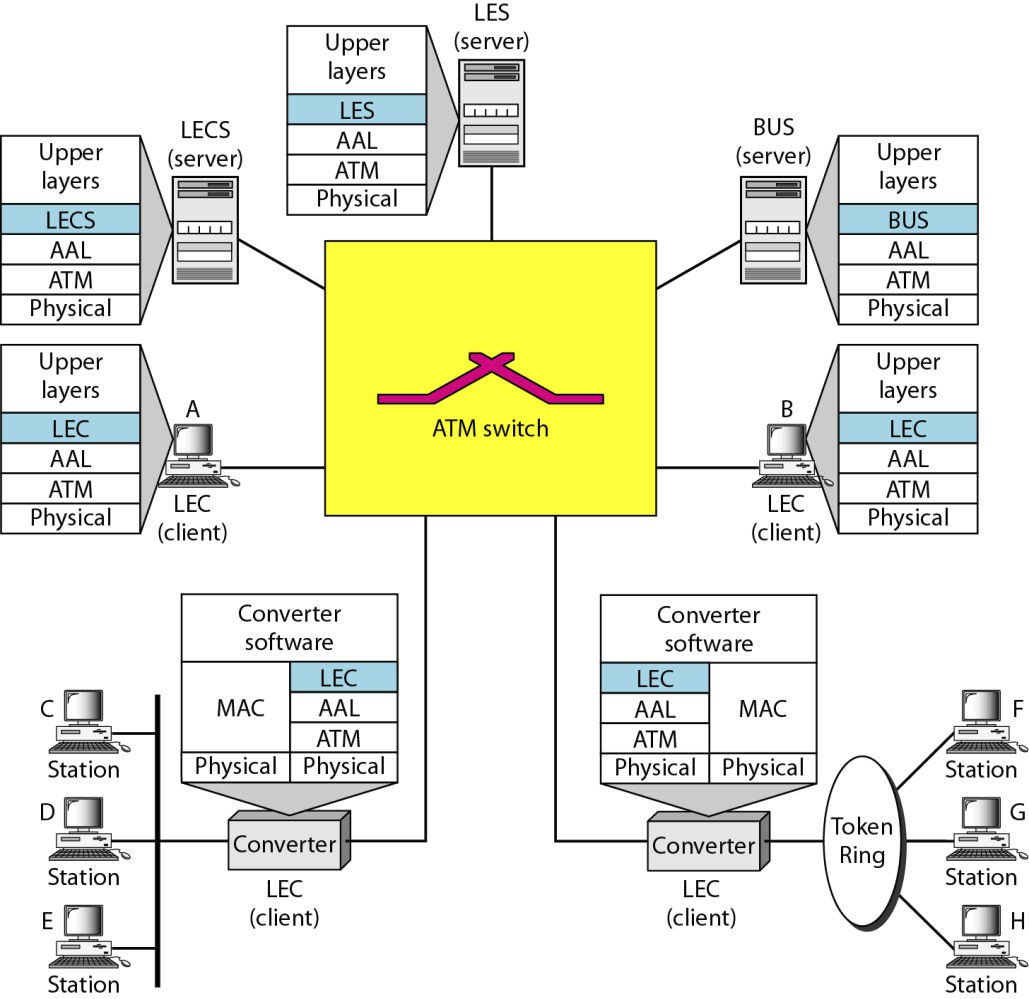
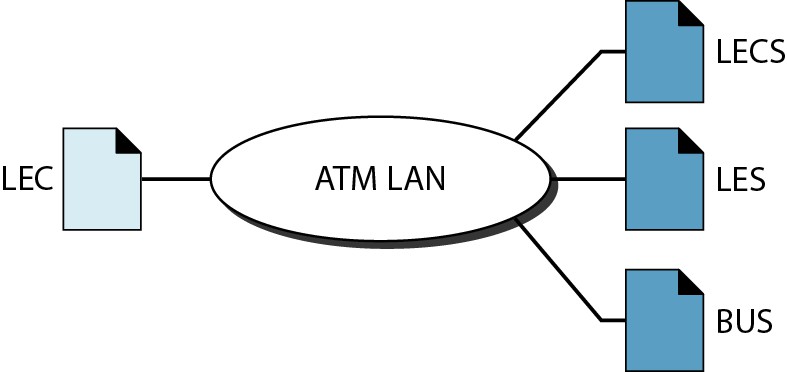
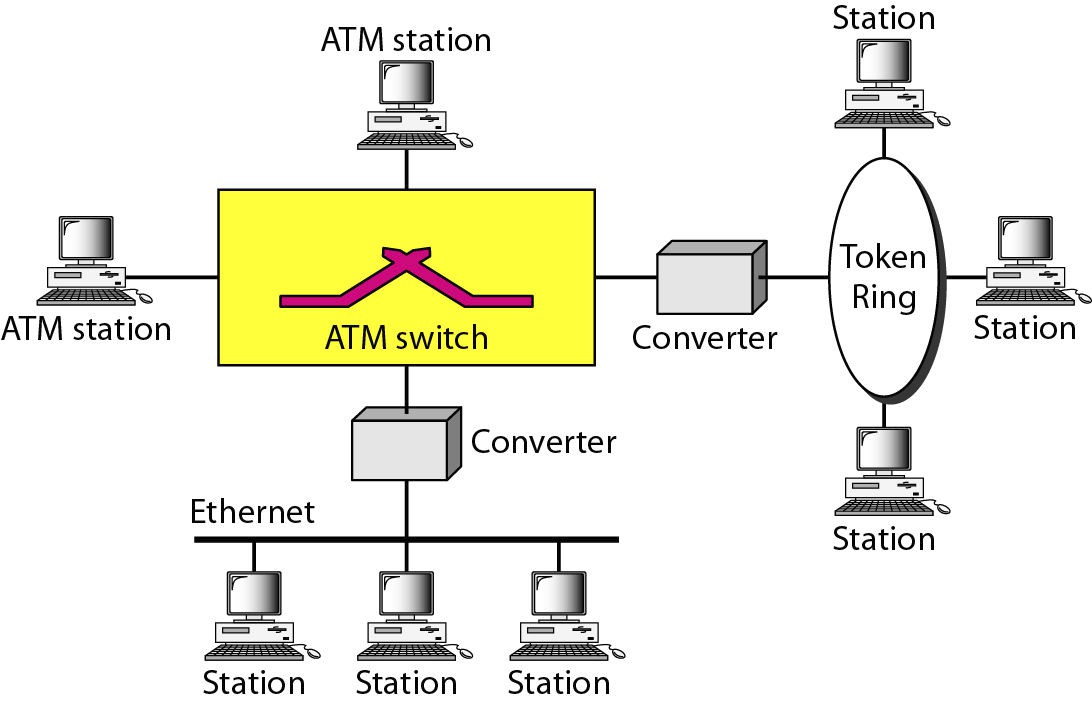


