ASSIGNMENT - I

CN

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CSE-A

1. A system has a n layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers, an h-byte is added. What fraction of the networks bandwidth is filled with headers?

Original message size = M bytes
At each layer h byte header is added

Message - M
Layer-1 - M+h
Layer-2 - M+h+h = M+2h
Layer-3 - M+h+h+h = M+3h
Layer-n - M+h+h+...+n = M+nh

Thus after n layers the total size of the message, including header is M+nh
The part of this total size that consist of header is nh bytes

The fraction of the network bandwidth filled with headers is $= \frac{nh}{M+nh}$

2. What metrics are used to assess the performance of a network
Calculate the latency for a 100Mbps ethernet with a single store and forward switch in the path and a packet size of 12000 bits. Assume that each link introduces a propogation delay of 10 μs and that the switch begins transmitting immediately after it has finished receiving the pack

Bandwidth: Number of bits per second that can be transmitted over a communication link

Bandwidth = $\frac{\text{Size of packet}}{\text{Transmission time}}$

Throughput : Number of messages transferred successfully per unit of time is referred to as throughput

Throughput = $\frac{\text{transfer size}}{\text{Transfer time}}$

Latency: How long it takes for a message to travel from one end of network to the other

Latency = Propagation time + transmission time + Queuing time

Packet loss: refers to the number of packets that fail to transfer from one destination to another

Jitter: The variance in time delay for data packets carried over a network is known as jitter

To calculate latency

BW = 100 Mbps = 100×10^6 bits per second

Packet size = 12000 bits

Propogation delay per link = 10 μs = 10×10^{-6} sec

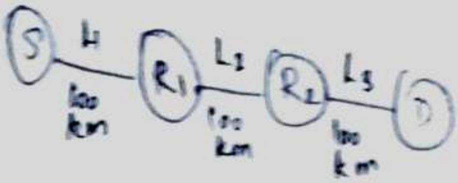
Latency = propogation delay of links + Transmission delay of links

= $2 \times$ (Propogation delay) + $2 \times$ (transmission delay) (2 links)

Transmission delay = $\frac{\text{Packet size}}{BW} = \frac{12000}{100 \times 10^{-6}} = 120 \times 10^{-6} = 120 \mu s$

Latency = $(2 \times 10) + 2(120) = 20 + 240 = 260 \mu s$

Total Latency = $260 \mu s$



Given

$V = 10^8$ m/s $\quad BW = 1$ Mbps $= 10^6$ bits/s

$N = 1000 \quad L = 1000$ bits $\quad d = 100$ km

Transmission delay = T
Propogation delay = P

$T = \frac{L}{BW} \qquad P = \frac{d}{V}$

Transmission delay for first packet to transmit from S to R1 : $\quad T = \frac{1000}{10^6} = 10^{-3}$ sec $= 1$ms

Transmission delay for first packet to transmit from S to D : $\quad T = 1 \times 3 = 3$ ms

Propogation delay for the first packet to transmit from S to R : $\quad P = \frac{100 \times 10^3}{10^8} = 10^{-3}$ s $= 1$ms

Propogation delay for the first packet to transmit from S to D : $\quad P = 1 \times 3 = 3$ ms

Total time of transmission & propogation for the first packet from S to D : $\quad T + P = 3 + 3 = 6$ ms

The file has 1000 packets

While the first packet was reaching D other packets must have been processing in parallel. D will receive remaining 1 packet per 1 ms from R2. Remaining 999 packets will take 999 ms

Total time $= 999 + 6 = 1005$ ms

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4. Given a network with a BW of 100 Mbps and an average latency of 50ms. Calculate the throughput if the network experiences a packet loss rate at 2%. Explain the impact of packet loss on overall network performance

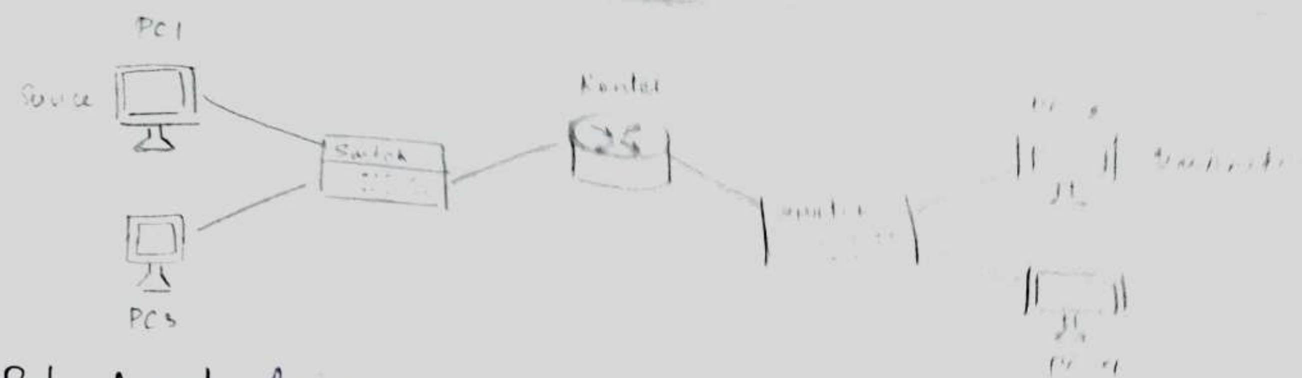
BW = 100 Mbps
Avg latency = 50ms
Packet loss rate = 2%

