Problema 1

$E(T) = 0{,}15$ seg/cl.

$\mu = 50$ cl./seg

$E(n) = ?$

$\lambda = ?$

$$E(T) = \frac{1}{\mu(1-\rho^2)}$$

$$0{,}15 \text{ seg/cl.} = \frac{1}{50 \text{ cl./seg}\,(1-\rho^2)}$$

$$0{,}15 \text{ seg/cl.} \cdot 50 \text{ cl./seg}\,(1-\rho^2) = 1$$

$$7{,}5\,(1-\rho^2) = 1$$

$$7{,}5 - 7{,}5\,\rho^2 = 1 \Rightarrow -7{,}5\,\rho^2 = 1 - 7{,}5$$

$$-7{,}5\,\rho^2 = -6{,}5 \Rightarrow \rho^2 = \frac{-6{,}5}{-7{,}5}$$

$$\rho = \sqrt{\frac{6{,}5}{7{,}5}} \Rightarrow \rho = 0{,}93$$

$$E(n) = \frac{2\rho}{1-\rho^2} = \frac{2 \cdot 0{,}93}{1-0{,}93^2} = \frac{1{,}86}{0{,}1351}$$

$$E(n) = 13{,}76$$

$$\rho = \frac{\lambda}{2\mu}$$

$$0{,}93 = \frac{\lambda}{2 \cdot 50 \text{ cl./seg}} \Rightarrow 0{,}93 \cdot 2 \cdot 50 \text{ cl./seg} \Rightarrow \lambda = 93 \text{ cl./seg}$$

Problema 2

$E(T) = 0{,}085$ seg/cli

$n = 12$ cli/seg

$E(n) = ?$

$\lambda = ?$

$$E(T) = \frac{1}{n(1-\rho^2)} \Rightarrow E(T) = \frac{1}{n} \cdot \frac{1}{1-\rho^2}$$

$$\frac{1}{n\,E(T)} = 1-\rho^2 \Rightarrow \frac{1}{12\ \text{cli/seg}\ 0{,}085\ \text{seg/cli}} - 1 = -\rho^2$$

$$-0{,}9803 + 1 = \rho^2 \Rightarrow \rho = \sqrt{0{,}0196}$$

$$\rho = 0{,}14002$$

$$E(n) = \frac{2\rho}{1-\rho^2} = \frac{2 \cdot 0{,}14002}{1-0{,}0196} = 0{,}2856$$

$$\rho = \frac{\lambda}{2n} = 0{,}14002 = \frac{\lambda}{2\ 12\ \text{cli/seg}}$$

$$\lambda = 0{,}14002 \cdot 2 \cdot 12\ \text{cli/seg}$$

$$\lambda = 3{,}36\ \frac{\text{cli}}{\text{seg}}$$

Problema 3

$\lambda = 28\ cl/seg$ $\qquad \sigma = 0$

$\sigma_s = 0{,}025\ seg/cl$

$E(n) = ?$

$E(T) = ?$

$$\rho = \frac{\lambda}{\mu} \Rightarrow \lambda \cdot \frac{1}{\mu} \Rightarrow \lambda \cdot \sigma_s = 28\frac{cl}{seg} \cdot 0{,}025\frac{seg}{cl}$$

$$\rho = 0{,}7$$

$$E(n) = \frac{\rho}{1-\rho}\left[1 - \frac{\rho}{2}\left(1 - \pi^2 \cdot \sigma^2\right)\right]$$

($\sigma \to 0$, $\pi \to 0$)

$$E(n) = \frac{0{,}7}{1-0{,}7}\left[1 - \left(\frac{0{,}7}{2} \cdot 1\right)\right] = 2{,}3333 \cdot 0{,}65$$

$$E(n) = 1{,}5166$$

$$E(T) = \frac{E(n)}{\lambda}$$

$$E(T) = \frac{1{,}5166}{28\frac{cl}{seg}} = 0{,}05541\frac{seg}{cl}$$

Problema 4

$\lambda = 20 \text{ cl./seg}$

$\pi = 30 \text{ cl./seg}$

$\nabla = 0{,}02 \text{ seg/cl}$

$$\rho = \frac{\lambda}{\pi} = \frac{20 \text{ cl./seg}}{30 \text{ cl./seg}} = 0{,}6666$$

$$E(n) = \frac{\rho}{1-\rho}\left[1 - \frac{\rho}{2}\left(1 - \pi^2 \nabla^2\right)\right]$$

$$E(n) = \frac{0{,}6666}{1-0{,}6666}\left[1 - \frac{0{,}6666}{2}\left(1 - \left(30\frac{\text{cl.}}{\text{seg}}\right)^2 \left(0{,}02\frac{\text{seg}}{\text{cl.}}\right)^2\right)\right]$$

$$E(n) = \frac{0{,}6666}{0{,}3334}\left[1 - 0{,}3333\left(1 - (900 \cdot 0{,}0004)\right)\right]$$

$$E(n) = 1{,}9994 \cdot 0{,}7866 = 1{,}5729$$

$$E(T) = \frac{E(n)}{\lambda}$$

$$E(T) = \frac{1{,}5729}{20 \text{ cl./seg}} = 0{,}0786 \frac{\text{cl.}}{\text{seg}}$$

