Application midterm
XIAOYU XIA
xix90@pitt.edu

1.

a. What are two specific ways in which Content Distribution Networks (CDNs) can improve Web performance.

A:

1. Aim to get content closer to clients: 1. Reduce RTT (assuming content is served directly from cache/replica). 2. Reduce the chance to encounter bottleneck links.

2. Avoid transferring the same data over the same part of the network multiple times: Reduce overall network traffic.

b. List one way in which TCP's reliable data transfer protocol is similar to Go-Back-N and one way it differs from Go-Back-N.

A:

a. Similar: Cumulative ACKs, Timeouts.
b. Different: when timeout, it doesn't retransmit the whole window.
congestion control.

c. Explain the notion of an Erlang in circuit switched telephony.

A:

Traffic intensity is measured in Erlangs. Moreover, one Erlang equals to completely occupied channel for 60 minutes.

2.

a.

A---S:

$$Tsignal_{A\ to\ S} = \frac{distance_{A\ to\ S}}{speed_{A\ to\ S}} = \frac{1000m}{3\times 10^8 m/_s} \times 10^3(ms) \approx 0.0033ms$$

$$Tpackage_{A\ to\ S} = \frac{package_{size}}{transmission\ rate_{AS}} = \frac{1500\times 8bits}{100\times 10^6 bps} \times 10^3(ms) \approx 0.12ms$$

S---B:

$$Tsignal_{S\ to\ B} = \frac{distance_{S\ to\ B}}{speed_{S\ to\ B}} = \frac{5000m}{2\times 10^8 m/_s} \times 10^3(ms) = 0.025ms$$

$$Tpackage_{S\ to\ B} = \frac{package_{size}}{transmission\ rate_{BS}} = \frac{1500\times 8bits}{200\times 10^6 bps} \times 10^3(ms) \approx 0.06ms$$

B---S:

$$Tsignal_{B\ to\ S} = Tsignal_{S\ to\ B} = 0.025ms$$

$$TACK_{B\ to\ S} = \frac{ACK_{size}}{transmission\ rate_{BS}} = \frac{100\times 8bits}{200\times 10^6 bps} \times 10^3(ms) \approx 0.004ms$$

S---A:

$$Tsignal_{S\ to\ A} = Tsignal_{A\ to\ S} = 0.0033ms$$

$$TACK_{S\ to\ A}=\frac{ACK_{size}}{transmission\ rate_{AS}}=\frac{100\times 8bits}{100\times 10^6 bps}\times 10^3(ms)\approx 0.008ms$$

$$Totaltime1=0.0033+0.12+0.025+0.06+0.025+0.004+0.0033+0.008(ms)$$
$$=0.2486ms$$

b.

$$Time\ tcp\ connection\ =2\times\left(\frac{control\ message\ size}{transmission\ rate_{AS}}+\frac{control\ message\ size}{transmission\ rate_{BS}}+Tsignal_{A\ to\ S}+Tsignal_{B\ to\ S}\right)$$
$$=2\times\left(\frac{200bits}{100\times 10^6 bps}+\frac{200bits}{200\times 10^6 bps}+0.0033+0.025\right)\times 10^3(ms)$$
$$=2\times(0.002+0.001+0.0033+0.025)\ ms$$
$$=0.0626ms$$

$$Time\ HTTP\ request\ =\frac{control\ message\ size}{transmission\ rate_{AS}}+\frac{control\ message\ size}{transmission\ rate_{BS}}+Tsignal_{A\ to\ S}+Tsignal_{B\ to\ S}$$
$$=\left(\frac{200bits}{100\times 10^6 bps}+\frac{200bits}{200\times 10^6 bps}\right)\times 10^3+0.0033+0.025(ms)$$
$$=0.002+0.001+0.0033+0.025ms$$
$$=0.0313ms$$

$$Time\ html\ transmission\ =\frac{html\ size}{transmission\ rate_{AS}}+\frac{html\ size}{transmission\ rate_{BS}}+Tsignal_{A\ to\ S}+Tsignal_{B\ to\ S}$$
$$=\left(\frac{5\times 1000\times 8bits}{100\times 10^6 bps}+\frac{5\times 1000\times 8bits}{200\times 10^6 bps}\right)\times 10^3+0.0033+0.025(ms)$$
$$=0.4+0.2+\ +0.0033+0.025(ms)$$
$$=0.6283ms$$

$$Time\ object\ transmission\ =\frac{object\ size}{transmission\ rate_{AS}}+\frac{object\ size}{transmission\ rate_{BS}}+Tsignal_{A\ to\ S}+Tsignal_{B\ to\ S}$$
$$=\left(\frac{200\times 1000\times 8bits}{100\times 10^6 bps}+\frac{200\times 1000\times 8bits}{200\times 10^6 bps}\right)\times 10^3+0.0033+0.025(ms)$$
$$=24.0283ms$$

i: *Using basic non-persistent HTTP:*

Frist, setting up a tcp connection and http request for html file, then transfer the http file.

$$Total\ time1\ for\ html\ file=Time\ tcp\ connection+Time\ HTTP\ request+Time\ Html\ transmission$$
$$=0.0626+0.0313+0.6283(ms)$$
$$=0.7222ms$$