Figure 18.27 *Mixed architecture ATM LAN*

18.36

Figure 18.29 *Client and servers in a LANE*

Figure 18.28 *Client and servers in a LANE*

18.37

Chapter 20

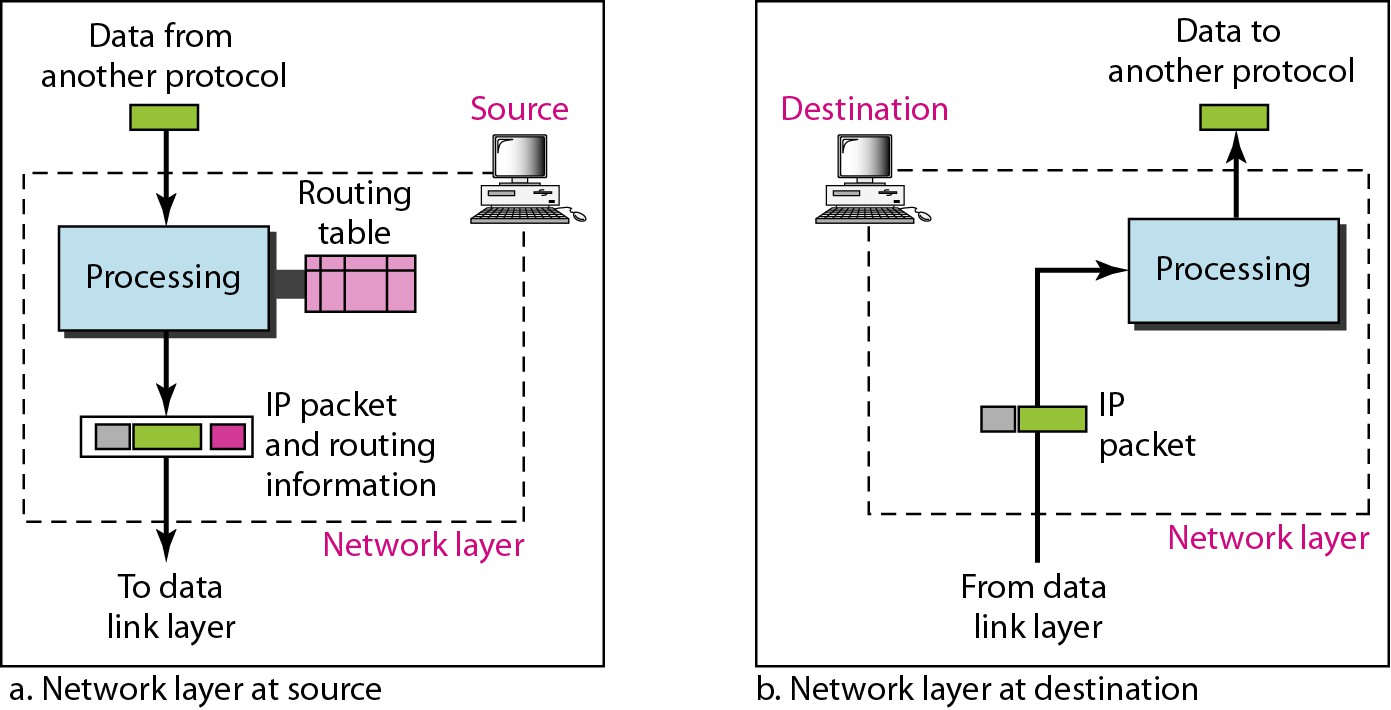
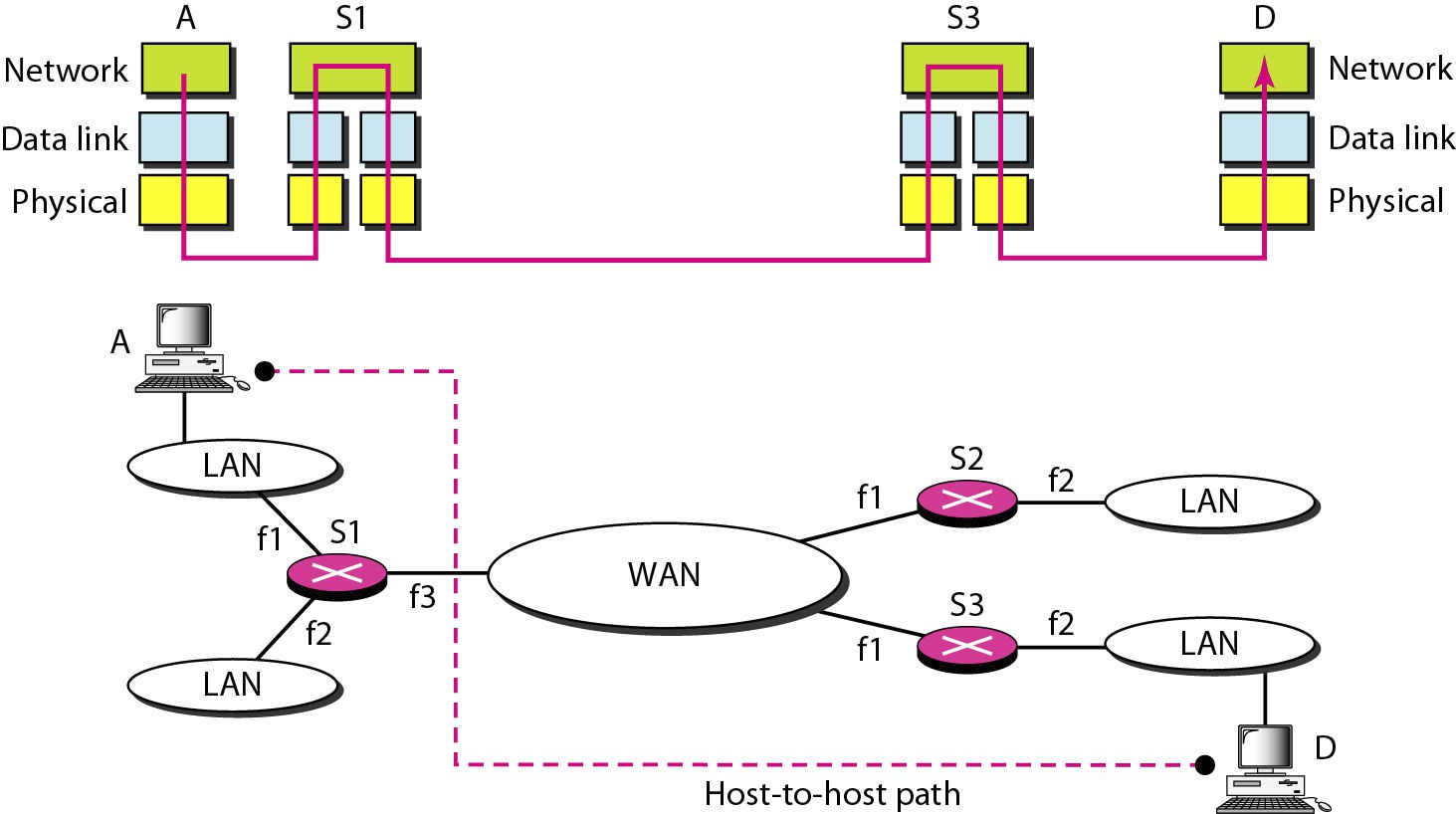
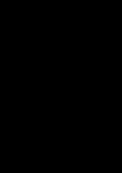
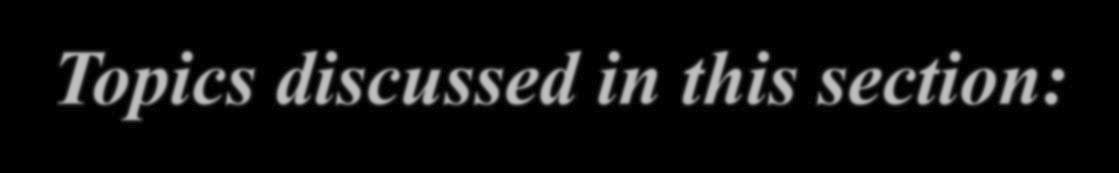
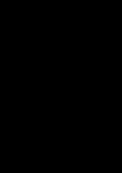
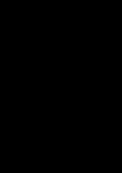
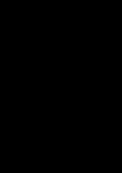
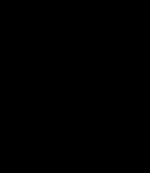
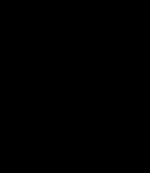
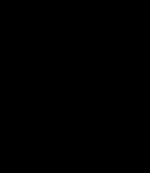
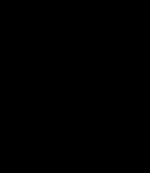
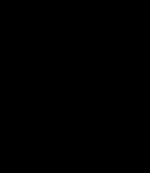
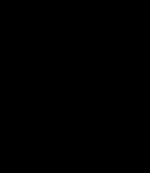
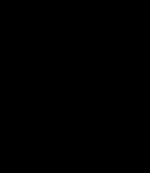
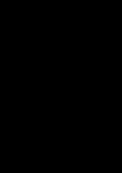
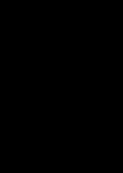
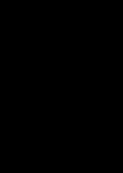
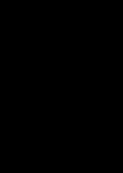
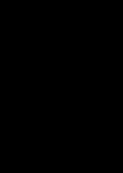
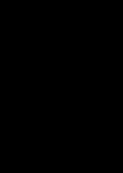
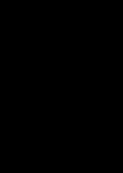
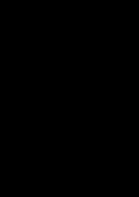
Network Layer:

Internet Protocol

18.38

20.1

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20-1 INTERNETWORKING

Figure 20.1 *Links between two hosts*

*In this section, we discuss internetworking, connecting*

*networks together to make an internetwork or an*

*internet.*

*Topics discussed in this section:*

Internet as a Datagram Network

Internet as a Connectionless Network

20.2 20.3

Figure 20.2 *Network layer in an internetwork* Figure 20.3 *Network layer at the source, router, and destination*

20.4

20.5

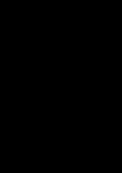
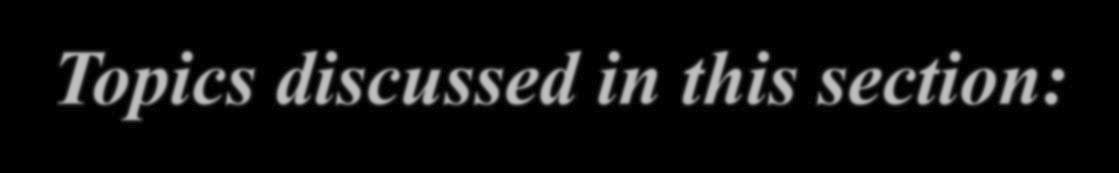
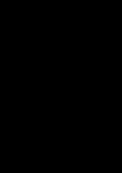
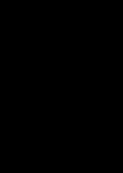
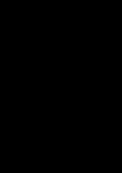
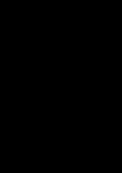
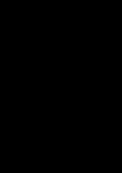
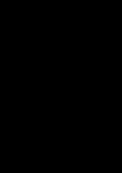
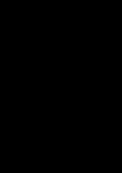
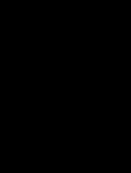
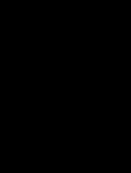
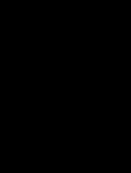
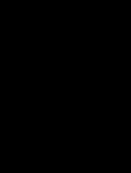
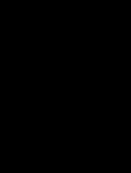
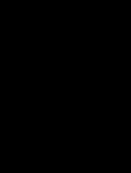
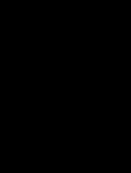
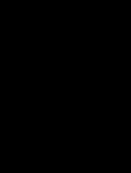
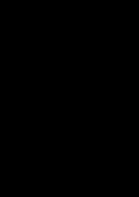
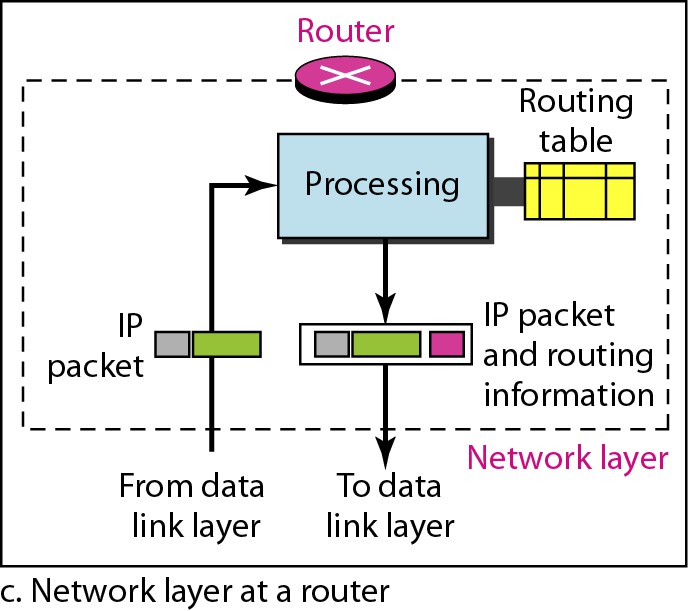


Figure 20.3 *Network layer at the source, router, and destination (continued)*

*Note*

Switching at the network layer in the   
Internet uses the datagram approach to

packet switching.

