Assignment-01

COMPUTER NETWORK (CS-208)

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(1) (a) Subnetting vs Supernetting :-

Subnetting	Supernetting
→ Dividing one network into smaller networks.	→ Combining multiple networks into one larger network.
→ Better management & security	→ Reduce routing table size.
→ Borrow bits from host portion.	→ Borrow bits from network portion.
→ More subnets, fewer hosts per subnet.	→ Fewer network, more host.
→ eg:- 192.168.1.0/24→/26	→ eg:- 192.168.0.0 /24 + 192.168.1.0/24 → /23

(b) FDM vs TDM :-

FDM	TDM
→ Frequency division multiplexing	→ Time division multiplexing
→ Frequency bands.	→ Time slots
→ Analog signals	→ Digital signals
→ Requires more bandwidth	→ Efficient bandwidth use.
→ eg:- Radio broadcasting.	→ Digital telephony.

(c) Switch vs Router:-

Switch	Router
→ Data link layer	→ Network layer
→ MAC address	→ IP address
→ Devices within same network.	→ Different networks.
→ Faster	→ Slower than switch
→ Frame forwarding	→ Packet routing.

(d) Circuit switching vs. Packet switching:-

→ Dedicated Path	→ No dedicated path
→ Continuous	→ In packets
→ Low after setup	→ Variable delay
→ less efficient	→ More efficient
eg:- → Telephone network	→ Internet

(e) Baseband	Broadband
→ Digital	→ Analog
→ Single channel	→ Multiple channels
→ Modulation isn't required	→ Modulation is required
eg:- → Ethernet	→ Cable TV

(f)

BOOTP	DHCP
→ Bootstrap Protocol	→ Dynamic Host configuration Protocol
→ Address assignment is static	→ Address assignment is dynamic.
→ Manual	→ Automatic
→ Less flexible	→ More flexible
→ Modern use is rare	→ widely use in modern.

(g)

Routing	Forwarding
→ Path determination	→ Moving packet to next hop.
→ Routing algorithm	→ Router hardware
→ Scope :- Entire network	→ Scope :- Local router
→ Slower	→ Faster

(h)

CRC	Checksum
→ Cyclic redundancy check	→ Checksum
→ More accurate	→ Less accurate
→ Polynomial division	→ Binary addition
→ used in Data Link Layer.	→ Used in Transport Layer.

(i)

ARP	RARP
→ Address Resolution Protocol	→ Reverse Address Resolution Protocol.
→ Finds Mac from IP.	→ Finds IP from Mac.
→ Usage :- Common	→ Usage :- Rare
→ IP → MAC	→ MAC → IP

(j) Synchronous Transmission	Asynchronous Trans.
→ Common clock	→ No common clock
→ Faster	→ Slower
→ Continuous stream	→ Start and stop bits
→ More efficient	→ Less efficient.

(K) Stop & Wait	Sliding Window
→ one frame sent at a time.	→ Multiple frames sent.
→ Less efficient	→ highly efficient
→ Low throughput	→ high throughput
→ window size is 1	→ Window size is more than 1.

(1) Bit Rate	Baud Rate	Bit Interval
→ Bits per second	→ Signal changes per seond	→ Time for 1 bit
→ unit :- Bps	→ Unit :- Baud	→ Unit :- seconds
→ ≥ Baud rate	→ ≤ Bit rate	→ 1 / Bit rate
eg :→ 1000 bps	→ 500 baud	→ 1ms (for 1000 bps)

(2) (a) Suggested Network Topology :-

* For this scenario, a Hybrid Topology, specially a Star-Bus (Tree) Topology, is the most effective solution.

→ Intra-department (Floor level) :- each department should use a Star Topology. All devices (PC's, printers) connect to a central departmental switch. This makes it easy to add or remove devices without affecting the rest of the floor.

→ Inter-department (Building level) :- These departmental switches then connect to a central "backbone", creating a Tree Structure. This hierarchy is ideal for multi-floor buildings because it organises traffic and makes troubleshooting much easier.

(ii.)

Device	Role ~~Ro~~	Justification
→ Layer 2 switches	Local connectivity	used on each floor to connect end-user devices. They provide high-speed data forwarding within department
→ Router	Inter-network & internet	Connects the different departmental networks to each other & Provides a gateway to the Internet.
→ Firewall	Security	Positioned b/w internal network & the internet to monitor incoming / outgoing traffic & prevent unauthorised access.
→ Access Points (WAP)	Wireless Mobility	Allows employees to move b/w floors or departments while staying connected to the network.
→ VLAN's (Logic)	Logic Segregation	While not a physical device, configuring VLAN's on the switches is crutial to ensure that sensitive departmental data is kept secure from other departments.

