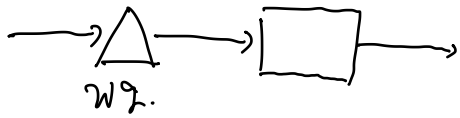
1.

(1): every 3 mins $= \frac{1}{\lambda}$ $\lambda = \frac{1}{3}$

every 2 mins $= \frac{1}{\mu}$ $\mu = \frac{1}{2}$

$\rho = \frac{\lambda}{\mu} = \frac{2}{3}$ $(1-\rho) \times 8h = \frac{1}{3} \times 8 \times 60 = 160$ mins

16 min $\times$ 1 page/min $= 160$ pages



(2): $C_{va} = \frac{\text{st-dev(inter-arrival-time)}}{\frac{1}{\lambda}} = 1$ $C_{VS} = \frac{\text{st-DEV(service time)}}{\frac{1}{\mu}} = \frac{1}{2}$

$$\text{Avg Wait-time} = \text{Avg. service time} \times \frac{\text{Utilization}}{1-\text{Utilization}} \times \frac{C_{va}^2 + C_{vs}^2}{2}$$

$$= \frac{1}{\mu} \times \frac{\rho}{1-\rho} \times \frac{1^2 + (\frac{1}{2})^2}{2} = 2 \times 2 \times 0.625 = 2.5 \text{ min}$$

(3) $E[L] = \lambda \times E[W]$ $E[W] = E[W_q] + \frac{1}{\mu}$

$E[\lambda] = \lambda [E[W_q] + \frac{1}{\mu}] = \frac{1}{3}[2.5\text{min} + 2\text{min}] = 1.5$

(4)

$E[W] = [E[W_q] + \frac{1}{\mu}] = 4.5$ min

# of customers on 8 hours $= 20 \times 8 = 160$

$160 \times E[W] = 720\text{min} = 12$ hs $12 \times 5 = 60$ dollors/8 hours = total cost

2:

$\lambda = 30/\text{hour}$ $C_{va} = \frac{2}{2} = 1.$

$\frac{1}{\mu} = 1.7$ $\mu = 0.588$ $C_{vs} = \frac{3}{1.7} = 1.76$

$\rho = \frac{\lambda}{\mu} \cdot \frac{0.5}{0.588} = 0.85.$

$$\text{Avg waittime} = \text{Avg service time} \times \frac{\rho}{1-\rho} \times \frac{C_{va}^2 + C_{vs}^2}{2}$$

$$= 1.7 \times \frac{0.85}{1-0.85} \times \frac{1^2 + 1.76^2}{2}$$

$$= 19.82 \text{ min}$$

$445.95 = 0.75 \times 19.76 \text{ min} \times 30 \longrightarrow$ waiting time cost /hour

$10\$/\text{hour} \longrightarrow$ labor cost

$\rho' = \frac{\lambda}{m\mu} = \frac{0.85}{m}$

1 server $45.75 + 10 = 55.75$

2 server $U = 0.4250$

$$E[W_q^{M/M/1}] = 0.3748$$

$$E[W_q^{G/G/1}] = 0.3748 \times \frac{C_a^2 + C_s^2}{2} = 0.77$$

$$0.77 \times 30 \times 0.75 = 17.325$$

$$17.325 + 20 = 37.325$$

3 server $U = 0.2833$

$$E[W_q^{M/M/1}] = 0.048$$

$$E[W_q^{G/G/1}] = 0.048 \times \frac{C_a^2 + C_s^2}{2} = 0.0987$$

$$0.0987 \times 30 \times 0.75 = 2.221$$

$$2.221 + 30 = 32.221 \quad \therefore 3 \text{ employees}$$

4 servers $\rho = 0.2125$

$$E[W_q^{M/M/m}] = 0.0064$$

$$E[W_q^{G/G/m}] = 0.0064 \times \frac{C_a^2 + C_s^2}{2} = 0.0132$$

$$0.0132 \times 30 \times 0.75 + 40 = €0.297$$