20.6 20.7

20-2 IPv4

*The Internet Protocol version 4 (IPv4) is the delivery*

*Note* *mechanism used by the TCP/IP protocols.*

Communication at the network layer in   
 the Internet is connectionless.

*Topics discussed in this section:*

Fragmentation

Checksum

Options

20.8

20.9

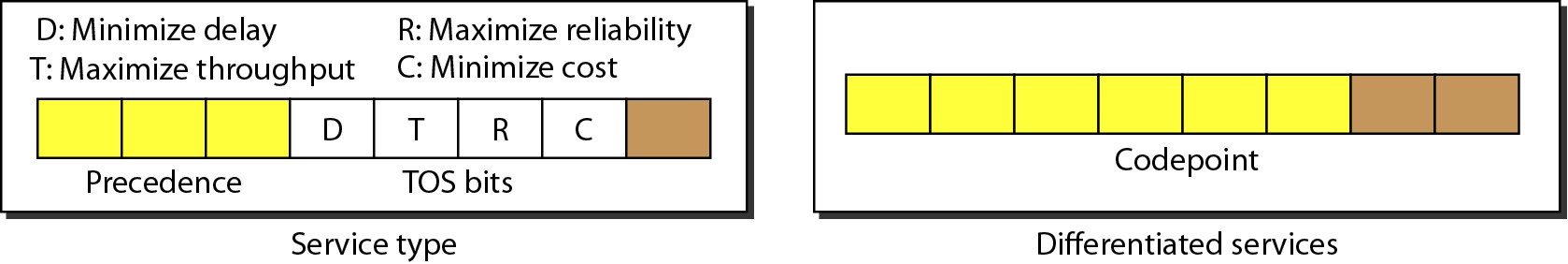
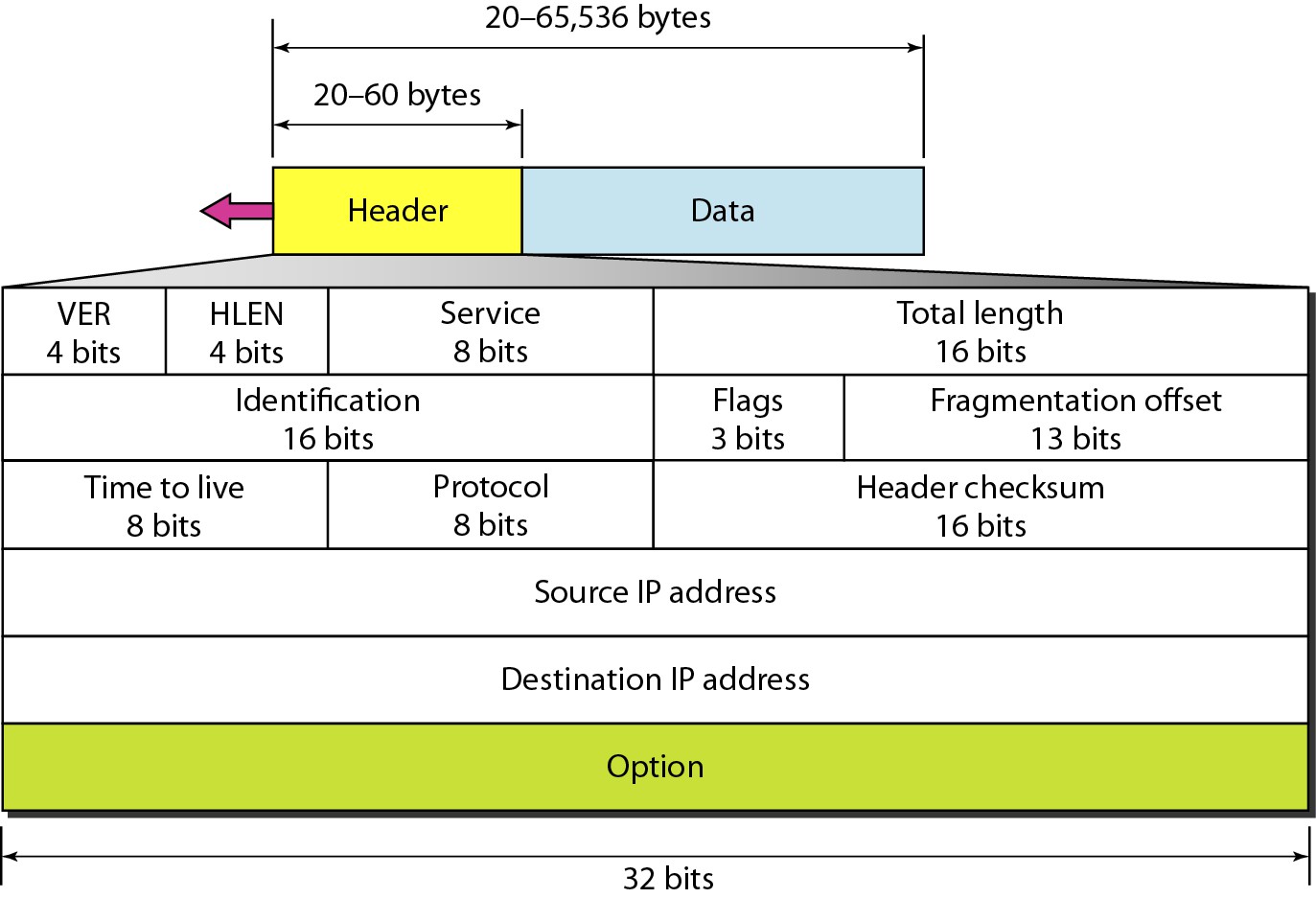
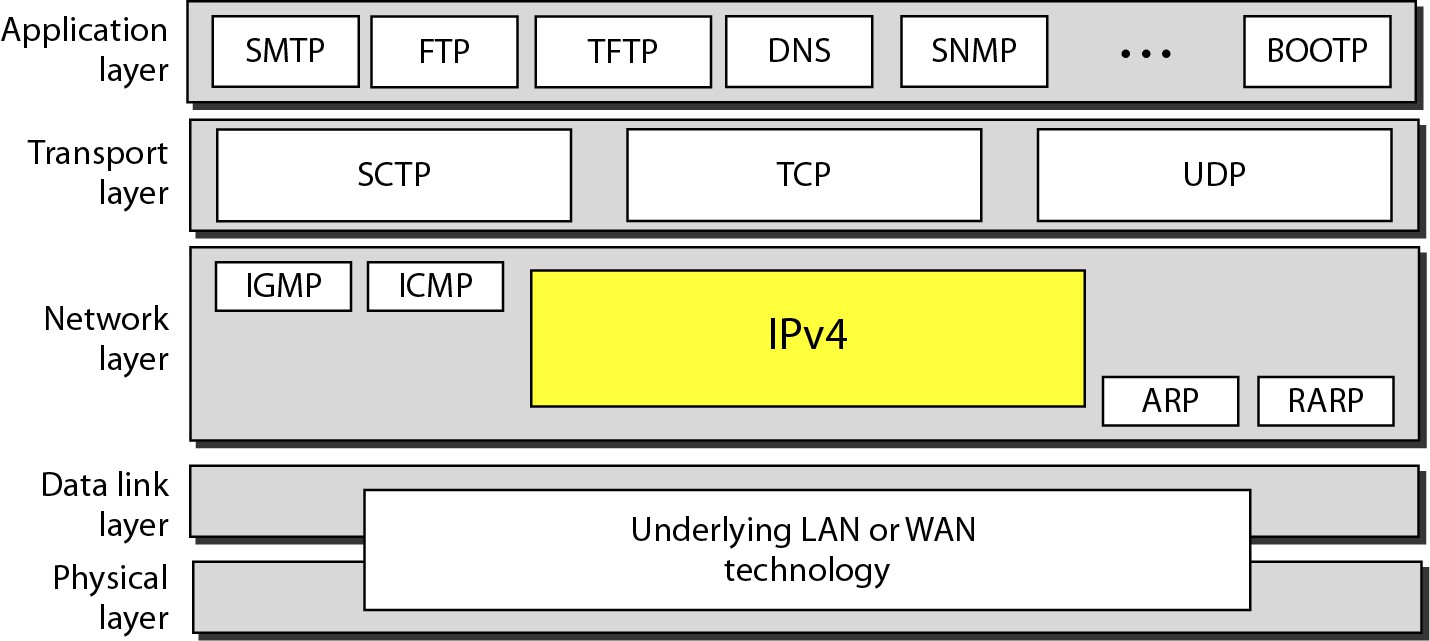


Figure 20.4 *Position of IPv4 in TCP/IP protocol suite* Figure 20.5 *IPv4 datagram format*

20.10 20.11

Figure 20.6 *Service type or differentiated services*

*Note*

The precedence subfield was part of   
 version 4, but never used.

