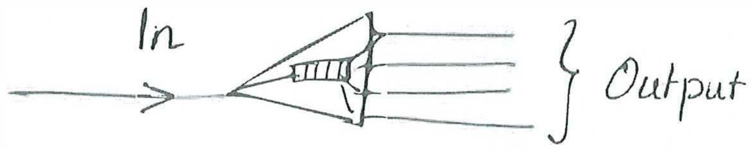
ELEC3500
Solution to Question Set 4

4-0



Packet Interarrival time $t_{int} = 20\,\mu s$

Time to check $t_{ch} = 10\,\mu s$

Time to Sequence packets $t_{seq} = 30\,\mu s$

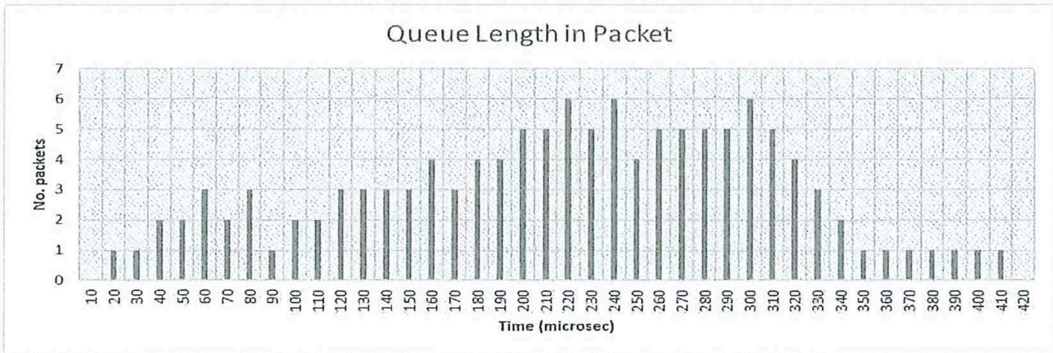
No. of misordering in first 15 blocks are:
2, 4, 0, 0, 1, 4, 3, 5, 2, 4, 0, 2, 5, 2 and 1.

$$\text{Service time } t_s = \begin{cases} 0 & \text{no misordering} \\ (10 + 30 \times n)\,\mu s & \text{misodering} \end{cases}$$

where n is no. of misordered packets/block

Following table shows the packet arrival, service and departure times.

Block No.	n	Packet arrival time μs	Service time μs	Departure time μs
1	2	20	70	90
2	4	40	130	170
3	0	60	10	70
4	0	80	10	90
5	1	100	40	140
6	4	120	130	250
7	3	140	100	280
8	5	160	160	320
9	2	180	70	250
10	4	200	130	330
11	0	220	10	230
12	2	240	70	310
13	5	260	160	420
14	2	280	70	350
15	1	300	40	340



(b) Mean no. of packets/block in the output queue

$$N_Q = \frac{\sum \text{Service time}}{\sum \text{Arrival time}} = \frac{1200}{300} = 4 \text{ packets}$$

(c) Percentage of the time buffer is not empty:

$$T_{NE} = \frac{\text{Total time} - \text{Time buffer empty}}{\text{Total time}}$$

$$= \cancel{\frac{420 - 400}{420}} \quad \frac{420-20}{420} = 0.95$$

4-1

$N_{home} = 100 \quad t_{int} = 100\ \mu s \quad L = 1500B$

(a) $\cancel{\lambda = \frac{1}{t_{int}} \times L = \frac{1}{100 \times 10^{-6}} \times 1500 \times 8 =}$

$$\lambda = \frac{1}{t_{int}} = \frac{1}{100 \times 10^{-6}} \Rightarrow 10{,}000 \text{ packets/sec}$$

$$\lambda_{hour} = 10{,}000 \times 3600 = 36000000 \text{ packets} = 36 \times 10^6 \text{ packets}$$

(b) $\lambda = 10{,}000 \times 1500 \times 8 = 1.2 \times 10^8 \text{ bps} = 0.12 \text{ Gbps}$

(c) $\rho = \frac{\lambda}{\mu}$, $\lambda = 10{,}000$ packets/sec

$$\mu = \frac{R}{L} = \frac{1 \times 10^9}{1500 \times 8} = 83333.33 \text{ packets/sec}$$

$$\rho = \frac{\lambda}{\mu} = \frac{10000}{83333.33} = 0.12$$

(d) Arrival is random, packet length is exponentially distributed, one server and no queue length specified, so assumed it is an infinite queue system.

