Assignment 1

Student name: *Jiaye Wang*
NSID: *jiw561* ID: *11231145*

Course: *Computer Network (CMPT 434)* – Professor: *Dr. Derek Eager*
Due date: *Feb 1, 2021*

Question 1

Let $d_{prog}, d_{tran}, d_{proc}$, and d_{total} denote propagation, transmission, processing, and total delay, respectively. We ignore the queuing delay. Then we can calculate each delay by:

$$\begin{aligned}
d_{prog} &= \text{distance between sender and receiver (m)/propagation speed of medium (m/sec)} \\
d_{tran} &= \text{packet size (bit) / link transmission rate (bps)} \\
d_{proc} &= \text{packet size delay (nanosec) + (0.5 nanosecond / byte)} \times \text{packet size (byte)} \\
d_{total} &= d_{prog} + d_{tran} + d_{proc}
\end{aligned}$$

For the given information, we have link data rate $4 \cdot 10^9$ *bps*, propagation speed of medium $2 \cdot 10^8$ *m/sec*, and packet size 100 *byte* = 800 *bit*. Then we have $d_{tran} = 800\ bit/4 \cdot 10^9\ bps = 2 \cdot 10^{-7}\ sec$ and we could simplicity $d_{proc} = $ packet size delay + 50 *nanosec*.

1. OCN

   Link distance is 0.5 *cm* = 0.005 *m* and packet size delay is 0 *nanosec*.

   $$\begin{aligned}
   d_{prog} &= \frac{0.005\ m}{2 \cdot 10^8\ m/sec} = 2.5 \cdot 10^{-11}\ sec \\
   d_{proc} &= 0\ nanosec + 50\ nanosec = 50\ nanosec = 5 \cdot 10^{-8}\ sec \\
   d_{total} &= 2.5 \cdot 10^{-11}\ sec + 2 \cdot 10^{-7}\ sec + 5 \cdot 10^{-8}\ sec = 2.50025 \cdot 10^{-7}\ sec
   \end{aligned}$$

   The percentage of the d_{prog} is $(d_{prog}/d_{total}) \cdot 100\% \approx 0.00999\%$.

2. SAN

   Link distance is 5 *m* and packet size delay is 0.3 *microsec* = 300 *nanosec*.

   $$\begin{aligned}
   d_{prog} &= \frac{5\ m}{2 \cdot 10^8\ m/sec} = 2.5 \cdot 10^{-8}\ sec \\
   d_{proc} &= 300\ nanosec + 50\ nanosec = 350\ nanosec = 3.5 \cdot 10^{-7}\ sec \\
   d_{total} &= 2.5 \cdot 10^{-8}\ sec + 2 \cdot 10^{-7}\ sec + 3.5 \cdot 10^{-7}\ sec = 5.75 \cdot 10^{-7}\ sec
   \end{aligned}$$

   The percentage of the d_{prog} is $(d_{prog}/d_{total}) \cdot 100\% \approx 4.349\%$.

3. LAN

Link distance is 5000 m and packet size delay is 3 $microsec = 3000\ nanosec$.

$$\begin{aligned}
d_{prog} &= \frac{5000\ m}{2 \cdot 10^8\ m/sec} = 2.5 \cdot 10^{-5}\ sec \\
d_{proc} &= 3000\ nanosec + 50\ nanosec = 3050\ nanosec = 3.05 \cdot 10^{-6}\ sec \\
d_{total} &= 2.5 \cdot 10^{-5}\ sec + 2 \cdot 10^{-7}\ sec + 3.05 \cdot 10^{-6}\ sec = 2.825 \cdot 10^{-5}\ sec
\end{aligned}$$

The percentage of the d_{prog} is $(d_{prog}/d_{total}) \cdot 100\% \approx 88.496\%$.

