Foundation for Advancement of Science & Technology

ASSIGNMENT # 1

Computer Networks

Roll no. 20L-1027

Name : Fatima Azfar

Section : BSDS - 7A

QUESTION NO. 1

Google's network, often reffered to as the Google Global Network is a vast and complex infrastructure that spans the globe. It consists of numerous data centers, fibre optic cables, and network infrastructure components. Google has invested heavily in building and maintaining this network to ensure fast and reliable access to its services for users worldwide.

Following are some motivations for content providers like Google to create their own networks :

(1) Performance Optimization : By controlling their network, they can optimize delivery of services, reduce latency and ensure faster loading times for their websites and apps.

(2) Cost Efficiency : It can reduce their reliance on third-party network providers & lower data

transit costs.

(3) Scalability: content providers can scale their network according to their specific needs.

(4) Data Security: Owning & managing their own data reduces risk of data breaches.

(5) Control: They can have full control over network routing, traffic management and quality of service.

QUESTION NO. 2

To determine the combinations, we need to calculate the transmission delay and propagation delay for each link.

$$\text{transmission delay} = \frac{\text{Packet size } (L)}{\text{transmission rate } (R)}$$

$$\text{propagation delay} = \frac{\text{link length } (d)}{\text{propagation speed } (s)}$$

packet size = 16000 bits

propagation speed on all links = 3×10^8 m/s

{Link 1}

transmission rate = 1000 Mbps = 1000000000 bps

ion for Advancement
Science & Technology

link length = 2 km = 2000 meters

$d_t = \frac{16000 \text{ bits}}{1000 \times 10^6 \text{ bits/sec}} \Rightarrow 0.000016$ seconds

$d_p = \frac{2000 \text{ m}}{3 \times 10^8 \text{ m/sec}} \Rightarrow 0.00000667$ seconds

total delay$_{L1}$ = $d_t + d_p = 0.000016 + 0.00000667$
$= 0.00002267$ sec

{Link 2}

transmission rate = 10 Mbps = 10000000 bps
link length = 1000 km = 1000000 meters

$d_t = \frac{16000 \text{ b}}{10000000 \text{ b/s}} = 0.0016$ sec

$d_p = \frac{1000000 \text{ m}}{3 \times 10^8 \text{ m/s}} = 0.003333$ sec

total delay$_{L2}$ = $d_t + d_p = 0.0016 + 0.003333$
$= 0.004933$

{Link 3}

transmission rate = 10 Mbps = 10,000,000 bps
link length = 1 km = 1000 m

$d_t = \frac{16000 \text{ b}}{10000000 \text{ b/s}} = 0.0016$ sec

$d_p = \frac{1000 \text{ m}}{3 \times 10^8 \text{ m/s}} = 0.0000033333$

total delay$_{L3}$ => $d_t + d_p = 0.0016 + 0.0000033333$
$= 0.00160333333$

① Sender finishes transmitting before first bit reaches receiver:

To achieve this, we need: a link with a total delay sorter than the time it takes for the first bit to propagate from sender to receiver on that link. In this case, link 3 satisfies this condition as its total delay (0.001603333) is shorter than the propagation time of first bit (0.000003333). Therefore, in this combination, sender finishes transmitting before first bit reaches the receiver on Link 3.

② First bit reaches receiver before sender finishes transmitting:

In this case, both Link 1 & link 2 satisfy the condition as link 1 has total delay of 0.00002267 sec, which is longer than propagation time of first bit (0.00000667 sec) and link 2 has total delay of 0.004933 seconds which is longer than propagation time of first bit (0.003333 sec).

QUESTION NO. 3

* End system A creates packets from a large file by dividing it into chunks. These packets consist of header and payload. The header contains essential information such as source and destination addresses, sequence number & more.

message	M	application	layers
segment	H_t M	transport	
datagram	H_n H_t M	network	
frame	H_l H_n H_t M	link	
	headers	physical	

* When a packet arrives at a router, the router uses the destination address in packet's header to determine next hop. The router consults its routing table to find most efficient path to reach destination.