For each referenced object, setting up a tcp connection and http request for each object, then transfer the object:

$$Totaltime\ 1for\ 8\ objects=8\times(Time\ tcp\ connection+Time\ HTTPrequest+Time\ object\ transmission)$$
$$=8\times(0.0626+0.0313+24.0283)\ (ms)$$
$$=192.9776ms$$

Total time1=0.7222+192.9776ms=193.6998ms

ii. Using non-persistent HTTP with parallel TCP connections? Assume the base file is retrieved first over a single TCP connection, and then 8 parallel TCP connections are opened to retrieve the 8 referenced objects. Assume the 1/8 TCP connections each receive 1/8 of the available bandwidth.

$$Total\ time2\ for\ html\ file=Time\ tcp\ connection+Time\ HTTP\ request+Time\ Html\ transmission$$
$$=0.0626+0.0313+0.6283(ms)$$
$$=0.7222ms$$

Because N parallel connections each receive 1/N of the link bandwidth, so:

$$Time\ tcp\ connection\ = 2\times\left(\frac{\frac{control\ message\ size}{transmission\ rate_{AS}}}{8}+\frac{\frac{control\ message\ size}{transmission\ rate_{BS}}}{8}+Tsignal_{A\ to\ S}+Tsignal_{B\ to\ S}\right)$$

$$=2\times\left(\frac{8\times 200bits}{100\times 10^6bps}+\frac{8\times 200bits}{200\times 10^6bps}+0.0033+0.025\right)\times 10^3(ms)$$

$$=2\times(0.016+0.008+0.0033+0.025)\,ms$$

$$=0.1046ms$$

$$Time\ HTTP\ request\ = \frac{\frac{control\ message\ size}{transmission\ rate_{AS}}}{8}+\frac{\frac{control\ message\ size}{transmission\ rate_{BS}}}{8}+Tsignal_{A\ to\ S}+Tsignal_{B\ to\ S}$$

$$=\left(\frac{8\times 200bits}{100\times 10^6bps}+\frac{8\times 200bits}{200\times 10^6bps}\right)\times 10^3+0.0033+0.025(ms)$$

$$=0.016+0.008+0.0033+0.025ms$$

$$=0.0523ms$$

$$Time\ object\ transmission\ = \frac{\frac{object\ size}{transmission\ rate_{AS}}}{8}+\frac{\frac{object\ size}{transmission\ rate_{BS}}}{8}+Tsignal_{A\ to\ S}+Tsignal_{B\ to\ S}$$

$$=\left(\frac{8\times 8\times 200\times 1000bits}{100\times 10^6bps}+\frac{8\times 8\times 200\times 1000bits}{200\times 10^6bps}\right)\times 10^3+0.0033+0.025(ms)$$

$$=192.0283ms$$

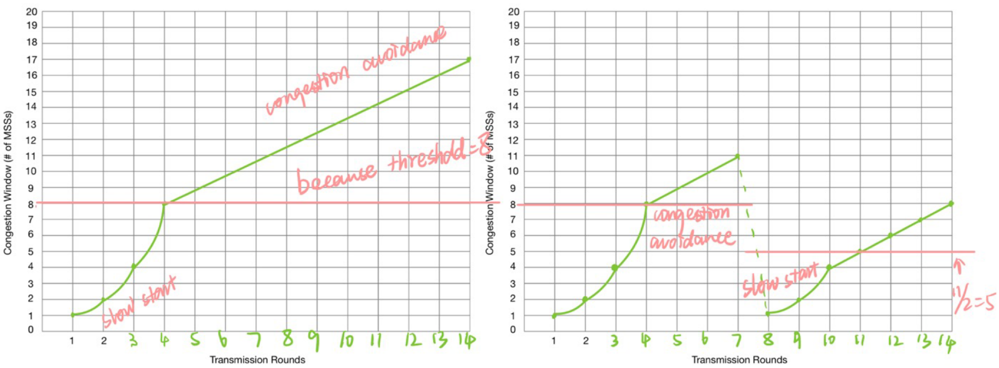
$$Totaltime\ 2for\ 8\ objects = Time\ tcp\ connection+Time\ HTTPrequest+Time\ object\ transmission$$

$$=0.1046+0.0523+192.0283(ms)$$

$$=192.1852ms$$

Total time2=0.7222+192.1852ms=192.9074ms

3.



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a. All subsequent packets are received correctly as are their ACKs.

A: There is a timeout at the sender before transmission round 1. So it begins at (1,1), and then after cwnd exponentially increases to the threshold which is 8 at round 4, the transmission process enters ‘congestion avoidance. And then cwnd linearly increases.

b. There is another timeout after six more rounds, but subsequent packets are received correctly as are their ACKs.

A: There is a timeout at the sender before transmission round 1. So it begins at (1,1), and then after cwnd exponentially increases to the threshold which is 8 at round 4, the transmission process enters ‘congestion avoidance’. And then cwnd linearly increases.
There is another timeout after six more rounds, so the cwnd turns to 1 at round 8(slow start). Under this situation, the new threshold which is [11/2]=5, so after cwnd exponentially increases to 4 at round 10, the transmission process enters ‘congestion avoidance’. And then cwnd linearly increases.