Computer Networks

OSI Layers,data units and Functions:

Layers	Data Units	Functions
Application Layer	Data	Mail Services,Directory Serices,FTAM
Presentation Layer	Data	Encryption/Decryption, Compression
Session Layer	Data	Session Establishment, Synchronization,Dialog Controller
Transport Layer	Segments,Datagram	Segementation
Network Layer	Packets	Traffic control,Fragmentation,Routing
Data Link Layer	Frames	Flow control,Error control,Access control
Physical Layer	Bits	Bit Synchronization,Bit rate control,Physical Topologies

Layers and their uses –

OSI Model	DoD Model	Protocols	Devices / Apps
Layer 5, 6, 7	Application	DNS, DHCP, NTP, SNMP, HTTPS, FTP, SSH, TELNET, HTTP, POP3...etc.	Web server, Mail server, Browser, Mail client ...etc.
Layer 4	Host to Host	TCP | UDP	Gateway
Layer 3	Internet	IP, ICMP, IGMP	Router, Firewall layer 3, Switch
Layer 2	Network access	ARP (MAC), RARP`	Bridge, Layer 2 switch
Layer 1		Ethernet, Token ring	Hub

Physical Layer

Network Topologies:

- **Mesh Topology:**
  In mesh topology, every device is connected to another device via particular channel.If suppose, N number of devices are connected with each other, then total number of links required to connect NC_2.
- **Bus Topology:**
  Bus topology is a network type in which every computer and network device is connected to single cable. If N devices are connected, then the number of cables required 1 which is known as backbone cable and N drop lines are required.
- **Star Topology:**
  In star topology, all the devices are connected to a single hub through a cable. If N devices are connected to each other, then the no. of cables required N.
- **Ring Topology:**
  In this topology, it forms a ring connecting a devices with its exactly two neighboring devices.

Transmission Modes:

- **Simplex Mode**: the communication is unidirectional, as on a one-way street.Only one of the two devices on a link can transmit, the other can only receive.
- **Half-duplex Mode**: each station can both transmit and receive, but not at the same

time.

- **Full-duplex Mode**: both stations can transmit and receive simultaneously.

Manchester Encoding: When there is a long sequence of 0s and 1s, there is a problem at the receiving end. The problem is that the synchronization is lost due to lack of transmissions.

- **NRZ-level encoding** : The polarity of signals changes when incoming siganl changes from '1' to '0' or from '0' to '1'. It considers the first bit data as polarity change.
- **NRZ-Inverted/ Differential encoding**:In this, the transitions at the beginning of bit interval is equal to 1 and if there is no transition at the beginning of bit interval is equal to 0.

Data Link Layer

1. **Flow Control**
   N = Sender's Window Size. (in SR both sender and receiver window are same)
   $a = T_p / T_t$

Properties	Stop and wait	Go back N	Selective repeat
efficiency	1 / (1+2a)	N / (1+2a)	N / (1+2a)
buffer	1 + 1	N + 1	N + N
sequence number	1 + 1	N + 1	N + N
retransmission	1	N	1
bandwidth	low	High	Moderate
CPU	low	Moderate	High
implementation	low	Moderate	Complex

2. Sequence No. >= (Sender's Window Size) + (Reciever's Window Size)
3. Efficiency in TDM(polling) = $T_t / (T_{poll} + T_t)$
4. In CSMA/CD, $T_t >= 2*T_p$
   Hence, min frame length = $2*T_p*B$
5. In CSMA/CD, Efficiency = 1/(1 + 6.44a)
6. **Back-off Algorithm for CSMA/CD**
   Waiting time = back-off time
   Let n = collision number or re-transmission serial number.

Then, Waiting time = K * T_{slot}
where K = [0, $2^n - 1$]

7. N = No. of stations
   Early Token Reinsertion : Efficiency = 1/(1 + a/N)
   Delayed Token Reinsertion : Efficiency = 1/(1 + (N+1)a/N)
8. Pure Aloha Efficiency = 18.4 %
   Slotted Aloha Efficiency = 36.8%
9. **Maximum data rate (channel capacity) for noiseless and noisy channels**
   - **Noiseless Channel : Nyquist Bit Rate**
     BitRate = 2 * Bandwidth * log2(L)
     where,L is the number of signal levels used to represent data.
   - **Noisy Channel : Shannon Capacity**
     Capacity = bandwidth * log2(1 + SNR)
     where, SNR is the signal-to-noise ratio