20.12

20.13

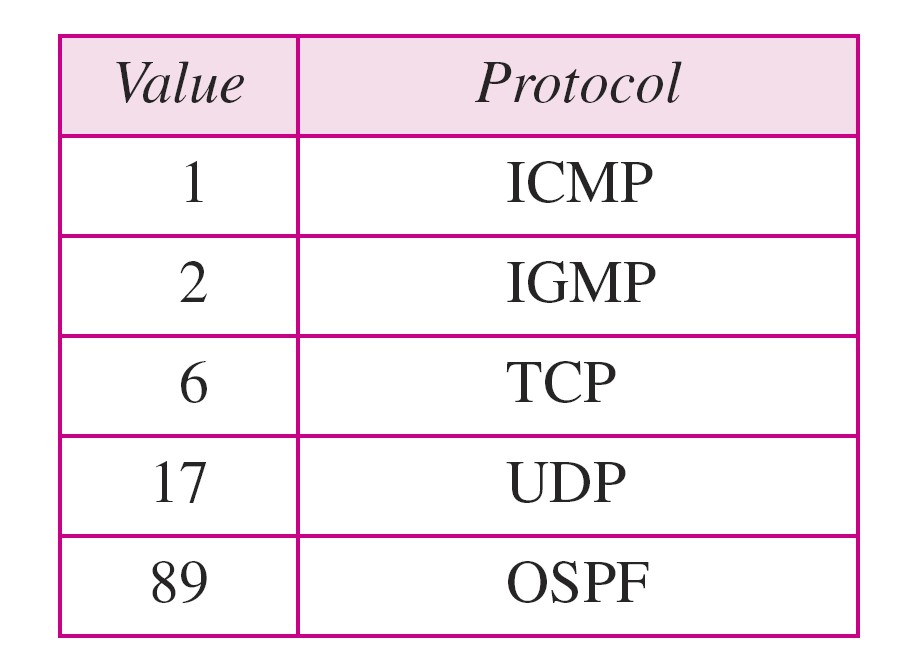
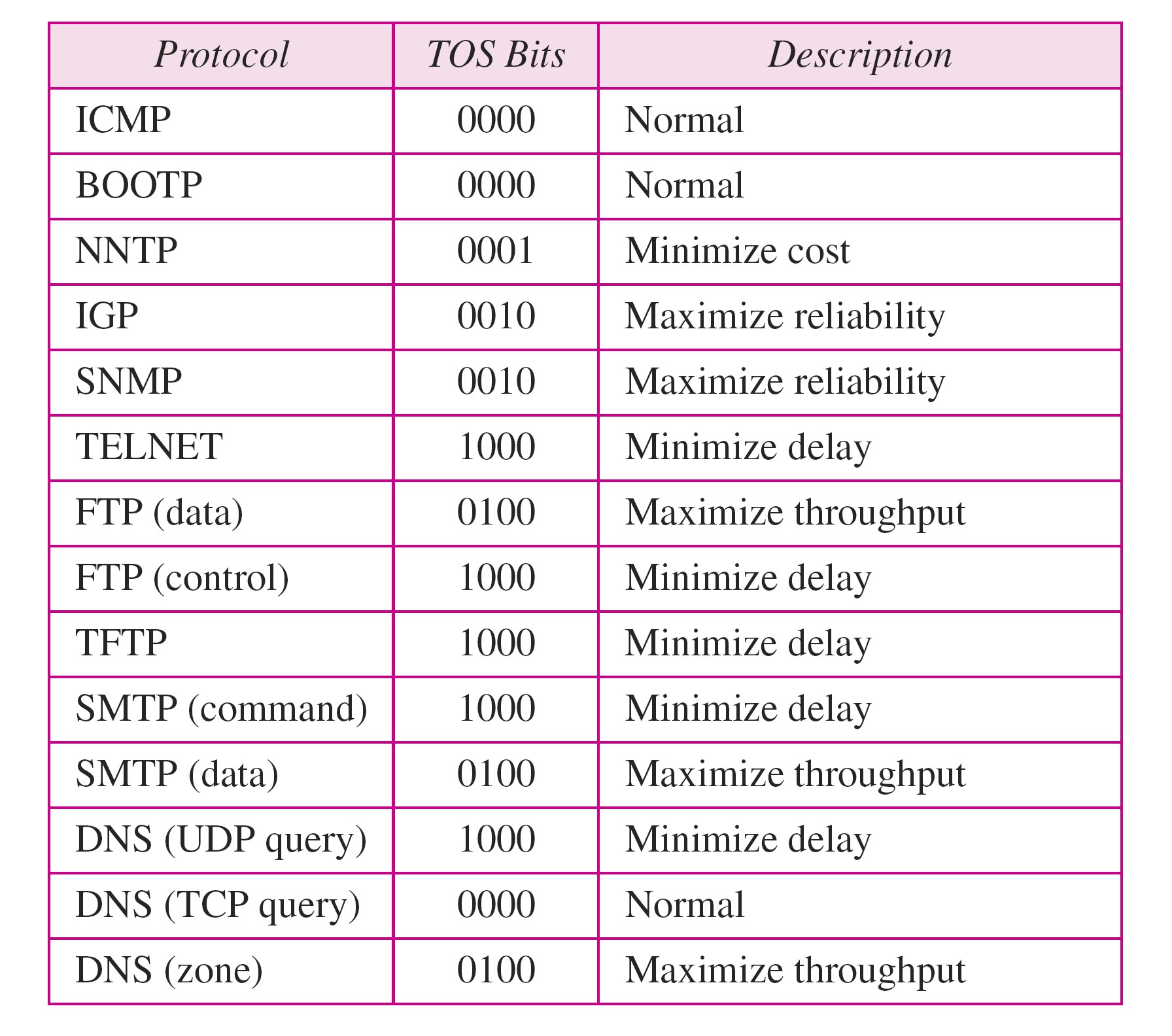
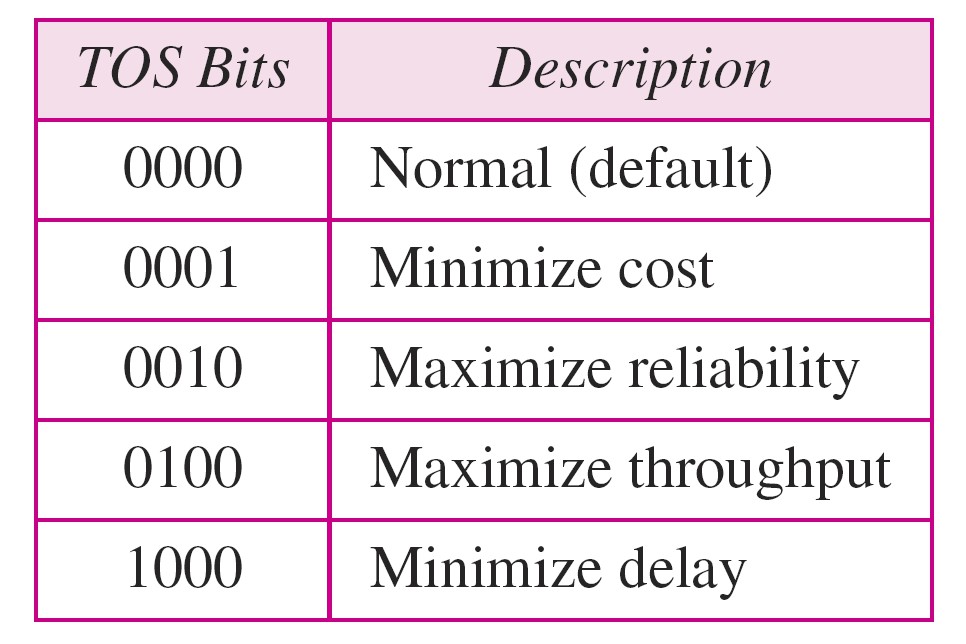


Table 20.2 *Default types of service*

Table 20.1 *Types of service*

20.14 20.15

Table 20.3 *Values for codepoints*

*Note*

The total length field defines the total   
length of the datagram including the

header.

