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MATHEMATICAL MODELING AND SENSITIVITY ANALYSIS OF LINEAR CONSECUTIVE 2:3:: G SYSTEM

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ABSTRACT

In this paper, reliability modelling and sensitivity analysis are applied to two of the three cold standby systems, an external supporting system with preventive maintenance, and a single server that is susceptible to failure. Two of the three units are used in this study so that the system is functioning at its most efficient level when all three are in use. A faultless switchover mechanism helps turn on the third unit, which is in cold standby mode. These online and offline units are operated by the supporting system, which also manages a repair facility with a model for dependability performance measurements and supervises preventative maintenance for all kinds of units. Regarding the starting and base states, a large number of primary, secondary, and tertiary circuits, base states, and simple paths are provided. RPGT is used to represent four reliability measures with various path probabilities, transition probabilities, mean sojourn periods, and expressions, maintaining one of the facility unit failure or repair rates while altering the other. After that, sensitivity analysis is carried out by making the relevant tables and graphs and having a conversation.

Keywords: MTSF, Sensitivity Analysis, RPGT, Availability Analysis

1. INTRODUCTION

In this paper, reliability modelling and profit analysis are applied to two of the three cold standby systems, an external supporting system with preventive maintenance, and a single server that is susceptible to failure. We have modelled a two-unit cold standby system for reliability measurements. This is an essential requirement that is dependent on the system's and its component parts' designs. Generally speaking, it is not always necessary to manage the operation of working units and maintenance facilities with the help of some external supporting system, which system which system which system which system which system which system which system which system which system which system which system which system which system which system which system it may also fail upon failure of one or more units. This is because most studies conducted thus far by various authors assume that systems once installed for operation will continue to do so. The mist group of a coal-fired thermal impact shrub was optimized by Malik et al. (2022). Dual categories of deficiencies—simple and hard as for the time in which these happen for disengagement and expulsion following their recognition—have been reported in Anchal et al(2021) .'s analysis of the SRGM classic using variance condition. Komal et al. (2009) described the reliability, availability, and maintainability analysis presents some strategies to carryout structure alteration. Benefit analysis of the agribusiness harvester plants in a stable condition using RPGT was discussed by Kumari et al. in 2021. Jieong et al. (2009) tackled multi-objective streamlining problems using GA, or a half-and-half calculation. Whereas Kumar et al. (2017) examined the urea compost sector for system parameters, the primary goal of the paper by Kumar et al. (2019) is to investigate the washing element in the paper company that consumes RPGT. In their 2018 study, Kumar et al. investigated an edible petroleum treatment plant and a bakery. Bhunia et al. (2010) introduced GA to address issues with unshakeable quality stochastic augmentation in a series structure with a span part. Given the chance imperatives of the series architecture, the review discovered a solution to the challenge of simplifying stochastic unshakeable quality. The continuous failure and repair rates of units and facilities are used to generate a steady state transition diagram using the Markov process, which displays transition rates and states. Regarding the starting and base states, a large number of primary, secondary, and tertiary circuits, base states, and simple paths are provided. Using RPGT, four reliability measures are modelled using various path probabilities, transition probabilities, mean sojourn times, and expressions. One of the reliability measures is possession of the facility units' repair or disappointment rates, while the other is changeable. After making the necessary tables and graphs, profit analysis is carried out and discussed.

2. ASSUMPTION, NOTATION AND TRANSITION DIAGRAM:

1) The systems having four units out of which two units are operating the rest are in cold standby.
2) The system fails if there are more than two failed units.
3) A fixed device functions exactly like a brand-new one.

mi Constant failure rates, i = 1,2, 3

hi constant repair rates, i = 1, 2, 3

Pleasing into reflection the upstairs assumptions and systems the Transition Illustration of the system is certain in Figure 1.

