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# RELIABILITY ANALYSIS OF ELECTRONIC DEVICES WITH HUMAN REDUNDANCY

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**Abstract**
Using the concept of human redundancy, stochastic models are created for a system (an electrical device, such as a computer system). In certain circumstances, the necessity of repair work and preventative hardware maintenance will also be taken into consideration to determine the optimum repair strategy for enhancing system reliability. Arbitrary values of the parameters are used to examine a range of reliability measures, including transition probabilities, mean sojourn time, MTSF, availability, busy period at the service facility, and anticipated number of repairs and treatments to the component. Profit function and Graphical representation of the study should be considered by assuming random values of the parameters associated with the human redundancy.
**Keywords:** Stochastic models, MTSF, Availability, Human Redundancy and Profit function.

## Introduction

Over the years, electronic devices (e.g. computers) become necessity and one of the best tool which have not only overcome the conventional workload but also improved the output of work quality as well. That is why the computers are so much in requirement and utilized to the fullest. In every field, the working professional, researchers, students and adults everyone in some way or the other use the computers in their daily lives. This is the reason that computers have become a vital role in our daily needs and almost it is difficult to survive without them. With computers being connected to the internet, its utility exponentially increased manifold. Almost all offices whose work is done entirely through the internet. Thus, they are very much relying on the computers and the internet to complete their daily assignments. Several financial transactions functioning are also possible through the computers and the internet, so it can be said that our daily routine lives are facilitate and prospers by both these things.

The reliability analysis focused on how use the resources in a sustainable way and also system can work more effective with the proper functioning which ensure the enhanced productivity and better quality of the end product. Reliability is an attribute of any component (hardware or software) that consistently performs according to its specifications. The basic definition of reliability was given by Robert Lusser (1960) at symposium in San-Diego. According to him "Reliability is a broad term that focuses on ability of the system to perform its intended function" [see 1]. In simple word, reliability is the probability of no failure of the system (or product) for a given period of time. In fact, it is the probability that a gadget will perform profitably for a limited period of time under clear-cut conditions when used in the manner and for the purpose intended.

Actually, the reliability comely used in during World War II. In World War II, almost all the maximum resources cessation during war, then scientist feels how use our resources in a stainable way. Therefore, after the war different research laboratories and universities started work on different system failures and Stochastic Model. The first important committee (called AGREE) was setup by the US Department of the Defense in 1950. During the 1950's, Britain and Japan begun to work on Reliability Modelling and their application used in different system failure and products.

Epstein and Sobel (1953) have used the exponential distribution for life testing. This paper becomes the first key in reliability modeling and exponential distribution becomes popular for solving research problems and daily life applications. Moskowitx and Meclean (1956) explained some Reliability measures in the series configuration system design. Birnbaum and Saunders (1958) have describes a stochastic model for long life of products. Sasaki (1962) explained an another simple method for life time testing reliability and its measures of obtaining the highest system reliability.

Gaver (1963) explained parallel redundant system by examine mean time to system failure and availability with different repair and failure policy. The classic books "Mathematical Theory of Reliability" by Barlow and Proschan(1965) offer a wonderful illustration of the theory of reliability and its various models. For evaluating reliability measures of a system with repair and failure time with exponential distribution, Branson and Shah (1971) employed a semi-Markov technique. The regenerative point technique was explained by Srinivasan and Gopalan(1973) to peruse a two-unit system model with warm standby unit with single repair facility. Murari and Goyal(1984) assume reliability models with three different types of repair facilities in a two- unit cold standby model . Singh (1989) applied profit analysis on a two-unit cold standby system model with a repair facility randomly. Mokadis et al. (1997) also describe about a two-unit warm standby system subject to lowering the server failure. Kadyan et al. (2004) go over a non-identical transition model with different failure mode using the concepts of priority.

Chander (2005) expand the concept of priority for operation and repair policy on reliability models of operating systems. Malik et al. (2008) discuss stochastic model of an operating system with two types of inspection subject to lowering the cost of a system. Another stochastic system go over under different weather conditions by Malik and Barak (2009). Malik and Bhardwaj (2010) analyzed a 2-out-of-3 system with different random failure of the repairman. Pawar et al.(2010) analyzed an operating system with repair the operating system at different level of run down subject to inspection and weather conditions. After a maximum operation time, Ashish (2013) conducted a cost-benefit analysis of software systems with preventive maintenance. Bhardwaj and Kaur (2014) investigated the reliability models for computer systems using the concepts of cold standby redundancy and inspection to determine the reliability and profitability of a system. The idea of component wise redundancy was considered by Munday and Malik (2015) while analyzing stochastic models of computer systems. They concluded that a computer system can be made more reliable and profitable by using component wise redundancy in cold standby. However, in the most of the above mentioned studies there are component and unit wise redundancies but no human redundancy.

**Some Fundamental Belief:**

**Model**

A model is an illustration which includes the essential structure of some object in the universe that allow for investigate a system with some specific rule and regulations. The behavior of the system isexplained by the model which is a description of the physical system. Model are used inquantitative and technical analyses.

**Modelling**

An easy tool which shows all the steps to improve the system and also timely provide all the feasible solution is called modeling. It reduces the complexity of the systemby saving the resources. Before employment of the system, modeling provides a structure for testing and feasibility of system before implementation.

**Reliability**

Reliability is the probability that a device will work frequently for a specific spam of time and under certain conditions. Reliability is the measure of capacity of a component to operate without failure when put into the services.

