OSI Transport Layer

Network Fundamentals – Chapter 4

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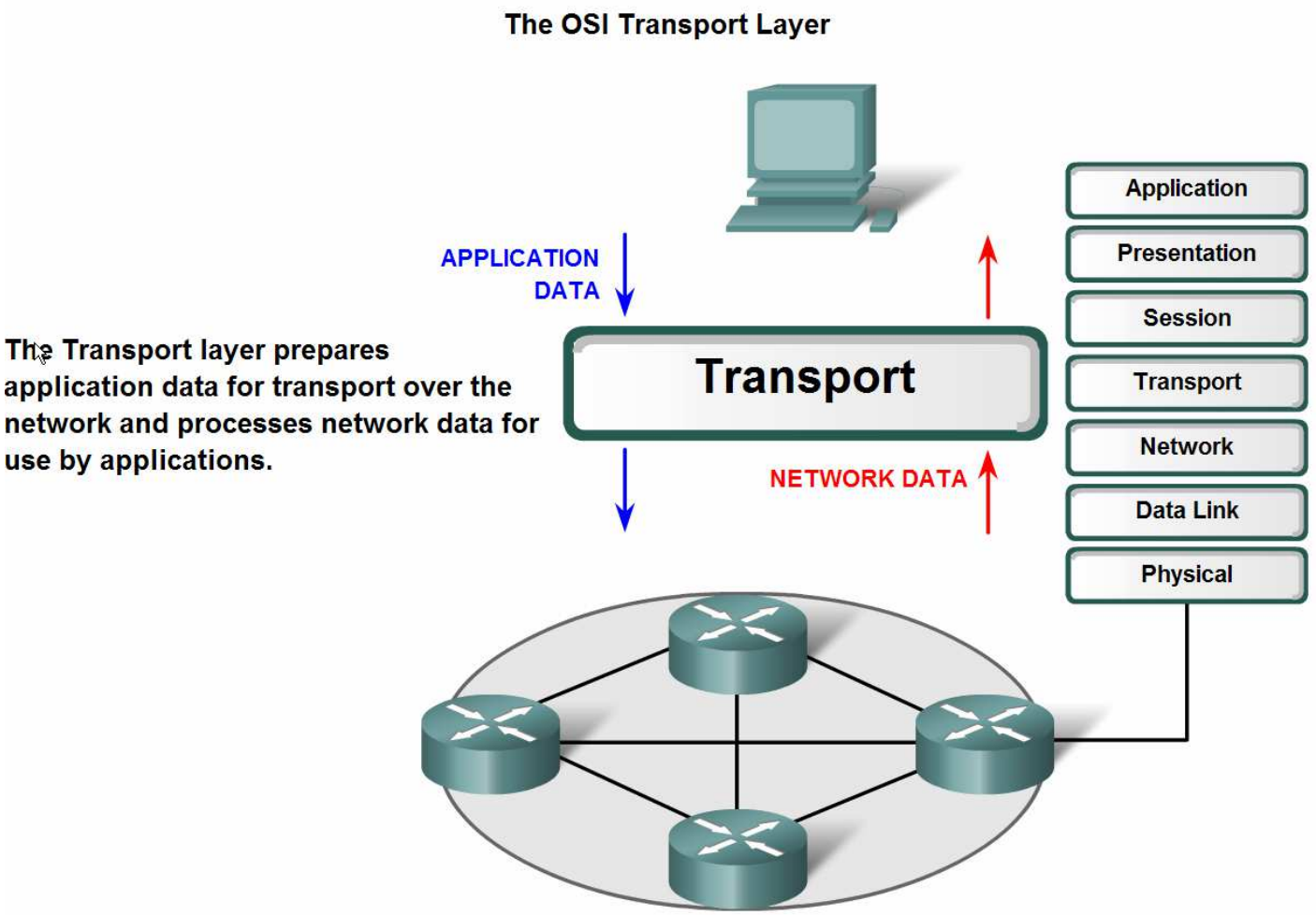
Objectives

- Explain the **role of Transport Layer protocols and services** in supporting communications across data networks
- Analyze the application and operation of **TCP** mechanisms that support *reliability, reassembly and manage data loss.*
- Analyze the operation of **UDP** to support communicate between two processes on end devices

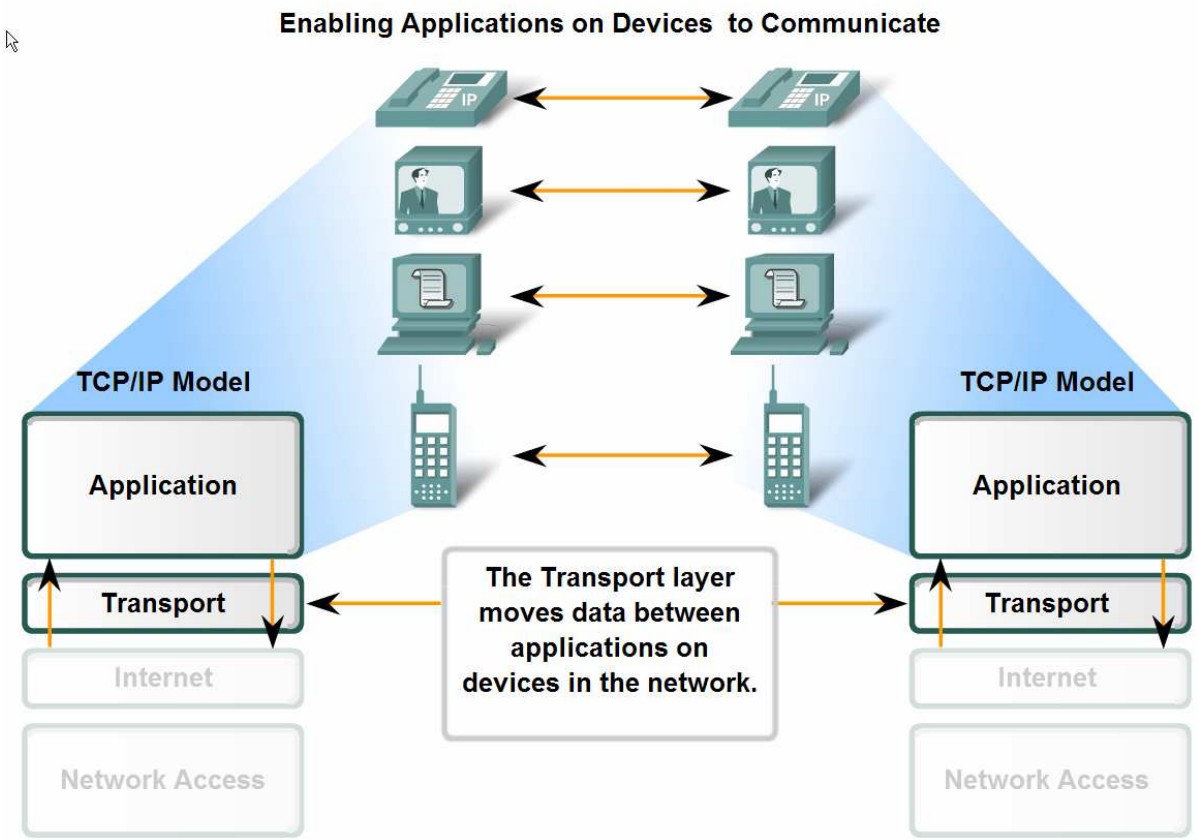
Transport Layer Role and Services

- The purpose of the Transport layer



Transport Layer Role and Services

- **Provides the end-to-end transfer of data between <u>applications</u>.**



Role of the Transport layer

- Encapsulating application data for use by the Network layer
- Enables multiple applications to communicate over the network at the same time on a single device
- Ensures that, if required, all the data is received reliably and in order by the correct application
- Employs error handling mechanisms

Responsibilities

- **Tracking** the individual communication between *applications* on the source and destination hosts (**Establishing a Session)**
- **Segmenting** data and managing each piece
- **Reassembling** the segments into streams of application data
- Identifying the **different** applications **(Port Number)**

Two TCP/IP Transport layer protocols

- There are multiple Transport layer protocols. Why?

  Because different applications have different requirements.

- The two most common Transport layer protocols of TCP/IP protocol suite are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). Both protocols manage the communication of multiple applications. The differences between the two are the specific functions that each protocol implements.

Two TCP/IP Transport layer protocols: TCP and UDP.

Some protocols **TCP** at the Transport layer provide:

- Connection-oriented conversations
- Reliable delivery
- Ordered data reconstruction
- Flow control

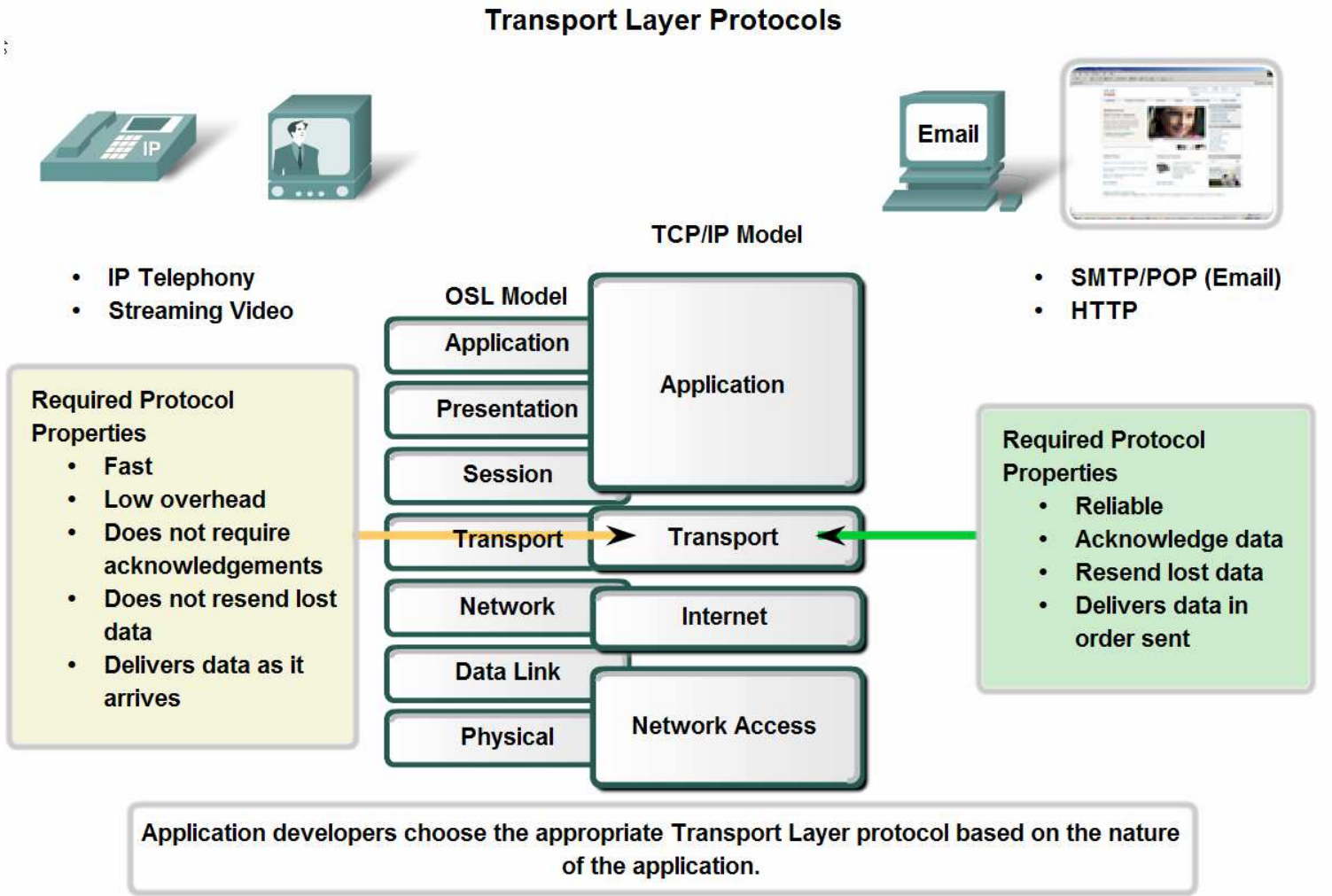
Basic characteristics of the UDP and TCP protocols

