Availability analysis of two parallel unit system under the provision of maintenance

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Abstract:

Objectives: This paper illustrates the availability investigation of a two unlike parallel unit stand-in system under the provision of preventive or protective maintenance (PM) as well as on the spot substitute of low cost unit. Only one repair man availability in the system has been considered for both repair work and maintenance work.

Methods/Statistical Analysis: We had analyzed the system/framework under the assistance of regenerative point techniques.

Findings: Many graphs have been plotted for discussing/examine the Graphical trends of MTSF and availability which are very useful for the manufacturer, Reliability engineers, managers etc. Novelty/Improvements: This study can be used or applicable for optimize the reliability of the electronics framework/system in the industry.

Keyword: **MTSF, Availability of the system, Analysis of Busy time of server.**

I. INTRODUCTION

Number of researchers/engineers are involved in the field of investigation of unwavering quality and accessibility of the electronics components/frameworks. A two unit cold stand-in arrangement discussed with the presupposition of the breakdown rate of a unit is steady and the renovate time dispersion is a two-phase Erlang distribution. For the framework execution examination they determined mean time before failure, system availability, and relentless state accessibility[1]. The unwavering quality examined ,of more than one component standby framework with alone repair facility. For acquiring desired reliabilility, they interchanged the active and the standby components at randomly and they also used the concept of preventive maintenance(PM) of functioning in addition to the stand-in component . After the completion of the work of repair, they sent the particular unit for examine whether the repair was satisfactory or not[2] . A paper presented on a framework wherein both PLC's were working in master-slave pattern. They had assumed that main component is Functioning, and the secondary component was in stand in phase. The secondary component had more reliability as compared to the main one[3].
A newly genetic algorithm concept discussed , to get the solution of reliability optimization problem in a *k* unrelated-component non-repairable surplus system. There they discussed that each component is linked with a number of self-sufficient components with Erlang distributions set in a series–parallel pattern. The main role of their work was to get the idea about the best component[4].
A work explained on the study of a computer database framework having Primary database and backup database component[5]. Reliability analysis done by two researchers on two unit stand by system under the concept of Poisson shock[6]. Reliability analysis explained under the perfect environment as far as repair work is concerned[7].
The purpose of our work is to investigate a real life model existing in a cable manufacturing plant located at Baddi, Himachal Pradesh, India. Single repairman was available there for both repair and maintenance work as well. So here we worked on such a system with two different parallel components, one and only of them is adequate for working the framework/system, framework comes up short totally if both the components fall flat simultaneously. And here preference of repair has been given to unit A over the unit B if both get failed and it is a choice of management or engineer that they can also go for replacement of unit B if both components get failed.

II. SYSTEM DESCRIPTION AND ASSUMPTIONS

1) System composed of two unlike components A and B, Component A is functioning in the starting for operation but the unit B is in rest mode.
2) There is only one server/repairman facility available. He/she may appear and disappears from the system randomly. It has been assumed

that if the repairman starts the repair or PM he cannot go for the vacation.

3) If both components are in failure mode then preference has been given to unit A for repairing first

Notations

For getting the MTSF and other reliability characteristics we are having the state transition table[1] and symbols as follows:

A_0 : Component A is in active state

B_0: Component B is in active state

A_{fr} : Component A under failure state

A_{pm} : Component A under PM state

B_{fr} : Component B under failure state

A_w : Component A is in Waiting state

B_w : Component B is in Waiting state

A_{Fr} : Component A is in failure mode from previous state

B_{Fr} : Component B is in failure mode from previous state

θ_1: Consistent rate of repairman's non-availability

θ_2: Consistent rate of repairman's availability

λ_1: Consistent rate of PM (preventive Maintenance) of single unit A

p: Probability of not replacement of B if both unit failed and waiting for repairperson

q: Probability of replacement of B if both unit failed and waiting for repairperson

$q_{ij}(.), Q_{ij}(.)$: pdf &cdf of (transition time)move time from regenerative state S_i to S_j.

