Chapter 7: Transport Layer

Introduction to Networking

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Chapter 7

7.1 Transport Layer Protocols

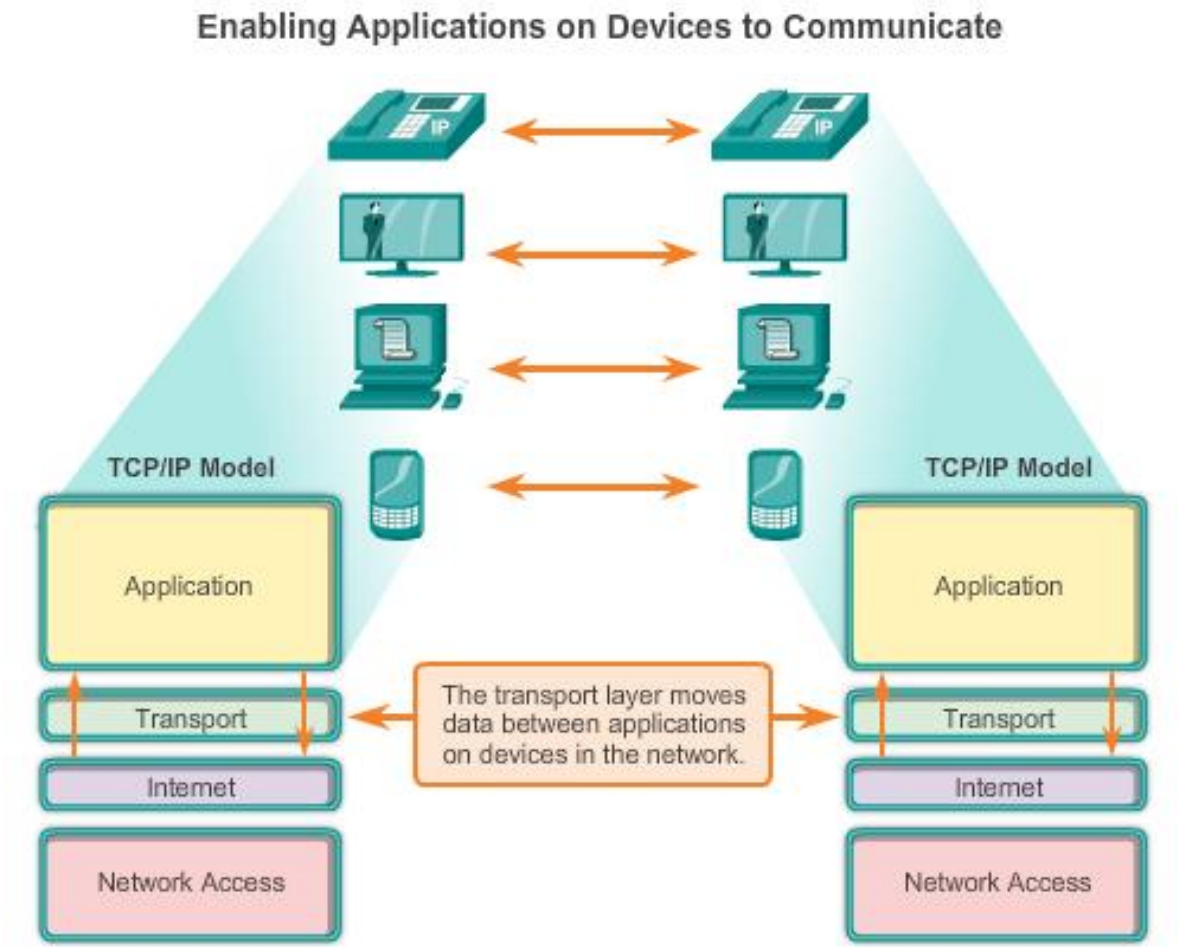
7.2 TCP and UDP

7.3 Summary

Chapter 7: Objectives

- Describe the purpose of the transport layer in managing the transportation of data in end-to-end communication.
- Describe characteristics of the TCP and UDP protocols, including port numbers and their uses.
- Explain how TCP session establishment and termination processes facilitate reliable communication.
- Explain how TCP protocol data units are transmitted and acknowledged to guarantee delivery.
- Explain the UDP client processes to establish communication with a server.
- Determine whether high-reliability TCP transmissions, or non-guaranteed UDP transmissions, are best suited for common applications.

Role of the Transport Layer



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)

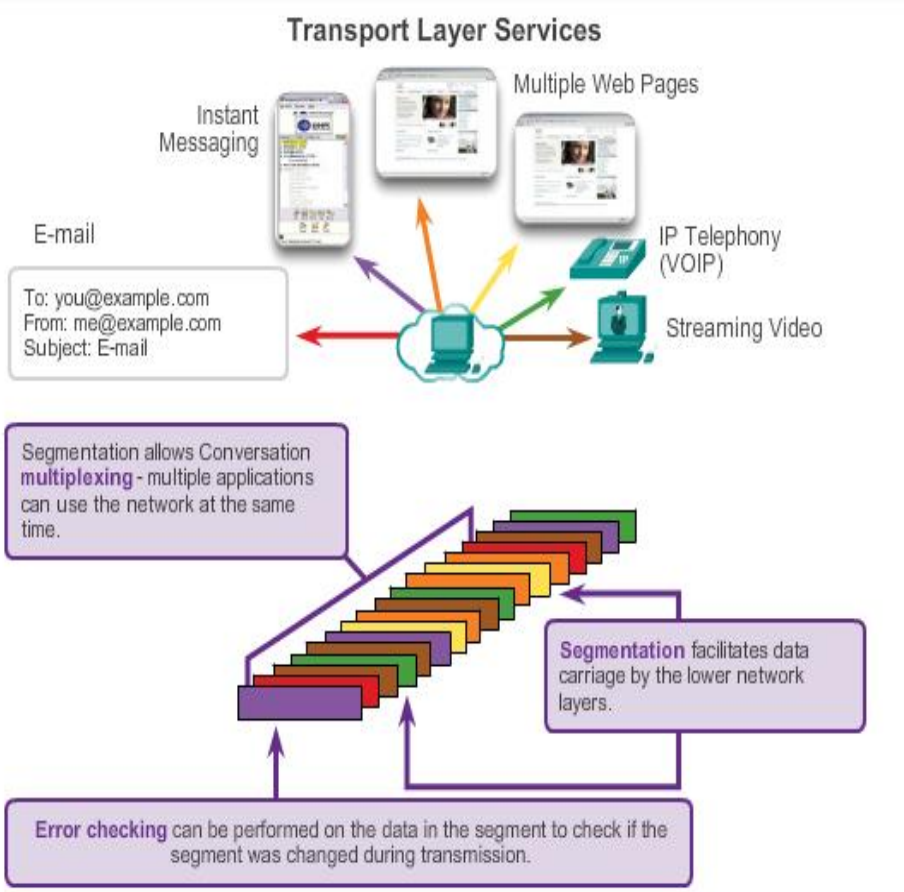
Primary Responsibilities of Transport layer Protocols

- 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

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.



