Chapter 7: Transport Layer

Introduction to Networking

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Role of the Transport Layer

The transport layer is responsible for establishing a temporary communication session between two applications and delivering data between them.

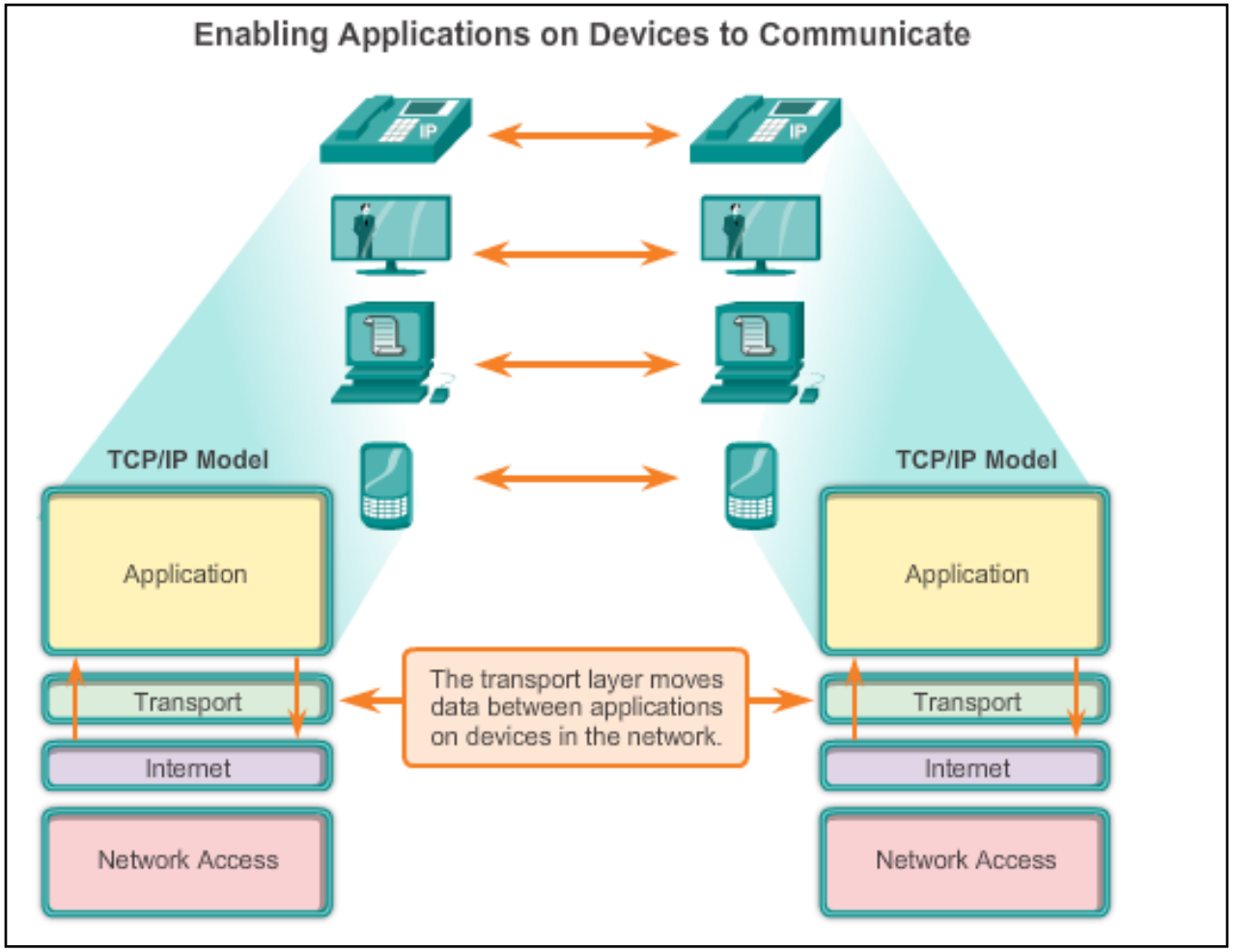
TCP/IP uses two protocols to achieve this:

- Transmission Control Protocol (TCP)
- User Datagram Protocol (UDP)

Primary Responsibilities of Transport Layer Protocols

- Tracking the individual communication between applications on the source and destination hosts
- Segmenting data for manageability and reassembling segmented data into streams of application data at the destination
- Identifying the proper application for each communication stream

Role of the Transport Layer (Cont.)

