Internet : Introduction & Terminology

ISP Hierarchy

→ Internet - a network of networks - is complex, consisting of a dozen or so ~~tier~~ tier 1 ISPs and hundreds of thousands of lower tier ISPs.

→ Lower tier ISPs connect to the higher-tier ISPs

→ Higher tier ISPs connected with one another

→ users and content providers are customers of lower tier ISPs.

→ Lower tier ISPs are customers of higher tier ISPs.

→ In recent years, major content providers have also created their own networks and connect directly into lower tier ISPs whereever possible.

Network edge

→ DSLAM is located in company's central office

→ DSL modem converts digital data to high frequency tones for transmission over the telephone wires to central office

→ Analog signals from many such houses are translated back into digital format at the DSLAM.

Hybrid fiber coaxial network

→ Fibre optics connect cable headend to neighbourhood level junctions.

→ Traditional coaxial cable is used to reach out to individual houses

→ HFC → combination of Fibre optics & coaxial cable

→ CMTS

→ FTTH → ONT

ONT to splitter

splitter to OLT in CO

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Enterprise access network :-

→ Twisted pair copper wires used to connect to a switch.

→ Ethernet switch connected to a larger internet.

→ users access capacity is 100 Mbps to tens of Gbps

→ Servers access capacity is 1 Gbps or 10 Gbps

Network core

ISI - Inter Symbol interference

Numerical #1 How long does it take to send a file of 6,40,000 bits from host A to host B over a Circuit switched network?

→ All links are 1.536 Mbps

→ Each link uses TDM with 24 slots/sec

→ Guard time is equal to $(1/8)^{th}$ of the slot time

→ 500 ms to establish end-to-end circuit

Solution :- user needs 1 slot per frame

Frame size = 1 sec

Number of slots per frame = 24

slot duration = $\frac{1}{24}$ = 41.67 ms

Effective transmission time per slot = $41.67m \times \frac{7}{8}$

= 36.458 ms

Number of bits transmitted by a user per frame = link rate * effective transmission time per slot

= 1.536M * 36.458 m

= 56 K bits

Number of frames needed to transmit (Nf) = $\frac{\text{file size}}{\text{bits/slot}}$ = 11.42 frames

≈ 12 frames [even if fraction of a slot is required, the entire slot is meant for the user]

Total delay = connection setup time + (Nf − 1) * frame duration + 1 slot duration

= 500m + (12 − 1) 1 sec + 41.67m

$\boxed{\text{Total delay} = 11.54167 \text{ sec}}$

2) How long does it take to send a file of 6,40,000 bits from host A to host B over a circuit switched network?

→ Available link rate is 1.536 Mbps

→ Link rate is distributed across 10 channels of 200 KHZ

→ Guard band of 50 Hz is used

→ 500msec to establish end-to-end circuit

Solution :- user needs one frequency channel per slot

Total delay = Connection setup time + transmission time

$$= 500m + \frac{\text{File size}}{\text{link rate of one channel}}$$

$$= 500\,m + \frac{64{,}000}{0.1536 \times 10^6}$$

$\boxed{\text{Total delay} = 4.667 \text{ sec}}$

$$d_{end\text{-}to\text{-}end} = N\left[d_{proc} + d_{trans} + d_{queue} + d_{prop}\right]$$

R5(config-if)#end
R5#

2. To configure OSPF router you need the network addresses (A.B.C.D) and the corresponding wildcard address (E.G.F.H where E=255-A,…,H=255-D) of the interfaces of that router. An example of configuring router R1 is given below

```
R1(config)# router ospf 1
R1(config-router)# network 10.0.0.0 0.0.0.3 area 0
R1(config-router)# network 20.0.0.0 0.0.0.3 area 0
R1(config-router)# network 40.0.0.0 0.0.0.3 area 2
R1(config-router)# end
```

3. For PC assign IP address as given in Section 1.2.4. As an example PC1 is configured as
PC1> 192.168.0.2/24 192.168.0.1

10.3 Analyses

1. Provide the screenshots of the IP addresses assigned to the interfaces
2. Verify the Router ID assigned to each router in the network (e.g., R1# show ip protocols). Try to give a new IP address (your choice) to the loopback interface of the routers and repeat the task.
3. Provide the screenshots of the routers neighbours (e.g., R1# show ip ospf neighbors).
4. Verify the forwarding table in each router (e.g., R1# show ip route)
5. Verify the ping operation by pinging PC2 from PC1. Show packet capture and write port numbers, IP addresses of each Echo request and reply. Explain ping statistics.
6. Provide screenshot of the packet listing window and the packet content window in Wireshark corresponding to any one OSPF LSA.

Queuing Delay

a = average rate at which packets arrive at the queue

R = transmission rate

L = no. of. bits / packet

Average rate at which bits arrive at the queue = La bits/Sec

ratio $\frac{La}{R}$ called traffic intensity plays an important role in estimating the extent of queuing delay.