Transport Layer Reliability

Different applications have different transport reliability requirements

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

Transmission Control Protocol (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

User Datagram Protocol (UDP)

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

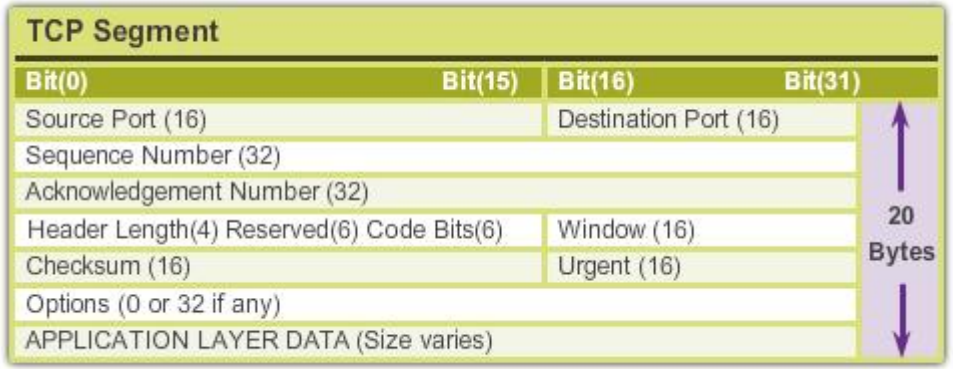
TCP or UDP

- 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

Transmission Control Protocol (TCP)

- RFC 793
- Connection-oriented – creating a session between source and destination
- Reliable delivery – retransmitting lost or corrupt data
- Ordered data reconstruction – numbering and sequencing of segments
- Flow control - regulating the amount of data transmitted
- Stateful protocol – keeping track of the session



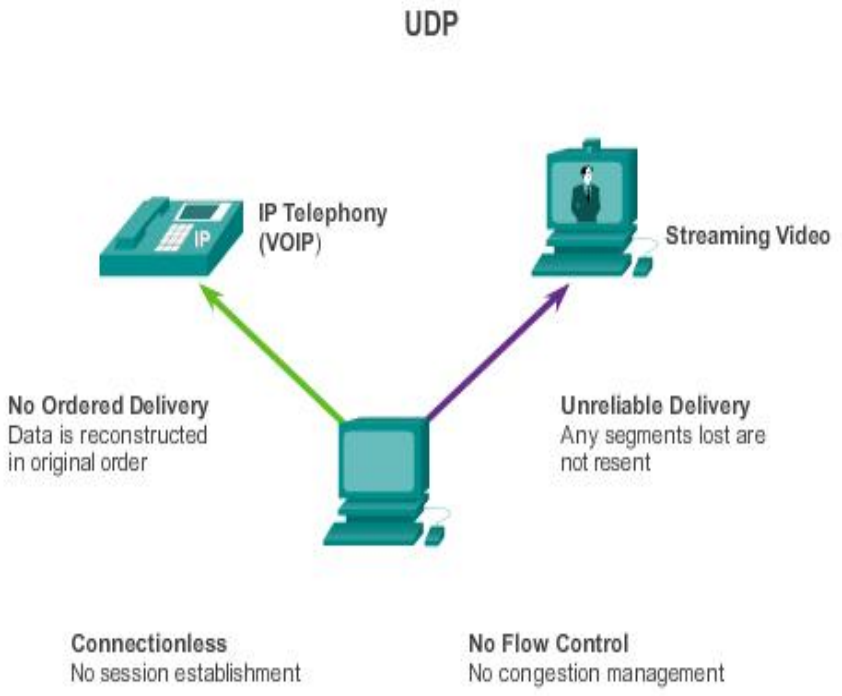
Introducing UDP

User Datagram Protocol (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
- Voice over IP (VoIP)



Separating Multiple Communications

Port Numbers are used by TCP and UDP to differentiate between applications.

