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SENSITIVITY ANALYSIS OF 3:4::GOOD SYSTEM

Arun Kumar*, Dr. Deepika Garg **, Dr. Pardeep Goel*, Dr. Ozen Ozer**
**Research Scholar, **Assistant Professor, G D Goenka University, Gurugram (Haryana),*
****Associate Professor M.M.(P.G.) College, Fatehabad -125050 (Haryana),*
*****Assistant Professor,Kayalı Campus, 39100, Kırklareli/TURKEY*

Abstract:.
The paper analyzes the sensitivity analysis of 3:4:: Good system plant is created with a solitary server which comprises of four non-indistinguishable units in which fundamental unit can work in diminished state because of partial failure. The primary unit can fail mostly and subsequently can be in up-state, incompletely fizzled state or completely fizzled state. The framework can work with decreased limit in a partially fizzled state. Taking disappointment and repair rates constant. A state graph of the framework delineating the transition rates is drawn.The fix of unit, treatment of server is considered as immaculate. Utilizing RPGT, articulations for the MTSF, available, busy period, Number of server's visits has been assessed to think about the system execution pursued by outlines, unique cases, Tables and Graphs.

Keywords:- Sensitivity Analysis, MTSF, busy- period of repairman, RPGT,System Parametersetc.

1. Introduction:

in this paper the reliability model for Sensitivity analysis of 3:4:: Good System is created. The entire industries into four units for a better analysis. Division of entire industry into four units can be taken up in different mix. Be that as it may, study can be taken for individual units. One section is considered as principle unit and other to be taken as backup units. In which principle unit can work in decreased state after incomplete/partial failure. The principle unit can flop partially and thus can be in up-state, in part fizzled state or completely fizzled state and one of the backup unit have remain by and third and fourth unit have units in arrangement. The framework can work with diminished limit in a partially fizzled state. The repair of the unit, treatment of the server is considered as perfect. In this paper a sensitivity analysis of 3:4:: Good System and exhibited the framework parameters using RPGT taking steady disappointment and fix rates of units. A advancement state graph framework in which it may be has been drawn using Markov technique. Repairman's is accessible 24*7 and these repairman's changes out the fizzled unit on its disappointment. The repairman is should be open constantly. The failed unit on fix is required to be in a similar class as though another. Need in fix is doled out in the solicitation C > D > E > F.More specialist have work been done in field of reliability analyzing models dependent on creating various kind of items.Kumar, J. & Malik, S. C. [1] have discussed the concept of preventive maintenance for a single unit system. Liu., R. [2], Malik, S. C. [3], Nakagawa, T. and Osaki, S. [4] have discussed reliability analysis of a one unit system with un-repairable spare units and its applications. Goel, P. & Singh J. [5], Gupta, P., Singh, J. & Singh, I.P. [6], Kumar, S. & Goel, P. [7], Gupta, V. K. [8], Chaudhary, Goel & Kumar [9] Sharma & Goel [10], Ritikesh & Goel [11], Goyal & Goel [12], Yusuf, I. [13], Gupta, R.,

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Sharma, S. & Bhardwaj, P. [14], Ms. Rachita and Garg, D.[15] and Garg, D. and Yadav, R. [16] have discussed behavior with perfect and imperfect switch-over of systems using various techniques.

2.Assumptions& Notations:-

1. Two repair man facilities are available in full time.
2. Repairs are statistically independent.
3. Nothing can come up short when system is in fizzled state.

$\left(i\overset{s_r}{\rightarrow}j\right)$: *r*-th directed straightforward way from *i*-state to j-state; r takes positive necessary qualities for various way from *i*-state to j-state.

$\left(\xi\overset{sff}{\longrightarrow}i\right)$: A coordinated basic disappointment freeway from ξ -state to i-state.

$V_{m,m}$: Probability factor of state m reachable from last state m of M-cycle.

$V_{\overline{m,m}}$: Probability factor of state m reachable from last state m of $m-\overline{cycle}$.