20.16

20.17

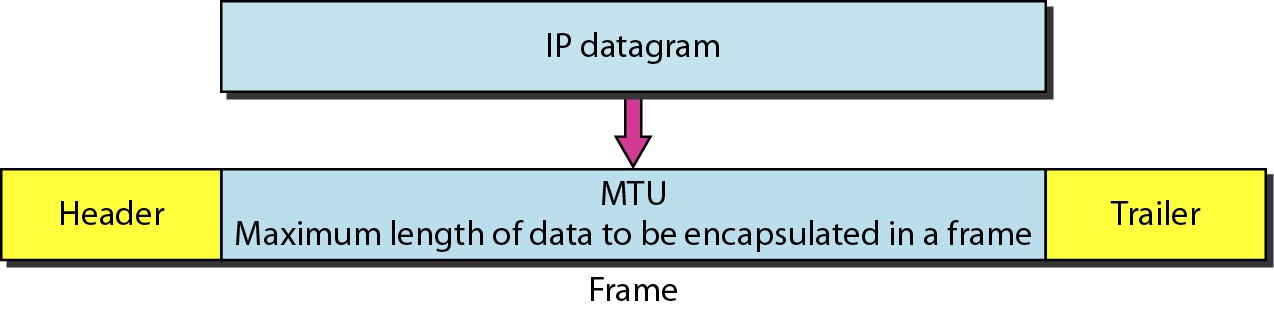
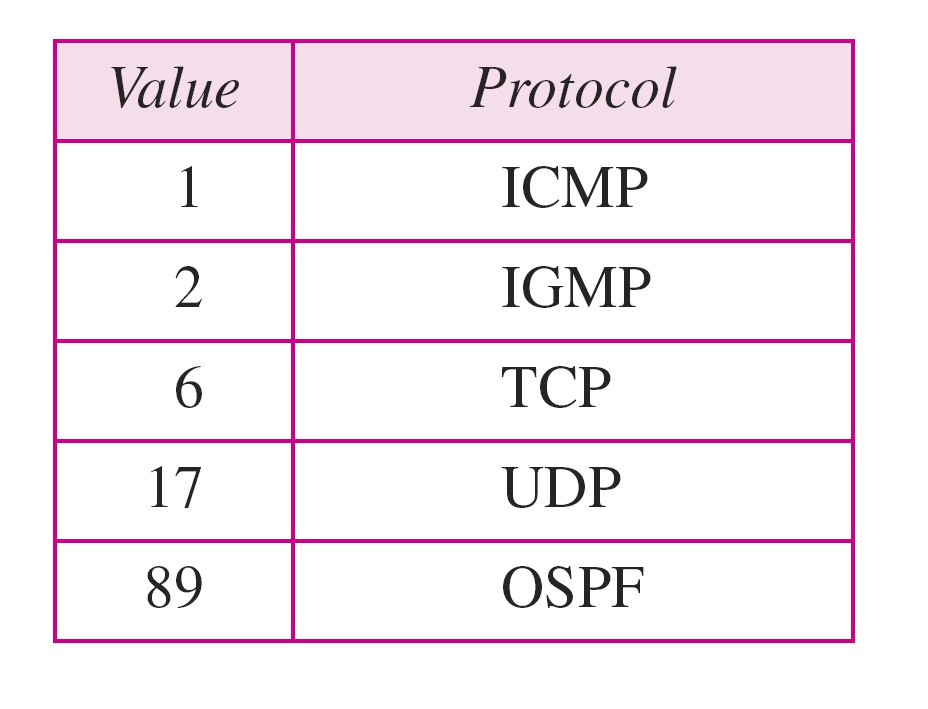
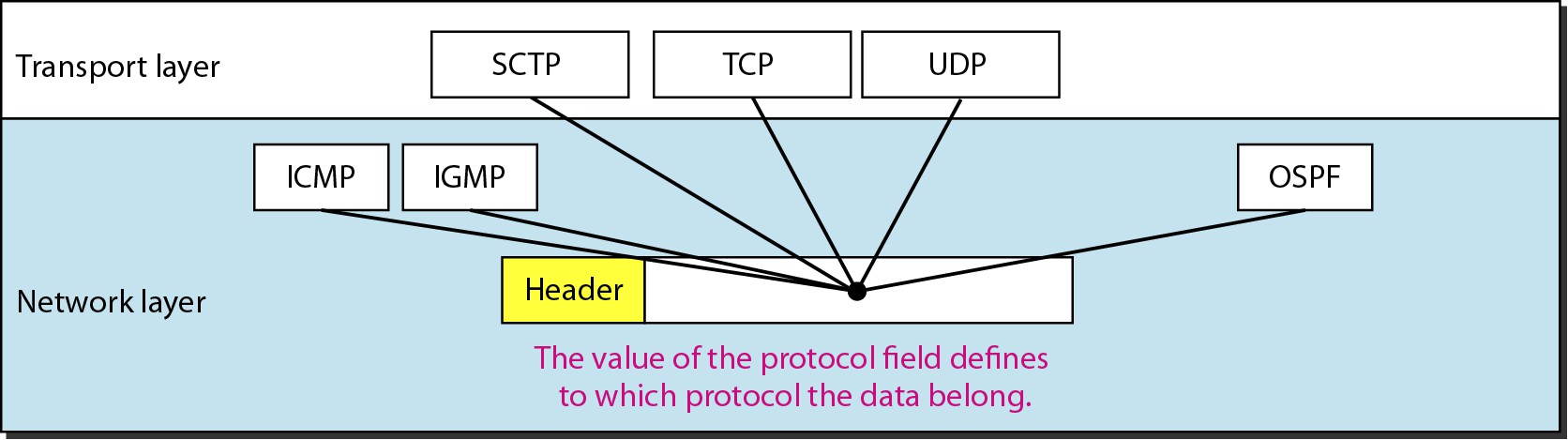
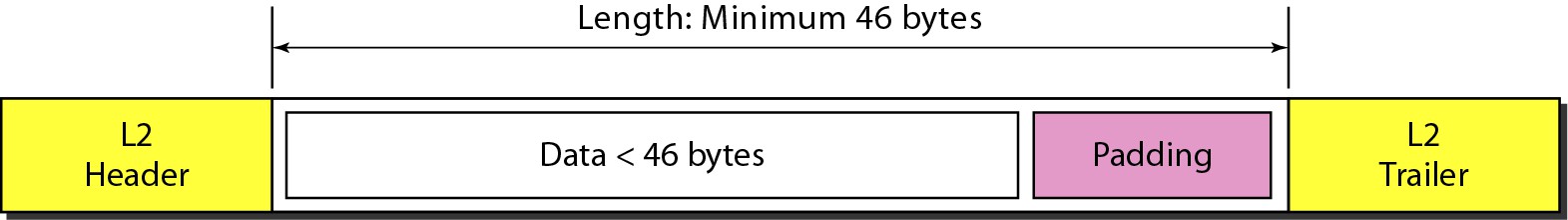


Figure 20.7 *Encapsulation of a small datagram in an Ethernet frame* Figure 20.8 *Protocol field and encapsulated data*

20.18 20.19

Figure 20.9 *Maximum transfer unit (MTU)*

Table 20.4 *Protocol values*

20.20

20.21

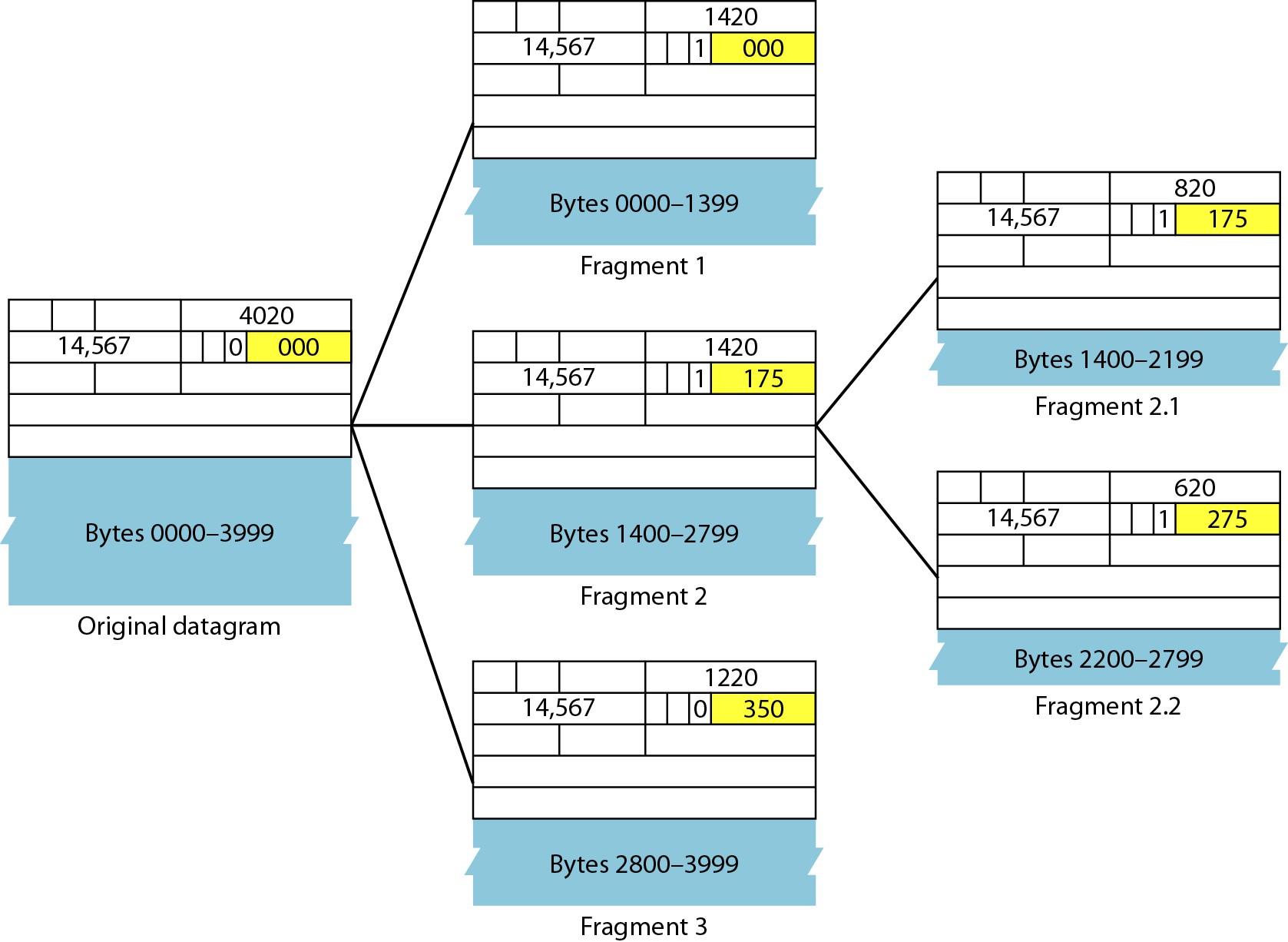
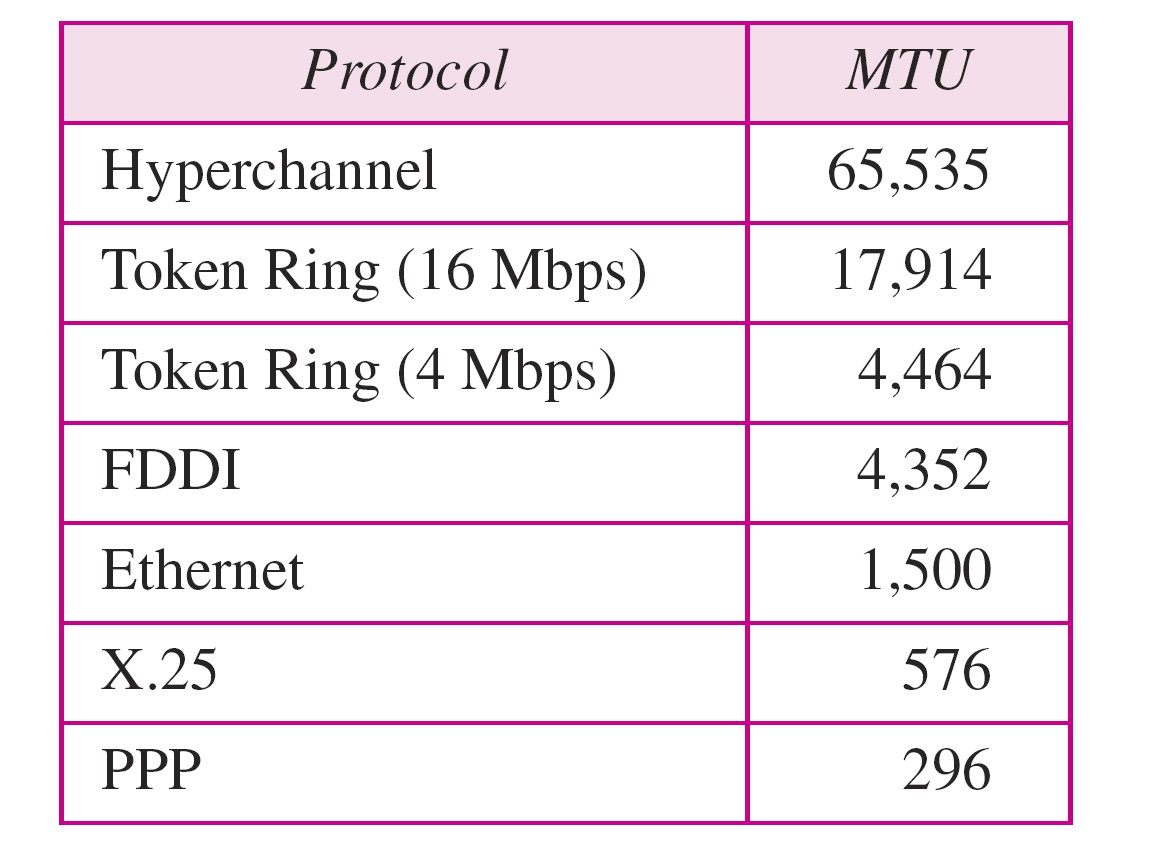