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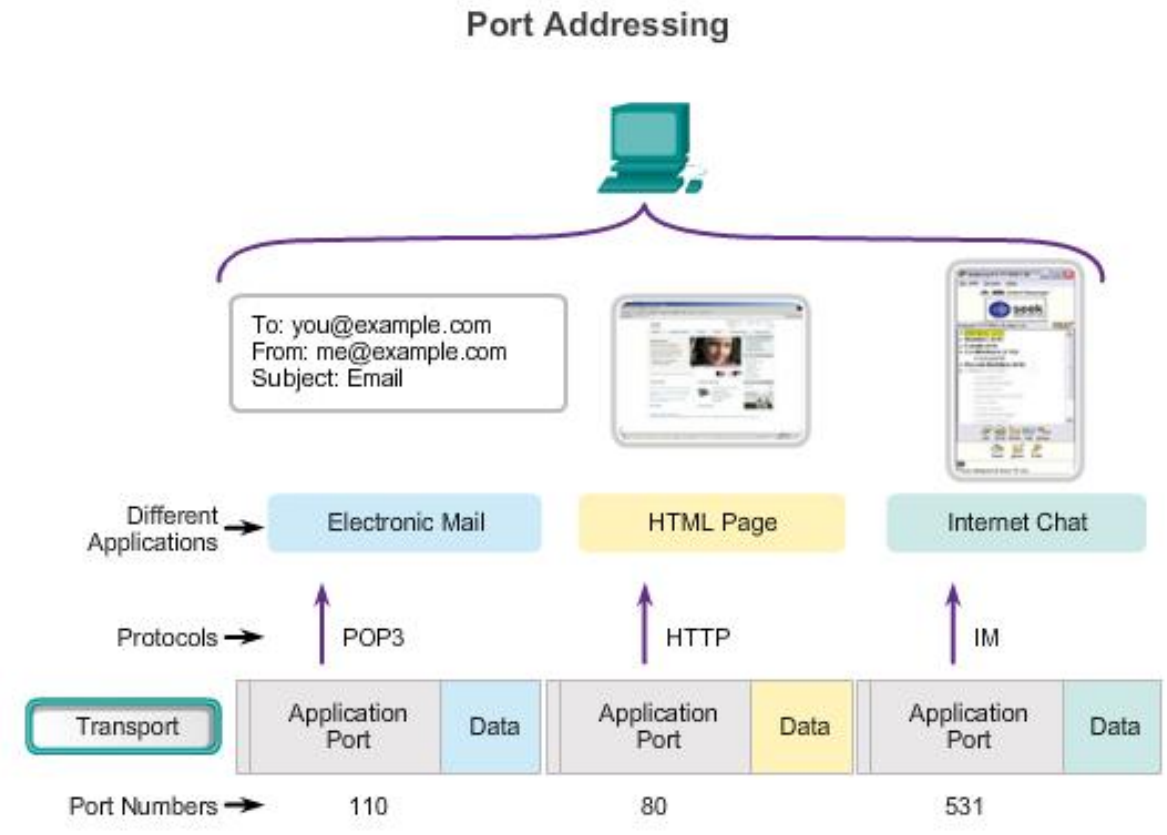
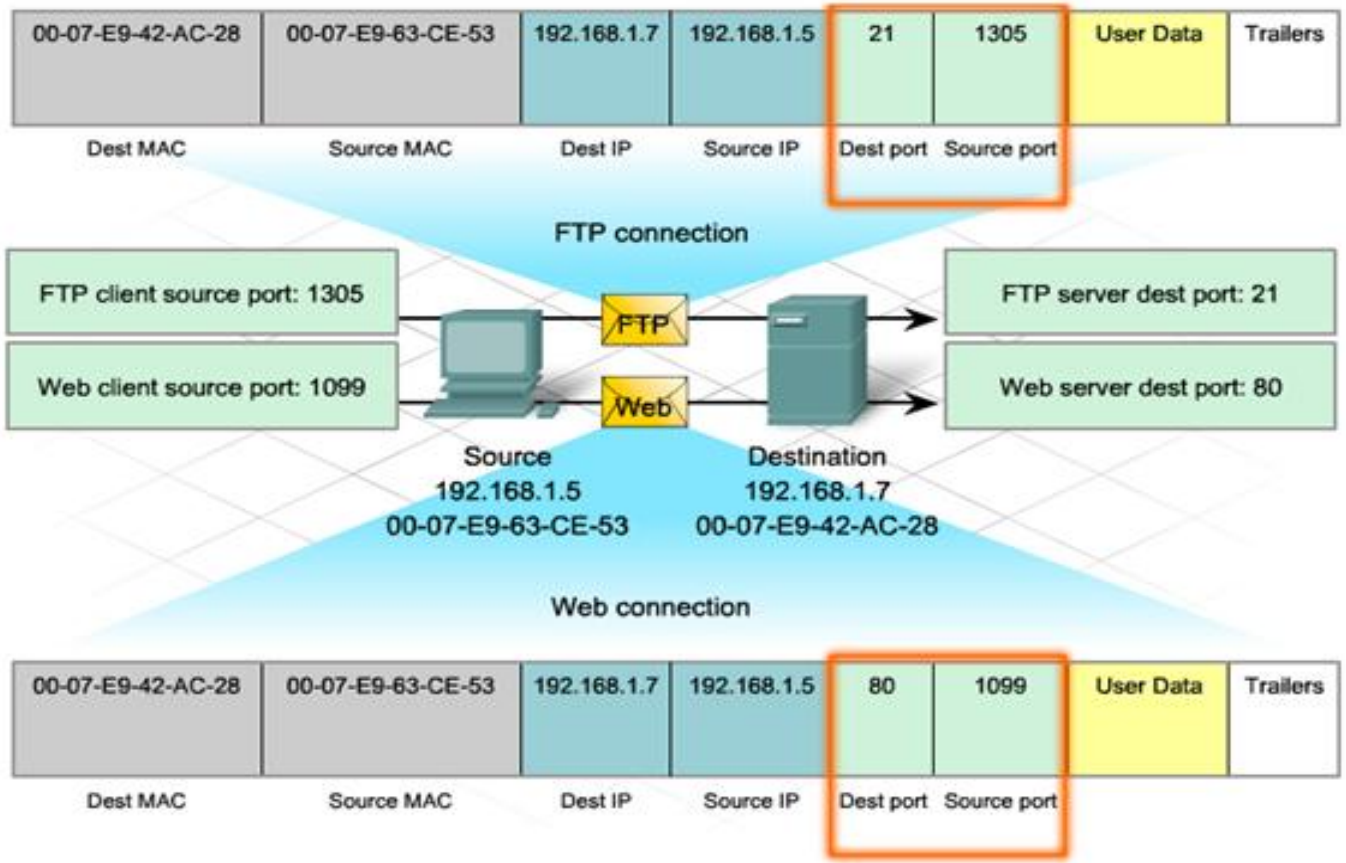


Data for different applications is directed to the correct application because each application has a unique port number.

TCP and UDP Port Addressing



TCP and UDP Port Addressing

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)

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

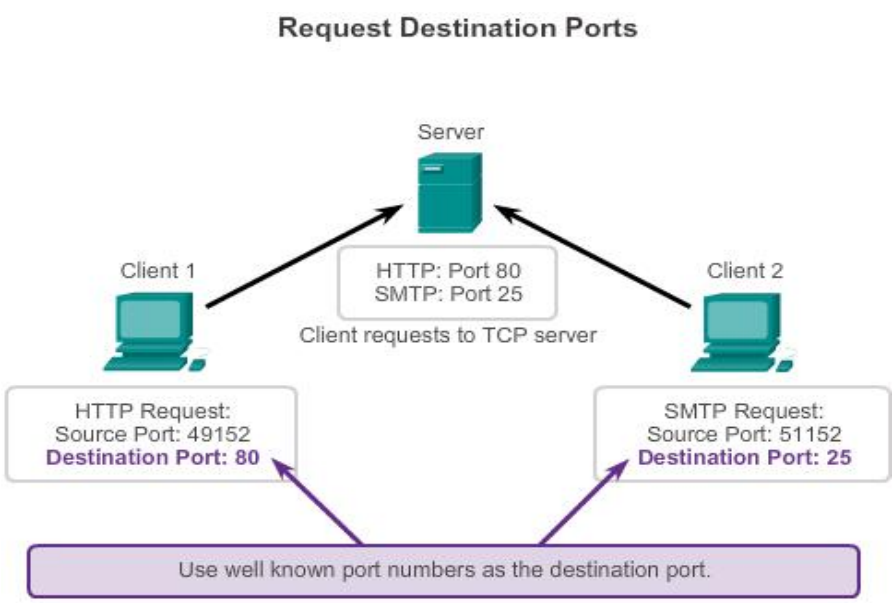
TCP and UDP Port Addressing

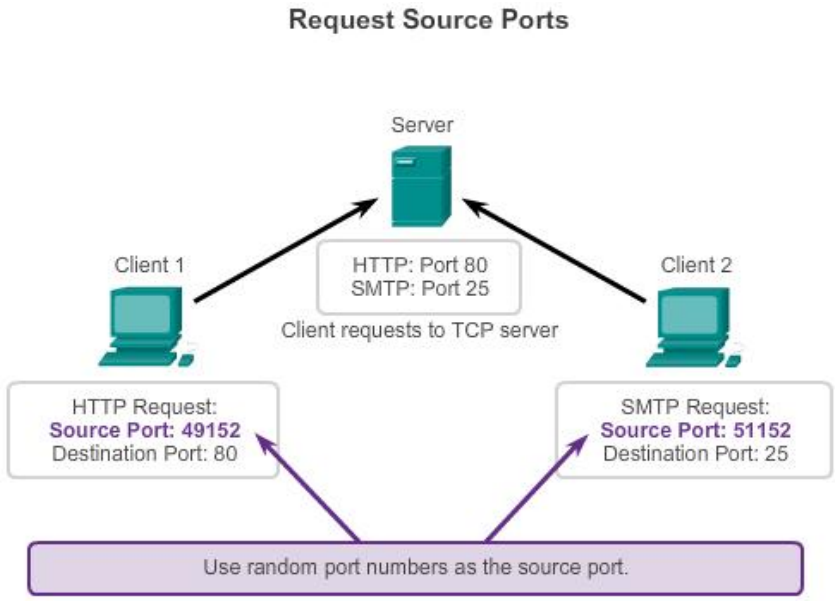
Netstat

- Used to examine TCP connections that are open and running on a networked host

```
C:\>netstat

Active Connections

Proto   Local Address   Foreign Address          State
TCP     kenpc:3126      192.168.0.2:netbios-ssn  ESTABLISHED
TCP     kenpc:3158      207.138.126.152:http     ESTABLISHED
TCP     kenpc:3159      207.138.126.169:http     ESTABLISHED
TCP     kenpc:3160      207.138.126.169:http     ESTABLISHED
TCP     kenpc:3161      sc.msn.com:http          ESTABLISHED
TCP     kenpc:3166      www.cisco.com:http       ESTABLISHED

C:\>
```

