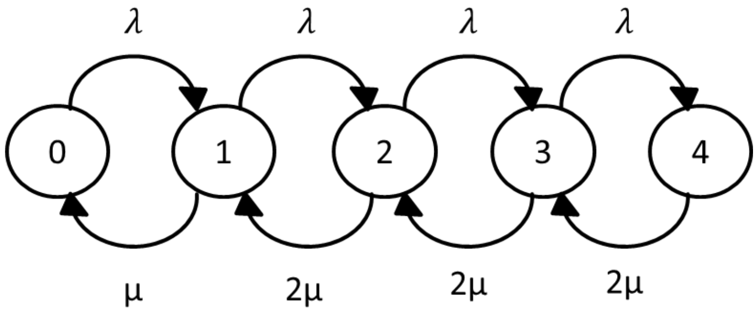
Exam
July 7, 2005

Exercise N. 2

Obtain the markovian process of a queue M/M/2/4 (2 servers, max 4 users in the system). Then calculate the probability, in parametric form, that a user at the request time is rejected from the queue, knowing the arrival rate ($\lambda = 0.5$) and the service rate ($\mu = 0.66$), the throughput and the utilization factor.



Flow-in = Flow-out :

$$\begin{cases} p_0\lambda = p_1 \cdot \mu \\ p_1\lambda = p_2 \cdot 2\mu \\ p_2\lambda = p_3 \cdot 2\mu \\ p_3\lambda = p_4 \cdot 2\mu \end{cases} \Rightarrow \begin{cases} p_1 = p_0 \left(\frac{\lambda}{\mu}\right) \\ p_2 = p_0 \left(\frac{\lambda}{\mu}\right)^2 \cdot \frac{1}{2} \\ p_3 = p_0 \left(\frac{\lambda}{\mu}\right)^3 \cdot \frac{1}{2} \cdot \frac{1}{2} \\ p_4 = p_0 \left(\frac{\lambda}{\mu}\right)^4 \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} \end{cases}$$

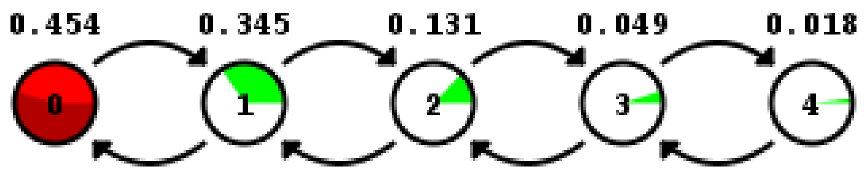
$$p_k = \begin{cases} p_0\left(\frac{\lambda}{\mu}\right)^k \frac{1}{k!}, & k \le 2 \\ p_0\left(\frac{\lambda}{\mu}\right)^k \frac{1}{2!2^{k-2}}, & k > 2 \end{cases}$$

$$\begin{cases} p_1 = p_0\left(\frac{0.5}{0.66}\right) \\ p_2 = p_0\left(\frac{0.5}{0.66}\right)^2 \cdot \frac{1}{2} \\ p_3 = p_0\left(\frac{0.5}{0.66}\right)^3 \cdot \frac{1}{4} \\ p_4 = p_0\left(\frac{0.5}{0.66}\right)^4 \cdot \frac{1}{8} \end{cases} \Rightarrow \begin{cases} p_1 = p_0 \cdot 0.757 \\ p_2 = p_0 \cdot 0.2869 \\ p_3 = p_0 \cdot 0.108 \\ p_4 = p_0 \cdot 0.0410 \end{cases}$$