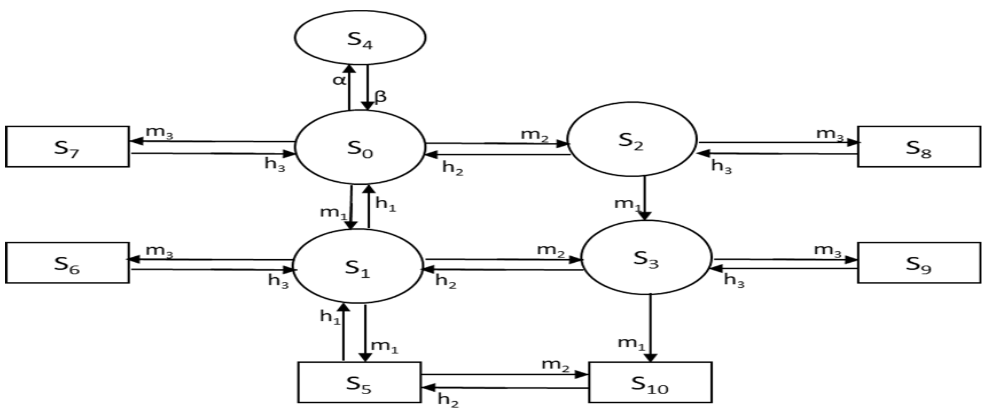

Figure 1 Transition Diagram

S0 = A1A2(A3)BD,S1 = a1A2A3BD, S2 = A1A2(A3)Bd, S3 = a1A2A3Bd,

S4 = A1A2(A3)BD,S5 =a1a2A3Bd, S6 = a1A2A3bD, S7 = A1A2(A3)bD,

S8 = A1A2(A3)bd, S9 = a1A2A3bd, S10 = a1a2A3Bd

3. STATE TRANSITION PROBABILITIES QI,J(T)

q_0,1 (t) = m_1 e^(-(m_1+m_2+m_3+α)t); q_0,2 (t) = m_2 e^(-(m_1+m_2+m_3+α)t)

q_0,4 (t) = αe^(-(m_1+m_2+m_3+α)t); q_0,7 (t) = m_3 e^(-(m_1+m_2+m_3+α)t)

q_1,0 (t) = h_1 e^(-(m_1+m_2+m_3+h_1)t); q_1,3 (t) = m_2 e^(-(m_1+m_2+m_3+h_1)t)

q_1,5 (t) = m_1 e^(-(m_1+m_2+m_3+h_1)t); q_1,6 (t) = m_3 e^(-(m_1+m_2+m_3+h_1)t)

$q_{2,0}(t) = h_2 e^{-(m_1+m_3+h_2)t}$; $q_{2,3}(t) = m_1 e^{-(m_1+m_3+h_2)t}$

$q_{2,8}(t) = m_3 e^{-(m_1+m_3+h_2)t}$; $q_{3,1}(t) = h_2 e^{-(m_1+m_3+h_2)t}$

$q_{3,9}(t) = m_3 e^{-(m_1+m_3+h_2)t}$; $q_{3,10}(t) = m_1 e^{-(m_1+m_3+h_2)t}$

$q_{4,0}(t) = ne^{-nt}$; $q_{5,1}(t) = h_1 e^{-(m_2+h_1)t}$; $q_{5,10}(t) = m_2 e^{-(m_2+h_1)t}$

$q_{6,1} = h_3 e^{-h_3 t}$; $q_{7,0} = h_3 e^{-h_3 t}$; $q_{8,2} = h_3 e^{-h_3 t}$; $q_{9,3} = h_3 e^{-h_3 t}$

$q_{10,3} = 0$; $q_{10,5} = h_2 e^{-h_2 t}$

$p_{ij} = q^*_{i,j}(0)$

$p_{0,1} = m1/(m1+m2+m3+\alpha)$; $p_{0,2} = m2/(m1+m2+m3+\alpha)$; $p_{0,4} = \alpha/(m1+m2+m3+\alpha)$

