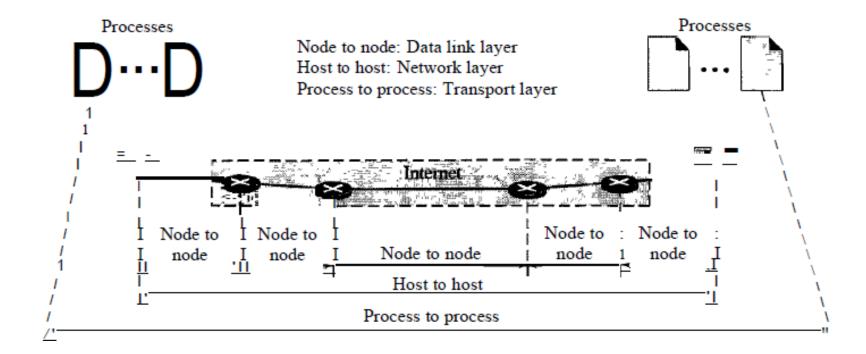
Transport Layer

UDP, TCP Protocols, Congestion control & QoS,Tunneling, Virtual Private Networks, MPLS,Overlay networks. Multiple Access & Ethernet:Random access, Controlled Access,Channelization, Socket programming

- process-to-process delivery of the entire message
- connectionless or connection-oriented
- Message -→segments



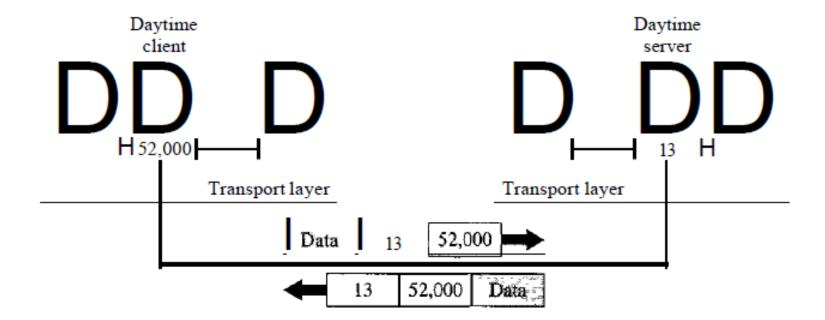
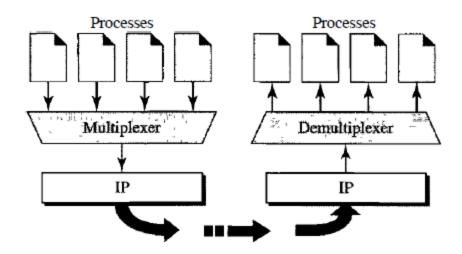


Figure 23.6 Multiplexing and demultiplexing



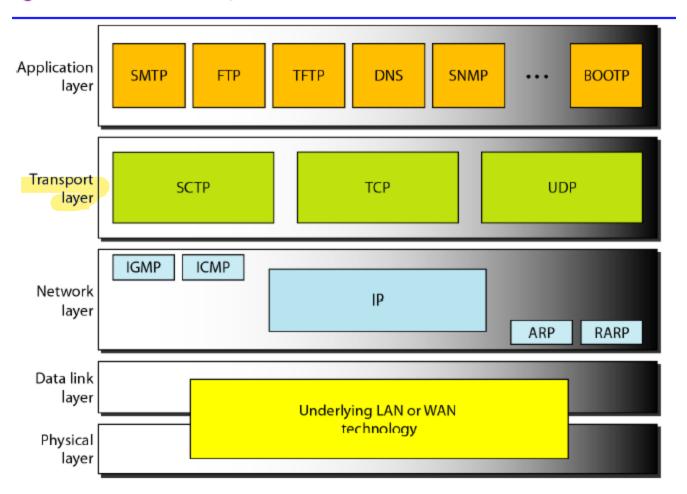
Connectionless Service

- No need for connection establishment or connection release.
- They may be delayed or lost or may arrive out of sequence
- no acknowledgment
- Unreliable

Connection Oriented Service

- First established between the sender and the receiver
- end, the connection is released
- Acknowledgment
- Reliable

igure 23.8 Position of UDP, TCP, and SCTP in TCP/IP suite



USER DATAGRAM PROTOCOL (UDP)

- connectionless, unreliable transport protocol.
- minimum of overhead
- small message
 \(\rightarrow\) takes much less interaction

Figure 23.9 User datagram format

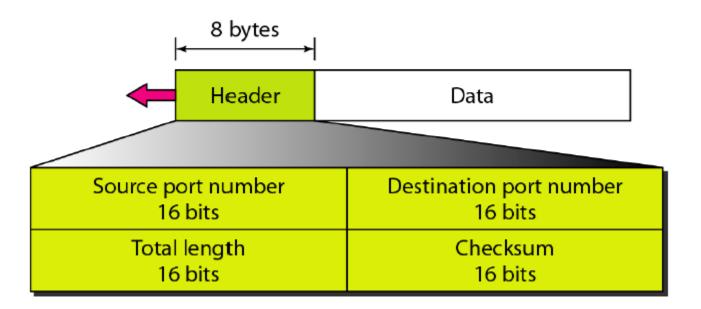
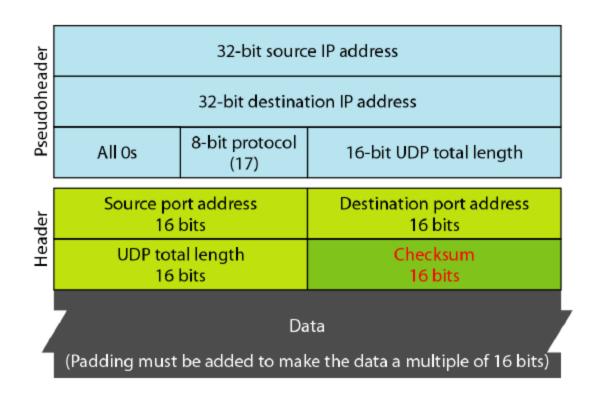


Table 23.1 Well-known ports used with UDP

Port	Protocol	Description
7	Echo	Echoes a received datagram back to the sender
9	Discard	Discards any datagram that is received
11	Users	Active users
13	Daytime	Returns the date and the time
17	Quote	Returns a quote of the day
19	Chargen	Returns a string of characters
53	Nameserver	Domain Name Service
67	BOOTPs	Server port to download bootstrap information
68	BOOTPc	Client port to download bootstrap information
69	TFTP	Trivial File Transfer Protocol
111	RPC	Remote Procedure Call
123	NTP	Network Time Protocol
161	SNMP	Simple Network Management Protocol
162	SNMP	Simple Network Management Protocol (trap)

