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PROFIT ANALYSIS OF REPAIRABLE COLD STANDBY SYSTEM SUBJECT TO REBOOT FACILITY UNDER REFRESHMENTS

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Abstract

This paper relates to the reliability measures analysis of two identical unit system with reboot facility. Initially, one unit of the system is in operative mode and another unit is kept in cold standby mode. A technician is always available with the system to perform repairing and rebooting activities. Here, the system operative unit failed in safe mode and unsafe mode. During unsafe failure, repair activity cannot be done immediately but first rebooting is done to transform unsafe failure into safe failure, and then repair activity is performed as usual. Sometimes, the technician needs refreshments due to continuous work and provides better services after taking refreshments. The unit works like a new one after repair. The failure time of the unit in safe mode, unsafe mode and technician refreshment request time are assumed to be general while the repair time of the unit, rebooting delay time and technician refreshment time are taken as exponential. Reliability measures such as mean time to system failure, availability of the system, busy period of the repairman, the expected number of visits by the technician and profit values are calculated using tables.

Keywords: Availability, cold standby, regenerative point, rebooting, and refreshment.

I. Introduction

In daily life, there are many situations such as the breakdown of the unit that caused machine failure. One way to avoid loss and increase the reliability of the system is to use the cold standby facility. With the occurrence of the complexity of machines and advancements in industrial sectors or organizations, the focus is on increasing the reliability and profit of the industry. The prominent point is that the designs and layout of complex machines or equipment should be so that it increases the reliability of the system and always tries to minimize the shortcomings responsible for its downtrends. Hence, designing a reliable system has become an essential step in almost every sector. So, the concept of rebooting is used to transform the unit from unsafe failure to safe failure. Sometimes, a technician is tired and needs refreshment. After taking refreshment, the repairman provides better service, and after getting the repair, the unit works like a new one. Many researchers such as Zhang and Wang [15] described a different unit repairable cold standby system that gives seniority to the operative unit. Hsu et al. [4] explored the standby system having reboot delay, general repair, switching failure, and unreliable repair facility. Jyh-Bin et al. [6] analyzed various reliability measures of a repairable system having standby switching failures and facility of reboot delay.

Dhall et al. [2] discussed the reliability of the similar unit stochastic approach under the repair and replacement of the failed unit subjected to inspection. Ke and Liu [7] examined the repairable system having a single server that identified the failed unit before repair and rebooting. Kumar and Goel [10] highlighted the two-unit cold standby redundant system subjected to inspection before repairing the failed unit and using the concept of preventive maintenance. Goel et al. [3] explained the performance of a cold standby redundant system with a server to inspect the failed unit before repair.

Temraz [14] evaluated the reliability measures for dependent system with load sharing and subject to degradation facility. Jain et al. [5] described the machine system as having online and standby units for system sustainability with server vacation, observing imperfect fault and its recovery using the reboot approach. Kumar and Jain [11] examined the reliability measures of a warm standby machine system having multiple components with recovery failure supported by the reboot process. Levitin et al. [12] evaluated the cold standby systems with elements exposed to shocks during operation and task transfers under preventive maintenance. Agrawal et al. [1] described the nature of the water treatment reverses osmosis plant using the regenerative point graphical technique. Sengar and Mangey [13] examined the complex manufacturing system subject to inspection facility using copula methodology. Kumar and Sharma [8] evaluated the availability and profit analysis of a repairable two unit cold standby system under refreshment using the regenerative point technique. Kumar et al. [9] explored the performance of two unit cold standby system under inspection and subject to refreshment facility.

II. System Assumptions

There are following system assumptions:

- The whole system has two identical units- first operative and second cold standby.
- The cold standby unit takes place when the operative unit stops functioning.
- A technician is always available to repair the failed unit.
- The failed unit behaves like a new one after repair.
- When the unit fails in unsafe mode then the reboot process is used to convert it to safe mode.
- Refreshment is offered to the technician to enhance his efficiency.
- Repair time, refreshment time and reboot delay time are exponentially distributed whereas times for failure of the unit in safe mode and unsafe mode and technician refreshment request are general.