- Fast
- Low overhead
- Does not require acknowledgements
- Does not resend lost data
- Delivers data as it arrives

-Reliable
- Acknowledges data
- Resends lost data
- Delivers data in the order sent

Transport Layer Role and Services

- Supporting Reliable Communication



UDP

- **UDP** is a simple, **connectionless** protocol
- **low overhead** data delivery.
- **datagrams** are sent as "**best effort**" by this Transport layer protocol.

Applications that use UDP include:

- Domain Name System (DNS)
- Video Streaming
- Voice over IP (VoIP)

Transmission Control Protocol (TCP)

- Connection-oriented protocol,
- Overhead
-]low control

flow control

Flow control is the management of data flow between devices in a network. It is used to avoid too much data arriving before a device can handle it, causing data overflow.

Applications that use TCP are:

- Web Browsers
- E-mail
- File Transfers

Transport Layer Headers

- segment or datagram?

TCP and UDP Headers

TCP SEGMENT & HEADER FIELDS

Bit 0	Bit 15 Bit 16	Bit 31
Source Port (16)	Destination Port (16)	
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 SEGMENT (Size varies)		

20 Bytes

UDP SEGMENT & HEADER FIELDS

Bit (0)	Bit (15) Bit (16)	Bit (31)
Source Port (16)	Destination Port (16)	
Length (16)	Checksum (16)	
APPLICATION LAYER DATA SEGMENT (Size varies)		

8 Bytes

Port Number, Identifying the Conversations

- Port numbers are assigned in various ways, depending on whether the message is a request or a response. While server processes have **static port numbers** assigned to them, **clients dynamically choose** a port number for each conversation.

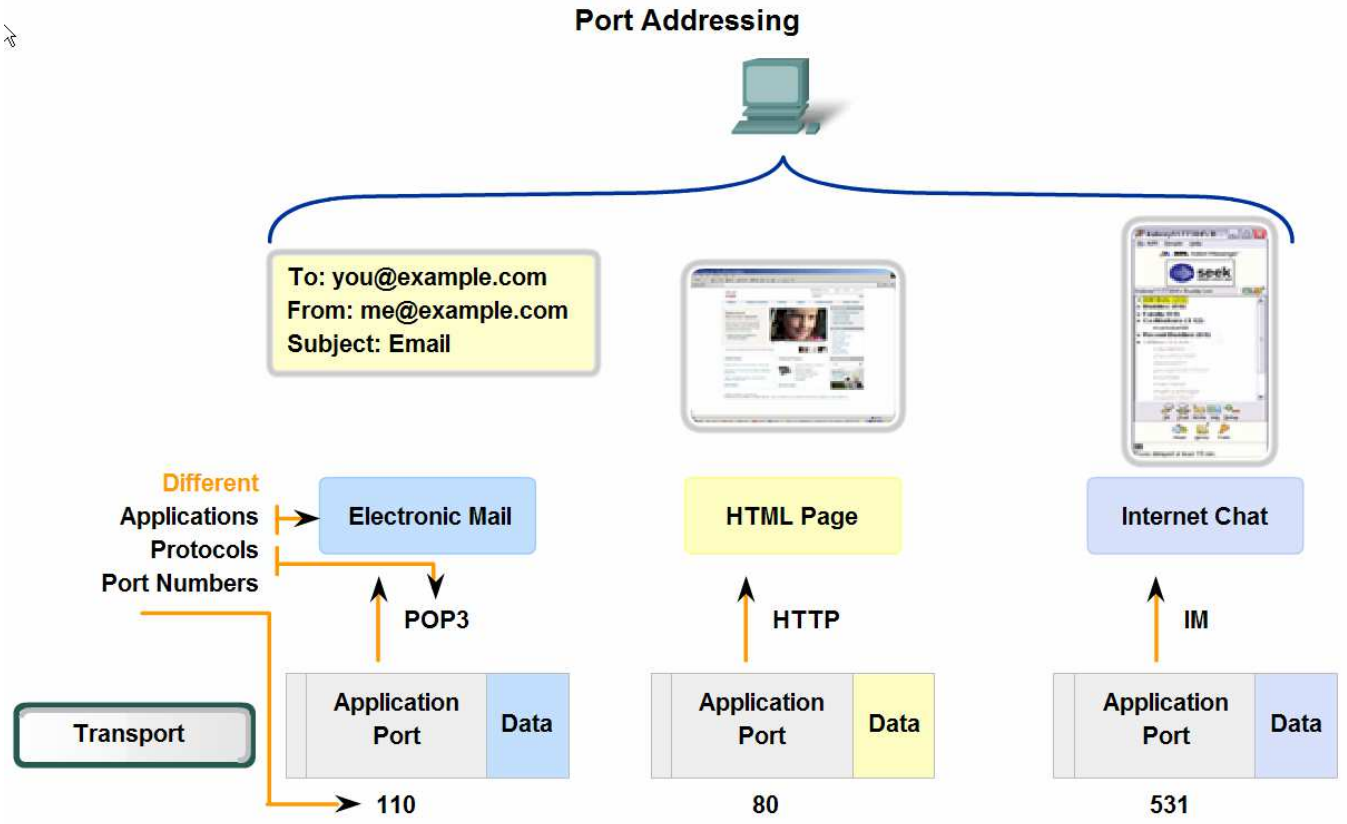
Port Number

- When a client application sends a request to a server application, the destination port contained in the header is the port number that is assigned to the service daemon running on the remote host. The client software must know what port number is associated with the server process on the remote host. This destination port number is configured, either by default or manually. For example, when a web browser application makes a request to a web server, the browser uses TCP and port number 80 unless otherwise specified. This is because TCP port 80 is the default port assigned to web-serving applications. Many common applications have default port assignments.

- The source port in a segment or datagram header of a client request is **randomly** generated from port numbers greater than 1023

- The combination of the Transport layer **port number** and the Network layer **IP address** assigned to the host uniquely identifies a particular process running on a specific host device. This combination is called a **socket**.
- 192.168.1.20:80.

Port Number



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

There are different types of port numbers:

- **Well Known** Ports (Numbers 0 to 1023)

These numbers are reserved for **services and applications**. They are commonly used for applications such as HTTP (web server) POP3/SMTP (e-mail server) and Telnet.

Registered Ports (Numbers 1024 to 49151)

These port numbers are assigned to **user** processes or applications. These processes are primarily individual applications that a user has chosen to install rather than common applications that would receive a Well Known Port. When not used for a server resource, these ports may also be used dynamically selected by a client as its source port.

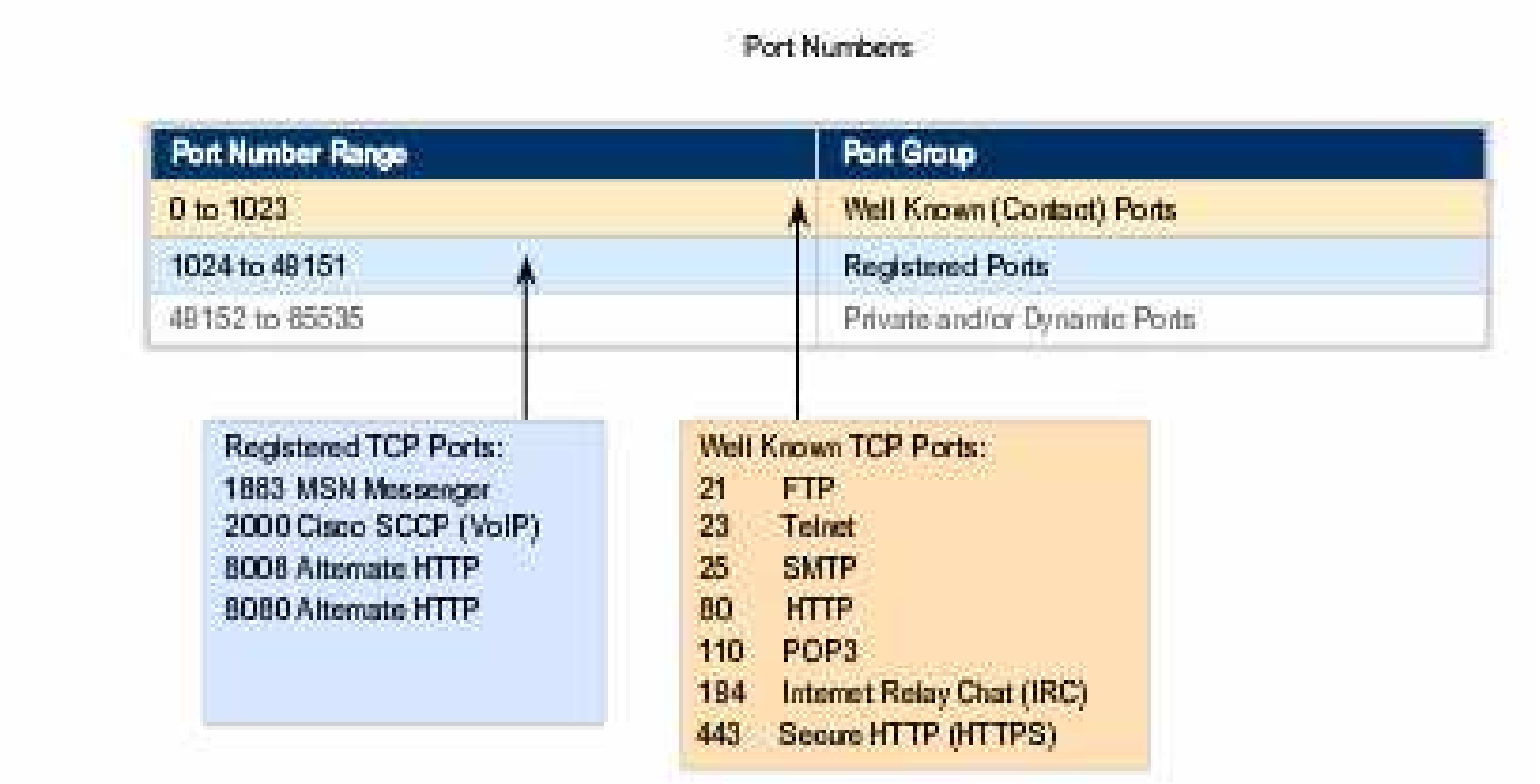
- **Dynamic or Private Ports** (Numbers 49152 to 65535) these are usually assigned dynamically to client applications when initiating a connection.