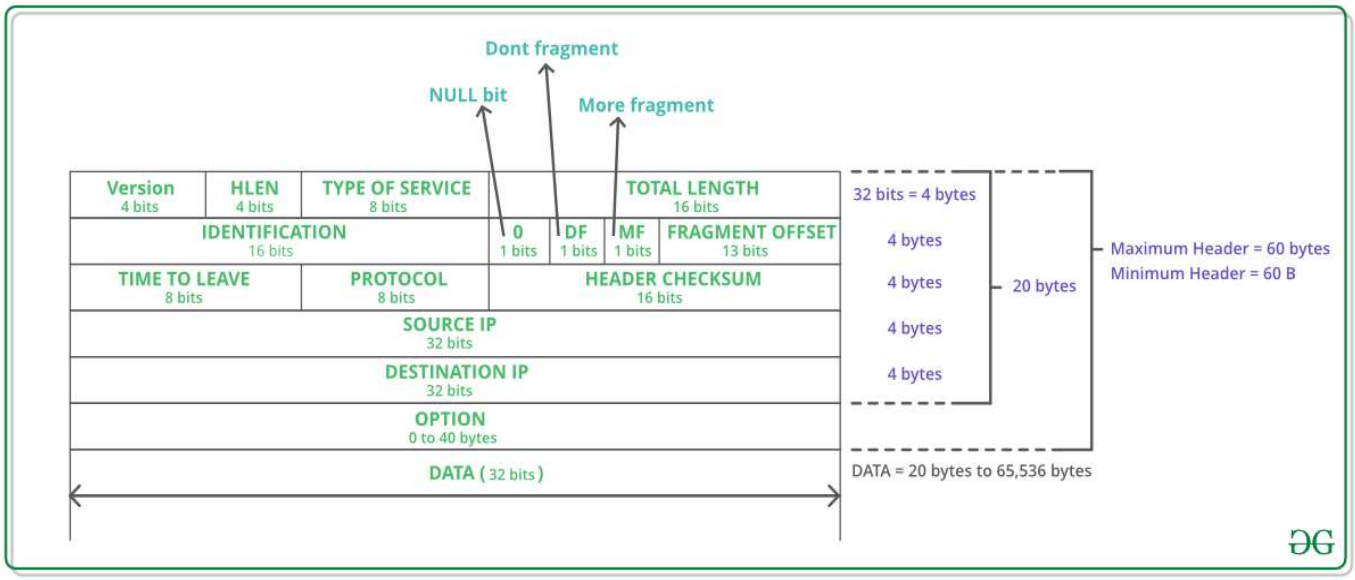
10. **Error Control**
    - **Hamming Code**: is a set of error-correction codes that can be used to detect and correct the errors that can occur when the data is moved or stored from the sender to the receiver.
      Redundant bits:
      $2^r \geq m + r + 1$
      where, r = redundant bit, m = data bit
    - **Framing in DLL**: It provides a way for a sender to transmit a set of bits that are meaningful to the receiver.
      Character/Byte Stuffing: Used when frames consist of character. If data contains ED then, byte is stuffed into data to diffentiate it from ED.
      Bit stuffing: Sender stuffs a bit to break the pattern i.e. here appends a 0 in data = 0111**0**1.

Network Layer

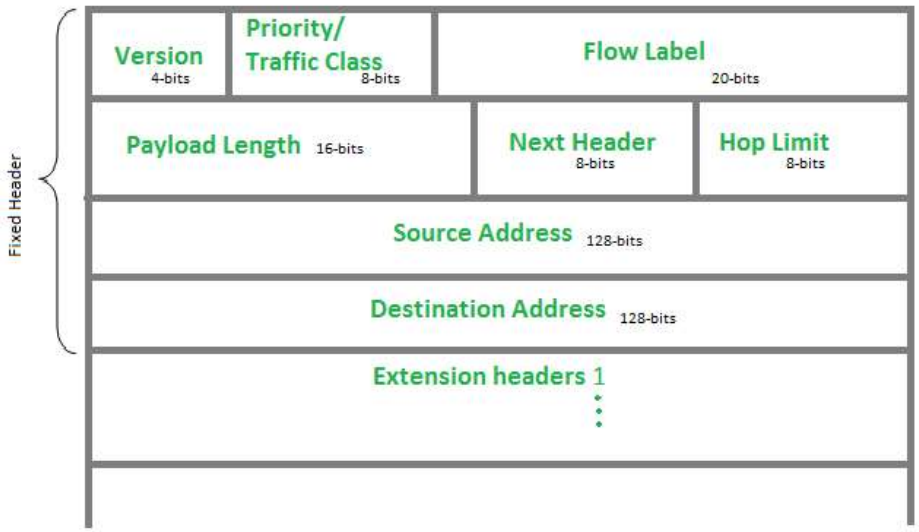
Class Full Addressing Table:

Address Class	First octet (Decimal)	First octet bits (red bits don't change)	Network (N) and Host (H) portion	Default Subnet Mask
A	1 – 127	0000 0000 – 0111 1111	N.H.H.H	255.0.0.0
B	128 – 191	1000 0000 – 1011 1111	N.N.H.H	255.255.0.0
C	192 – 223	1100 0000 – 1101 1111	N.N.N.H	255.255.255.0
D	224 – 239	1110 0000 – 1110 1111	n/a (multicast)	
E	240 – 255	1111 1111 – 1111 1111	n/a (experimental)	

IPv4 header datagram:



IP version 6 Header Format



Internet Control Message Protocol: Since IP does not have a inbuilt mechanism for sending error and control messages. It depends on Internet Control Message Protocol(ICMP) to provide an error control.

1. Source quench message
2. Parameter problem
3. Time exceeded message
4. Destination un-reachable

Difference between DVR and LSR

Distance Vector Routing (DVR)	Link State Routing (LSR)
Sends the entire table	Sends only link state information
Slow convergence	Fast convergence
Susceptible to routing loops	Less susceptible to routing loops
Updates are sometimes sent using broadcast	Always uses multicast for the routing updates
Doesn't know the network topology	Knows the entire network topology
Simpler to configure	Can be harder to configure
Examples: RIP, IGRP	Examples: OSPF, IS-IS

Open shortest path first (OSPF): Open shortest path first (OSPF) is a link-state routing protocol which is used to find the best path between the source and the

destination router using its own SPF algorithm.
Designated Router(DR) and Backup Designated Router(BDR) election takes place in broadcast network or multi-access network.

Criteria for the election:

1. Router having the highest router priority will be declared as DR.
2. If there is a tie in router priority then highest router will be considered. First, highest loopback address is considered. If no loopback is configured then the highest active IP address on the interface of the router is considered.

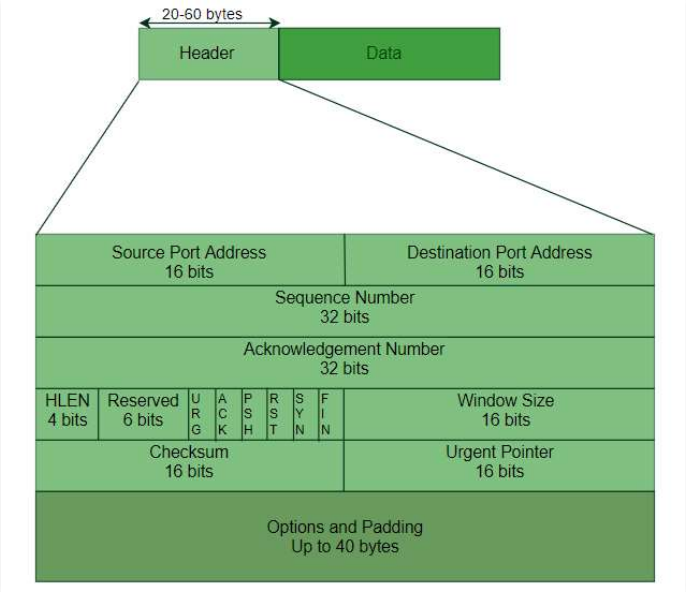
Routing Information Protocol(RIP): is a dynamic routing protocol which uses hop count as a routing metric to find the best path between the source and the destination network. It is a distance vector routing protocol which has AD value 120 and works on the application layer of OSI model. RIP uses port number 520.

Hop Count :

1. Hop count is the number of routers occurring in between the source and destination network. The path with the lowest hop count is considered as the best route to reach a network and therefore placed in the routing table.
2. The maximum hop count allowed for RIP is 15 and hop count of 16 is considered as network unreachable.

