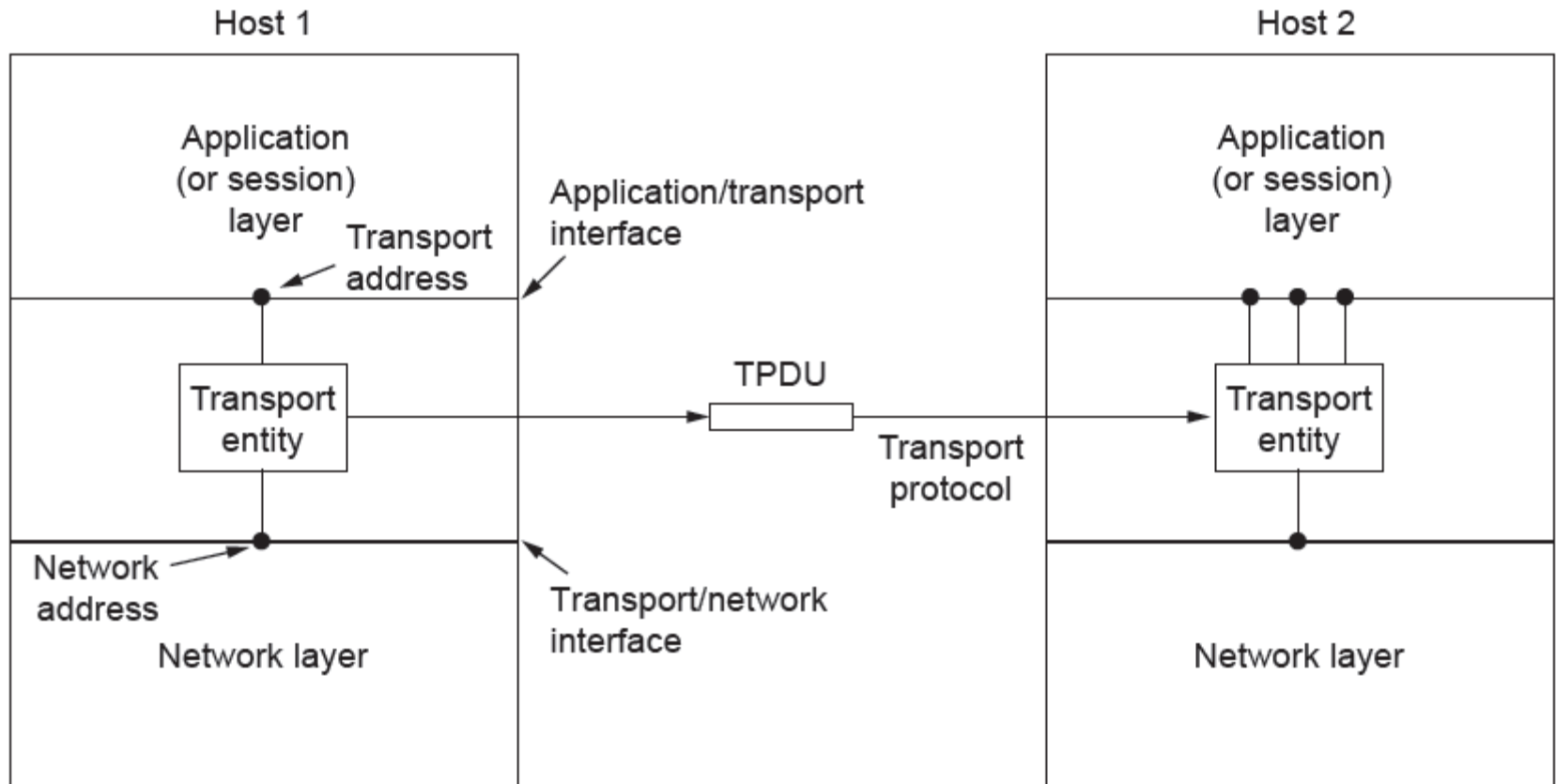


The Transport Layer

Chapter 6

Services Provided to the Upper Layers



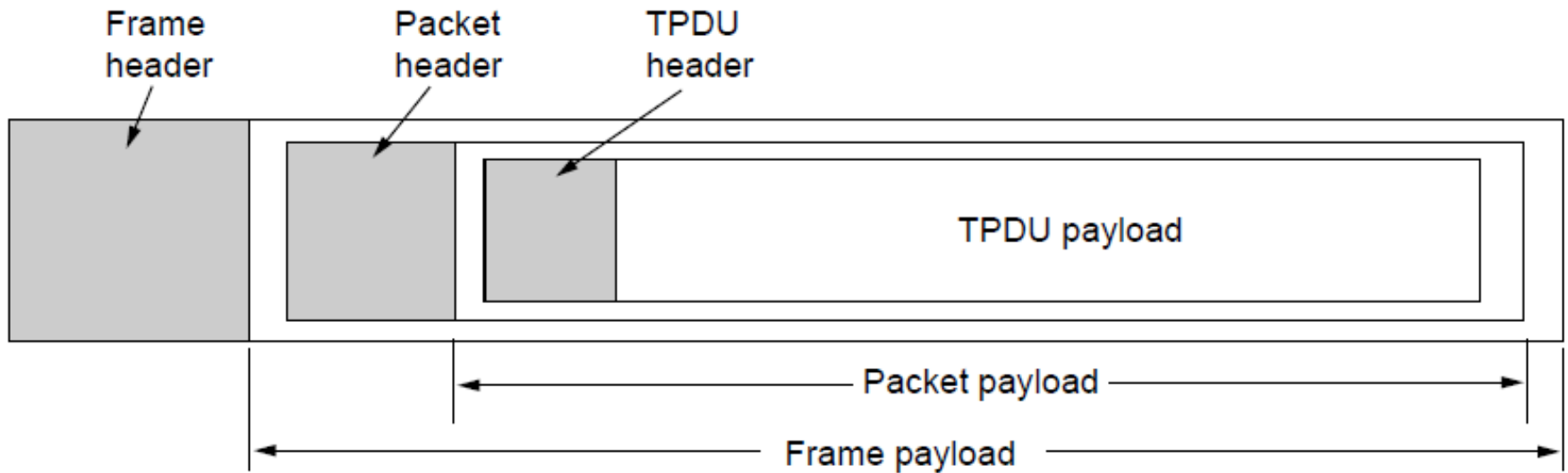
The network, transport, and application layers

Transport Service Primitives (1)

Primitive	Packet sent	Meaning
LISTEN	(none)	Block until some process tries to connect
CONNECT	CONNECTION REQ.	Actively attempt to establish a connection
SEND	DATA	Send information
RECEIVE	(none)	Block until a DATA packet arrives
DISCONNECT	DISCONNECTION REQ.	This side wants to release the connection