* Packet switching on internet is analogous to driving from one city to another and asking directions along the way because packets take different routes through the network, just as drivers may take different roads to reach same

destination based on real-time traffic conditions and guidance from navigation systems.

QUESTION NO. 4

To find the maximum emission delay (a_{max}), minimum transmission (R_{min}), and the traffic intensity (I), we use following formulas:

Traffic Intesity $(I) = La/R$

Queuing delay (Q_{delay}) $= I(L/R)(1-I)$

Given:

constant transmission delay $(R) = 1900000$ bps

constant packet length $(L) = 5300$ bits

① Maximum emission rate:

Considering the condition $I < 1$ i.e traffic intensity should be less than 1 to avoid congestion, we'll use $I = 1$ as maximum traffic intensity allowed:

$$I = L a_{max} / R$$

$$1 = \frac{a_{max} \times L}{R}$$

$$a_{max} = \frac{R}{L} \Rightarrow a_{max} = \frac{1900000 \text{ bps}}{5300 \text{ bits}} = 358.49 \text{ pps}$$

Foundation for Advancement of Science & Technology

(2) Minimum transmission rate:

R_{min} corresponds to a traffic intensity of $I = 1$, thus

$$R_{min} = 1900000 \text{ bps}$$

(3) Traffic intensity with a_max:

$I = 1$ as determined earlier.

* Running the animation twice with maximum emission rate and minimum transmission rate, the time it takes to start packet loss remains the same. This is because the transmission rate (R) in both cases is set to match maximum traffic intensity i.e $I = 1$ without congestion, which is determined ~~to~~ by a_{max}. Thus, as long as the traffic conditions remain the same, queuing delay and packet loss would be the same.

QUESTION NO. 5

Transmitting 50 terabytes of data from Boston to Los Angeles using a 100 Mbps dedicated link would not be practical or efficient, using FedEx overnight delivery would be a better option. Following are the reasons as to why:

① **Data size & transfer time:**

$$\text{Transfer time} = \frac{\text{Data size (bits)}}{\text{Transfer rate (bps)}}$$

$$= \frac{50\cancel{0000000}\,TB \times 8\,(\text{bits/byte}) \times 10^{12}\,(\cancel{\text{bits/mByte}})}{100000000\,bps}$$

$$= 4000000 \text{ seconds}$$

So, it would take 46 days if the link is used which is extremely infeasible.

② **Cost and Reliability:**

Using a 100Mbps link for such a long time would be expensive. Plus, there is risk of interruptions and data corruption.

QUESTION NO. 6

① Bandwidth-delay product:

$R = 5\,Mbps$

$d_p = \frac{d}{s} \Rightarrow \frac{20000\,km}{2.5 \times 10^8\,m/s} \Rightarrow 0.08\,s\ (80\,ms)$

Foundation for Advancement of Science & Technology

$$R \times d_p = 5\ \text{Mbps} \times 0.08\ \text{sec}$$
$$= (5 \times 10^6 \times 0.08)\ \text{bits}$$
$$= 400000\ \text{bits}$$

② maximum number of bits in link:

maximum bits $= R \times d_p = 400000$ bits.

③ Interpretation of Bandwidth-delay product:

The bandwidth delay product represents maximum amount of data that can be "in flight" mode in the network at any given time. It reflects the capacity of link to hold data while taking into account the propagation delay.

④ width of a bit in link:

$$\text{width} = \frac{\text{propagation speed}}{\text{transmission rate}}$$
$$= \frac{2.5 \times 10^8\ m/s}{5 \times 10^6\ b/s}$$
$$= 50\ \text{meters per bit}$$

The size of a football feild is 100 meters long & 60 meters wide so it is not longer than a football feild.