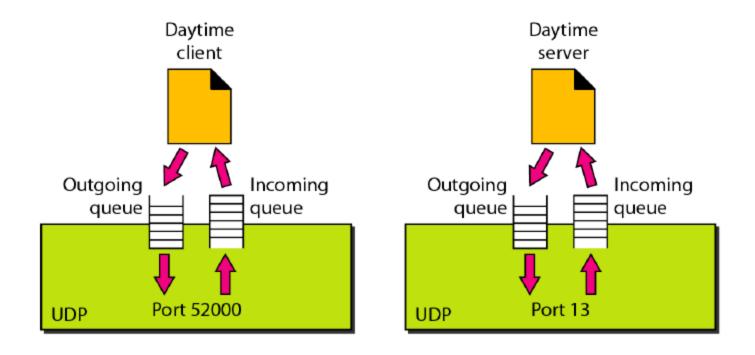
Figure 23.10 Pseudoheader for checksum calculation



UDP Operation

- Connectionless Services
 - no connection establishment and no connection termination
 - NO ACK
- Flow and Error Control
 - no flow control /no error control
 - Receiver detects an error through the checksum
- Encapsulation and Decapsulation

Figure 23.12 Queues in UDP



Use of UDP

- simple request-response communication with little concern for flow and error control.
- suitable for a process with internal flow and error control mechanisms.
- UDP is a suitable transport protocol for multicasting.
- updating protocols such as Routing Information
 Protocol

TCP Protocols Transmission Control Protocol

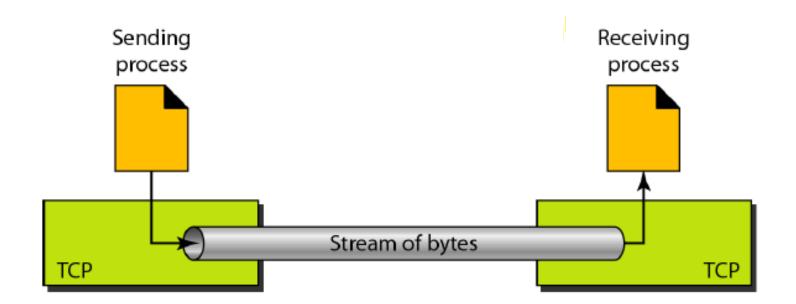
connection-oriented, reliable

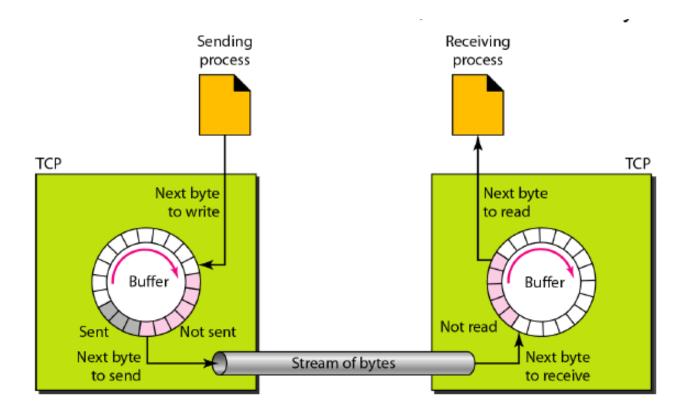
- TCP Services
- TCP Features
- Segment
- A TCP Connection
- Flow Control
- Error Control

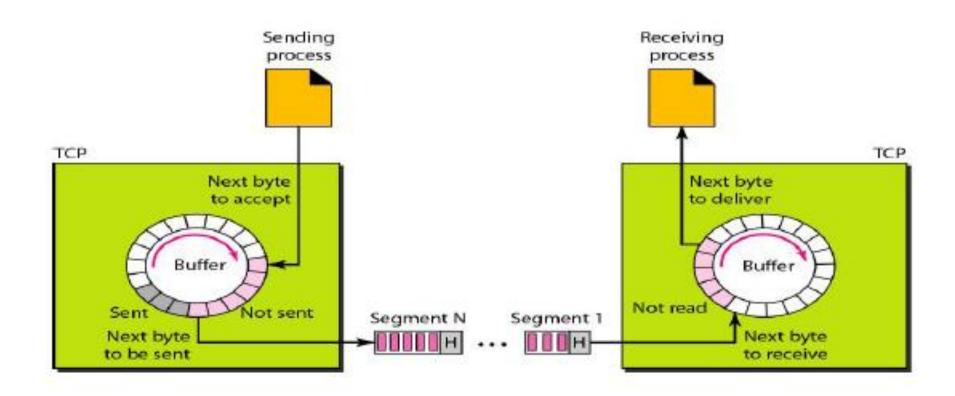
TCP Services

Port	Protocol	Description
7	Echo	Echoes a received datagram back to the sender
9	Discard	Discards any datagram that is received
11	Users	Active users
13	Daytime	Returns the date and the time
17	Quote	Returns a quote of the day
19	Chargen	Returns a string of characters
20	FTP, Data	File Transfer Protocol (data connection)
21	FTP, Control	File Transfer Protocol (control connection)
23	TELNET	Terminal Network
25	SMTP	Simple Mail Transfer Protocol
53	DNS	Domain Name Server
67	ВООТР	Bootstrap Protocol
79	Finger	Finger
80	HTTP	Hypertext Transfer Protocol
111	RPC	Remote Procedure Call

Stream Delivery Service







Connection-Oriented Service

- The two TCPs establish a connection between them.
- 2. Data are exchanged in both directions.
- 3. The connection is terminated.

