# Unit - 7

# Transport Layer

- The transport layer is a 4th layer from the top.
- The main role of the transport layer is to provide the communication services directly to the application processes running on different hosts.

## Services provided by the Transport Layer

The services provided by the transport layer are similar to those of the data link layer. The data link layer provides the services within a single network while the **transport layer provides the services across an internetwork made up of many networks**. The data link layer controls the physical layer while the **transport layer controls all the lower layers**.

**The services provided by the transport layer protocols can be divided into following categories:**

- End-to-end delivery
    - The transport layer transmits the entire message to the destination. Therefore, it ensures the end-to-end delivery of an entire message from a source to the destination
- Reliable delivery
    - The transport layer provides reliability services by retransmitting the lost and damaged packets.
- Flow control
    - **Flow control is used to prevent the sender from overwhelming the receiver**. If the receiver is overloaded with too much data, then the receiver discards the packets and asking for the retransmission of packets. This increases network congestion and thus, reducing the system performance.
- Multiplexing
    - The transport layer uses the multiplexing to improve transmission efficiency.

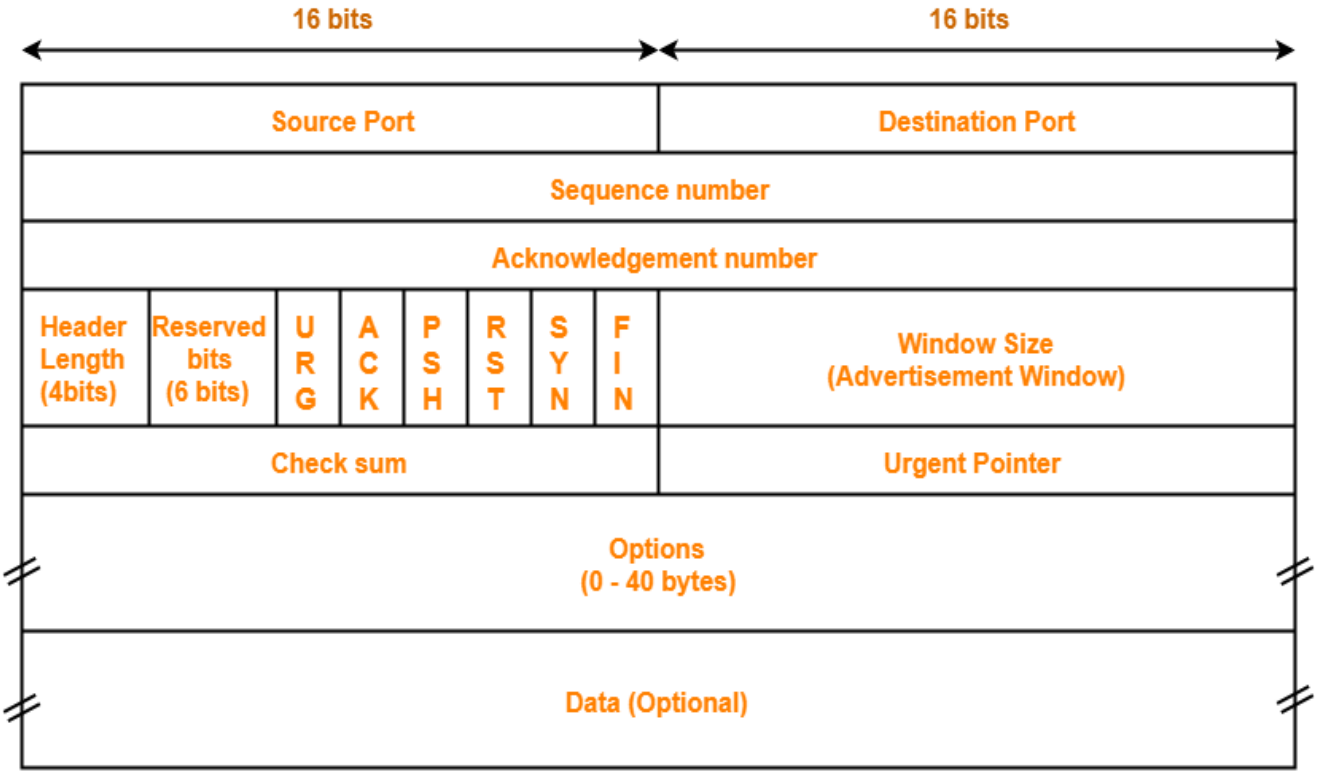
## TCP

- TCP stands for Transmission Control Protocol.
- It provides full transport layer services to applications.

- It is a connection-oriented protocol means the connection established between both the ends of the transmission. For creating the connection, TCP generates a virtual circuit between sender and receiver for the duration of a transmission.

## TCP Header-

The following diagram represents the TCP header format-




TCP Header

### 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.

## 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 x 4 = 40 bytes
- If header length field contains decimal value 15 (represented as 1111), then-
  Header length = 15 x 4 = 60 bytes

## 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 to 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.

## 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.

## 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.

## 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.

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.

## 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:

$$\text{Number of urgent bytes} = \text{Urgent pointer} + 1$$

Formula-02:

$$\text{End of urgent byte} = \text{Sequence number of the first byte in the segment} + \text{Urgent pointer}$$

## 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-

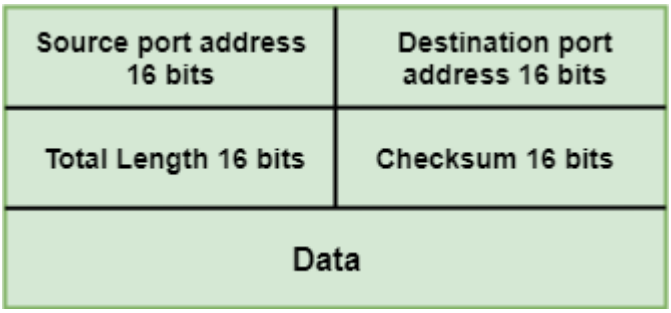
- When header length is not a multiple of 4, extra zeroes are padded in the Options field.
- By doing so, header length becomes a multiple of 4.
- If header length = 30 bytes, 2 bytes of dummy data is added to the header.
- This makes header length = 32 bytes.
- Then, the value 32 / 4 = 8 is put in the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

# UDP

- UDP stands for **User Datagram Protocol**.
- UDP is a simple protocol and it provides non sequenced transport functionality.
- UDP is a connectionless protocol.
- This type of protocol is used when reliability and security are less important than speed and size.
- UDP is an end-to-end transport level protocol that adds transport-level addresses, checksum error control, and length information to the data from the upper layer.
- The packet produced by the UDP protocol is known as a user datagram.

## User Datagram Format

The user datagram header is shown below:




**Where,**

- **Source port address:** It defines the address of the application process that has delivered a message. The source port address is of 16 bits address.
- **Destination port address:** It defines the address of the application process that will receive the message. The destination port address is of a 16-bit address.
- **Total length:** It defines the total length of the user datagram in bytes. It is a 16-bit field.

- **Checksum:** The checksum is a 16-bit field which is used in error detection.

## Disadvantages of UDP protocol

- It does not provide any sequencing or reordering functions and does not specify the damaged packet when reporting an error.
- UDP can discover that an error has occurred, but it does not specify which packet has been lost as it does not contain an ID or sequencing number of a particular data segment.