Throughput = BW × (1 - packet loss ratio)
= 100 × (1 - 0.02) = 100 × 0.98 = 98 Mbps

Impact of packet loss on network performance
* Reduced throughput
* Increased latency
* Decreased efficiency

5. Consider a network with a mix of PCs, switches, routers. Explain how data is transmitted from a PC in one LAN to a PC in another LAN. Illustrate the path taken by the data packet and the role of each device in the process

* PC1 is the source PC in LAN A
* The data is first sent to its local switch
* The switch receives the data packet & check the destination IP
* Since PC2 is in a different LAN (LANB) the switch determines that the data needs to be sent to a router
* The switch forwards the data packet to the router that connects LAN A to other networks including LANB
* The router examines the destination IP address of the data packet & determine the best path to forward the packet to destination LANB
* The packet is then directed to the switch in LANB
* Switch in LANB receives the data packet from router & examines the destination MAC address
* The switch then forwards the packet to PC2 based on MAC address



Role of each device.

PC. (Source / Destination) initiates + receives data packets
Switch (within each LAN) forwards packets to devices within the same LAN based on MAC address
Router: Connects two LANs and routes packets between them based on IP addresses

6. a) File size $= 1.5\,MB = 1.5 \times 1024 \times 1024 \times 8 = 12{,}582{,}912$ bits
Round Trip Time $=$ RTT $= 80\,ms$
Packet size $= 1KB = 8192$ bits
Initial Handshaking: $2 \times RTT \quad 2 \times 80 \cdot 160ms$
Bandwidth $= 10\,Mbps = 10 \times 10^6$ bps
Total time = initial handshaking + network delays
Network delays = propogation delay + transmission delay

$$= \frac{80 \times 10^{-3}}{2} + \frac{12582912}{10 \times 10^6}$$

$$= (40 \times 10^{-3}) + 1.2582912$$

$$= 0.04 + 1.2582912$$

$$= 1.2982912 \text{ seconds}$$

Total time: $160\,ms + (1.2982912 \times 10^3)\,ms$

$$= 160 + 1298.2912\,ms$$

Total time $= 1458.2912\,ms$ or 1.46 seconds

b) Number of packets $= \frac{1.5 \text{ MB}}{1 \text{ KB}} = 1.5 \times 1024 = 1536$ packets

1535 inter-packet gaps between 1536 packets

transmission time for 1536 packets $= 1536 \times \frac{8192}{10 \times 10^6}$ seconds

$= 1.258$ seconds

total time = initial handshaking + network delays

network delays = transmission time for 1536 packets + waiting time of first 1535 packets + Propagation time of the last packet

$= 1.258 + \left(\frac{1535 \times 80}{1000}\right) + \left(\frac{80 \times 10^{-3}}{2} \times \frac{1}{1536}\right)$

$= 1.258 + 122.8 + \frac{0.02604}{1000}$

$= 124.05832$ seconds

total time $= (160 \times 10^{-3}) + 124.05832$

total time $= 124.21832$ seconds

c) packets per RTT = 20

No of batches $= \frac{1536 \text{ packets}}{20 \text{ packets per RTT}} = 76.8$ batches

Propogation delay for 1st batch $= \frac{RTT}{2} = \frac{80}{2} = 40$ ms

Transmission time for remaining batches: $76 \times RTT = 76 \times 80$

$= 6080$ ms

Initial handshaking time: 160 ms

Total time: $160 + 40 + 6080 = 6280$ ms $= 6.28$ sec

Difference between

i) OSI + TCP/IP

Open System Interconnection	Transaction Control Protocol / Internet Protocol
* It has 7 layers	* It has 4 layers
* It is vertically approached	* It is horizontally approached
* Delivery of package is guaranteed	* Delivery of package is not guarenteed
* It is low in usage	* It is highley used
* Less reliable	* More reliable
* Protocols like: HTTP (Application) SSL/TLS (presentation) TCP (Transport) IP (Network) Ethernet Datalink	* HTTP, FTP, TCP, UDP, IP, ethernet
* Both connection-oriented (TCP) by connectionless (UDP) protocols are covered in the transport layer	* TCP (connection-oriented) UDP (connectionless)

ii) Types of topology

Topology	Structure	Advantages	Disadvantages
Bus Topology	All devices are connected to a single central cable	→ easy to implement + extend → requires less cable than others topologies	→ Difficult to trouble shoot → central cable failure brings down the entire network → Performance degrades with more devices
Star Topology	All devices are connected to a central hub or switch	→ easy to install + manage → failure of one device does not affect the others → easy to add/remove devices	→ Requires more cable than bus topology → Central hub failure disrupts the entire network
Ring topology	Devices are connected in a circular manner each to two others	→ data flows in one direction, reducing packet collisions → easy to install + reconfigure	→ failure of one device affect the entire network → Trouble shooting is difficult