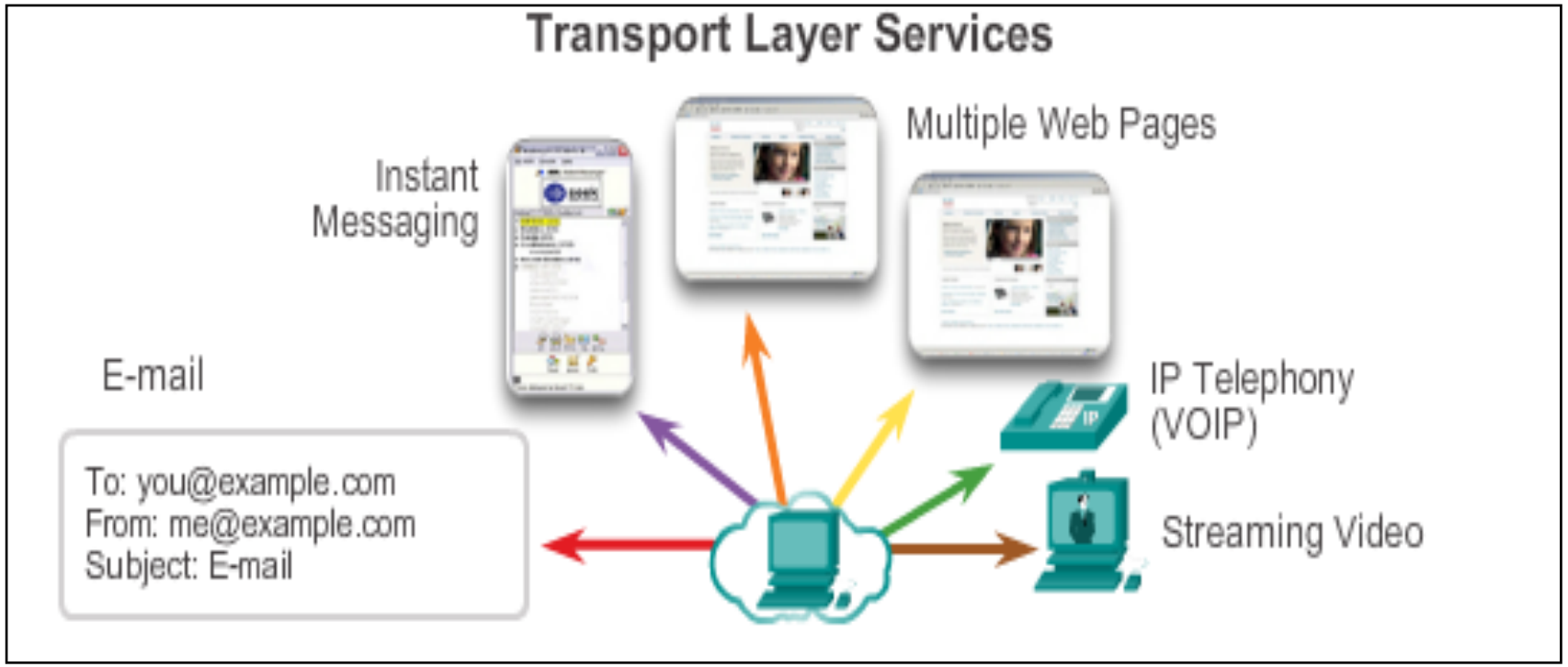


Conversation Multiplexing

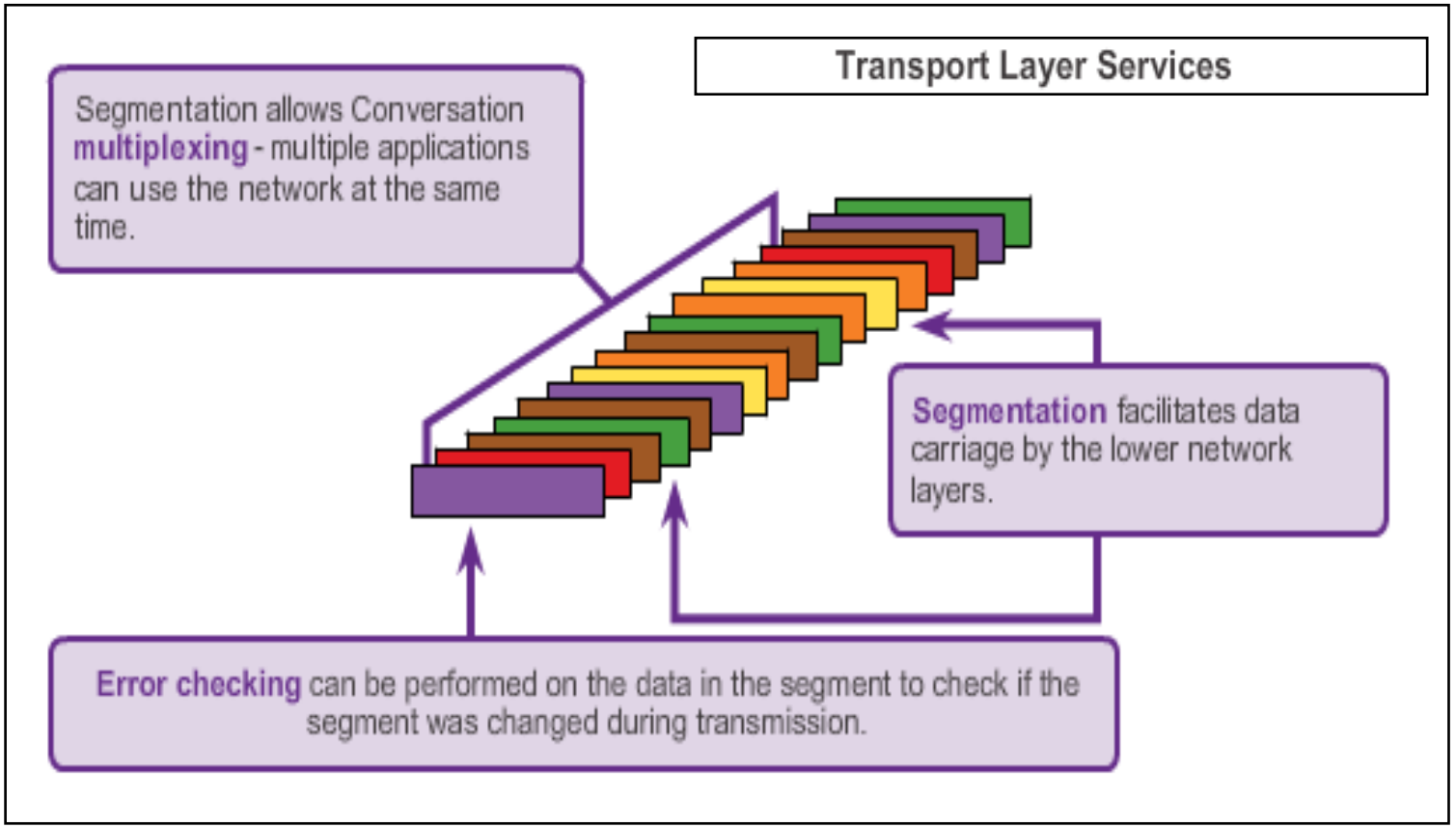
Segmenting the Data

- Enables many different communications, from many different users, to be interleaved (multiplexed) on the same network, at the same time.
- Provides the means to both send and receive data when running multiple applications.
- Header added to each segment to identify it.

Conversation Multiplexing (Cont.)



Conversation Multiplexing (Cont.)



Transport Layer Reliability

Different applications have different transport reliability requirements.

TCP/IP provides two transport layer protocols, **TCP and UDP.**

TCP

- Provides reliable delivery ensuring that all of the data arrives at the destination.
- Uses acknowledged delivery and other processes to ensure delivery
- Makes larger demands on the network – more overhead.

UDP

- Provides just the basic functions for delivery – no reliability.
- Less overhead.

TCP or UDP

- There is a trade-off between the value of reliability and the burden it places on the network.
- Application developers choose the transport protocol based on the requirements of their applications.

