

## TCP : Transmission Control Protocol

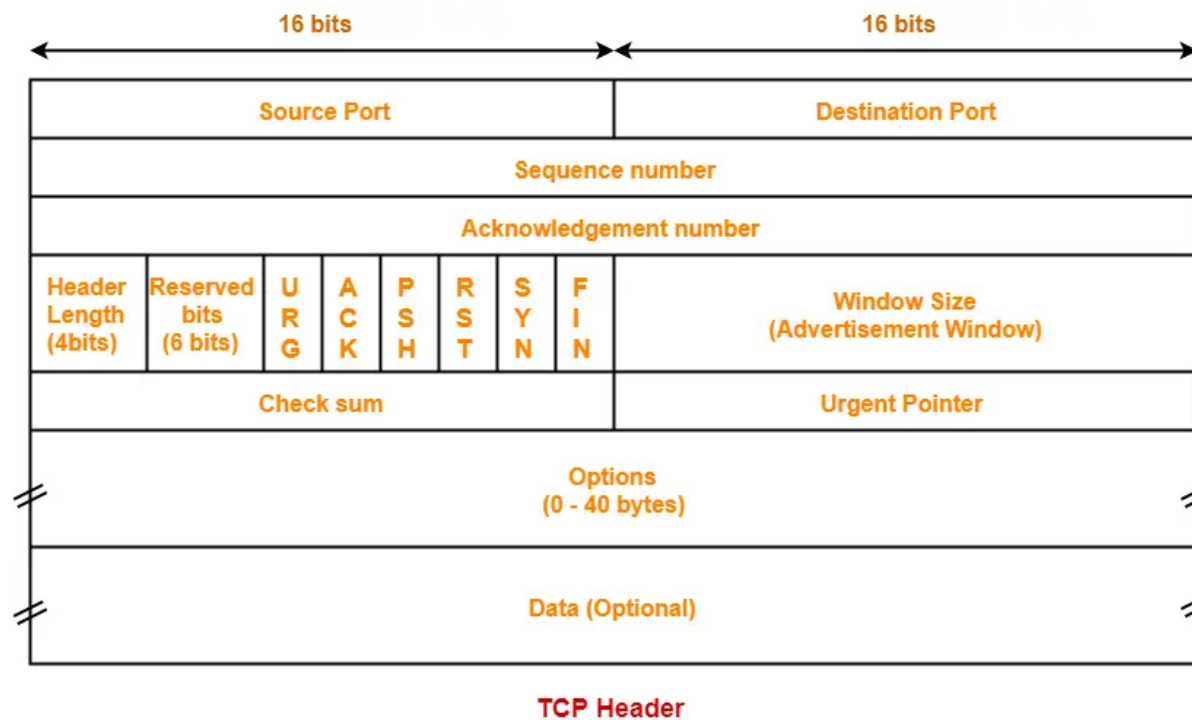
- Byte Streaming
- Connection Oriented
- Full Duplex
- Piggybacking
- Error Control
- Flow Control
- Congestion Control

TCP segment = TCP header + Data chunk

In this article, we will discuss about TCP Header.

### TCP Header-

The following diagram represents the TCP header format-



### **1. Source Port-**

- Source Port is a 16 bit field.
- It identifies the port of the sending application.

### **2. Destination Port-**

- Destination Port is a 16 bit field.
- It identifies the port of the receiving application.

#### **NOTE**

It is important to note-

- A TCP connection is uniquely identified by using- Combination of port numbers and IP Addresses of sender and receiver
- IP Addresses indicate which systems are communicating.
- Port numbers indicate which end to end sockets are communicating.

### **3. Sequence Number-**

- Sequence number is a 32 bit field.
- TCP assigns a unique sequence number to each byte of data contained in the TCP segment.
- This field contains the sequence number of the first data byte.

### **4. Acknowledgement Number-**

- Acknowledgment number is a 32 bit field.
- It contains sequence number of the data byte that receiver expects to receive next from the sender.
- It is always sequence number of the last received data byte incremented by 1.

### **5. Header Length-**

- Header length is a 4 bit field.
- It contains the length of TCP header.
- It helps in knowing from where the actual data begins.

#### **Minimum and Maximum Header length-**

The length of TCP header always lies in the range-  
[20 bytes , 60 bytes]

- The initial 5 rows of the TCP header are always used.
- So, minimum length of TCP header = 5 x 4 bytes = 20 bytes.
- The size of the 6th row representing the Options field vary.
- The size of Options field can go up to 40 bytes.
- So, maximum length of TCP header = 20 bytes + 40 bytes = 60 bytes.

#### **Concept of Scaling Factor-**

- Header length is a 4 bit field.
- So, the range of decimal values that can be represented is [0, 15].
- But the range of header length is [20, 60].
- So, to represent the header length, we use a scaling factor of 4.