$\sum_{k=0}^{4} p_k = 1$

$$\sum_{k=0}^{4} p_k = 1 = \sum_{k=0}^{2} p_0\left(\frac{\lambda}{\mu}\right)^k \frac{1}{k!} + \sum_{k=3}^{4} p_0\left(\frac{\lambda}{\mu}\right)^k \frac{1}{2!\,2^{k-2}}$$

$$p_0\left[\sum_{k=0}^{2}\left(\frac{\lambda}{\mu}\right)^k \frac{1}{k!} + \sum_{k=3}^{4}\left(\frac{\lambda}{\mu}\right)^k \frac{1}{2!\,2^{k-2}}\right] = 1$$



$$p_0 = \left[(0.7575)^0\frac{1}{0!} + (0.7575)^1\frac{1}{1!} + (0.7575)^2\frac{1}{2!} + (0.7575)^3\frac{1}{2!2^{3-2}} + (0.7575)^4\frac{1}{2!2^{4-2}}\right]^{-1} = 0.454$$

$p_1 = p_0 \cdot 0.7575 = 0.344$

$p_2 = p_0 \cdot 0.2869 = 0.131$

$p_3 = p_0 \cdot 0.108 = 0.049$

$p_4 = p_0 \cdot 0.0410 = 0.018$

Probability that a user at request time is rejected from the queue.

$\boldsymbol{X} = \boldsymbol{p_1} \cdot \mu + \sum_{i=2}^{4} \boldsymbol{p_i} \cdot \boldsymbol{2}\mu = 0{,}23 + 0{,}172 + 0{,}064 + 0{,}023 = 0{,}49\ users/sec$

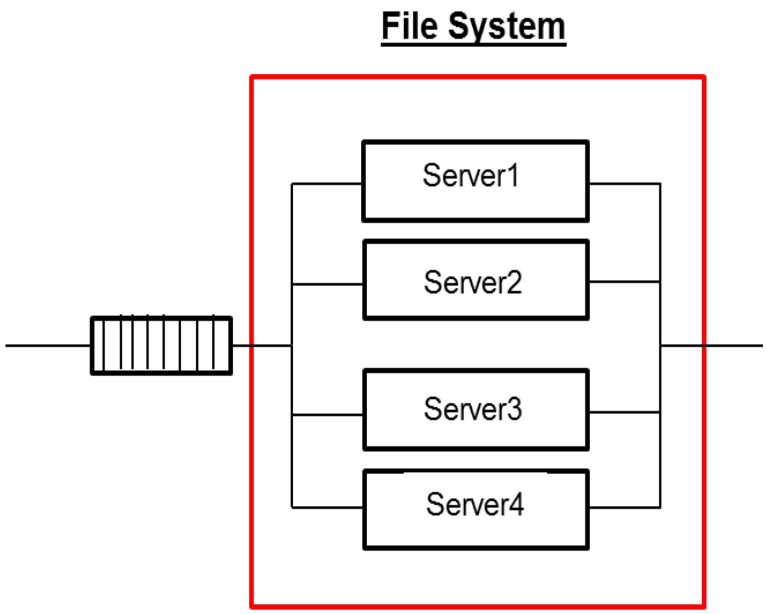
$\boldsymbol{U} = \frac{\lambda}{\mu} = 0{,}75$

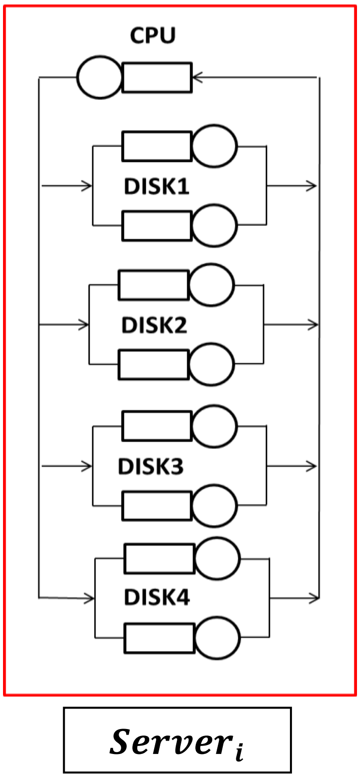
Exercise N. 3

Calculate performability of a read-only file system consists of 4 servers (CPU + memory + RAID1 consists of 8 disks (4+4)). Assume that all servers have the same data. Overall at most 6 users at same time can access to the servers and if all available servers are busy serving a request, then subsequent requests are queued. The average rate of requests, when a user is in the phase of think time, is equal to 1/10 sec^{-1} and service's rate is equal to 1/5 sec^{-1}, assuming that the server is operating according to the design specifications (i.e. is capable to process and to provide the informations on the system disk).

