Tutorial Sheet 2
Answers

1. Arrival rate to both queues $= \Lambda = \frac{\lambda}{1-p}$

(i) $\frac{\Lambda}{\mu_1} < 1,\ \frac{\Lambda}{\mu_2} < 1$

(ii) Let $p_{(i,j)}$ denote the steady state probability of system containing i customers in queue 1 and j customers in queue 2. Then $p_{(i,j)} = \rho_1^i(1-\rho_1)\rho_2^j(1-\rho_2)$

(iii) $N_i = \frac{\rho_i}{1-\rho_i},\ i = 1,2$

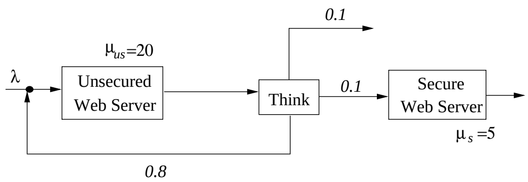
(iv) $\frac{1}{(1-p)}\left[\frac{1}{\mu_1-\Lambda} + \frac{1}{\mu_2-\Lambda}\right]$

2. $\Lambda_1 = \frac{\lambda_2 p+(1-p)\lambda_1}{1-p-q},\ \Lambda_2 = \frac{\lambda_1+\lambda_2}{1-p-q}$. Delay $=\frac{N_1+N_2}{\lambda_1+\lambda_2}$ where $N_i = \frac{\rho_i}{1-\rho_i},\ \rho_i = \frac{\Lambda_i}{\mu},\ i = 1,2$

3. $\frac{N}{\lambda(1-P_b)}$

4. $\rho_a = \frac{\lambda_3+p(\lambda_1+\lambda_2)}{\mu_a} = \frac{1}{2}$, $\rho_b = \frac{(1-p)(\lambda_1+\lambda_2)}{\mu_b} = \frac{3}{4}$, $N_i = \frac{\rho_i}{1-\rho_i},\ i = 1,2$, $N_a = 1,\ N_b = 3$, $T = \frac{4}{16}$

5. $N_1 = \frac{\rho_1}{1-\rho_1},\ N_2 = \rho_2(1-P_B),\ P_B = \frac{\rho_2^s}{S!\sum_{i=0}^{S}\frac{\rho_2^i}{i!}}$, $T_1 = \frac{N_1}{\lambda_1}$, $T_2 = \frac{N_2}{(\lambda_1+\lambda_2)(1-P_B)}$, $T = \frac{N_1+N_2}{\lambda_1+\lambda_2}$



6. $\lambda_{us} = \lambda + 0.8\lambda_t$, $\lambda_t = \lambda_{us}$, $\lambda_s = 0.1\lambda_t \ \Rightarrow\ \lambda_t = \lambda_{us} = 5\lambda$ and $\lambda_s = \frac{\lambda}{2}$

(b)For secure web server: $\frac{1}{5-\lambda_s} < 2 \ \Rightarrow\ \lambda < 9$

For unsecure web server : $\frac{1}{20-\lambda_{us}} < \frac{1}{2} \ \Rightarrow\ \lambda < \frac{18}{5}$

Therefore unsecure web server will require upgradation first.

(c) When $\lambda = \frac{18}{5}$

(d) If capacity is doubled:

$E(R)$ at secure web server gives $\lambda < 9$

$E(R)$ at unsecure web server gives $\lambda < \frac{38}{5}$

Again unsecure web server will require upgrade