TEORIA DE COLAS

Sistemas con una sola cola, población infinita Estadísticas en Estado Estacionario

- $\rho = \frac{\lambda}{\mu}$
- $P(0) = 1 - \rho$
- $P(n) = \rho^n(1 - \rho)$
- $L_q = \frac{\rho^2}{1-\rho}$
- $L_s = \frac{\rho}{1-\rho} = L_q + \rho$
- $W_q = \frac{L_q}{\lambda}$
- $W_s = \frac{1}{\mu-\lambda}$
  Restricción $\rho \leq 1$

Sistemas con Prioridades

- $\lambda_i, \mu_i, \sigma_i^2, \rho_i, L_q(i), W_q(i), L_s(i), W_s(i)$, características de la cola para las clases i=1..m.
- $\rho_i = \frac{\lambda_i}{\mu_i}$
- $S_j = \sum_{i=1}^{j} \rho_i$, con $S_0 = 0$
- $L_q(i) = \lambda_i W_q(i)$
- $L_s(i) = \lambda_i W_s(i)$
- $W_q(i) = \frac{\sum_{j=1}^{m} \frac{\rho_j^2(1+\mu_j^2\sigma_j^2)}{\lambda_j}}{2(1-S_{i-1})(1-S_i)}$
- $W_s(i) = W_q(i) + \frac{1}{\mu_i}$
- $\lambda = \sum_{i=1}^{m} \lambda_i$

- $W_q = \frac{L_q}{\lambda}$
- $L_s = \sum_{i=1}^{m} L_s(i)$
- $L_q = \sum_{i=1}^{m} L_q(i)$
- $W_s = \frac{L_s}{\lambda}$

Sistemas con Múltiples Servidores

- $\rho = \frac{\lambda}{k\mu}$
- $\frac{1}{P(0)} = \sum_{n=0}^{k-2} \frac{(\rho k)^n}{n!} + \frac{(\rho k)^{k-1}}{(k-1)!(1-\rho)}$
- $P(n) = \begin{cases} (\rho k)^n \frac{}{n!} \, \mathrm{P}(0) & \text{si } n \leq k \\ \rho^n k^k \frac{}{k!} \, \mathrm{P}(0) & \text{si } n \geq k \end{cases}$
  $\mathrm{L}_q = \frac{\rho^{k+1} k^{k-1}}{(k-1)!(1-\rho)^2} \, \mathrm{P}(0)$
- $L_s = L_q + \rho k$
- $W_q = \frac{L_q}{\lambda}$
- $W_s = W_q + \frac{1}{\mu} = \frac{L_s}{\lambda}$
  Restricciones $\mu_i = \mu, \forall i$

Sistemas con Población Finita

- $\lambda_e = \lambda(M - L_s) = \mu(1 - P(0))$
- $R = \frac{\lambda}{\mu}$
- $\frac{1}{P(0)} = \sum_{n=0}^{k-1} \begin{pmatrix} M \\ n \end{pmatrix} R^n + \frac{M!}{k!} \sum_{n=k}^{M} \frac{R^n}{(M-n)! k^{n-k}}$
- $P(n) = \begin{cases} \begin{pmatrix} M \\ n \end{pmatrix} R^n P(0) & \text{si } 0 \leq n \leq k \\ \frac{R^n M! P(0)}{(M-n)! k! k^{n-k}} & \text{si } k \leq n \leq M \end{cases}$
- $L_q = \lambda_e W_q$
- $L_s = \sum_{n=1}^{M} nP(n)$
- $W_q = W_s - \frac{1}{\mu}$
- $W_s = \frac{L_s}{\lambda_e}$