Also assume that:

- The disks faults happen with a rate equal to 1/(500 hours) and will be repaired with a rate equal to 1/(50 hours);
- The set CPU + memory faults happen with a rate equal to 1/(1000 hours) and will be repaired with a rate equal to 1/(10 hours).



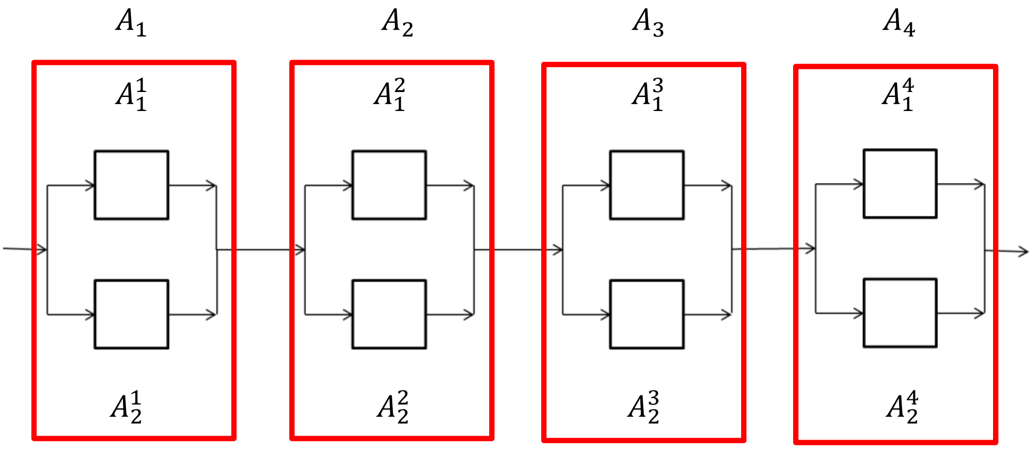


$$\boldsymbol{A_{SERVER} = A_{CPU} \cdot A_{RAID1}}$$

$$A_{CPU} = \frac{MTTF_{CPU}}{MTTF_{CPU} + MTTR_{CPU}} = \frac{1000}{1000 + 10} = 0{,}99$$

$$A_{DISK} = \frac{MTTF_{DISK}}{MTTF_{DISK} + MTTR_{DISK}} = \frac{500}{500 + 50} = 0{,}9$$

Availability RAID1 (4+4 disks):



$$\boldsymbol{A_{RAID1} = A_1 \cdot A_2 \cdot A_3 \cdot A_4}$$

$A_1 = 1 - (1 - A_1^1) \cdot (1 - A_2^1) = 1 - (1 - 0{,}9) \cdot (1 - 0{,}9) = 0{,}99$

$A_2 = 1 - (1 - A_1^2) \cdot (1 - A_2^2) = 1 - (1 - 0{,}9) \cdot (1 - 0{,}9) = 0{,}99$

$A_3 = 1 - (1 - A_1^3) \cdot (1 - A_2^3) = 1 - (1 - 0{,}9) \cdot (1 - 0{,}9) = 0{,}99$

$A_4 = 1 - (1 - A_1^4) \cdot (1 - A_2^4) = 1 - (1 - 0{,}9) \cdot (1 - 0{,}9) = 0{,}99$

$A_{RAID1} = 0{,}99 \cdot 0{,}99 \cdot 0{,}99 \cdot 0{,}99 = 0{,}96$

$A_{SERVER} = A_{CPU} \cdot A_{RAID1} = 0{,}99 \cdot 0{,}96 = 0{,}95$

To find the availability of the whole system:

$q_4 = prob\{0\ server\ funzionanti\} = (1 - A_{SERVER})^4 = (1 - 0{,}95)^4 = 0{,}00000625$

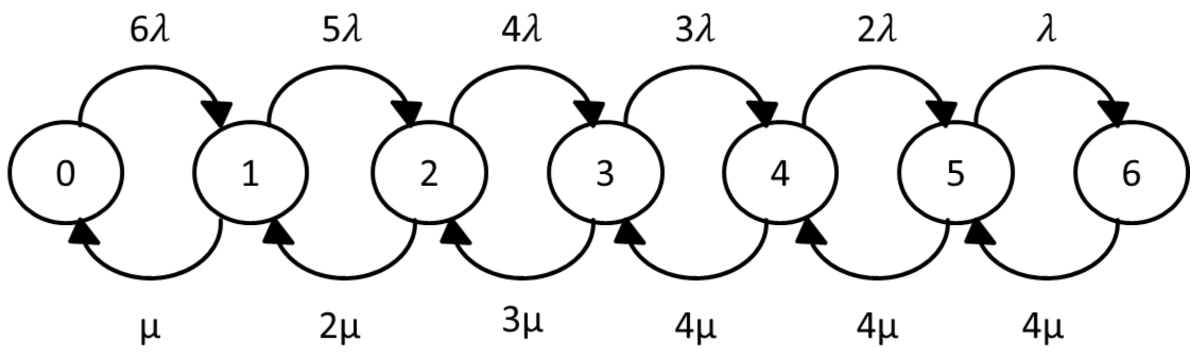
$q_3 = prob\{1\ server\ funzionanti\} = \binom{4}{3} \cdot A_{SERVER} \cdot (1 - A_{SERVER})^3 = \binom{4}{3} \cdot 0{,}95 \cdot (1 - 0{,}95)^3 = 0{,}000475$

$q_2 = prob\{2\ server\ funzionanti\} = \binom{4}{2} \cdot (A_{SERVER})^2 \cdot (1 - A_{SERVER})^2 = \binom{4}{2} \cdot (0{,}95)^2 \cdot (1 - 0{,}95)^2 = 6 \cdot 0{,}90 \cdot 0{,}0025 = 0{,}01$

$q_1 = prob\{3\ server\ funzionanti\} = 4 \cdot (A_{SERVER})^3 \cdot (1 - A_{SERVER}) = 4 \cdot 0{,}85 \cdot 0{,}05 = 0{,}17$

$q_0 = prob\{4\ server\ funzionanti\} = (A_{SERVER})^4 = 0{,}81$

Considering that each state represent the number of user in the system, we have:



Flow-in = Flow-out :

$$\begin{cases} p_0 \cdot 6\lambda = p_1 \cdot \mu \\ p_1 \cdot 5\lambda = p_2 \cdot 2\mu \\ p_2 \cdot 4\lambda = p_3 \cdot 3\mu \\ p_3 \cdot 3\lambda = p_4 \cdot 4\mu \\ p_4 \cdot 2\lambda = p_5 \cdot 4\mu \\ p_5 \cdot \lambda = p_6 \cdot 4\mu \end{cases} \Rightarrow \begin{cases} p_1 = p_0 \left(\frac{\lambda}{\mu}\right) \cdot 6 \\ p_2 = p_0 \left(\frac{\lambda}{\mu}\right)^2 \cdot \frac{6 \cdot 5}{2} \\ p_3 = p_0 \left(\frac{\lambda}{\mu}\right)^3 \cdot \frac{6 \cdot 5 \cdot 4}{2 \cdot 3} \\ p_4 = p_0 \left(\frac{\lambda}{\mu}\right)^4 \cdot \frac{6 \cdot 5 \cdot 4 \cdot 3}{2 \cdot 3 \cdot 4} \\ p_5 = p_0 \left(\frac{\lambda}{\mu}\right)^5 \cdot \frac{6 \cdot 5 \cdot 4 \cdot 3 \cdot 2}{2 \cdot 3 \cdot 4 \cdot 4} \\ p_6 = p_0 \left(\frac{\lambda}{\mu}\right)^6 \cdot \frac{6 \cdot 5 \cdot 4 \cdot 3 \cdot 2}{2 \cdot 3 \cdot 4 \cdot 4 \cdot 4} \end{cases}$$

$$p_j = \begin{cases} p_0 \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\, j!}, & j \leq 4 \\ p_0 \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\, 4!\, 4^{j-4}}, & j > 4 \end{cases}$$