In general,

Header length = Header length field value x 4 bytes

#### **Examples-**

- If header length field contains decimal value 5 (represented as 0101), then-  
Header length = 5 x 4 = 20 bytes

- If header length field contains decimal value 10 (represented as 1010), then-Header length =  $10 \times 4 = 40$  bytes
- If header length field contains decimal value 15 (represented as 1111), then-Header length =  $15 \times 4 = 60$  bytes

#### **NOTES**

It is important to note-

- Header length and Header length field value are two different things.
- The range of header length field value is always [5, 15].
- The range of header length is always [20, 60].

While solving questions-

- If the given value lies in the range [5, 15] then it must be the header length field value.
- This is because the range of header length is always [20, 60].

#### **6. Reserved Bits-**

- The 6 bits are reserved.
- These bits are not used.

#### **7. URG Bit-**

URG bit is used to treat certain data on an urgent basis.

When URG bit is set to 1,

- It indicates the receiver that certain amount of data within the current segment is urgent.
- Urgent data is pointed out by evaluating the urgent pointer field.
- The urgent data has be prioritized.
- Receiver forwards urgent data to the receiving application on a separate channel.

#### **8. ACK Bit-**

ACK bit indicates whether acknowledgement number field is valid or not.

- When ACK bit is set to 1, it indicates that acknowledgement number contained in the TCP header is valid.
- For all TCP segments except request segment, ACK bit is set to 1.
- Request segment is sent for connection establishment during [Three Way Handshake](#).

#### **9. PSH Bit-**

PSH bit is used to push the entire buffer immediately to the receiving application.

When PSH bit is set to 1,

- All the segments in the buffer are immediately pushed to the receiving application.
- No wait is done for filling the entire buffer.
- This makes the entire buffer to free up immediately.

#### **NOTE**

It is important to note-

- Unlike URG bit, PSH bit does not prioritize the data.
- It just causes all the segments in the buffer to be pushed immediately to the receiving application.
- The same order is maintained in which the segments arrived.
- It is not a good practice to set PSH bit = 1.
- This is because it disrupts the working of receiver's CPU and forces it to take an action immediately.

#### **10. RST Bit-**

RST bit is used to reset the TCP connection.

When RST bit is set to 1,

- It indicates the receiver to terminate the connection immediately.
- It causes both the sides to release the connection and all its resources abnormally.
- The transfer of data ceases in both the directions.
- It may result in the loss of data that is in transit.

This is used only when-

- There are unrecoverable errors.
- There is no chance of terminating the TCP connection normally.

#### **11. SYN Bit-**

SYN bit is used to synchronize the sequence numbers.

When SYN bit is set to 1,

- It indicates the receiver that the sequence number contained in the TCP header is the initial sequence number.
- Request segment sent for connection establishment during Three way handshake contains SYN bit set to 1.

#### **12. FIN Bit-**

FIN bit is used to terminate the TCP connection.

When FIN bit is set to 1,

- It indicates the receiver that the sender wants to terminate the connection.
- FIN segment sent for [TCP Connection Termination](#) contains FIN bit set to 1.

#### **13. Window Size-**

- Window size is a 16 bit field.
- It contains the size of the receiving window of the sender.
- It advertises how much data (in bytes) the sender can receive without acknowledgement.
- Thus, window size is used for [Flow Control](#).

#### **NOTE**

It is important to note-

- The window size changes dynamically during data transmission.
- It usually increases during TCP transmission up to a point where congestion is detected.
- After congestion is detected, the window size is reduced to avoid having to drop packets.

#### **14. Checksum-**

- Checksum is a 16 bit field used for error control.
- It verifies the integrity of data in the TCP payload.
- Sender adds CRC checksum to the checksum field before sending the data.
- Receiver rejects the data that fails the CRC check.

Also Read- [CRC](#) | [Checksum](#)

#### **15. Urgent Pointer-**

- Urgent pointer is a 16 bit field.
- It indicates how much data in the current segment counting from the first data byte is urgent.
- Urgent pointer added to the sequence number indicates the end of urgent data byte.
- This field is considered valid and evaluated only if the URG bit is set to 1.

#### **USEFUL FORMULAS**

**Formula-01:**

Number of urgent bytes = Urgent pointer + 1

**Formula-02:**

End of urgent byte

= Sequence number of the first byte in the segment + Urgent pointer

**16. Options-**

- Options field is used for several purposes.
- The size of options field vary from 0 bytes to 40 bytes.

Options field is generally used for the following purposes-

1. Time stamp
2. Window size extension
3. Parameter negotiation
4. Padding

**A. Time Stamp-**

When wrap around time is less than life time of a segment,

- Multiple segments having the same sequence number may appear at the receiver side.
- This makes it difficult for the receiver to identify the correct segment.
- If time stamp is used, it marks the age of TCP segments.
- Based on the time stamp, receiver can identify the correct segment.