TCP Server Processes





TCP Connection, Establishment and Termination

Three-Way Handshake

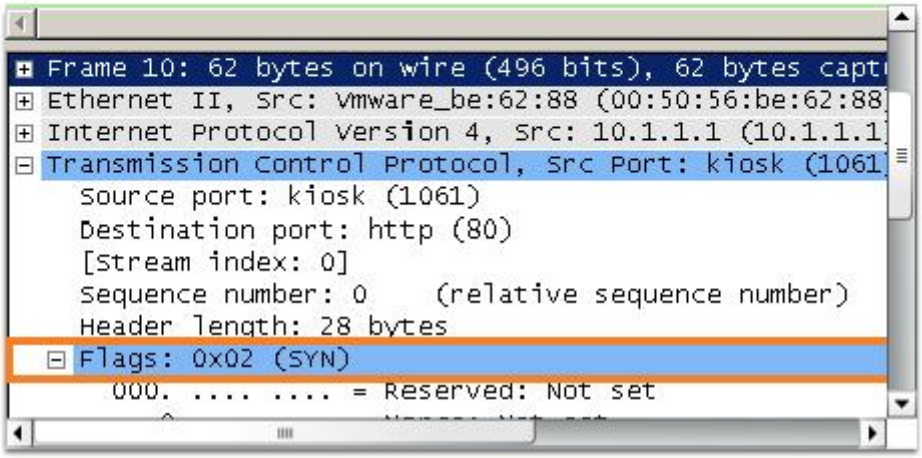
- Establishes that the destination device is present on the network.
- Verifies that the destination device has an active service and is accepting requests on the destination port number that the initiating client intends to use for the session.
- Informs the destination device that the source client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

 NEED New Graphic for this and next two slides

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)



Protocol Analyzer shows initial client request for session in frame 14

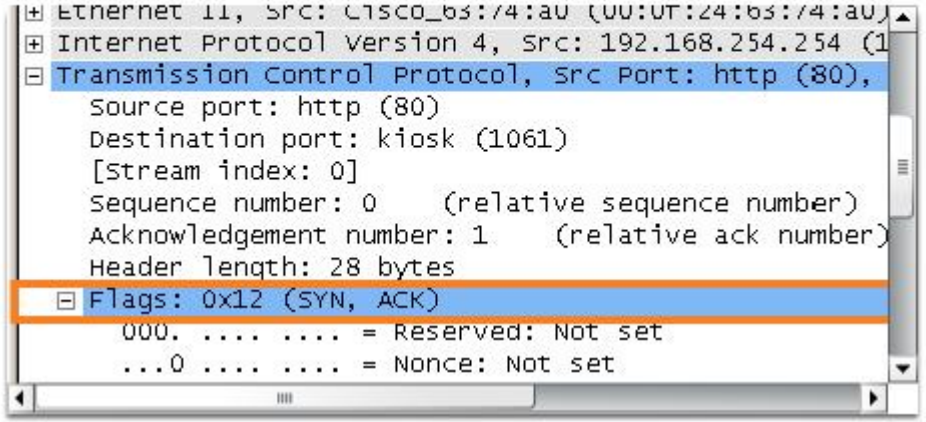
TCP segment in this frame shows:

- 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 3-way Handshake (SYN, ACK)



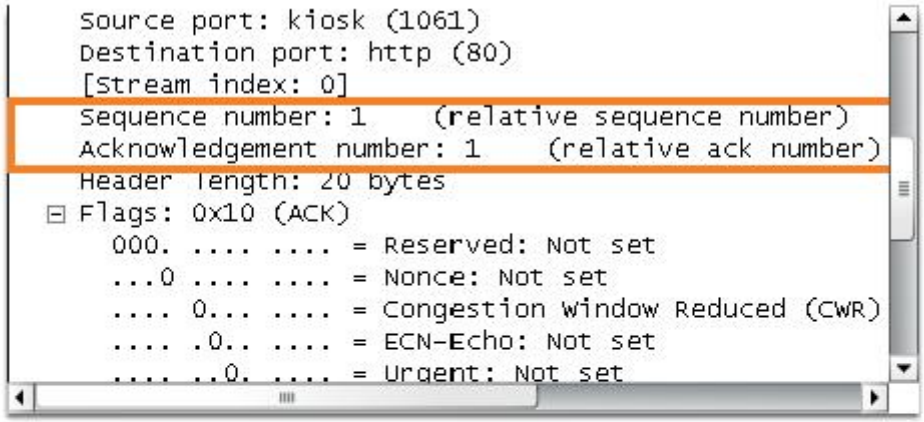
A protocol analyzer shows server response in frame 15

- ACK flag set to indicate a valid Acknowledgement number
- Acknowledgement number response to initial sequence number as relative value of 1
- SYN flag set to indicate the Initial Sequence Number for the server to client session
- Destination port number of 1061 to corresponding to the clients source port
- Source port number of 80 (HTTP) indicating the web server service (httpd)

TCP Three-Way Handshake – Step 3

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

TCP 3-way Handshake (ACK)



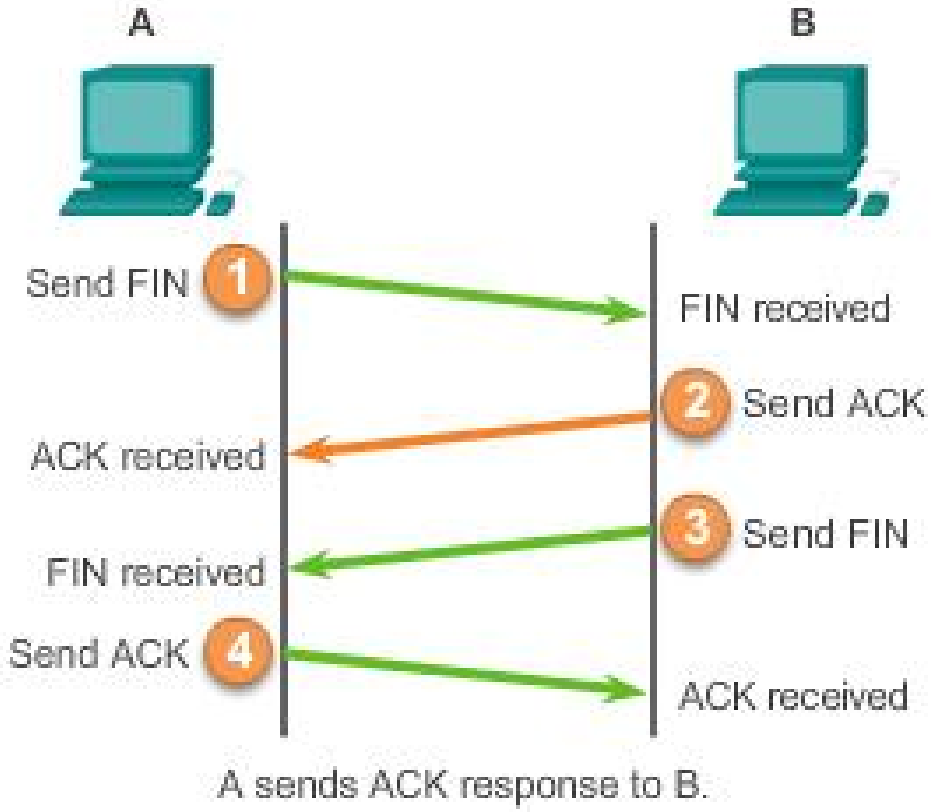
Protocol Analyzer shows client response to session in frame 16