If $\frac{La}{R} > 1$ - average rate at which bits arrive at the queue exceed the rate at which the bits can be transmitted from the queue.

$\therefore$ Queuing delay approaches ∞.

Case 1

If traffic intensity is close to 0 ⇒ Packet arrivals are few & far between. It is unlikely that an arriving packet will find another packet in the queue.

∴ Average Queuing delay will be zero.

Case 2

When the traffic intensity is close to 1, there will be intervals of time when the arrival rate exceeds the transmission capacity and a queue will form during these periods of time

Packet loss

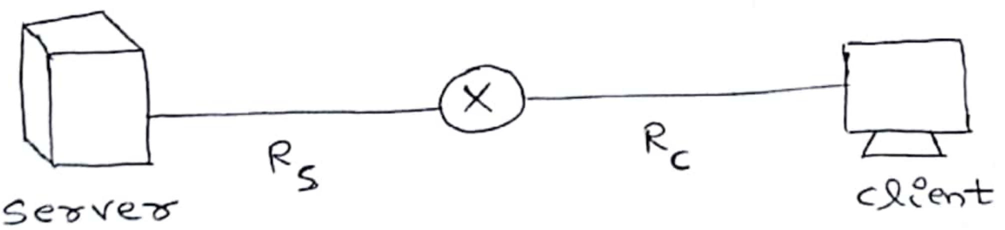
→ A packet can arrive to find a full queue.

→ With no place to store such a packet, a router will drop that packet; the packet will be lost.

Throughput in computer Networks

→ Instantaneous throughput at any instant of time is the rate at which host is receiving the file.

→ If the file consists of F bits and the Transfer takes T seconds for the host to receive all F bits, then the average throughput of the file transfer is F/T bits/sec.



If $R_s < R_c$, the bits pumped by the server will flow right through the router and arrive at the client at a rate of R_s bits/sec giving a throughput of R_s bps.

If $R_c < R_s$, the router will not be able to forward bits as quickly as it receives them. In this case, bits will only leave the router at rate R_c, giving a throughput of R_c bps.

→ For a simple two-link network, Throughput $= \min\{R_c, R_s\}$

→ Approximate time it takes to transfer a large file of F bits from Server to client is $\dfrac{F}{\min\{R_c, R_s\}}$

→ <u>Example</u> Suppose you are downloading an MP3 file of F = 32 million bits, the server has a transmission rate of $R_s = 2$ Mbps and $R_c = 1$ Mbps.

∴ Time needed to transfer the file $= \dfrac{F}{\min\{R_c, R_s\}} = \dfrac{32 \times 10^6}{1 \times 10^6}$

$= 32s$

→ <u>Example 2</u> Consider 10 servers and 10 clients connected to the core of the computer network.

→ There are 10 simultaneous downloads taking place involving client-server pairs.

→ There is a link in the core that is traversed by all 10 downloads

→ Let R be the transmission rate of this link.

→ server access links have the rate R_s

→ client access links have the rate R_c

What will be the throughput in this case?

→ suppose $R_s = 2$ Mbps, $R_c = 1$ Mbps, $R = 5000$ Mbps, and the common link divides its transmission rate equally among the 10 downloads.

→ The bottleneck for each download is no longer in the access network, but is now instead the shared link in the core, which only provides each download with 500 kbps of throughput.

→ Thus, the end-to-end throughput for each download is now reduced to 500 kbps.

Class 14 - Web & HTTP - message format :-

Method ↓ URL Version

GET/ somedir/page.html HTTP/1.1

Host : www.someschool.edu ← Host name

Connection : close ← client wants the server to close the connection after sending the requested object

browser type ← User-agent : Mozilla/5.0

Accept-language : fr

Method - GET, POST, HEAD, PUT and DELETE

GET - when browser requests an object.

Host - One on which the object resides.

↙ required by Web proxy caches

Accept-language → user prefers to receive a French version of the object, if such an object exists on the server.

Typical HTTP Response Message :-

protocol version / status code / corresponding status message

HTTP/1.1 200 OK → status line

six header lines:

Connection : close → to close the TCP connection after sending the message

Date : Tue, 18 Aug 2015 15:44:04 GMT

Server : Apache/2.2.3 (CentOS) → Message generated by this server

Last-Modified : Tue, 18 Aug 2015 15:11:03 GMT

Content length : 6821 → No. of bytes in the object being sent

Content-Type : text/html

(data data data data data....) → entity body

Date → indicates the time & date when the HTTP response was created & sent by the server.

Last-Modified → Indicates time & date when the object was last modified.

status codes

200 OK → Request succeeded and the information is returned in the response.

301 Moved Permanently → Requested object has been moved permanently.

400 Bad Request → request could not be understood by the server

404 Not Found → Requested document does not exist on this server

505 HTTP Version supported → The requested HTTP protocol version is not supported by the server.