Table 20.5 *MTUs for some networks* Figure 20.10 *Flags used in fragmentation*

20.22 20.23

Figure 20.12 *Detailed fragmentation example*

Figure 20.11 *Fragmentation example*

20.24

20.25

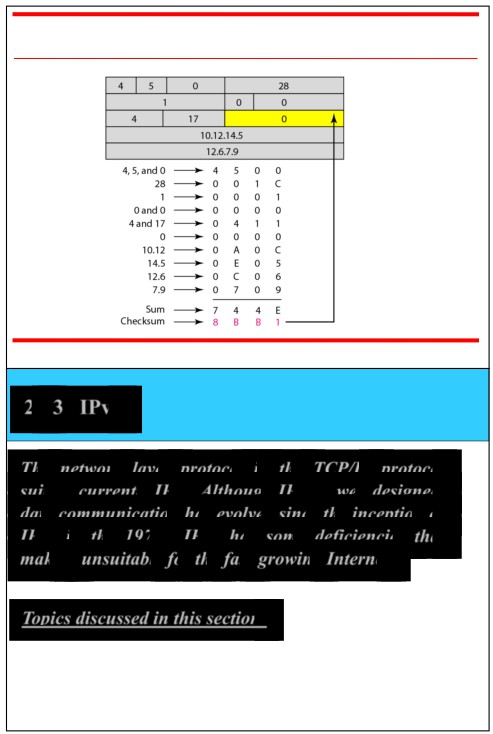
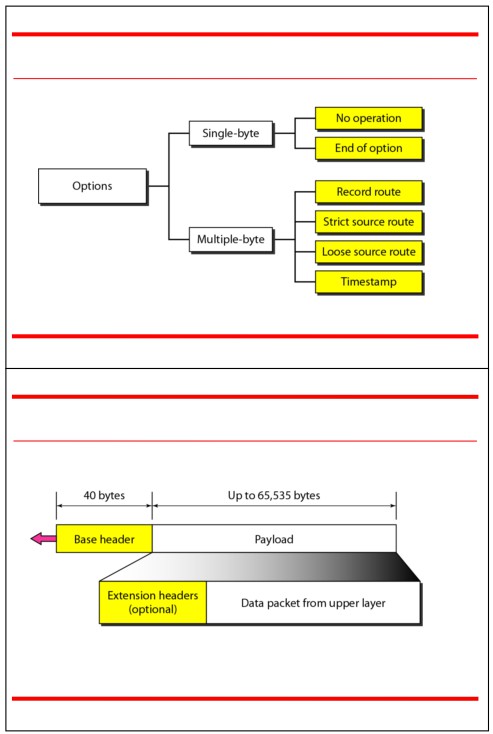


Figure 20.13 *Example of checksum calculation in IPv4*

Figure 20.14 *Taxonomy of options in IPv4*

20.26 20.27

20-3 IPv6

Figure 20.15 *IPv6 datagram header and payload*

*The network layer protocol in the TCP/IP protocol*   
*suite is currently IPv4. Although IPv4 is well designed,*   
*data communication has evolved since the inception of*   
*IPv4 in the 1970s. IPv4 has some deficiencies that*   
*make it unsuitable for the fast-growing Internet.*