Using both TCP and UDP

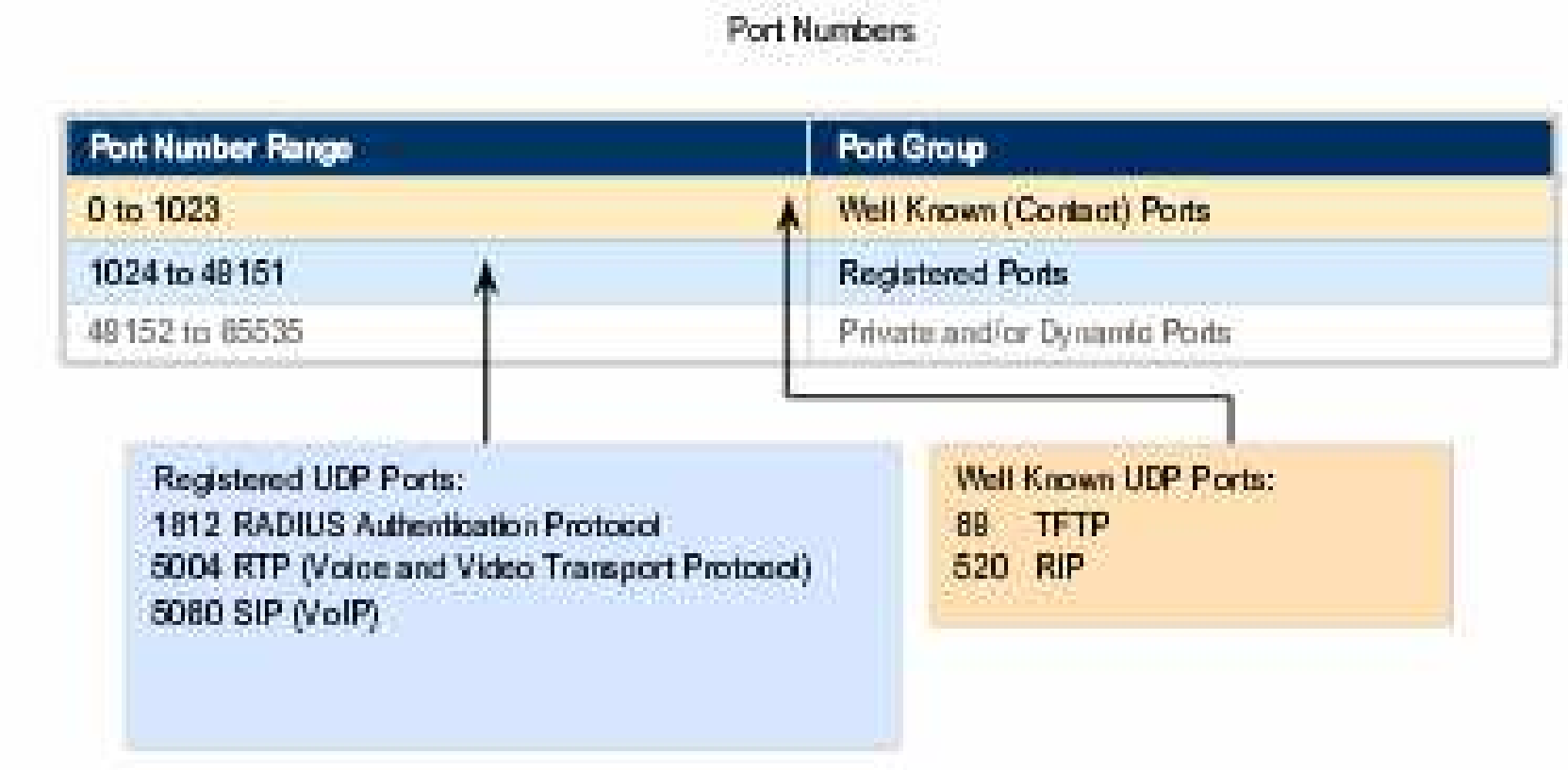
- Some applications may use both TCP and UDP.

  For example, the low overhead of UDP enables DNS to serve many client requests very quickly. Sometimes, however, sending the requested information may require the reliability of TCP. In this case, the well known port number of 53 is used by both protocols with this service.

TCP Ports



UDP Ports



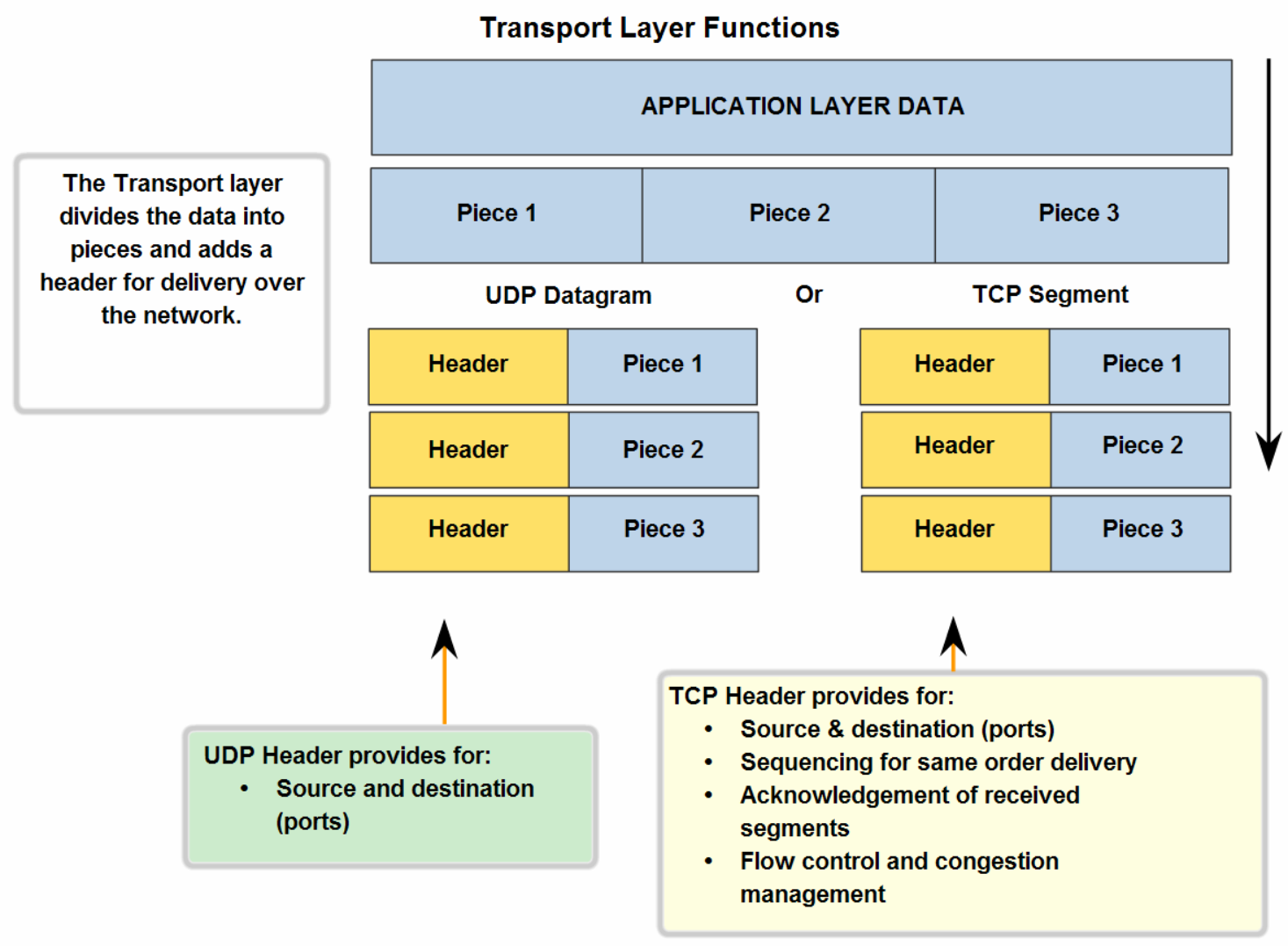
Netstat

- Netstat lists the protocol in use, the local address and port number, the foreign address and port number, and the state of the connection.

Segments

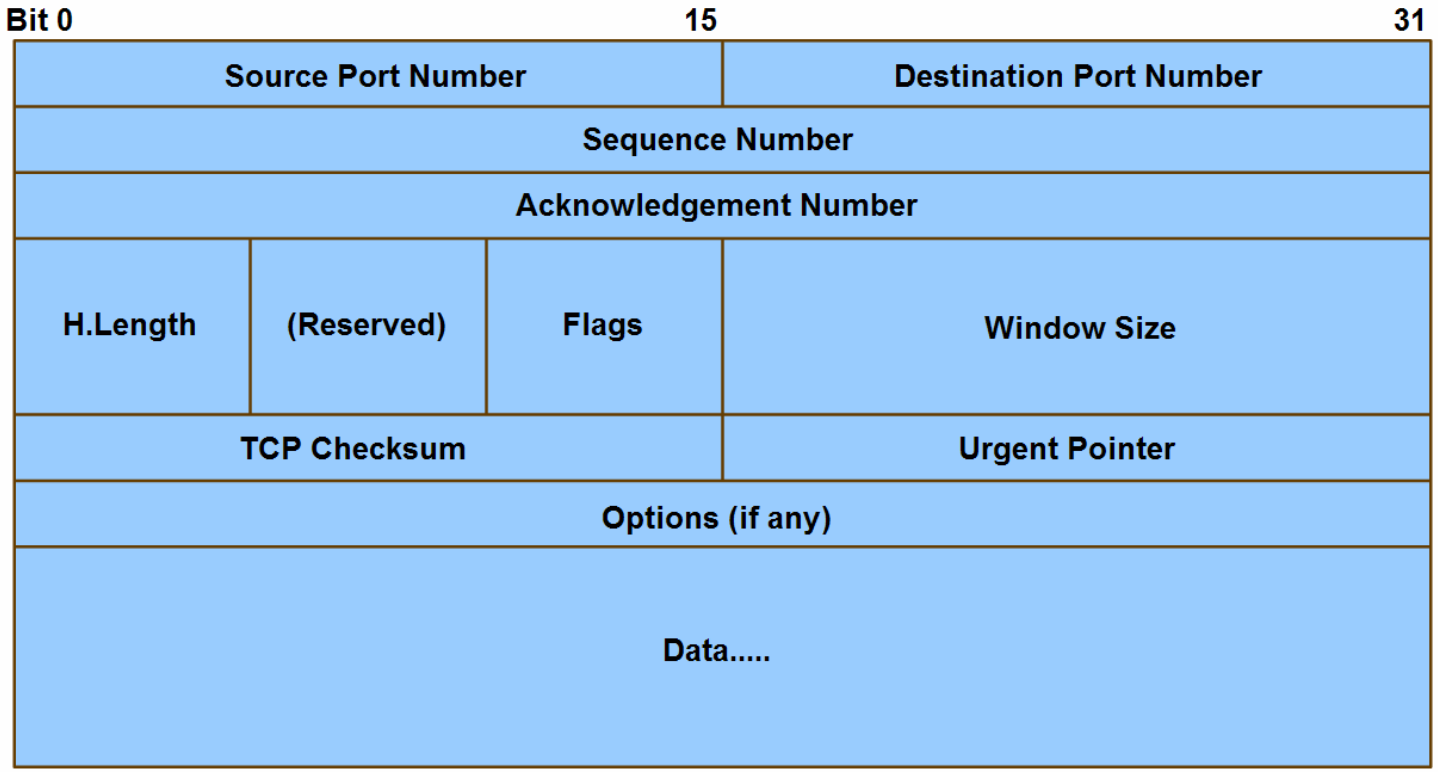
- Dividing application data into pieces both ensures that *data is transmitted within the limits of the media* and that data from different applications can be *multiplexed* on to the media.

