Suggested Solution to CE3005 Computer Networks Semester 2, 2018-2019

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1

a

To achieve 1 9's reliability, the total reliability is:

$$r = \prod_{i=1}^{n} r_i$$

where $r_i = 0.99\ for i = 1, 2, \cdots, n$.
Solve for n, we have $n \leq log_{r_i} r \approx 10.48$.
Note that $n \in \mathbb{N}^+$, we take $n_{max} = 10$.

b

We shall increase the reliability between the link (or link equivalence) between two cities. Thus, we consider add an additional link between two cities, so that there are two parallel links with a 2 9's reliability for each connection two cities.
The reliability between two cities become:
$r'_i = 1 - b_i^2 = 0.9999$
The total reliability is $(r'_i)^{20} \approx 0.998 > 0.99$.
Therefore, we can propose a solution as above.

c

i

From the question, we have:
message length $u = 80$, reservation length $v = 4$, reservation utilization $S_r = 0.6$.
By the formula, we can calculate the throughput directly: $S = \frac{u}{u+v/S_r} \cdot 100\% = 92.31\%$.

ii

Take derivative of the pure Aloha protocol w.r.t. G:

$$\begin{aligned}\frac{\partial Pr}{\partial G} &= e^{-2G} - 2Ge^{-2G} \\ &= (1-2G)e^{-2G}\end{aligned}$$

We let $\frac{\partial Pr}{\partial G} = 0 \Rightarrow G = 0.5$. Here we do not verify that such function $G = 0.5$ is a maxima point. However, you should do this in exam.
Such that, we have $p = G/100 = 0.005$ for getting a maximum utilization. The throughput of the pure Aloha is $S = Pr = 18.39\%$.
The throughput of MARP using pure Aloha as the reservation phase will be $S' = \frac{u}{u+v/S} \cdot 100\% = 78.62\%$.
The throughput gain will be $Gain = S'/S = 4.28$.

2

a

i

Average frame transmission time $= 1000b/1Mbps = 1ms$.
Propagation delay $= 40km \times 0.5ms/km = 20ms$.
Normalized propagation delay $a = 20ms/1ms = 20$.
For selective reject ARQ, the utilization:

$$U = \begin{cases} 1-P & N \geq 1+2a \\ \frac{N(1-P)}{1+2a} & N < 1+2a \end{cases}$$

Window size $N = 10 < 1 + 2a = 21$, therefore, utilization $U = 42.86\%$.

ii

The minimum window size N to maximize the link utilization would be $N_{min} = 1+2a = 21$.
In this case, the maximum utilization is $U = 1 - P = 90\%$.

iii

To use a selective reject ARQ with a window size of 21, the number of bits for identify sequence number is k. In such case, $2^{k-1} \geq N$.
Therefore, $k \geq log_2 N + 1 \approx 5.39$, and $k \in \mathbb{N}^+$.
Thus, $k_{min} = 6$.

As such bits are not part of the data payload, the actual utilization would be:

$$U' = U \cdot \frac{payload\ bits}{frame\ length} = 89.46\%$$

b

i

From the question description, we know that:
Under the circumstance of a M/M/1 queue, Newly arrival rate $\lambda = 200$ frame/s
Service rate $\mu = \frac{data\ rate}{package\ size} = \frac{1Mbps}{1000b} = 1000$ frame/s
Error probability (re-queue rate) $p = 0.2$
Equivalent arrival rate $\lambda_a = \lambda \cdot \frac{1}{1-p} = 250$.
Therefore, the expected total delay T experienced by a frame in the M/M/1 queue would be:

$$T = \frac{1}{\mu - \lambda_a} = 0.001333 \text{ s}$$

, which is $T = 1.333ms$.