III. System Notations

There are following system notations:

R	Collection of regenerative states S_i $(i = 0,1,2,3,9)$
$O / O(g) / Cs$	The system unit is operative and in normal mode / suitable good condition mode /cold standby mode
a / b	The probability that the cold standby unit is working/ not working
$\lambda / \lambda_1 / \mu$	The constant failure rate of the unit of the system in safe mode/rate with unit goes to unsafe mode/ rate by which the repairman needs refreshment
$g_1(t) / G_1(t)$	PDF/ CDF of the repair time of the unit
$f_1(t) / F_1(t)$	PDF/ CDF of refreshments time that restores freshness to the technician
$h_1(t) / H_1(t)$	PDF/ CDF of reboot delay time

$q_{r,s}(t)/Q_{r,s}(t)$	PDF/ CDF of first passage time from rth to sth regenerative state or sth failed state without halting in any other $S_i \in R$ in (0,1]
$M_r(t)$	Represents the probability of the system that it initially works $S_r \in R$ at a time (t) without moving through another state $S_i \in R$
$W_r(t)$	Probability that up to time (t) the server is busy at the state S_r without transit to another state $S_i \in R$ or before return to the same state through one or more non regenerative states
$\oplus/\otimes$	Laplace convolution / Laplace Stieltjes Convolution
$*/**/'$	Symbol for Laplace Transform/ Laplace Stieltjes Transform/ Function's derivative
○ / ● / ▭	Upstate/ regenerative state/ failed state

IV. State Descriptions

The system has up states as well as down states and these individual states are described in table 1:

Table 1: *State Descriptions*

States	Descriptions
S_0	It is a regenerative upstate with two units such that one is operative (O) and other is cold standby (Cs).
S_1	This regenerative upstate has two units such that one is failed under repair (*Fur*) and the other is in operative mode (O).
S_2	It is a regenerative upstate under refreshment facility (*sut*) where one unit is failed & waiting for repair (*Fwr*) and the other is in operative mode (O).
S_3	It is a regenerative down state and the system has two units such that one is failed under repair (*Fur*) and the other is failed and waiting for repair (*Fwr*).
S_4	It is a down state where one unit fails under repair (*FUR*) continuously from the prior state and the other unit is failed & waiting for repair (*Fwr*).
S_5	It is a down state that has two units under refreshment facility (*sut*) such that one is failed and waiting for repair (*Fwr*) and other is failed & waiting for repair (*FWR*) continuously from the previous state.
S_6	At this down state, the system has two units such that one is failed under repair (*FUR*) continuously from the previous state and the other unit is failed and waiting for repair (*FWR*) continually from the prior state.
S_7	This down state has two units under continuous refreshment facility (*SUT*) such that one is failed & waiting for repair (*Fwr*) and the other is failed & waiting for repair (*FWR*) continuously from the previous state.
S_8	This down state has two units under refreshment facility continuously from the prior state (*SUT*) in unsafe mode of failure of unit such that operative unit is failed under unsafe mode *F*(*uns*) and the other is failed and waiting for repair (*FWR*) continuously from the previous state.

S_9	This down state has two units such that the operative unit is failed under unsafe mode *F*(*uns*) and the other is in good condition.
S_{10}	This down state has two units such that the operative unit is failed under unsafe mode *F*(*uns*) and the other is failed under repair (*FWR*) continuously from the previous state.