Problema 5

$\lambda = 40$ cl/seg

$\eta_1 = 48$ cl/seg

$\eta_2 = 8$ cl/seg

(A)

$$\rho\, \eta/\eta_1 = \frac{\lambda}{\eta} = \frac{40 \text{ cl/seg}}{48 \text{ cl/seg}} = \frac{5}{6} = 0,8333$$

$$P_c = 1 - \sqrt{\frac{r(1+r)}{1+r^2}}$$

$$r = \frac{\eta_2}{\eta_1} = \frac{8 \text{ cl/seg}}{48 \text{ cl/seg}} = 0,1666$$

$$P_c = 1 - \sqrt{\frac{0,1666\,(1+0,1666}{1+(0,1666)^2}}$$

$$P_c = 1 - \sqrt{\frac{0,1943}{1,0277}} = 1 - \sqrt{0,1890} = 1 - 0,4347$$

$$P_c = 0,5650$$

$$\rho\, \eta/\eta_1 > P_c$$

$$0,8333 > 0,5650$$

Si conviene agregar el servidor sin selección de servidor

(8)

$$\pi_0 = \frac{1 - \rho\, M/M/2}{1 - \rho\, M/M/2 + \frac{\lambda}{a}}$$

$$\rho\, M/M/2 = \frac{\lambda}{\mu_1 + \mu_2} = \frac{40 \text{ cl/seg}}{48 \frac{\text{cl}}{\text{seg}} + 8 \frac{\text{cl}}{\text{seg}}}$$

$$\rho\, M/M/2 = \frac{40 \text{ cl/seg}}{56 \text{ cl/seg}} = 97142$$

$$a = \frac{2\,\mu_1\,\mu_2}{\mu_1 + \mu_2} = \frac{2 \cdot 48 \text{ cl/seg} \cdot 8 \text{ cl/seg}}{48 \text{ cl/seg} + 8 \text{ cl/seg}}$$

$$a = \frac{768 \text{ cl/seg}^2}{56 \text{ cl/seg}} = 13,7142 \text{ cl/seg}$$

$$\pi_0 = \frac{1 - 0,7142}{1 - 97142 + \frac{40 \text{ cl/seg}}{13,7142 \text{ cl/seg}}} = \frac{0,2858}{0,2858 + \frac{40 \text{ cl/seg}}{13,714 \text{ cl/seg}}}$$

$$\pi_0 = \frac{0,2858}{3,2024} = 0,0892$$

$$\bar{N} = \frac{\lambda}{(1 - \rho\, M/M/2)\left[\lambda + (1-\rho)a\right]}$$

$$\bar{N} = \frac{40 \text{ cli/seg}}{(1-0{,}7142)\left[40\frac{\text{cli}}{\text{seg}} + (1-0{,}7142)\,13{,}7142\frac{\text{cli}}{\text{seg}}\right.}$$

$$\bar{v} = \frac{40 \text{ cli/seg}}{0{,}2858\,(40 \text{ cli/seg} + 3{,}9195 \text{ cli/seg})}$$

$$\bar{v} = \frac{40 \text{ cli/seg}}{12{,}55 \text{ cli/seg}} = \boxed{3{,}1877}$$

(C) Como conviene agregar el servidor sin selección de servidor entonces conviene aún más agregar el servidor con selección de servidor

$$P\,n/n/1 > P_c(\text{sin selec}) > P_c(\text{con selec})$$

(D) $$\Pi_0 = \frac{1 - P\,n/n/2}{1 - P\,n/n/2 - \frac{\lambda}{a'}}$$

$$n_s = n_1 + n_2 \Rightarrow n_s = 48 \text{ cli/seg} + 8 \text{ cli/seg}$$

$$n_s = 56 \text{ cli/seg}$$

$$\lambda' = \frac{(2\lambda + \mu_3)\,\mu_1\,\mu_2}{\mu_3\,(\lambda + \mu_2)}$$

$$\lambda' = \frac{(2 \;\; 40\ cl/seg + 56\ cl/seg)\ 48\ \frac{cl}{seg}\ \ 8\ \frac{cl}{seg}}{56\ cl/seg\ (40\ cl/seg + 8\ cl/seg)}$$

$$\lambda' = \frac{136\ cl/seg \cdot 48\ cl/seg \cdot 8\ cl/seg}{56\ cl/seg\ (40\ cl/seg + 8\ cl/seg)}$$

$$\lambda' = \frac{52224}{2688} = 19,4285\ cl/seg$$

$$\pi_0 = \frac{1 - \rho\mu_1/\mu_2}{1 - \rho\mu_1/\mu_2 + \frac{\lambda}{\lambda'}} = \frac{1 - 0,7142}{1 - 0,7142 + \frac{40\ cl/seg}{19,4285\ cl/seg}}$$