The primitives for a simple transport service

Transport Service Primitives (2)



Nesting of TPDU, packets, and frames.

Berkeley Sockets (2)

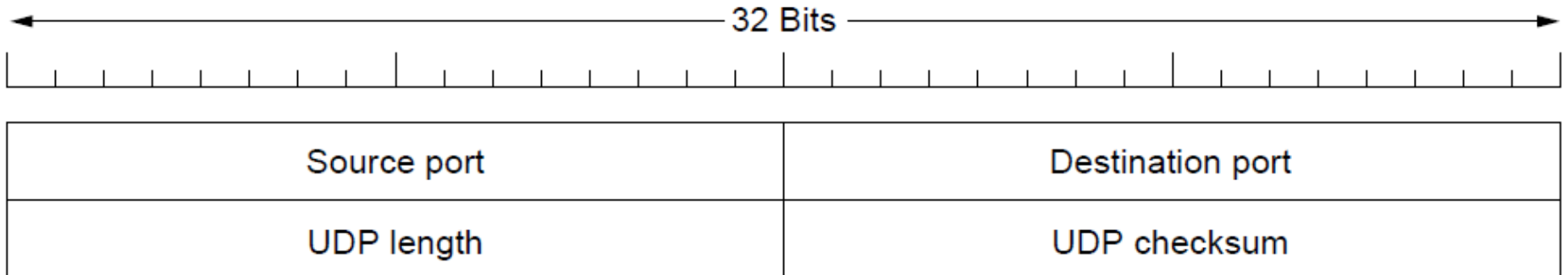
Primitive	Meaning
SOCKET	Create a new communication end point
BIND	Associate a local address with a socket
LISTEN	Announce willingness to accept connections; give queue size
ACCEPT	Passively establish an incoming connection
CONNECT	Actively attempt to establish a connection
SEND	Send some data over the connection
RECEIVE	Receive some data from the connection
CLOSE	Release the connection

