CN ASSIGNMENT #01

23K-0842

Q1) Page # 36, 37, 38

a) $d_{end\text{-}to\text{-}end} = \frac{L}{R_1} + \frac{L}{R_2} + d_1 + d_2 = \boxed{\frac{L}{R_1} + \frac{L}{R_2}}$ ← ignoring propagation delay according to Q

where:-

L/R_1 → Transmission delay on first link. It shows the time to push all bits of length L onto link 1.

L/R_2 → Transmission delay on second link. It shows the time to push all bits of length L onto link 2.

d_1 → propagation delay on first link. It shows time for bit to travel the distance of link 1.

d_2 → propagation delay on second link. It shows the time for bit to travel the distance of link 2.

Page 41 (End to End delay)

b) If $R_2 << R_1$

so $\frac{L}{R_2} >> \frac{L}{R_1}$, transmission delay on the second link dominates.

so $D_{total} \approx \frac{L}{R_2} + d_1 + d_2 \approx \frac{L}{R_2}$

∴ The slowest link R_2 determines the bottleneck. No matter how fast R_1 is, the packet has to wait longer to be transmitted on the slower link.

Q2) Book Page : 13, 14, 15

a) • HFC (Hybrid Fiber Coax) is a cable, TV based communication medium where the coaxial cable is shared among multiple houses in neighbourhood. The advertised 100Mbps is the total capacity of that link (shared). The bandwidth is divided among users on the same cable segment.

• DSL uses existing telephone lines where each subscriber has its own dedicated line. The advertised 100Mbps is per-customer, which isn't shared with neighbours.

b) At 8 P.M many HFC customers are streaming video. All the traffic flows through a shared coaxial cable. The 100 Mbps is split among all active users due to which effective throughput per customer drops, causing a slowdown in stream while DSL customers don't slow down because they have dedicated lines that are not shared with neighbours.

Q3) Page :- 50, 51, 52

a) Headers are added at Application, Transport, Network & Link layer.

- At application layer, HTTP request header is added, it tells the server which website is being requested. It ensures that server knows what resource the client wants.
- At transport layer, TCP or UDP header is added. It contains the source & destination ports. It allows multiple apps to share the same network.
- At network layer, IP header is added. It contains source & destination IP addresses. Ensures that packet is forwarded across internet to correct host.
- At link layer, Ethernet header containing source & destination MAC addresses added. Ensures the physical delivery between 2 directly connected devices.

b). Router examines → link layer header to know if the frame is addressed to the router itself. → Network layer header to read the destination IP address & decide where to forward packets.

Router ignores :-

→ Transport layer (TCP) header since it doesn't care about ports.

→ Application layer (HTTP) header since it is not relevant for forwarding.

Since router's job is to deliver the packets closer to their destination.

host, It needs IP addresses & MAC addresses. It doesnot need to know what application (TCP, HTTP) is inside.

c) Page : 30

Advantage :- If one packet is lost or corrupted, only that packet needs retransmission instead of entire image.

Disadvantage :- More packets mean more overhead on header, & extra processing in the network which increases congestion.

Q4) Page 30: (Packet vs Circuit Switching)

a) $N = \dfrac{\text{Total link capacity}}{\text{Transmission rate per user}} = \dfrac{1 \times 10^9}{1 \times 10^8} = 10$

Hence, Max users = 10.

b) In packet switching, the bandwidth is dynamically shared. When a user is inactive, their share of the bandwidth is free for others. Because it is unlikely that all users are active at same time, the system can support more than 10 users.

Q5) R20

(a). The "asking director" analogy illustrates packet switching because a packet (car) doesnot know the full path to its destination. Instead, it carries destination IP address (driver's information) & at each router (intersection), decisions are made. Eventually the packets arrive at final destination.

b). Pg#56 & #57

A malicious fake detour sign corresponds to spoofing of routing information, That maps to network layer. In this network layer, the attacker can eavesdrop, modify packets, inject false messages, hijack the session or launch a replay attack by recording & resending messages later.

