ON SOME POINTS OF RELIABILITY THEORY

THESIS

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By

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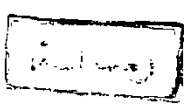

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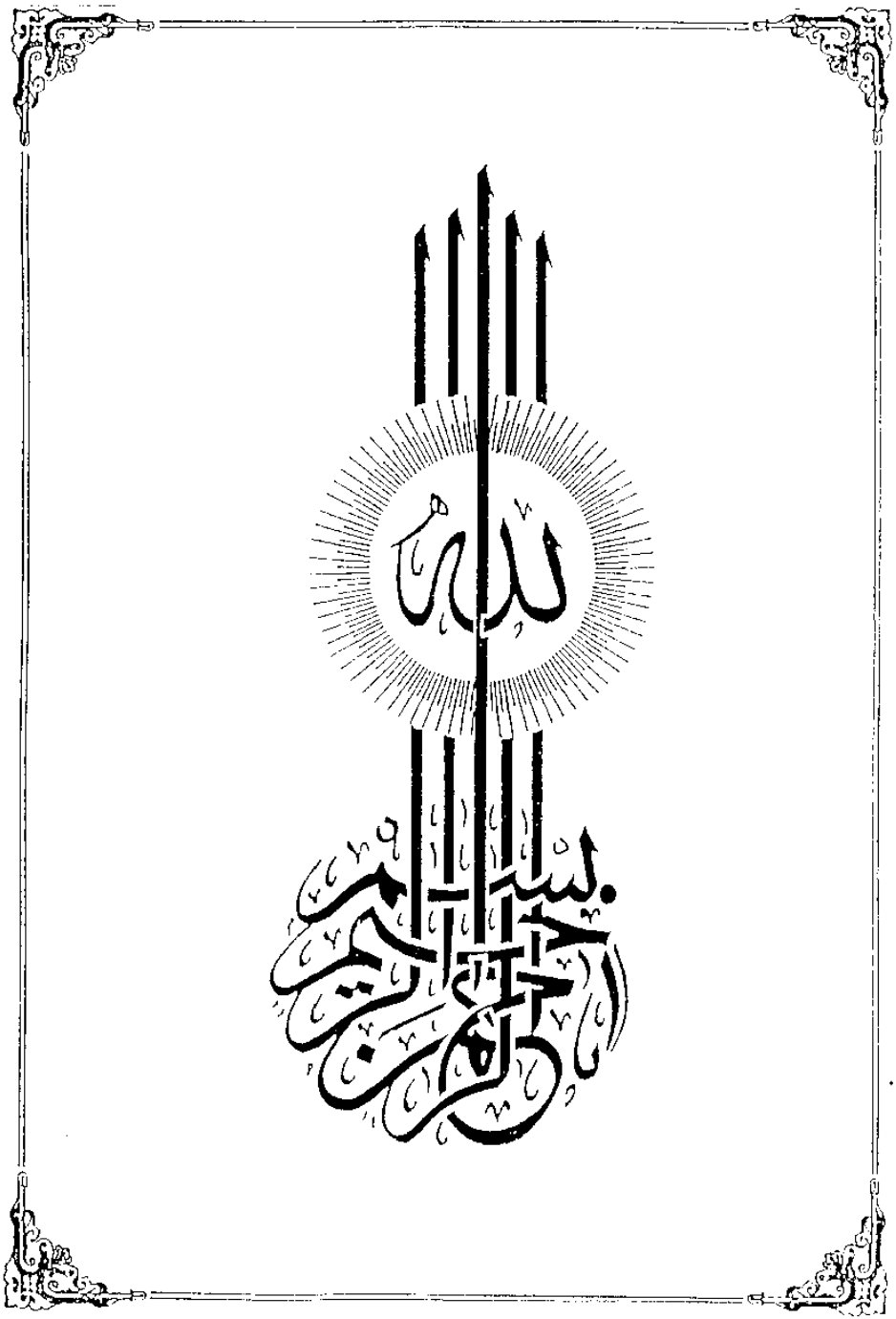

CONTENTS

ABSTRACT

The thesis deals with analytical methods for studying some problems in reliability theory from many points of view. It consists of six chapters. The first chapter exposes some basic concepts of reliability theory while the materials of the other five chapters are supposed to be an addition to the subject.