$R_i(t)$: Reliability of frameworkat time t, given that framework entered the un-fizzled Regenerative state 'i' & t = 0.

$A_i(t)$: Probability of framework in up time at time t, given that framework entered Regenerative state 'i' & t = 0.

$B_i(t)$: Reliability that server is busy for completing points of interest work at time t; given framework entered regenerative state 'i' & t = 0.

$V_i(t)$: Expected no. of server for carrying out a responsibility in (o,t] given that framework Entered regenerative state 'i'& t = 0.

',' : denote derivative

μ_i : Mean stay time spent in state i, before visiting some other states;

μ_i : = $\int_0^\infty R_i(t)dt$

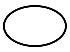
μ_i^1 : The absolute un-restrictive time spent before traveling to some other regenerative states, given that framework entered regenerative state 'i' at t=0.

n_i : Expected holding up time spent while completing a given activity, given that framework entered regenerative state 'i' & t=0; $n_i W_i^*(0)$.

ξ : Base state of system.

f_j : Fuzziness proportion of j-state.

α_i/ β_i: Constant repair /failure rate of units ($1 \le i \le 4$)

: Good State 

: Reduced State 

: Fizzled State 

C/c : Unit in full working / failed.

D/d : Unit in full working / failed.

3. Model Description:-Following above assumptions &notations Transition Diagram of framework/system is given in Figure 1.

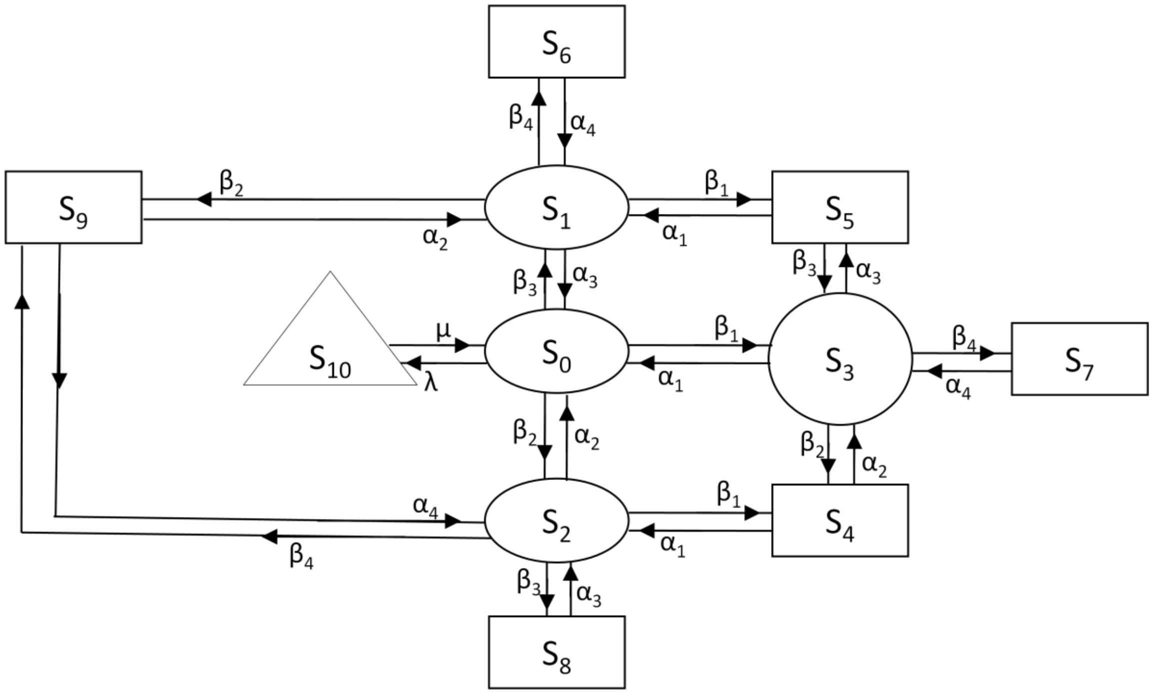


Figure-1

S_0 = CDEF, S_1 = CD$\bar{E}$F, S_2 =C$\bar{D}$EF, S_3 = $\bar{C}$DEF,

S_4 = $\overline{CD}$EF, S_5 = $\bar{C}$D$\bar{E}$F, S_6 = CD$\overline{EF}$, S_7 = $\bar{C}$DE$\bar{F}$,