(3.) ∵ Bit length = Propagation speed X Bit duration

∵ Bit duration $= \frac{1}{\text{Bandwidth}}$

∴ Bit length $= \frac{\text{Propaga}^{n}\text{ speed}}{\text{Bandwidth}}$

Also, Given: Pro. speed $(v) = 2 \times 10^8$ m/s

∴ (a) For bandwidth of 2 Mbps :- (2×10^6 bits per sec) (bps)

$$* \text{ Bit length} = \frac{2 \times 10^8 \text{ m/s}}{2 \times 10^6 \text{ bps}} = 100 \text{ meters}$$

(b) B.W = 20 Mbps (2×10^6 bps)

$$\therefore \text{bit length} = \frac{2 \times 10^8 \text{ m/s}}{20 \times 10^6 \text{ bps}} = 10 \text{ meters}$$

(c) For b.w. = 300 Mbps

$$\text{bit length} = \frac{2 \times 10^8 \text{ m/s}}{300 \times 10^6 \text{ bps}} \approx 0.67 \text{ meters}$$

(4.)

Features	OSI Model	TCP/IP Model
→ Number of layers	7 layers	→ 4 layers
→ Development	Developed by ISO as a theoretical standard.	Developed by DOD for practical implementation
→ Upper layers	splits functions into Application, Presentation, & session	Combines these into a single Application layer.
→ Lower layers	Separates Data link and Physical layers	often combines these into the Network Access layer
→ Approach	Rigidly defined boundaries b/w layers.	Loose, protocol-oriented approach.

(5.)

(a) $2^r \geq m + r + 1$

where m is no. of data bits. Here, m = 6

* If r = 3 : $2^3 \geq 6+3+1 \rightarrow 8 \geq 10$ (False)

* If r = 4 : $2^4 \geq 6+4+1 \rightarrow 16 \geq 11$ (True)

Result : 4 redundant bits are required. The total codeword length will be 6+4 = 10 bits

(b) Construct the Hamming Code :-

Position	10	9	8	7	6	5	4	3	2	1
Type	D_6	D_5	P_8	D_4	D_3	D_2	P_4	D_1	P_2	P_1
Value	1	0	?	1	1	0	?	1	?	?

Now, we calculate the parity bits (using even parity) :

* P_1 (posiⁿ's 1, 3, 5, 7, 9) : bits are $D_1(1)$, $D_2(0)$, $D_4(1)$, $D_5(0)$. sum = 2. To make it even, $P_1 = 0$.

* P_2 (posiⁿ's 2, 3, 6, 7, 10) : bits are $D_1(1)$, $D_3(1)$, $D_4(1)$, $D_6(1)$. Sum = 4. To make it even, $P_2 = 0$.

* P_4 (Posiⁿ's : 4, 5, 6, 7) : bits are $D_2(0)$, $D_3(1)$, $D_4(1)$. sum = 2. To make it even, $P_4 = 0$

* P_8 (Posiⁿ's 8, 9, 10) : bits are $D_5(0)$, $D_6(1)$, sum = 1. To make it even, $P_8 = 1$.

Constructed codeword :- 1011100100

(C) Identify and correct the error in 1010011101

↳ let's map it to posiⁿ's 1-10 (reading right to left):-

$P_1 = 1,\ P_2 = 0,\ D_1 = 1,\ P_4 = 1,\ D_2 = 1,\ D_3 = 0,\ D_4 = 0,\ P_8 = 1,\ D_5 = 0,\ D_6 = 1$

→ We check the parity groups again:

* Check C_1 (1, 3, 5, 7, 9) : bits are 1, 1, 1, 0, 0. sum = 3 (odd). $C_1 = 1$
* Check C_2 (2, 3, 6, 7, 10): bits are 0, 1, 0, 0, 1 sum = 2 (even). $C_2 = 0$
* Check C_4 (4, 5, 6, 7): bits are 1, 1, 0, 0 . sum = 2 (even). $C_4 = 0$.
* Check C_8 (8, 9, 10) : bits are 1, 0, 1 . sum = 2 (even). $C_8 = 0$

* Binary error Posiⁿ ($C_8C_4C_2C_1$) : $0001_2 = 1$

→ Error Posiⁿ : The error is at Posiⁿ 1

→ Correcⁿ : Flip the bit at posiⁿ 1 from 1 to 0.