The socket primitives for TCP

The Internet Transport Protocols: UDP

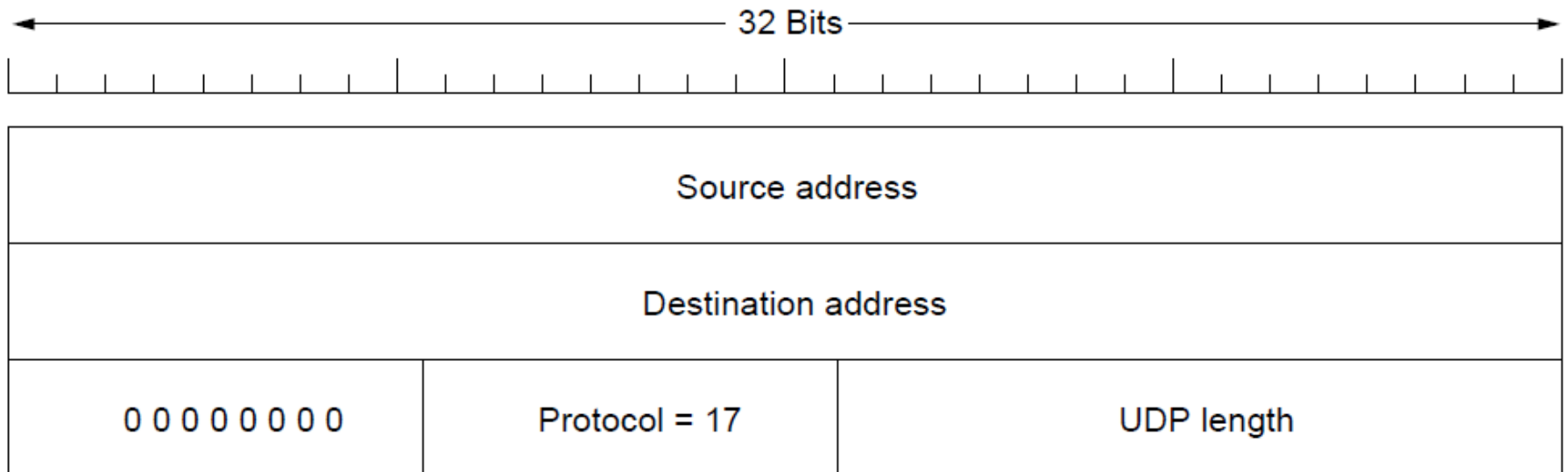
- Introduction to UDP
- Remote Procedure Call
- Real-Time Transport

Introduction to UDP (1)



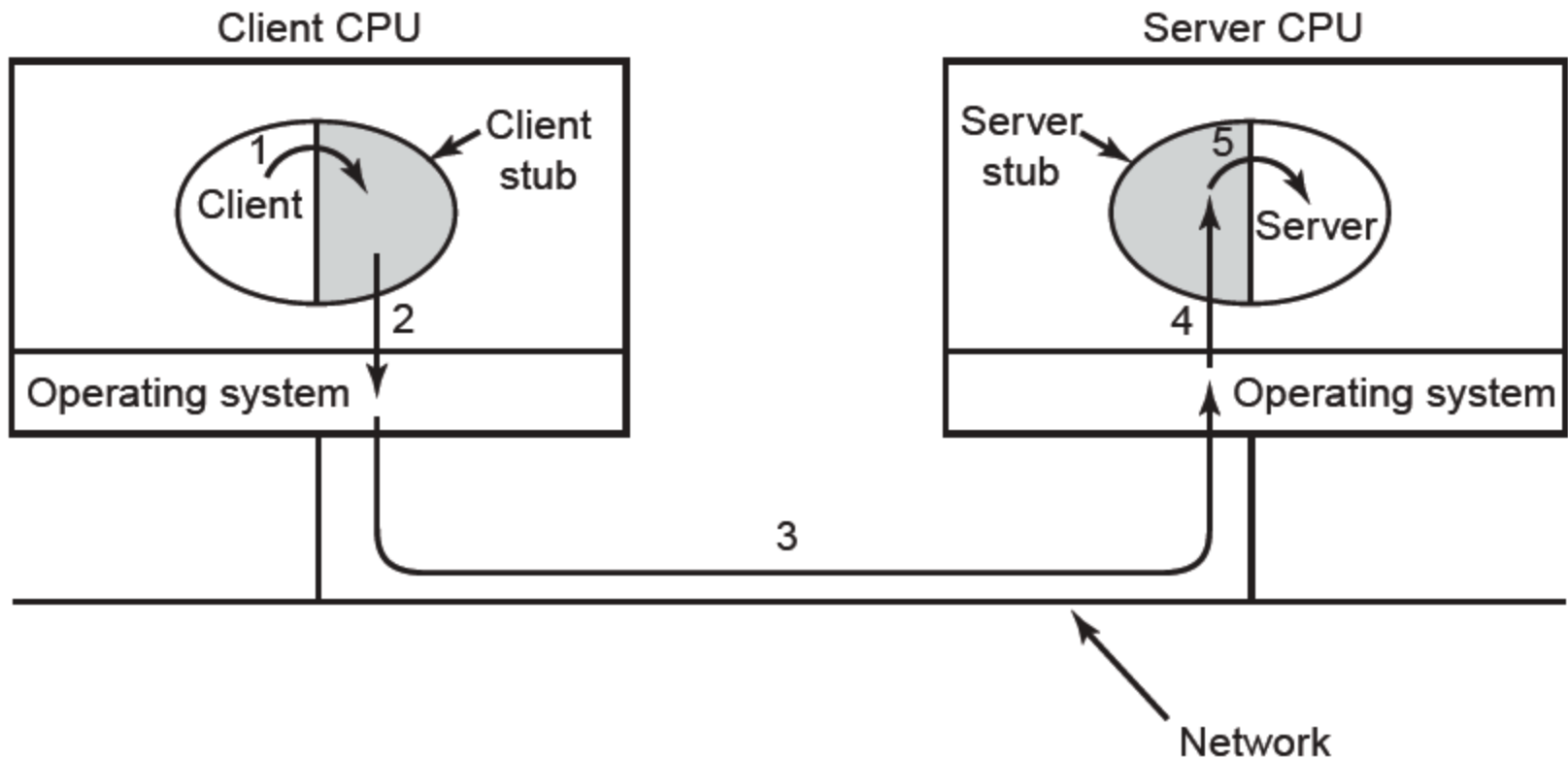
The UDP header.