Mathematically, the reliability R(t) is given as under where 'T' is the total life time of the system/product:

$$R(t) = P_r(T > t) = \int_t^{\infty} f(u)du = 1 - F(t) = \bar{F}(t)$$

where, f(t) is a probability density function(pdf) of the total life time 'T' and F(t) is the cumulative density function(cdf) of the total life time 'T'

Properties of reliability are as follows:

(i) $0 \leq R(t) \leq 1$

(ii) $\lim_{t \to 0} R(t) \to 1$i.e. it is assumed that the system was operating at time t=0.

(iii) $\lim_{t \to \infty} R(t) \to 0$ i.e. system must fail.

(iv) R(t) is non-increasing function of 't'.

**Failure Rate**

Failure rate, which is measured, for example, in failures per hour, is the frequency with which an engineering system or component fails. It plays an essential role in dependability theory and is frequently represented by the Greek letter λ (Lamda) The likelihood that a failure will occur within a particular time frame, assuming there was no failure prior to time t, is known as the failure rate λ (t). It can be defined as follows in a discrete case

$$\lambda = \frac{R(t_1) - R(t_2)}{(t_2 - t_1)R(t_1)} = \frac{R(t) - R(t + \Delta t)}{\Delta t . R(t)}$$

where, $t_1$and $t_2$ are respectively the beginning and ending of a specified interval of timespanning$\Delta t$. This is a conditional probability, hence the R(t) in the denominator.

Now, the instantaneous failure rate or hazard rate h(t) at time is defined as:
$h(t) = -\lim_{\Delta t \to 0} \frac{R(t+\Delta t) - R(t)}{R(t)\Delta t} = -\frac{R'(t)}{R(t)} = \frac{f(t)}{R(t)}$
where f(t) is the pdf of the device life time. The failure rate h(t) as a function of 't' plays animportant role in the choice of a life time distribution model.The inter-relationships between f(t), F(t), R(t) and h(t) is given as:

(i) $f(t) = \frac{d}{dt}F(t) = -\frac{d}{dt}R(t)$ Since $F(t) = 1 - R(t)$

(ii) $h(t) = \frac{f(t)}{R(t)} = \frac{1}{R(t)}\left[-\frac{d}{dt}R(t)\right] = -\frac{d}{dt}\log R(t)$

(iii) $R(t) = e^{-\int_0^t r(u)du}$

(iv) $F(t) = 1 - e^{-\int_0^t r(u)du}$

**Mean Sojourn Time**

Mean sojourn time is the anticipated amount of time the system spends in one condition before moving on to another. In that stage, it is also referred to as survival time. The sojourn time in state i is determined by if Ti is the sojourn time in state i.
$\mu_i = \int_0^\infty P(T_i > t)dt$

**First Passage Time**

First passage time is the amount of time it takes a system to move from the starting state i to a given state j. It is a measurement of how long it takes to go from one state to another. .Let $q_{ij}(t)$ and $Q_{ij}(t)$ be the pdf and cdf respectively of first passage time from state i to statej once in time (0,t]. Then contribution to mean sojourn time in state $S_i$ when system transitsdirectly to state $S_j$ is given by $m_{ij}$.

$$m_{ij} = \int_0^\infty td\, Q_{ij}(t) = \int_0^\infty t\, q_{ij}(t)dt$$

Also, $\mu_i = \sum_j m_{ij}$

**Mean Time to System Failure**

The Mean Time to System Failure(MTSF) measures how long a system is expected to function before it completely fails. If f(t) is the system's lifetime pdf, then we get

$$MTSF = E(t) = \int_0^\infty tf(t)dt = \int_0^\infty R(t)dt$$

Also, $MTSF = \lim_{s \to 0} R^*(s)$
where $R^*(s)$ be the Laplace transform of R(t).

**Stochastic Process**

The stochastic process is sometimes called a random process (or probabilistic process). If X is a continuous process if 't' is an interval and X is a discrete process if 't' is finite or countable

infinite set.
**Example:** The development of industries in the particular region will affect the region such changes are random over time.

### Availability

Availability is one of the most important reliability measure of maintained system which includes both reliability and maintainability. The probability that the component is in good working order at time t is known as the system's availability. It is represented by A(t). Availability is merely reliability when full redundancy, such as repair or replacement, is not present. The reliability means system always in operation with respect an interval, while availability be the system always in operation at a given instant of time or the time when a system need repair/service without failure of the system.

### Busy Period of the Server

In the long run, if B(t) is the probability that a server will be busy with the system in the period (0,t], then the total percentage of time that a server will be busy is given as

$$B(t) = \lim_{t\to\infty} B(t) = \lim_{s\to 0} s\, B_0^*(s)$$

### Economic Analysis

The economic analysis is done to determine how well, how poorly, a planned action will turnout. An economic analysis is most commonly done on financial system. In order to calculate the net result of an economic analysis, positive components must be added and negative ones subtracted. The economic analysis (in term of profit) finds, quantifies and add all the positive factors then subtracts all the negatives, the cost.

The profit analysis, P(t) be

P(t)= Expected total earning in (0, t] – Expected total expenditure in (0, t]

### Summary

The main focus of the chapter be on the improvement of stochastic models for a system (electronic device, e.g. computer system) by taking the idea of human redundancy. The aspects of priority in repair discipline, software up gradation, hardware repair, inspection to verify the necessity of repair activity and preventive maintenance of the hardware will also be considered to identify the best possible repair policy for improving reliability of the systems. The applicability for several reliability measures such as transition probabilities, mean sojourn times, mean time to system failure, availability of the system models, busy period of the service facility, expected number of repair activities done by the service facility, expected number of treatments given to human being, expected number of repairs and replacements of the components. The system models will be analyzed for arbitrary values of the parameters. The comparison of some important reliability characteristics will be made through graphs by assuming arbitrary values of the parameters associated with failure time, repair time, up gradation time, preventive maintenance time and treatment time.

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