TCP Features

- Byte Number
- Sequence Number
- Acknowledgment Number
- Flow Control
- Error Control
- Congestion Control

TCP segment format Header Data Source port address Destination port address 16 bits 16 bits Sequence number 32 bits Acknowledgment number 32 bits Reserved Window size **HLEN** S 4 bits 6 bits 16 bits Ν Checksum Urgent pointer 16 bits 16 bits Options and Padding

URG: Urgent pointer is valid ACK: Acknowledgment is valid

PSH: Request for push

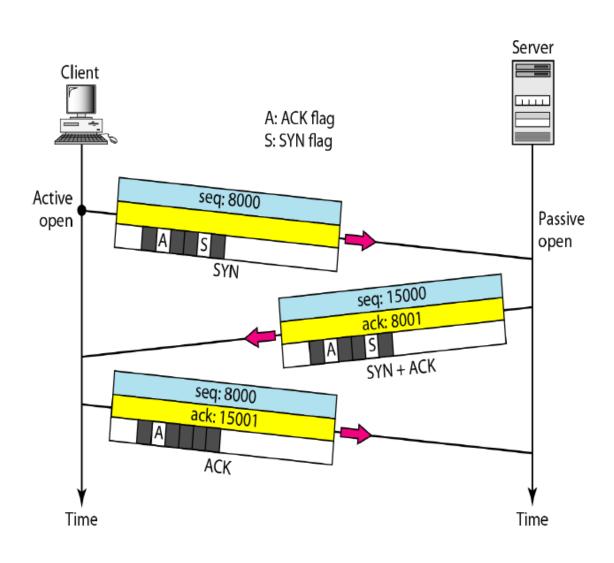
RST: Reset the connection

SYN: Synchronize sequence numbers

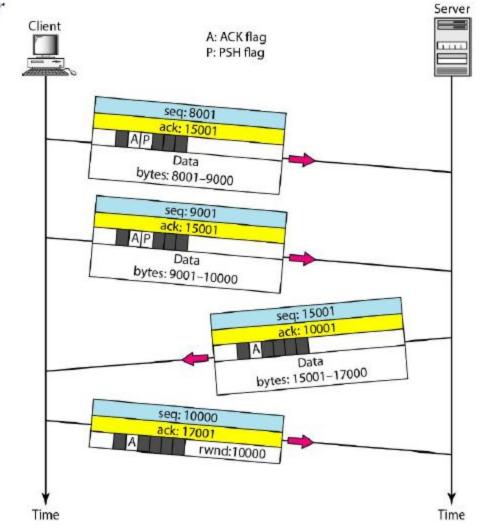
FIN: Terminate the connection

URG ACK PSH RST SYN FIN

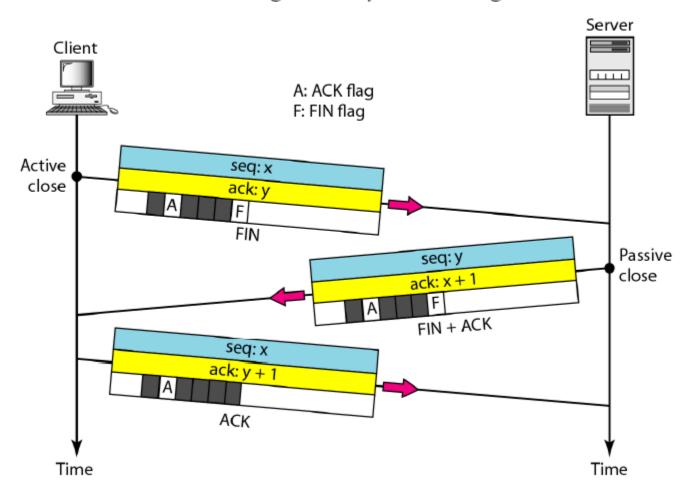
TCP connection establishment(3 way handshaking)



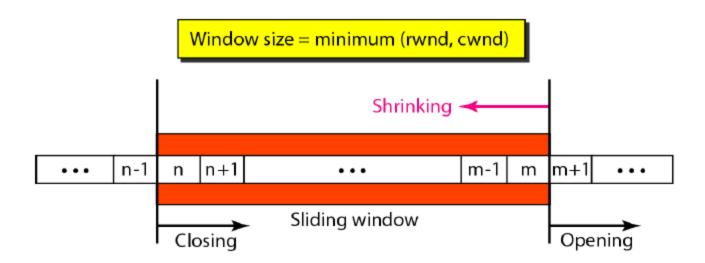
Data transfer



Connection termination using three-way handshaking



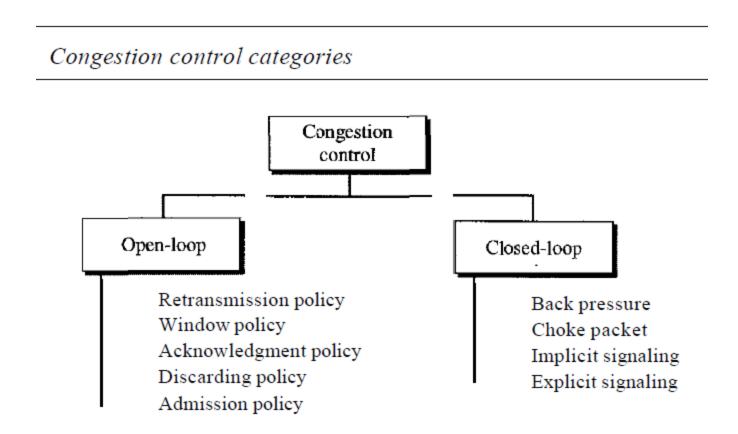
Sliding window



size of the window = receiver window (rwnd) or congestion window (cwnd).

CONGESTION CONTROL

 Congestion control refers to techniques and mechanisms that can either prevent congestion, before it happens, or remove congestion, after it has happened



Open-Loop Congestion Control

(prevent congestion before it happens)

- Retransmission Policy
 - Retransmission increase congestion in the network
- Window Policy
 - Selective Repeat window is better than the Go-Back-N window
- Acknowledgment Policy
 - slow down the sender and help prevent congestion
 - load in a network
- Discarding Policy
 - not harm the integrity of the transmission
 - EXAMPLE : TELEPHONE CALL
- Admission Policy:
 - check the resource requirement of a flow before admitting it to the network

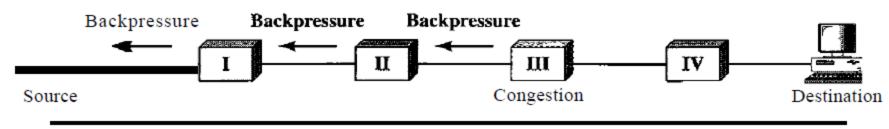
Closed-Loop Congestion Control

(congestion after it happens)

Backpressure:

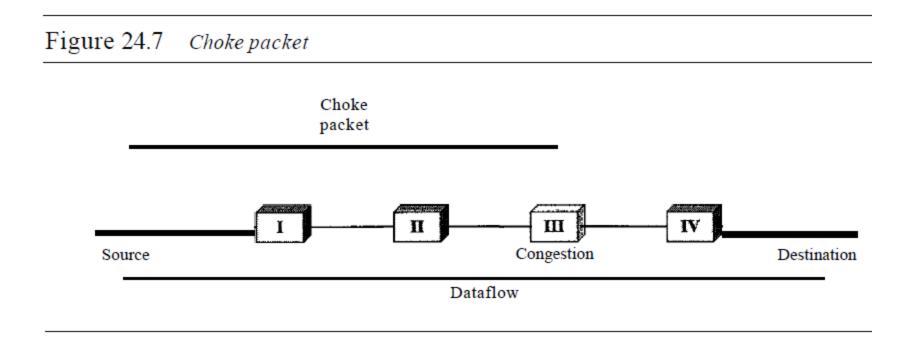
- congested node stops receiving data from the immediate upstream node or nodes
- node and propagates, in the opposite direction of data flow, to the source

Figure 24.6 Backpressure methodfor alleviating congestion



Choke Packet

packet sent by a node to the source to inform it of congestion

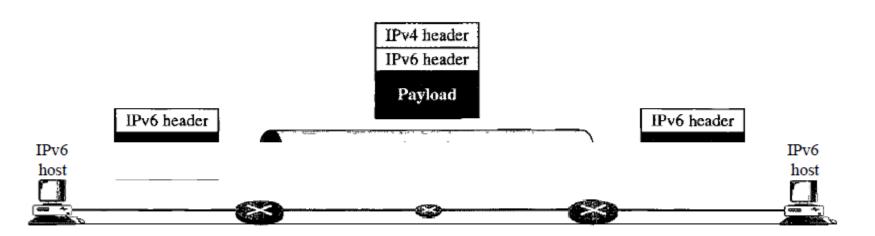


- Implicit Signaling source guesses that there is a congestion somewhere in the network from other symptoms
- Explicit Signaling send a signal to the source or destination
 - Backward Signaling direction opposite to the congestion
 - Forward Signaling SAME direction of the congestion

Tunneling

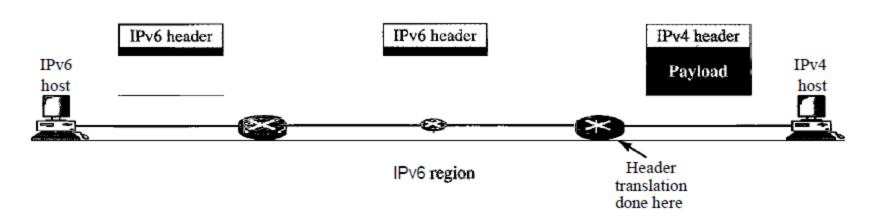
 When two computers using IPv6 want to communicate with each other and the packet must pass through a region that uses IPv4

igure 20.20 Tunneling strategy



Header Translation

Figure 20.21 Header translation strategy

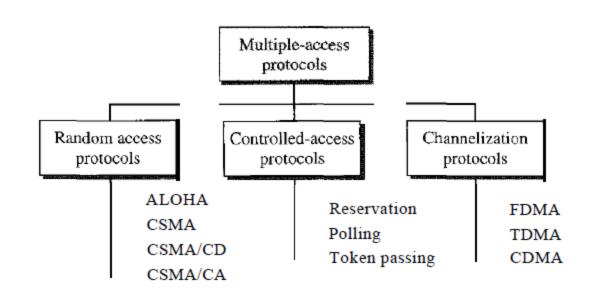


VPN

 https://www.youtube.com/watch?v=40-ie6O-Wkw

multiple-access protocols

Figure 12.2 Taxonomy of multiple-access protocols discussed in this chapter



RANDOM ACCESS

- random access or contention methods
- no station is superior to another station
- Decision depends on the state of the medium (idle or busy)
- Two features
 - no scheduled time for a station to transmit
 - no rules specify which station should send next