ii

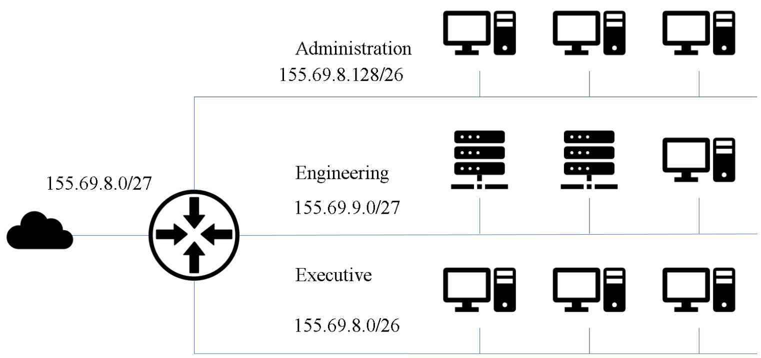
System utilization $\rho = \frac{\lambda_a}{\mu} = 0.25$
The number of package in the buffer $N = \frac{\rho}{1-\rho} = 0.3333$ frame
The probability that the frame in queue is the new arrival $p = \frac{\lambda}{\lambda_a} = 0.8$
Therefore, the number of frames that are waiting in the queue upon a newly arrived frame:

$$N' = N \cdot p = 0.2667 \text{ frames.}$$

3

a

We would like to divide the IP address into three subnets, with each one contains 100, 130 and 36 respectively.
Therefore, each of the subnets will have host number to be 7bits, 8bits and 6bits, which is the subnet masks should be /25, /24 and /27. As the executive floor shall contains the IP address 155.69.8.8, and have a subnet mask of /27. Therefore, it should take 155.69.8.0/27 or 155.69.8.0/26.
The engineering floor has to take 155.69.9.0/24.
The administration takes 155.69.8.128/26.
We draw the network diagram from the above information:



b

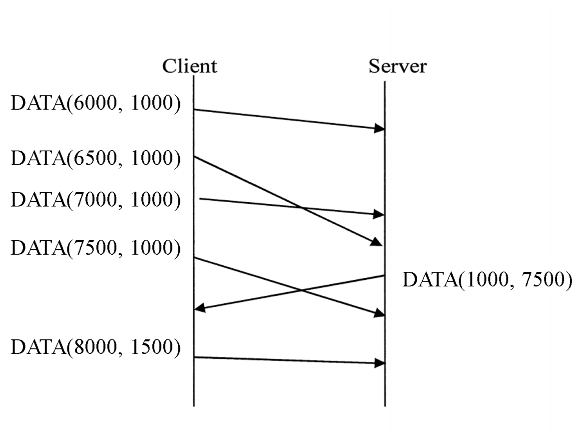
Packet	P_1	P_2	P_3	P_4
Destination MAC address	CC-22-F8-34-28-89	BB-33-55-23-68-90	DD-78-92-EF-45-33	AA-22-11-22-A5-AA
Source MAC address	AA-22-11-22-A5-AA	DD-78-92-EF-45-33	BB-33-55-23-68-90	CC-22-F8-34-28-89
Source IP address	10.8.8.10	155.69.8.10	155.69.8.250	155.69.8.250
Destination IP address	155.69.8.250	155.69.8.250	155.69.8.10	10.8.8.10
Source port address	5000	4980	6080	6080
Destination port address	6080	6080	4980	5000

4

a

As $MSS < MTU - 40$, the server can always fire at the maximum segment size. (40 bytes is the length of IP protocol header plus TCP protocol header).
For RTT = 10 ms, throughput = 8000 B $\cdot$ $1/RTT \cdot MSS \geq 1$ Gbps, as the maximum throughput of the link is 1 Gbps.
For RTT = 200ms, throughput = 8000 B $\cdot$ $1/RTT \cdot MSS = 0.06144$ Gbps
Therefore, $MSS = 192$.
For RTT = 100 ms, throughput = 0.12288
For RTT = 350 ms, throughput = 0.03511

b



From client packet 2 (DATA(6500, 1000), we know that client is requesting for SN = 1000 from server. Therefore, $a, c, d, g = 1000$.
Packet size = 500, therefore, $b = 7000$.
At the time of server packet 1 (DATA(g, h)), server has received SN = 7499 from client. Therefore, $h = 7500$.
At the time of client packet 5 (DATA(e, f)), client has received SN = 1499 from server, and has sent SN = 7999. $e = 8000, f = 1500$.
Note that client would not resent from SN = 7500, as it is the first duplicate ACK = 7500 it received. DATA(7500, ...) will only resent when client receives three dulicate ACK = 7500.
In summary, $a, c, d, g = 1000, b = 7000, e = 8000, f = 1500, h = 7500$.