A New Model for Accessibility Optimization Applied to a Series-Parallel System

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Abstract

Redundancy technique is notorious as a way to augment the reliability and accessibility of non-reparable systems, but for repairable systems, a different factor is receiving important called as the number of continuance resources. In this study, accessibility optimization of series-parallel systems is modeled by using Markovian process by which the numeral of continuation resources is positioned into the purpose model under constraints such as cost, weight, and volume. Due to difficulty of the model as nonlinear indoctrination, solving the model by profitable software is not possible, and a straightforward heuristic method called as imitation annealing is applied. Our main giving in this study is correlated to the expansion of a new availability model consider a new decision variable called as the number of continuance resources. A numerical replication is solved and the results are shown to display the proficient of the method.

Keywords - *Availability optimization, Maintenance resource, Redundancy level.*

I. INTRODUCTION

Evaluate the presentation of repairable system such as industrialized systems, power industry, aircraft and oil industry. Two common ways has been residential to increase availability of an engineering system known as increasing the accessibility of each element and redundancy level. Accessibility of a system straight depends on ease of use of its components. Reliability and maintainability of every components lead to augmentation in accessibility. Appropriate to control in technology, the second way is joblessness allocation. Redundancy in a system means that the apparatus are structured in parallel. Redundancy allocation problem (RAP) is the mainly ordinary method to meet the optimization of consistency and availability subject to the realistic constraints such as cost, weight, volume, etc. Allowing for nature and submission of systems, they are categorizing into repairable and non-repairable systems. In the real world, so numerous systems are repairable and a repairable system can be restored and work properly.

Repairable series-parallel systems are regularly used in practice, power systems, telecommunications systems, industrialized construction systems, and industrial systems. In this regard, accessibility is getting more serious. An inclusive study on repairable system is presented. Barlow and Hunter first accessible a minimal renovate model in which the nominal repair does not influence the lifetime of the system. A cold stand-by repairable system has been studied. Each constituent after repair is not 'as good as new. With deference to this hypothesis, a geometric process was used. Baron et al. Investigates a k-out-of-n system with several programmed repair facilities in which phase type repair time and both strategies are painstaking. Vanderperre studies on a system consisting of several active and standby machinery with constant failure rate and arbitrary allocation for repair time. A single repair facility is measured. In Frostige et al. propose a study on the accessibility of a k-out-of-n repairable system. They use Markov revitalization processes for a k-out-of-n system in which machinery are repairable. Zhang et al. analyze a k-out-of-(m+n) warm standby repairable system. The system is separated into two disconnect types of components, m and n components. The first type is imaginary to have lower failure rate. In harmony with the Markov process, a method is proposed to find the solutions of system availability. Levitin and Lisnianski accessible an optimization method that minimizes the total cost considers replacement frequency, preventive and corrective continuance. Elegbede and Adjallah proposed a method based on Genetic Algorithm and experiment plan to optimize the accessibility and the cost of repairable parallel-series systems. Castro and Cavalca studied on accessibility optimization of series-parallel systems considering idleness level and team preservation action as decision variables allowing for constraints such as cost, weight, and volume. Castro and Cavalca applied dependability ratio to consider maintenance team as a decision variable in objective function. Genetic algorithm was the method to solve their problem. The impact index "I" has been introduced as an input parameter to the model, defined as the steadiness ratio sensitivity to the counteractive maintenance resources on a specific component.

The aim of this paper is to there a new model for accessibility optimization of series-parallel system using Markovian process allowing for common constraints such as cost, weight, and volume. Due to complication degree of the model, a replicated annealing method is proposed to solve the model. Simulated annealing as a uncomplicated heuristic algorithm is used to solve the proposed problem of the new model. In this study, our foremost contribution is that maintenance resources are taken account into the objective function without any supplementary input, vital parameters such as parameter in that its value considerably affects the solution. In an input parameter is added to the model called as impact index "I" touching obtained solutions, to properly determine the value of "I" is vital to get the optimal or near optimal solution. This paper organized as follows. Section 2 presents a proposed model and mathematical formulation. The simulated annealing method and its application are described in section 3. An adapted example is solved in section 4. Finally, section 5 presents conclusion.

II. THE PROPOSED AVAILABILITY OPTIMIZATION PROBLEM

A. System Description

This study proposes an accessibility model for a series system with numerous unneeded subsystems including repairable active apparatus. In this model, to increase the ease of use of system, two decision variables are measured: the number of continuance resources and redundancy level. The goal of the problem is to find the most favorable values of these decision variables in each subsystem in the presence of the constraints such as weight, cost, and volume. The notations and postulation of the model are obtainable in the following.