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)

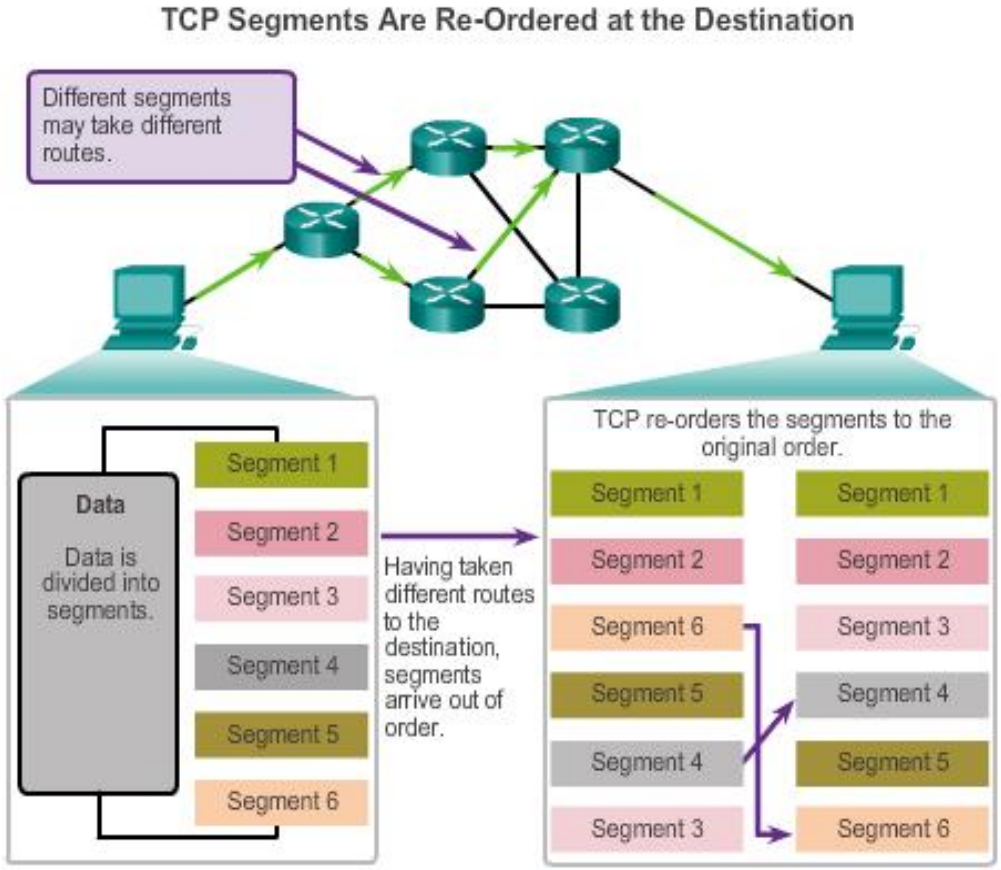
TCP Communication

TCP Session Termination



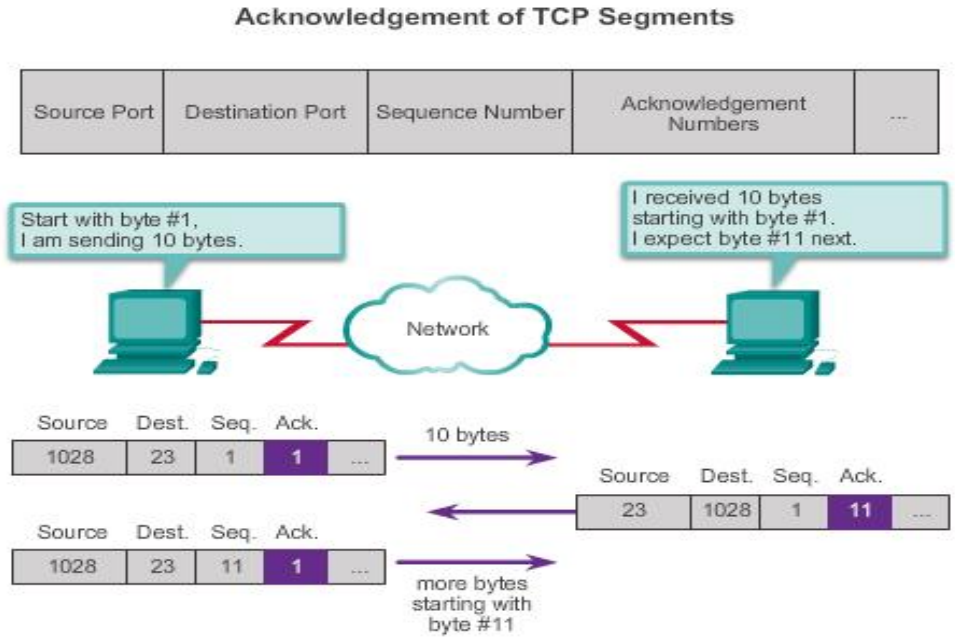
TCP Reliability – Ordered Delivery

Sequence numbers used to reassemble segments into original order



TCP Reliability – Acknowledgement and Window Size

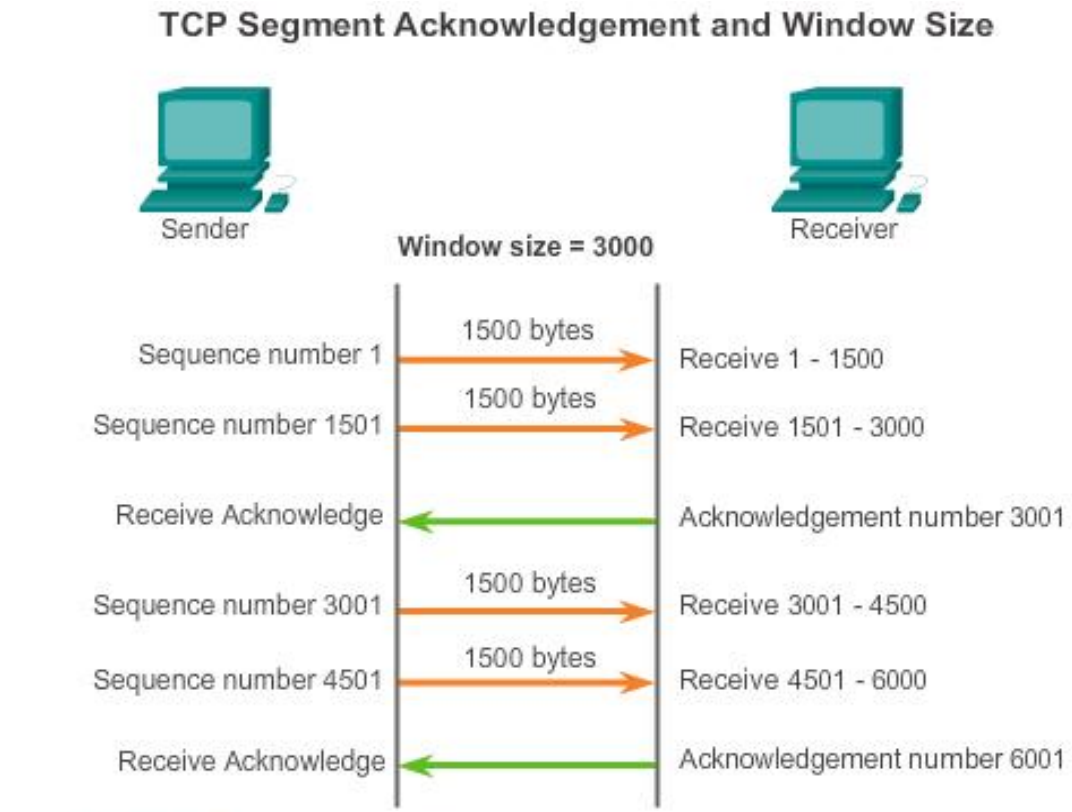
The sequence number and acknowledgement number are used together to confirm receipt.