4. WAN

   Link distance is 5000 $km = 5 \cdot 10^6\ m$ and packet size delay is 30 $microsec = 30000\ nanosec$.

$$\begin{aligned}
d_{prog} &= \frac{5 \cdot 10^6\ m}{2 \cdot 10^8\ m/sec} = 0.025\ sec \\
d_{proc} &= 30000\ nanosec + 50\ nanosec = 30050\ nanosec = 3.005 \cdot 10^{-5}\ sec \\
d_{total} &= 0.025\ sec + 2 \cdot 10^{-7}\ sec + 3.005 \cdot 10^{-5}\ sec = 0.02503025\ sec
\end{aligned}$$

   The percentage of the d_{prog} is $(d_{prog}/d_{total}) \cdot 100\% \approx 99.879\%$.

Question 2

For one link transfer we have $dr = 0.001\ s + 8000\ bits/1 \cdot 10^8\ bps = 1.08 \cdot 10^{-3}\ s$. Let n be the number of packets, then total delay is $4 \cdot dr + (n-1) \cdot dr$.

(a) For $n = 1$, total delay is $4 \cdot 1.08 \cdot 10^{-3} = 4.32 \cdot 10^{-3}\ s$.

(b) For $n = 12$, total delay is $4 \cdot 1.08 \cdot 10^{-3} + (11 \cdot 1.08 \cdot 10^{-3}\ s) = 1.62 \cdot 10^{-2}\ s$.

Question 3

The Shannon's theorem, will always gives the same result in this situation, such that $400000\ Hz \cdot \log_2(1+63) = 400000\ Hz \cdot 6 = 2.4 \cdot 10^6\ bps$.

According Nyquist's theorem, the baud rate is $2H$. In this case will be 800 KHz

(a) $2 = 2^1$. Since there is only one bit per symbol, therefore the data rate is $1 \cdot (8 \cdot 10^5\ Hz) = 8 \cdot 10^5\ bps < 2.4 \cdot 10^6\ bps$. Thus, the maximum data rate is $8 \cdot 10^5\ bps$.

(b) $2 = 2^5$. The data rate is $5 \cdot (8 \cdot 10^5\ Hz) = 4 \cdot 10^6\ bps > 2.4 \cdot 10^6\ bps$. Thus, the maximum data rate is $2.4 \cdot 10^6\ bps$ in this case.

Question 4

(a) If there are 100 sessions share a link of data rate of 100 $Mbps$, then each sessions will take 1/100 of the channel capacity with circuit switching, that is, the achievable data transmission rate a session can achieve during its busy period is

   $100 \cdot 10^6\ bps/100 = 1 \cdot 10^6\ bps$.

(b) Note that we can calculate average data rate, DR_{avg} of each session by:

$$DR_{avg} = \frac{100\ Mbps}{1 + (99 \cdot (B/(1\ s + B)))}$$

- $B = 10\ s$, $DR_{avg} \approx 1.0989 \cdot 10^6\ bps$
- $B = 1\ s$, $DR_{avg} \approx 1.9802 \cdot 10^6\ bps$
- $B = 100\ ms = 0.1\ s$, $DR_{avg} = 1 \cdot 10^7\ bps$
- $B = 10\ ms = 0.01\ s$, $DR_{avg} = 5.05 \cdot 10^7\ bps$

Question 5

(a) $1000\ bytes = 8000\ bits$ and $RTT = 100\ ms = 0.1\ s$. Then the maximum achievable data transfer rate is $8000\ bits/0.1\ s = 0.08\ Mbps$.

(b) Let n be maximum sending window size. When $n = 10$, we have $(10 \cdot 8000\ bits)/0.1\ s = 0.8\ Mbps$. When $n = 1000$, we will have $80\ Mbps$.

(c) Since the network path of capacity is $100\ Mbps$, then we have

$$1 \cdot 10^8\ bps = \frac{n \cdot 8000\ bits}{0.1\ s}$$

Solve for $n = 1250$.

(d) Parallel computing could benefit to have a windows size larger than the windows size in part (c). When the window size increasing, it will able to splitting the data over multiple streams without overlap and reach the maximum transfer rate. Increasing window size also will let the sender to continue send new frames while resending previous frames without stop and wait the acknowledgements. Hence, lower the error or losing rate of data transmission.