*Topics discussed in this section:*

Packet Format

Extension Headers

20.28

20.29

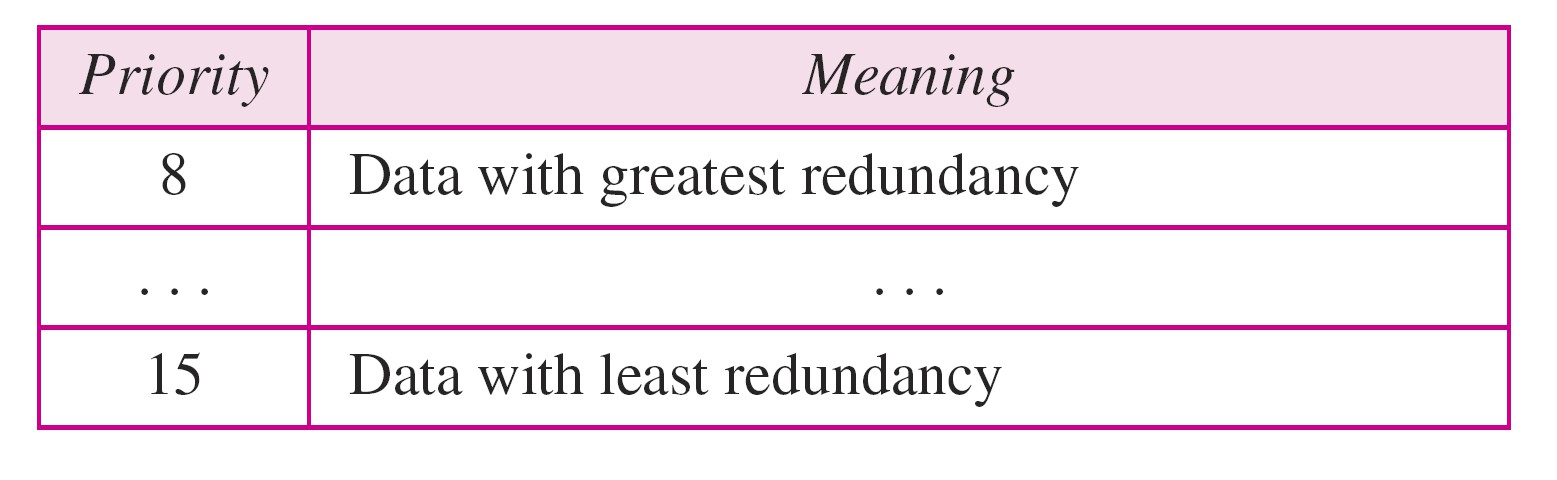
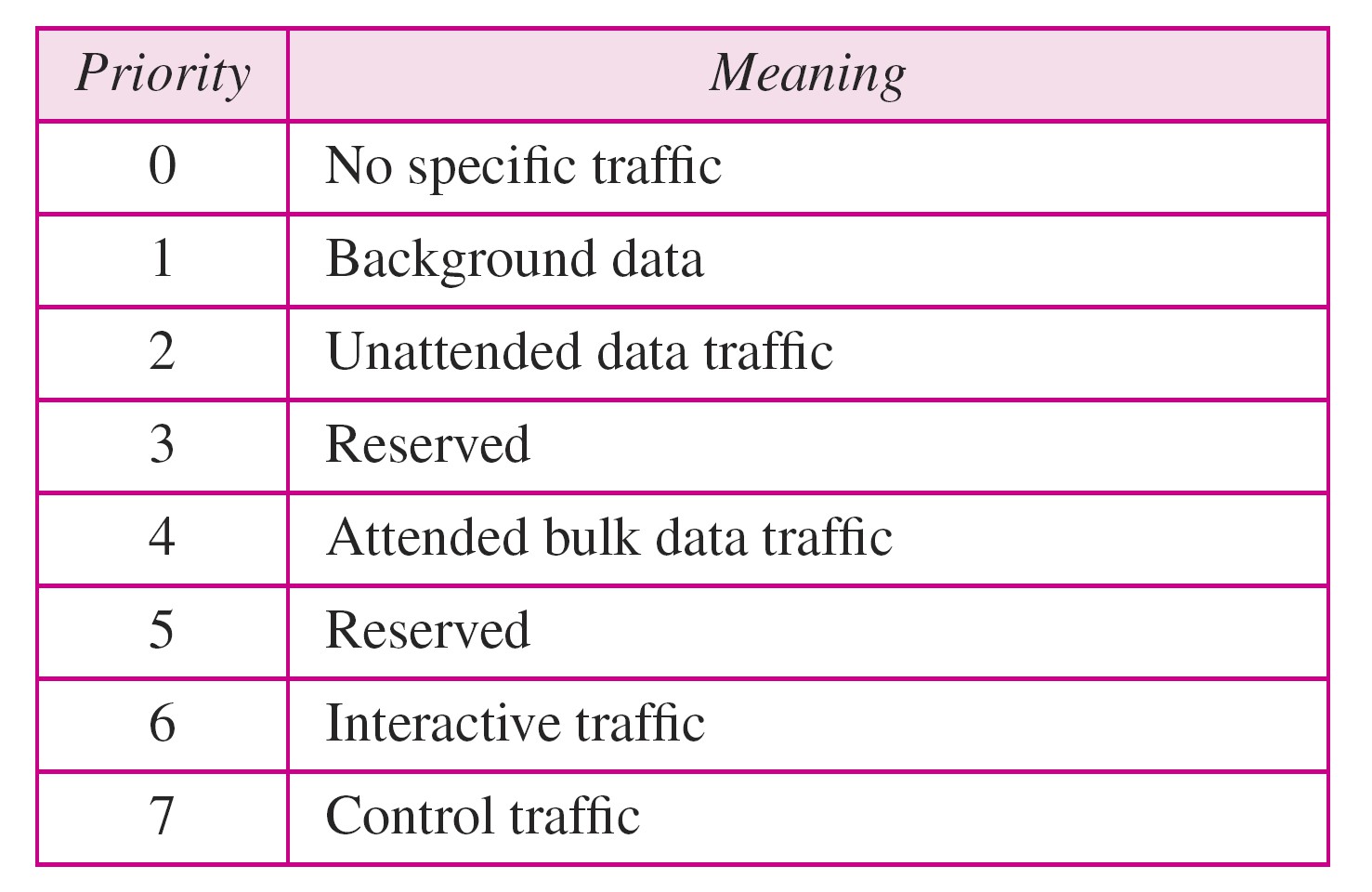
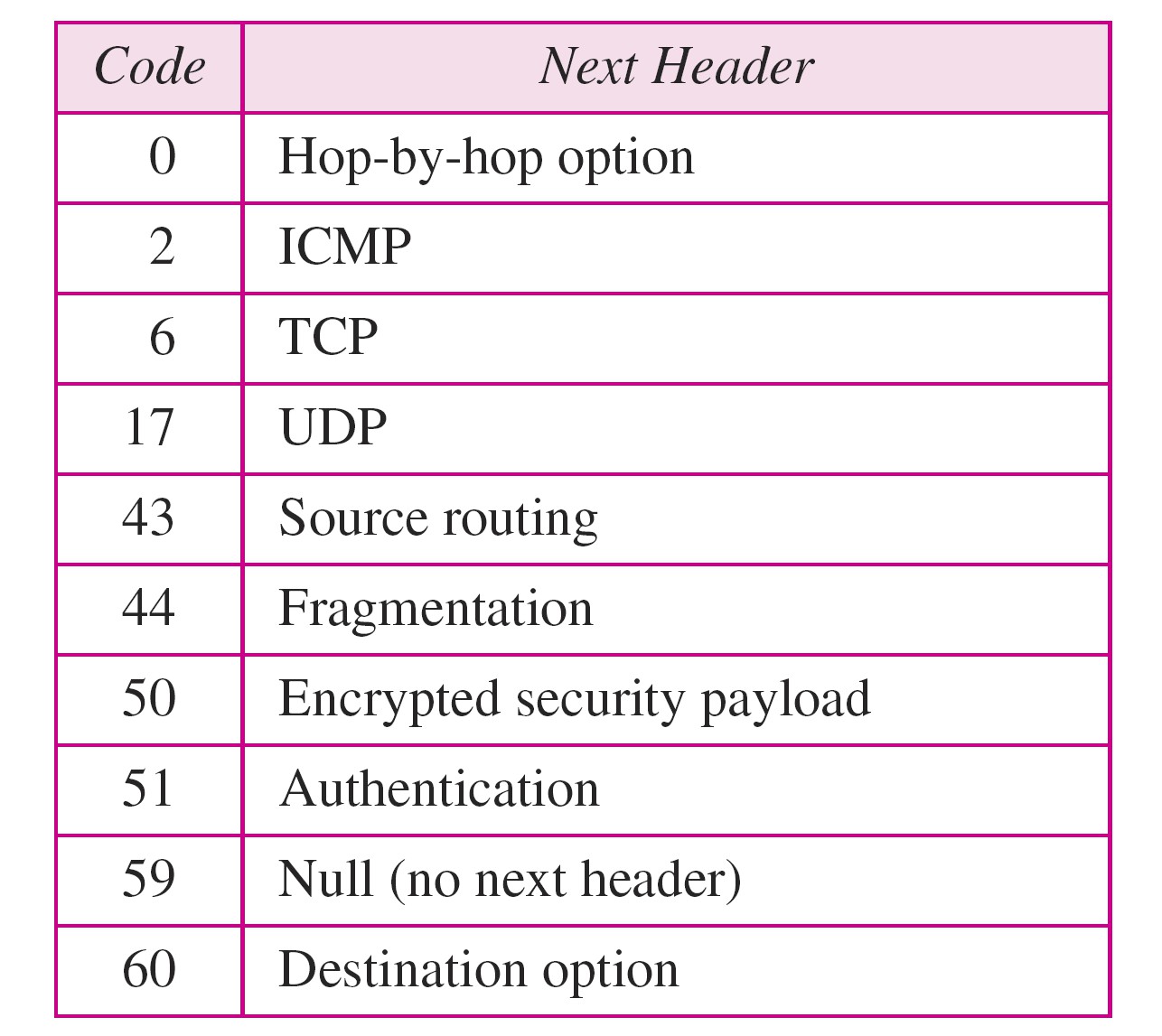
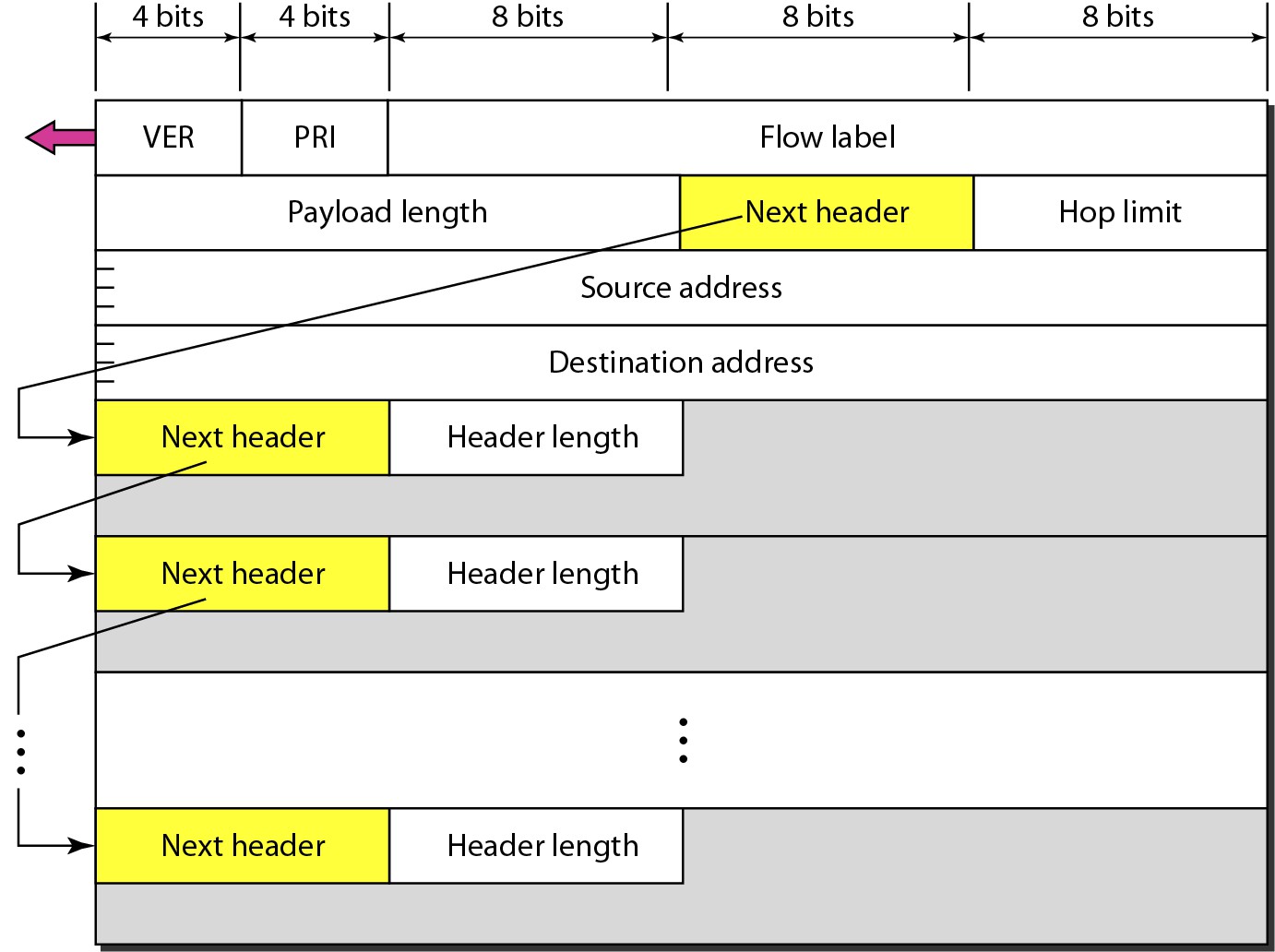


Figure 20.16 *Format of an IPv6 datagram* Table 20.6 *Next header codes for IPv6*

20.30 20.31

Table 20.7 *Priorities for congestion-controlled traffic*

Table 20.8 *Priorities for noncongestion-controlled traffic*

20.32

20.33

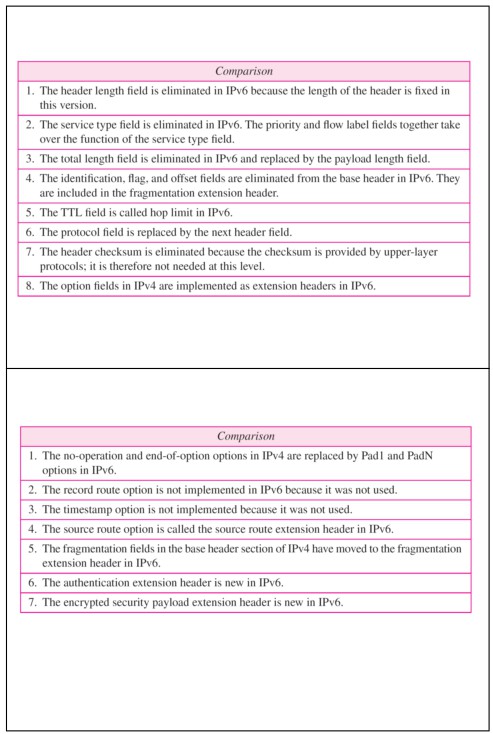
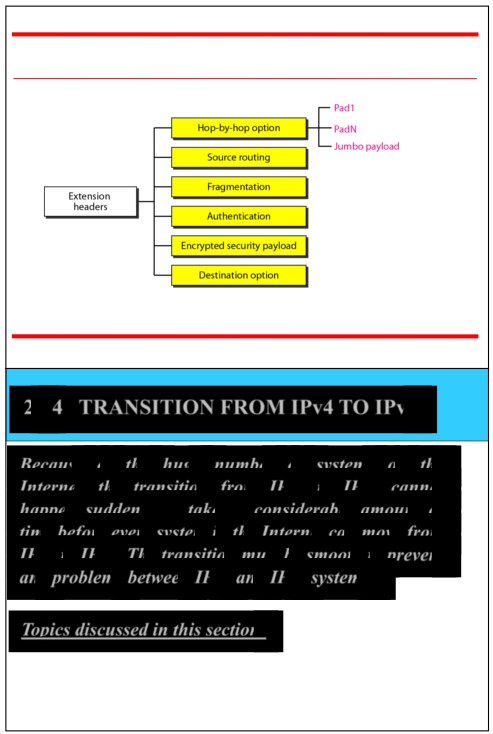