Consider k = number of working server, we have:

$$p_j(k) = \begin{cases} p_0 \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\, j!}, & j \leq k \\ p_0 \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\, k!\, k^{j-k}}, & j > k \end{cases}$$

$$\sum_{j=0}^{6} p_j = 1$$

$$p_0\left[\sum_{j=0}^{k}\left(\frac{\lambda}{\mu}\right)^j\binom{6}{j}+\sum_{j=k+1}^{6}\left(\frac{\lambda}{\mu}\right)^j\frac{6!}{(6-j)!\,k!\,k^{j-k}}\right]=1$$

$$\boldsymbol{p_0}=\left[\sum_{j=0}^{k}\left(\frac{\lambda}{\mu}\right)^j\binom{6}{j}+\sum_{j=k+1}^{6}\left(\frac{\lambda}{\mu}\right)^j\frac{6!}{(6-j)!k!k^{j-k}}\right]^{-1}$$

If k = 4 (4 working servers):

$$p_0=\left[\sum_{j=0}^{4}\left(\frac{\lambda}{\mu}\right)^j\binom{6}{j}+\sum_{j=4+1}^{6}\left(\frac{\lambda}{\mu}\right)^j\frac{6!}{(6-j)!4!4^{j-4}}\right]^{-1}=[1+0{,}5\cdot 6+0{,}25\cdot 15+0{,}125\cdot 20+0{,}0625\cdot 15+0{,}031\cdot 7{,}5+0{,}0156\cdot 1{,}875]^{-1}=0{,}087$$

If k = 3 (3 working servers):

$$p_0=\left[\sum_{j=0}^{3}\left(\frac{\lambda}{\mu}\right)^j\binom{6}{j}+\sum_{j=3+1}^{6}\left(\frac{\lambda}{\mu}\right)^j\frac{6!}{(6-j)!3!3^{j-3}}\right]^{-1}=[1+0{,}5\cdot 6+0{,}25\cdot 15+0{,}125\cdot 20+0{,}0625\cdot 20+0{,}031\cdot 13{,}33+0{,}0156\cdot 4{,}44]^{-1}=0{,}083$$

If k = 2 (2 working servers):

$$p_0=\left[\sum_{j=0}^{2}\left(\frac{\lambda}{\mu}\right)^j\binom{6}{j}+\sum_{j=2+1}^{6}\left(\frac{\lambda}{\mu}\right)^j\frac{6!}{(6-j)!2!2^{j-2}}\right]^{-1}=[1+0{,}5\cdot 6+0{,}25\cdot 15+0{,}125\cdot 30+0{,}0625\cdot 45+0{,}031\cdot 45+0{,}0156\cdot 22{,}5]^{-1}=0{,}062$$

If k = 1 (1 working servers):

$$p_0=\left[\sum_{j=0}^{1}\left(\frac{\lambda}{\mu}\right)^j\binom{6}{j}+\sum_{j=1+1}^{6}\left(\frac{\lambda}{\mu}\right)^j\frac{6!}{(6-j)!1!1^{j-1}}\right]^{-1}=[1+0{,}5\cdot 6+0{,}25\cdot 30+0{,}125\cdot 120+0{,}0625\cdot 360+0{,}031\cdot 720+0{,}0156\cdot 720]^{-1}=0{,}012$$

