A Review on Repairable Redundant Engineering System in Reliability Theory by Using Regenerative point Technique

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Abstract: The primary goal of this study is to determine the most effective design for a fault-tolerant machining system while dealing with different forms of machining hindrances in diverse situations. Throughout this article, we will look at redundant repairable machining systems, which are an essential component of computer and communication systems, manufacturing and production systems, security systems, and other similar systems. In the present research, which also features unexpected switching failure and a lengthy boot-up time, an automated switch of the available standby unit in lieu of a failed operational unit is an essential worry. It is common practise to distribute workload across M operational units, however the task is carried out in brief mode as overload until there are at least MK units in the system with a degradable failure rate.

Key Word: MK units, Machining System, Reliability Theory, Regenerative Point Technique, Redundancy Configurations.

I. Introduction

If the engineering systems aren't reliable enough, they won't be able to accomplish their intended goal. In order to establish and sustain high dependability in both discrete components and the system as a whole, engineering systems (ES) reliability encompasses a wide variety of difficulties. The growth of computer systems in our daily lives has greatly increased our reliance on them, ranging from commercial to life-critical applications. It is possible for catastrophic failures to occur in the air traffic control system, the hospital patient monitoring system, and nuclear reactors. Regular and timely maintenance is required to improve repairability and ensure appropriate performance from repairable systems. In the literature, there are several methods for increasing the security of repairable systems. Parallel pathways with the main unit are constructed in the redundancy configuration, one of the most popular and well-known.

Due to their widespread and important application in contemporary businesses and industries, two-unit redundant systems have been widely researched in the literature on dependability. The general repair of a two-unit passive (standby) system has been studied by a number of writers, including [1-4]. The standby unit is critical to the functioning of the system since it helps keep it more dependable, efficient, and sufficient. When the working unit fails, the redundant unit is activated. As an additional option, the standby unit may be configured to operate in a variety of standby modes, such as hot standby, cold standby, and idle standby. Real-world systems show that the redundant component takes a long time to come online. As a result, the system will be unusable for an extended period of time, which might result in a massive and unconscionable loss. Authors have studied the performance of two-unit active redundant systems to address this problem by assuming a single repairman would be on hand to check and repair the system as soon as it enters a partly or completely failed state [5-8]. Even if the system is down for a few minutes in the real world, there may be irreparable harm that results. The death of a dialysis patient may be caused by a single second of dialysis failure. A patient's life may be lost if the electricity is suddenly cut off during an OT operation. In order to avoid such issues, it is necessary to set up a redundant unit in a parallel configuration with active standby mode so that in the event of a failure of the primary unit, the backup unit is ready to take over.

II. Literature review

Kakkar et.al., (2015), Two distinct parallel unit systems are studied in this paper, with the premise that the operational units cannot fail after post-repair inspection and replacement, and that only one repair facility is available. Uncorrelated failure and repair timeframes are assumed for each unit. Various features of dependability may be acquired using the regeneration point approach.

Jain, M. (2016), S different warm standby units and a repair facility are included in the design of the system. Repair delay, switching failure, reboot, and poor repair all play important roles in the development of the Markov model, which aids in determining the machinability of a given machining system. Chapman-Kolmogorov equations regulating the model are created using suitable transition rates in order to derive the transient probabilities of system states. Using transient probabilities, system dependability indices are examined in more detail. Various metrics, like as availability and failure frequency, are simulated using the Runge–Kutta fourth-order method.

Soltani, R. (2014), It is the goal of this study to review the current state of the art in models and approaches for reliability optimization problems (ROPs), covering the allocation of reliability as well as the allocation of redundant reliability. There are just a few of surveys that examine ROP literature. Separately, Tillman et al. (1980) organised the relevant studies according to the structure of the system, problem type, and technique of solution. On the subject of optimum reliability allocation, Kuo (2007) evaluated recent achievements in the field. As a follow-up to the prior literature surveys, this research concentrates on articles published after 2000, but provides a brief summary of the past studies to familiarise its audience with the current state of knowledge. This study examines the literature concurrently from the perspectives of system structure, system performance, uncertainty state, and solution technique.