Segments



TCP Segment Header

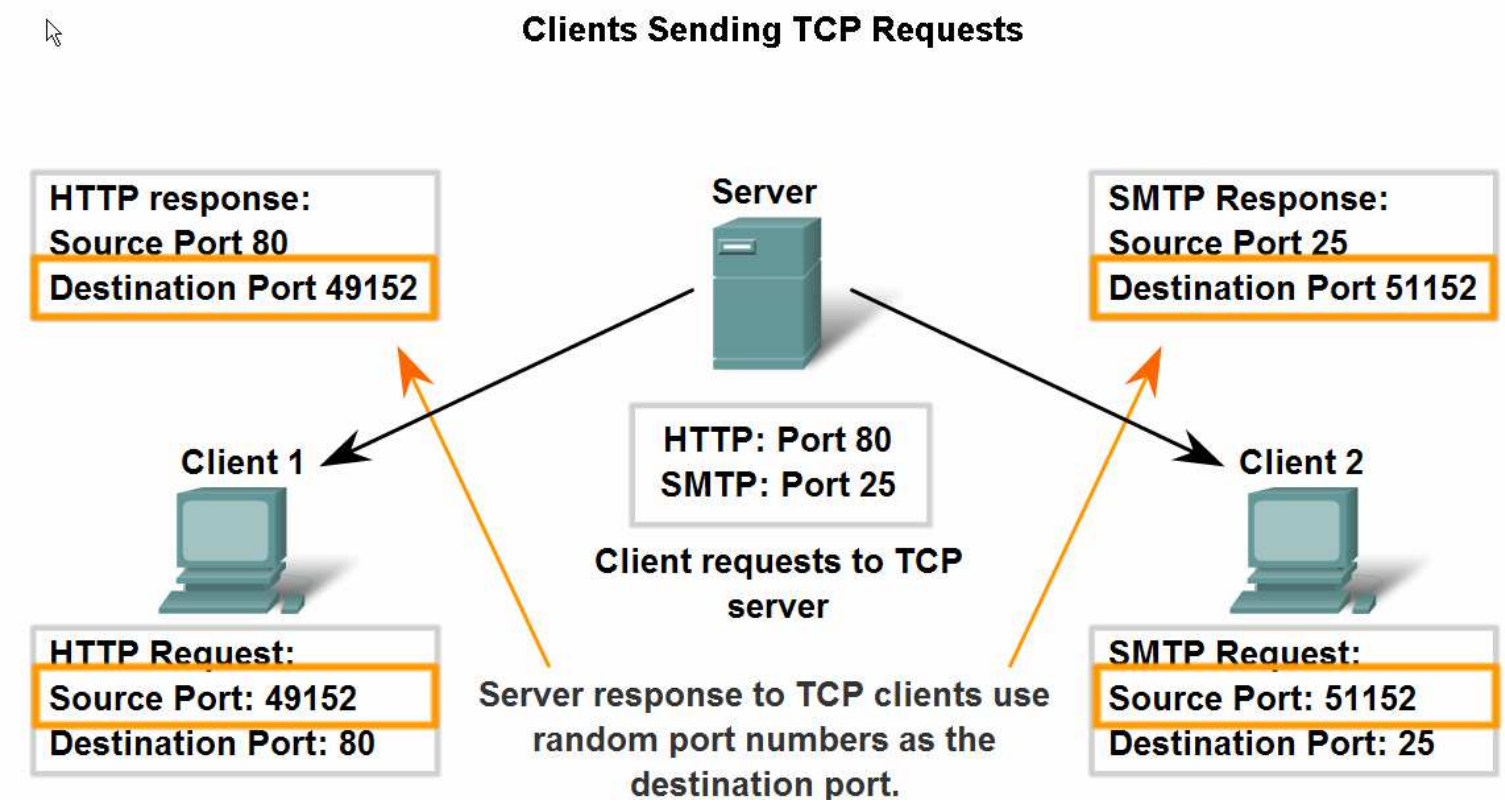
TCP Segment Header Fields



The fields of the TCP header enable TCP to provide connection-oriented, reliable data communications.

Application and Operation of TCP Mechanisms

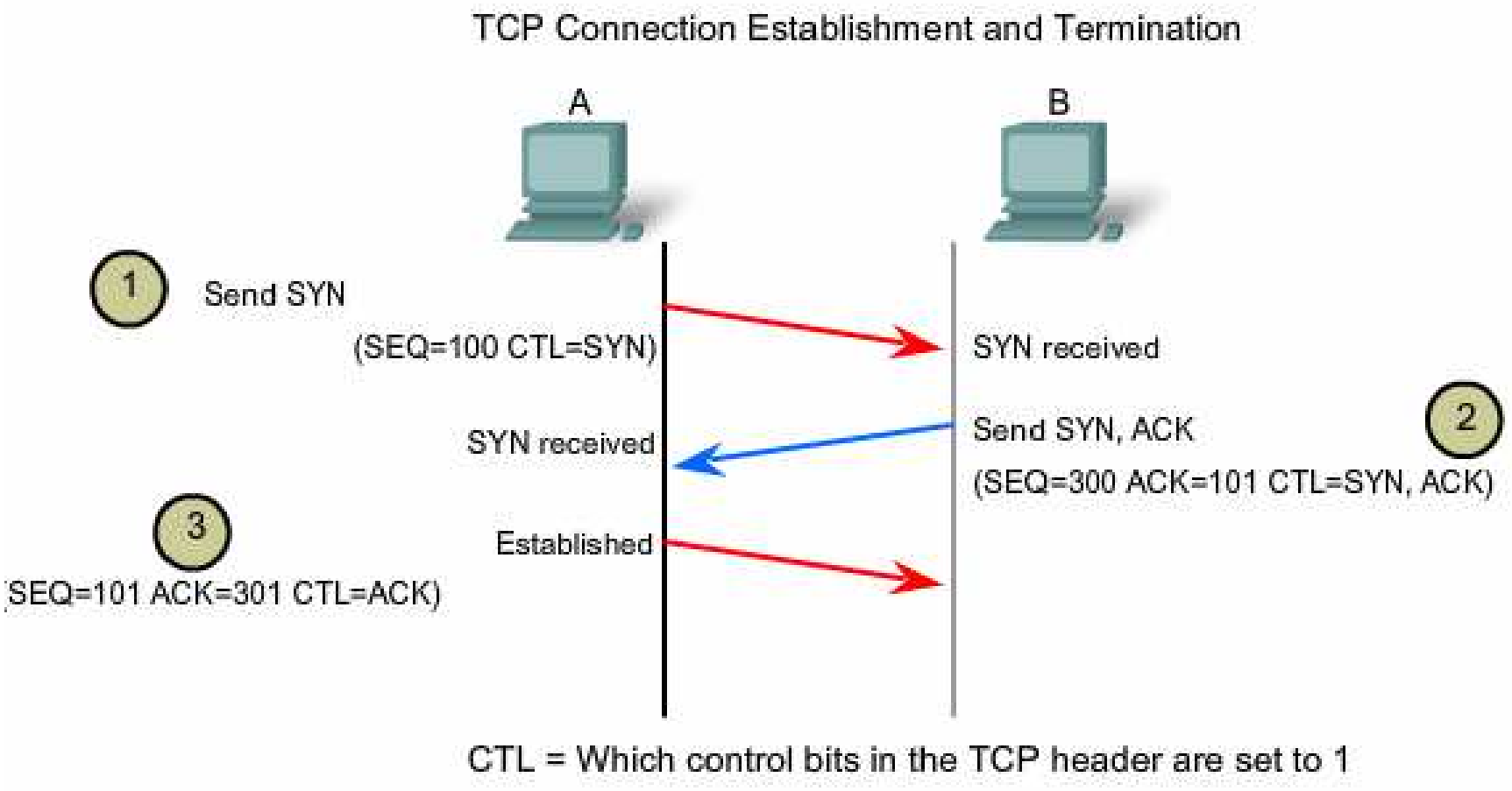
- port numbers in establishing TCP sessions and directing segments to server process



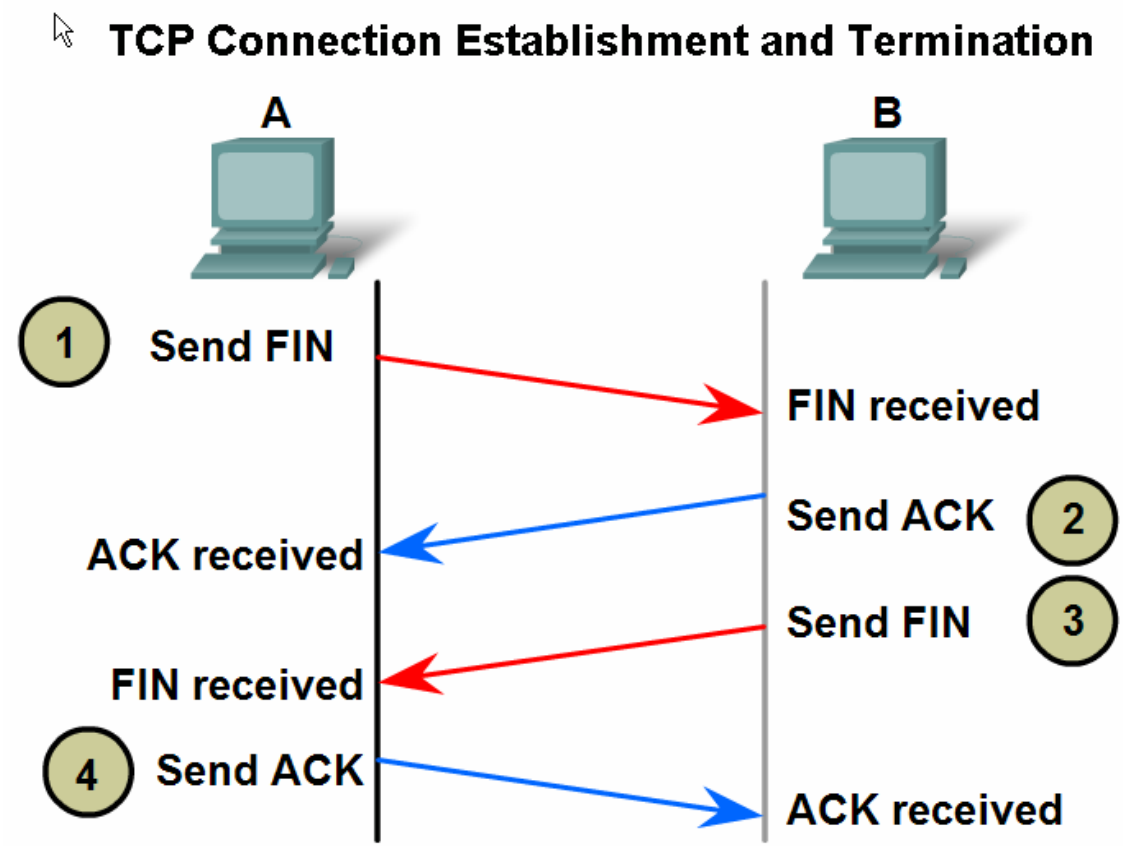
TCP Connection Establishment and Termination