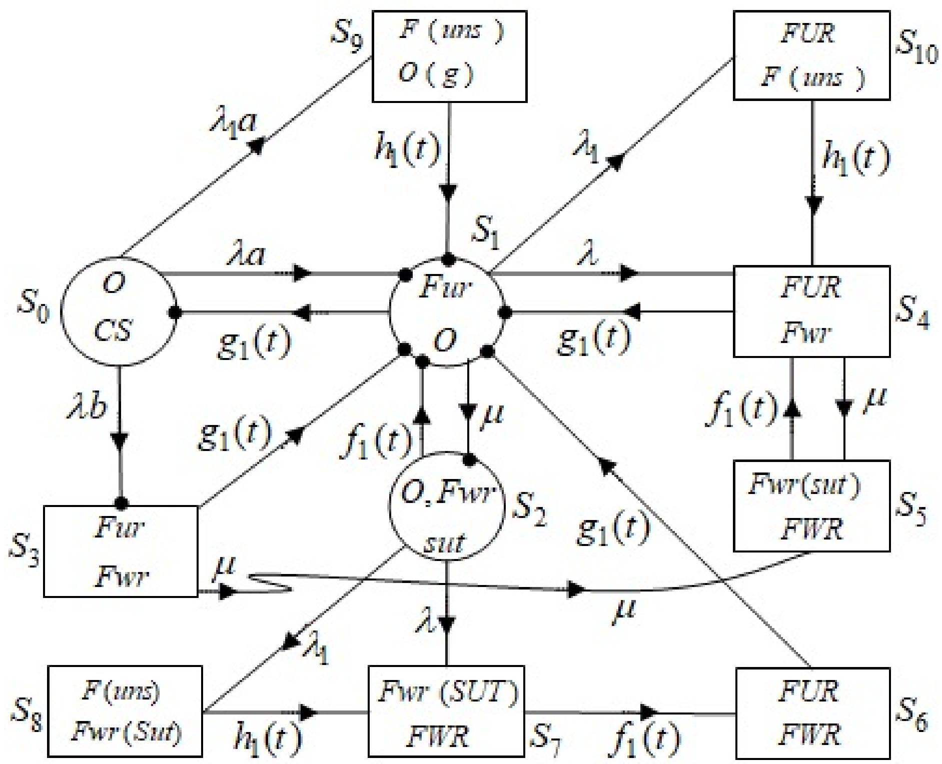

Figure 1: *State Transition Diagram*

V. Transition Probabilities

The transition probabilities are calculated using

$$f_1(t) = \theta e^{-\theta t}, g_1(t) = \phi e^{-\phi t}, h_1(t) = \xi e^{-\xi t} \tag{1}$$

$$p_{01} = \frac{\lambda a}{\lambda + \lambda_1 a}, \; p_{03} = \frac{\lambda b}{\lambda + \lambda_1 a}, p_{09} = \frac{\lambda_1 a}{\lambda + \lambda_1 a}, \; p_{10} = \frac{\phi}{\phi + \lambda + \lambda_1 + \mu}$$

$$p_{12} = \frac{\mu}{\phi + \lambda + \lambda_1 + \mu}, p_{14} = \frac{\lambda}{\phi + \lambda + \lambda_1 + \mu}, \; p_{1,10} = \frac{\lambda_1}{\phi + \lambda + \lambda_1 + \mu}, \; p_{21} = \frac{\theta}{\theta + \lambda + \lambda_1}$$

$$p_{27} = \frac{\lambda}{\theta + \lambda + \lambda_1}, \; p_{28} = \frac{\lambda_1}{\theta + \lambda + \lambda_1}, \; p_{31} = p_{41} = \frac{\phi}{\phi + \mu}, \; p_{35} = p_{45} = \frac{\mu}{\phi + \mu}$$

$$p_{54} = p_{61} = p_{76} = p_{87} = p_{91} = p_{10,4} = 1 \tag{2}$$

It is smoothly verified that

$$p_{01} + p_{03} + p_{09} = 1 \; p_{41} + p_{45} = 1$$

$$p_{10} + p_{12} + p_{14} + p_{1,10} = p_{10} + p_{12} + p_{11.4} + p_{11.(45)^n} + p_{11.(10,4)} + p_{11.10(45)^n} = 1$$

$$p_{21} + p_{27} + p_{28} = p_{21} + p_{21.(76)} + p_{21.8(76)} = 1,\ p_{31} + p_{35} = p_{31} + p_{31.(54)^n} = 1 \quad (3)$$

VI. Mean Sojourn Time

In the cold standby redundant system, μ_i represents the mean sojourn time. Mathematically, time consumed by a system in a particular state is, $\mu_i = \sum_j m_{i,j} = \int_0^\infty P(T > t)\,dt$. Then

$$\mu_0 = m_{01} + m_{03} + m_{09} = \int_0^\infty P(T > t)dt = \frac{1}{\lambda + \lambda_1 a}$$

$$\mu_1 = m_{10} + m_{12} + m_{14} + m_{1,10} = \frac{1}{\phi + \lambda + \lambda_1 + \mu},\ \mu_2 = m_{21} + m_{27} + m_{28} = \frac{1}{\theta + \lambda + \lambda_1}$$

$$\mu_3 = m_{31} + m_{35} = \frac{1}{\phi + \mu},\ \mu_4 = m_{41} + m_{45} = \frac{1}{\phi + \mu} \quad \mu_5 = \mu_7 = \frac{1}{\theta},\ \mu_6 = \frac{1}{\phi}$$

$$\mu_8 = \mu_9 = \mu_{10} = \frac{1}{\xi},\ \mu_3' = m_{31} + m_{31.(54)^n} = \frac{(\theta + \mu)}{\theta\phi}$$