3.2 Probabilities for Transition states

Probabilities are mentioned below

$$p_{01}=\frac{\alpha_1(1-r_1)}{\alpha_1(1-r_1)+\lambda_1+\theta_1}$$

$$p_{02}=\frac{\theta_1}{\alpha_1(1-r_1)+\lambda_1+\theta_1}$$

$$p_{08}=\frac{\lambda_1}{\alpha_1(1-r_1)+\lambda+\theta_1}$$

$$p_{10}=\frac{\beta_1(1-r_1)}{\beta_1(1-r_1)+\alpha_2(1-r_2)}$$

$$p_{13}=p_{15.3}=\frac{\alpha_2(1-r_2)}{\beta_1(1-r_1)+\alpha_2(1-r_2)}$$

$$p_{46}=\frac{\alpha_2(1-r_2)}{\alpha_2(1-r_2)+\theta_2}$$

$$p_{50}=\frac{\beta_2(1-r_2)}{\beta_2(1-r_2)+\alpha_1(1-r_1)}$$

$$p_{20}=\frac{\theta_2}{\alpha_1(1-r_1)+\theta_2}$$

$$p_{24}=\frac{\alpha_1(1-r_1)}{\alpha_1(1-r_1)+\theta_2}$$

$$p_{41}=\frac{\theta_2}{\alpha_2(1-r_2)+\theta_2}$$

$$p_{46}=\frac{\alpha_2(1-r_2)}{\alpha_2(1-r_2)+\theta_2}$$

$$p_{63}=p$$

$$p_{64}=q$$

$$p_{57}=\frac{\alpha_1(1-r_1)}{\beta_2(1-r_2)+\alpha_1(1-r_1)}$$

After calculation we are getting

$P_{01}+P_{02}+P_{08}=1$

$P_{13}+P_{10}=1$

$P_{35}=1$

$P_{20}+P_{24}=1$

$P_{41}+P_{46}=1$

$P_{50}+P_{57}=1$ **(1-20)**

Mean sojourn Time

The mean (interim) time consumed by the framework to passage for state "j" when it is counted from epoch of passage into state "i" mathematically or scientifically expressed as:

$$m_{ij}=\int_0^\infty tq_{ij}(t)dt=-q_{ij}^{*'}(0) \qquad \textbf{(21)}$$

III. ANALYSIS OF CHARACTERISTICS OF RELIABILITY

MTSF (Mean Time to System Failure)

To decide the MTSF of the framework, we assumed the fizzled condition of the framework as engrossing state, by applying some mathematical concepts like probability and Laplace Stieltjes transforms and solving for $\phi_0^{**}(s)$,we get

$$\phi_0^{**}(s)=\frac{N(s)}{D(s)},$$

$$\text{MTSF}=\lim_{s\to o}\frac{(1-\phi_0^{**}(s))}{s}=\frac{N}{D}$$

After taking the limit with the help of L-Hospital's rule we have

$$N=\mu_0+\mu_1(p_{01}+p_{02}p_{08}p_{24}p_{41})+\mu_2 p_{02}p_{08}+\mu_4 p_{02}p_{24}p_{08}$$

$$D=1-p_{01}p_{10}-p_{10}p_{02}p_{24}p_{41}-p_{02}p_{20}p_{08} \qquad \textbf{(22-25)}$$

Availability Analysis

Utilizing numerical approach availability (accessibility) $A_i(t)$ can be described by the following expressions,

$$A_0^*(s)=\frac{N_1(s)}{D_1(s)}$$

The steady state availability is

$$A_0=\lim_{s\to o}sA_0^*(s)=\frac{N_1}{D_1}$$

Where

$$N_1=\mu_0(1-p_{46}p_{64})(\mu_0+\mu_1 p_{01}+\mu_2 p_{02}p_{08})-p_{51.7}(1-p_{46}p_{08}p_{64})(\mu_{01}p_{15.3}+\mu_2 p_{02}p_{08})$$
$$+(1-p_{46}p_{64})p_{01}p_{15.3}\mu_5$$

$$D_1=(1-p_{46}p_{64})(1-p_{51.7}p_{15.3}+p_{24}p_{08}p_{02})+(1-p_{46}p_{64})p_{01}p_{08}p_{15.3} \qquad \textbf{(28-29)}$$