M/M/1

(e) Delay equation of M/M/1 system is given by:

$$E[T] = \left[\frac{\rho}{1-\rho}\right]\frac{1}{\mu} + \frac{1}{\mu}$$

$$= \left[\frac{0.12}{1-0.12}\right]\frac{1}{83333.33} + \frac{1}{83333.33} = \frac{0.1363}{83333.33} + 12\times10^{-5}$$

$$= 1.635\times10^{-6} + 1.2\times10^{-5} = 1.363\times10^{-5}\text{ sec} = 13.63\ \mu s$$

4-2 Given $\lambda = 40$ packets/sec, Load $\rho = 0.9$ ~~$\mu = \lambda/\rho = \frac{0.9}{40} =$~~

Using the delay equation

$$E[T] = \left[\frac{\rho}{1-\rho}\right]\frac{1}{\mu} + \frac{1}{\mu} = \cancel{\left[\frac{0.9}{1-0.9}\right]}$$

$$\mu = \frac{\lambda}{\rho} = \frac{40}{0.9} = 44.44 \text{ pac}$$

$$\Rightarrow E[T] = \left[\frac{0.9}{1-0.9}\right]\frac{1}{44.44} + \frac{1}{44.44}$$

$$= 0.202 + 0.022 = 0.224\text{ sec} = 224\text{ ms}.$$

Using the Little's theoram

$$E[N] = \lambda E[T] = 40\times0.224 = 8.96\text{ packets.}$$

4-3 Buffer size 4 MB, packet size $L = 1500$ B

$$K = \left\lfloor\frac{4\times1024\times1024}{1500}\right\rfloor = \lfloor 2796.2 \rfloor = 2797\text{ packets.}$$

(b) Probability of packet loss

$$P_{loss} = \frac{(1-\rho)\rho^K}{1-\rho^{K+1}}$$ Given $\rho = 0.12$ [from 4.1]

$$= \frac{(\cancel{1}-0.12)(0.12)^{2797}}{1-(0.12)^{2797}} = \frac{0.88 \times 0}{1-0} = 0$$

(c) $$E[N] = \frac{\rho}{1-\rho} - \frac{(K+1)\rho^{K+1}}{1-\rho^{K+1}} = \frac{0.12}{0.88} - \frac{2797 \times (0.12)^{2797}}{1-(0.12)^{2797}}$$

$= 0.1363 - 0 = 0.1363$ packet

(d) $$E[T] = \frac{E[N]}{\lambda(1-P_{loss})} = \frac{E[N]}{\lambda} = \frac{0.1363}{10000} = 1.363 \times 10^{-5}\ \text{Sec}$$

$= 13.63\ \mu\text{Sec}.$

4-4 Total arrival traffic at the core network $\lambda = 4 \times 50 \times 10^3 = 200 \times 10^3$ packets/sec

$$\mu = \frac{40 \times 10^9}{8000 \times 8} =$$ ~~156 1250000 packets/sec = 1250×10^3 p/s~~

$\cancel{\mu} = 625,000$ packets/sec.

$$\rho = \frac{\lambda}{\mu} = \frac{200 \times 10^3}{625 \times 10^3} = 0.32$$

(b) This is a M/D/1 system

$$E[T] = \left[\frac{\rho}{2(1-\rho)}\right]\frac{1}{\mu} + \frac{1}{\mu} = \left[\frac{0.32}{2(1-0.32)}\right]\frac{1}{625 \times 10^3} + \frac{1}{625 \times 10^3}$$

$$= \frac{0.2352}{625 \times 10^3} + \frac{1}{625 \times 10^3} = 3.76 \times 10^{-7} + 1.6 \times 10^{-6} = 1.976 \times 10^{-6}\ \text{Sec}$$

(c) This system becomes a M/M/1 system

$$E[T] = \left[\frac{\rho}{1-\rho}\right]\frac{1}{\mu} + \frac{1}{\mu} = \left[\frac{0.32}{1-0.32}\right]\frac{1}{625 \times 10^{-3}} + \frac{1}{625 \times 10^{-3}}$$

$= 2.352 \times 10^{-6}$ Sec.

4-5 For the client server distribution we use the following formula:

$$D_{cs} = \max\{NF/u_s,\ F/d_{min}\}$$

For the P2P distribution

$$D_{P2P} = \max\left\{F/u_s,\ F/d_{min},\ \frac{NF}{(u_s + \sum_{i=1}^{N} u_i)}\right)$$

$F =$ ~~15 Gbps~~ 15 Gbits $= 15 \times 10^9$ bits.

$u_s = 30$ Mbps $d_{min} = 2$ Mbps.

$$\frac{F}{u_s} = \frac{15 \times 10^9}{30 \times 10^6} = 500 \text{ sec} \Rightarrow \frac{NF}{u_s} = 5000 \text{ sec } [N=10]$$

$$\frac{F}{d_{min}} = \frac{15 \times 10^9}{2 \times 10^6} = 7500 \text{ sec}$$

$N = 10$, $D_{cs} = \max\{10 \times 500,\ 7500\}$ sec $= 7500$ sec.

$N = 100$, $D_{cs} = \max\{100 \times 500,\ 7500\}$ sec $= 50,000$ sec.

For the peer to peer network

$$\frac{NF}{(u_s + \sum_{i=1}^{N} u_i)}$$

For $N = 10$, $u = 300$ kpps $\Rightarrow \frac{NF}{(u_s + \sum_{i=1}^{N} u_i)} = \frac{10 \times 15 \times 10^9}{30 \times 10^6 + 3 \times 10^6} = 4545$ sec.

