CAPACITY PLANNING

20 june 2012

Name of the student

Exercise n. 1

Evaluate the reliability, the steady state availability and the safety of a system composed of five CPU (working in parallel and whose output is given by a voter), one RAID 2 system with four disks for data, two bus system (working in parallel and whose outputs are given by voters), one keyboard, one printer and one monitor, with the hypothesis that the faults happen according to an exponential distribution with rate equal to λ_{CPU}, λ_{DISK}, λ_{BUS}, λ_{KEY}, λ_{MON}, λ_{PRI}, $\lambda_{VOTER\text{-}CPU}$, $\lambda_{VOTER\text{-}BUS}$, with covering factors equal to C_{CPU}, C_{DISK}, C_{BUS}, C_{KEY}, C_{MON}, C_{PRI} (the covering factor for the voters is equal to one) and with the same repair rate (μ) for all kind of components. A single "repair technician for component type" is available and the repair rate is independently by the number of fault occurrences of the same type.

N.B. Advice: evaluate each global index analyzing by single subsystem.

Exercise n. 2

Evaluate the average response time and throughput for a system composed of a single server with a finite queue (at most 5 users in the system), with a finite number of users (number of users equal 8), given that the think time for each user is 30 sec and the service rate is 20 sec.

Exercise n.3

A Web site receives 10 requests per second. These requests are served by a cluster of 2 identical servers, composed only by a CPU (CPU-SERVER) and by a main memory RAM, and by a file server composed by a CPU (CPU-FS) and by 4 disks (all with the same data), all connected to an Ethernet with a bandwidth of 1GB/sec. The Ethernet is connected to internet by a router (with negligible delay). The average file dimension is of 10Kbytes, instead the requests have a dimension of 300 bytes. A workload balancer divides in equal parts the load among the servers, even for the four disk there is a load balancer. In case of hit the request needs 10 ms of CPU, instead in case of miss the request needs of 20 msec of CPU-SERVER, 10 msec of CPU-FS and 20 msec of DISK. The probability of hit is 80%.

Every component type (CPU, DISK, Ethernet, Router) has a MTTF equal to 10.000 hours and a MTTR equal to 10 hours.

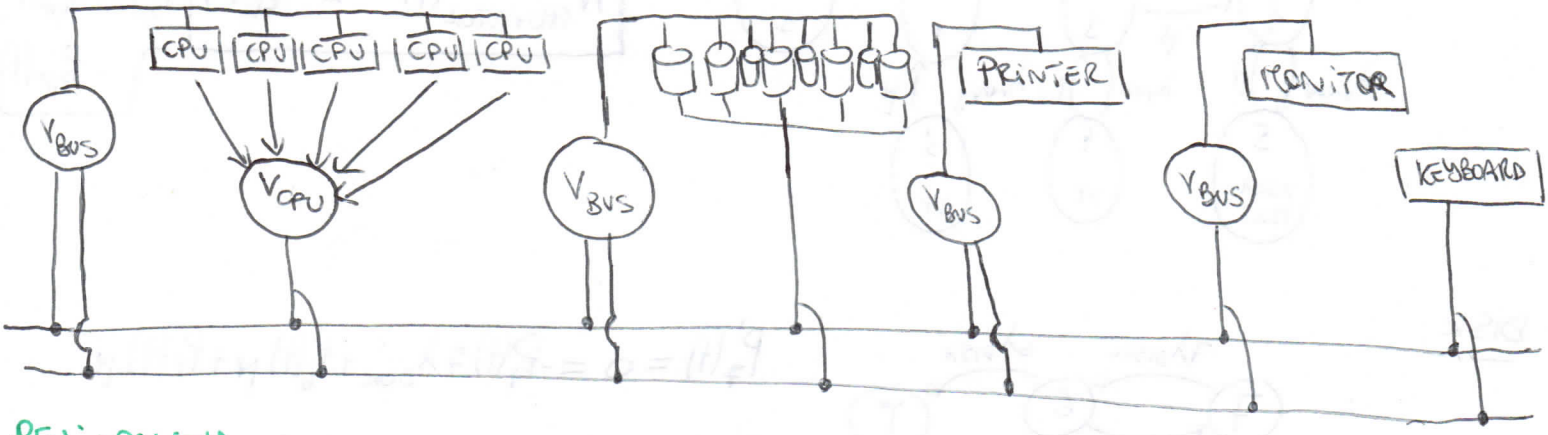
You have

1) To evaluate the average service time and the average throughput when all che component are fault-free.
2) Identify the system performance bottleneck
3) To show the methodology to evaluate the average service time when there is the possibility of faults and recoveries.

