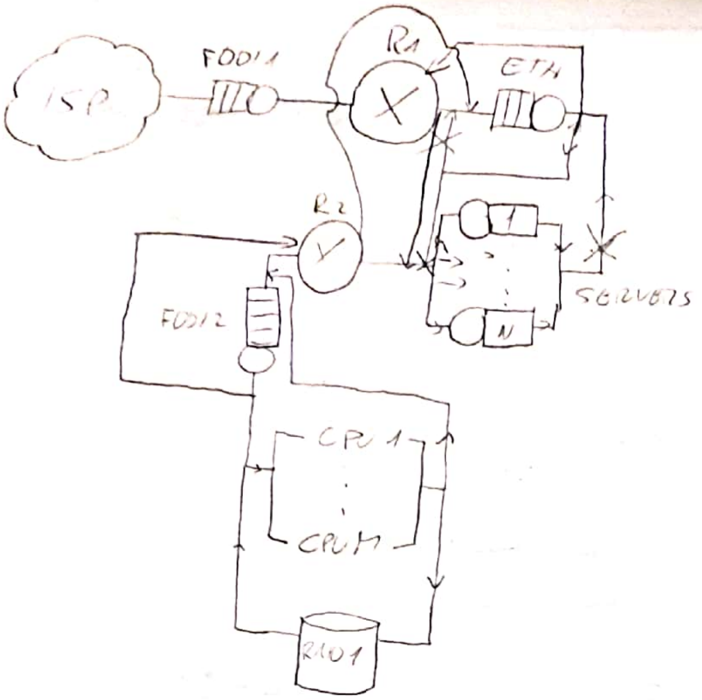
① ~~RXXXX~~



$|RES| = 200$ kbytes

$\lambda = 200$ Reqs/sec

$|REQ| = 400$ bytes

N servers
↓
CPU+RAM

FS: $\begin{cases} M \text{ CPU\_FS} \\ \text{RAID1} \quad 2L \text{ disks } (L+L) \end{cases}$

$ETH_B = 10$ Gbit/s

$R_{1L} = 10\ \mu s$/packet

~~FDDI = 5 Gbit/s~~

$FDDI_1 = 5$ Gbit/s

$FDDI_2 = 8$ Gbit/s

$R_{2L} = 10\ \mu s$/packet

$S_{CPU}^{MISS} = 20$ ms

$S_{CPU}^{HIT} = 10$ ms

$S_{CPU\_FS} = 20$ ms

$S_{DISK} = 10$ ms for 10kb

MAX 3 users CPU

infinite FS

$P_{HIT} = 50\%$

$R < 1$ sec

$P_{LOST} < 10\%$

NETWORK:

$$D_{FDDI1} = S_{FDDI1,REQ} + S_{FDDI1,RES}$$

$$S_{FDDI1,REQ} = \frac{[|400| + (FDDI_{OVD} + TCP_{OVD} + IP_{OVD}) \cdot \#PACK] \cdot 8}{FDDI1_B}$$

$$S_{FDDI1,RES} = \frac{[|200000| + (\text{-- -- --}) \cdot \#PACK] \cdot 8}{FDDI1_B}$$

$\#PACK_{REQ} = 3+1$ 2H — Handshake & connection

$\#PACK_{RES} = \begin{cases} \text{Hp: TCP knows MTU} \\ TCP: 20|1460 \cdot 136 \quad IP: 20|20|1460 \cdot 136 \\ 20|1440 \cdot 1 \quad 20|20|1440 \cdot 1 \end{cases}$

FDDI: $28|20|20|1460 \cdot 136$
$28|20|20|1440 \cdot 1$

$$S_{FDDI1,REQ} = \frac{[400 + 68 \cdot 7] \cdot 8}{5 \cdot 10^9} = 1.08 \cdot 10^{-6} \text{ secs}$$

3 packets to close connection

$$S_{FDDI1,RES} = \frac{[200000 + (137+3) \cdot 68] \cdot 8}{5 \cdot 10^9} = 335.2 \cdot 10^{-6} \text{ secs}$$

$D_{FDDI1} = 3.36 \cdot 10^{-4}$ secs $= 0.336 \cdot 10^{-3}$ secs.

Visits al router 1: $144 \cdot 10\ \mu s$ ~~[illegible]~~ $1.44 \cdot 10^{-3}$

$$D_{ETH} = \frac{[200000 + (137+3)\cdot O_{VO} + 400 + 3\cdot O_{VO}]\cdot 8}{10\,\cancel{3}\cdot 10^9} = 0.167\cdot 10^{-3}\ sec$$

$O_{VO} = TCP_{OVO} + IP_{OVO} + ETH_{OVO} = 20 + 20 \cdot 18 = 58$

~~[illegible]~~ In the ethernet network ~~[illegible]~~ travel every request and every response.