Analysis of Busy time of server

Let Bi(t) be the probability that the only server given by the company's organization is engaged at instant t, provided the framework is entered to regenerative state "i" initially. By probability theory, we have the following equations for busy period,

$$B_0^*(s)=\frac{N_2(s)}{D_1(s)}$$

$$B_0=\lim_{s\to o}sB_0^*(s)=\frac{N_2}{D_1}$$

$$N_2=\mu_0(1-p_{46}p_{64})+p_{51.7}(\mu_1 p_{15.3}+\mu_2 p_{02}p_{24})$$
$$+p_{02}p_{08}p_{24}[\mu_4(1-p_{15.3}p_{51.7})] \qquad \textbf{(30-32)}$$

D1 has already been mentioned earlier.

IV. CONCLUSION

The Profit of the organization would depend on the earned money by the system and on expenditure during repair process by the server. So following expression is representing the profit function of the system

$$P=C_0A_0-C_1B_0 \qquad \textbf{(33)}$$

where

C_0 = earned money per unit by the system,

C_1 = Expenditure during repairing process per unit time in which repairperson was busy,

Number of graphs has been plotted to analyze the system performance like MTSF, Profit and Availability. All of these graphs have been plotted w.r.t. component A's failure rate . All the graphs has been plotted with respect to the variations in failure parameter (α) of unit A for three unique estimations of relationship coefficient, amongst X and Y , some parameters for reliability characteristics are mentioned below(assumed to be constant).

$$\theta_1=0.002,\theta_2=0.05,\lambda=0.02,p=0.4,q=1-p,,r_2=0.7$$
$$\alpha=0.6,\beta_1=0.003,\beta_2=0.035,C_0=500,C_1=300 \qquad \textbf{(26-27)}$$

Figure-1 depicts that the curves of MTSF bending towards horizontal axis as the failure rate getting high and high. These curves also showing the trend that for the specific value of fizzled rate, MTSF is rising for diverse values of correlation coefficient(r), From the **Figure-2** it can be observed that availability getting in the downward direction as failure rate moving right direction. **Figure-3** shows the trend of revenue earned by the framework w.r.t. fizzled rate of component..In **Figure-4** explains itself that profit of the system is going high as the revenue of the system is shifting towards right direction of the graph. And as far as busy period of repairman is concerned it also increasing with the high failure rate, this can be shown by the **Figure-5.** Busy period is also varies with different correlation coefficients.

V. REFERENCES

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Table 1
(State Transition Table)

States	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
Components	A_o, B_s	A_{fr}, B_o	A_{Fr}, B_w	A_o, B_s	A_w, B_o	A_o,B_{fr}	A_w, B_w	A_w, B_{Fr}	A_{pm},B_0
Status of the state	operative	operative	Operative	failed	operative	Operative	failed	failed	Operative
Repairman Availability	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes

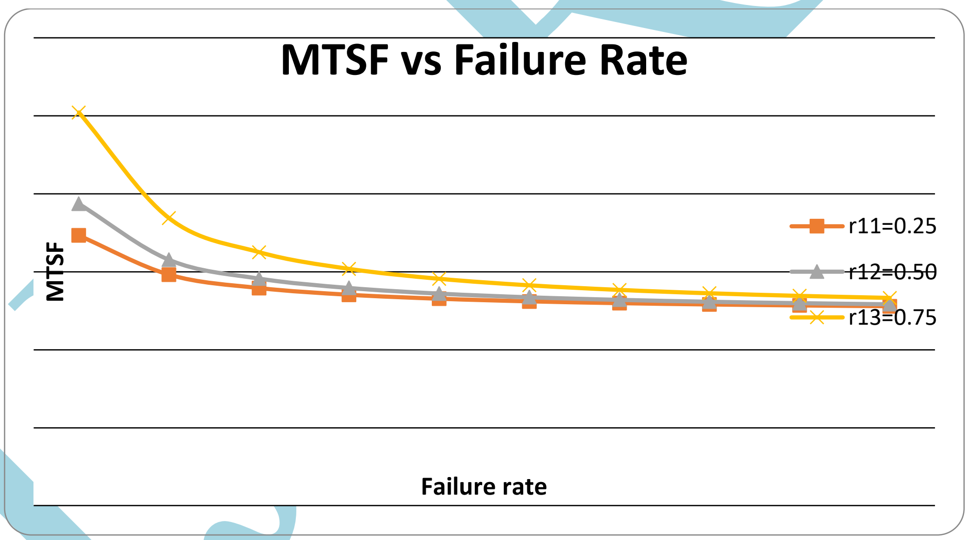

Figure.1 (MTSF vs Failure Rate)