Table 20.9 *Comparison between IPv4 and IPv6 packet headers*

Figure 20.17 *Extension header types*

20.34

Table 20.10 *Comparison between IPv4 options and IPv6 extension headers*

20.36

20.35

20-4 TRANSITION FROM IPv4 TO IPv6

*Because of the huge number of systems on the*

*Internet, the transition from IPv4 to IPv6 cannot*   
*happen suddenly. It takes a considerable amount of*

*time before every system in the Internet can move from*

*IPv4 to IPv6. The transition must be smooth to prevent any problems between IPv4 and IPv6 systems.*

*Topics discussed in this section:*

Tunneling

Header Translation

20.37

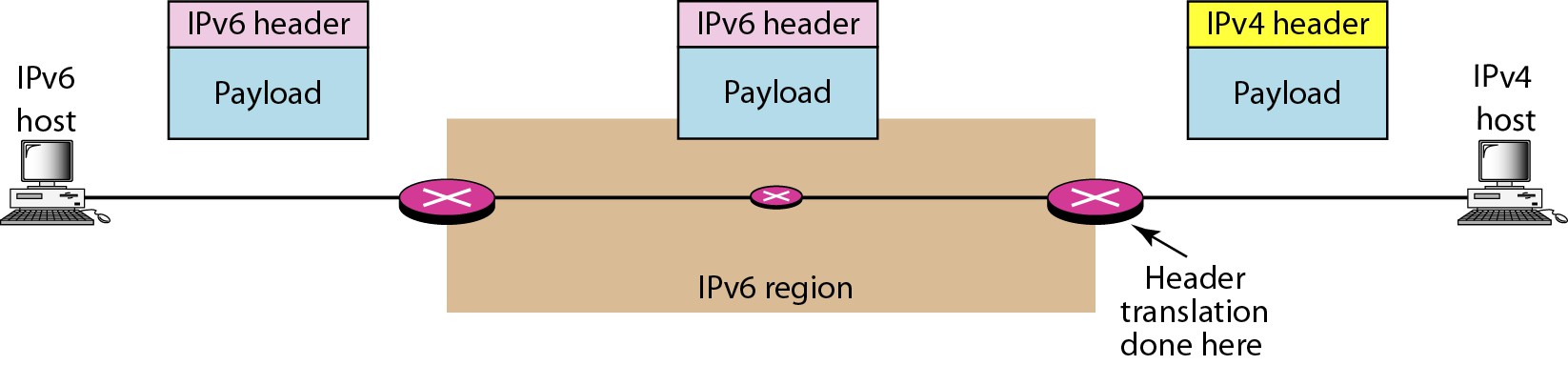
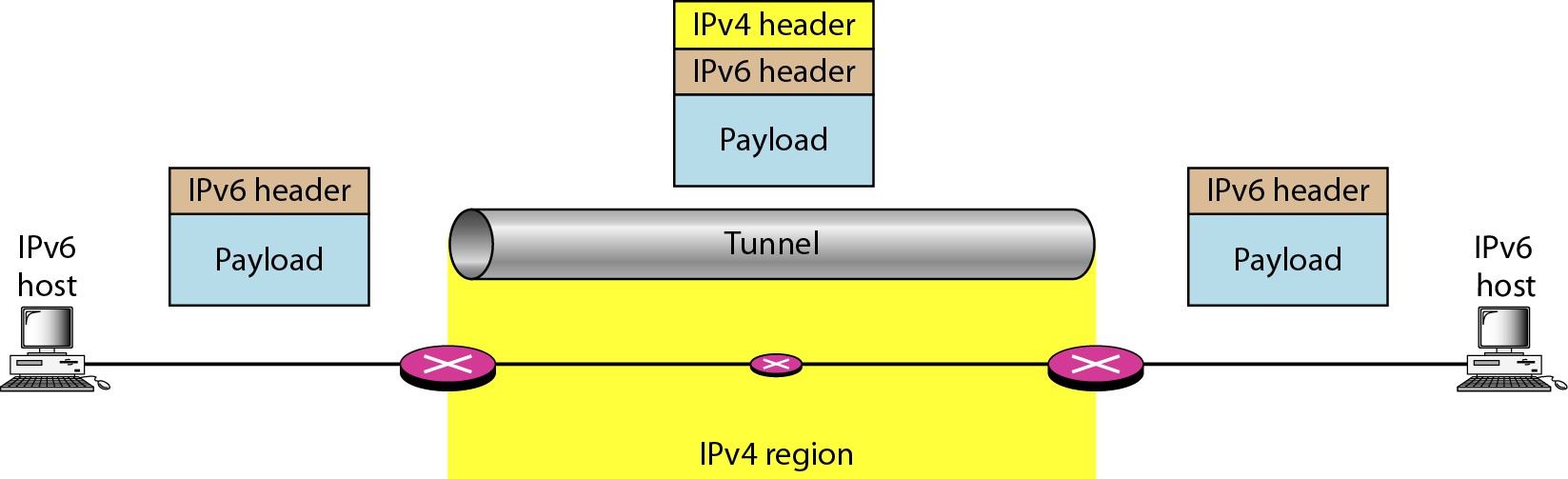
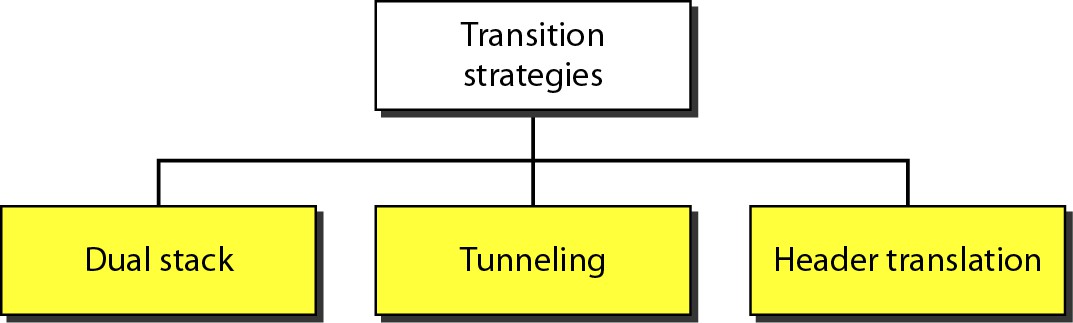


Figure 20.18 *Three transition strategies* Figure 20.19 *Dual stack*

20.38 20.39

Figure 20.20 *Tunneling strategy* Figure 20.21 *Header translation strategy*

20.40

20.41

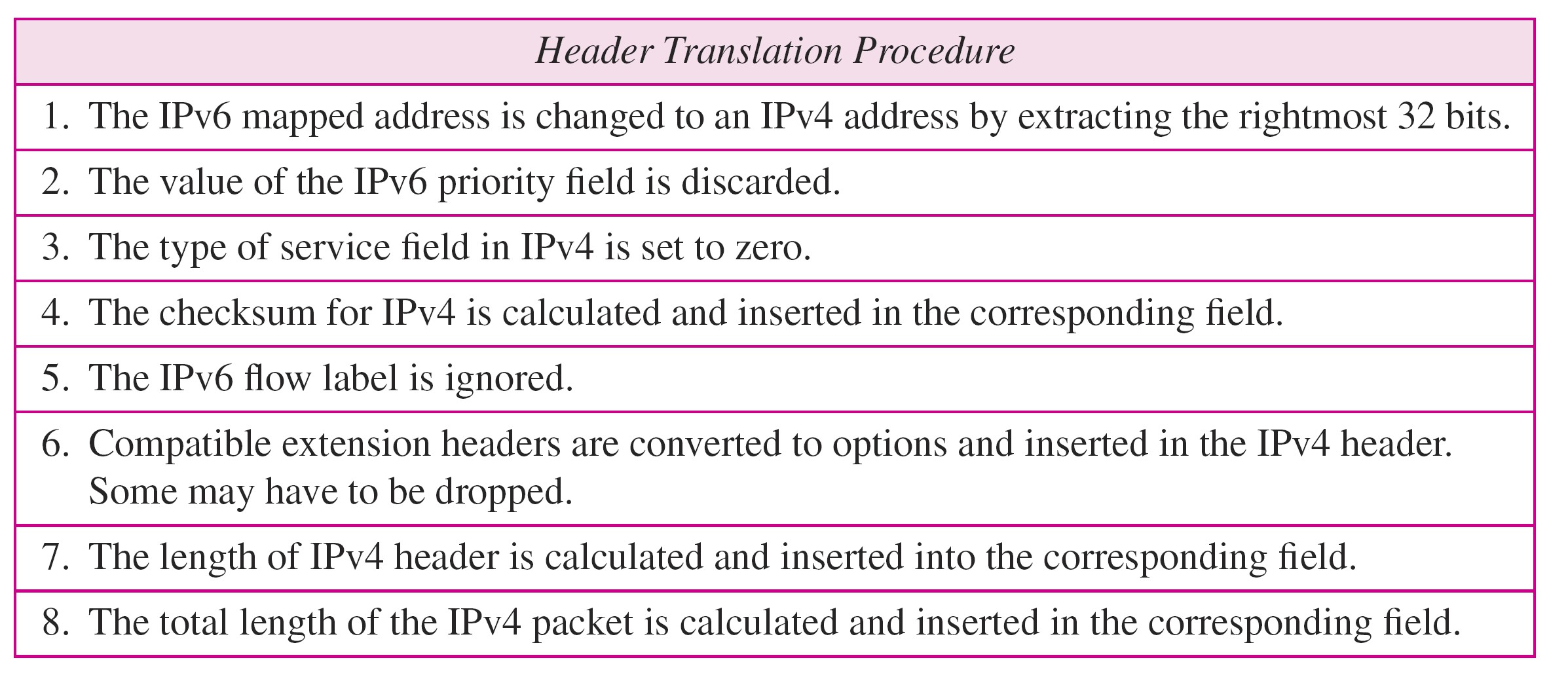


Table 20.11 *Header translation*

20.42