15 Questions (0.5 point for the first 10 questions, 2 points for the last 5 questions)

1. List 5 layers of the Internet Protocol Stack and 7 Layers of the ISO/OSI Reference Model:
    a. 5 Layers of the Internet Protocol Stack
        i. Application
        ii. Transport
        iii. Network
        iv. Link
        v. Physical
    b. 7 Layers of the ISO/OSI Reference Model
        i. Application
        ii. Presentation
        iii. Session
        iv. Transport
        v. Network
        vi. Link
        vii. Physical

2. List Three Different Access Networks:
    a. Home Access Networks - DSL, Cable, FTTH
    b. Local Area Network (or Enterprise Network)
    c. Wide-Area wireless Access (or Mobile network)

3. The four sources of packet Delay:
    a. D_nodal = D_proc + D_queue + D_trans + D_prop
        i. Processing delays
        ii. Queuing delays
        iii. Transmission delays
        iv. Propagation delays

4. What is the key difference between **circuit-switched** and **packet_switched** network?
    a. In a packet switched network, there is no connection reserved on the route a packet takes from Host A to Host B. On a circuit-switched network, there is: a connection is established between host A and host B for the remainder of their connection and on every communication link between A and B, a circuit is allocated (using either TDM or FDM) to transport only packets from A or B to B or A respectively. Key difference then is that bandwidth is reserved in circuit switched but not in packet-switched.

5. List two differences between Servers and Clients in a CS architecture?
    a. Clients are the process which initiates the connection with another process
        i. Servers are the process which wait for a connection request from another process
    b. Clients typically request data from Servers whereas Servers give it.
        i. Note that a process running on what would be considered a server may still act as a client process. (In the example of a cache miss for instance, the server process servicing the data which resulted in a cache miss will act as the client process with another server process to get that data).

6. List two drawbacks of a Centralized DNS solution:
    a. Redundancy, if one DNS solution fails, another may perform its job. This isn't possible with Centralized DNS solution.
    b. Too much network traffic for one server process to handle (even using server virtualization).

7. List key difference between Nonpersistent and persistent HTTP
    a. A new HTTP connection requires 1 RTT handshaking procedure and TCP variables and buffers allocated on both the client and server end (which is costly).
        i. In a non-persistent HTTP connection, each request for an object requires 1 RTT handshaking procedure and var/buffer allocation
        ii. In persistent HTTP connection, the server keeps the TCP variables and buffers allocated after sending a response. So the key difference is that the TCP connection persists after request of an object.

8. List Three advantages of Content Distribution Networks (CDNs):
    a. Absence of single point of failure and load balancing so one server process isn't handling all of the requests
    b. Reduces the number of communication links between client end-systems accessing content - this reduces the chances of finding a link that results in low throughput
    c. Allows the storage of content is that typically accessed by geographically surrounding or servicing locations of some distribution node

9. List key difference between Active FTP and Passive FTP connection
    a. The server initiates a connection in Active FTP to service the request but in Passive, the client always initiates connection.
        i. In an active FTP connection, after the Client process at port x handshakes with the Server at port 21, the server services the FTP connection using a different port in the server with port x+1 in the client. In this regard, the server initiates the second portion of the connection to service the FTP request.
        ii. In a passive FTP connection, the original request comes with a PASV command whereby the server responds with a port it is prepared to service this request on. The second portion of the FTP connection is thus also initiated by the client to the listening port from the first response.

10. List key difference between SMTP and MAP
    a. SMTP is used to deliver mail from one mail server to another mail server
    b. MAP is used for interactive access for a client Bob to Bob's mail server
    A mail server is not the same as an interactive client. For example we could replace MAP with HTTP (using gmail for instance).

11.
    a. 16 maximum connections open.
        i. All circuits are occupied connecting adjacent nodes
    b. Assuming there are more than 4 end-systems that connect to router A and C, the maximum number of simultaneous connections between A and C are 8.
        i. 4 from A to B to C
        ii. 4 from A to D to C
    c. True, you can have 2 connections for A : C traversing 2 circuits in A to B to C and 2 traversing A to D to C. For connection B : D, you can have 2 circuits in B to A to D and 2 traversing B to C to D.

12. The minimum is min { R_s , R_c , (R/M) }

13. :
    a. HTTP uses TCP so we will need TCP as the transport layer protocol
    b. Since the destination IP is not known, but URL is known we will need to query the DNS for the destination IP. Thus DNS - application layer protocol will be needed.
        i. DNS uses UDP for logical communication between DNS processes, and hence UDP will be needed.
    c. Additionally, we could use SSL (secure sockets layer) - application layer protocol, to secure TCP connection since the client uses HTTP instead of HTTPS

14. DNS uses UDP. Hence there is no TCP handshake between DNS host A requesting IP from DNS host B.

a. The total time it takes for the Client to receive the web server IP is:
    i. Total_IP_query = RTT1 + RTT2 + … RTT(n-1) + RTTn
b. To request the object from the destination IP received after DNS query, the client uses HTTP (which uses TCP).
    i. Total_request_object = RTT0 + RTT0. (TCP handshake + request/response)
c. Total Time from when client clicks on link until client receives the object =
    i. = total_IP_query + Total+request_object
    ii. = RTT1 + .. + RTTn + 2* RTT0

    Let **PRIMARY** = RTT1 + .. + RTTn + 2* RTT0

15. TCP handshake will need to be repeated (variables + buffers allocation) for each non-persistent connection. Let us assume a request may involve at most 1 object. Let RTT_0 be referred to by simply RTT:
    i. Non-persistent with no parallel TCP connections:
        1. **PRIMARY** time will be needed
        2. For one object, 1 RTT {TCP conn} + 1 RTT {req/resp}
        3. For 8 objects, (1 RTT + 1 RTT) * 8 = 16*RTT
        4. We will need **16*RTT + PRIMARY** to get all 8 objects from server

    ii. Non-persistent with 5 parallel connections:
        1. **PRIMARY** time will be needed
        2. For 5 TCp establishments = 1 RTT {at the same time}
        3. For 5 objects = 1 RTT {at the same time}
        4. For 3 TCP establishments = 1 RTT {non-persistent so we can't use the previous 5 TCP conns}
        5. For 3 TCP objects = 1 RTT
        6. Total = **4*RTT + PRIMARY**

    iii. Persistent HTTP with 5 parallel connections and no pipelining:
        1. **PRIMARY** will be needed
        2. 1 RTT to establish 4 TCP connections {at the same time, 4 since one already exists from PRIMARY}
        3. 1 RTT to req/res 5 objects {at the same time}
        4. 1 RTT to req/res 3 objects from 3 of the 5 open TCP conns
        5. Total = **3*RTT + PRIMARY**