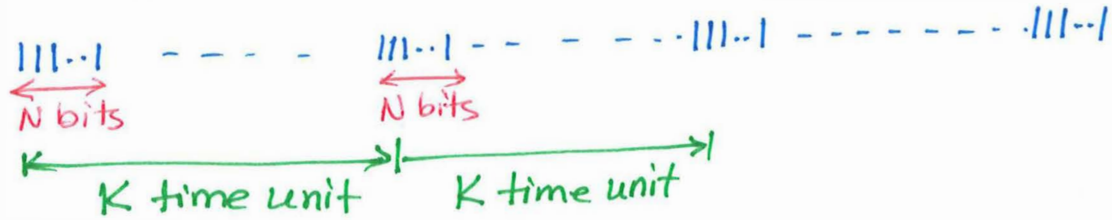
ELEC 3500

Question Set - 2 (solution)

2-0 (a) A circuit switched network will be suitable for this scenario since the application generates data for a long period of time where data is continuously generated. Since the data generation characteristics is known, network resources can be reserved in advance. In addition, the overhead cost of setting up and tearing down connections frequently will introduce additional processing load and delay.

Data generation pattern:



(b) Assume $\sum_{i=1}^{X} N_i < R_{Link}$ where N_i is the data generated in every burst.

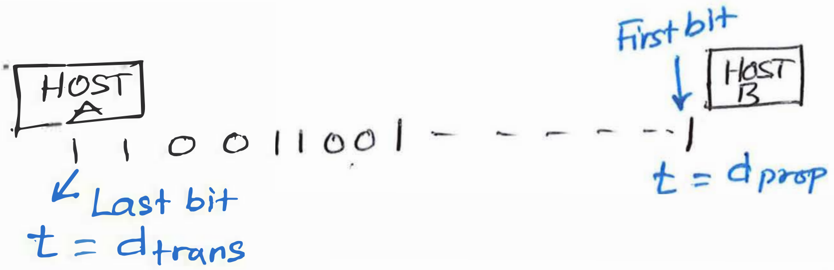
$X = \frac{1\ sec}{KTU}$, where X is no. of data samples

$KTU \leq 1sec$

exist i.e. total data

~~Assum~~ If the above condition generated by the application in a time unit is less than the transmission rate of the link, then no queue will build up hence, no congestion control is necessary.

2-1: (a) First bit is transmitted at $t = 0$, where the last bit will be transmitted at $t = d_{trans}$



At $t = d_{trans}$, the last bit will leave the host A.

[2020, S2]

(b) $d_{prop} > d_{trans}$, at time $t = d_{trans}$

The first bit is still in transit, hasn't reached the host B.

(c) $d_{prop} < d_{trans}$, at time $t = d_{trans}$

First bit has reached host B, host A is still transmitting bits

(d) $S = 2.5 \times 10^8$ m/sec, $L = 120$ bits, $R = 56$ kbps

$d = ?$

Given $d_{prop} = d_{trans}$

$$d_{prop} = \frac{d}{s} \Rightarrow d = s \times d_{prop} = s \times \frac{L}{R}$$

$$= 2.5 \times 10^8 \times \frac{120}{56 \times 10^3} = 2.5 \times 10^8 \times 2.14 \times 10^{-3}$$

$$= 535{,}000 \text{ meter}$$

$$= 535 \text{ km}$$

2-2: (a) A circuit switched link provide a connection between a pair of users for the duration of a call, irrespective of active call time. In this case call active period is 20% of the total call time. Data is transmitted continuously @ 1 Mbps whereas the link data rate is 2 Mbps.

No. of circuit switched users is given by:

$$N_{circuit} = \frac{R}{R_u} = \frac{2 \text{ Mbps}}{1 \text{ Mbps}} = 2$$

(b) When two or less than two users transmit at the same time there will be no queuing delay $\Sigma R_U < R$.

When three or more users transmit at the same time, i.e. $\Sigma R_U > R$, there will be queuing delay.

