Multiprocessor computing system reliability analysis

A multiprocessor system is composed of two computing modules: CM_1 and CM_2. Each of them contains one processor(P_1 and P_2, respectively), one memory module (M_1 and M_2) and two disks: a primary disk (D_{11} and D_{21} respectively) and a backup disk (D_{12} and D_{22} respectively).

Initially, the primary disk is accessed by the corresponding computing module, while the backup disk contains the copy of the primary disk's data, and it is accessed only periodically for updating operations. If the primary disk fails, it is replaced in its function by the backup disk. In terms of reliability the disks are identical, they are characterized by the same failure rate or reliability cumulative distribution function (cdf). The computing modules are connected by means of the bus B; moreover, P_1 and P_2 are energized by the power supply PS: the failure of PS forces P_1 and P_2 to fail.

M_3 is a spare memory replacing M_1 or M_2 in the case of failure. If both M_1 and M_2 are operational, M_3 is just kept alive or in warm standby in order to maintain the data stored, but it is not accessed to read or write any data. When M_1 or M_2 or both fail, M_3 substitutes the failed unit.

In order to properly work, the multiprocessor computing system requires that at least one computing module (CM_1 or CM_2), the PS and the bus B correctly operate. Moreover, a computing module (CM_1 and CM_2) is operational if the processor (P_1 and P_2, respectively), one between the local memory (M_1 and M_2) and the shared memory M_3 and one disk (D_{11} or D_{21} for CM_1 and D_{12} or D_{22} for CM_2) are not failed.

Assuming that all the component have a failure time exponentially distributed and the memory module M_3 has different failure rates, when it is in warm standby and or active, as reported in Table 1, compute the system reliability function and the MTTF. Failure rates in Table 1 are expressed in failures in time (FIT), i.e. number of faults per billion device hours.

Moreover, compute the system availability assuming that the system is reparable and the component repair rates are as in Table 1 (Remark: a repair rate equal to 0 means the component is reliable).

Component	**Failure rate** (FIT)	**Repair rate** (repairs/h)
B	2	0
P_1, P_2	500	$3.85 \cdot 10^{-2}$
PS	6000	1
M_1, M_2	30	$4.00 \cdot 10^{-2}$
M_3 (active)	30	$4.00 \cdot 10^{-2}$
M_3 (standby)	25	$4.00 \cdot 10^{-2}$
D_{11}	80000	$3.45 \cdot 10^{-2}$
D_{21}	80000	$3.45 \cdot 10^{-2}$
D_{12}	80000	$3.45 \cdot 10^{-2}$
D_{22}	80000	$3.45 \cdot 10^{-2}$

Table 1: System parameter values