ALOHA

Carrier Sense Multiple Access

Carrier Sense Multiple Access with Collision Detection

Carrier Sense Multiple Access with Collision Avoidance

Figure 12.3 Frames in a pure ALOHA network

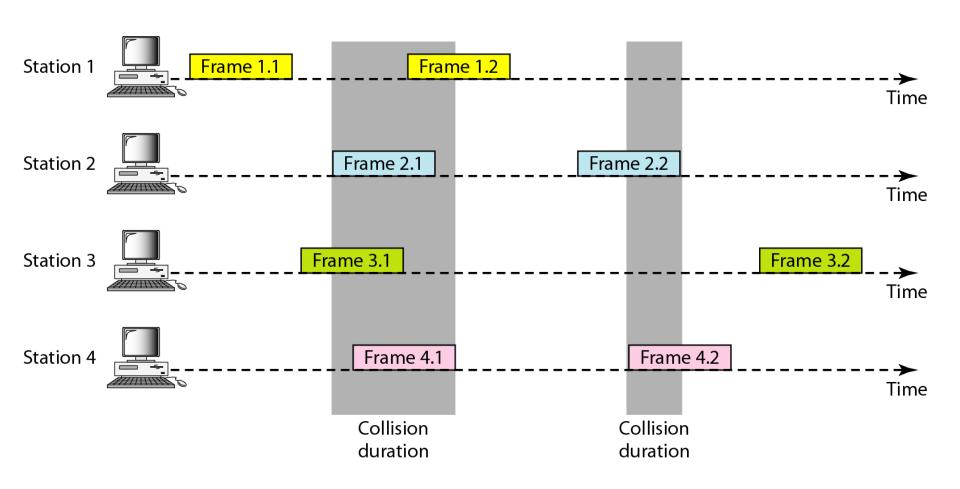


Figure 12.4 Procedure for pure ALOHA protocol

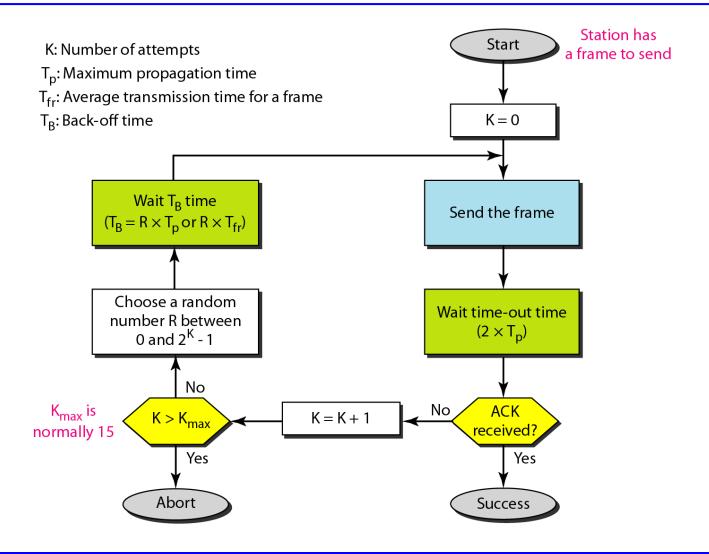


Figure 12.5 Vulnerable time for pure ALOHA protocol

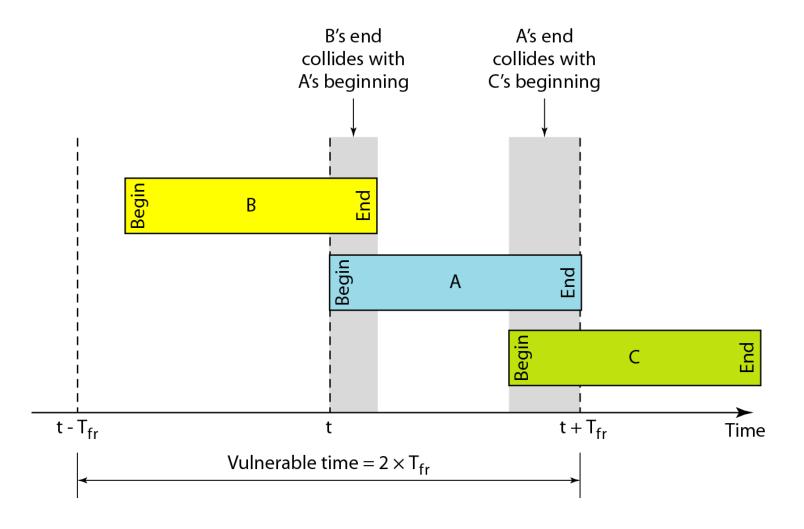


Figure 12.6 Frames in a slotted ALOHA network

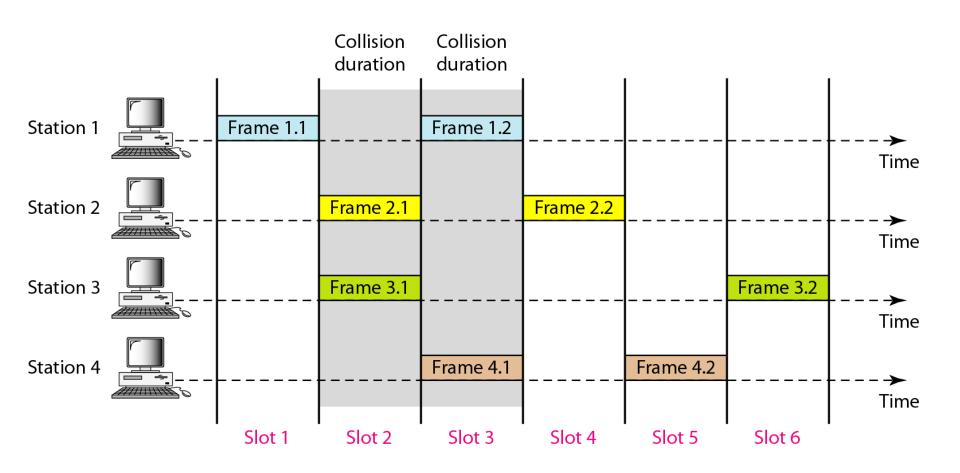


Figure 12.7 Vulnerable time for slotted ALOHA protocol

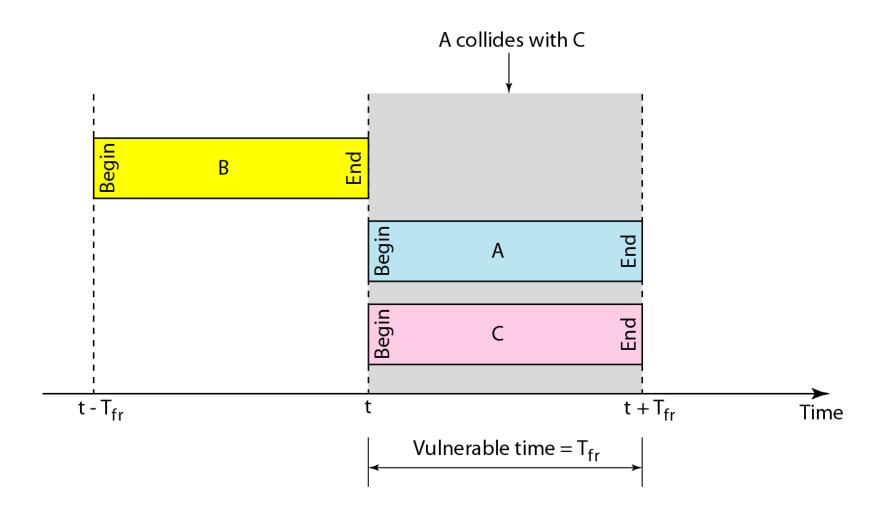


Figure 12.9 Vulnerable time in CSMA

