1

A

$M/M/1/\infty$

$\mu_i = \min\{i\mu, m\mu\}, \; m=5$

$\Rightarrow \mu, 2\mu, 3\mu, 4\mu, 5\mu, 5\mu \dots$

B

$M/M/5/\infty$

$\lambda = 1 \quad \mu = \frac{1}{4} \quad \Rightarrow \quad \rho = \frac{\lambda}{\mu} = 4$

a)

b) From balance equations: $p_0 = \frac{1}{77}$

P(2 customer waits) $= p_2$

P(2 customer waits) $= p_7$

This is a standard queue. Let us work with this first. Some results may be true for A.

c) $N_q = ?$

$N_q = \lambda T - N_S = 6.21 - 0.987 = 5.22$

$N_{q_B} = \frac{\lambda}{m\mu - \lambda} \cdot P(\text{wait}) = \dots = 2.21$

$P(\text{wait}) = \frac{5 \cdot E_5(4)}{5 - 4(1 - E_5(4))} = 0.554$

d) $T = ?$

$\bar{T}_B = \frac{N}{\lambda} = \frac{N_q + N_s}{\lambda} = \frac{N_q + \rho}{\lambda} = 6.21$ [s]

This is true for A as well!

e) Service time changes with state!

$T_S = \frac{\bar{N}_s}{\lambda} = \frac{1 - p_0}{\lambda} = \frac{76}{77} = 0.987$

$T_S = \{Exp(\mu)\} = 4s$

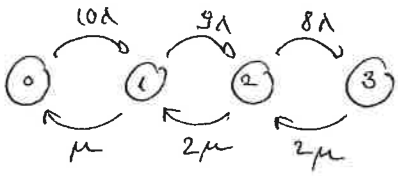
2

1

A, B } 5 + 5 customers $\lambda = 2$ calls/hour

$\bar{x} = 0.1$ hour, $\mu = 10$ calls/hour

a) M / M / 2 / 3 // 10



b) Time blocking: p_3

Call blocking: $\dfrac{p_3 \cdot 7}{p_0 10 + p_1 \cdot 9 + p_2 \cdot 8 + p_3 \cdot 7}$

$$\left.\begin{aligned} p_0 10\lambda &= p_1 \mu \\ p_1 9\lambda &= p_2 2\mu \\ p_2 8\lambda &= p_3 2\mu \end{aligned}\right\} \Rightarrow p_0 = \frac{25}{156},\ p_1 = \frac{50}{156},\ p_2 = \frac{45}{156},\ p_3 = \frac{36}{156}$$

Time blocking $= p_3 = \dfrac{36}{156} = \dfrac{3}{13} \approx 0.23$

Call blocking $= \dots = 0.192$

c) Expected waiting time

- only one queuing position:

$E[\text{waiting}] = E[\text{time until first service}] = \dfrac{1}{2\mu} = \dfrac{1}{20}$ hour $= 3$ min

d) State: {Type of customers in the servers}