Introduction to UDP (2)



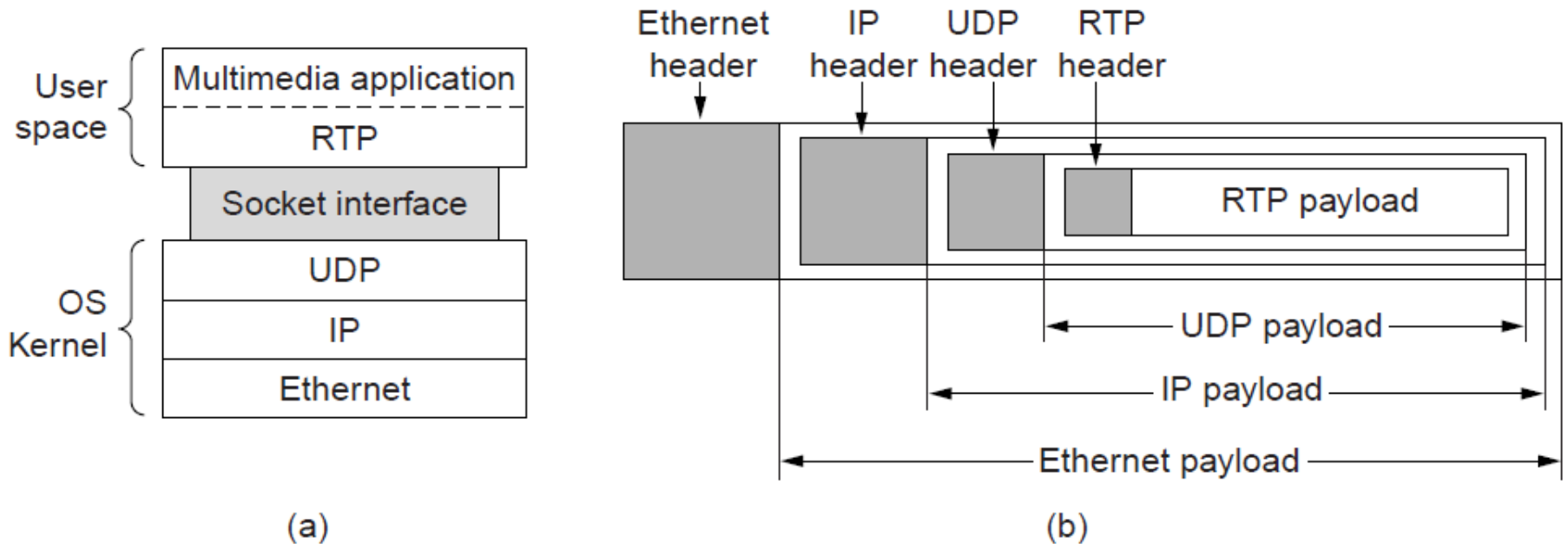
The IPv4 pseudoheader included in the UDP checksum.