$$\pi_0 = \frac{0,2858}{0,2858 + 2,05} = \frac{0,2858}{2,3358} = 0,12$$

$$\bar{N} = \frac{\lambda}{(1 - \rho\mu_1/\mu_2)\left[\lambda + (1 - \rho\mu_1/\mu_2)\,\lambda'\right]}$$

$$\bar{N} = \frac{40\ cl/seg}{(1 - 0,7142)\left[40\ \frac{cl}{seg} + (1 - 0,7142)\ 19,4285\ \frac{cl}{seg}\right.}$$

$$\bar{\lambda} = \frac{40\ cl_1/sec}{0{,}2858\ \frac{40\ cl_1}{sec} + 5{,}5826\ cl_1/sec}$$

$$\bar{\omega} = \frac{40\ cl_1/sec}{12{,}0189\ cl_1/sec} = 3{,}0734$$

Problema 6

$W_0 = 38 \text{ mseg}$

$Q_1 = 5 \text{ cl}_1$

$T_{S1} = 58 \text{ mseg/cl}_1$

$W_1 = W_0 + Q_1 T_{S_1} + 1 \text{ cl}_1 T_{S1}$

$W_1 = 38 \text{ mseg} + 5 \text{ cl}_1 \, 58 \frac{\text{mseg}}{\text{cl}_1} + 1 \text{ cl}_1 \cdot 58 \text{ mseg/cl}_1$

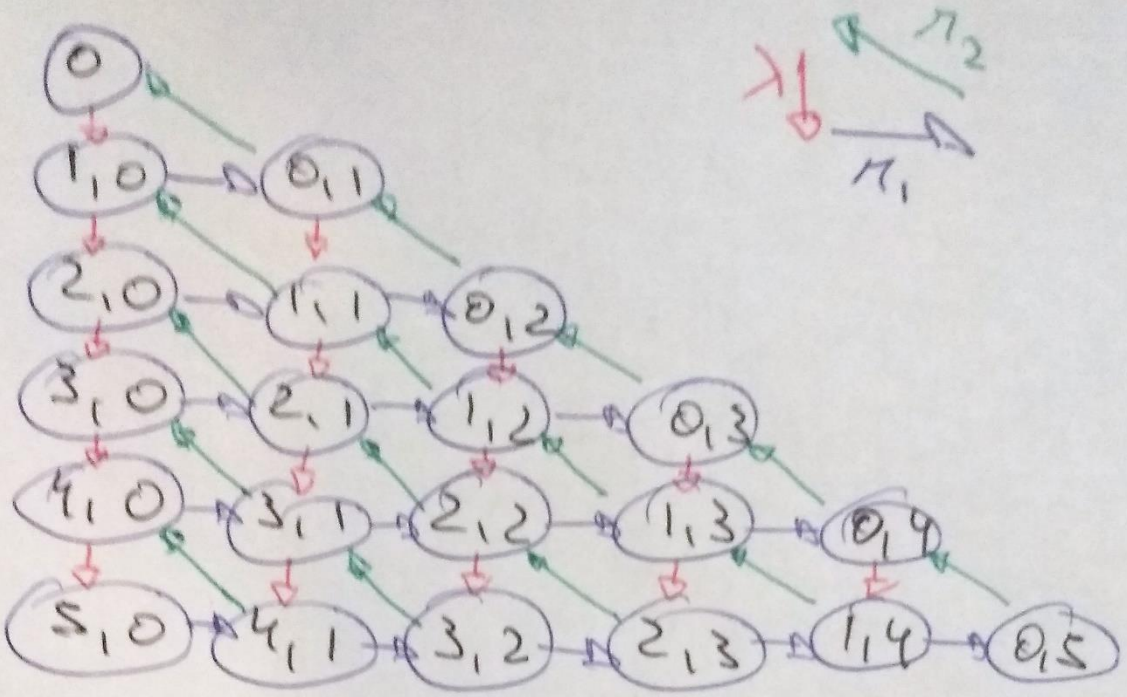
$W_1 = 386 \text{ mseg}$

$W_{f1} = W_0 + Q_1 T_{S1}$

$W_{f1} = 38 \text{ mseg} + 5 \text{ cl}_1 \, 58 \frac{\text{mseg}}{\text{cl}_1}$

$W_{f1} = 328 \text{ mseg}$

Problema 7



$$\text{Entrada} = \text{Saída}$$

$$\lambda \pi_{1,2} + \mu_1 \pi_{3,1} + \mu_2 \pi_{2,3} = \lambda \pi_{2,2} + \mu_1 \pi_{2,2} + \mu_2 \pi_{2,2}$$

$$\lambda \pi_{1,2} + \mu_1 \pi_{3,1} + \mu_2 \pi_{2,3} = \pi_{2,2} (\lambda + \mu_1 + \mu_2)$$

$$\pi_{2,2} = \frac{\lambda \pi_{1,2} + \mu_1 \pi_{3,1} + \mu_2 \pi_{2,3}}{\lambda + \mu_1 + \mu_2}$$