S_8= C$\overline{DE}$F, S_9 = C$\bar{D}$E$\bar{F}$, S_{10} = CDEF

Model Description

Initially there are four units C, D, E, F in good state S_0 out of these three units are online in working condition and fourth units is under preventive maintenance. The rates of inspection and preventive maintenance are λ and μ respectively. On failure of one of the three online units, the failed unit is replaced by the fourth unit which is under preventive maintenance thereby system reaches the states S_1, S_2, S_3 on failure of units C, D, E, the transition rates of which are β_3, β_1, β_2 on repair of the failed unit the system renters the initial state S_0 from states S_3, S_2, S_1 with transition rates α_1, α_2, α_3 respectively before failure of any other unit. From the state S_3 if there is failure of one more unit then the system enters the failed states S_4, S_5, S_7 depending upon the kind of unit fails. Similarly from S_2 on failure of one more unit system enters the failed states S_4, S_8, S_9 and on failure of one more unit from the state S_1 system enters the failed states S_5, S_6, S_9 depending upon the kind of failed unit.

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4.Transition Probability

Table 1: Transition Probabilities

$q_{i,j}(t)$	$P_{ij} = q^*_{i,j}(t)$
$q_{0,1}(t) = \beta_3 e^{-(\beta_1+\beta_2+\beta_3+\lambda)t}$ $q_{0,2}(t) = \beta_2 e^{-(\beta_1+\beta_2+\beta_3+\lambda)t}$ $q_{0,3}(t) = \beta_1 e^{-(\beta_1+\beta_2+\beta_3+\lambda)t}$ $q_{0,10}(t) = \lambda e^{-(\lambda+\beta_1+\beta_2+\beta_3)t}$	$p_{0,1}= \beta_3/(\beta_1+\beta_3+\beta_2+\lambda)$ $p_{0,2}= \beta_2/(\beta_3+\beta_2+\beta_1+\lambda)$ $p_{0,3}= \beta_1/(\beta_1+\beta_3+\beta_2+\lambda)$ $p_{0,10}= \lambda/(\beta_3+\beta_1+\beta_2+\lambda)$
$q_{1,0}(t) = \alpha_3 e^{-(\alpha_3+\beta_1+\beta_4+\beta_2)t}$ $q_{1,6}(t) = \beta_4 e^{-(\beta_1+\beta_2+\beta_4+\alpha_3)t}$ $q_{1,5}(t) = \beta_1 e^{-(\beta_1+\beta_2+\beta_4+\alpha_3)t}$ $q_{1,9}(t) = \beta_2 e^{-(\beta_1+\beta_2+\beta_4+\alpha_3)t}$	$p_{1,0}= \alpha_3/(\alpha_3+\beta_2+\beta_4+\beta_1)$ $p_{1,6}= \beta_4/(\beta_2+\beta_1+\beta_4+\alpha_3)$ $p_{1,5}= \beta_1/(\beta_4+\beta_2+\beta_1+\alpha_3)$ $p_{1,9}= \beta_2/(\beta_2+\beta_4+\beta_1+\alpha_3)$