Throughput of the web server and its response time when in the file system there are n faulty server:

$$\boldsymbol{X(n) = \sum_{j=1}^{6} p_j\,(4-n) X_0(j)}$$

$$X(0) = \sum_{j=1}^{6} p_j\,(4) X_0(j) = \sum_{j=1}^{4} 0{,}087 \cdot \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\,j!} X_0(j) + \sum_{j=5}^{6} 0{,}087 \cdot \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\,4!\,4^{j-4}} X_0(j) = 0{,}087 \cdot 0{,}5 \cdot 6 \cdot 0{,}2 + 0{,}087 \cdot 0{,}25 \cdot 15 \cdot 0{,}4 + 0{,}087 \cdot 0{,}125 \cdot 20 \cdot 0{,}6 + 0{,}087 \cdot 0{,}0625 \cdot 15 \cdot 0{,}8 + 0{,}087 \cdot 0{,}031 \cdot 7{,}5 \cdot 0{,}8 + 0{,}087 \cdot 0{,}01 \cdot 1{,}875 \cdot 0{,}8 = 0{,}05 + 0{,}13 + 0{,}13 + 0{,}06 + 0{,}016 + 0{,}0013 = 0{,}3873$$

$$X(1) = \sum_{j=1}^{6} p_j\,(3) X_0(j) = \sum_{j=1}^{3} 0{,}083 \cdot \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\,j!} X_0(j) + \sum_{j=4}^{6} 0{,}083 \cdot \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\,3!\,3^{j-3}} X_0(j) = 0{,}083 \cdot 0{,}5 \cdot 6 \cdot 0{,}2 + 0{,}083 \cdot 0{,}25 \cdot 15 \cdot 0{,}4 + 0{,}083 \cdot 0{,}125 \cdot 20 \cdot 0{,}6 + 0{,}083 \cdot 0{,}0625 \cdot 20 \cdot 0{,}6 + 0{,}083 \cdot 0{,}031 \cdot 13{,}33 \cdot 0{,}6 + 0{,}083 \cdot 0{,}01 \cdot 4{,}44 \cdot 0{,}6 = 0{,}05 + 0{,}12 + 0{,}12 + 0{,}062 + 0{,}020 + 0{,}002 = 0{,}3743$$

$$X(2) = \sum_{j=1}^{6} p_j\,(2) X_0(j) = \sum_{j=1}^{2} 0{,}062 \cdot \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\,j!} X_0(j) + \sum_{j=3}^{6} 0{,}062 \cdot \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\,2!\,2^{j-2}} X_0(j) = 0{,}062 \cdot 0{,}5 \cdot 6 \cdot 0{,}2 + 0{,}062 \cdot 0{,}25 \cdot 15 \cdot 0{,}4 + 0{,}062 \cdot 0{,}125 \cdot 30 \cdot 0{,}4 + 0{,}062 \cdot 0{,}0625 \cdot 45 \cdot 0{,}4 + 0{,}062 \cdot 0{,}031 \cdot 45 \cdot 0{,}4 + 0{,}062 \cdot 0{,}01 \cdot 22{,}5 \cdot 0{,}4 = 0{,}037 + 0{,}093 + 0{,}093 + 0{,}069 + 0{,}034 + 0{,}0055 = 0{,}3315$$

$$X(3) = \sum_{j=1}^{6} p_j\,(1) X_0(j) = 0{,}012 \cdot \left(\frac{\lambda}{\mu}\right)^1 \frac{6!}{(6-1)!\,1!} X_0(1) + \sum_{j=2}^{6} 0{,}012 \cdot \left(\frac{\lambda}{\mu}\right)^j \frac{6!}{(6-j)!\,1!\,1^{j-1}} X_0(j) = 0{,}012 \cdot 0{,}5 \cdot 6 \cdot 0{,}2 + 0{,}012 \cdot 0{,}25 \cdot 30 \cdot 0{,}2 + 0{,}012 \cdot 0{,}125 \cdot 120 \cdot 0{,}2 + 0{,}012 \cdot 0{,}0625 \cdot 360 \cdot 0{,}2 + 0{,}012 \cdot 0{,}031 \cdot 720 \cdot 0{,}2 + 0{,}012 \cdot 0{,}01 \cdot 720 \cdot 0{,}2 = 0{,}0072 + 0{,}018 + 0{,}036 + 0{,}054 + 0{,}053 + 0{,}017 = 0{,}185$$

