(3). How many times have each process use the NIC service?

(4). For each process, what is the average waiting time respectively when it waits in the NIC queue?

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Process 5 has the largest number of NIC visit.

Process 1 & 2 have similar # → smallest #

Process 5 waiting time < 5 sec

EventList [5]

Status = ["Using other resource" ("O"), "waiting in queue" ("W"), "Using NIC" ("N")]

$-\ln U/\lambda$

5-th erlang : $= -\frac{\ln U_1}{\mu} - \frac{\ln U_2}{\mu} - \frac{\ln U_3}{\lambda} - \frac{\ln U_4}{\mu} - \frac{\ln U_5}{\mu}$

$= -\ln(U_1 \cdot U_2 \cdot U_3 \cdot U_4 \cdot U_5)/\mu$

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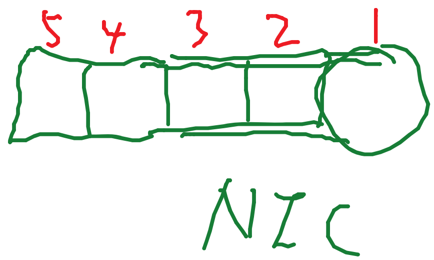
process status = "O" → "N" when NIC is idle

→ "W" when NIC is busy

Queue[5] → Queue[1] → process being served by NIC

→ queueNum



Process status "N" → "O"

passive event: "W" → "N"

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$$\pi_0\lambda = \pi_1\mu \quad \Rightarrow \pi_1 = \rho\pi_0$$

$$\pi_1\lambda = \pi_2\mu \quad \Rightarrow \pi_2 = \rho^2\pi_0$$

$$\vdots \qquad\qquad \vdots$$

$$\pi_{n-1}\lambda = \pi_n\mu \quad \Rightarrow \pi_n = \rho^n\pi_0$$

$$\pi_2 = \frac{\lambda}{\mu}\pi_1 = \rho\pi_1 = \rho^2\pi_0$$

$$\pi_n = \rho^n\pi_0$$

$$\sum_{i=0}^{\infty}\pi_i = 1 \Rightarrow \pi_0 + \rho\pi_0 + \rho^2\pi_0 + \rho^3\pi_0 + \cdots = 1$$

$$\Rightarrow \pi_0 = \frac{1}{1+\rho+\rho^2+\rho^3+\cdots} = 1-\rho$$

$$S = 1+\rho+\rho^2+\rho^3+\cdots$$

$$S = 1+\rho+\rho^2+\rho^3+\cdots$$

$$\rightarrow \rho S = \rho+\rho^2+\rho^3+\rho^4+\cdots$$

$$(1-\rho)S = 1+\rho^n_{n\to\infty} = 1 \Rightarrow S = \frac{1}{1-\rho}$$

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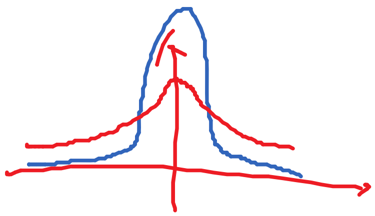
exp. distr. $\lambda = 0.2/\text{sec} \longrightarrow \text{mean} = \frac{1}{\lambda} = 5 \text{ sec}$

5-th Erlang distr. $\mu = 1/\text{sec} \longrightarrow \text{mean} = \frac{5}{\mu} = 5 \text{ sec}$



$$E[N] = \sum_{k=1}^{\infty} k\pi_k = \pi_0 \sum_{k=1}^{\infty} k\rho^k = \frac{\rho}{1-\rho}$$

$\pi_0 = 1-\rho$

$$S = \rho + 2\rho^2 + 3\rho^3 + 4\rho^4 + \cdots$$

$$-)\ \rho S = \rho^2 + 2\rho^3 + 3\rho^4 + 4\rho^5 + \cdots$$

$$(1-\rho)S = \rho + \rho^2 + \rho^3 + \rho^4 + \cdots = \frac{\rho}{1-\rho}$$

$$\Longrightarrow S = \frac{\rho}{(1-\rho)^2} \Longrightarrow E[N] = \frac{\rho}{1-\rho}$$

$$E[W] = E[N] \cdot E[X], \quad E[N] \to \frac{\rho}{1-\rho}, \quad E[X] \to \frac{1}{\mu}$$

$$= \frac{\lambda/\mu}{1-\lambda/\mu} \cdot \frac{1}{\mu} = \frac{\lambda}{\mu(\mu-\lambda)}$$

$$E[T] = \frac{1}{\mu} + E[W] = \frac{1}{\mu} + \frac{\lambda}{\mu(\mu-\lambda)} = \frac{\mu-\lambda+\lambda}{\mu(\mu-\lambda)} = \frac{1}{\mu-\lambda} = \frac{1}{1-\rho}\cdot\frac{1}{\mu}$$

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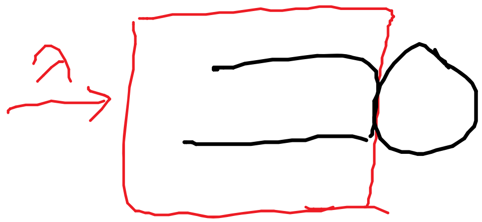

$N = \lambda T$

N: # of jobs in waiting queue

T: time in waiting