Foundation for Advancement of Science & Technology

⑤ General expression for width of a bit:

$$W = \frac{\text{propagation speed}}{\text{transmission rate}} \quad (\underbrace{\text{meters per bit}}_{\text{unit}})$$

OR

$W = [\text{transmission Rate } (R) \times \text{Speed } (S)] / \text{length of link } (m)$

QUESTION NO. 7

distance b/w Los angeles & Boston = 4808 km

speed = 299792458 m/s

$$W = \frac{S}{R}$$

$$R = \frac{S}{W} \Rightarrow \frac{299792458 \text{ m/s}}{4808000 \text{ m}}$$

$$R = 62.35 \simeq 62 \text{ b/s}$$

Now, R has a much wider bit width i.e 4808 km due to extremely low transmission rate of 62 bits/sec making each bit space a vast distance.

QUESTION NO. 8

① Bandwidth-delay product:

Bandwidth-delay product = $R \times dp$

$$R \times d_p = (500 \times 10^6 \ b/s) \times (4808000/299792458) \quad \therefore d_p = \frac{d}{s}$$

$$= (500 \times 10^6) \times (0.016037761 7)$$

$$R \times d_p = 8018880 \text{ bits}$$

② Maximum number of bits at any given time:

$$\text{max bits} = 8018880 \text{ bits.}$$

So, the complete file of 800,000 bits.

③ width of bit in link:

$$w = \frac{299792458 \ m/s}{500 \times 10^6 \ b/s}$$

$$w = 0.5995 \text{ meters/bit}$$

QUESTION NO: 9

(a) Transfer time $= \dfrac{50 \times 8 \times 10^{12} \text{ bits}}{100 \times 10^6 \text{ bits/sec}}$

$$= 4000000 \text{ sec}$$

So, it takes 46 days to send 50TB file continuously.

(b) Total packets $= \dfrac{50 \times 8 \times 10^{12} \text{ bits}}{40000 \text{ bits/packet}} = 10^{10}$ packets

Transmission time for 1 packet $= \dfrac{\text{packet size}}{\text{data rate}}$

lation for Advancement
cience & Technology

$$= \frac{40000}{100 \times 10^6} \Rightarrow 0.0004 \text{ sec}$$

propagation time of 1 packet $= \frac{\text{Length of link}}{\text{speed}_p}$

$$= \frac{4808000 \text{ m}}{299792458 \text{ m/s}}$$

$$= 0.016037 \approx 16.04 \text{ ms}$$

time for 1 packet & acknowledgment = transmission time + propagation time $= 0.0004 + 0.01604$

$$= 0.01644 \text{ sec}$$

* Since sender cannot send packet until previous one is acknowledged:

total time = total packets × time for 1 packet

$$= 10^{10} \times 0.01644$$

$$= 164400000 \text{ sec} \approx 5 \text{ years.}$$

(c) Sending file continuously is faster because it avoids the overhead of waiting for acknowledgements after sending each packet.

Scanned with CamScanner

QUESTION NO: 10

The OSI (Open Systems Interconnection) model is a conceptual framework that standardizes the functions of a telecommunication or networking system into seven distinct layers.

A real world analogy for OSI could be the postal system:

* Physical layer: The letter itself
* Data Link layer: adding sender & receiver addresses on the letter
* Network layer: choosing the right postal service or route for delivery
* Transport layer: ensuring letter doesn't get lost or damaged.
* Session layer: scheduling when the letter is delivered or picked up.
* Presentation layer: involves data translation or decryption.
* Application layer: content of letter.

The Internet Protocol stack (IP) is a specific set of protocols used to enable communication in computer networks with a focus on the internet. A real world analogy for IP could be mailing a package:

* Physical layer: the package itself
* Link layer: adds address info to package
* Internet layer (IP): routes package across various courier hubs.
* Transport layer: ensures reliable delivery, may divide a large packet into smaller ones
* Application layer: contents of package.