1) 1 copiadora => 1 servidor

$\lambda = 60 \frac{\text{alunos}}{h}$ → dist. Poisson => M

$E[t_s] = 10 \frac{s}{\text{cópia}} => \mu = \frac{1}{10} \frac{\text{cópias}}{s}$ → M ∴ Fila M/M/1

Convertendo as unidades:

$\lambda = 60 \frac{a}{h} = \frac{\cancel{60}\, a}{\cancel{60}\, \text{min}}$ ∴ $\lambda = 1 \frac{\text{aluno}}{\text{min}}$

Estamos analisando os alunos: 1 aluno ≡ 4 cópias => 1 cópia ≡ 1/4 aluno

$=> \mu = \frac{1}{10} \frac{\text{cópia}}{s} = \frac{1}{4} \cdot \frac{1}{10} \frac{\text{aluno}}{s} = \frac{1}{40} \cdot \frac{1}{1/60} \frac{\text{aluno}}{\text{min}}$

∴ $\mu = \frac{3}{2} \frac{\text{aluno}}{\text{min}}$

$\rho = \frac{\lambda}{\mu} = \frac{1}{3/2}$ ∴ $\rho = \frac{2}{3}$

b) Sistema => q => E[q] = ?

$E[q] = \frac{\rho}{1-\rho}$ ∴ $E[q] = 2$ alunos

c) $E[t_q] = \frac{1}{\mu - \lambda}$ ∴ $E[t_q] = 2$ min

d) Fila => W => E[t_w] = ?

a) Fila => W => E[t_w] = ?

$$E[t_q] = E[t_w] + E[t_s] \Rightarrow E[t_w] = E[t_q] - E[t_s]$$ → está em $\frac{s}{\text{cópia}}$

$$E[t_s] = 10\,\frac{s}{\text{cópia}} = 10\,\frac{s}{1/4\ \text{aluno}} = 40\,\frac{s}{\text{aluno}} \Rightarrow E[t_w] = 2\cdot 60 - 40$$

$$= 80s$$

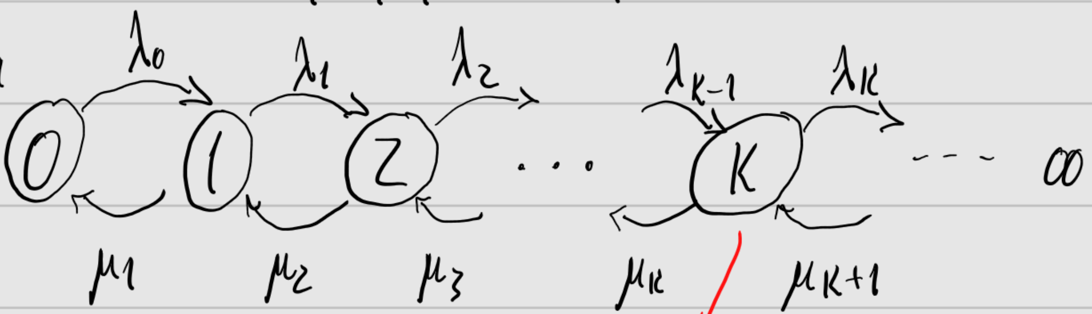
$$\therefore E[t_w] = 1\text{min } 20s$$

2) 1 interface => 1 servidor λ é M e μ é M $\therefore$ M/M/1

a) Notação de Kendall:

$$M/M/1/\infty/\infty/\infty/FIFO$$

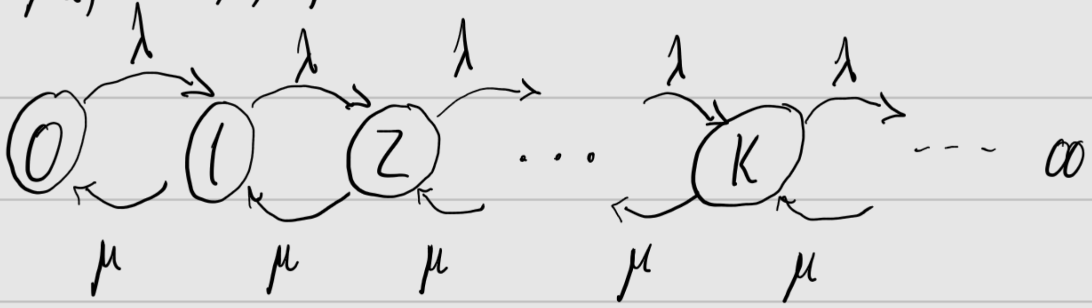
Diagrama geral:



nº de elementos no sistema

Como $\lambda = \lambda_K$, $K = 0, 1, 2, \ldots$

e $\mu = \mu_K$, $K = 0, 1, 2, \ldots$



b) $\lambda = 480\ pc/min = \frac{480\ pc}{60\ s} \therefore \lambda = 8\ pc/s$

$$\mu = 64\,Kbps = 64\cdot 10^3\,\frac{b}{s} = 64\cdot 10^3 \cdot \frac{\frac{1}{4\cdot 10^3}\ pc}{s} \therefore \mu = 16\ pc/s$$

$1\ pc = 4000 b$

$\Rightarrow 1b = 1\ pc$

$$4000$$

$$\rightarrow E[t_s] = \frac{1}{16} s = 62{,}5 ms$$

c) $\rho = \frac{\lambda}{\mu} = \frac{8}{16} \therefore \rho = 0{,}5$

d) $P(K=0) = P_0 = 1 - \rho \therefore P_0 = 0{,}5$

e) $P_1 = \rho^1 \cdot P_0 \therefore P_1 = 0{,}25$

f) $P_{10} = \rho^{10} \cdot P_0 \therefore P_{10} = 0{,}000488$

g) $E[t_q] = \frac{1}{\mu - \lambda} \therefore E[t_q] = 125 ms$

h) $E[t_w] = E[t_q] - E[t_s] = 125 - 62{,}5 \therefore E[t_w] = 62{,}5 ms$

3) 1 cabine => 1 servidor

$E[t_s] = 2 \, min/mot$

$\lambda = 25 \frac{mot}{h}$ M/M/1

Sempre nas mesmas unidades.

$$\mu = \frac{1}{2}\frac{mot}{min} = \frac{1}{2} \cdot \frac{mot}{1/60 h} = 30 \, mot/h$$

a) $\rho = \frac{\lambda}{\mu} \therefore \rho = 0{,}8333$

b) Praça -> sistema -> $E[q]$

$E[q] = \frac{\rho}{1-\rho} \therefore E[q] = 5$ pessoas

c) Passar pelo pedágio -> sistema -> $E[t_q]$

$E[t_q] = \frac{1}{\mu - \lambda} \therefore E[t_q] = 0{,}2\,h = 12$ min

d) Fila -> W

$E[W] = \frac{\rho^2}{1-\rho} \therefore E[W] = 4{,}1667$ mot

e) $E[t_w] = E[t_q] - E[t_s]$

ou $E[t_w] = \frac{E[W]}{\lambda}$ -> pelo Teo. de Little

$\therefore E[t_w] = 0{,}1667\,h = 10$ min