(c) Since each user is transmitting for 20% of the call time, the probability a user transmit is 0.2.

[2020, S2]

(d) To solve this problem we have to use the Bionomial distribution which is given by

$$P_r(x=K) = \binom{n}{K} p^K (1-p)^{n-k}$$

where n is the population size and K is no. of active users. p is the probability of transmission.

With $n=3$ and $k=3$

$$P_r(X=3) = \binom{3}{3} p^3 (1-p)^{3-3}$$

$$= \frac{3!}{3!\,(3-3)!} (0.2)^3 (1-0.2)^0$$

$$= 1 \times 0.008 \times 1 = 0.008$$

Prob. that all three transmitters will transmit simultaneously is 0.008

2-3:

(a) $R = 3$ Mbps, $R_u = 150$ kbps, $p = 0.1$

$$N_{circuit} = \frac{3 \times 10^6}{150 \times 10^3} = 20$$

(b) $p = 0.1$

Probability a given user is transmitting

(c) $$P(x=k) = \binom{n}{k} (p)^k (1-p)^{n-K}$$

$n = 50$, $k = 5$, $p = 0.1$

$$p(X=5) = \binom{50}{5} (0.1)^5 (1-0.1)^{50-5}$$

$$= \frac{50!}{5!\,45!} (0.1)^5 (0.9)^{45}$$

$$= \frac{3.041 \times 10^{64}}{120 \times 1.196 \times 10^{56}} \times 1 \times 10^{-5} \times 8.727 \times 10^{-3}$$

$$= 2118868.5 \times 8.727 \times 10^{-8}$$

$$= 0.1849$$

[2020, S2]

2-4: (a) $N_{Circuit} = \frac{1\times10^9}{100\times10^3} = 10{,}000$

(b) Probability that more than N users out of M users are transmitting.

$$Pr(X \geq N) = \sum_{n=N+1}^{M} \binom{M}{n} p^n (1-p)^{M-n}$$

For $n = 5$, and $M = 10$, $p = 0.1$

$$Pr(X \geq 5) = \sum_{n=6}^{10} \binom{M}{n} p^n (1-p)^{M-n}$$

$$\Rightarrow Pr(X \geq 5) = \frac{10!}{6!(10-6)!}(0.1)^6(0.9)^{10-6} + \frac{10!}{7!(10-7)!}(0.1)^7(0.9)^{10-7}$$

$$+ \frac{10!}{8!(10-8)!}(0.1)^8(0.9)^{10-8} + \frac{10!}{9!(10-9)!}(0.1)^9(0.9)^{10-9}$$

$$+ \frac{10!}{10!(10-10)!}(0.1)^{10}(0.9)^{10-10}$$

$$= \frac{3628800}{720\times24}\times1\times10^{-6}\times0.6561 + \frac{3628800}{5040\times6}\times1\times10^{-7}\times0.729$$

$$+ \frac{3628800}{40320\times2}\times1\times10^{-8}\times0.81 + \frac{3628800}{3628800\times1}\times1\times10^{-9}\times0.9 + (0.1)^{10}$$

$$= 1.377\times10^{-4} + 8.748\times10^{-6} + 3.645\times10^{-7} + 9\times10^{-9} + 1\times10^{-10}$$

$$= 1.4682\times10^{-4} \simeq 1.47\times10^{-4}$$

2-5: Host B to router A has lower propagation delay

Host B packet arrival delay $d_{P,B} = d_{prop} + \frac{L}{R}$

$$\Rightarrow d_{P,B} = 2\times10^{-3} + \frac{1500\times8}{4\times10^6} = 2\times10^{-3} + 3\times10^{-3}$$