Introducing TCP

- Defined in RFC 793
- Connection-oriented – Creates a session between the source and destination
- Reliable delivery – Retransmits lost or corrupt data
- Ordered data reconstruction – Reconstructs numbering and sequencing of segments
- Flow control – Regulates the amount of data transmitted
- Stateful protocol – Tracks the session

TCP Segment

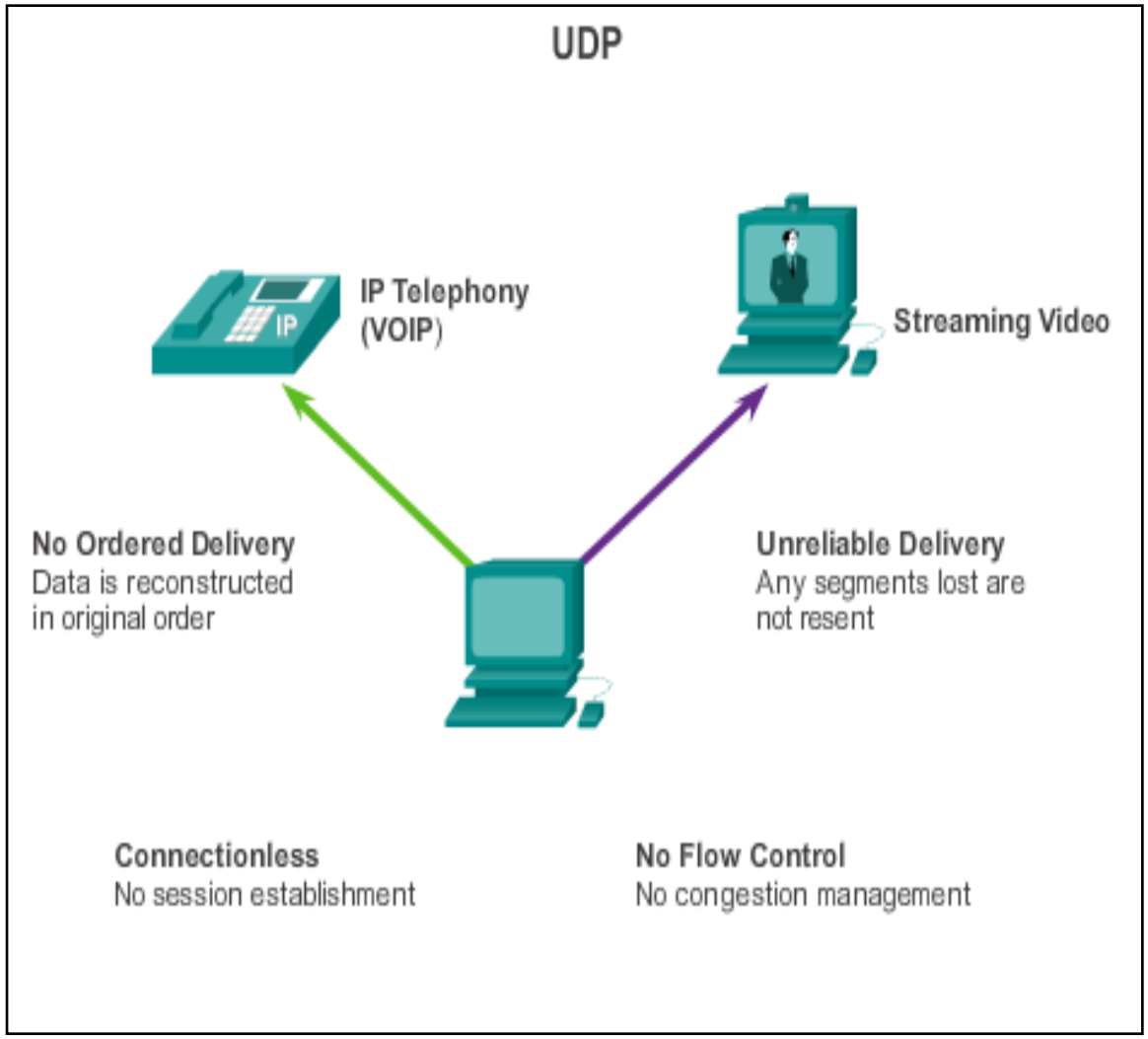
Bit(0)	Bit(15)	Bit(16)	Bit(31)	
Source Port (16)		Destination Port (16)		20 Bytes
Sequence Number (32)				
Acknowledgement Number (32)				
Header Length(4) Reserved(6) Code Bits(6)		Window (16)		
Checksum (16)		Urgent (16)		
Options (0 or 32 if any)				
APPLICATION LAYER DATA (Size varies)				

Introducing UDP

- RFC 768
- Connectionless
- Unreliable delivery
- No ordered data reconstruction
- No flow control
- Stateless protocol

Applications that use UDP:

- Domain Name System (DNS)
- Video Streaming
- VoIP



Separating Multiple Communications

TCP and UDP use port numbers to differentiate between applications.