Mesh Topology	Every device is connected to every other device	→ High redundancy & fault tolerance → ensures consistent performance	→ expensive & complex to inst[illegible] → requires lot of cabling + configur[illegible]
Tree Topology	A combination of star & bus topologies. devices are connected heirarchially	→ scalable & easy to manage → failure of one segment dont affect entire network	→ Requires lot of cabling → Central hub failure in a segment can isolate that segment
Hybrid Topology	Combines two or more different topologies	→ flexible, scalable. → benefits from advantages of combined topologies	→ complex design & configuration → expensive to implement + maintain

iii) Types of Modes

Transmission Mode	Description	Advantages	Disadvantages	Example
Simplex	Data transmission in only one direction	Simple & straight forward communication	No feedback or response from receiver	Radio broadcasting
Half Duplex	Data transmission in both directions but not simultaneously	Allows bidirectional communication	Cannot send & receive data at the same time	Walkie Talkie
Full Duplex	Data transmission in both directions simultaneously	Simultaneous Exchange of data	Requires more complex systems	Telephone Conversations

give the hamming code for the data bits 10011011100 using odd parity & even parity Suppose the bit string 0101001 is received. Find & correct the error

message : 10011011100

M = 11

$2^P \geq (P + m + 1) \Rightarrow 2^P \geq P + 12$ [P = 1, 2, 3, 4, ...]

Condition becomes true at P = 4

P_1	P_2	m_1	P_3	m_2	m_3	m_4	P_4	m_5	m_6	m_7	m_8	m_9	m_{10}	m_{11}
		1		0	0	1		1	0	1	1	1	0	0

To find the parity bits. odd parity

P_1 positions : 1, 3, 5, 7, 9, 11, 13, 15

P_1 positions : P_1, 1, 0, 1, 1, 1, 1, 0 ⇒ odd 1's so $P_1 = 0$

P_2 positions : 2, 3, 6, 7, 10, 11, 14, 15

P_2 positions : P_2, 1, 0, 1, 0, 1, 0, 0 ⇒ odd 1's so $P_2 = 0$

P_3 positions : 4, 5, 6, 7, 12, 13, 14, 15

P_3 positions : P_3, 0, 0, 1, 1, 1, 0, 0 ⇒ odd 1's so $P_3 = 0$

P_4 positions : 8, 9, 10, 11, 12, 13, 14, 15

P_4 positions : P_4, 1, 0, 1, 1, 1, 0, 0 ⇒ even 1's so $P_4 = 1$

Hamming code

001000111011100

even parity

P_1 position :	1	3	5	7	9	11	13	15
	P_1	1	0	1	1	1	1	0

odd no of 1's $P_1 = 1$

P_2 position :	2	3	6	7	10	11	14	15
	P_2	1	0	1	0	1	0	0

odd no of 1's $P_2 = 1$

P_3 position :	4	5	6	7	12	13	14	15
	P_3	0	0	1	1	1	0	0

odd no of 1's so $P_3 = 1$

P4 position : 8 9 10 11 12 13 14 15

P4 1 0 1 1 1 0 0

even no of 1s so P4 = 1

Hamming code :

1 1 1 1 0 0 1 1 1 0 1 1 1 0 0

9. generator polynomial = $x^3 + 1$

1 0 0 1 Divisor

i) Dividend 1 0 0 1 1 1 0 1 0 0 0

```
           10001100
      ____________
1001 ) 10011101000
       1001
       ----
        0001
        0000
        ----
         0011
         0000
         ----
          0110
          0000
          ----
           1101
           1001
           ----
            1000
            1001
            ----
             0010
             0000
             ----
              0100
              0000
              ----
               100
```

remainder → 100

Transmitted bit string : 10011101100

ii)

```
           1010100
      ____________
1001 ) 10111101100
       1001
       ----
        01011
         1001
         ----
         01001
          1001
          ----
         000100
```

remainder → 100

receiver detects that there is an error

In the standard ethernet with transmission rate of 10 Mbps assume that the length of the medium is 2500 m and size of a frame is 512 bytes. The propogation speed of a signal in a cable is normally 2×10^8 m/s. Transmission delay + propagation delay are

$d = 2500$

frame size = 512 bytes = $512 \times 8 = 4096$ bits

transmission rate = 10 Mbps

Propogation speed = 2×10^8 m/s

Transmission delay = $\frac{\text{frame size}}{\text{transition rate}} = \frac{4096}{10 \times 10^6 \text{ bits}} = 0.4096$ ms

Propogation delay = $\frac{\text{Distance}}{\text{propogation speed}} = \frac{2500}{2 \times 10^8} = 0.0125$ ms

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