B. Notation

m: the number of subsystem
n_j: the number of redundant components in the subsystem
λ_i: failure rate of each component when there are i failed component
λ_j: failure rate of each component in the subsystem j
μ_i: repair rate, when there are i failed component
μ_j: repair rate of each component in the subsystem j
r_j: the number of maintenance resource allocated to the subsystem j
$P_{i,j}(t)$: the probability that there are i failed components in the subsystems j at time t
$P_{i,j}$: steady-state probability that there are i failed components in the subsystem j
C : system cost
W: system weight
V: system volume
CM: system maintenance cost
crec: corrective maintenance cost
cm: component maintenance cost
c_j: component cost in the subsystem j
w_j: components weight in the subsystem j
v_j: component volume in the subsystem j
q_j: probability of failure in the subsystem j

C. Assumptions

- Only one continuance resource is allowed to allocate to the repair of an unsuccessful component. The time to repair a abortive component follows identical independent exponential. ($l \leq r_j \leq n_j$)
- All machinery in each subsystem follows autonomous exponential lifetime distribution. Subsystem j is called failed as soon as the number of abortive constituent just reached, and the n_j system is considered failed as soon as one of the subsystem has failed.
- When a component of a subsystem fails, billed repairman of the subsystem, if accessible, immediately begins; if not, the failed component must wait for the repairman. The repair is based on first-come, first-served.
- The prospect that two or more machinery are restored or become failed concurrently in a small interval is not considered.

D. Mathematical Model

This model presents a purpose function related to the maximization of the availability. The equation (1) can express the accessibility of the system regarding Fig. 1as follows:

$$A_s = \prod_{j=1}^{m} A_{subj} \quad \text{----------(1)}$$

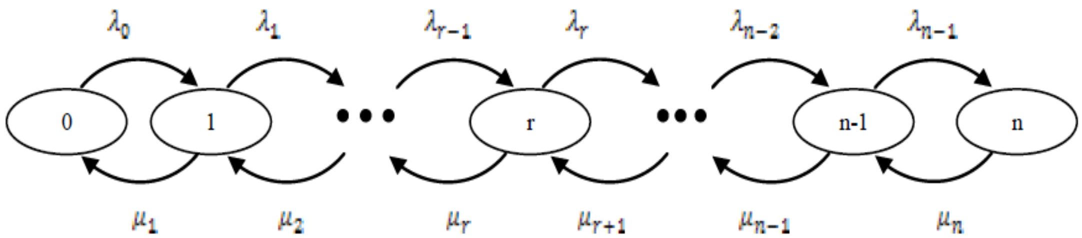

Fig. 1. The State Transition Diagram of a Repairable Parallel System

III. SIMULATED ANNEALING ALGORITHM

The proposed model is so hard, and software such as LINGO and GAMS cannot find good solutions in a competent time. So, a meta-heuristic algorithm role is so imperative in this problem to find good quality results in a resourceful time. This algorithm was proposed by Kirkpatrick, Gelat, and Vecchias an extension of the Metropolis-Hastings algorithm. Its name refers to substantial process of annealing in metallurgy. Achieving a minimum energy crystalline structure is a motivation that SA performance is unlimited in metallurgy, and it requires heating and slow cooling of materials. The SA algorithm follows this process with the aim of finding a proper solution while provided that the occasion to escape from local optima. The opportunity to jump from local optima depends on the temperature. The more temperature provides the more opportunity. As per the process 'cools', the focus is on finding an finest solution, so the prospect of a jump to a new neighborhood is reduced.

IV. A NUMERICAL EXAMPLE

To demonstrate the analysis of the proposed problem, a numerical instance is solved by the simulated annealing method. The input data is presented in Table1. Time T is set to 100 time units. A system with five subsystems has been solved by the replicated annealing described in the previous section. By using MATLAB R2009ea on the Intel Core 2 Duo CPU 2.66 and GHz 2.67 GHz PC, an algorithm has been coded to find the resolution. Due to the stochastic nature of the proposed SA, 50 autonomous runs were made for the illustration involving 50 diverse initial solutions.

Table 1 System Data

Subsystem	λ	μ	Design Cost	Weight	Volume	Corrective Maintenance Cost	Corrective Maintenance Resource Cost
1	0.002	0.02	50	50	55	60	7
2	0.0018	0.028	55	45	50	40	3
3	0.0016	0.025	55	80	70	45	4
4	0.0013	0.033	40	35	35	30	2
5	0.002	0.033	60	70	65	50	5

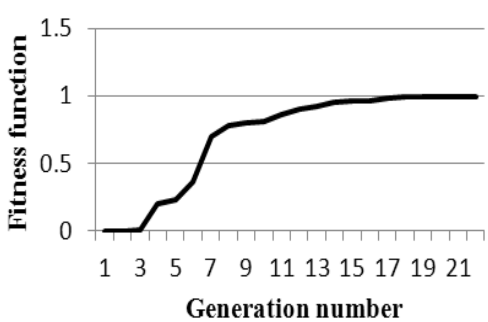

Fig. 2. Fitness Convergence

Fig. 2 illustrates the union of the fitness for the example; the near optimal solution is roughly achieved after 20 generations. It is perceptibly indicated that all standard deviations are trivial and distinction between maximum and minimum is also trivial in each example. The results to indicate that the proposed algorithm strongly converge to the optimal solution.

V. CONCLUSION

In this paper, accessibility optimization of a succession system with five superfluous subsystems has been modeled through Markovian process. The most important giving of this study refers to regard as the number of continuance resources and redundancy level together as decision variables subject to constraint such as weight, cost, and volume. The presented model has been formulate as nonlinear integer programming. To find the accurate solution of the problem is not easy especially for large systems. A heuristic method called as replicated annealing used to solve the problem.

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