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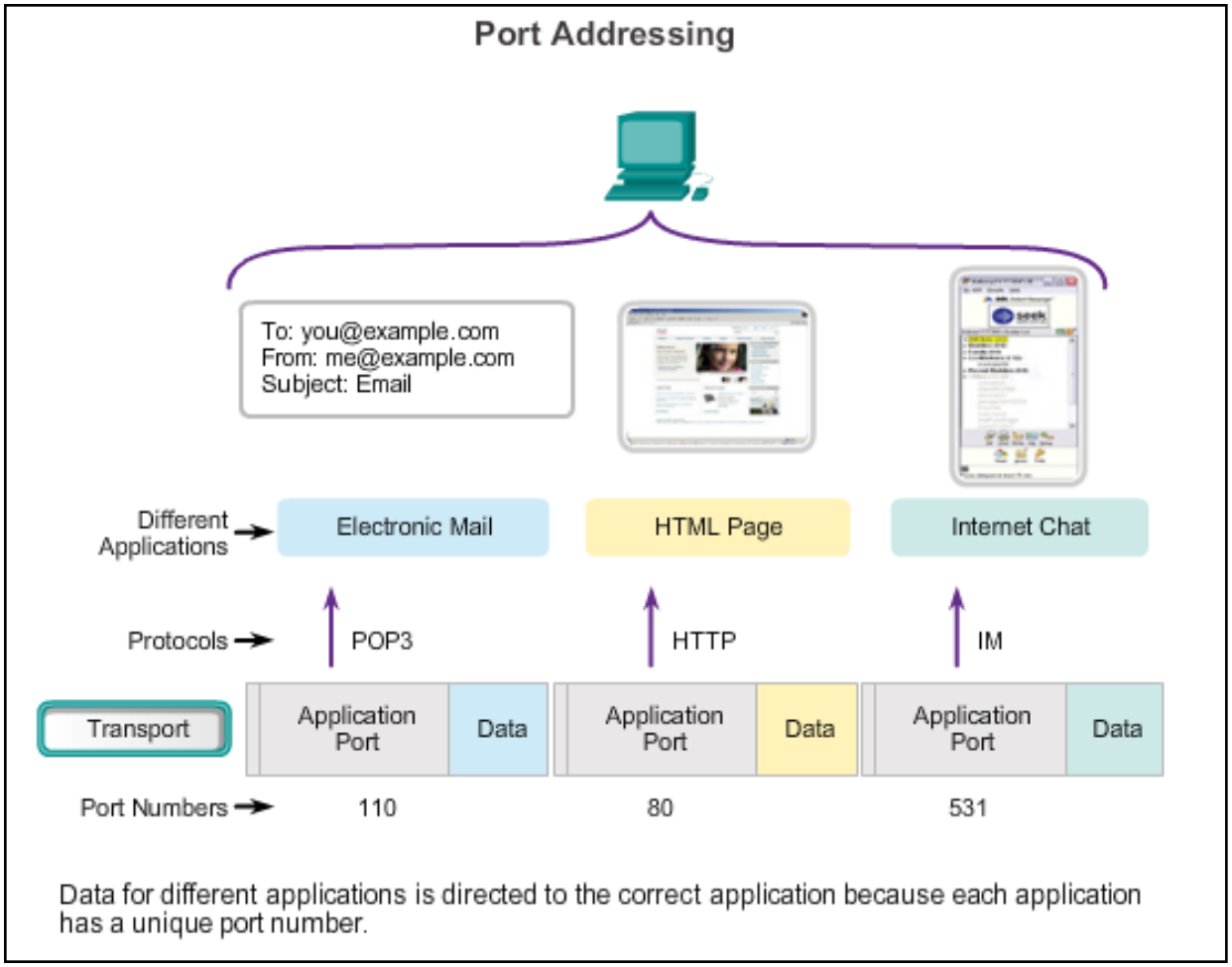
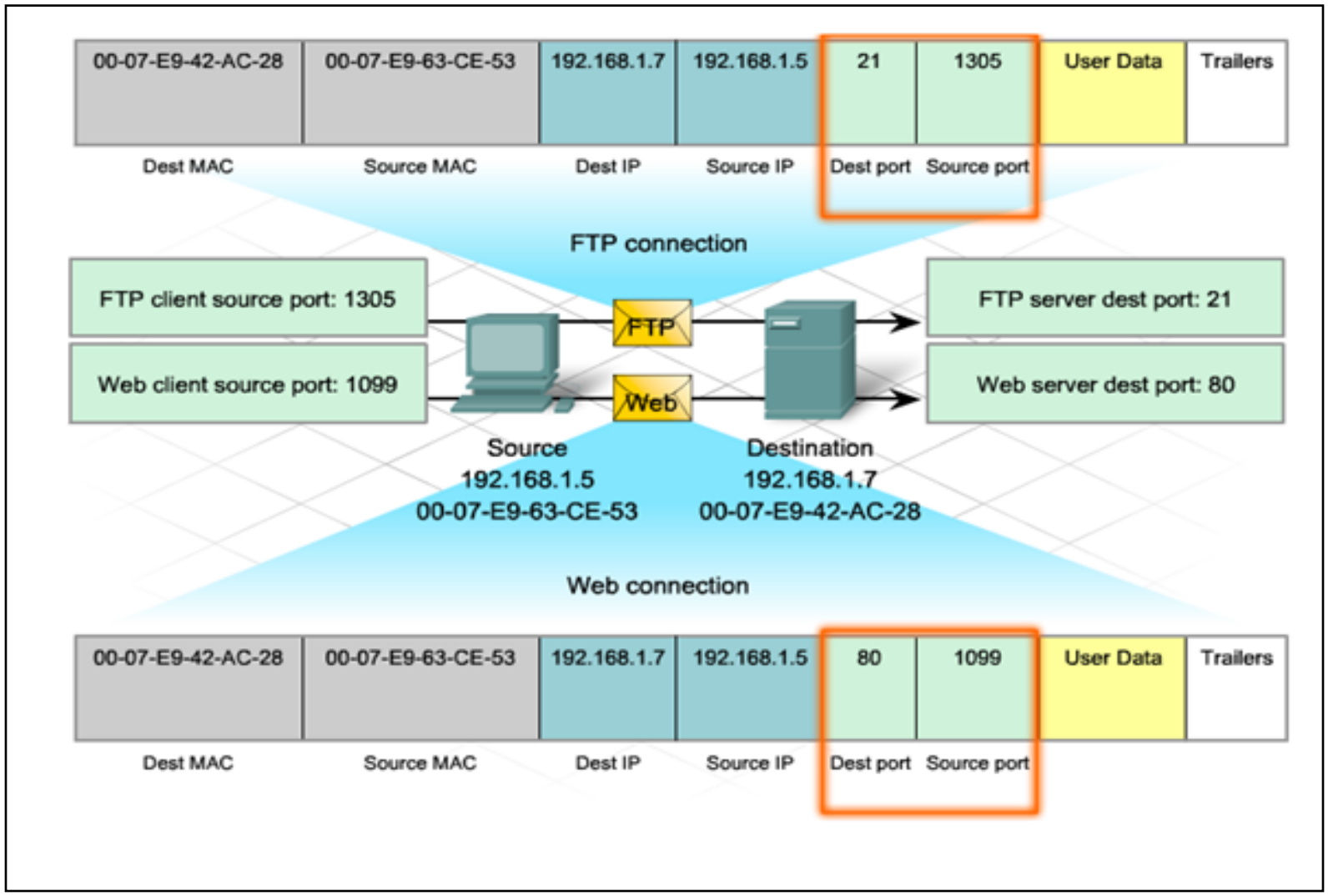


TCP and UDP Port Addressing



TCP and UDP Port Addressing (Cont.)

Port Numbers

Port Number Range	Port Group
0 to 1023	Well Known (Contact) Ports
1024 to 49151	Registered Ports
49152 to 65533	Private and/or Dynamic Ports

Registered TCP Ports:

1863	MSN Messenger
2000	Cisco SCCP (VoIP)
8008	Alternate HTTP
8080	Alternate HTTP

Well Known TCP Ports:

21	FTP
23	Telnet
25	SMTP
80	HTTP
110	POP3
194	Internet Relay Chat (IRC)
443	Secure HTTP (HTTPS)

TCP and UDP Port Addressing (Cont.)