- When two hosts communicate using TCP, a connection is established before data can be exchanged.
- After the communication is completed, the sessions are closed and the connection is terminated.
- The connection and session mechanisms enable TCP's **reliability** function.

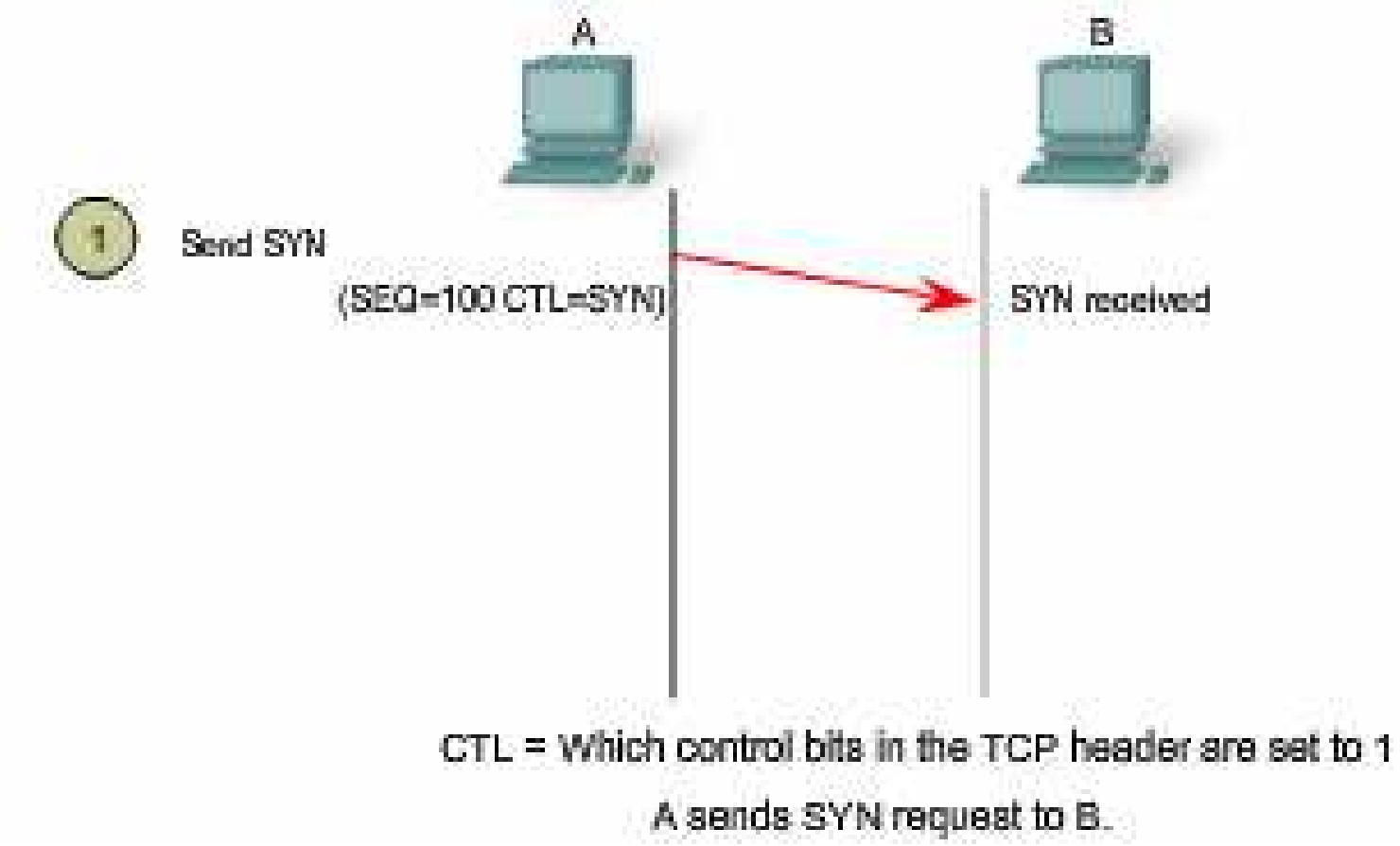
Handshake in the establishment of TCP sessions



Handshake in the termination of TCP sessions



TCP 3 way handshake



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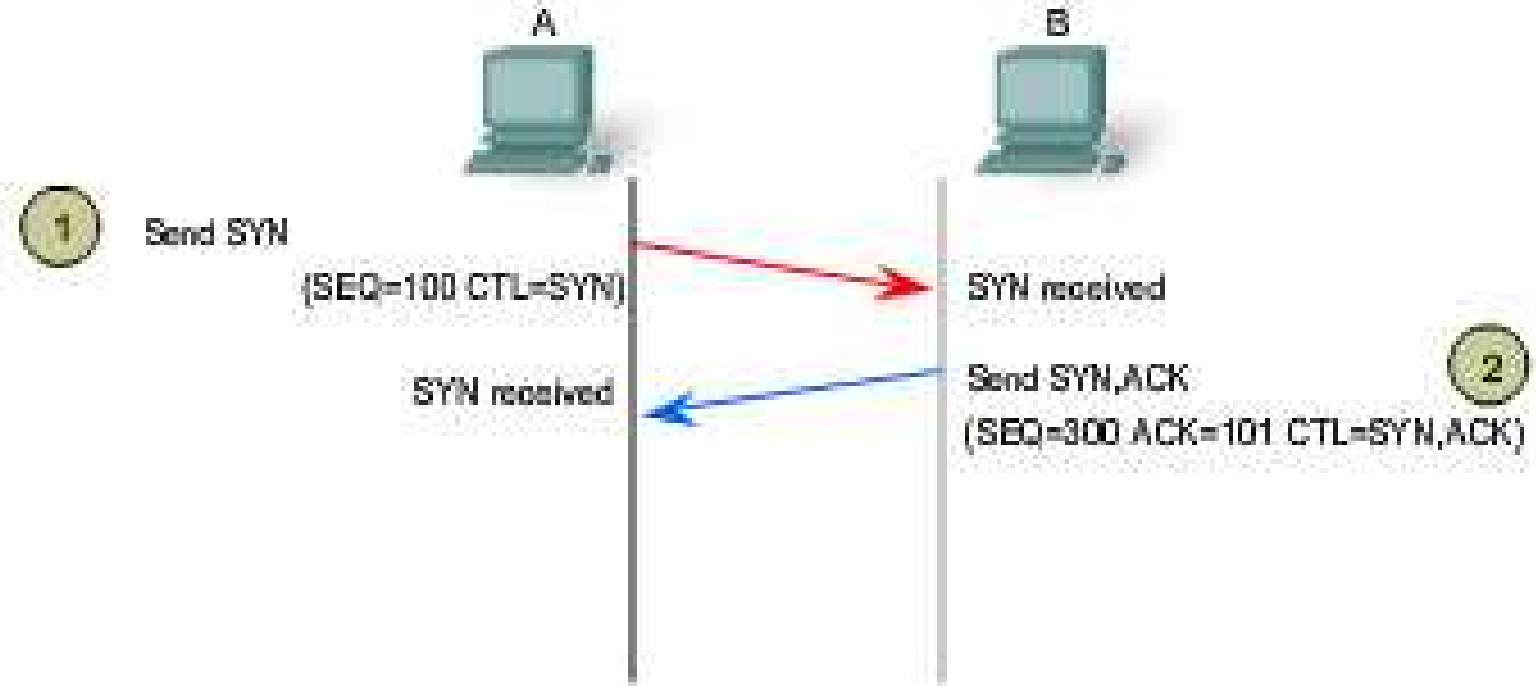