$$\mu_1' = m_{10} + m_{12} + m_{11.4} + m_{11.(45)^n} + m_{11.(10,4)} + m_{11.10(45)^n}$$

$$= \frac{[\theta\phi(\xi + \lambda_1) + \xi(\theta + \mu)(\lambda + \lambda_1)]}{\theta\phi\xi(\phi + \lambda + \lambda_1 + \mu)}$$

$$\mu_2' = m_{21} + m_{21.(76)} + m_{21.8(76)} = \frac{[\theta\phi(\xi + \lambda_1) + \xi(\lambda + \lambda_1)(\phi + \theta)]}{\theta\phi\xi(\theta + \lambda + \lambda_1)} \quad (4)$$

VII. Reliability Measures Evaluations

I. Mean Time to System Failure (MTSF)

Let the cumulative distribution function of the first elapsed time be $\varphi_i(t)$ from the regenerative state S_i to the failed state of the system. Treating the failed states as an absorbing state then the repetitive interface for $\varphi_i(t)$ being

$$\varphi_0(t) = Q_{09}(t) + Q_{03}(t) + Q_{01}(t) \otimes \varphi_1(t)$$

$$\varphi_1(t) = Q_{1,10}(t) + Q_{14}(t) + Q_{12}(t) \otimes \varphi_2(t) + Q_{10}(t) \otimes \varphi_0(t)$$

$$\varphi_2(t) = Q_{28}(t) + Q_{27}(t) + Q_{21}(t) \otimes \varphi_1(t) \quad (5)$$

Taking LST on the above equation (5) then get

$$R^*(s) = \frac{1 - \varphi_0^{**}(s)}{s} \quad (6)$$

Now, system reliability is accessed by using the inverse LT on equation (6) such that

$$MTSF = \lim_{s \to 0} \frac{1 - \varphi_0^{**}(s)}{s} = \frac{(1 - p_{01}p_{10})\mu_2 + p_{21}\mu_1 + p_{21}p_{10}\mu_0}{(1 - p_{01}p_{10} - p_{12}p_{21})} \quad (7)$$

II. Availability of the system

From the transition diagram, the system is available at the regenerative up states S_0, S_1 and S_2. Let $A_i(t)$ is the probability that the system is in upstate at time (t) specified that the system arrives at the regenerative state S_i at t = 0. Then the repetitive interface for $A_i(t)$ is

$$A_0(t) = q_{09}(t) \oplus A_9(t) + q_{03}(t) \oplus A_3(t) + q_{01}(t) \oplus A_1(t) + M_0(t)$$
$$A_1(t) = q_{12}(t) \oplus A_2(t) + q_{10}(t) \oplus A_0(t) + [q_{11.4}(t) + q_{11.(45)^n}(t) + q_{11.(10,4)}(t) + q_{11.10(45)^n}(t)] \oplus A_1(t) + M_1(t)$$
$$A_2(t) = [q_{21}(t) + q_{21.(76)}(t) + q_{21.8(76)}(t)] \oplus A_1(t) + M_2(t)$$
$$A_3(t) = [q_{31}(t) + q_{31.(54)^n}(t)] \oplus A_1(t)$$
$$A_9(t) = q_{91}(t) \oplus A_1(t) \tag{8}$$

Where, $M_0(t) = e^{-(\lambda+\lambda_1 a)t}$, $M_1(t) = \overline{G(t)}\, e^{-(\lambda+\lambda_1+\mu)t}$, $M_2(t) = \overline{F(t)}\, e^{-(\lambda+\lambda_1)t}$ (9)

Using LT of the above relation (8), then get

$$A_0(\infty) = \lim_{s\to 0} sA_0^*(s) = \frac{N_A}{D'} \tag{10}$$

where, $N_A = [\mu_0 p_{10} + \mu_1 + \mu_2 p_{12}]$

and $D' = [(\mu_0 + \mu_3' p_{03} - \mu_9 p_{09}) p_{10} + \mu_1' + \mu_2' p_{12}]$