$\boldsymbol{N(n) = \sum_{j=1}^{6} p_j(4-n) \cdot j}$

$N(0) = \sum_{j=1}^{6} p_j(4) \cdot j = \sum_{j=1}^{4} p_0 \cdot \left(\frac{\lambda}{\mu}\right)^j \cdot \frac{6!}{(6-j)!\,j!} \cdot j + \sum_{j=5}^{6} p_0 \cdot \left(\frac{\lambda}{\mu}\right)^j \cdot \frac{6!}{(6-j)!\,4!\,4^{j-4}} \cdot \mathrm{j} = 0{,}087 \cdot 0{,}5 \cdot 6 \cdot 1 + 0{,}087 \cdot 0{,}25 \cdot 15 \cdot 2 + 0{,}087 \cdot 0{,}125 \cdot 20 \cdot 3 + 0{,}087 \cdot 0{,}0625 \cdot 15 \cdot 4 + 0{,}087 \cdot 0{,}031 \cdot 7{,}5 \cdot 5 + 0{,}087 \cdot 0{,}01 \cdot 1{,}875 \cdot 6 = 0{,}261 + 0{,}65 + 0{,}65 + 0{,}326 + 0{,}1 + 0{,}0097 = 1{,}996$

$N(1) = \sum_{j=1}^{6} p_j(3) \cdot j = \sum_{j=1}^{3} p_0 \cdot \left(\frac{\lambda}{\mu}\right)^j \cdot \frac{6!}{(6-j)!\,j!} \cdot j + \sum_{j=4}^{6} p_0 \cdot \left(\frac{\lambda}{\mu}\right)^j \cdot \frac{6!}{(6-j)!\,3!\,3^{j-3}} \cdot \mathrm{j} = 0{,}083 \cdot 0{,}5 \cdot 6 \cdot 1 + 0{,}083 \cdot 0{,}25 \cdot 15 \cdot 2 + 0{,}083 \cdot 0{,}125 \cdot 20 \cdot 3 + 0{,}083 \cdot 0{,}0625 \cdot 20 \cdot 4 + 0{,}083 \cdot 0{,}031 \cdot 13{,}33 \cdot 5 + 0{,}083 \cdot 0{,}01 \cdot 4{,}4 \cdot 6 = 0{,}249 + 0{,}622 + 0{,}622 + 0{,}415 + 0{,}171 + 0{,}021 = 2{,}1$

$N(2) = \sum_{j=1}^{6} p_j(2) \cdot j = \sum_{j=1}^{2} p_0 \cdot \left(\frac{\lambda}{\mu}\right)^j \cdot \frac{6!}{(6-j)!\,j!} \cdot j + \sum_{j=3}^{6} p_0 \cdot \left(\frac{\lambda}{\mu}\right)^j \cdot \frac{6!}{(6-j)!\,2!\,2^{j-2}} \cdot \mathrm{j} = 0{,}062 \cdot 0{,}5 \cdot 6 \cdot 1 + 0{,}062 \cdot 0{,}25 \cdot 15 \cdot 2 + 0{,}062 \cdot 0{,}125 \cdot 30 \cdot 3 + 0{,}062 \cdot 0{,}0625 \cdot 45 \cdot 4 + 0{,}062 \cdot 0{,}031 \cdot 45 \cdot 5 + 0{,}062 \cdot 0{,}01 \cdot 22{,}5 \cdot 6 = 0{,}186 + 0{,}465 + 0{,}697 + 0{,}697 + 0{,}432 + 0{,}0837 = 2{,}56$