Remote Procedure Call



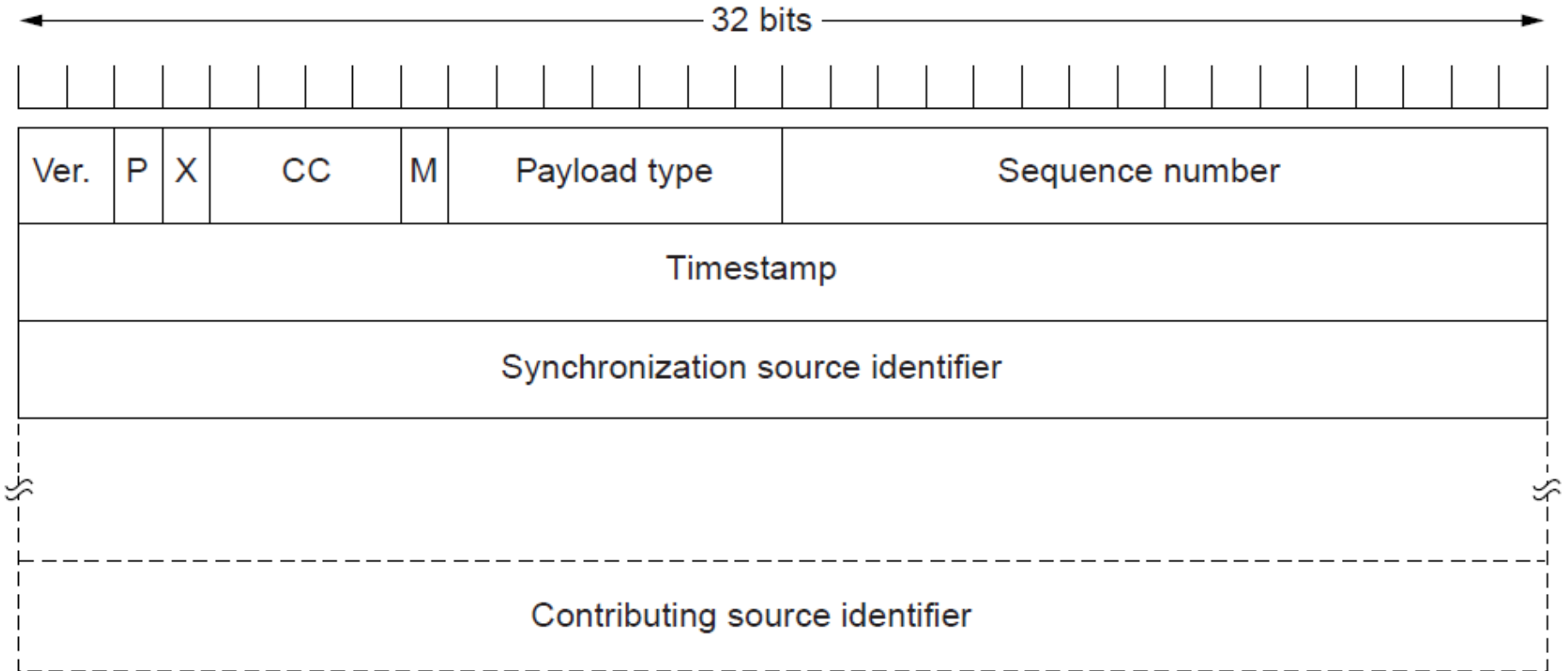
Steps in making a remote procedure call. The stubs are shaded.

Real-Time Transport (1)



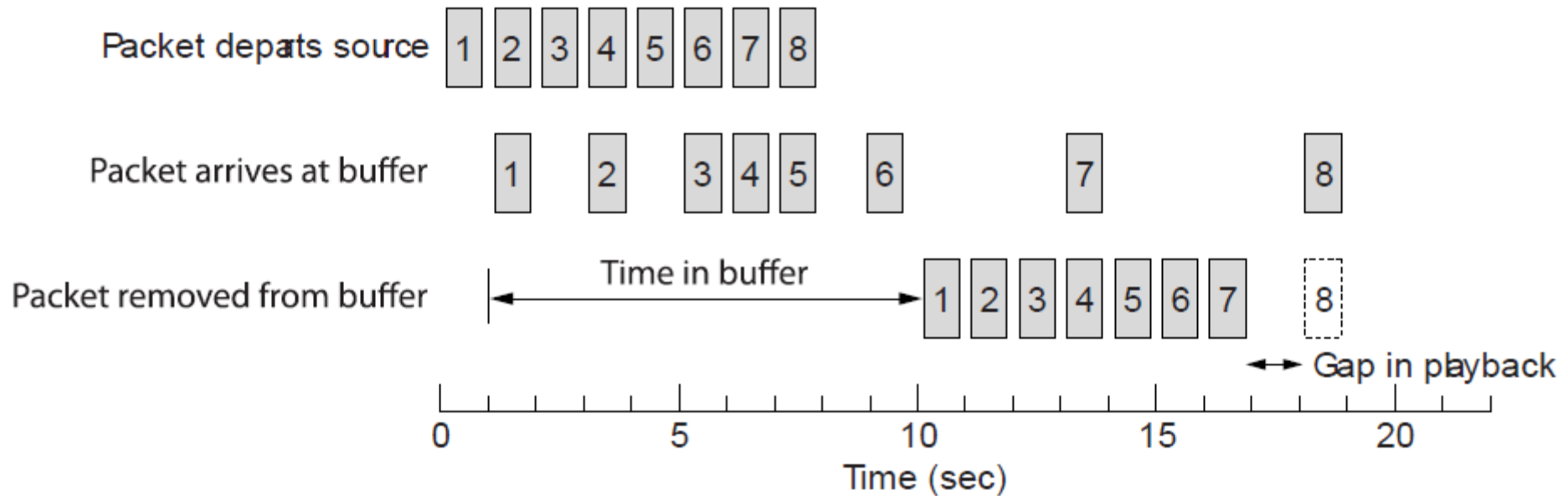
(a) The position of RTP in the protocol stack. (b) Packet nesting.