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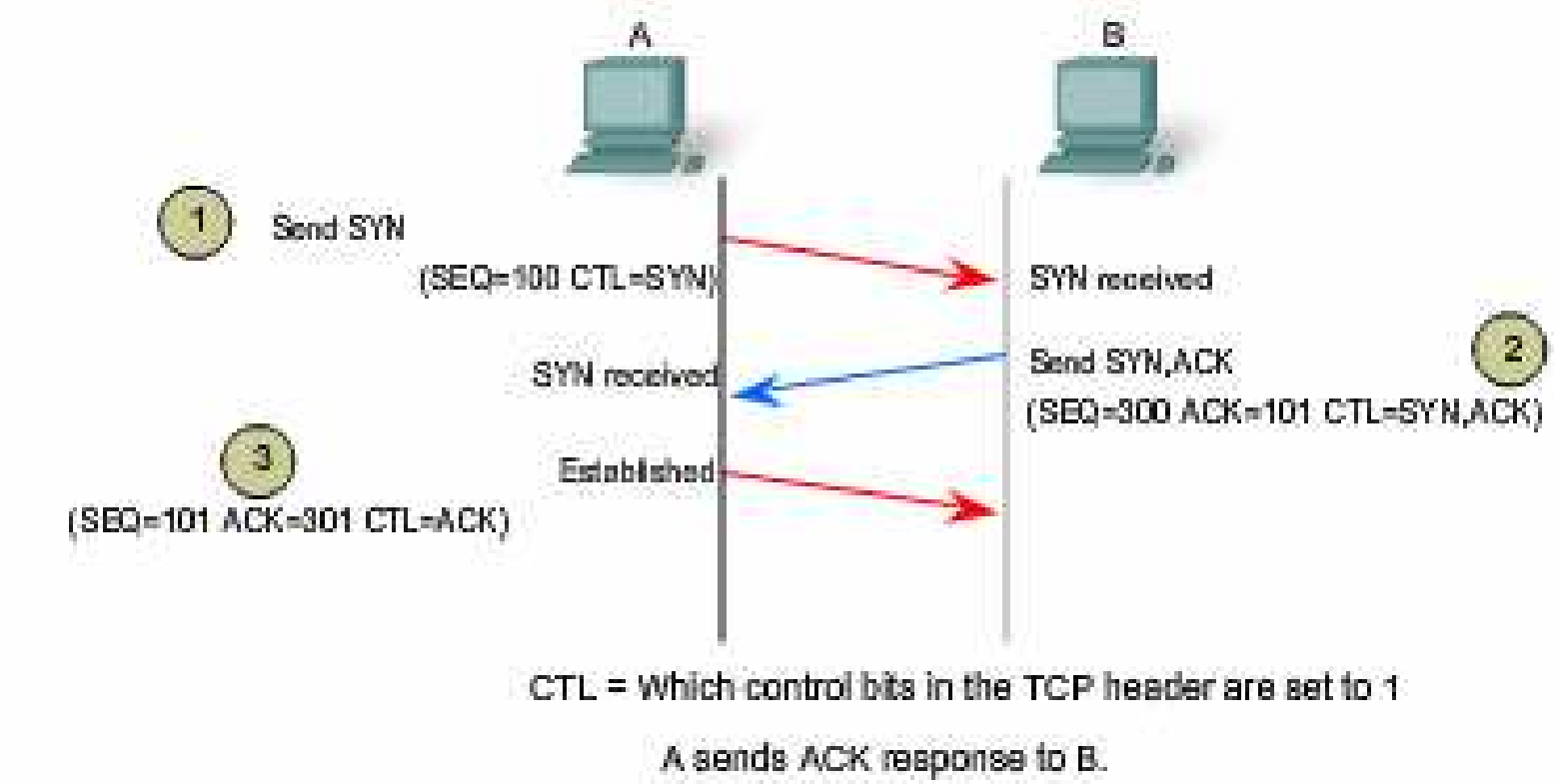
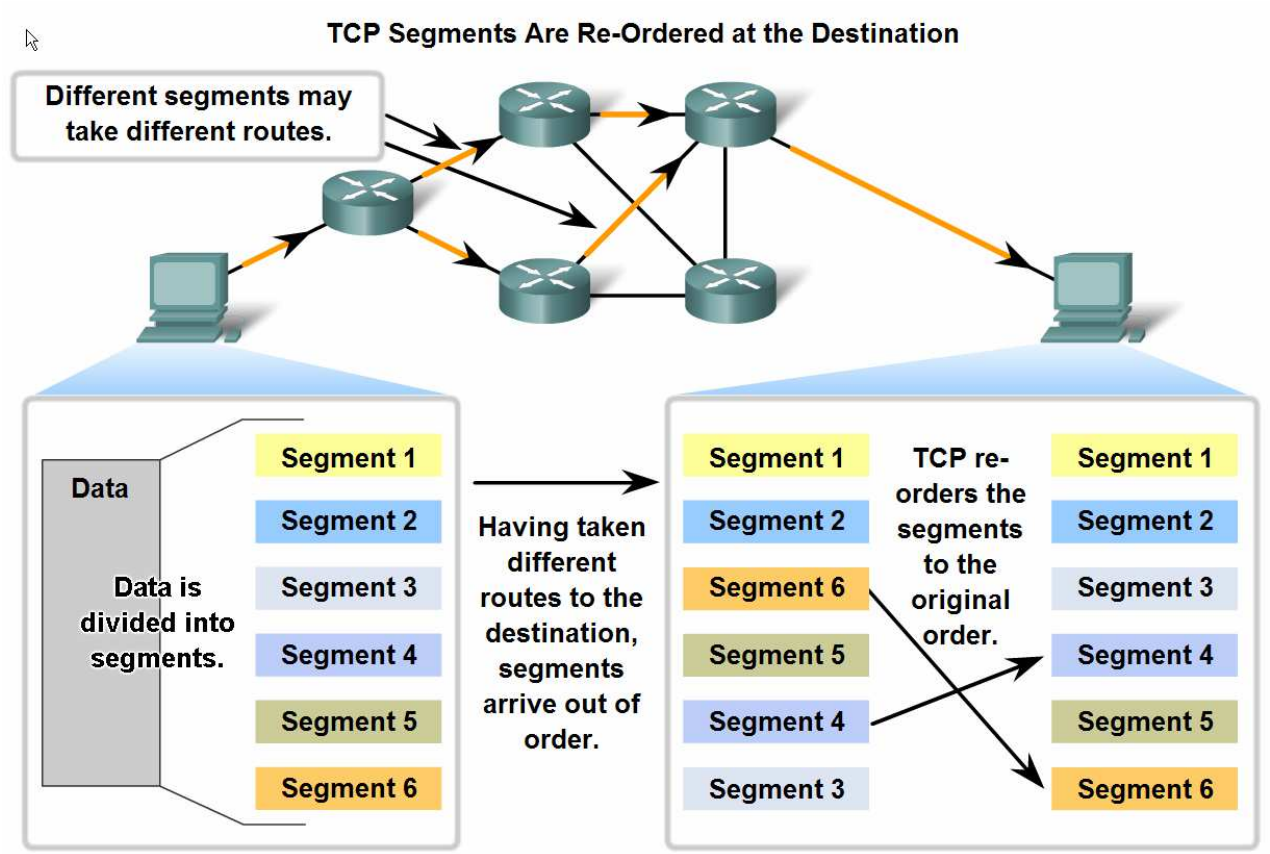


- **The sequence number** is the relative **number of bytes that have been transmitted** in this session plus 1

- **acknowledgement number** indicate the **next byte in this session that the receiver expects to receive**.

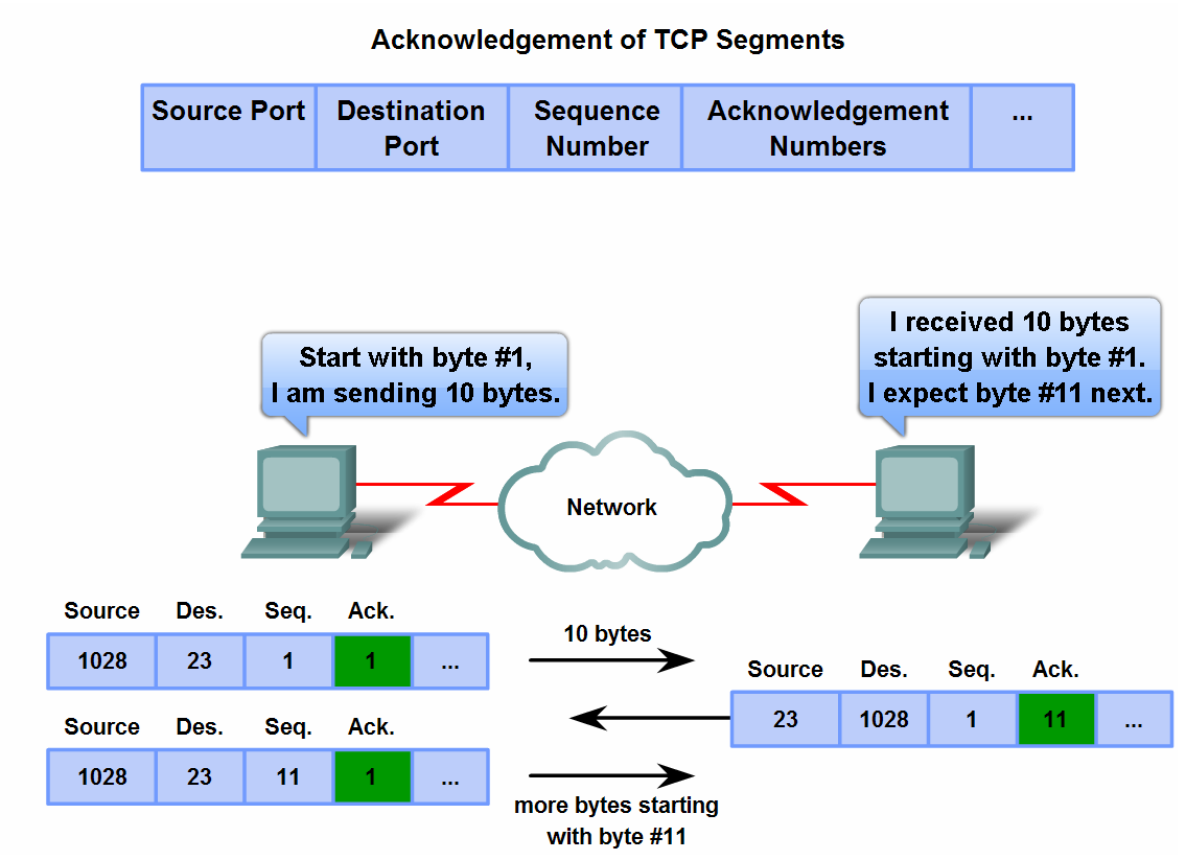
Managing TCP Sessions

- TCP sequence numbers are used to reconstruct the data stream with segments placed in the correct order



Managing TCP Sessions

- Trace the steps used by the TCP protocol in which sequence numbers and acknowledgement numbers are used to manage exchanges in a conversation



- The amount of data that a source can transmit before an acknowledgement must be received is called the window size. **Window Size** is a field in the TCP header that enables the management of lost data and flow control.