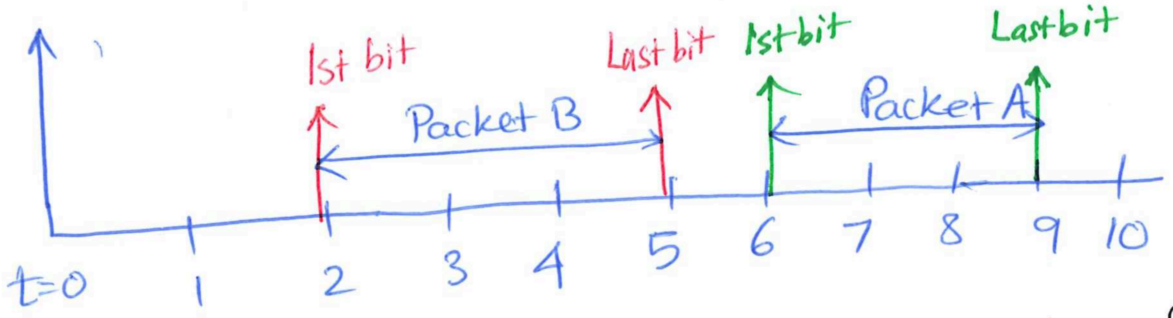
$$= 5\times10^{-3}\text{ sec} = 5\text{ ms}$$

[2020, S2]

Host A packet arrival delay $d_{P,A} = 6\times10^{-3} + \frac{1500\times8}{4\times10^{6}}$

$$\Rightarrow d_{P,A} = 9\times10^{-3}\text{ sec} = 9\text{ ms}$$

Timing diagram:



From the above diagram we see that packet from host B will arrive ahead of packet A, hence, no queuing delay occur.

<u>2-6:</u> 1 KB = 1024 byte in binary, 1000 Byte (decimal)

1 MB = 1 KB × 1 KB = 1,048576 byte in binary

1 MB = 10^6 Byte in decimal

1 GB = 1 KB × 1 MB = 1024 × 1048576 = 1.07374×10^{9} bytes

1 GB = 10^9 in decimal

Use the binary conversion

(a) $d_{file} = d_{prop} + \frac{L}{R} = \frac{150\times10^{3}}{3\times10^{8}} + \frac{1.07374\times10^{9}\times8}{2\times10^{6}}$

$= 5\times10^{-4} + 4294.96 \approx 4295$ sec (ignore 1st term)

$= 71.58$ min $= 1.193$ hour

(b) $d_{file} = \left(d_{prop} + \frac{L}{R_1}\right) + d_{journey} + \left(d_{prop} + \frac{L}{R_2}\right)$

We ignore the propagation delays

$\Rightarrow d_{file} = \frac{L}{R_1} + \frac{d}{S_b} + \frac{L}{R_2}$ | S_b speed of bus

[2020, S2]

$$d_{file} = \frac{1.07374\times10^9\times8}{100\times10^6} + \frac{150\times10^3}{S_b} + \frac{1.07374\times10^9\times8}{1\times10^9}$$ (6)

$$S_b = 60\ km/h = 1\ km/min = 16.66\ m/sec$$

$$\Rightarrow d_{file} = 85.89 + \frac{150\times10^3}{16.66} + 8.589$$

$$= 85.89 + 9003.6 + 8.589 = 9098.07\ sec$$

$$= 2.527\ hour$$

2-7: $R_{Coder} = 32\ kbps$, $T_p = 20\ ms$, $H = 18\ byte$

$d = 10\ km$, $R = 10\ Mbps$

Voice packets are generated every 20 ms.

No. of bits accumulated in a packet is given by

$$N_{packet} = R_{coder}\times T_p$$

$$= 32\times10^3 \times 20\times10^{-3} = 640\ bits = 80\ bytes$$

Voice packet:

H	Payload
18	80

$$D_{packet} = D_{prop} + \frac{L}{R} = \frac{10\times10^3}{3\times10^8} + \frac{(80+18)\times8}{10\times10^6}$$

$$= 3.33\times10^{-5} + 7.84\times10^{-5}$$

$$= 1.117\times10^{-4}\ sec$$

$$= 0.1117\ ms$$

—— X ——

[2020, S2]