Registered UDP Ports:

1812	RADIUS Authentication Protocol
5004	RTP (Voice and Video Transport Protocol)
5040	SIP (VoIP)

Well Known UDP Ports:

69	TFTP
520	RIP

Registered TCP/UDP Common Ports:

1433	MS SQL
2948	WAP (MMS)

Well Known TCP/UDP Common Ports:

53	DNS
161	SNMP
531	AOL Instant Messenger, IRC

TCP Connection, Establishment and Termination

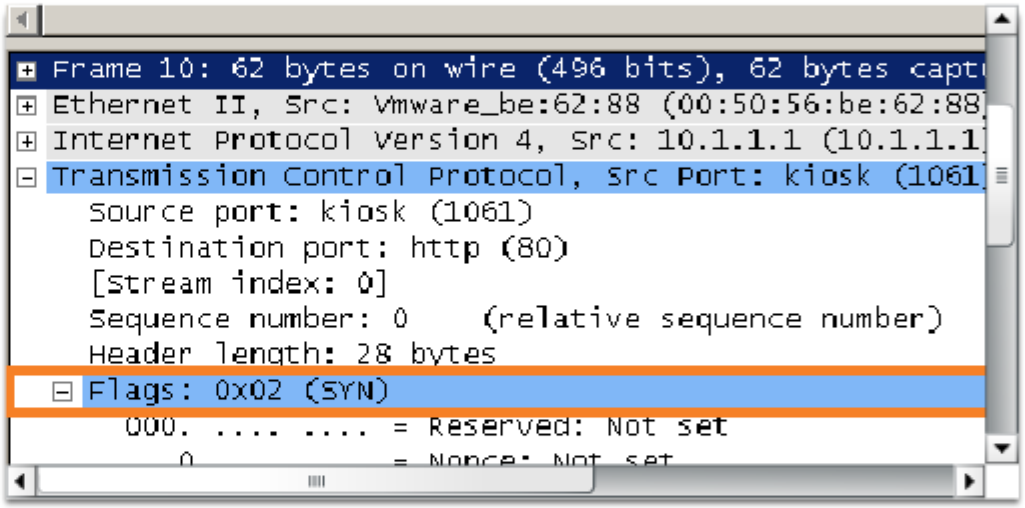
Three-Way Handshake

- Establishes that the destination device is present on the network
- Verifies that the destination device has an active service and is accepting requests on the destination port number that the initiating client intends to use for the session
- Informs the destination device that the source client intends to establish a communication session on that port number

TCP Three-Way Handshake – Step 1

Step 1: The initiating client requests a client-to-server communication session with the server

TCP 3-Way Handshake (SYN)



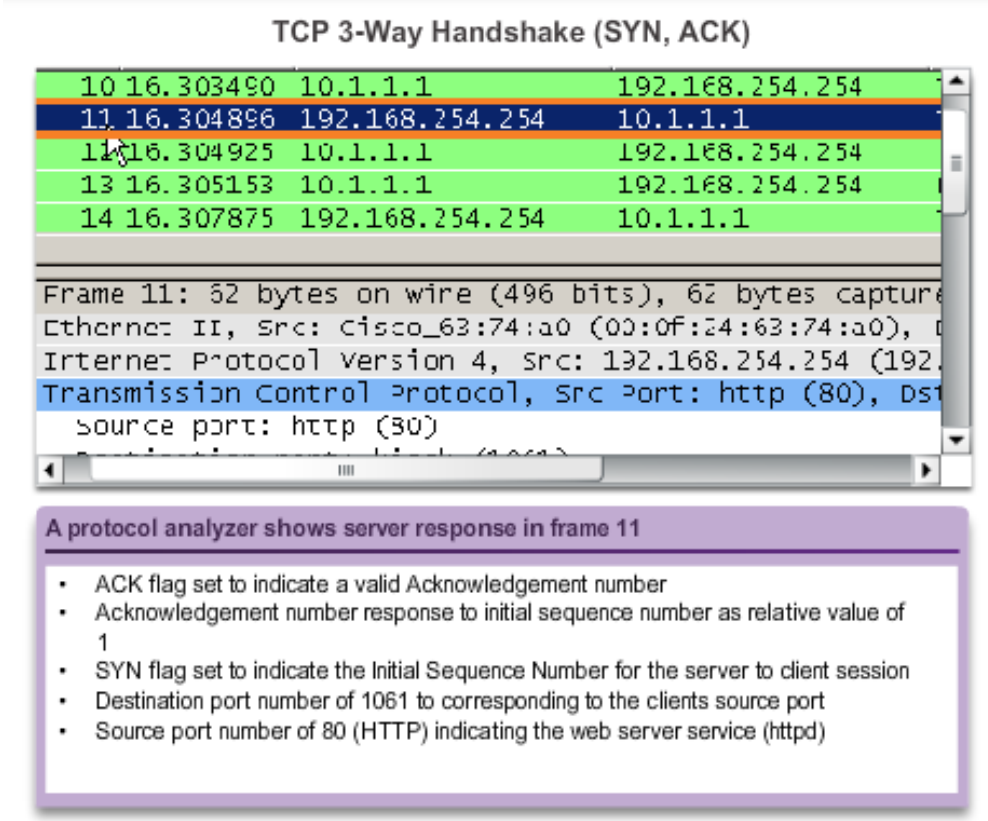
A protocol analyzer shows initial client request for session in frame 10

TCP segment in this frame shows:

- SYN flag set to validate an Initial Sequence Number
- Randomized sequence number valid (relative value is 0)
- Random source port 1061
- Well-known destination port is 80 (HTTP port) indicates web server (httpd)

TCP Three-Way Handshake – Step 2

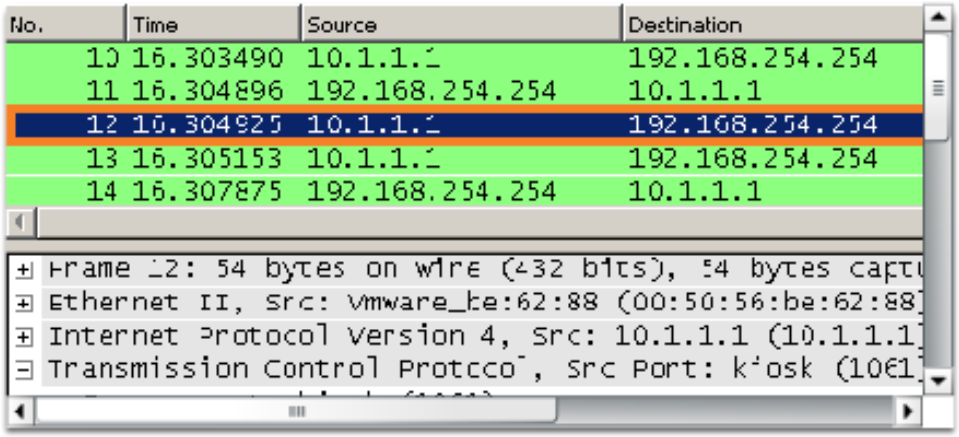
Step 2: The server acknowledges the client-to-server communication session and requests a server-to-client communication session.