$N(3) = \sum_{j=1}^{6} p_j(1) \cdot j = p_0 \cdot \left(\frac{\lambda}{\mu}\right)^1 \cdot \frac{6!}{(6-1)!\,1!} \cdot 1 + \sum_{j=2}^{6} p_0 \cdot \left(\frac{\lambda}{\mu}\right)^j \cdot \frac{6!}{(6-j)!\,1!\,1^{j-1}} \cdot \mathrm{j} = 0{,}012 \cdot 0{,}5 \cdot 6 \cdot 1 + 0{,}012 \cdot 0{,}25 \cdot 30 \cdot 2 + 0{,}012 \cdot 0{,}125 \cdot 120 \cdot 3 + 0{,}012 \cdot 0{,}0625 \cdot 360 \cdot 4 + 0{,}012 \cdot 0{,}031 \cdot 720 \cdot 5 + 0{,}012 \cdot 0{,}01 \cdot 720 \cdot 6 = 0{,}036 + 0{,}18 + 0{,}54 + 1{,}08 + 1{,}33 + 0{,}51 = 3{,}68$

$\boldsymbol{R(n) = \frac{N(n)}{X(n)}}$

$R(0) = \frac{N(0)}{X(0)} = \frac{1{,}996}{0{,}3873} = 5{,}15$

$$R(1) = \frac{N(1)}{X(1)} = \frac{2{,}1}{0{,}3743} = 5{,}61$$

$$R(2) = \frac{N(2)}{X(2)} = \frac{2{,}56}{0{,}3315} = 7{,}72$$

$$R(3) = \frac{N(3)}{X(3)} = \frac{3{,}68}{0{,}185} = 19{,}89$$

The throughput and the response time of the whole file system:

$$\boldsymbol{X_{tot} = \sum_{n=0}^{3} q_n X(n)(4-n)}$$

$$X_{tot} = \sum_{n=0}^{3} q_n X(n)(4-n) = q_0 \cdot X(0) \cdot (4) + q_1 \cdot X(1) \cdot (3) + q_2 \cdot X(2) \cdot (2) + q_3 \cdot X(3) \cdot (1) = 0{,}81 \cdot 0{,}3873 \cdot 4 + 0{,}17 \cdot 0{,}3743 \cdot 3 + 0{,}01 \cdot 0{,}3315 \cdot 2 + 0{,}000475 \cdot 0{,}185 \cdot 1 = 1{,}254 + 0{,}190 + 0{,}0066 + 0{,}00008 = 1{,}45$$

$$\boldsymbol{R_{tot} = \frac{1}{1-q_4} \sum_{n=0}^{3} q_n R(n)}$$

$$R_{tot} = \frac{1}{1-q_4} \sum_{n=0}^{3} q_n R(n) = \frac{1}{1-q_4} \cdot q_0 \cdot R(0) + \frac{1}{1-q_4} \cdot q_1 \cdot R(1) + \frac{1}{1-q_4} \cdot q_2 \cdot R(2) + \frac{1}{1-q_4} \cdot q_3 \cdot R(3) = 0{,}81 \cdot 5{,}15 + 0{,}17 \cdot 5{,}61 + 0{,}01 \cdot 7{,}72 + 0{,}000475 \cdot 19{,}89 =$$

$$4{,}17 + 0{,}95 + 0{,}077 + 0{,}009 = 5{,}20$$

Fraction of rejected requests:

Probability 4 faulty servers

Probability al least 1 working server

Probability there are 6 requests

$$\boldsymbol{q_4 + \sum_{k=0}^{3} q_k \cdot p_6(4-k)}$$

$$\boldsymbol{q_4} + \sum_{\boldsymbol{k=0}}^{\boldsymbol{3}} \boldsymbol{q_k} \cdot \boldsymbol{p_6}(\boldsymbol{4} - \boldsymbol{k}) = 0{,}00000625 + 0{,}81 \cdot 0{,}0016 + 0{,}17 \cdot 0{,}0036 + 0{,}01 \cdot 0{,}013 + 0{,}000475 \cdot 0{,}086 = 0{,}00000625 + 0{,}0013 + 0{,}0006 + 0{,}0001 + 0{,}00004 = 0{,}002$$