$N = 10$, $u = 700$ kpps $\Rightarrow \frac{10 \times 15 \times 10^9}{30 \times 10^6 + 7 \times 10^6} =$ ~~7500 sec~~ 4054 se

N=10, u=300kbp $D_{p2p} = \max\{500,\ 7500,\ 4545\}$ sec $= 7500$ sec.

N=10, u=700kbps $D_{p2p} = \max\{500,\ 7500,\ 4054\}$ sec $= 7500$ sec.

A6 $R_c = 12$ Mbps $VF = 25$ fps $L = 4000B$

(a) Server to client propagation delays

$$d_{p,SA} = \frac{(6+1)\times10^3}{3\times10^8} = 2.33\times10^{-5}\text{ sec}$$

$$d_{p,SB} = \frac{(6+1.5)\times10^3}{3\times10^8} = 2.5\times10^{-5}\text{ sec.}$$

$$d_{p,SC} = \frac{(6+0.5)\times10^3}{3\times10^8} = 2.16\times10^{-5}\text{ sec.}$$

Server to client ~~prop~~ packet transmission, same for all clients.

$$d_t = \frac{32\times8}{1\times10^9} + \frac{32\times8}{50\times10^6} = 2.56\times10^{-7} + 5.12\times10^{-6}$$

$$= 5.376\times10^{-6}\text{ sec.}$$

$$RTT_A = 2(d_{p,SA} + d_t) = 2(2.33\times10^{-5} + 5.376\times10^{-6})$$

$$= 5.73\times10^{-5}\text{ sec} = 57.3\ \mu s$$

$$RTT_B = 2(2.5\times10^{-5} + 5.376\times10^{-6}) = 6.06\times10^{-5}\text{ sec} = 60.6\ \mu s$$

$$RTT_C = 2(2.16\times10^{-5} + 5.376\times10^{-6}) = 2.69\times10^{-5}\times2$$

$$= 5.38\times10^{-5}\text{ sec} = 53.8\ \mu s$$

(b) $R_c = 12$ Mbps, $VF = 25$ fps, $L = 4000B$

$$N_{pF} = \frac{12\times10^6}{25\times4000\times8} = 15$$

(c) A video frame is consists of 15 packets

Video frame delay is given by:

$$d_{p,A} = N(d_t + d_p + d_q)$$

$$d_t = \frac{4000 \times 8}{1 \times 10^9} + \frac{4000 \times 8}{50 \times 10^6} = 3.2 \times 10^{-5} + 6.4 \times 10^{-4}$$

$= 6.72 \times 10^{-4}$ sec.

$d_p = 2.33 \times 10^{-5}$ sec

Since the packet size is fixed and no queue size is mentioned, the system can be modelled as a M/D/1 system

λ = VF × packets/Frame × no. of download users

$= 25 \times 15 \times 3 = 1125$ packets/sec.

$\mu = \frac{R}{L} = \frac{50 \times 10^6}{4000 \times 8}$ [Since the outgoing rate is 50×10^6 bps]

$= 0.7197 \approx 0.72$

$$E[T_0] = \left[\frac{\rho}{2(1-\rho)} \frac{1}{\mu} \right] + \frac{1}{\mu}$$

$$= \left[\frac{0.72}{2(1-0.72} \frac{1}{1563} \right] + \frac{1}{1563} = 1.461 \times 10^{-3} \text{ sec.}$$

$d_{P,A} = N(d_t + d_{PA} + d_q)$

$= 15(6.72 \times 10^{-4} + 2.33 \times 10^{-5} + 1.461 \times 10^{-3})$

$= 0.03234 = 32.34$ ms.

4-7 Three nonproprietary protocols

Web protocol : HTTP
File transfer : FTP
Remote Login : Telnet

4-8 Network architecture refers to the organisation of the communication process involving all five layers of the TCP/IP protocol. Network architecture refers to both hardware and software needed to support operational requirements of a network. For ~~exa~~ example, Local Area Network structure and protocols ~~are~~ forms the network architecture.

The application architecture on the other hand is designed by an application developer which dictates the broad structure of application. For example, NETFLIX a video streaming whose architecture is dictated by video ~~eq~~ coders, ~~applications are~~ storage and protocol ~~archi~~ in the application layer.

4-9 HTTP is an application layer protocol for transfering documents such a webpages and the objects contained within ~~the~~ a web page. The HTTP protocol only provides the function to request and retrieve files. Another important ~~issue~~ component to ~~ret~~ realise a web application in a document format that describes a hypertext. The hypertext allows a web browser to understand which objects needs to be requested after downloading a web page. Sequence of different objects ~~are~~ is described by the hypertext. The Standard format for the Web is the Hyper Text Markup Language (HTML).

4-10 Reliable Data Transfer : TCP provide this service but not the UDP.

Throughput Guarantee : Neither protocol

Delivery Time Guarantee : Neither

Congestion control : TCP provide but not UDP

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