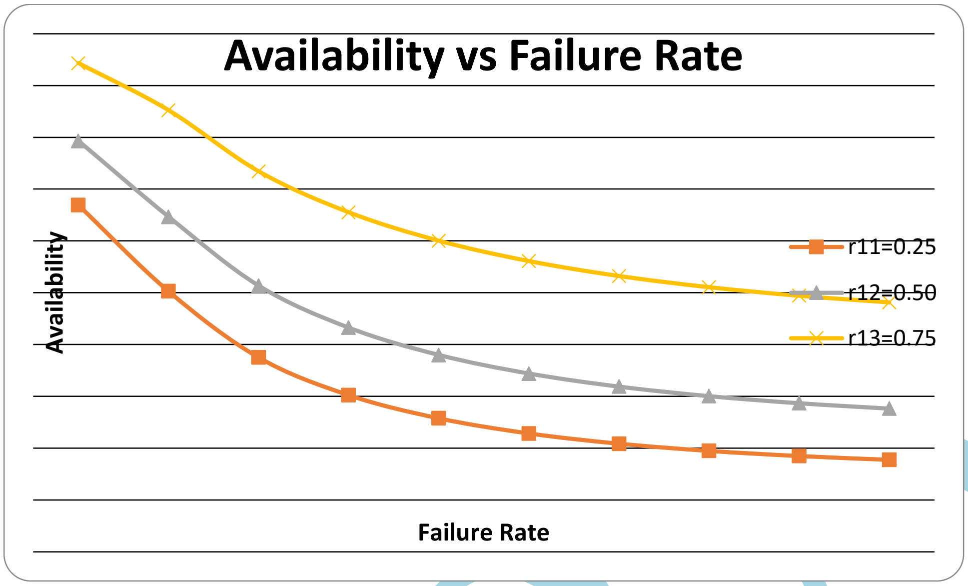

Figure 2. (Availability vs Failure Rate)

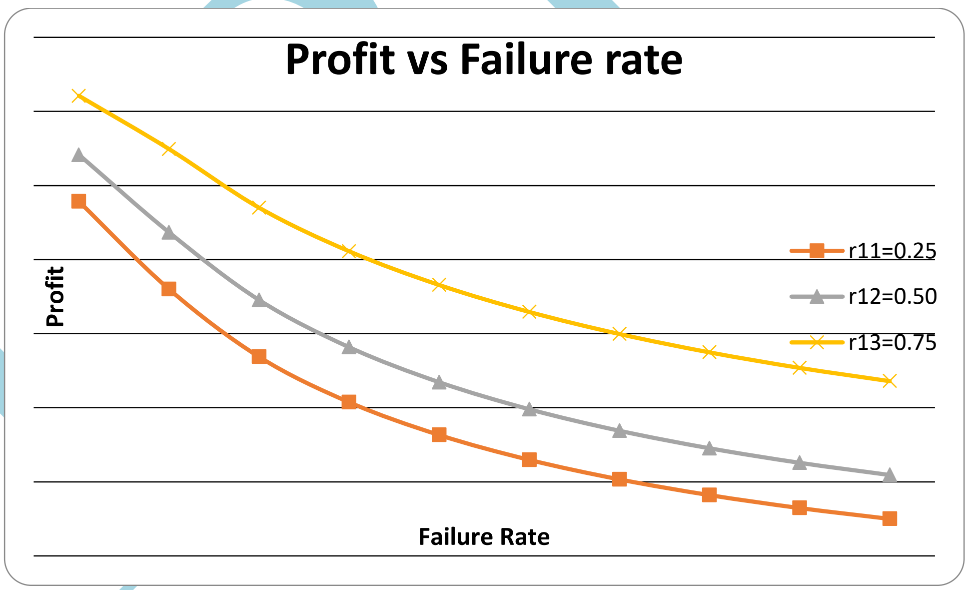

Figure 3. (Profit vs Failure Rate)