Window Size - The amount of data that a source can transmit before an acknowledgement must be received.

TCP Reliability and Flow Control

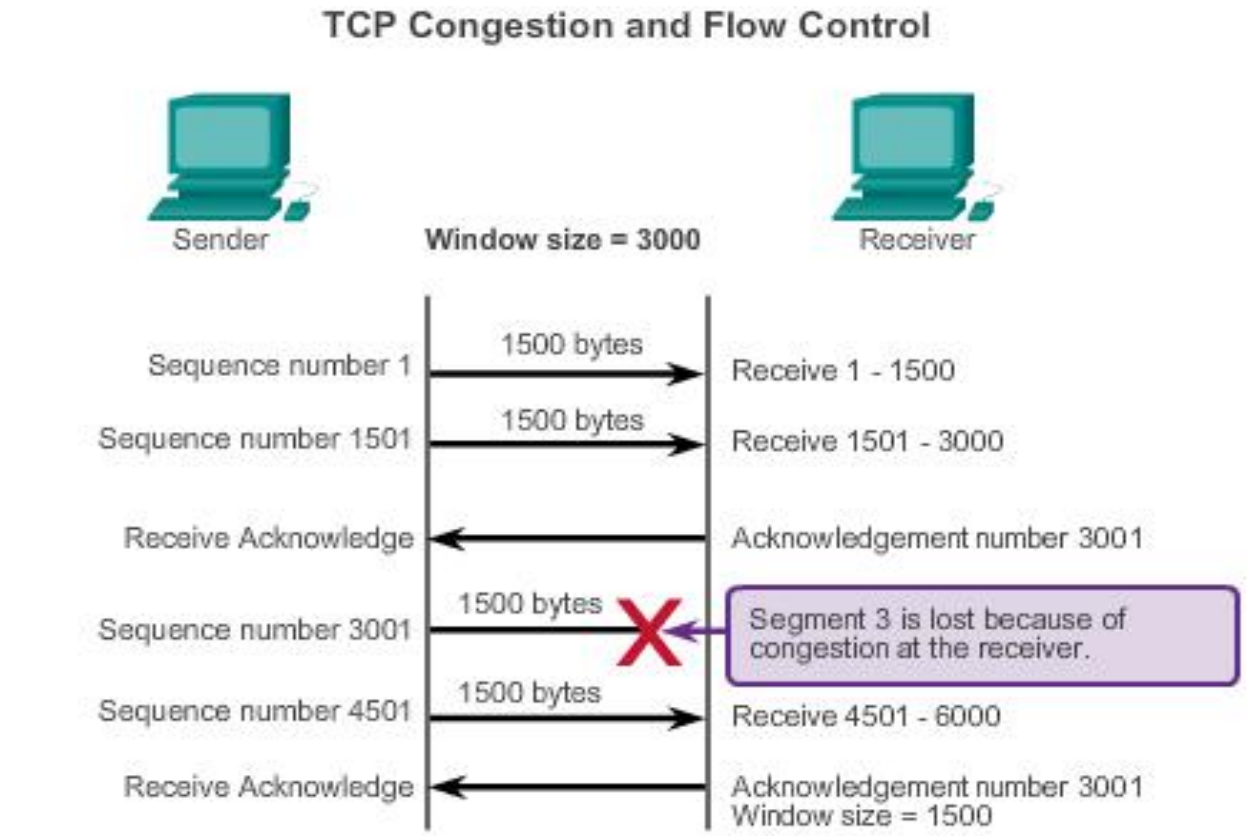
Window Size and Acknowledgements



The **window size** determines the number of bytes sent before an acknowledgment is expected.

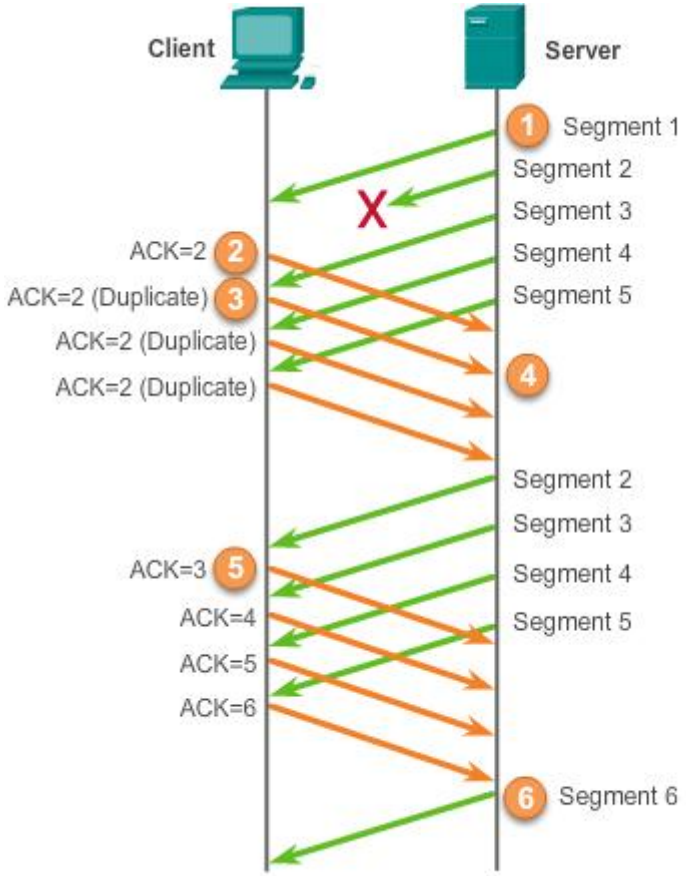
The **acknowledgement** number is the number of the next expected byte.