20/06/2012

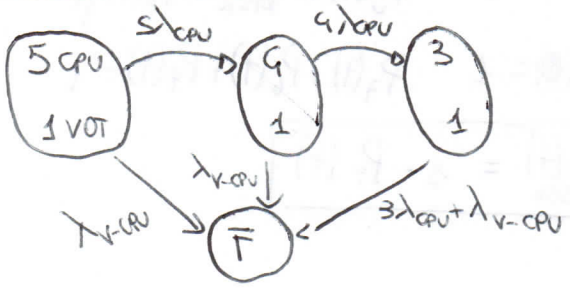
EX 1

HP: SWITCH OFF THE SYSTEM AS SOON AS A COMPONENT IS FAULTY



RELIABILITY

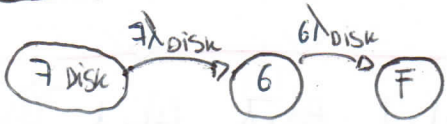
CPU SUBSYSTEM + VOTER-CPU



$$\begin{cases} P'_{5,1}(t) = -P_{5,1}(t)5\lambda_{CPU} - P_{5,1}(t)\lambda_{V\text{-}CPU} \\ P'_{4,1}(t) = P_{5,1}(t)5\lambda_{CPU} - P_{4,1}(t)4\lambda_{CPU} - P_{4,1}(t)\lambda_{V\text{-}CPU} \\ P'_{3,1}(t) = P_{4,1}(t)4\lambda_{CPU} - P_{3,1}(t)(3\lambda_{CPU} + \lambda_{VCPU}) \\ P'_{F}(t) = P_{5,1}(t)\lambda_{V\text{-}CPU} + P_{4,1}(t)\lambda_{V\text{-}CPU} + P_{3,1}(t)(3\lambda_{CPU} + \lambda_{V\text{-}CPU}) \\ P_{5,1}(0) = 1 \qquad P_{5,1} + P_{4,1} + P_{3,1} + P_F = 1 \end{cases}$$

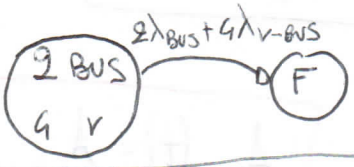
$$\boxed{R_{CPU+VOTER}(t) = 1 - P_F(t)}$$

RAID SUBSYSTEM



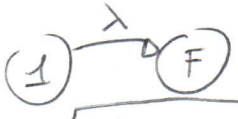
$$\boxed{R_{DISK}(t) = 1 - P_F(t)}$$

BUS + VOTER SUBSYSTEM



$$\boxed{R_{BUS+VOTER}(t) = 1 - P_F(t)}$$

PRINTER / MONITOR / KEYBOARD

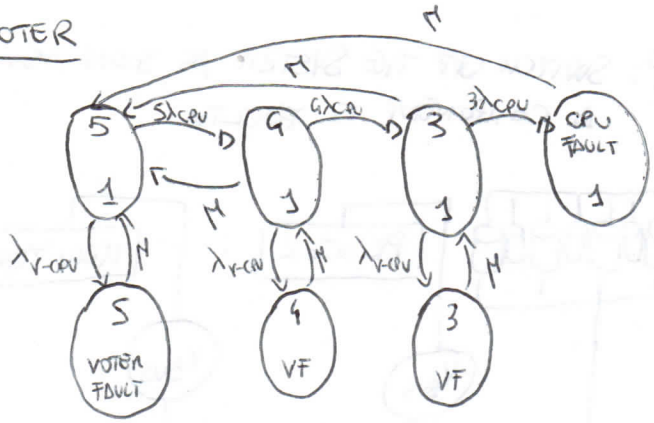


$$\boxed{R(t) = 1 - P_F(t)}$$

$$\boxed{R_{TOT}(t) = R_{CPU+VOTER}(t) \cdot R_{DISK}(t) \cdot R_{BUS+VOTER}(t) \cdot R_{MON}(t) \cdot R_{PRI}(t) \cdot R_{KEY}(t)}$$