CamScanner

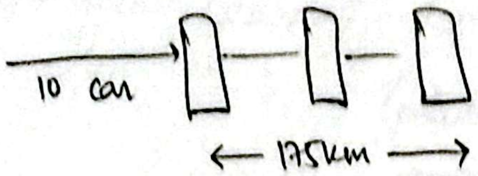
c) Pg # 568 # 57

The fake sign attack primarily violates Authentication of routing information.

Q6)

P5. page 38 (caravan Analogy)

a).



Propagation delay $= \frac{d}{s} = \frac{175 \text{ km}}{100 \text{ km/hr}} = 1.75$ hr or 105 mins

Delay on 1 toolboth $= 12 \times 10 = 120$ s or 2 mins

Total toolboth $= 3$

Delay on booths $= 3 \times 2 = 6$ mins

End-End delay $= d_{prop} + d_{trans}$
$= 105 + 6 = 111$ mins or 1hr 51 min

b) 8 car caravan

Delay on toolboth $= (12 \times 8) \times 3$
$= 288$ sec $= 4.8$ min

Propagation delay $= 105$ mins.

$d_{end\text{-}to\text{-}end} = 105 + 4.8 = 109.8$ mins

P6.

a) $d_{prop} = \frac{m}{s}$ $\frac{\text{(propagation distance)}}{\text{(propagation speed)}}$

b) $d_{trans} = \frac{L}{R}$ $\frac{\text{(length of packet)}}{\text{(Transmission Rate)}}$

c) $d_{end\text{-}to\text{-}end} = \frac{m}{S} + \frac{L}{R}$

d) At $t = d_{trans}$, sender A has just finished putting last bit onto the link so that it leaves A & begins to propagate onto the link.

e) If $d_{prop} < d_{trans}$, at $t = d_{trans}$ the 1st bit arrives at host B & last bit is just leaving Host A.

f) If $d_{prop} > d_{trans}$, at $t = d_{trans}$ the first bit is still propagating along the link. It has not reached the Host B yet.

g). When $d_{prop} = d_{trans}$

$$\frac{m}{s} = \frac{L}{R}$$

$$m = \frac{s \times L}{R} = \frac{(2.5 \times 10^8)(1500 \times 8)}{10 \times 10^6}$$

$$m = 300000\,m$$

$$\boxed{m = 300\,km}$$

P18. traceroute Page # 41

1st destination :- www.nu.edu.pk (Pak)

2nd destination :- www.mit.edu (USA)

a) 1st Hr & 1st Dest:-

$x_1 = 45\,ms$, $x_2 = 38\,ms$, $x_3 = 47\,ms$

$$avg = \frac{45 + 38 + 47}{3} = 43.33\,ms$$

$$std.dev = \sqrt{\frac{(45-43.33)^2 + (38-43.33)^2 + (47-43.33)^2}{3}}$$

$$= 3.858$$

1st Hr & 2nd Dest:-

$x_1 = 252\,ms$, $x_2 = 253\,ms$, $x_3 = 253\,ms$.

$$avg = \frac{252 + 253 + 253}{3} = 252.67\,ms$$

$$std.dev = \sqrt{\frac{2(253-252.67)^2 + (252-252.67)^2}{3}}$$

$$= 0.471$$

2^{nd} Hr & 1^{st} Dest :-

$x_1 = 26ms$, $x_2 = 53ms$, $x_3 = 100ms$

$$avg = \frac{26+53+100}{3} = 59.67\ ms$$

$$std.\ dev = \sqrt{\frac{(26-59.67)^2+(53-59.67)^2+(100-59.67)^2}{3}}$$

$= 30.57$

2^{nd} Hr & 2^{nd} Dest :-

$x_1 = 261\ ms$, $x_2 = 305\ ms$, $x_3 = 307\ ms$.

$$avg = \frac{261+305+307}{3} = 291$$

$$std.\ dev = \sqrt{\frac{(261-291)^2+(305-291)^2+(307-291)^2}{3}}$$

$= 21.228$

3^{rd} Hr & 1^{st} Dest :-

$x_1 = 24ms$, $x_2 = 41\ ms$, $x_3 = 44ms$

$$avg. = \frac{24+41+44}{3} = 36.33ms$$

$$std.\ dev = \sqrt{\frac{(250-249.667)^2+(248-249.66)^2+(251-249.66)^2}{3}}$$

$= 1.247$

b)