$q_{2,0}(t) = \alpha_2 e^{-(\alpha_2+\beta_1+\beta_4+\beta_3)t}$ $q_{2,4}(t) = \beta_1 e^{-(\beta_1+\alpha_2+\beta_4+\beta_3)t}$ $q_{2,8}(t) = \beta_3 e^{-(\beta_3+\beta_1+\beta_4+\alpha_2)t}$ $q_{2,9}(t) = \beta_4 e^{-(\beta_4+\beta_1+\beta_3+\alpha_2)t}$	$p_{2,0}= \alpha_2/(\alpha_2+\beta_1+\beta_4+\beta_3)$ $p_{2,4}= \beta_1/(\beta_1+\alpha_2+\beta_4+\alpha_3)$ $p_{2,8}= \beta_3/(\beta_3+\beta_1+\beta_4+\alpha_2)$ $p_{2,9}= \beta_4/(\beta_4+\beta_1+\beta_3+\alpha_2)$
$q_{3,0}(t) = \alpha_1 e^{-(\alpha_1+\beta_2+\beta_3+\beta_4)t}$ $q_{3,5}(t) = \beta_3 e^{-(\beta_3+\beta_4+\alpha_1+\beta_2)t}$ $q_{3,7}(t) = \beta_4 e^{-(\alpha_1+\beta_2+\beta_3+\beta_4)t}$ $q_{3,4}(t) = \beta_2 e^{-(\alpha_1+\beta_2+\beta_3+\beta_4)t}$	$p_{3,0}= \alpha_1/(\alpha_1+\beta_2+\beta_3+\beta_4)$ $p_{3,5}= \beta_3/(\beta_2+\beta_4+\alpha_1+\beta_3)$ $p_{3,7}= \beta_4/(\alpha_1+\beta_4+\beta_3+\beta_2)$ $p_{3,4}= \beta_2/(\alpha_1+\beta_2+\beta_3+\beta_4)$
$q_{4,2}(t) = \alpha_1 e^{-(\alpha_1+\alpha_2)t}$ $q_{4,3}(t) = \alpha_2 e^{-(\alpha_1+\alpha_2)t}$	$p_{4,2}= \alpha_1/(\alpha_1+\alpha_2)$ $p_{4,3}= \alpha_2/(\alpha_1+\alpha_2)$
$q_{5,1}(t) = \alpha_1 e^{-(\alpha_1+\alpha_3)t}$ $q_{5,3}(t) = \alpha_3 e^{-(\alpha_3+\alpha_1)t}$	$p_{5,1}= \alpha_1/(\alpha_1+\alpha_3)$ $p_{5,3}= \alpha_3/(\alpha_3+\alpha_1)$
$q_{6,1}(t)= \alpha_4 e^{-\alpha_4 t}$	$p_{6,1}= 1$
$q_{7,3}(t)= \alpha_4 e^{-\alpha_4 t}$	$p_{7,3}= 1$
$q_{8,2}(t)= \alpha_3 e^{-\alpha_3 t}$	$p_{8,2}= 1$
$q_{9,1}(t) = \alpha_2 e^{-(\alpha_2+\alpha_4)t}$ $q_{9,2}(t) = \alpha_4 e^{-(\alpha_4+\alpha_2)t}$	$p_{9,1}= \alpha_2/(\alpha_2+\alpha_4)$ $p_{9,2}= \alpha_4/(\alpha_4+\alpha_2)$
$q_{10,0}(t)= \mu e^{-\mu t}$	$p_{10,0}= 1$

5. Mean Sojourn Times:- .

Table 2: -Mean Sojourn Times

$R_i(t)$	$\mu_i=R_i^*(0)$
$R_0(t)= e^{-(\beta_1+\beta_2+\beta_3+\lambda)t}$	$\mu_0 = 1/(\beta_1+\beta_2+\beta_3+\lambda)$
$R_1(t)= e^{-(\beta_1+\beta_2+\beta_4+\alpha_3)t}$	$\mu_1 = 1/(\beta_1+\beta_2+\beta_4+\alpha_3)$
$R_2(t)= e^{-(\beta_1+\beta_3+\beta_4+\alpha_2)t}$	$\mu_2 = 1/(\beta_1+\beta_3+\beta_4+\alpha_2)$
$R_3(t)= e^{-(\alpha_1+\beta_2+\beta_3+\beta_4)t}$	$\mu_3= 1/(\alpha_1+\beta_2+\beta_3+\beta_4)$
$R_4(t)= e^{-(\alpha_1+\alpha_2)t}$	$\mu_4 = 1/(\alpha_1+\alpha_2)$
$R_5(t)= e^{-(\alpha_3+\alpha_1)t}$	$\mu_5 = 1/(\alpha_3+\alpha_1)$
$R_6(t)= e^{-\alpha_4 t}$	$\mu_6 = 1/\alpha_4$
$R_7(t)= e^{-\alpha_4 t}$	$\mu_7 = 1/\alpha_4$
$R_8(t)= e^{-\alpha_3 t}$	$\mu_8 = 1/\alpha_3$
$R_9(t)= e^{-(\alpha_2+\alpha_4)t}$	$\mu_9 = 1/(\alpha_2+\alpha_4)$
$R_{10}(t)= e^{-\mu t}$	$\mu_{10} = 1/\mu$