Shekhar et.al., (2017), Modeling and dependability analysis of a multi-machine redundant manufacturing system is the focus of this research. Switching failure and geometric reneging are used to examine more realistic situations. Machine downtime and maintenance times are considered to follow an exponential distribution in both use and storage. Machine interference may be quantified using a variety of performance indicators, such as mean-time-to-failure, reliability and reneging rate. We've included a numerical example to demonstrate the model's usefulness. System descriptor sensitivity analysis was used to demonstrate the validity and practical rationale of the findings produced.

Singh et.al., (1991), The cost of a cold-standby system with two operating modes (normal and complete failure) that includes a single server and two units (one priority and the other ordinary) is examined. Priority units that cannot be repaired within a reasonable amount of time are rejected and replaced with new ones. Negative exponentials are used for failure and delivery time distributions, whereas random distributions are used for repair and replacement time distributions. The regeneration point approach is used to determine the reliability metrics (MTSF (mean time to system failure), steady-state availability, busy period analysis of repairman, etc.) in the system.

EL-Sherbeny, M. S. (2016), Two-unit cold standby systems are examined in this work, taking into consideration that the operational and standby units switch at random intervals. Faulty, repaired, and replaced times are distributed in a predictable manner. A semi-Markov process and the regeneration point approach in a Markov renewal process are used to construct explicit formulations for the system's MTSF and A () availability. The influence of system parameters on system performance has been explored numerically and visually in certain circumstances. As part of our examination of MTSF and A (), we also do sensitivity and relative sensitivity analyses for the individual values of the system parameters.

III. Redundancy

It is possible to add additional components that are not essential to the usual operation of the system, but may take over functional tasks in the event of a component failure. Thus, prolonging the system's life expectancy. In most cases, the redundant components are the same as the primary ones, although this is not always the case.

3.1 Active, Standby and Passive Redundancy

Partially activating (standby), entirely deactivating (active), or totally deactivating redundant components are all options (passive). When a component's starting time is too lengthy, standby redundancy is frequently used. It's also feasible to have a combination of the aforementioned degrees of activity.

3.2 Common Causes of Failure

As part of a reliable system's dependability study, it's commonly overlooked that additional hardware is needed to connect the components together. System failure may occur even when redundant components are able to manage the failure modes of a single component (short-circuit, significant leakage) without the need of extra hardware. A virtual series component may account for both the additional hardware and "overload" problems as additional failure possibilities.

3.3 Redundancy & Maintenance

The combination of redundancy and maintenance creates highly dependable systems. Breakdowns of critical components should be identified and fixed or replaced at a rate that is much larger than the overall failure rate of the other components.

This will result in a significant increase in system reliability and availability. The majority of the time, broken pieces are repaired before the whole machine fails.

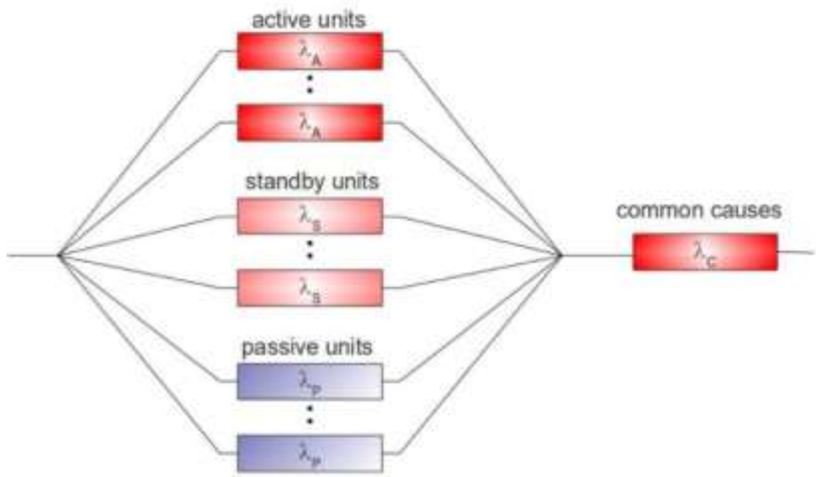

Fig: Redundancy & Maintenance Path diagram

3.4 Redundancy configurations

M-out-N redundancy

Redundancy in the M-out-N type is the most common. Special examples of the M-out-N redundancy include the well-known configurations of parallel redundancy and majority voting redundancy. When at least M components are operational, an M-out-N redundant design works well. The following Markov diagram holds for a homogeneous system (with all identical components) and no maintenance.