Dest 1	Dest 2
Hr 1 : 10 hops total	Hr 1 : 13 hops total
Hr 2 : 10 hops total	Hr 2 : 10 hops total
Hr 3 : 10 hops total	Hr 3 : 10 hops total
Path remained consistent as same sequence of router IPs.	significant path changed. Hr 1 reached (104.69.90.155) final, Hr 2 & 3 : (173.222.144.77), also different intermediate routers used.

1) My LAN
2) My ISP
3) Backbone/transit ISP
4) International transit
5) Destination (nu or mit)

In this experiment, largest delays most occured at final hop, not at ISP peering interfaces.

d) Intra-continent paths are stable, consistent 10 hops, gradual increase with moderate spikes at ISP boundaries, 4-5 clear ISP Networks.

Inter continent paths are unstable (multiple route changes), variable hops (10,13), sharp increase at intercontinental links, many timeout, complex ISP transitions with CDN involvements.

P24.

$50TB = 50 \times 10^{12}$ bytes

speed $= 100 \times 10^6$ bits/sec

$$Time = \frac{50 \times 10^{12} \times 8 \text{ bits}}{100 \times 10^6 \text{ bits/sec}}.$$

$Time = 4 \times 10^6 s \approx 66666.67$ min

$= 46.3$ days

It will take 46.3 days for data transfer via the link whereas 1 day (24hrs) with FedEx.
Hence, FedEx will be much better option.

P31.

a) Message size $= 10^6$ bits

Link rate $= 5 \times 10^6$ bps

Transmission delay per link $= \frac{10^6}{5\times10^6} = 0.2s$

since 3 links are involved :

$0.2 \times 3 = 0.6s$

Time needed for message transfer $= 0.6s$

b). Packet size $= 10000$ bits

Transmission time per packet $= \frac{10\,000}{5\times10^6} = 2ms$

→ Time to move first packet onto first link $= 2ms$

→ Second packet is fully received at first switch at 4ms.

c). d_{trans} (for 1 packet) $= \frac{10000}{5\times10^6} = 2ms$

$$T_{end\text{-}to\text{-}end} = (100-1)(2ms) + 3(2ms)$$

$$= (P-1)\frac{L}{R} + N \times \frac{L}{R} \text{ (formula)}$$

$$= 198 + 6ms$$

$$= \boxed{204 \text{ ms}}$$

without segmentation : 600ms

With segmentation : 204 ms.

Almost 3 times faster file transfer with segmentation due to pipelined transmission.

d). It reduces end-to-end delay, improves multiplexity & makes buffer management efficient.

e). More headers, retransmission cost, & can cause extra delays.

BONUS QUESTION:-

delay for each hop = $\text{delay}_{\text{transmission}} + \text{delay}_{\text{propagation}} + \text{delay}_{\text{queuing}} + \text{delay}_{\text{processing}}$

$\text{delay}_{\text{processing}}$ assumed as 0.

$d_{\text{transmission}} = L/R$

L = packet size $= 1500 \times 8 = 12\,000$ bits

Hop 0 :-

$d_{\text{trans}} = \dfrac{12000}{1 \times 10^9} = 1.2 \times 10^{-5}\,s = 0.012\text{ ms}$

$d_{\text{prop}} = \dfrac{d}{s} = \dfrac{10}{2.0 \times 10^8} = 5 \times 10^{-8}\,s = 0.000050\text{ ms}$

$d_{\text{queuing}} = 0.1\text{ ms}$

sum $= 0.1 + 0.012 + 0.000050$

$= \boxed{0.11205\text{ ms}}$

Hop 1 :-

$d_{\text{trans}} = \dfrac{12000}{1 \times 10^9} = 0.012\text{ ms}$

$d_{\text{prop}} = \dfrac{5{,}000}{2.0 \times 10^8} = 2.5 \times 10^{-5} = 0.025\text{ ms}$