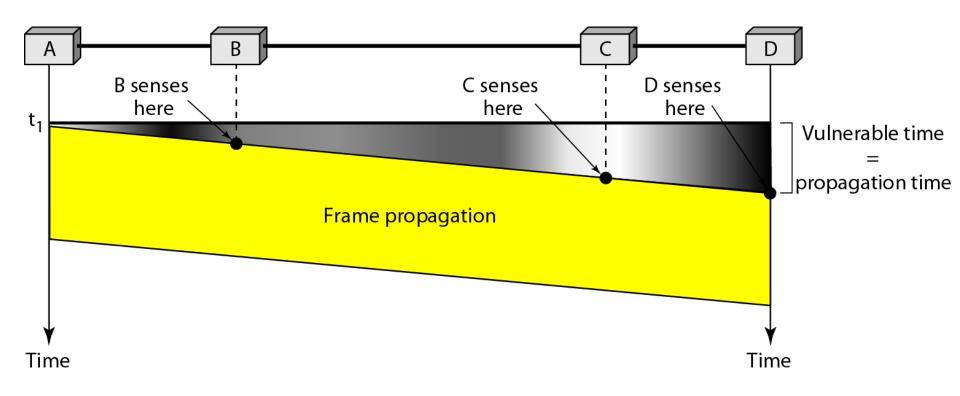


Figure 12.13 Collision and abortion in CSMA/CD

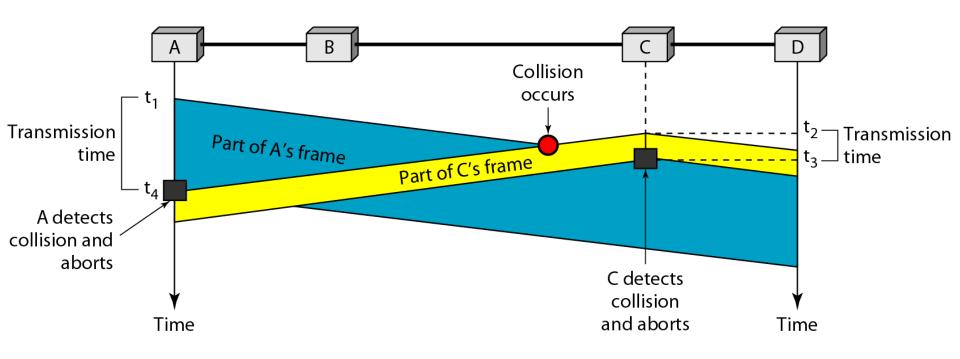


Figure 12.14 Flow diagram for the CSMA/CD

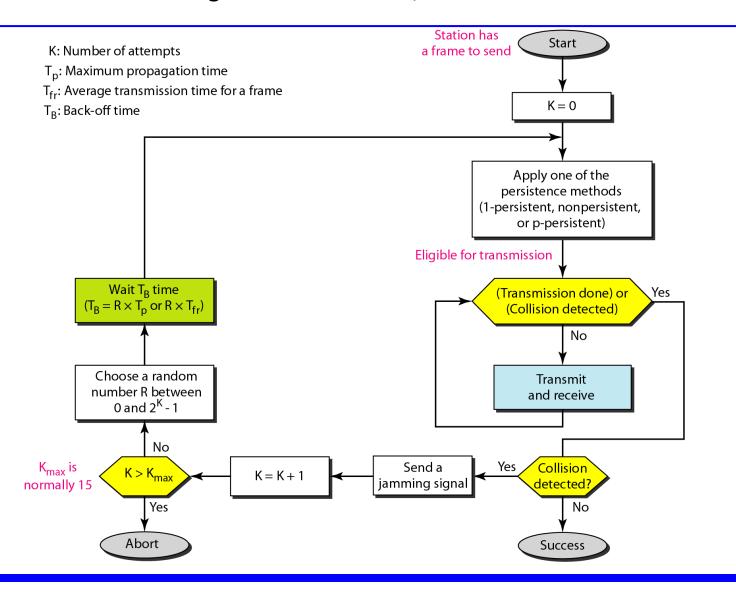


Figure 12.15 Energy level during transmission, idleness, or collision

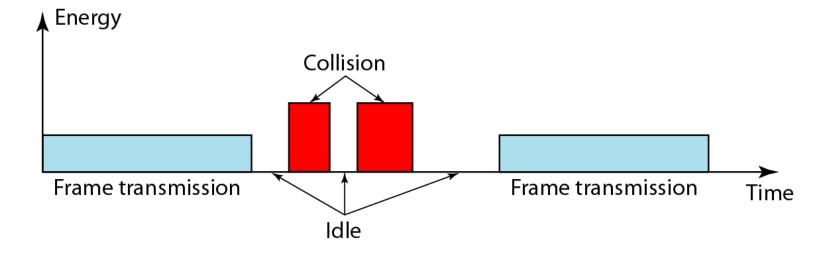
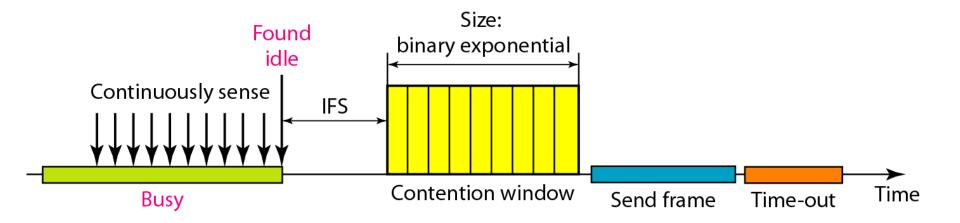


Figure 12.16 Timing in CSMA/CA

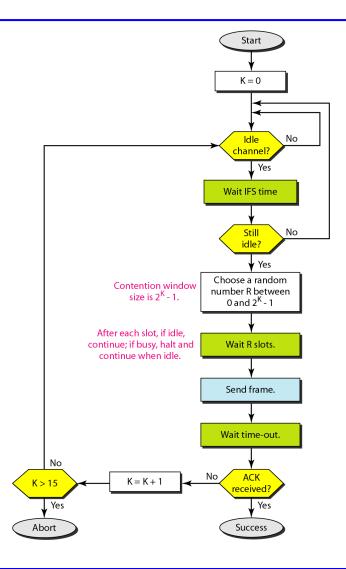




Note

In CSMA/CA, if the station finds the channel busy, it does not restart the timer of the contention window; it stops the timer and restarts it when the channel becomes idle.