$p_{0,7} = m3/(m1+m2+m3+\alpha)$; $p_{1,0} = h1/(m1+m2+m3+h1)$; $p_{1,3} = m2/(m1+m2+m3+h1)$

$p_{1,5} = m1/(m1+m2+m3+h1)$; $p_{1,6} = m3/(m1+m2+m3+h1)$; $p_{2,0} = h2/(m1+m3+h2)$

$p_{2,3} = m1/(m1+m3+h2)$; $p_{2,8} = m3/(m1+m3+h2)$; $p_{3,1} = h2/(m1+m3+h2)$

$p_{3,9} = m3/(m1+m3+h2)$; $p_{3,10} = m1/(m1+m3+h2)$; $p_{4,0} = 1$

$p_{2,0} = h2/(m3+h2)$; $p_{5,10} = m2/(m2+h1)$; $p_{6,1} = 1$; $p_{7,0} = 1$

$p_{8,2} = 1$; $p_{9,3} = 1$; $q_{10,3} = 0$; $p_{10,8} = 1$

4. MEAN SOJOURN TIMES RI(T)

$R_0(t) = e^{-(m_1+m_2+m_3+\alpha)t}$; $R_1(t) = e^{-(m_1+m_2+m_3+h_1)t}$; $R_2(t) = e^{-(m_3+h_2)t}$

$R_3(t) = e^{-(m_1+m_3+h_2)t}$; $R_4(t) = e^{-\beta t}$; $R_5(t) = e^{-(m_2+h_1)t}$; $R_6(t) = e^{-h_3 t}$

$R_7(t) = e^{-h_3 t}$; $R_8(t) = e^{-h_3 t}$; $R_9(t) = e^{-h_3 t}$; $R_{10}(t) = e^{-h_2 t}$

$\mu i = Ri^*(0)$

$\mu 0 = 1/(m1+m2+m3+\alpha)$; $\mu 1 = 1/(m1+m2+m3+h1)$; $\mu 2 = 1/(m3+h2)$

$\mu 3 = 1/(m1+m3+h2)$; $\mu 4 = 1/\beta$; $\mu 5 = 1/(m2+h1)$; $\mu 6 = 1/h3$; $\mu 7 = 1/h3$

$\mu 8 = 1/h3$; $\mu 9 = 1/h3$; $\mu 10 = 1/h2$

5. EVALUATION OF TRANSITION PATH PROBABILITIES (TPP)

Smearing RPGT and by '0' as the initial-state of the organization as beneath: TPP issues of all the accessible states after the first state 'ξ' = '0' remain: Likelihoods after state '0' to dissimilar vertices remain assumed as

$V0,0 = 1$

$V0,1 = p0,1/\{(1-p1,3p3,1)/(1-p3,9p9,3)\}\{(1-p1,3p3,10p10,5p5,1)/(1-p10,5p5,10)\}(1-p1,6p6,1)$
$(1-p1,5p5,1)$

$V0,2 = p0,2/(1-p2,8p8,2)$

V0,3 = ……..Continuous

TPP issues of all the accessible states after the dishonorable state 'ξ' = '1' is: Likelihoods after state '1' to dissimilar vertices stand assumed as

$V1,0 = p1,0/\{(1-p0,2p2,0)/(1-p2,8p8,2)\}(1-p0,4p4,0)(1-p0,7p7,0)$

V1,1 = 1 (Verified)

$V1,2 = p1,0p0,2/\{(1-p0,2p2,0)/(1-p2,8p8,2)\}(1-p0,4p4,0)(1-p0,7p7,0)(1-p2,8p8,2)$

V1,3 = ……..Continuous

6. MODELING SYSTEM PARAMETERS

MTSF(T0): The re-forming un-failed conditions to which the scheme can transit(original state '0'), previously ingoing any unsuccessful state stand: 'i' = 0 to 4 enchanting 'ξ' = '0'.