III. Busy Period of the Server

From the transition diagram, it is clear that the technician is busy at states S_1, S_2 and S_3. Let $B_i(t)$ is the probability that the repairman is busy due to the repair of the failed unit at time 't' specified that the system arrives at the regenerative state S_i at t = 0. Then the repetitive interface for $B_i(t)$ is

$$B_0(t) = q_{09}(t) \oplus B_9(t) + q_{03}(t) \oplus B_3(t) + q_{01}(t) \oplus B_1(t)$$
$$B_1(t) = q_{12}(t) \oplus B_2(t) + q_{10}(t) \oplus B_0(t) + [q_{11.4}(t) + q_{11.(45)^n}(t) + q_{11.(10,4)}(t) + q_{11.10(45)^n}(t)] \oplus B_1(t) + W_1(t)$$
$$B_2(t) = [q_{21}(t) + q_{21.(76)}(t) + +q_{21.8(76)}(t)] \oplus B_1(t) + W_2(t)$$
$$B_3(t) = [q_{31}(t) + q_{31.(54)^n}(t)] \oplus B_1(t) + W_3(t)$$
$$B_9(t) = q_{91}(t) \oplus B_1(t) + W_9(t) \tag{11}$$

where, $W_1(t) = \overline{G_1(t)} e^{-(\lambda+\mu)t} + \overline{G_1(t)} \lambda e^{-(\lambda+\mu)t} \oplus \overline{G_1(t)} e^{-\mu t} + ...$

$W_2(t) = [\{\lambda e^{-(\lambda+\lambda_1)t}\, \overline{F_1(t)} + \lambda_1 e^{-(\lambda+\lambda_1)t}\, \overline{F_1(t)} \oplus h_1(t)\} f_1(t)] \oplus \overline{G_1(t)}$

$W_3(t) = \overline{G_1(t)} e^{-\mu t} + \overline{G_1(t)} \mu e^{-\mu t} \oplus f_1(t) \oplus \overline{G_1(t)} e^{-\mu t} + ...$

and $W_9(t) = \overline{H_1(t)}$

Using LT on the above relations (11) then get

$$B_0^R = \lim_{s\to 0} sB_0^*(s) = \frac{N_B}{D'}$$

Where, $N_B = W_1^*(0) + W_2^*(0) p_{12} + (W_3^*(0) p_{03} - W_9^*(0) p_{09}) p_{10}$ (12)

and D' is formerly declared.

IV. Estimated number of visits made by the server

The transition diagram explores that the technician visits at states S_1 and S_2. Let $N_i(t)$ is the estimated number of visits made by the repairman for repair in (0, t] specified that the system arrives at the regenerative state S_i at t = 0. Then the repetitive interface for $N_i(t)$ is

$$V_0(t) = Q_{09}(t)\otimes[1+V_9(t)]+Q_{03}(t)\otimes[1+V_3(t)]+Q_{01}(t)\otimes[1+V_1(t)]$$

$$V_1(t) = Q_{12}(t)\otimes V_2(t)+Q_{10}(t)\otimes V_0(t)$$
$$+[Q_{11.4}(t)+Q_{11.(45)^n}(t)+Q_{11.(10,4)}(t)+Q_{11.10(45)^n}(t)]\otimes V_1(t)$$

$$V_2(t) = [Q_{21}(t)+Q_{21.(76)}(t)+Q_{21.8(76)}(t)]\otimes V_1(t)$$

$$V_3(t) = [Q_{31}(t)+Q_{31.(54)^n}(t)]\otimes V_1(t)$$

$$V_9(t) = Q_{91}(t)\otimes V_1(t) \tag{13}$$

Using LST on the above relations (13), then get

$$V_0(\infty) = \lim_{s\to 0} sV_0^{**}(s)$$

$$V_0 = \frac{V_n}{D'} \quad \text{Where} \quad V_n = p_{10} \tag{14}$$

and D' is formerly declared.

V. Particular Cases

Suppose that $f_1(t) = \theta e^{-\theta t}$, $g_1(t) = \phi e^{-\phi t}$, $h_1(t) = \xi e^{-\xi t}$

$$p_{11.4} = \frac{\lambda\phi}{(\phi+\lambda+\lambda_1+\mu)(\phi+\mu)},\; p_{11.(45)^n} = \frac{\lambda\mu}{(\phi+\lambda+\lambda_1+\mu)(\phi+\mu)}$$

$$p_{11.(10,4)} = \frac{\lambda_1\phi}{(\phi+\lambda+\lambda_1+\mu)(\phi+\mu)},\; p_{11.10(45)^n} = \frac{\lambda_1\mu}{(\phi+\lambda+\lambda_1+\mu)(\phi+\mu)}$$

$$p_{21.(76)} = \frac{\lambda}{(\theta+\lambda+\lambda_1)},\; p_{21.8(76)} = \frac{\lambda_1}{(\theta+\lambda+\lambda_1)},\; p_{31.(54)^n} = \frac{\mu}{(\phi+\mu)}$$