TCP Flow Control – Congestion Avoidance



If segments are lost because of congestion, the Receiver will acknowledge the last received sequential segment and reply with a reduced window size.

TCP Reliability - Acknowledgements



UDP Low Overhead vs. Reliability

UDP

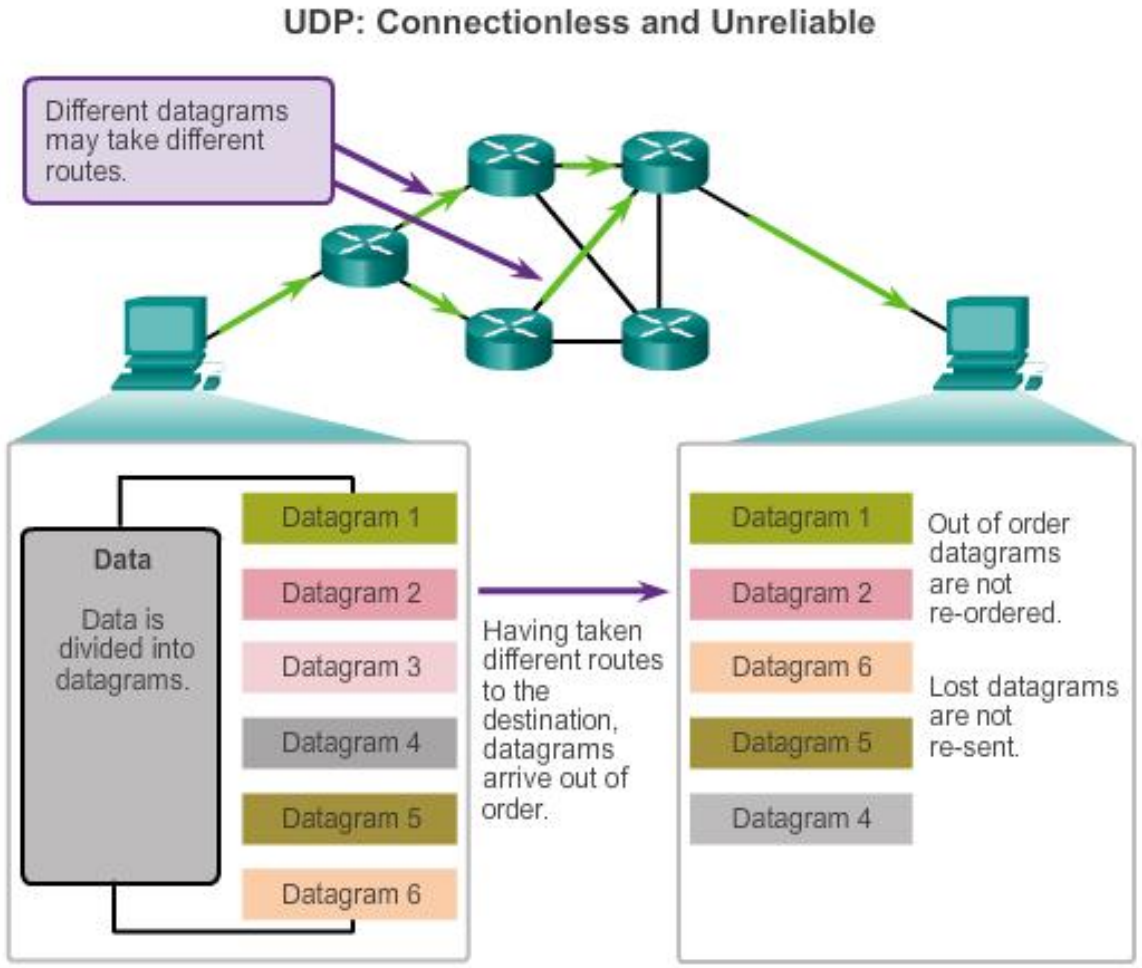
- Simple protocol that provides the basic transport layer functions
- Used by applications that can tolerate small loss of data
- Used by applications that cannot tolerate delay