$T0 = (V0,j\mu j)/[\{1-(0,1,0)-(0,2,0)-(0,4,0)\}]$; j = 0 to 4

Availability of the System (A0): The reformative states at which the scheme is accessible are 'j' = 0 to 4 and the reformative states are 'i' = 0 to 8 captivating 'ξ' = '1' the total fraction of period aimed at which the organization is accessible is certain by

$$A_0 = \left[\sum_j V_{\xi,j}, f_j, \mu_j\right] \div \left[\sum_i V_{\xi,i}, f_j, \mu_i^1\right]$$

$$= (V_{1,1}\mu_1+V_{1,2}\mu_2+V_{1,3}\mu_3+V_{1,4}\mu_4)/D_1$$

Where D1 = V1,0μ0+V1,1μ1+V1,2μ2+V1,3μ3+V1,4μ4+V1,5μ5+V1,6μ6+V1,7μ7+V1,8μ8+V1,9μ9 +V1,10μ10

Busy Period of the Server: The reformative states where server is full are j = 1 to 8 and reformative states are 'i' = 0 to 8, captivating ξ = '0', the total fraction of period for which the waiter remains busy is

$$B_0 = \left[\sum_j V_{\xi,j}, n_j\right] \div \left[\sum_i V_{\xi,i}, \mu_i^1\right]$$

= (V0,jμj)/D j = 0 to 8

Where D = (V0,iμi); i = 0 to 10

Expected Number of Inspections by the repair man: The reformative states where the repairman appointments again are j = 1,2,4,7 the reformative states are i = 0 to 8, Attractive 'ξ' = '0', the integer of call by the overhaul man is assumed by

$$V_0 = \left[\sum_j V_{\xi,j}\right] \div \left[\sum_i V_{\xi,i}, \mu_i^1\right]$$

$$= (V_{0,1}+V_{0,2}+V_{0,4}+V_{0,7})/ D$$

7. DATA ANALYSIS AND RESULTS

Sensitivity Analysis:

Scenario1: Effect of change of failure rates on system parameters taking h = h2 = h3 = h3= 0.50 and varying failure rates

Table 1 MTSF

T_0	m_1	m_2	m_3	m_4
$m_i = 0.05$	277.22	288.45	306.23	320.86
$m_i = 0.10$	256.51	277.22	285.47	303.40
$m_i = 0.15$	223.20	260.25	277.22	283.60
$m_i = 0.20$	211.50	244.20	258.61	277.22

Figure 2 MTSF

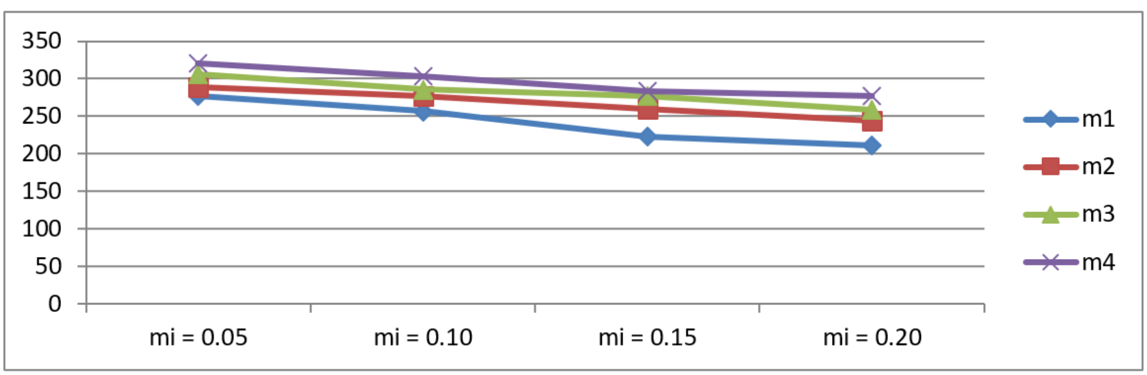

Table 2 Availability of System (A0)