Also, $M_0 = \frac{1}{(\lambda+\lambda_1 a)} = \mu_0$, $M_1 = \frac{1}{(\phi+\mu+\lambda+\lambda_1)} = \mu_1$, $M_2 = \frac{1}{(\theta+\lambda+\lambda_1)} = \mu_2$

$$W_1(t)=\mu_1', \quad W_2(t)=\mu_2', \quad W_3(t)=\mu_3', \quad W_9(t)=\mu_9$$

$$MTSF = \frac{[(\lambda+\lambda_1 a)\{(\phi+\lambda+\lambda_1+\mu)+\theta\}-\phi(\lambda a+\theta)]}{[(\theta+\lambda+\lambda_1)\{(\lambda+\lambda_1 a)(\phi+\lambda+\lambda_1+\mu)-\lambda a\phi\}+\mu\theta(\lambda+\lambda_1 a)]} \tag{15}$$

$$A_0 = \frac{\theta\phi\xi[\phi(\theta+\lambda+\lambda_1)+(\lambda+\lambda_1 a)(\theta+\lambda+\lambda_1+\mu)]}{A_1+A_2} \tag{16}$$

where, $A_1=[\phi(\theta+\lambda+\lambda_1)\{\theta\phi\xi+(\theta+\mu)\lambda b\xi-\lambda_1 a\theta\phi\}]$

$$A_2 = (\lambda+\lambda_1 a)\begin{bmatrix}\theta\phi(\xi+\lambda_1)(\theta+\lambda+\lambda_1+\mu)\\ +\xi(\lambda+\lambda_1)\{(\theta+\mu)(\theta+\lambda+\lambda_1)+\theta\phi\mu(\phi+\theta)\}\end{bmatrix}$$

$$B_0 = \frac{\phi\begin{bmatrix}\{\lambda b\xi(\theta+\mu)-\lambda_1 a\theta\phi\}(\theta+\lambda+\lambda_1)\\ +\theta\xi(\lambda+\lambda_1 a)(\theta+\lambda+\lambda_1+\mu)\end{bmatrix}}{A_1+A_2} \tag{17}$$

where A_1 and A_2 are defined above.

$$V_0 = \frac{\theta\phi^2\xi(\lambda + \lambda_1 a)(\theta + \lambda + \lambda_1)}{A_1 + A_2} \tag{18}$$

VI. Profit Analysis

Using reliability parameters, the profit (P) of the system during the time interval (0,t] is

$$P = T_0 A_0 - T_1 B_0^R - T_2 V_0 \tag{19}$$

Where, $T_0 = 1000$ (Price tag per unit uptime)

$T_1 = 500$ (Cost per unit time for technician Busy)

$T_2 = 100$ (Charge per visit by the technician)

VIII. Discussion

Generally, cold standby redundancy is used to enhance the system performance and sometimes refreshment is offered to the technician to enhance his efficiency.

The system performance is calculated with reliability measures such as MTSF, availability of the system and profit values. Table 2 shows the increasing trend of MTSF with respect to refreshment rate θ, keeping the values of other parameters λ=0.3, λ_1=0.2, μ=0.4, ϕ=0.3, ξ=0.2 are failure rate of the unit in safe mode, unsafe mode, refreshment request rate, repair rate of unit, rebooting delay rate respectively, and these are taken constantly for simplicity. When λ changing from 0.3 to 0.4, λ_1 changing from 0.2 to 0.3, μ varying from 0.4 to 0.5 then MTSF declined.

The table reveals that as the rate of repair ϕ changes from 0.3 to 0.4, and reboot delay rate ξ changes from 0.2 to 0.3 then MTSF enhances.