$D_{F001,2}$ equal to $D_{F001,1}$ but with bandwidth different. So we repeat same calculus:

$$D_{F001,2} = S_{F001,2\ REQ} + S_{F001,2\ RES} = \frac{[400 + 68\cdot 4)]\cdot 8}{8\cdot 10^9} + \frac{[200000 + (\overset{140\cdot 68}{\cancel{60}})]\cdot 8}{8\cdot 10^9}$$

$= 0.672\cdot 10^{-6} + 209.52\cdot 10^{-6}$

$= 0.210\cdot 10^{-3}\ secs.$ X

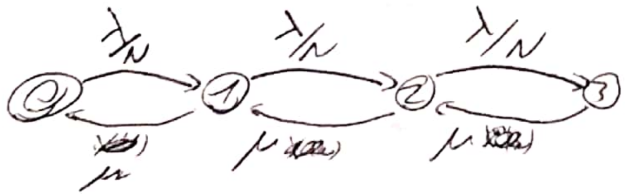
Visite al Router 2 $= 140 + 4 \cdot$ ~~[illegible]~~ $= 144\cdot 10\mu s$

$= 1.4\cdot 10^{-3}$

SERVERS We calculate the average service demand of each server:

$$D_{CPU} = S_{CPU}^{HIT}\cdot P_{HIT} + S_{CPU}^{MISS}\cdot P_{miss} = 15\ ms$$

SINGLE SERVER MARKOV MODEL



$$\begin{cases} \mu P_1 = P_0\,\lambda/N \\ \mu P_2 = P_1\,\lambda/N \\ \mu P_3 = P_2\,\lambda/N \end{cases} \Rightarrow \begin{cases} P_1 = P_0\left(\frac{\lambda}{N\mu}\right) \\ P_2 = P_0\left(\frac{\lambda}{N\mu}\right)^2 \\ P_3 = P_0\cdot\left(\frac{\lambda}{N\mu}\right)^3 \\ \sum P_i = 1 \end{cases}$$

$$P_0 = \frac{1}{1 + \left(\frac{\lambda}{N\mu}\right) + \left(\frac{\lambda}{N\mu}\right)^2 + \left(\frac{\lambda}{N\mu}\right)^3}$$

single server $\rightarrow X = \sum P_i \cdot \mu \qquad N = \sum P_i \cdot i \qquad R = \frac{N}{X}$

$X_{TOT} = N \cdot X$

# of servers

FILE-SYSTEM

$$D_{CPU-FS} = 10\,ms \qquad \lambda_{FS} = \frac{\lambda}{M} \cdot P_{min}$$

$$D_{DISK} = 10\,ms \cdot \frac{\cancel{200000}}{\cancel{10000}} = 200\,ms \qquad \lambda_{DISK} = \frac{\lambda}{L} \cdot P_{min}$$

$$\lambda_{MAX} = \frac{1}{D_{max}} = \frac{1}{D_{DISK}} = \frac{1}{200} =$$

$D_{max} \rightarrow$ bottleneck

from now on we are going to use λ_{max} for U_i.

$$U_i = D_i \cdot \lambda_{MAX} \Rightarrow \quad U_{CPU} = D_{CPU} \cdot \frac{\lambda_{MAX}}{N}$$

$$U_{CPU-FS} = D_{CPUFS} \cdot \frac{\lambda_{MAX}}{M} \cdot P_{min}$$

$$U_{DISK} = D_{DISK} \cdot \frac{\lambda_{MAX}}{L} \cdot P_{min}$$

$$R_{CPU} = \frac{D_{CPU}}{1-U_{CPU}}$$

$$R_{CPU-FS} = \frac{D_{CPU-FS}}{1-U_{CPU-FS}} \quad \Rightarrow R = \sum R_i < 1$$

$$R_{DISK} = \frac{D_{DISK}}{1-U_{DISK}}$$

From these equations ~~we~~ can retrieve M, N and L

The percentage of requests lost can be calculated using P_3 of the previous Markov Model:

$$\% = P_3 < 10\%$$

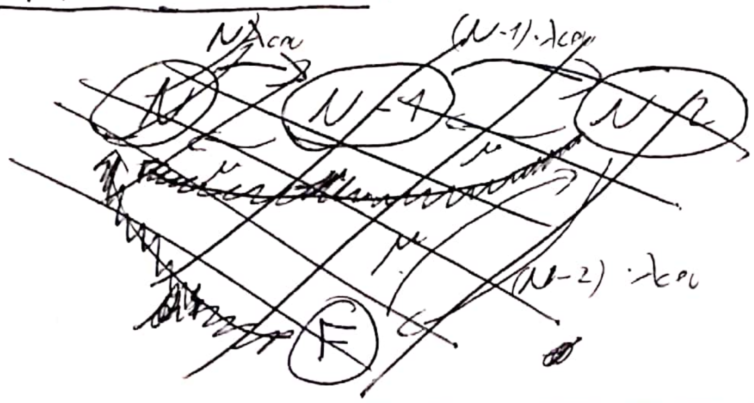
we can find the right P_3 value changing the number of servers.