TCP Three-Way Handshake – Step 3

Step 3: The initiating client acknowledges the server-to-client communication session.

TCP 3-Way Handshake (ACK)

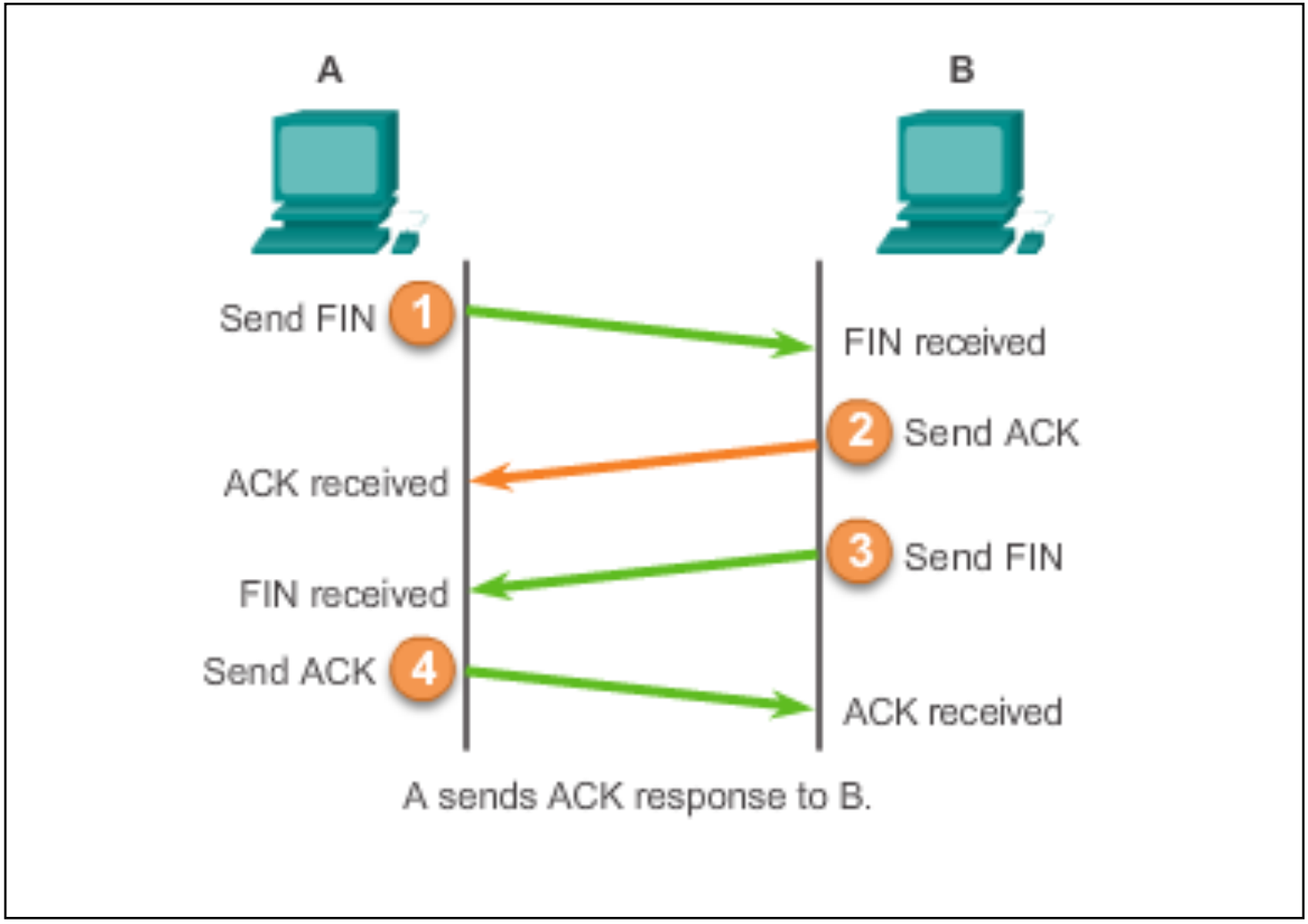


A protocol analyzer shows client response to session in frame 12

The TCP segment in this frame shows:

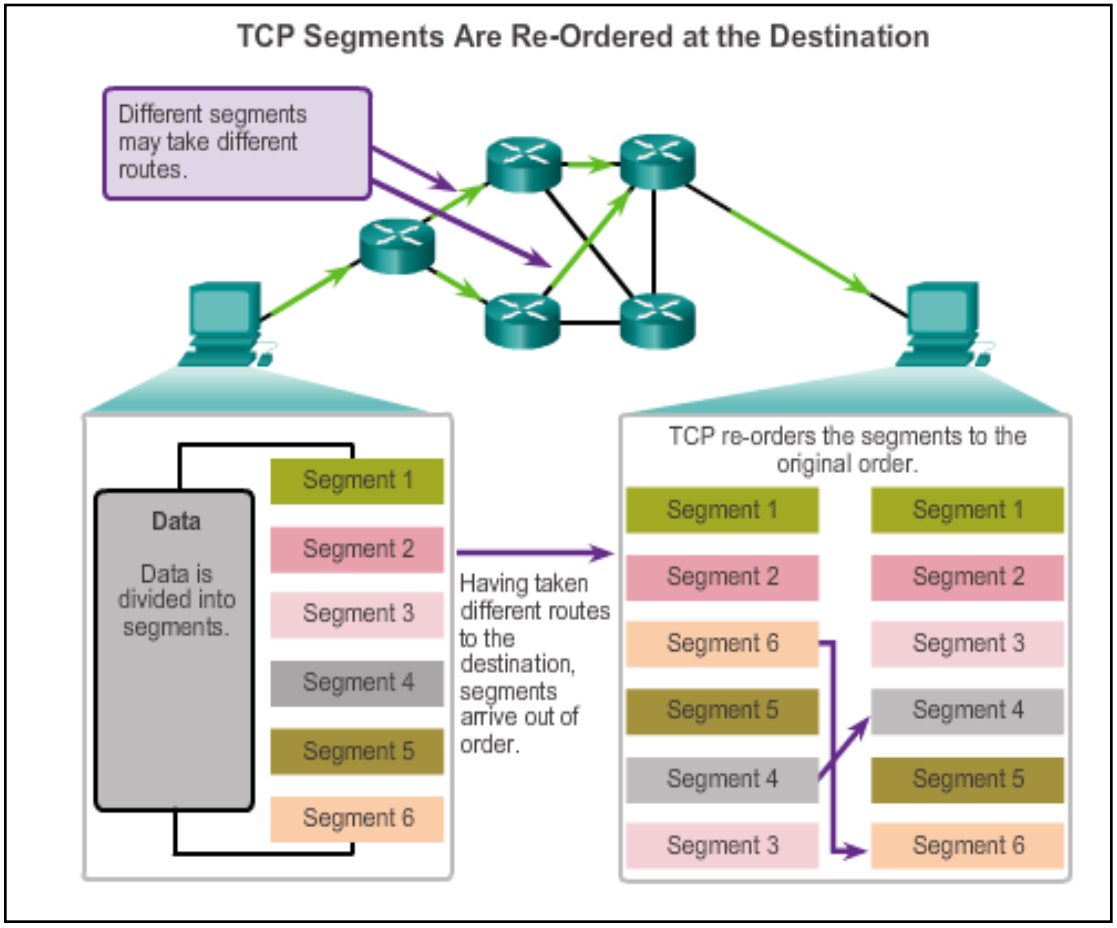
- ACK flag set to indicate a valid Acknowledgement number
- Acknowledgement number response to initial sequence number as relative value of 1
- Source port number of 1061 to corresponding
- Destination port number of 80 (HTTP) indicating the web server service (httpd)

TCP Session Termination



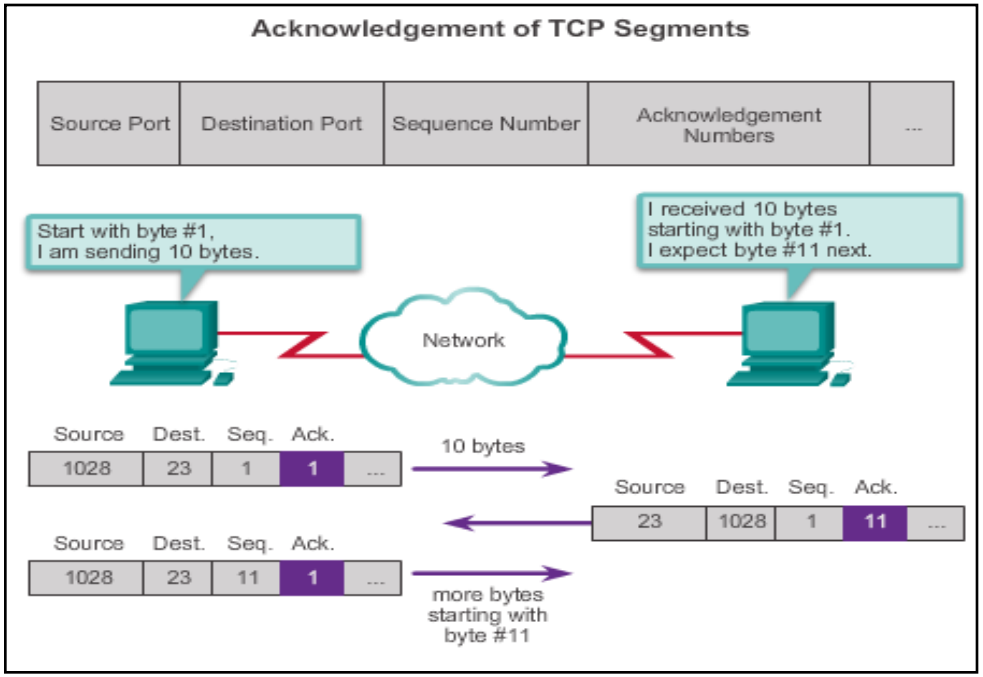
TCP Reliability – Ordered Delivery

Sequence numbers are used to reassemble segments into their original order.



Acknowledgement and Window Size

The sequence number and acknowledgement number are used together to confirm receipt.



The window size is the amount of data that a source can transmit before an acknowledgement must be received.