Transport Layer

TCP header



In TCP congestion control Algorithm

When Time Out Occurs Algorithm Enters Slow Start Phase

When 3 Duplicate occurs algorithm enters congestion avoidance phase

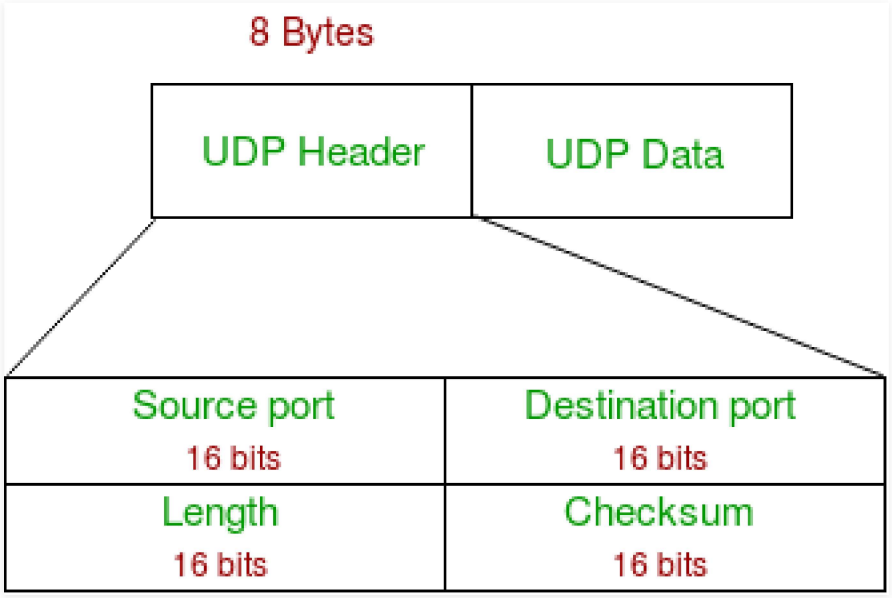
TCP 3-Way Handshake Process

Step 1 (SYN) : In the first step, client wants to establish a connection with server, so it sends a segment with SYN(Synchronize Sequence Number) which informs server that client is likely to start communication and with what sequence number it starts segments with

Step 2 (SYN + ACK): Server responds to the client request with SYN-ACK signal bits set. Acknowledgement(ACK) signifies the response of segment it received and SYN signifies with what sequence number it is likely to start the segments with

Step 3 (ACK) : In the final part client acknowledges the response of server and they both establish a reliable connection with which they will start eh actual data transfer.

UDP header



Refer the Differences between TCP and UDP

Application Layer

Domain Name Server: DNS is a host name to IP address translation service. DNS is a distributed database implemented in a hierarchy of name servers. It is an application layer protocol for message exchange between clients and servers.

Dynamic Host Configuration Protocol(DHCP) is an application layer protocol which is used to provide:

Subnet Mask (Option 1 – e.g., 255.255.255.0)
Router Address (Option 3 – e.g., 192.168.1.1)
DNS Address (Option 6 – e.g., 8.8.8.8)
Vendor Class Identifier (Option 43 – e.g., 'unifi' = 192.168.1.9 ##where unifi = controller)

Simple Network Management Protocol (SNMP) : SNMP is an application layer protocol which uses UDP port number 161/162.SNMP is used to monitor network, detect network faults and sometimes even used to configure remote devices.

Simple Mail Transfer Protocol (SMTP): SMTP is an application layer protocol. The client who wants to send the mail opens a TCP connection to the SMTP server and then sends the mail across the connection. The SMTP server is always on listening mode. As soon as it listens for a TCP connection from any client, the SMTP process initiates a connection on that port (25). After successfully establishing the TCP connection the client process sends the mail instantly.

File Transfer Protocol (FTP): File Transfer Protocol(FTP) is an application layer protocol which moves files between local and remote file systems. It runs on the top of TCP, like HTTP. To transfer a file, 2 TCP connections are used by FTP in parallel: control connection and data connection.

Hypertext Transfer Protocol (HTTP): is an application-level protocol that uses TCP as an underlying transport and typically runs on port 80. HTTP is a stateless protocol i.e. server maintains no information about past client requests.

Network Security

For Symmetric Key : n*(n-1)/2 keys are required.
For Public Key : 2*n key are required (each node will have private and public key).

RSA Algorithm in Cryptography

Key generation:

$Select\ \ p, q$	$p, q\ \ both\ \ prime$
$calculate\ \ n = p * q$	
$calculate\ \ \phi(n) = (p-1) * (q-1)$	
$select\ \ integer\ \ e$	$gcd(\phi(n), e) = 1; 1 < e < \phi(n)$
$calculate\ \ d$	
$PublicKey$	$KU = e, n$
$PrivateKey$	$KR = d, n$

Encryption:

$Plaintext$	$M < n$
$Ciphertext$	$C = M^e (mod\ n)$

Decryption:

$Ciphertext$	C
$Plaintext$	$M = C^d (mod\ n)$

Deffie Hellman Key Exchange

R1 = g^x mod p

R2 = g^y mod q

Both will have same key = g^{xy} mod p.