→ Corrected codeword : 1010011100.

(6.) (a) Recommended Topology:-

→ Physical Star-Bus (Tree) Topology or a Hierarchial Star Topology.

In this setup:-

* Core layer : A central "Backbone" connects the main server room or administrative centre to each building.
* Distribution layer : Each building acts as a node. Inside each building, there is a local star topology where a central switch connects to all computers, Wi-Fi access points, and labs in that specific block.

(ii) Justifica^n:-

(A) Scalability :-

* Modular expansion :- If college builds a new hostel, you simply run one main line from central core to the new building's switch. You don't need to reconfigure the entire network.
* Ease of management :- Since each building is its own "star", IT staff can manage & upgrade the library's network independently of the academic blocks.

(7)

(a) Max. data rate using Shannon's capacity formula:-

$$C = B \times \log_2(1+SNR)$$

Given : * B.W. (B) = 1MHz = 10^6 Hz
* Signal-to-Noise Ratio in dB (SNR_{dB}) = 30 dB

$\because$

$$SNR_{dB} = 10 \log_{10}(SNR)$$

$$30 = 10 \log_{10}(SNR) \Rightarrow SNR = 1000$$

Now, $C = 10^6 \times \log_2(1+1000) \approx 9.967$ Mbps

(b) Comparison with Nyquist's formula :-

For binary signaling, L = 2.

Formula is : Bit Rate = $2 \times B \times \log_2(L)$

$\therefore$ Bit Rate = $2 \times 10^6 \times 1 = 2$ Mbps

(8.) (1) Max. no. of subnets is determined by formula 2^n, where n is no. of borrowed subnet bits

Given: subnet bits $(n) = 6$

$\therefore$ Max subnets $= 2^6 = 64$ subnets

(2.) Max. no. of hosts per subnet :-

* original Class B host Bits $= 16$
* Borrowed bits $= 6$
* Remaining host bits $(h) = 16 - 6 = 10$ bits

$\therefore$ Max hosts $= 2^h - 2 = 2^{10} - 2 = 1022$ hosts per subnet

(9.) (a) No. of packets :-

= Total Message size / Payload per packet

$$= \frac{5000000 \text{ bytes}}{1000 \text{ bytes/packet}} = 5000 \text{ packets}$$

(b) Total Transmission Time :-

(i) Calculate Total Data Sent :-

1000 bytes (payload) + 40 bytes (header) = 1040 bytes

$\therefore$ Total Data = 5000 packets $\times$ 1040 bytes = 5200000 bytes

(ii) Convert to Bits :- $8 \times 5200000 = 41600000$ bits

(iii) Calculate Time (T = size / Rate) :-

$$\text{Transmission Time} = \frac{41600000 \text{ bits}}{10000000 \text{ bits/sec}}$$

$= 4.16$ sec.

(10.)

* Given :- → window size (W) : 5 packets
→ Packet size (L) : 1000 bytes (8000 bits)
→ Transmission Time (T_t) : 50 MS
→ Propogaⁿ Delay (T_p) : 200 MS

* RTT :-

$$RTT = T_t + 2 \times T_p = 50\,MS + 2(200\,MS) = 450\,MS$$

* Efficiency (η) :-

$$\eta = \frac{W \times T_t}{RTT} = \frac{5 \times 50\,MS}{450\,MS} = \frac{250}{450} = 0.555\text{---} \; (55.5\%)$$

* ∵ $B.W.(B) = \frac{L}{T_t} = \frac{8000 \text{ bits}}{50 \times 10^{-6} \text{ sec}} = 160 \text{ Mbps}$

∴ Max. Throughput $= \eta \times B = 0.555\text{---} \times 160 \text{ Mbps} = 88.89$ Mbps

(11.) (a) Signal Rate (S) = $C \times R \times r$

where : $C = 1$, $R = 10$ Mbps, $r = 2$

∴ Signal Rate = 10 Mbps × 2 = 20 M baud

(b) estimate the minimum Bandwidth required :-

$$B_{min} = \frac{S}{2} = \frac{20\,MHz}{2} = 10\,MHz$$

(12.) * Identify the subnets :-

→ The netmask 255.255.255.224 creates subnets in increments of 32 (∵ 256 − 224 = 32).

* Host X (192.168.1.97): Falls in range 96-127. Its subnet is 192.168.1.96
* Host Y (192.168.1.80): Falls in the range 64-95. Its subnet is 192.168.1.64.