Table 2

6. Path Probability: - Probabilities from state '0' to various vertices are given

$V_{0,0}$ = 1 (Verified)

$V_{0,1}$ = [(0,1)/(1-M_1){1-{M_2/(1-M_{17})}}{1-{M_3/(1-M_{21})}}][1/1-{M_4/(1-M_5)(1-M_6)(1-M_7)(1-M_9)(1-M_{10}) (1-M_{11})}]+[(0,3,5,1)/(1-M_1){1-{M_2/(1-M_{17})}}{1-{M_3/(1-M_2)}}(1-M_{11}){1-{M_9/(1-M_{18})}}][1/1-{M_4/(1-M_5)(1-M_6)(1-M_7)(1-M_9)(1-M_{10})(1-M_{11})}][1/1-{M_{12}/(1-M_1)(1-M_2)(1-M_3)(1-M_5)(1-M_6)(1-M_7)}][1/1-{M_{14}/(1-M_1)(1-M_3)(1-M_5)(1-M_6)(1-M_7)(1-M_9)(1-M_{11})}][1/1-{M_{10}/(1-M_{16})}]+[(0,2,4,3,5,1)/(1-M_1){1-{M_2/(1-M_{17})}}{1-{M_3/(1-M_{21})}}{1-{M_6/(1-M_{20})}}(1-M_5)][1/{1-{M_7/(1-M_{19})}}{1-{M_9/(1-M_{18})}}{1-{M_{10}/(1-M_{16})}}(1-M_{11})])}}][1/1-{M_4/(1-M_5)(1-M_6)(1-M_7)(1-M_9)(1-M_{10}) (1-M_{11})}][1/1-{M_8/(1-M_1)(1-M_2)(1-M_3)(1-M_9)(1-M_{10})(1-M_{11})}][1/1-{M_{12}/(1-M_1)(1-M_2)(1-M_3)(1-M_5)(1-M_6)(1-M_7)}][1/1-{M_{13}/(1-M_1)(1-M_2)(1-M_3)(1-M_5)(1-M_6)(1-M_{10})(1-M_{11})}][1/1-{M_{14}/(1-M_1)(1-M_3)(1-M_5)(1-M_6)(1-M_7)(1-M_9)(1-M_{11})}]+[(0,2,9,1)/(1-M_1){1-{M_2/(1-M_{17})}}{1-{M_3/(1-M_{21})}}(1-M_5)][1/{1-{M_6/(1-M_{20})}}{1-{M_7/(1-M_{19})}}][1/1-{M_{15}/(1-M_1)(1-M_2)(1-M_5)(1-M_7)(1-M_9)(1-M_{10})(1-M_{11})}][1/1-{M_8/(1-M_1)(1-M_2)(1-M_3)(1-M_9)(1-M_{10})(1-M_{11})}]+[(0,3,4,2,9,1)/(1-M_1){1-{M_2/(1-M_{17})}}{1-{M_3/(1-M_{21})}}(1-M_5){1-{M_6/(1-M_{20})}}][1/{1-{M_7/(1-M_{19})}}{1-{M_9/(1-M_{18})}}(1-M_{11})][1/1-{M_4/(1-M_5)(1-M_6)(1-M_7)(1-M_9)(1-M_{10})(1-M_{11})}][1/1-{M_8/(1-M_1)(1-M_2)(1-M_3)(1-M_9)(1-M_{10})(1-M_{11})}][1/1-{M_{12}/(1-M_1)(1-M_2)(1-M_3)(1-M_5)(1-M_6)(1-M_7)}][1/1-{M_{13}/(1-M_1)(1-M_2)(1-M_3)(1-M_5)(1-M_6)(1-M_{10})(1-M_{11})}][1/1-{M_{15}/(1-M_1)(1-M_2)(1-M_3)(1-M_5)(1-M_7)(1-M_9)