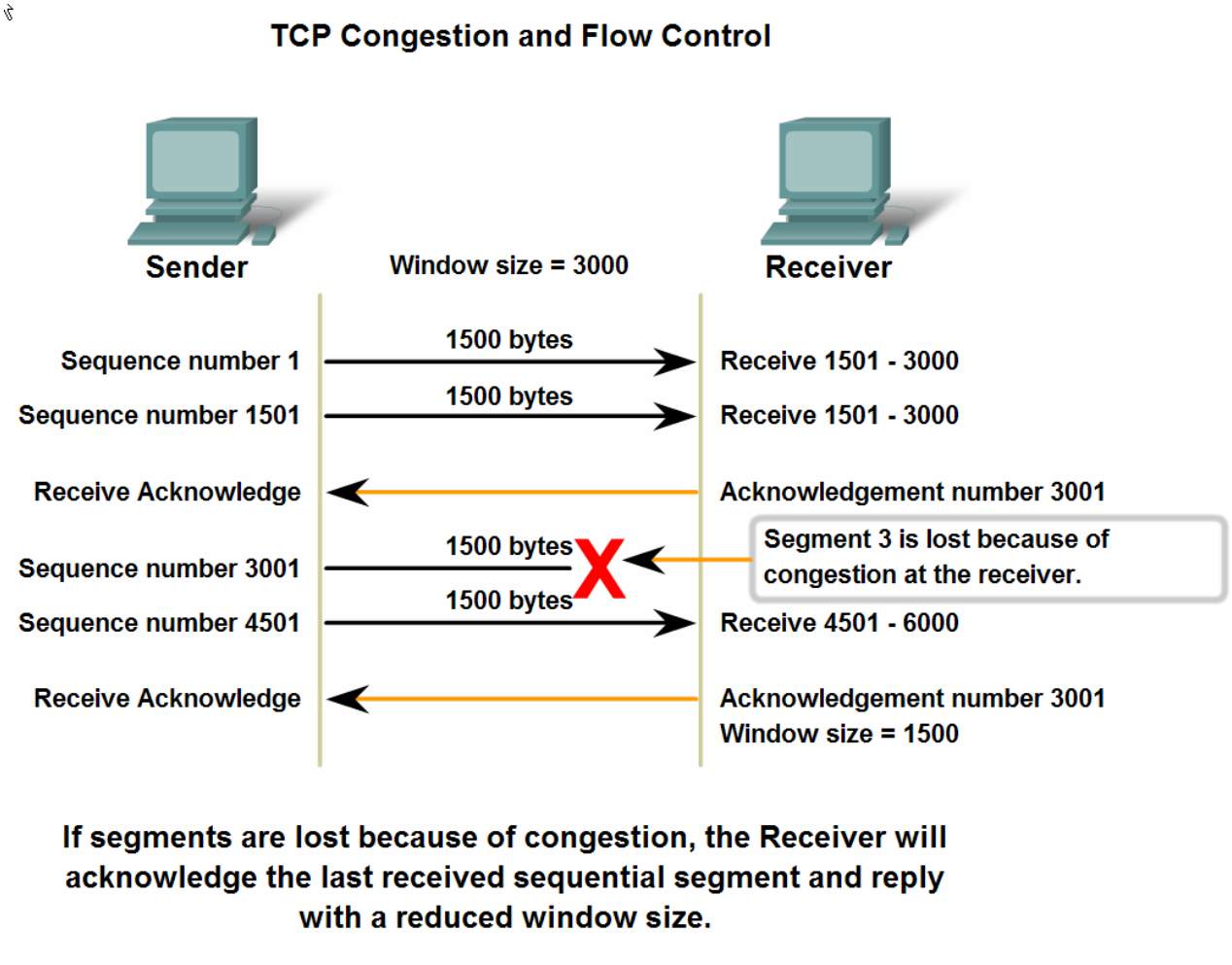
TCP Retransmission

- For example, if segments with sequence numbers 1500 to 3000 and 3400 to 3500 were received, the acknowledgement number would be 3001. This is because there are segments with the sequence numbers 3001 to 3399 that have not been received.

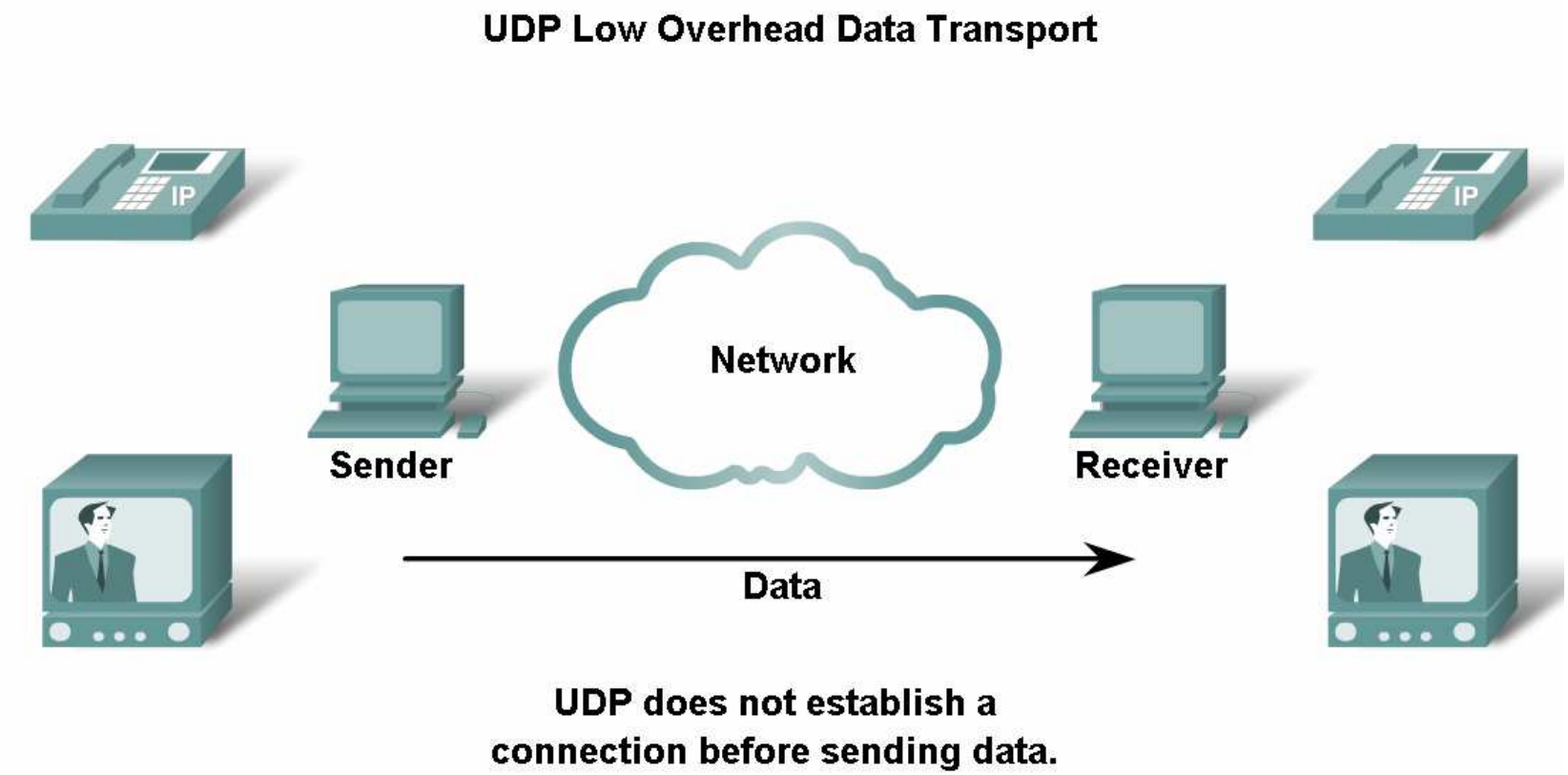
- When TCP at the source host has not received an acknowledgement after a predetermined amount of time, it will go back to the last acknowledgement number that it received and retransmit data from that point forward.

Flow Control

- window size, and congestion during a session



UDP Protocol



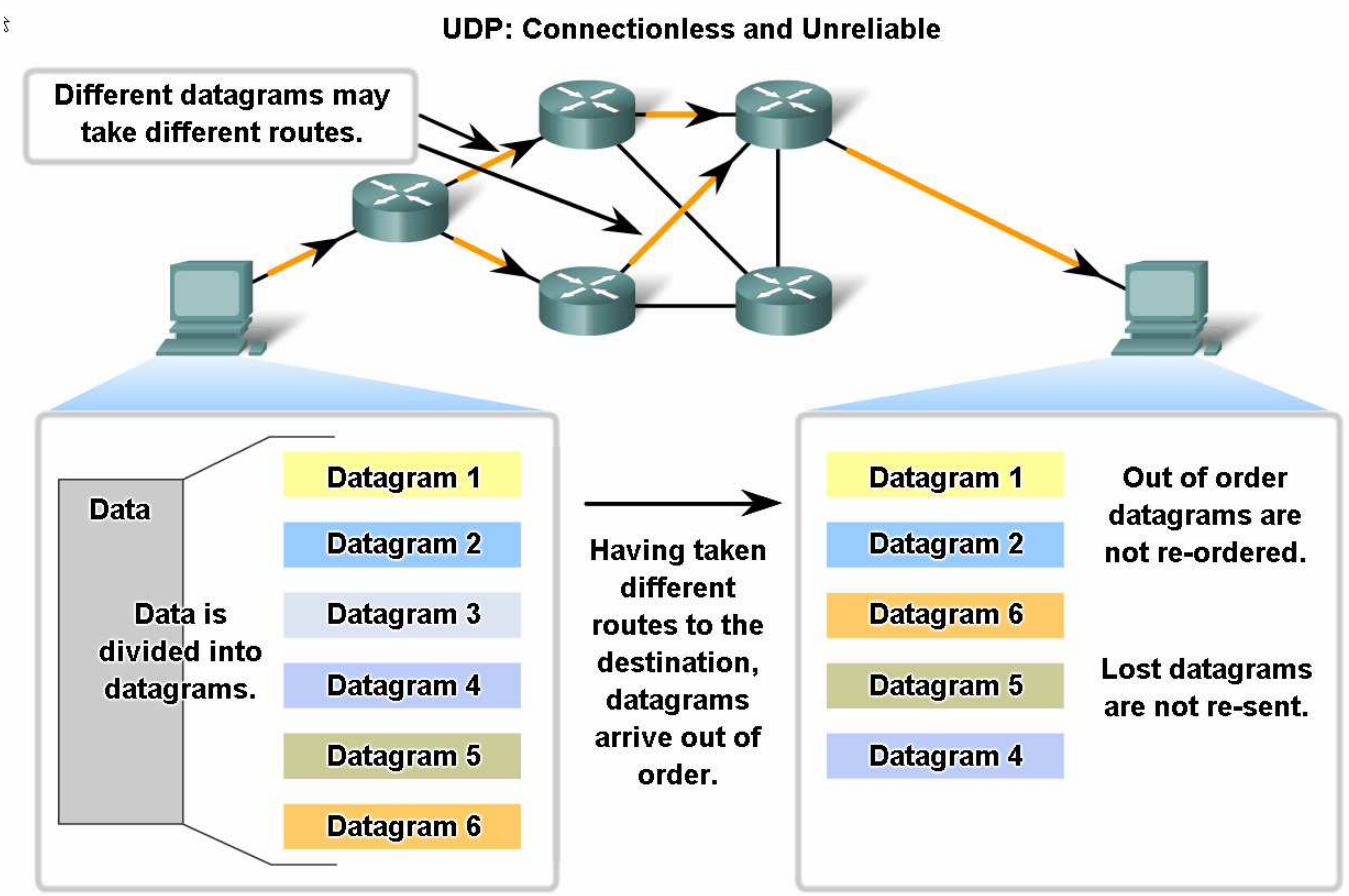
- UDP is a simple protocol that provides the basic Transport layer functions.
- It has a much lower overhead than TCP, since it is not connection-oriented and does not provide the sophisticated retransmission, sequencing, and flow control mechanisms.