AVAILABILITY:

We can evaluate Availability using Combinatorial model or Markov:

~~Combinatorial~~

CPU + RAM SERVERS:



$P_N(t+\Delta t) = P_N(t)\cdot(1-N\lambda_c) + P_{N-1}(t)\mu$

$P_{N-1}(t+\Delta t) = P_{N-1}(t)(1-(N-1)\lambda_c) + P_{N-2}(t)\mu$

$P_{N-2}(t+\Delta t) = P_{N-2}(t)\cdot(1-(N-2)\lambda_c) + P_F(t)\mu$

$P_F(t+\Delta t) = P_{N-2}(t)(N-2)\lambda_c$

$\sum P_i = 1$

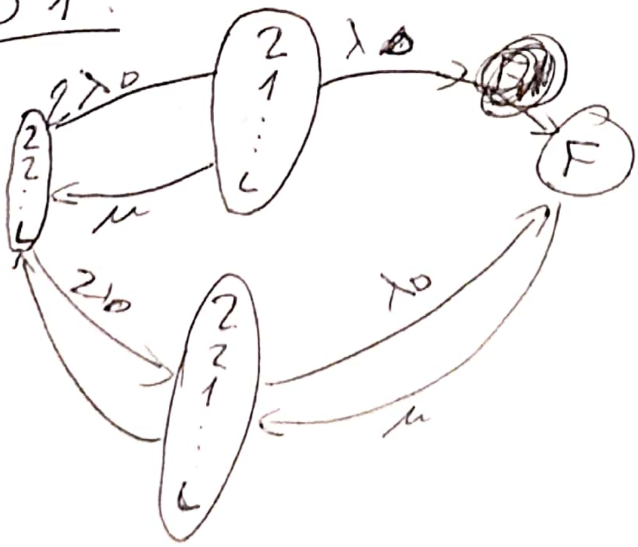
$A_{SERVER} = 1 - P_F$

COMBINATORIAL: $\boxed{\text{CONTINUA A PAGINA DOPO}}$

$$A_i = \frac{1/\lambda_i}{1/\mu + 1/\lambda_i} \Rightarrow A_{SERVER} = \cancel{A_1(1-A_2)}\ 1 - [(1-A_1)\cdot(1-A_2)\cdots]$$

Equal for CPUs of file system just substituting N with M

RAID 1:



We continue for all ~~combinat~~ combination and then can calculate P_i.

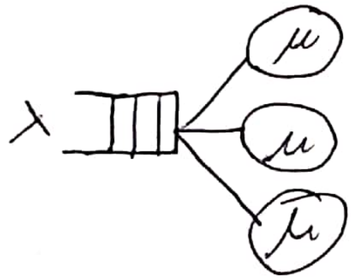
Combinatorial:

$A_{COPPIA} = 1 - (1 - A_{DISK})^2$

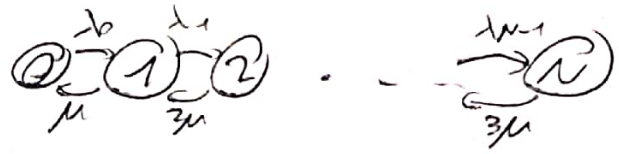
$A_{RAID} = A_{COPPIA}^{\,L}$

②

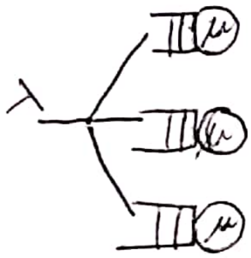
M/M/3 Indicate service and arrival rates exponential distributed and 3 servers in the system.

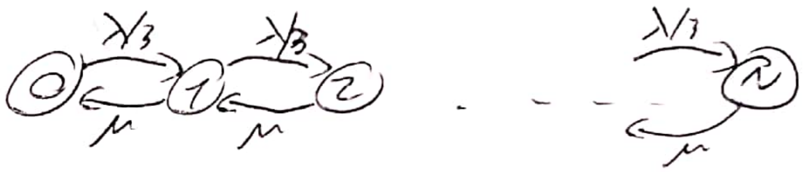


With infinite queue



3/M/M/1 optimise the previous configuration





$$\begin{cases} P_N(t+\Delta t) = P_N(t)\cdot(1-N\lambda_c) + P_{(N-1)}(t)(\mu)\cdot\Delta t \\ P_{N-1}(t+\Delta t) = P_{N-1}(t)\cdot(1-(N-1)\cdot\lambda_c) + P_{N-2}(t)(\mu)\cdot\Delta t + P_N(t)\cdot N\lambda\cdot\Delta t \\ P_{N-2}(t+\Delta t) = P_{N-2}(t)\cdot(1-(N-2)\cdot\lambda_c) + P_F(t)\cdot\mu\cdot\Delta t + P_{N-1}(t)\cdot(N-1)\lambda\cdot\Delta t \\ P_F(t+\Delta t) = P_F(t)\cdot(1-\mu) + P_{N-2)}(t)(\cdot(N-2)\cdot\lambda)\cdot\Delta t \\ \sum_i P_i = 1 \\ P_N(\emptyset) = 1 \end{cases}$$

$$A = 1 - P_F$$

Then we derivate the equations and solve the systems of equations.

CPU + RAM : (SERVERS)