Table 2: *MTSF vs. Refreshment Rate*

θ ↓	λ=0.3, λ_1=0.2 μ=0.4, ϕ=0.3 ξ=0.2 *a*=0.8 *b*=0.2	λ=0.4	λ_1=0.3	μ=0.5	ϕ=0.4	ξ=0.3
0.1	1.49505	1.40182	1.38431	1.42983	1.45287	1.50588
0.2	1.52616	1.42729	1.40848	1.45878	1.48644	1.53438
0.3	1.55598	1.45179	1.4316	1.48666	1.51862	1.56687
0.4	1.58457	1.47538	1.45372	1.51351	1.54951	1.59368
0.5	1.61202	1.4981	1.47492	1.53948	1.57917	1.62598
0.6	1.63839	1.51475	1.49524	1.56438	1.60768	1.64788
0.7	1.66375	1.54115	1.51475	1.58849	1.6351	1.67466
0.8	1.68814	1..5615	1.53349	1.61178	1.6615	1.69586
0.9	1.71164	1.58118	1.5515	1.63429	1.68694	1.72568
1	1.73427	1.60021	1.56883	1.65605	1.71145	1.74655

The availability of the redundant system is also affected by the refreshment and reboot facilities. Table 3 explores the availability of the system and its value increase corresponding to increments in refreshment rate θ when the system's other parameters λ=0.3, λ_1=0.2, μ=0.4, ϕ=0.3, ξ=0.2 possess constant values. When the failure rate of a unit in safe mode changes (λ=0.3 to 0.4), unsafe mode changes (λ_1=0.2 to 0.3) then the availability of system declines.

Also, when the technician request rate changes (μ=0.4 to 0.6) then the system's availability declines but when the repair rate of unit changes (ϕ=0.5 to 0.7), reboot rate of unit changes (ξ=0.2 to 0.3) then the availability of the system enhances.

Table 3: *Availability vs. Refreshment Rate*

θ ↓	λ=0.3, λ_1=0.2 μ=0.4, ϕ=0.3 ξ=0.2 a=0.8 b=0.2	λ=0.4	λ_1=0.3	μ=0.5	ϕ=0.4	ξ=0.3
0.1	0.11217	0.10168	0.0973	0.10666	0.1181	0.11682
0.2	0.156	0.14251	0.13534	0.14863	0.16336	0.16537
0.3	0.19261	0.17718	0.16728	0.18385	0.20078	0.20742
0.4	0.22302	0.20641	0.19401	0.21326	0.23162	024353
0.5	0.24825	0.23098	0.21639	0.23776	0.25703	0.2744
0.6	0.26922	0.25162	0.23516	0.25819	0.27804	0.30074
0.7	0.28668	0.26899	0.25094	0.27525	0.29546	0.32323
0.8	0.30128	0.28362	0.26427	0.28955	0.30998	0.34246
0.9	0.31354	0.296	0.27557	0.30157	0.32214	0.35894
1	0.32389	0.3065	0.28525	0.31172	0.33237	0.3731

It is evident from table 4 that the system uses constant parameters such that λ=0.3, λ_1=0.2, μ=0.4, ϕ=0.3, ξ=0.2and the trend of profit values enhanced with respect to increments in refreshment rate θ. When the failure rate of a unit λ in safe mode changes from 0.3 to 0.4 and unsafe mode changes from 0.2 to 0.3 then the profit of the system decreases.

Also, when the technician request rate μ changes from 0.4 to 0.5 then profit values decline but when the repair rate of unit ϕ changes from 0.5 to 0.7 and reboot rate changes from ξ=0.2 to 0.3 then the profit value enhances.

Table 4: *Profit vs. Refreshment Rate*

θ ↓	λ=0.3, λ_1=0.2 μ=0.4, ϕ=0.3 ξ=0.2 a=0.8 b=0.2	λ=0.4	λ_1=0.3	μ=0.5	ϕ=0.4	ξ=0.3
0.1	46.91405	41.65736	39.76882	43.94127	50.09497	50.82808
0.2	66.50537	59.48843	55.46915	62.40709	70.57429	74.43605
0.3	83.49143	75.18573	68.73058	78.49941	88.13762	96.1274
0.4	98.10396	88.87597	79.89434	92.41253	103.1117	115.7624
0.5	110.635	100.7582	89.2898	104.399	115.8591	133.3744
0.6	121.3797	111.0531	97.21094	114.7191	126.7243	149.0903
0.7	130.6097	119.9755	103.9094	123.616	136.0128	163.0801
0.8	138.5628	127.7217	109.5955	131.3055	143.9851	175.5265
0.9	145.4418	134.4642	114.4424	137.9734	150.859	186.6077
1	151.4167	140.3518	118.5933	143.7773	156.8144	196.4892

IX. Conclusion

The refreshment and reboot approach plays a vital role in system configuration and its functioning. These features enhance the capacity of the technician and performance of the system. Tables explore the increasing trends of MTSF, availability and profit values of the system using reboot and refreshment facilities.

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