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$(1-M_{10})(1-M_{11})\}]$

$V_{0,2}$ = ………Continue

7. Path Modeling:-

7.1 MTSF (T_0): The un-fizzled states to which frameworkmay travel, before joining any fizzled state are: 'i'= 0, 1, 2, 3, 10 & 'ξ' = '0'.

$$\text{MTSF}(T_0) = \left[\sum_{i,sr}\left\{\frac{\left\{pr\left(\xi\xrightarrow{sr\,(sff)} i\right)\right\}\mu i}{\Pi_{m_{1\neq\xi}}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[1-\sum_{sr}\left\{\frac{\left\{pr\left(\xi\xrightarrow{sr\,(sff)}\xi\right)\right\}}{\Pi_{m_{2\neq\xi}}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

7.2 Availability of System (A_0): The regenerative states at which framework is working are 'j' = 0, 1, 2, 3, 10, 'i' = 0 to 10 &'ξ' = '0' availability is given by

$$A_0 = \left[\sum_{j,sr}\left\{\frac{\{pr\,(\xi^{sr}\rightarrow j)\}fj,\mu j}{\Pi_{m_{1\neq\xi}}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\{pr\,(\xi^{sr}\rightarrow i)\}\mu_i^1}{\Pi_{m_{2\neq\xi}}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

7.3 Busy Period of Server: The regenerative states where server j = 1 to10, 'i' = 0 to 10 & ξ = '0', the modeling server is

$$B_0 = \left[\sum_{j,sr}\left\{\frac{\{pr(\xi^{sr}\rightarrow j)\},nj}{\Pi_{m_{1\neq\xi}}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\{pr(\xi^{sr}\rightarrow i)\}\mu_i^1}{\Pi_{m_{2\neq\xi}}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

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

7.4 Expected Fractional No. of Inspections by repair man (V_o): Regenerative states where repairmen do this job j = 1, 3, 2, 10, i = 0 to 10 &'ξ' = '0', number of visit by repair man is given by

$$V_0 = \left[\sum_{j,sr}\left\{\frac{\{pr(\xi^{sr}\rightarrow j)\}}{\Pi_{k_{1\neq\xi}}\{1-V_{\overline{k_1 k_1}}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\{pr(\xi^{sr}\rightarrow i)\}\mu_i^1}{\Pi_{k_{2\neq\xi}}\{1-V_{\overline{k_2 k_2}}\}}\right\}\right]$$

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

8. Sensitivity Analysis of System

Scenario1: Sensitivity Analysis w. r. t. change in repair rates**.** Taking $\beta_i = 0.1\ (1 \le i \le 4)$, λ= 0.5, μ=1, and varying $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ one by one respectively at 0.70, 0.80, 0.90, 1.00

Mean Time to System Failure (T_0):-

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Mean Time to System Failure Graph

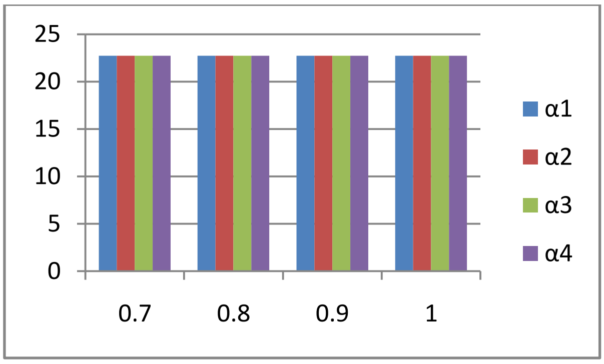

Figure 2

From graph we conclude that MTSF is independent of repair rates of various units.