Real-Time Transport (2)



The RTP header

Real-Time Transport (3)



Smoothing the output stream by buffering packets

The Internet Transport Protocols: TCP (1)

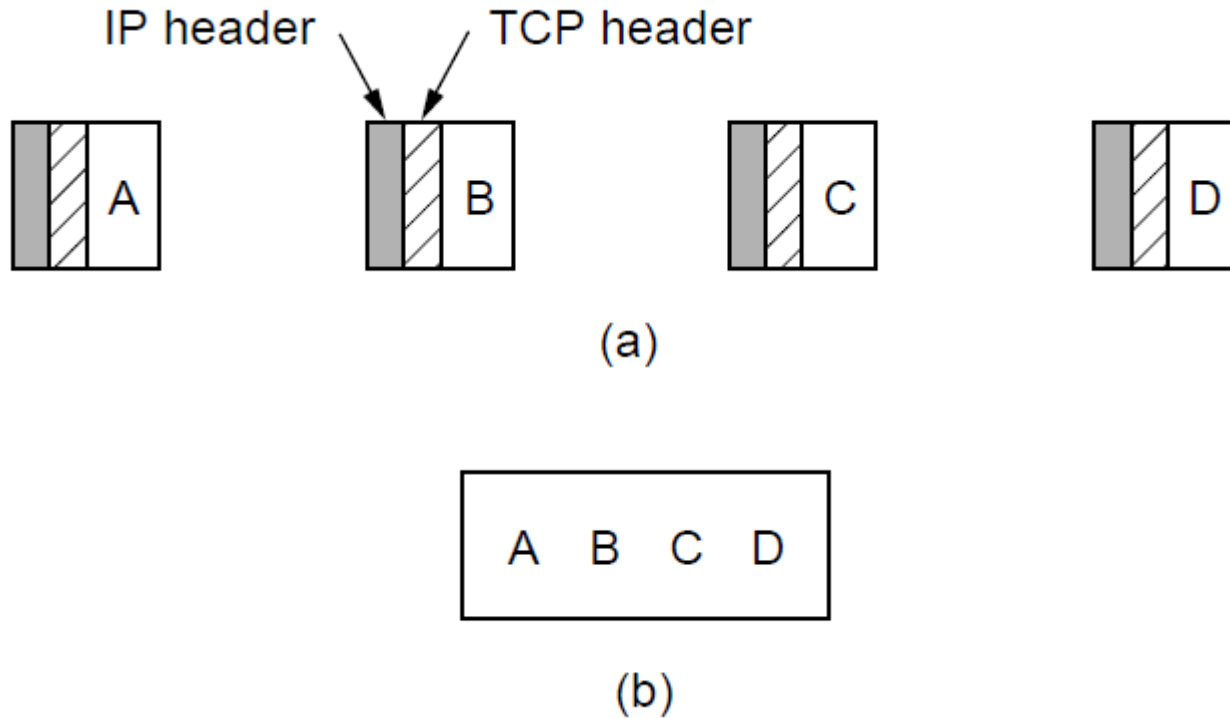
- Introduction to TCP
- The TCP service model
- The TCP protocol
- The TCP segment header
- TCP connection establishment
- TCP connection release

The TCP Service Model (1)

Port	Protocol	Use
20, 21	FTP	File transfer
22	SSH	Remote login, replacement for Telnet
25	SMTP	Email
80	HTTP	World Wide Web
110	POP-3	Remote email access
143	IMAP	Remote email access
443	HTTPS	Secure Web (HTTP over SSL/TLS)
543	RTSP	Media player control
631	IPP	Printer sharing

