1. Briefly discuss how various fields in the TCP header are used in the connection establishment and termination process in TCP.

To indicate a connection request, the SYN flag is set. The sequence number field indicates the starting sequence number. An acknowledgement to a connection request has ACK flag set with an ACK number one higher than the sequence number in the request. FIN and ACK flags are used to terminate connections. A packet with FIN flag set indicates that the sender has no more application data to send. To acknowledge a FIN packet the ACK flag is set with acknowledgment number one higher than the sequence number in the request.

2. What is the purpose of the field Window size in the TCP header? Explain the need for dynamic window size in TCP.

The window size represents the available receive buffer space for the connection. During the connection establishment stage this is the total space reserved for the connection. Subsequently, it is the amount of space currently available. As the available space may reduce if the buffer is not cleared by the application (by calling read()) the window size is dynamic. A window size that is substantially higher than the MTU size indicates that multiple packets can be sent before an acknowledgement is received. This enables pipelining to increase throughput.

3. Briefly explain the “slow start” mechanism in TCP.

When a connection is established, the congestion window size is set to one MTU size to ensure that only one packet can be sent before an ACK is received. If the ACK is received in time the congestion window size is doubled to 2 MTU size. If every time the ACKs are received in time, the congestion window size grows exponentially to 4, 8, 16, etc until a threshold is reached. After the threshold the congestion window size is increased linearly. If at any point an ACK is not received in time (before the retransmission time fires) the congestion window size is reduced to 1, and the threshold is halved. The process for exponential growth of congestion windows size starts again.

4. What are the three timers used by TCP? Why are they used?

Retransmission timer: Stated when any packet is sent. ACK should be received before this timer fires – else the packet will be retransmitted.

Persistence timer: Used to prevent deadlocks. Started when a non-zero window size is announced to indicate the other side to resume sending.

Keep alive timer: To keep a connection alive even if there are no application data to send.

5. What are the advantages of UDP over TCP? Are there application scenarios where it is impractical to use TCP?

Very low overhead especially for scenarios where the request and response have well-defined formats. TCP will require 3 additional packets to establish connection, 4 to stop the connection and at least two ACK packets (for request and response). TCP cannot be used for multicasting.