A_0	m_1	m_2	m_3	m_4
m_i = 0.05	1.76	1.78	1.80	1.82
m_i = 0.10	1.74	1.76	1.78	1.80
m_i = 0.15	1.72	1.74	1.76	1.78
m_i = 0.20	1.70	1.72	1.74	1.76

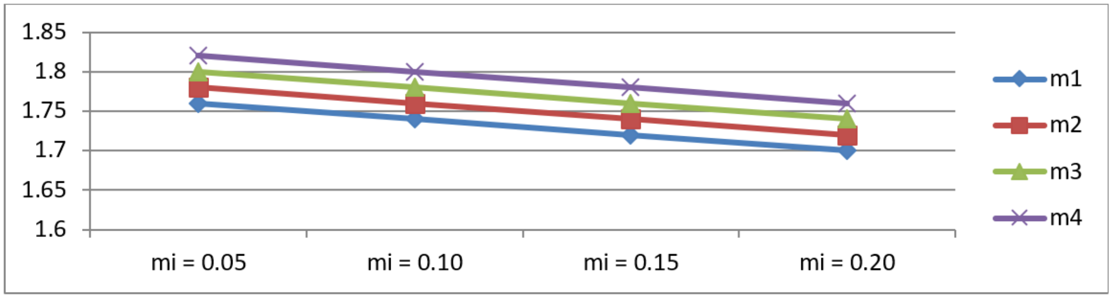

Figure 3: Availability of System (A0)

Table 3 Busy period of server (B0)

B_0	m_1	m_2	m_3	m_4
m_i = 0.05	1.20	1.09	0.97	0.77
m_i = 0.10	1.31	1.20	1.10	0.80
m_i = 0.15	1.42	1.32	1.20	1.04
m_i = 0.20	1.54	1.41	1.31	1.20

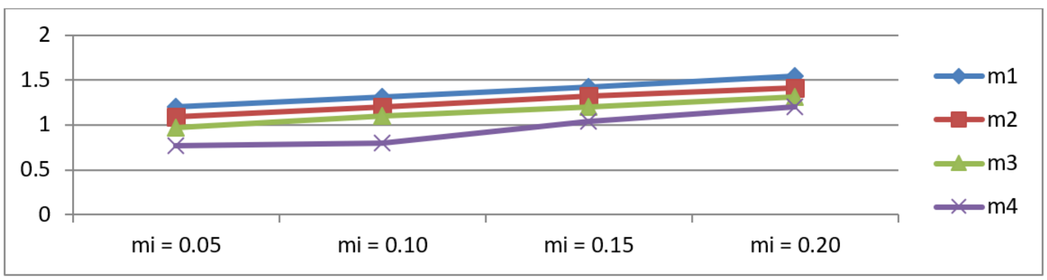

Figure 4 Busy period of server (B0)

Table 4 Expected Fractional Number of Inspections by Repairman (V0)

V_0	m_1	m_2	m_3	m_4
m_i = 0.05	0.379	0.257	0.240	0.109
m_i = 0.10	0.446	0.379	0.312	0.187
m_i = 0.15	0.515	0.444	0.379	0.256
m_i = 0.20	0.586	0.520	0.443	0.379

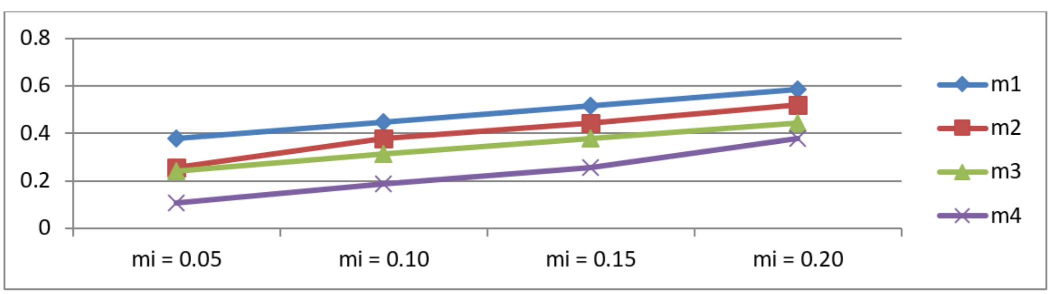

Figure 5 Expected Fractional Number of Inspections by Repairman (V0)

Scenario2: Effect of change of repair rates on system parameters taking m1 = m2 = m3 = m4 = 0.10 and varying repair rates.

