# SOLVING RELIABILITY REDUNDANCY ALLOCATION PROBLEM IN USING GENETIC ALGORITHM

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## Abstract

Reliability is a critical subject in engineering field. Increasing system's reliability is one of the challenging parts of engineering. There are several structures for reliability's model and one of them is *k*-out-of-*n*. Redundancy allocation problem (RAP) is a method to improve system reliability. It is divided into two types, namely, active and standby subsystems. Standby subsystem is divided into Cold, Warm and Hot standby. This study is focused on solving redundancy allocation reliability model by using genetic algorithm (GA). A *k-out-of-n* reliability's system is chosen as a case study which was introduced by Coit (2003). Failure rate for each subsystem is dependent on the number of components which is used in the system design. Cold standby and active strategies are used in the redundancy allocation problem (RAP). The study has proposed the best setting for the RAP based on GA. The best setting among the investigated scenarios is the designing with cold standby strategy; experimental results give beta value and number of component for each subsystem. for system reliability at 0.97661 is the best reliability value given by the GA.

## ABSTRAK

Kebolehpercayaan adalah satu subjek yang kritikal dalam bidang kejuruteraan. Meningkatkan kebolehpercayaan sistem adalah salah satu cabaran dalam kejuruteraan; Terdapat beberapa struktur model kebolehpercayaan dan salah satunya ialah *k*-out-of-*n*. *Redundancy allocation Problem* (RAP) adalah satu kaedah untuk meningkatkan kebolehpercayan. Ia dibahagikan kepada dua bahagian iaitu subsistem aktif dan siap sedia. Subsistem siap sedia terbahagi kepada sejuk, hangat dan panas. Kajian ini memberi tumpuan kepada penyelesaian model RAP dengan mengunakan Algoritma Genetik, (GA). Sistem kebolehpercayaan k-out-of-n dipilih sebagai kes kajian seperti yang diperkenalkan Coit (2003). Kadar kegagalan setiap subsistem adalah bergantung kepada bilangan komponen yang digunakan dalam sistem reka bentuk. Strategi siap sedia sejuk dan actif sejuk digunakan dalam masalah RAP. Kajian ini mencadangkan penetapan yang terbaik untuk RAP berdasarkan GA. Penetapan terbaik untuk kajianes adalah mengunakan strategi siap sedia sejuk. Hasil kajian memberikan nilai beta dan bilangan komponen untuk setiap subsistem adalah berdasarkan nilai keboleh percayaanterbail oleh penetapan GA iaitu 0.97661.

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Thanks to

God for all the given opportunities and blesses...

**My beloved parents**

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Everything may fail. Maybe you have experience in one of the following situations in your life: washing machine has a problem, toaster breaks down suddenly, battery discharges, remote does not work and a hole is created on part of roof. Some of these failures (defective) have enormous damages on economy (production) and some others will put stress on customers. Although they will not have any damages on them but these defectives have main effect on economy and customer satisfaction.

Initial goal of reliability engineering is to develop the reliability of the whole systems. In the primary design activity, redundancy allocation is a main approach to increase the system reliability. Redundancy allocation problem is a kind of NP-hard problems. The challenge is to choose the best alternative components and redundancy for each subsystem in order to maximize the system reliability under system- level constraints such as cost, weight and volume.

Due to its complexity, it is so sophisticated to optimality solve such a problem by using traditional optimization tools. Genetic Algorithm (GA) is used in this project to solve the reliability redundancy allocation problem.

GA is a type of meta heuristic algorithm to solve an NP-hard problem. It is useful in many range of engineering field. Redundancy allocation is a type of NP-hard problem. Thus, it seems that genetic algorithm is a suitable method to solve this kind of problem.

Nowadays focus on reliability to increase a life cycle of the products is a challenging topic in the real world. Redundancy allocation is a part of it. Improvement of new system design involves the collection of section and configuration to satisfy detailed functional and performance condition, for systems considered by using off-the-shelf component, with identified cost, weight and other attributes. System design can be formulated as a combinational optimization problem. The best know reliability design problem of this type is the redundancy allocation problem where system reliability maximized or cost is minimized. Formulation generally involves system level constrains on allowable weight, cost, power, space and/or minimum system reliability level (Coit and Smith 1996).