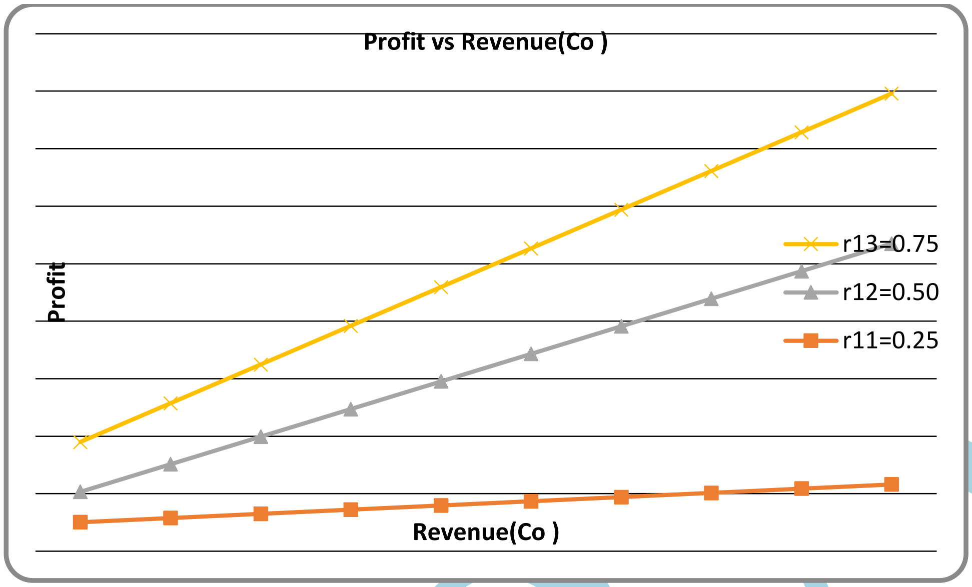

Figure 4. (Profit vs Failure Rate)

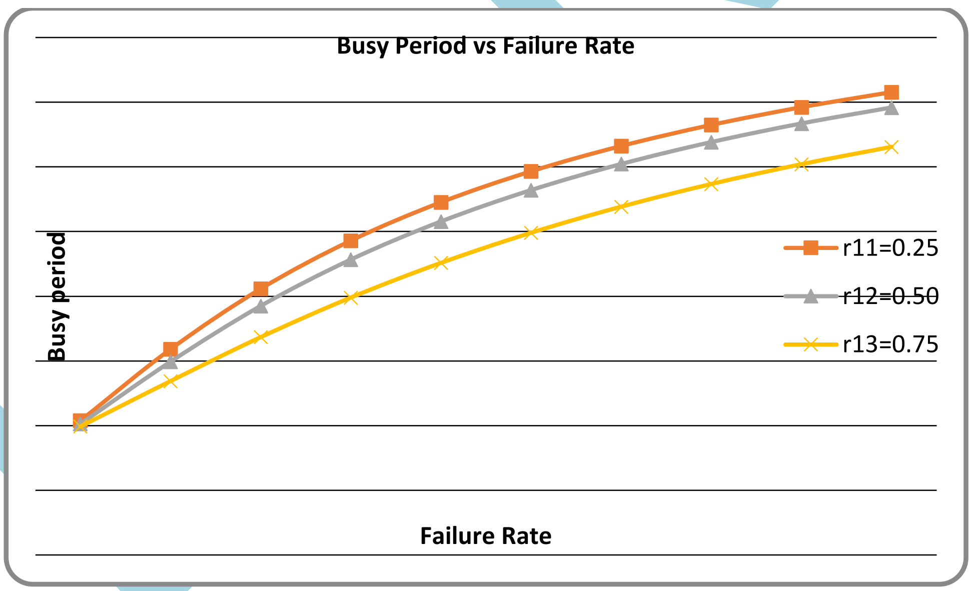

Figure 5. (Profit vs Failure Rate)