Table 5 MTSF

T_0	h_1	h_2	h_3	h_4
h_i = 0.85	233.11	233.11	233.11	233.11
h_i = 0.90	233.11	233.11	233.11	233.11
h_i = 0.95	233.11	233.11	233.11	233.11
h_i = 1.00	233.11	233.11	233.11	233.11

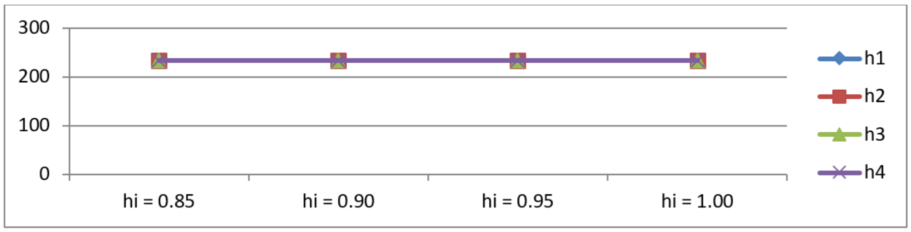

Figure 6 MTSF

Table 6 Availability of System

A_0	h_1	h_2	h_3	h_4
h_i = 0.85	18.76	18.72	18.68	18.64
h_i = 0.90	18.80	18.76	18.72	18.68
h_i = 0.95	18.84	18.80	18.76	18.72
h_i = 1.00	18.88	18.84	18.80	18.76

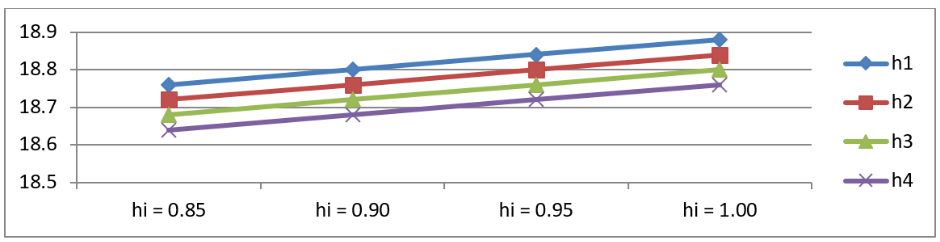

Figure 7 Availability of System

Table 7: Busy Period of server (B0)

B_0	m_1	m_2	m_3	m_4
m_i = 0.85	3.20	3.2	3.47	3.51
m_i = 0.90	3.11	3.20	3.35	3.45
m_i = 0.95	3.03	3.15	3.20	3.32
m_i = 1.00	2.93	3.07	3.13	3.20

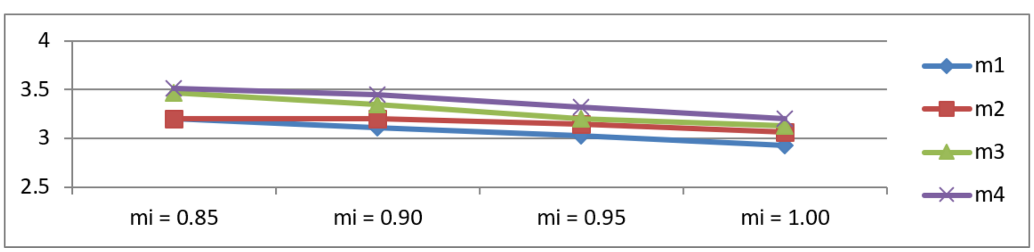

Figure 8 Busy Period of server (B0)