- key Application layer protocols that use UDP include:
- Domain Name System (DNS)
- Simple Network Management Protocol (SNMP)
- Dynamic Host Configuration Protocol (DHCP)
- Routing Information Protocol (RIP)
- Trivial File Transfer Protocol (TFTP)
- Online games

UDP Reassembles

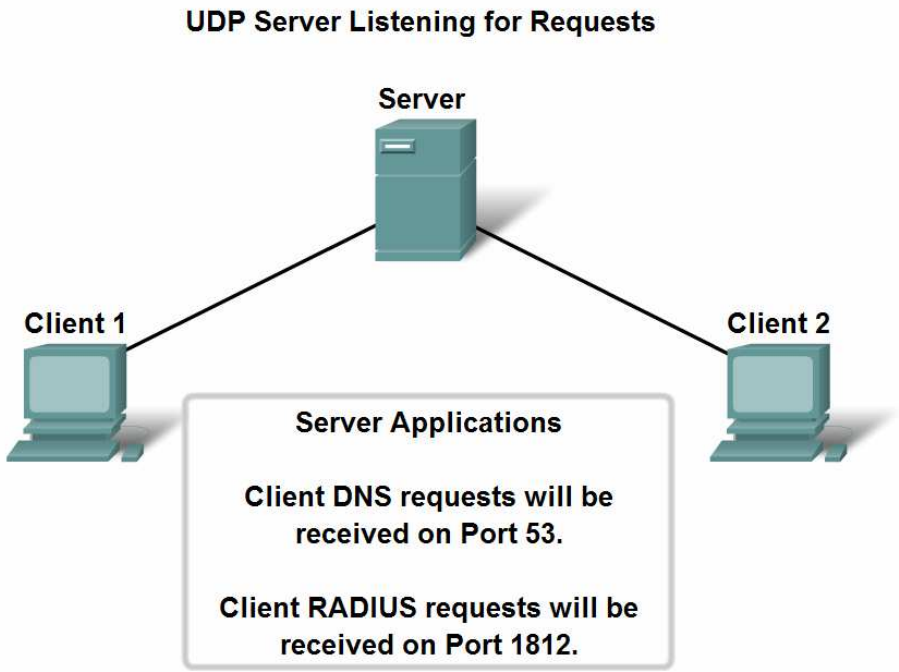
- UDP does not keep track of sequence numbers the way TCP does. UDP has no way to reorder the datagrams into their transmission order.
- UDP simply reassembles the data in the order that it was received and forwards it to the application.
- If the sequence of the data is important to the application, **the application will have to identify the proper sequence of the data and determine how the data should be processed**.

UDP Protocol



UDP Protocol – Port Number

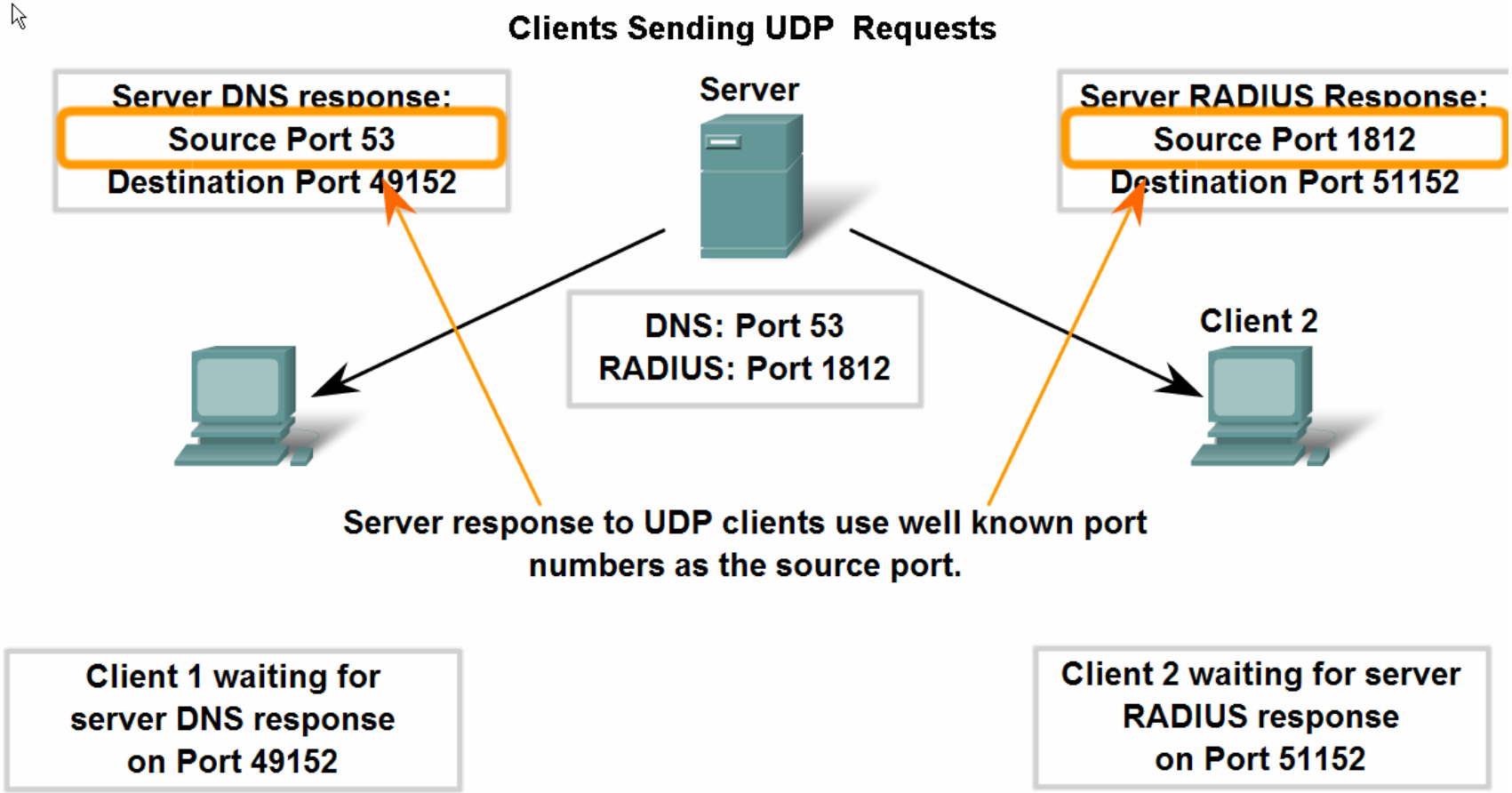
- servers use port numbers to identify a specified application layer process and direct segments to the proper service or application



Client requests to servers have well known ports numbers as the destination port.

UDP Protocol

- Trace the steps as the UDP protocol and port numbers are utilized in client-server communication.



Quiz

At the transport layer, which of the following controls is used to avoid a transmitting host overflowing the buffers of a receiving host?

- best effort
- encryption
- flow control
- compression
- congestion avoidance

End systems use port numbers to select the proper application. What is the smallest port number that can be dynamically assigned by a host system?

- 1
- 64
- 128
- 256
- 512
- 1024

During data transfer, what are the main responsibilities of the receiving host? (Choose two.)

- [ ] throughput
- [ ] encapsulation
- [ ] acknowledgment
- [ ] bandwidth
- [ ] segmentation
- [ ] reassembly

At which layer of the TCP/IP model does TCP operate?

- session
- transport
- network
- data link

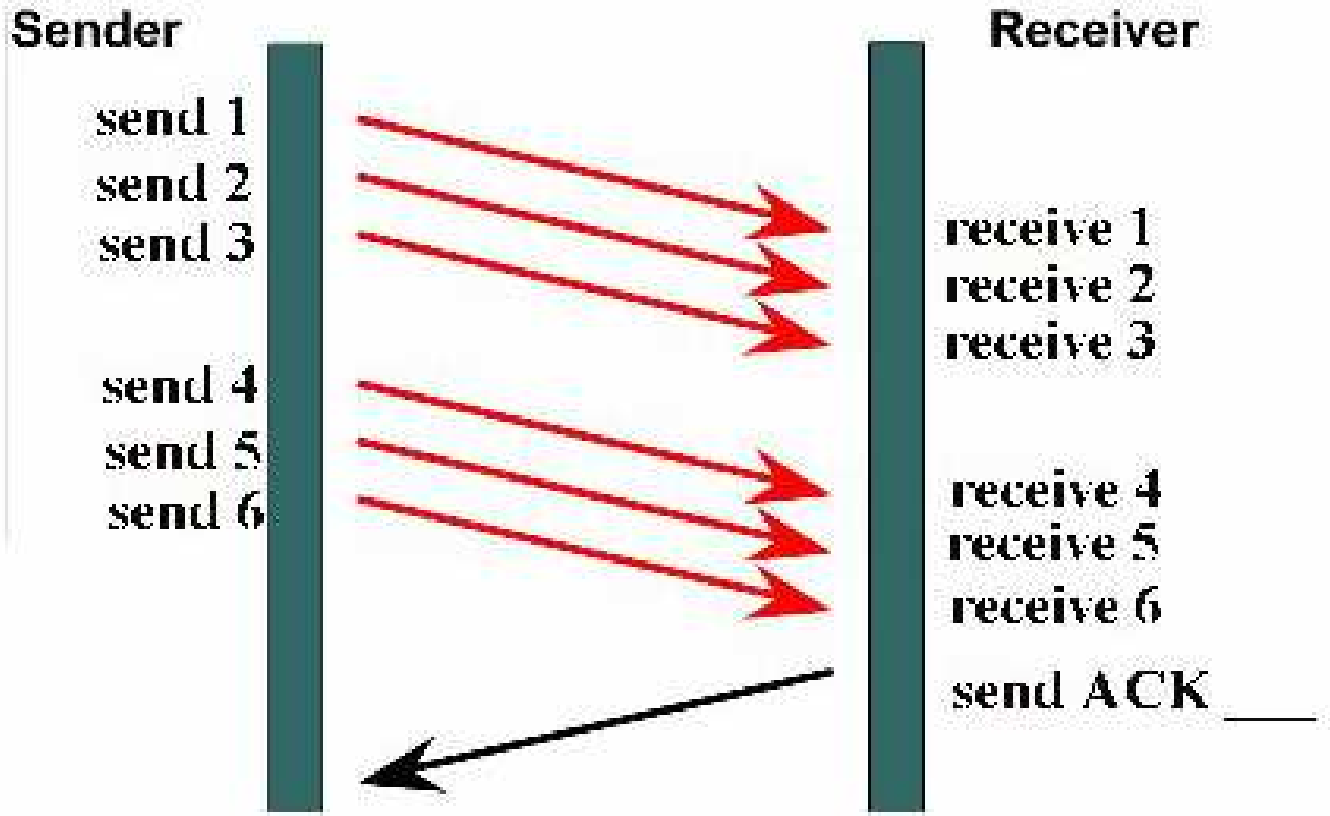
What determines how much data a sending station running TCP/IP can transmit before it must receive an acknowledgment?

- segment size
- transmission rate
- bandwidth
- window size
- sequence number

What is the purpose of the sequence number in the TCP header?

- reassemble the segments into data
- identify the application layer protocol
- indicate the number of the next expected byte
- show the maximum number of bytes allowed during a session

Which acknowledgement number should be sent by the receiver shown in the graphic?



- 3
- 4
- 6
- 7

What is the purpose of TCP/UDP port numbers?

- indicate the beginning of a three-way handshake
- reassemble the segments into the correct order
- identify the number of data packets that may be sent without acknowledgment
- track different conversations crossing the network at the same time