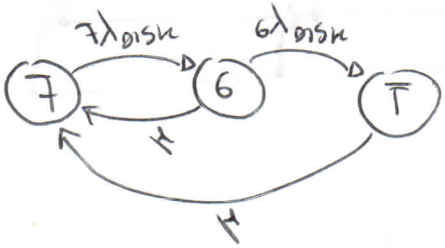
STEADY STATE AVAILABILITY

CPU + VOTER



$$A_{CPU+VOTER}(t) = 1 - P_{CF_1}(t) - P_{5,VF}(t) - P_{4,VF}(t) - P_{3,VF}(t)$$

DISK



$$P_7'(t) = 0 = -P_7(t)\,7\lambda_{DISK} + P_6(t)\,M + P_F(t)\,M$$

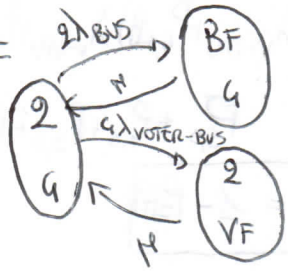
$$P_6'(t) = 0 = P_7(t)\,7\lambda_{DISK} - P_6(t)\,6\lambda_{DISK} - P_6(t)\,M$$

$$P_F'(t) = 0 = P_6(t)\,6\lambda_{DISK} - P_F(t)\,M$$

$$P_7(0) = 1 \qquad P_7(t) + P_6(t) + P_F(t) = 1$$

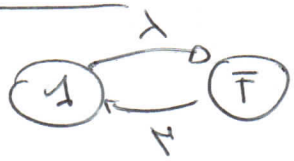
$$A_{DISK}(t) = 1 - P_F(t)$$

BUS + VOTER



$$A_{BUS}(t) = 1 - P_{BF_4}(t) - P_{2,VF}(t)$$

PRINTER / MONITOR / KEYBOARD

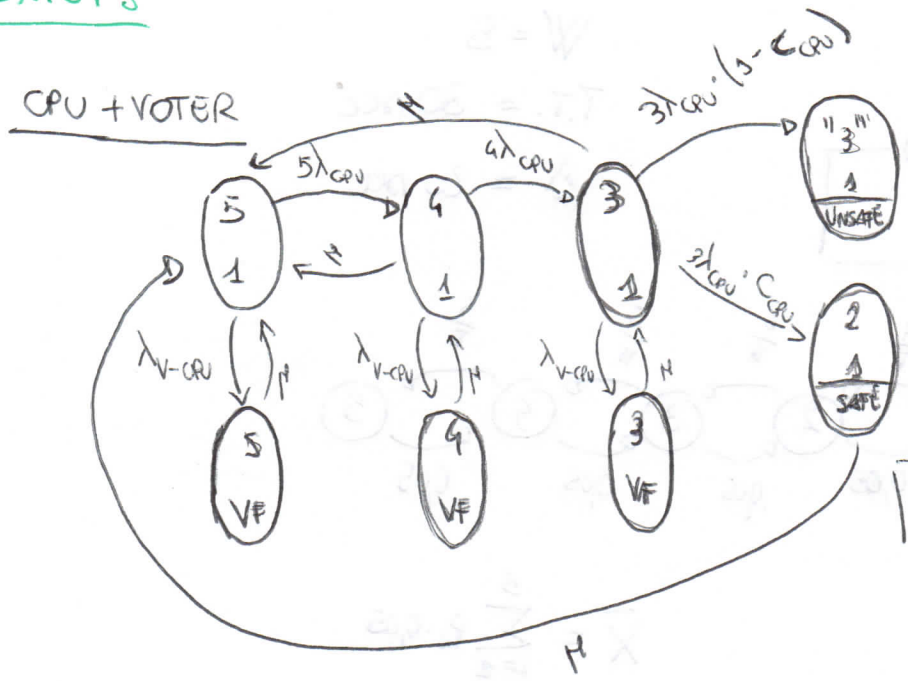


$$A(t) = 1 - P_F(t)$$

$$A_{TOT}(t) = A_{CPU+VOTER}(t) \cdot A_{DISK}(t) \cdot A_{BUS}(t) \cdot A_{MON}(t) \cdot A_{PRI}(t) \cdot A_{KEY}(t)$$