Table 8: Expected Fractional Numbers of Inspections by Repairman (V0)

V_0	m_1	m_2	m_3	m_4
m_i = 0.85	2.323	2.322	2.321	2.320
m_i = 0.90	2.324	2.323	2.322	2.321
m_i = 0.95	2.325	2.324	2.323	2.322
m_i = 1.00	2.326	2.325	2.324	2.323

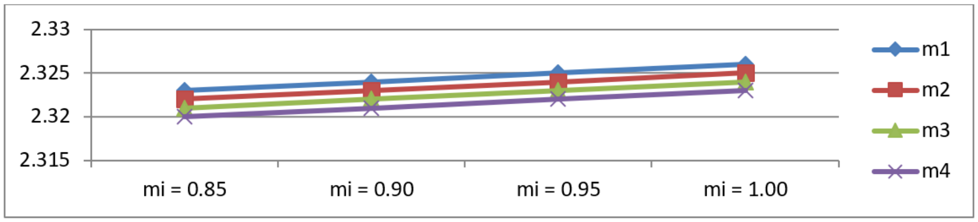

Figure 9 Expected Fractional Numbers of Inspections by Repairman (V0)

8. CONCLUSION

Real data gathered from the various Haryanan plants was used to create and analyse the models. Various aspects and feasible scenarios of the framework and systems were considered, such as various redundant, significant faults, minor faults, investigations, faults during repairs, proper repairs, improper repairs, expert repairman, redundancy of the system, and so forth. Coordination of processes and activities required to create a desired product or part with appropriate presentation is referred to as a manufacturing framework. A key component of the regular operation of many contemporary technical systems is reliability. From table 1 and graph 2 managements can have conclusions suitable to them. A0 should be large for a good system, as shown by table 2 and graph 3, which show that A0 is maximum for very low unit failure rates. When comparing the columns, values A0 decline more quickly as the unit S value increases. N0 should be large for a good system, as shown by table 3 and graph 4, which show that B0 is maximum for very low unit failure rates. When comparing the columns, values B0 decline more quickly as the unit S value increases. The value of V0 does not significantly alter due to a rise in the upside of the units' disappointment rates; however, it does decrease when the fourth sub-unit or disappointment rate is the lowest when compared to the disappointment rates of other units in table 4 and figure 5 above. Table 5 and Figure 6 show that the MTSF is constant of unit maintenance rates and is justly big, or 233.11. According to Table 6 and Figure 7, availability is highest when a unit's maintenance rate is at its highest relative to its repair rate. Since A0 corresponds to the greatest unit repair rate, a good system should have a very big value. As a result, when providing maintenance facilities, the units should receive more attention than the other units. Low maintenance costs can be achieved by keeping the value of B0 minimal for a well-functioning system. We can see from table 7 and graph 8 that B0 is at its smallest when the repair rate of each unit is one and its worth is 2.93, and at its smallest when the repair rate of each unit is one. Table 8 and Graph 9 demonstrate that the qualities in columns presuppose a minimal relative V0 as they proceed from start to conclusion. As a result, maintenance rates are the lowest; in order to correct the challenging, workers will need to put in more hours. As one looks through and through in portions, they see that the worker of the occupied period decreases, which is a consistent pattern in almost all of the diagram's reproductions and supports the similar results. It is highly desirable for a nation with low revenues, such as India, to make the most of its resources in order to increase productivity by enhancing the equipment and organization's consistency. Even though dependability education has been moving a little more quickly, mutual formulae in the secure form are not generated for semi-Markov, where the technique's conditions change and result in a partial, aperiodic, and irreducible Markov chain. This makes it difficult to calculate the frameworks' essential and crucial statistical parameters, such as MTSF, accessibility, server of busy period, etc., of various forms of replacements (under steady state circumstances).

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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