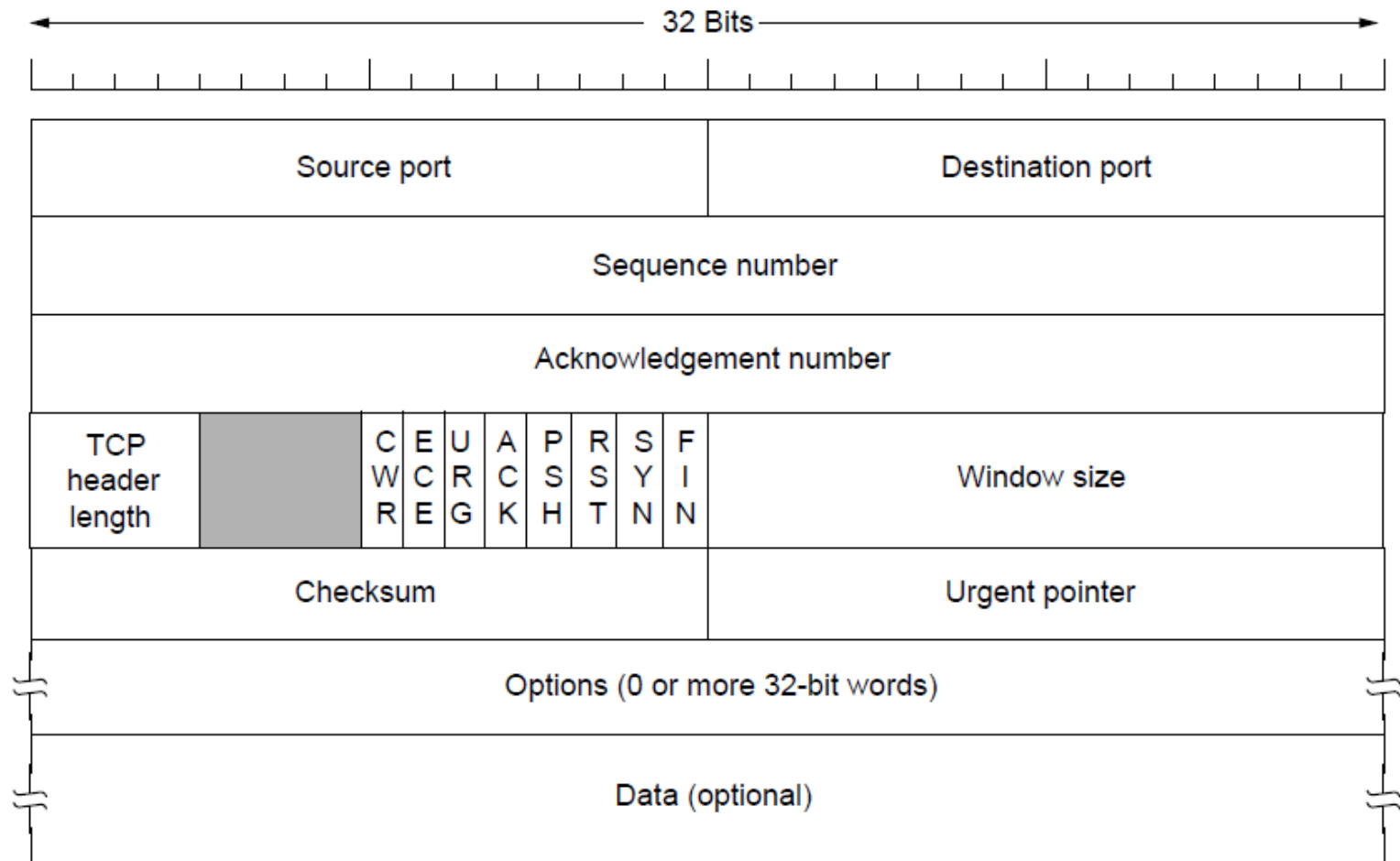
Some assigned ports

The TCP Service Model (2)



