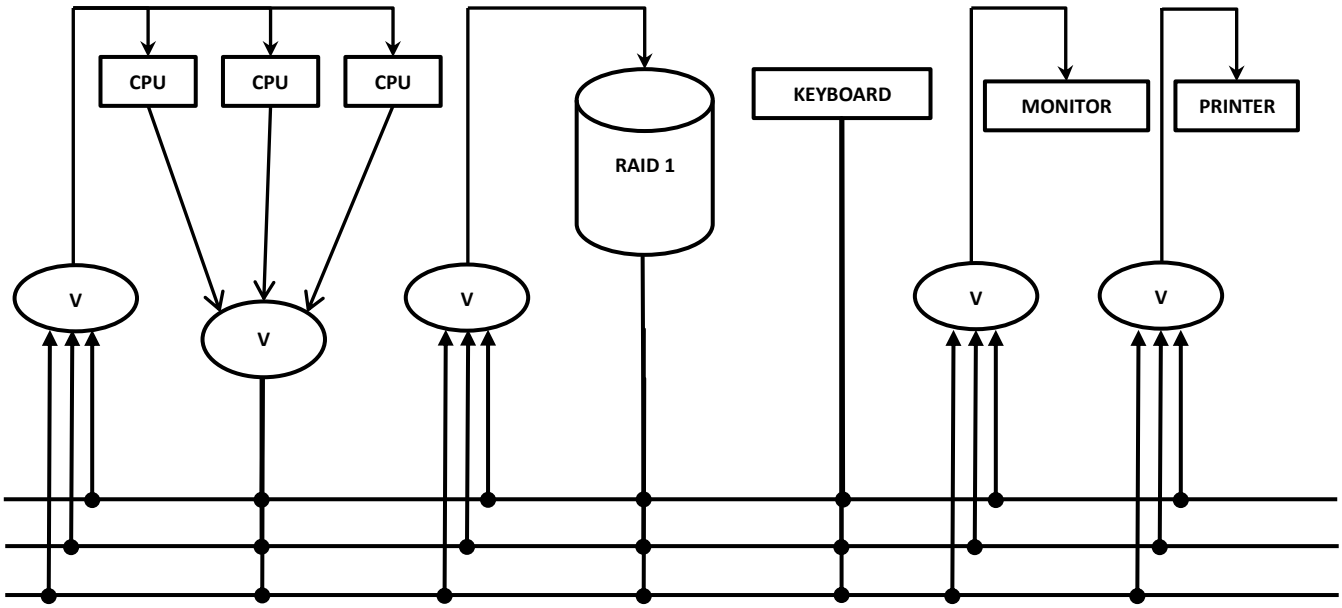
Evaluate the reliability and the availability of a system composed of three CPUs (working in parallel and whose output is given by a voter), a RAID 1 storage system with 4+4 disks three buses (working in parallel and whose outputs are given by voters), one keyboard, one printer and one monitor. Assume that faults are exponentially distributed with rates equal to λ_{CPU} , λ_{DISK}, λ_{BUS}, λ_{KEY}, λ_{PRI} , λ_{MON} , $\lambda_{VOT-CPU}$, $\lambda_{VOT-BUS}$. The repair rate μ is equal for all components.



Subsystems: $\boldsymbol{SUB_{CPU}}$, $\boldsymbol{SUB_{BUS}}$, $\boldsymbol{SUB_{DISK}}$, $\boldsymbol{SUB_{PRI}}$, $\boldsymbol{SUB_{KEY}}$ and $\boldsymbol{SUB_{MON}}$ (SUB_{CPU} and SUB_{BUS} include voters).