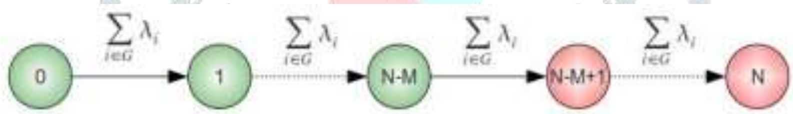

Fig 2: M-out-N redundancy

When all 'good' components are operating in active mode (i=a), standby mode (i=s), or passive mode (i=p), the overall failure rate in each state equals the sum of the failure rates of all 'good' components in each state.

3.5 Redundancy Degree

It is a metric used to represent the level of redundancy present in a configuration, and it runs from 0 for a (non-redundant) series system to 1 for a pure parallel system with the number of nodes equal to one.

η=n-mn-1

3.6 Active M-out-N redundancy

In case all components are active from the start the following solution results:

R(t)=∑k=mn(nk)(e-λat) k(1-e-λ)n-k

MTTF=θ=1λa∑k=mn1k

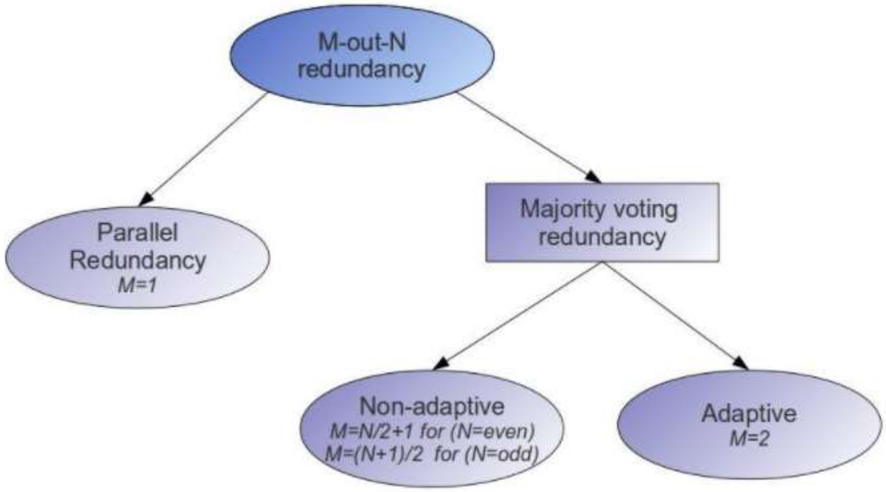

Fig 3: Decision path for Active M-out-N redundancy

IV. Exploration of M-out-N redundancy

4.1 Majority voting redundancy

mn/2 indicates that the function is successfully completed when the vast majority of the components are in good working order, as in this case. This form of redundancy is often used when it is difficult (or impossible) to identify a component failure based on the output of the component in question. This issue may be resolved by comparing the output of the component with the output of numerous other components. There are two forms of majority voting.

n=odd then m=n+12 and η=12

- n=even then
- m=n2+1 and η=12·n-2n-1<12.

Adaptive majority voting is a voting method in which components that have been shown to be ineffective are no longer included in the voting process. It is common to meet this sort of redundancy in information systems, when the appropriate output signal is picked from a pool of redundant signals. As long as two units are in working order, making an informed judgement is still feasible.

m=2 so η=n-2n-1

4.2 Parallel redundancy

This is a 1-out-of-N configuration, which means that just one functioning component is necessary for the system to operate properly. Since m=1, the redundancy degree is equal to one. Given those passive components and standby component are not susceptible to failure, the following solutions are valid.

Active parallel redundancy

R(t)=1-∏k=1n(1-e-λat)

MTTF=θ=1λa∑k=1n1k

Passive parallel redundancy

R(t)=e-λat∑k=1n(λat) k-1(k-1)!

MTTF=θ=nλa

V. Conclusion

As a result, many of today's systems in the sectors of manufacturing, transportation, and information energy are both artificial and natural, which means that they may be simple or complex. Because of a lack of reliability, the engineering systems will not be able to perform their intended purpose. An engineering system's (ES) reliability comprises a number of challenges in order to achieve and maintain high system dependability. From commercial to life-saving applications, we have become more dependent on computer technology. Air traffic control systems, hospital patient monitoring systems, and nuclear reactors are all susceptible to catastrophic failures. Maintaining repairable systems on a regular basis is critical to their long-term viability and performance.

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