SAFETY

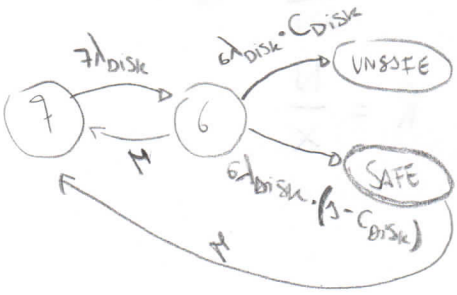
CPU + VOTER



HP. AN UNSAFE FAULT WILL BE NEVER DETECT

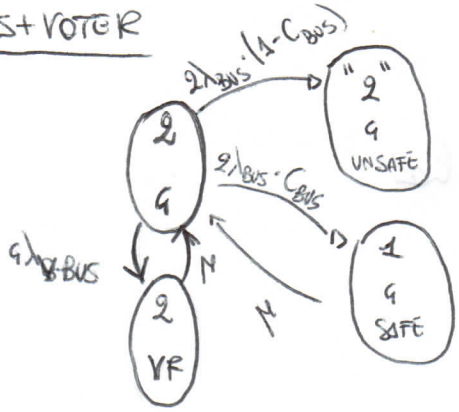
$$S(t)_{CPU} = 1 - P_{"3",1,UNSAFE}(t)$$

DISK



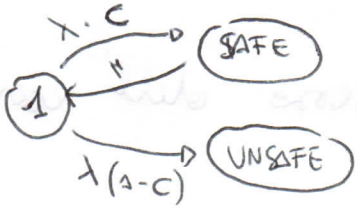
$$S(t)_{DISK} = 1 - P_{UNSAFE}(t)$$

BUS + VOTER



$$S(t)_{BUS} = 1 - P_{"2",4,UNSAFE}(t)$$

PRINTER / MONITOR / KEYBOARD



$$S(t) = 1 - P_{UNSAFE}(t)$$

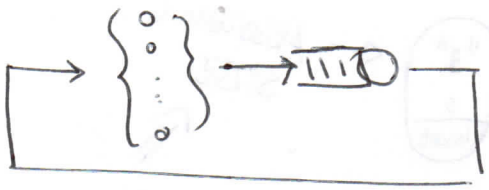
$$S_{TOT}(t) = S_{CPU} \cdot S_{DISK} \cdot S_{BUS} \cdot S_{KEB} \cdot S_{MON} \cdot S_{PRI}$$

EX 2

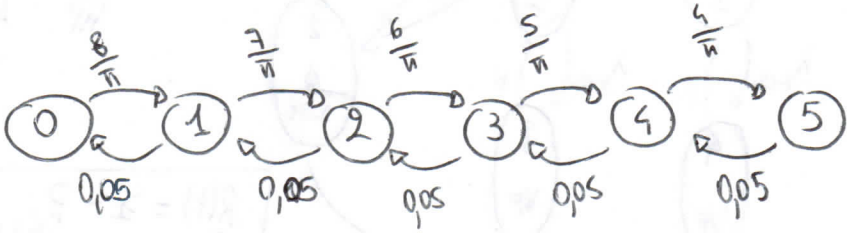
$W = 5$

T.T. = 30 sec

$S = 20$ sec



$$X = \frac{N}{R} = \frac{1}{20} = 0{,}05$$



$$\begin{cases} \frac{8}{11} P_0 = 0{,}05\, P_1 \\ \frac{7}{11} P_1 = 0{,}05\, P_2 \\ \frac{6}{11} P_2 = 0{,}05\, P_3 \\ \frac{5}{11} P_3 = 0{,}05\, P_4 \\ \frac{4}{11} P_4 = 0{,}05\, P_5 \\ \sum_{i=0}^{5} P_i = 1 \end{cases}$$

$\Rightarrow$ calcolo P_i

$$\bar{X} = \sum_{i=1}^{5} P_i \cdot 0{,}05$$

$$\bar{N} = \sum_{i=1}^{5} i \cdot P_i$$

$$R = \frac{N}{X}$$

EX 3

Lo stesso dell'esercizio in aula