UDP Low Overhead vs. Reliability

UDP

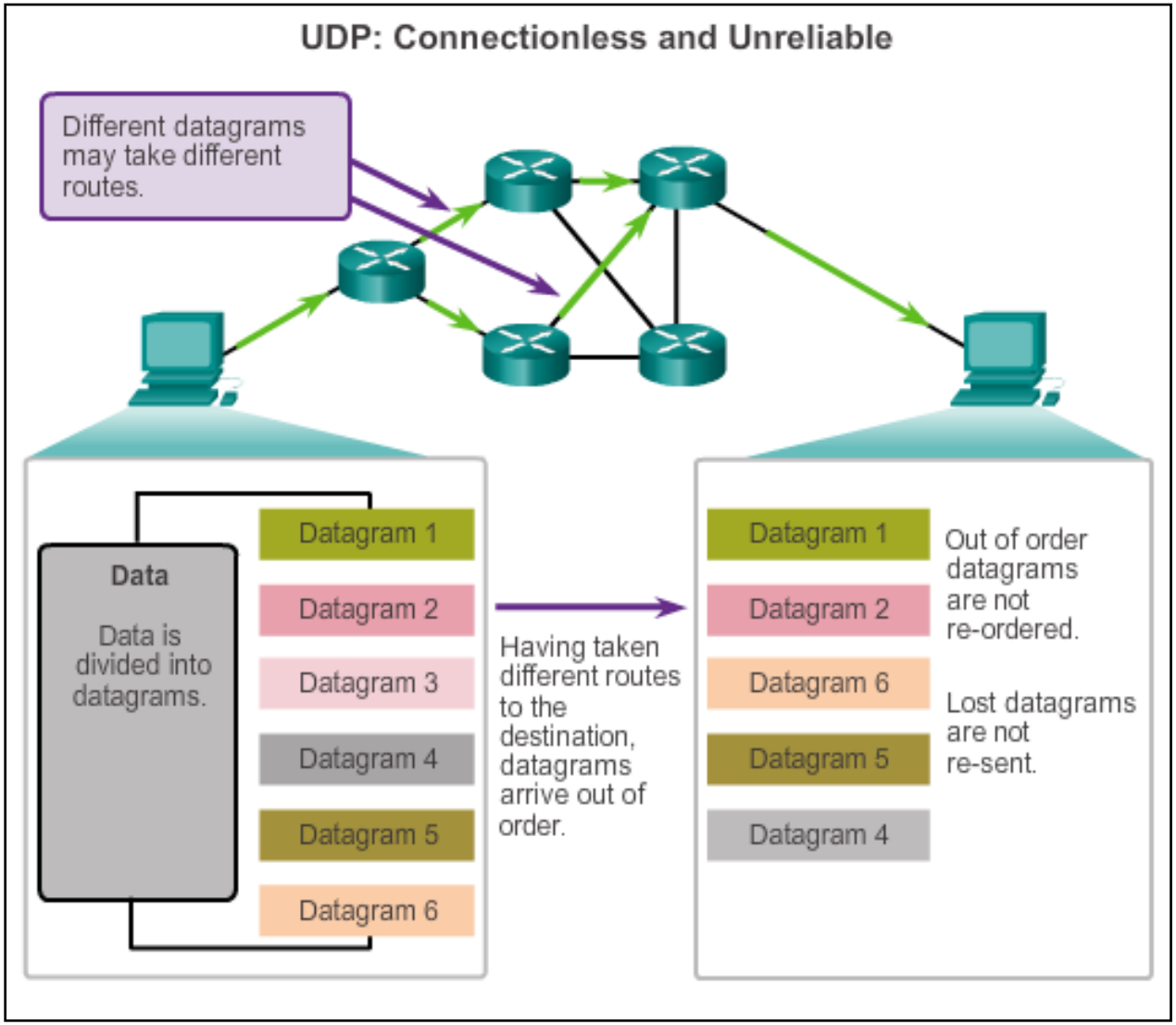
- Simple protocol that provides the basic transport layer function
- Used by applications that can tolerate small loss of data
- Used by applications that cannot tolerate delay

Used by

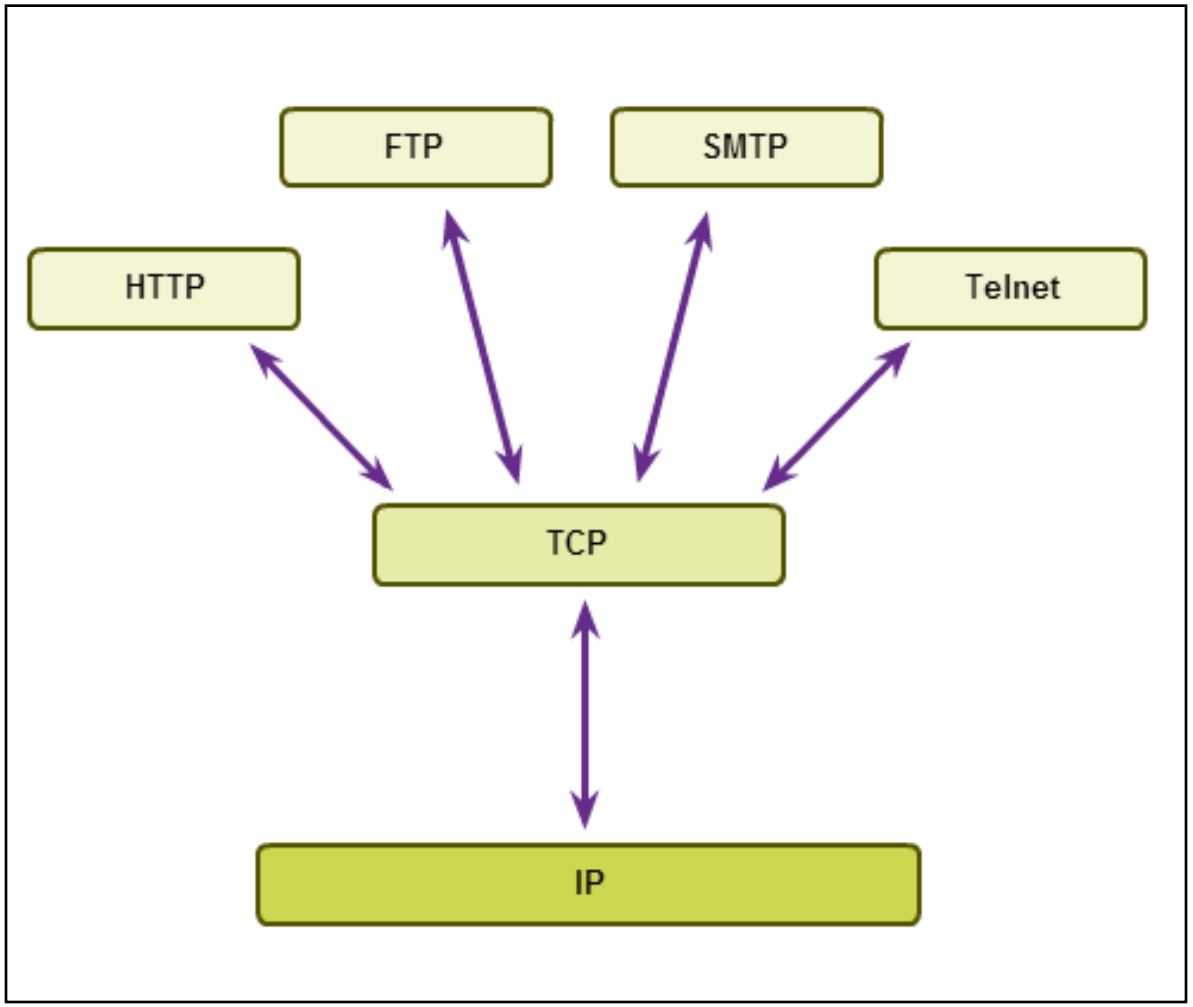
- DNS
- Simple Network Management Protocol (SNMP)
- Dynamic Host Configuration Protocol (DHCP)
- Trivial File Transfer Protocol (TFTP)
- IP telephony or VoIP
- Online games

UDP Communication

Datagram Reassembly



Applications that use TCP



Applications That Use UDP