**B. Window Size Extension-**

- Options field may be used to represent a window size greater than 16 bits.
- Using window size field of TCP header, window size of only 16 bits can be represented.
- If the receiver wants to receive more data, it can advertise its greater window size using this field.
- The extra bits are then appended in Options field.

**C. Parameter Negotiation-**

Options field is used for parameters negotiation.

Example- During connection establishment,

- Both sender and receiver have to specify their maximum segment size.
- To specify maximum segment size, there is no special field.
- So, they specify their maximum segment size using this field and negotiates.

**D. Padding-**

- Addition of dummy data to fill up unused space in the transmission unit and make it conform to the standard size is called as padding.
- Options field is used for padding.

**Example-**

- When header length is not a multiple of 4, extra zeroes are padded in the Options field.
- By doing so, header length becomes a multiple of 4.
- If header length = 30 bytes, 2 bytes of dummy data is added to the header.
- This makes header length = 32 bytes.
- Then, the value  $32 / 4 = 8$  is put in the header length field.
- In worst case, 3 bytes of dummy data might have to be padded to make the header length a multiple of 4.

Suppose you are asked to design a new reliable byte-stream transport protocol like TCP. This protocol, named myTCP, runs over a 100 Mbps network with Round Trip Time of 150 milliseconds and the maximum segment lifetime of 2 minutes. Which of the following is/are valid lengths of the Sequence Number field in the myTCP header?

- ☒ A 30 bits
- ☐ B 32 bits
- ☐ C 34 bits
- ☐ D 36 bits

Consider the data transfer using TCP over a 1 Gbps link. Assuming that the maximum segment lifetime (MSL) is set to 60 seconds, the minimum number of bits required for the sequence number field of the TCP header, to prevent the sequence number space from wrapping around during the MSL is

- ☒ A 31
- ☐ B 32
- ☐ C 33
- ☐ D 34

Consider the three-way handshake mechanism followed during TCP connection establishment between hosts P and Q. Let X and Y be two random 32-bit starting sequence numbers chosen by P and Q respectively. Suppose P sends a TCP connection request message to Q with a TCP segment having SYN bit =1, SEQ number =X, and ACK bit =0. Suppose Q accepts the connection request. Which one of the following choices represents the information present in the TCP segment header that is sent by Q to P?

- A** SYN bit =1, SEQ number =X+1, ACK bit =0, ACK number =Y, FIN bit =0
- B** SYN bit =0, SEQ number =X+1, ACK bit =0, ACK number =Y, FIN bit =1
- C** SYN bit =1, SEQ number =Y, ACK bit =1, ACK number =X+1, FIN bit =0
- D** SYN bit =1, SEQ number =Y, ACK bit =1, ACK number =X, FIN bit =0

Consider two hosts P and Q connected through a router R. The maximum transfer unit (MTU) value of the link between P and R is 1500 bytes, and between R and Q is 820 bytes.

A TCP segment of size 1400 bytes was transferred from P to Q through R, with IP identification value as 0x1234. Assume that the IP header size is 20 bytes. Further, the packet is allowed to be fragmented, i.e., Don't Fragment (DF) flag in the IP header is not set by P.

Which of the following statements is/are correct?

**[MSQ]**

- A** Two fragments are created at R and the IP datagram size carrying the second fragment is 620 bytes.
- B** If the second fragment is lost, R will resend the fragment with the IP identification value 0x1234.
- C** If the second fragment is lost, P is required to resend the whole TCP segment.
- D** TCP destination port can be determined by analysing only the second fragment.

A TCP server application is programmed to listen on port number P on host S. A TCP client is connected to the TCP server over the network.

Consider that while the TCP connection was active, the server machine S crashed and rebooted. Assume that the client does not use the TCP keepalive timer. Which of the following behaviors is/are possible?

[MSQ]

- ☒ A If the client was waiting to receive a packet, it may wait indefinitely.
- ☐ B The TCP server application on S can listen on P after reboot.
- ☐ C If the client sends a packet after the server reboot, it will receive a RST segment.
- ☐ D If the client sends a packet after the server reboot, it will receive a FIN segment.

Consider a TCP connection between a client and a server with the following specifications; the round trip time is 6 ms, the size of the receiver advertised window is 50 KB, slow-start threshold at the client is 32 KB, and the maximum segment size is 2 KB. The connection is established at time  $t=0$ . Assume that there are no timeouts and errors during transmission. Then the size of the congestion window (in KB) at time  $t+60$  ms after all acknowledgements are processed is \_\_\_\_\_

- ☒ A 22
- ☐ B 44
- ☐ C 18
- ☐ D 36



Consider a long-lived TCP session with an end-to-end bandwidth of 1 Gbps ( $= 10^9$  bits-per-second). The session starts with a sequence number of 1234. The minimum time (in seconds, rounded to the closest integer) before this sequence number can be used again is \_\_\_\_\_.

- ☒ A 35
- ☐ B 40
- ☐ C 50
- ☐ D 30