Used by

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

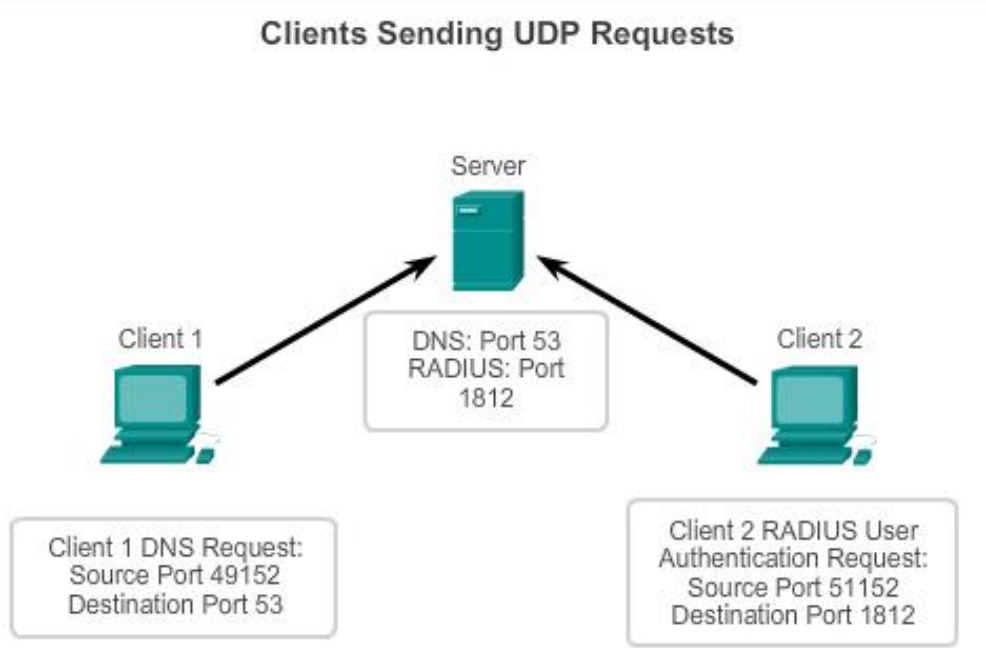
UDP Communication

Datagram Reassembly

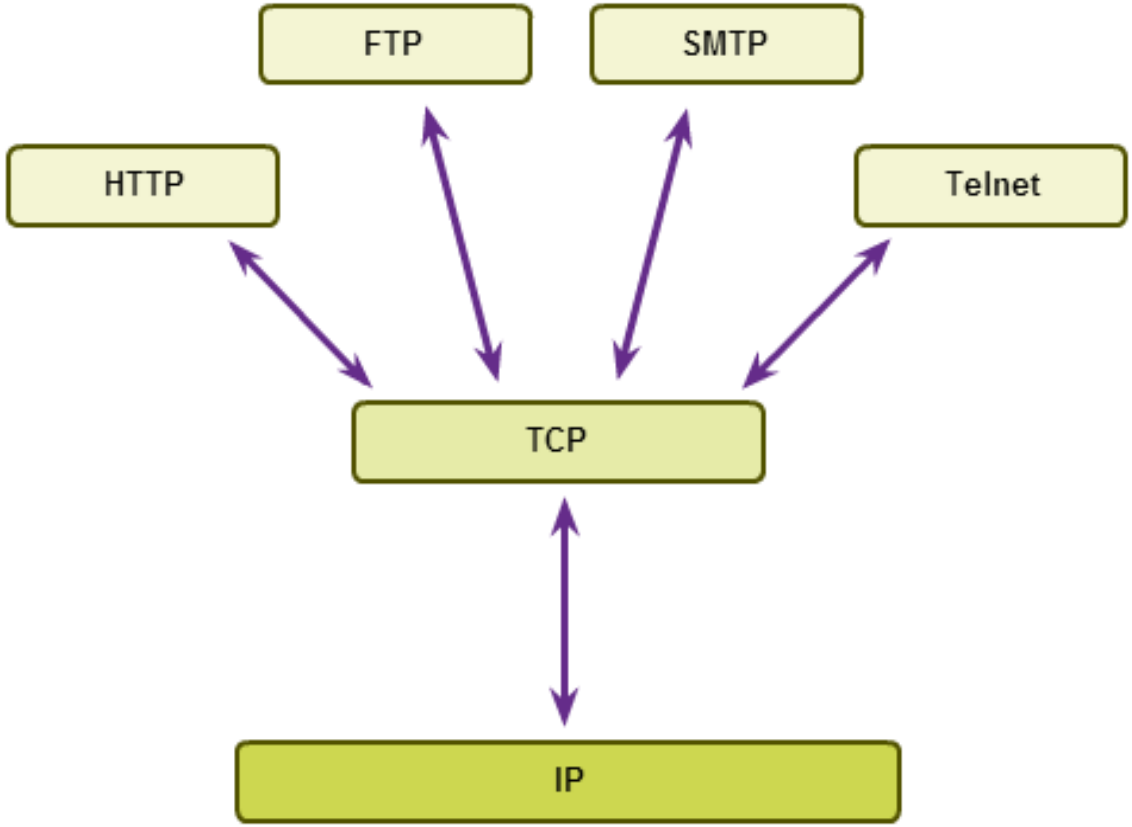


UDP Server and Client Processes

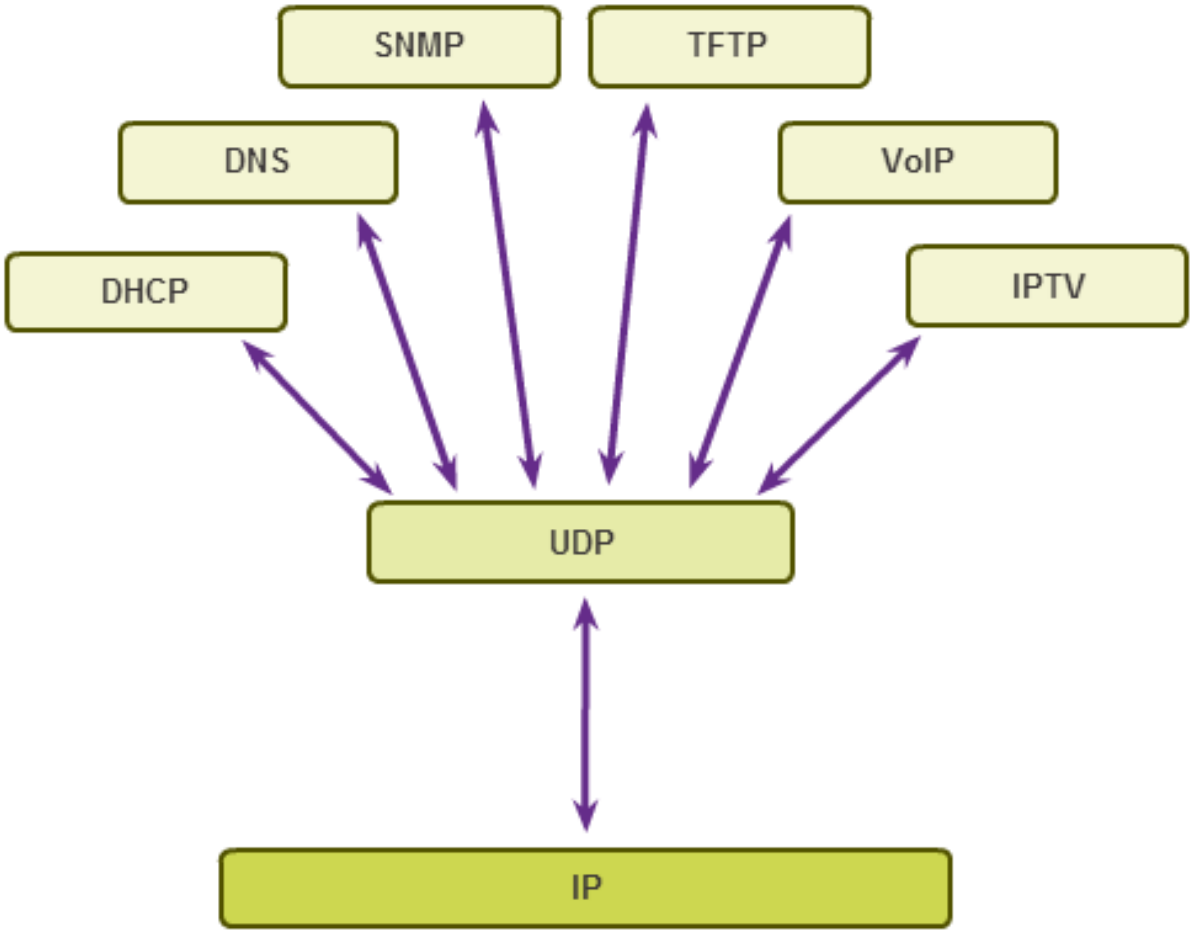
- UDP-based server applications are assigned well-known or registered port numbers.
- UDP client process randomly selects port number from range of dynamic port numbers as the source port.



Applications that use TCP



Applications that use UDP



Chapter 7: Summary

- The role of the Transport layer is to provide three main functions: multiplexing, segmentation and reassembly, and error checking.
- These functions are necessary in order to address issues in quality of service and security on networks.
- Knowing how TCP and UDP operate and which popular applications use each protocol will allow the implementation of quality of service and build more reliable networks.
- Ports provide a “tunnel” for data to get from the Transport layer to the appropriate application at the destination.