Reliability:

Serial interconnections:

$$\boldsymbol{R(t)} = \prod_{\boldsymbol{i=1}}^{\boldsymbol{K}} \boldsymbol{R_i(t)}$$

Thus:

$$\boldsymbol{R(t)} = \boldsymbol{R_{SUB-CPU}(t)} \cdot \boldsymbol{R_{SUB-BUS}(t)} \cdot \boldsymbol{R_{SUB-DISK}(t)} \cdot \boldsymbol{R_{SUB-PRI}(t)} \cdot \boldsymbol{R_{SUB-KEY}(t)} \cdot \boldsymbol{R_{SUB-MON}(t)}$$

Reliability of a generic component *i*:

$$R_i(t) = e^{-\lambda_i t}$$

Availability:

$$\boldsymbol{A} = \prod_{\boldsymbol{i}}^{\boldsymbol{K}} \boldsymbol{A_i}$$

Availability of a generic component *i*:

$$A_i = \frac{MTTF_i}{MTTF_i + MTTR_i} ;$$

where $MTTF_i = \frac{1}{\lambda_i}$ and $MTTR_i = \frac{1}{\mu_i}$

Reliability and availability of subsystems

SUB_{CPU}

$Triple\ Modular\ Redundant$ system.

$$R_{SUB-CPU}(t) = [R_C(t)^3 \quad + \quad 3\ R_C(t)^2 \cdot (1 - R_C(t))\ ]\ R_{V-CPU}(t)$$

$$A_{SUB-CPU} = [\ A_C^3 + 3\ A_C^2 \cdot (1 - A_C)\ ]\ A_{V-CPU}$$

where :

$R_C(t)$	: reliability of the CPU ;
$R_{VOT-CPU}(t)$	: reliability of the VOTER-CPU ;
A_C	: availability of the CPU;
$A_{VOT-CPU}$	: availability of the VOTER-CPU .

SUB_{BUS}

BUS: $Hybrid\ M\ out\ of\ N$ interconnection.

$$R_{SUB-BUS}(t) = [R_B(t)^3 \quad + \quad 3\ R_B(t)^2 \cdot (1 - R_B(t))\ ]\ R_{VOT-BUS}(t)^4$$

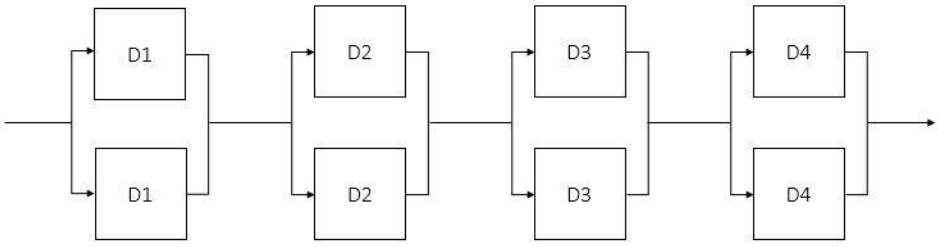
$$A_{SUB-BUS} = [\ A_B^3 + 3\ A_B^2 \cdot (1 - A_B)\ ]\ A_{VOT-BUS}^4$$

where :

$R_B(t)$	: reliability of a BUS ;
$R_{VOT-BUS}(t)$	: reliability of a VOTER- BUS;
A_B	: availability of a BUS;
$A_{VOT-BUS}$	: availability of a VOTER- BUS;

SUB_{DISK}

- RAID 1



$$R_{SUB-DISK}(t) = R_{couple}(t)^4$$
$$A_{SUB-DISK} = A_{couple}^4$$

where :

$R_{couple}(t)$: reliability of disk couple;
A_{couple} : availability of disk couple;

Reliability of a disk couple:

$$R_{couple}(t) = 1 - \left(1 - R_{DISK}(t)\right)^2$$

Availability of a disk couple:

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

SUB$_{PRI}$

$$R_{SUB-PRI}(t) = R_P(t)$$

$$A_{SUB-PRI} = A_P$$

where :

$R_P(t)$: reliability of the printer;
A_P : availability of the printer;

SUB$_{KEY}$

$$R_{SUB-KEY}(t) = R_K(t)$$

$$A_{SUB-KEY} = A_K$$

where :

$R_K(t)$: reliability of the keyboard ;
A_K : availability of the keyboard.

SUB$_{MON}$

$$R_{SUB-MON}(t) = R_M(t)$$
$$A_{SUB-MON} = A_M$$

where :

$R_M(t)$: reliability of the monitor;
A_M : availability of the monitor.