Figure 12.17 Flow diagram for CSMA/CA



CONTROLLED ACCESS

- In controlled access, the stations consult one another to find which station has the right to send. A station cannot send unless it has been authorized by other stations.
- ReservationPollingToken Passing

Figure 12.18 Reservation access method

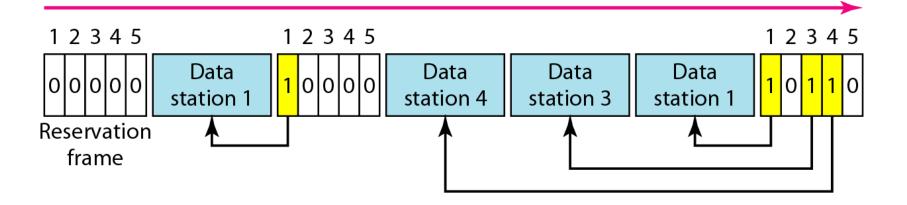


Figure 12.19 Select and poll functions in polling access method

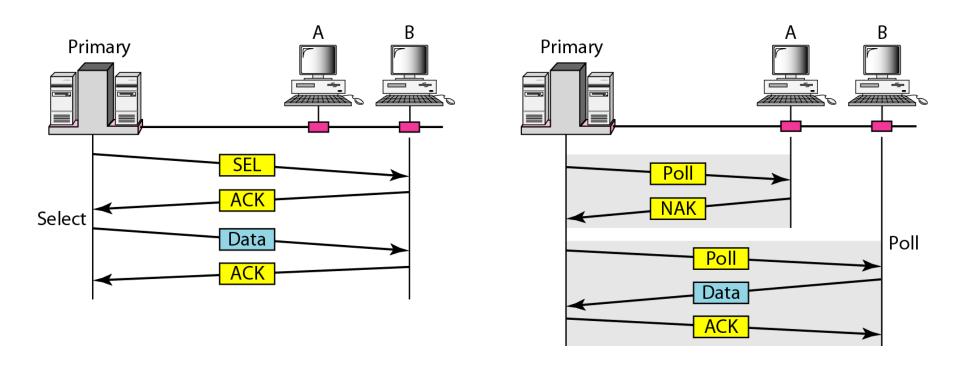
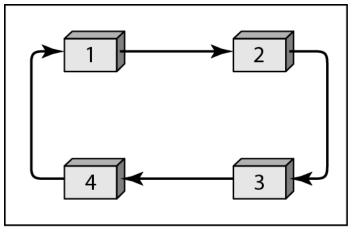
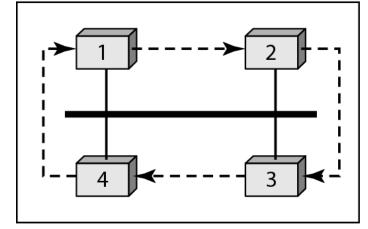


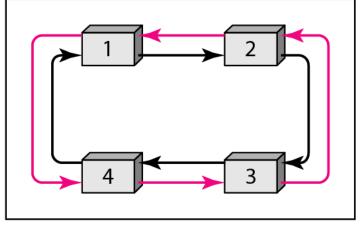
Figure 12.20 Logical ring and physical topology in token-passing access method



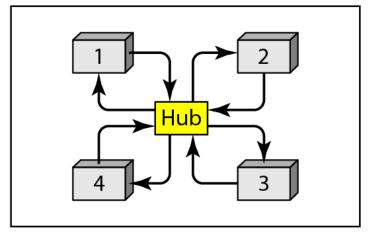
a. Physical ring



c. Bus ring



b. Dual ring



d. Star ring

CHANNELIZATION

Channelization is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, between different stations.

- Frequency-Division Multiple Access (FDMA)
- Time-Division Multiple Access (TDMA)
- Code-Division Multiple Access (CDMA)

Figure 12.22 Time-division multiple access (TDMA)

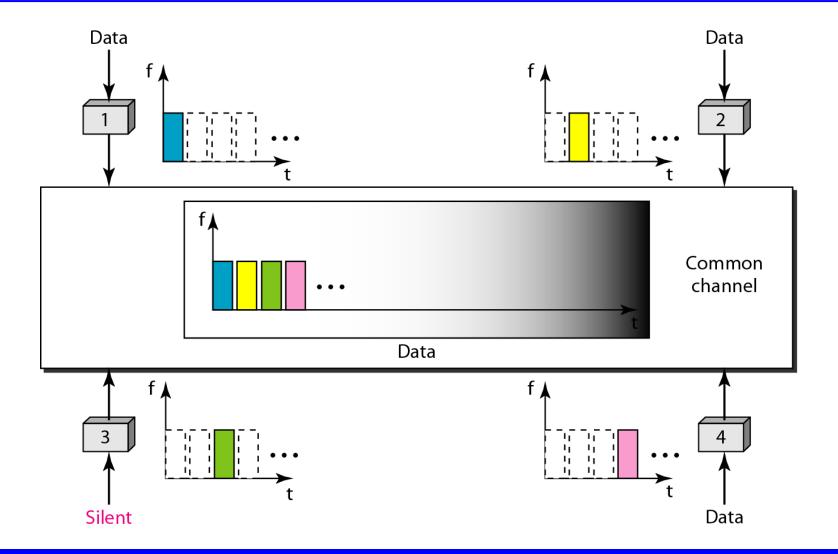


Figure 12.21 Frequency-division multiple access (FDMA)