Most researchers used the mathematical model which is offered by Fyffe et al (1986). There is a method to increase reliability (solving) according to redundancy allocation. Methods have been devised by which system allowance or reliable failure rate may be apportioned among the functional unit of a proposed new product (Nakagawa and Miyazaki, 1981).

Researchers in this area of reliability perform many tasks using variety of approaches and techniques. During the years; researchers tried to formulate other part of redundancy allocation or improve a Fyffe model and solve it with different methods. Bulfin liu (1985) solved Fyffe model by using branch and bound method based on knapsack algorithm, Yuji Nakagawa and Hitachi Ltd (1981) proposed a creative algorithm which is N&M. Kawasaki was another researcher who investigated Fyffe problem, Coit focused on reliability models and solve many problems in this area. He tried to extend Fyffe model and solve them with integer programming and genetic algorithm.

The current study focuses on a special type of redundancy allocation model which is the combination of two models; one of them is the model which is offered by Coit (1995) and the other one that is offer by Mani Sharifi (2009). There are some constraints about budget, weight and maximum of enhancing reliability. This study wants to solve this model with genetic algorithm.

## 1.2 Problem Statement

Many studies worked on redundancy allocation model, especially Fyffe or extended Fyffe model with different constraints. There are different types of solution methods namely either mathematical or heuristic methods, however the real world cases demonstrate that focusing only on one strategy function cannot support all limitations of real cases. To satisfy this needed samples, combination of several models is necessary.

This research is conducted to propose model of combination cold standby and active mode when there is relationshio between number of component and failure rate.

## 1.3 Objective of Study

The objectives of this study are:

i. To develop reliability model with redundancy allocation in cold standby and active modes
ii. To solve and evaluate the proposed reliability's model by using a meta heuristic algorithm

## 1.4 Scope of study

The scopes of this researches are:

i. Genetic Algorithm will be used for optimization
ii. Simulation of the model is by using MATALB software
iii. A case study will be used to demonstrate the application of the model

## 1.5 Significant of Study

Redundancy allocation plays an important role in reliability systems, Finding a suitable model and set it with a real world can solve many problems of the engineers who work in this field. Because of the gap between combination of two or more models of redundancy allocation with certain limitation, this investigation try to solve combination of cold standby and active model in redundancy allocation.

Meta heuristic algorithms have a wide range of the application area. This category is composed of many algorithms such as genetic algorithm (GA), simulating annealing (SA), neural network, particle swarm optimization (PSO) and many others. This research uses GA as a solution method because:

a. This algorithm has been effective in many application areas
b. It finds a better optimum solution rather than other algorithms.
c. It finds a solution faster than other algorithms.

## 1.6 Organization of Report

This report consists of six chapters, as summarized in the following:

Chapter 1 is the introduction of the study. This chapter explains about the research statement, problem statement, objective of study, scope of study and matters that have relate to the introduction of project. Chapter 2 is the literature review of the project and contains on several topics related to this study. It describes definitions, principles and approaches used in the conducting this project. Many others topics reviewed include reliability, redundancy allocation, cold standby and active model, and GA algorithm and model constraints. Chapter 3 discusses genetic algorithm (GA) and how its implementation in MATLAB. Chapter 4 is about finding

mathematical model based on the limitation and assumptions. Chapter 5 provides the result and data analysis. Discussions for each result is in Chapter 6 concludes, the study with suggestions for future researches.

## 1.7 Summary

This chapter has given a general introduction about the study. At the beginning of this chapter, the introduction of reliability and redundancy allocation was briefly discussed. It was followed by the problem statement. The objectives and scopes of the project were stated to address the boundaries of the study. The significance of the study was discussed. Lastly, the arrangement of the entire report was explained.

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