Availability of the System (A_0) :-

Availability of the System (A_0) Graph

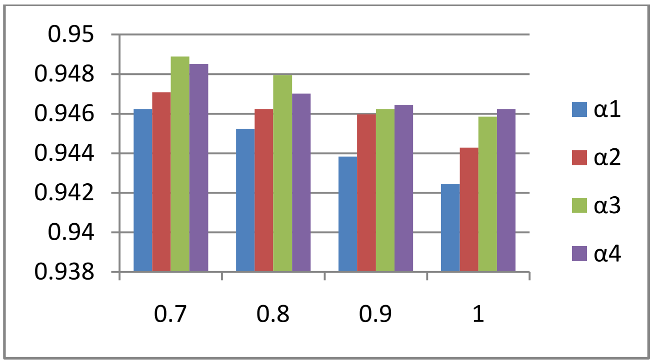

Figure 3

We conclude that increase in repair rates do not have significant increase in the value of availability of the system. However, for maximum of availability repair rate of unit 'E' kept Maximum.

Busy Period of the Server (B_0) :-

Busy Period of the Server Graph

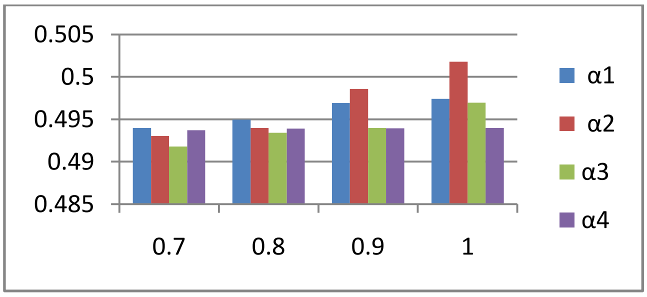

Figure 4

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It is concluded that B_0 maximum when repair rate of unit 'D' maximum in comparison to other units, hence repairman should be efficient in repairing the unit 'D' to have lower value of busy period of the server.

Expected Fractional Number of Inspection by the Repairman (V_0)

Expected Fractional Number of Inspection by the Repairman Graph

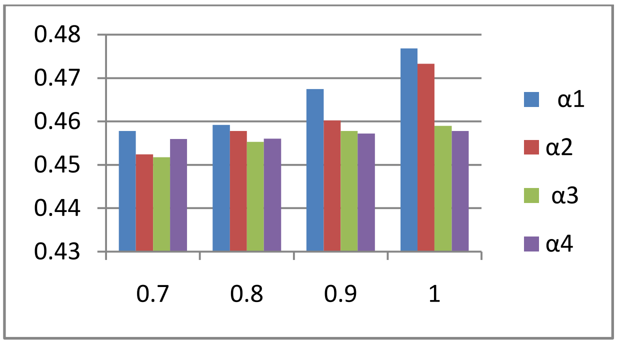

Figure 5

We see that there is no significant change in the value of V_0 with the increase in repair rates of unit.

Scenario2: Now we consider Sensitivity Analysis scenario 2 with respect to change in failure rates: taking $\alpha_i = 0.80$ $(1 \le i \le 4)$ and varying β_0, β_1, β_2, β_3 one by one respectively at 0.10, 0.20, 0.30, 0.40.

Mean Time to System Failure (T_0):

Mean Time to System Failure Graph

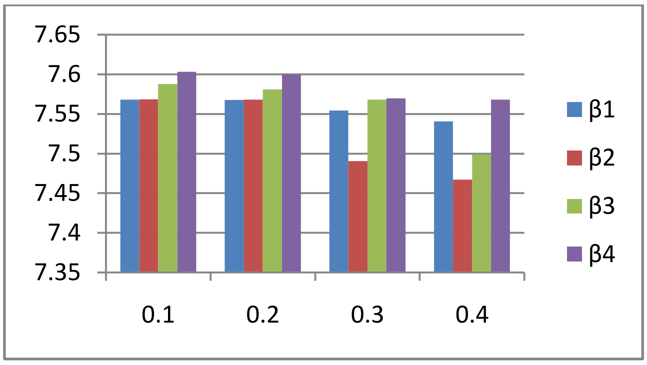

Figure 6

There is no significant change in the value of T_0 with the increase in failure rates of units.