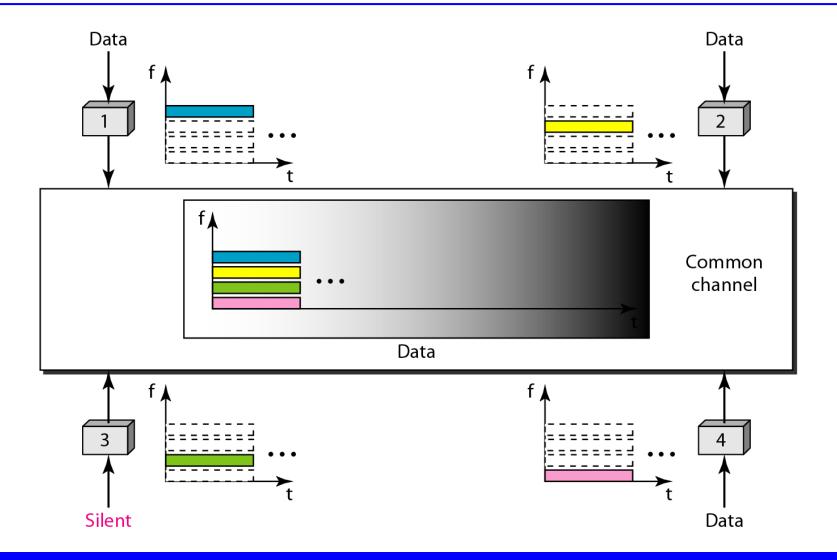


Figure 12.23 Simple idea of communication with code

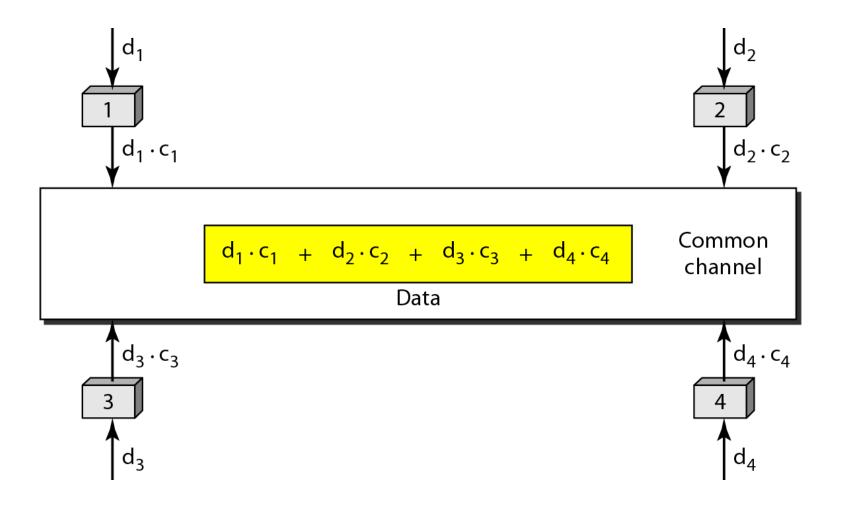


Figure 12.24 Chip sequences

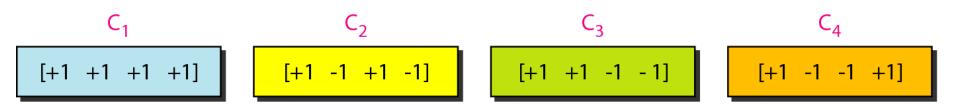
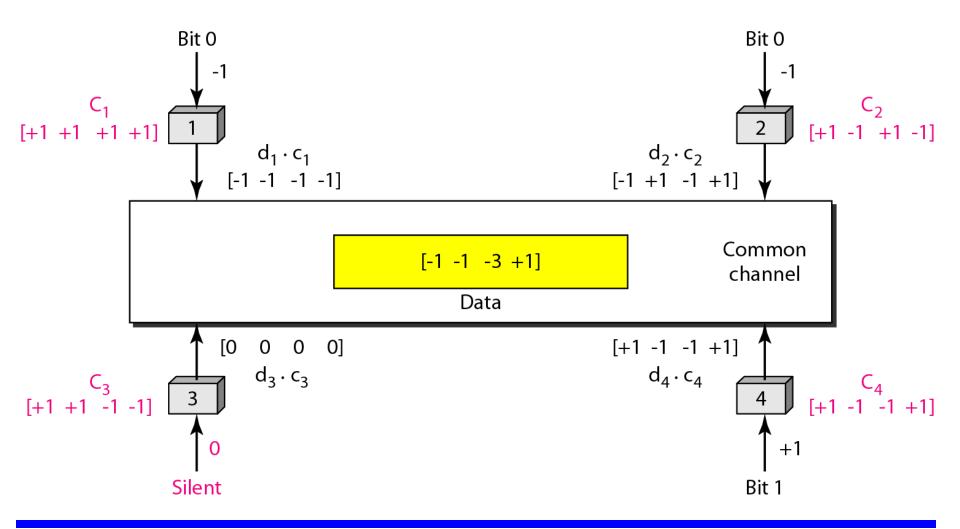


Figure 12.25 Data representation in CDMA



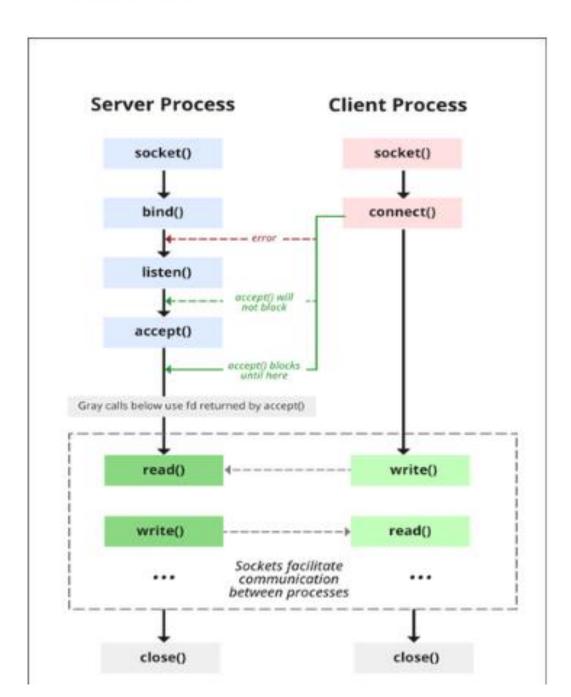
Figure 12.26 Sharing channel in CDMA



socket programming

- Socket programming shows how to use socket APIs to establish communication links between remote and local processes
- reside on the same system or different systems on different networks.
- Sockets are useful for both stand-alone and network applications.

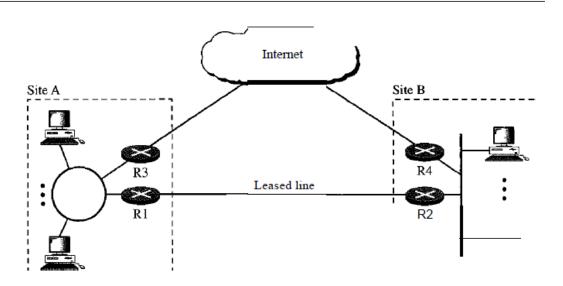
State diagram for server and client model



Virtual Private Networks

- Private wide-area networks (WANs) are expensive
- high monthly fee

Figure 32.11 Hybrid network



 global Internet - both private and public communications -- > virtual private network

Figure 32.12 Virtual private network

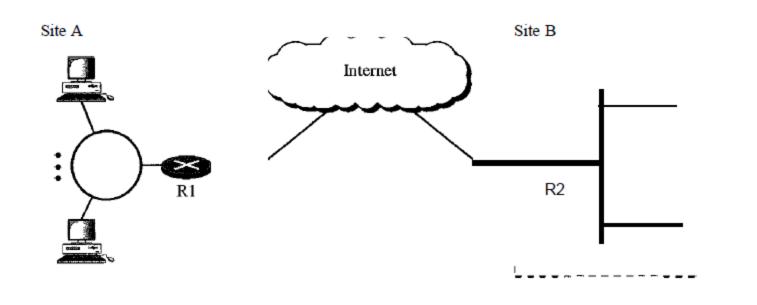


Figure 32.13 Addressing in a VPN