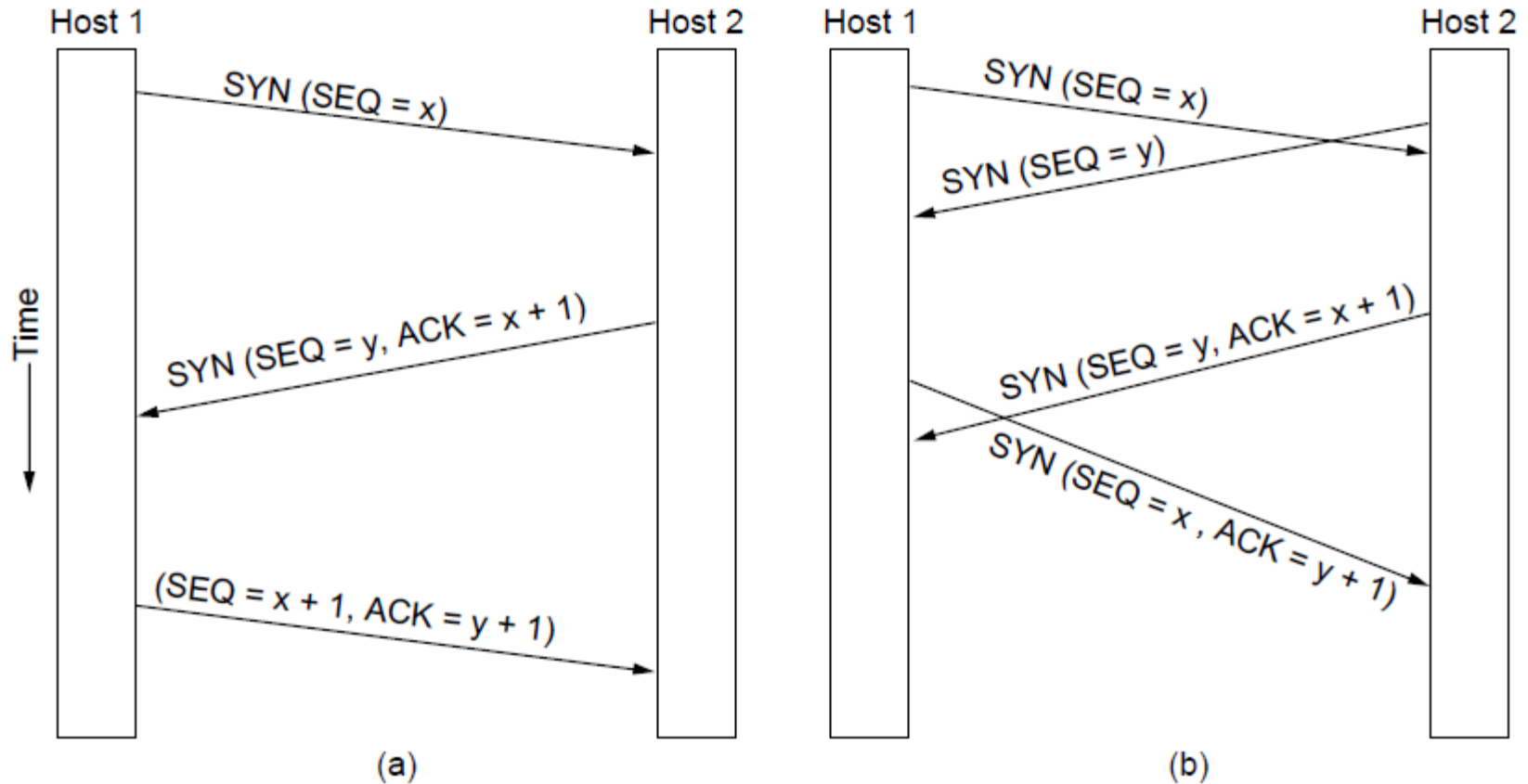
- (a) Four 512-byte segments sent as separate IP diagrams
- (b) The 2048 bytes of data delivered to the application in a single READ call

The TCP Segment Header



The TCP header.

TCP Connection Establishment



- a) TCP connection establishment in the normal case.
- b) Simultaneous connection establishment on both sides.

TCP Connection Management Modeling (1)

State	Description
CLOSED	No connection is active or pending
LISTEN	The server is waiting for an incoming call
SYN RCVD	A connection request has arrived; wait for ACK
SYN SENT	The application has started to open a connection
ESTABLISHED	The normal data transfer state
FIN WAIT 1	The application has said it is finished
FIN WAIT 2	The other side has agreed to release
TIME WAIT	Wait for all packets to die off
CLOSING	Both sides have tried to close simultaneously
CLOSE WAIT	The other side has initiated a release
LAST ACK	Wait for all packets to die off

The states used in the TCP connection management finite state machine.

TCP vs UDP

- Both use **port numbers**

- application-specific construct serving as a communication endpoint and consist of 16-bit unsigned integer, thus ranging from 0 to 65535 to provide **end-to-end** transport

- UDP: User Datagram Protocol

- no acknowledgements
 - no retransmissions
 - out of order, duplicates possible
 - connectionless, i.e., app indicates destination for each packet

- TCP: Transmission Control Protocol

- reliable **byte-stream channel** (in order, all arrive, no duplicates)
 - similar to file I/O
 - flow control
 - connection-oriented
 - bidirectional

TCP vs UDP

- TCP is used for services with a large data capacity, and a persistent connection
- UDP is more commonly used for quick lookups, and single use query-reply actions.
- Some common examples of TCP and UDP with their default ports:

DNS lookup	UDP	53
FTP	TCP	21
HTTP	TCP	80
POP3	TCP	110
Telnet	TCP	23

End

Chapter 6