$d_{\text{queue}} = 0.5\text{ ms}$

sum $= 0.012 + 0.025 + 0.5 = \boxed{0.537\text{ ms}}$

Hop 2 :-

$d_{\text{trans}} = \dfrac{12000}{100 \times 10^9} = 1.2 \times 10^{-7} = \boxed{0.000120\text{ ms}}$

$d_{\text{prop}} = \dfrac{800 \times 10^3}{2.0 \times 10^8} = 4 \times 10^{-3} = 4\text{ ms}$

$d_{\text{queue}} = 0.2\text{ ms}$

sum $= 0.2 + 0.000120 + 4 = \boxed{4.200120\text{ ms}}$

Hop 3 :-

$d_{\text{trans}} = \dfrac{12000}{100 \times 10^9} = 0.000120\text{ ms}$

$d_{\text{prop}} = \dfrac{200 \times 10^3}{2.0 \times 10^8} = 1 \times 10^{-3} = 1\text{ ms}$

$d_{\text{queue}} = 0.2\text{ ms}$

sum $= 0.000120 + 1 + 0.2 = \boxed{1.200120\text{ ms}}$

Hop 4 :-

$d_{trans} = \frac{12000}{50 \times 10^{12}} = 2.4 \times 10^{-10} s$

$d_{prop} = \frac{6500 \times 10^3}{2.0 \times 10^8} = 0.0325 s = 32.5 ms$

$d_{queue} = 2 ms$

sum $= 0.00000024 + 32.5 + 2 = \boxed{34.50000024 ms}$

Hop 5 :-

$d_{trans} = \frac{12000}{100 \times 10^9} = 1.2 \times 10^{-7} = 0.000120 ms$

$d_{prop} = \frac{150 \times 10^3}{2.0 \times 10^8} = 7.5 \times 10^{-4} = 0.75 ms$

$d_{queue} = 0.3 ms$

sum $= 0.3 + 0.75 + 0.000120 = \boxed{1.05012 ms}$

Hop 6 :-

$d_{trans} = \frac{12000}{100 \times 10^9} = 0.000120 ms$

$d_{prop} = \frac{20 \times 10^3}{2.0 \times 10^8} = 1 \times 10^{-4} = \boxed{0.1 ms}$

$d_{queue} = 0.1 ms$

sum $= 0.000120 + 0.1 + 0.1 = \boxed{0.20012 ms}$

Hop 7 :-

$d_{trans} = \frac{12000}{10 \times 10^9} = 0.00120 ms$

$d_{prop} = \frac{50}{2.0 \times 10^8} = 0.000250 ms$

$d_{queue} = 0.05 ms$

sum $= 0.00120 + 0.000250 + 0.05 = \boxed{0.051450 ms}$

a. One way End-to end delay for a single packet

- total transmission time = 0.02568 ms
- total propagation time = 38.37530 ms
- total queuing time = 3.450 ms

one-way $= 0.02568 + 38.37530 + 3.450 \approx \boxed{41.8509 ms}$

RTT (Round trip time) $= 2 \times 41.85 ms \approx \boxed{83.70 ms}$

b) 10 GB file = $80 * 10^9$ bits

One packet → 12000 bits

so number of packets = N

$$N = \left\lceil \frac{80 \times 10^9}{12{,}000} \right\rceil = \lceil 6666666.666\ldots \rceil = 6{,}666{,}667 \text{ packets}$$

For long transfer, throughput is determined by the bottleneck link bandwidth.

Smallest bandwidths are 1 Gbps (hop 0 & 1).

$R_{bottleneck} = 1$ Gbps.

Time to push the whole file out of sender at 1 Gbps.

$$T_{send} = \frac{80 \times 10^9 \text{ bits}}{1 \times 10^9 \text{ bps}} = 80 \text{ seconds.}$$

- Sum prop = 38.37530 ms
- Sum queuing = 3.45000 ms

$T_{total} \approx T_{send} + \text{Sum}_{prop} + \text{Sum}_{queuing}$

$$= 80 + 38.37530 + 3.4500 \approx \boxed{80.041\,s}$$