→ Since the subnet ID's are different, Host X & Host Y can't be on the same network segment.

* Now, Trace the connections:-

To get from Host X to Host Y through two routers (R_1 & R_2), the path looks like this :-

Host X → Subnet 1 → Router R1 → Subnet 2 → Router R_2 ↓

Host Y ← Subnet 3

(i) Subnet 1: Connects Host X to R1
(ii) Subnet 2: Connects R_1 to R_2
(iii) Subnet 3: Connects R_2 to Host Y.

∴ There are 3 distinct subnets guaranteed to exist

(13.)

* Initialization :-

We start by setting the distance to A as 0 & all others to ∞.

→ Distances :- A : 0, B : ∞, C : ∞, D : ∞, E : ∞, ~~F : ∞ G : ∞ H : ∞~~ ~~I : ∞~~

→ Visited Set : $\emptyset$

* Step by Step execution :-

Step	Current Node	Neighbours updated	New shortest distances (Tentative)
1	A(0)	B, ~~H~~ D	B = 6, ~~H = 2~~ D = 1
2.	D(1)	B, C, E	B = min (6, 1+2) = 3 C = 1+1 = 2 E = 1+7 = 8
3.	C(2)	B, E	B = min (3, 2+5) = 3 (no change) E = min (8, 2+3) = 5
4.	B(3)	C	C = min (2, 3+5) = 2 (no change)
5.	E (5)	—	All nodes visited

* Final Shortest Paths from A :-

To node	Shortest Distance	Shortest Path
B	3	A → D → B
C	2	A → D → C
D	1	A → D
E	5	A → D → C → E

(14.) (a) * Calculate total Sequence number (L) :-

Given: sequence number field is given as 3 bits.

$L = 2^n = 2^3 = 8$

Sequence no. range :- 0 to 7

* Apply GBN window size Rule:-

$\therefore W_{max} = 2^n - 1 = 7$

$\therefore$ Max. window size allowed is 7.

(b) Check whether the given window size is valid.

→ The problem states that the current sender window size is 7.

* Criteria :- For a protocol to be valid, the actual window size (W) must satisfy: $2^n - 1 \geq W \therefore 7 \geq 7$

→ Comparison : yes, the given window size of 7 is valid.

(15.) Shortest Path Tree Construction :-

Step	confirmed Nodes	Distances from A	Path Chosen
1	{A}	A = 0, B = 4, C = 2, D = ∞	A → C (cost 2 is min)
2	{A,C}	B = 3 (via C: 2+1) D = 10 (via C: 2+8)	A → C → B (cost 3 is min)
3	{A, C, B}	D = 8 (via B: 3+5)	A → C → B → D (cost 8 is min)

∴ Final shortest Path Tree (SPT)

→ A to C : cost 2

→ A to B : A→C→B : Total cost : 3

→ A to D : A→C→B→D : Total cost : 8

(16.) Given :-

Data : 110101

Divisor : 1011

n-1 zeros to append : since the divisor has 4 bits, we append 3 zeros (000) to data

* Binary Division (Modulo-2) :

we divide the padded data 110101000 by 1011 :-

```
          111101        (Quotient)
    1011 ) 110101000
           1011↓            ↓
           01100        (XOR result, then drop 0)
           1011             ↓
           01111        (XOR result, then drop 1)
           1011             ↓
           01000 0      (XOR result, then drop 0)
           1011             ↓
           00110        (XOR result, then drop 0)
           0000         ↓ (∵ first bit is 0, use 0's)
           01100        (Drop last 0)
           1011
           0111         (Final remainder)
```

Final result :-

* CRC (remainder) :- 111

* Transmitted frame : 110101 + 111 = 110101111

→ The rem. 111 is appended to data to form codeword.

17.) (a) Probability of successful Transmission :-

$$P_{success} = N.p.(1-p)^{N-1}$$

$$= 200 \times 0.01 \times (1-0.01)^{199}$$

$$\approx \underset{\sim\sim\sim}{0.2707}$$

(b) Probability of collision :-

→ P. of an idle slot (P_{idle}): No nodes transmit

$$P_{idle} = (1-P)^N = (0.99)^{200} \approx 0.1340$$

→ P of collision ($P_{collision}$) $= 1 - P_{success} - P_{idle}$

$$= 1 - 0.2707 - 0.1340$$

$$\approx \underset{\sim\sim\sim}{0.5953}$$