Availability of the System (A_0)

Availability of the System Graph

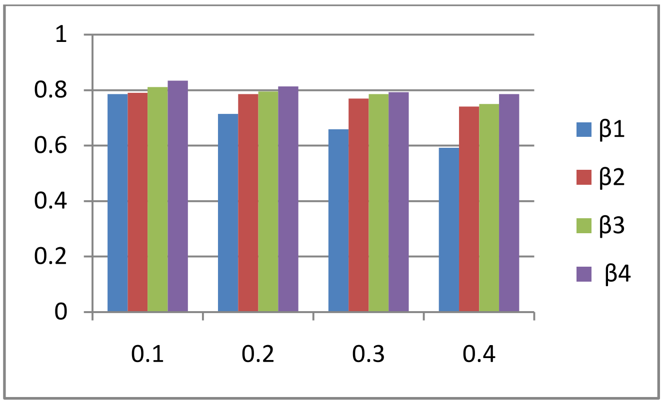

Figure 7

We see that A_0 is maximum when failure rate of Unit 'F' is 0.10 and its values is 0.83418 and availability is minimum when failure rate of sub-units are maximum.

Busy Period of the Server (B_0)

Busy Period of the Server (B_0) Graph

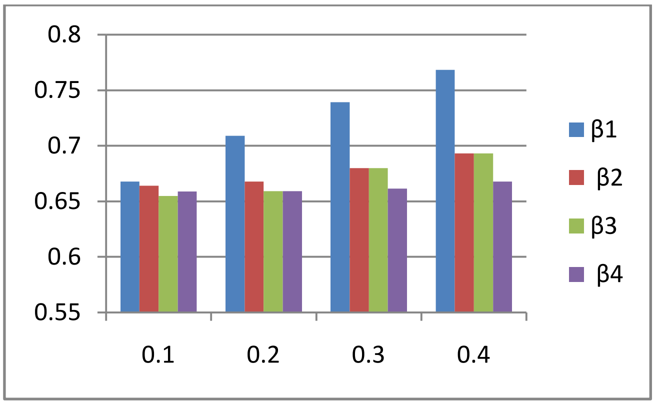

Figure 8

From the above graph we see that optimum value of busy period is 0.65889 which suggests that failure rate of unit 'F' should be minimum. To avoid lower value of B_0 failure rate should be kept lowest.

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Expected Fractional Number of Inspection by the Repairman (V_0)

Expected Fractional Number of Inspection by the Repairman Graph

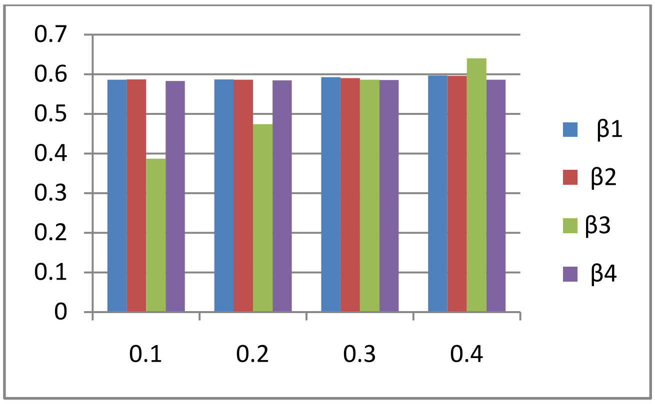

Figure 9

From the above Figure 9for optimum value of V_0 failure rate of sub-unit 'E' should be Minimum in comparison to other units.

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