Chapter I introduces the fundamental quantitative characteristics encountered in reliability theory. It presents, also, a brief survey of the problems discussed in the different chapters and describes the procedures that were used. It also points out the connection with the corresponding less general problems which have been studied by earlier authors.

Chapter II considers two models for a standby redundant system subject to a repair facility of the type first arrived, first served and an imperfect instantaneous switch-over device. The first model consists of dissimilar units and one cold standby unit while the second consists of similar units and a finite number of warm standby units. Explicit expressions for Laplace transform of the reliability function and the mean lifetime for the two models have been obtained. The results in [1] have been derived as special

cases from the results of this chapter. The material of this chapter has been published in the Proceedings of the 11 th International Congress for Statistics, Computer Science, Social and Demographic Research, Ain Shams University, Cairo, Vol. 8, 1986.

Chapter III deals with an analytical method for carrying out the availability and the reliability analysis of a two-unit system with a warm standby having a single service facility for the performance of preventive maintenance and repair. The results obtained include, as special case, those obtained in [15, 39]. The material of this chapter has been accepted for publication in "Microelectronics and Reliability", England, 1987.

Chapter IV discusses two models for two-dissimilar units standby redundant systems subject to repair and preventive maintenance. The mean lifetime and the Laplace transform of the distribution of the first -time to system down for the two models were derived using the results of regenerative process. The results in [10, 38] are obtained as special cases from the results of this chapter. The material of this chapter has been accepted for publication in "Microelectronics and Reliability" England, 1987.

Chapter V investigates the stochastic behaviour of two-dissimilar unit cold standby system with connect switching and switchover device and subject to a repair facility of the type pre-emptive repeat. Using semi-Markov process technique, the steady-state availability of the system is obtained. The results in [2,20] are derived from the results of this chapter as special cases. The material of this chapter has been accepted for publication in "Microelectronics and Reliability", England 1987.

Chapter VI considers a two-dissimilar unit cold standby redundant system where each unit has three modes: normal mode, partial mode and total failure mode, under the assumption that there is an administrative delay in getting the repairman at the system location. The steady-state availability of the system is derived using semi-Markov process technique. The results obtained include, as special case those obtained in [17, 35].

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

This chapter is of an introductory nature. It introduces the basic concepts of reliability theory and the fundamental quantitative characteristics encountered in it. It presents, also, a brief survey of the current state of the topics in reliability theory related to the work done in this thesis. Moreover, it gives a description of the problems discussed in the different chapters and describes the procedures that were used. It also points out the connection with the corresponding less general problems which have been studied by earlier authors.

1.1. BASIC CONCEPTS OF RELIABILITY THEORY

In order to reach maximum efficiency in the operation of large-scale military and commercial engineering systems, the complexity of equipments and configurations has been an even-increasing phenomenon. Reliability theory is composed of the systematic procedures based on analytical techniques employed to ensure the operational efficiency of such complex systems.

The reliability is defined as the probability that a system will adequately perform its intended purpose for

a given period of time under stated environmental conditions. So the reliability of a system is connected in a very well way with the concept of its quality. On the other hand, the quality of a system depends in a very well way on the manner in which it is used.

The problem of increasing reliability of units becomes ever more important and urgent in connection with the complex mechanization and automation of industrial processes in many fields. Redundance, renewal and maintenance are considered in order to maximize the efficiency of the operation of systems. As quantitative measures for the efficiency of systems, the mean lifetime and the availability coefficient are considered.

One of the basic concepts in reliability theory is that of failure-free operation. Failure-free operation is the ability of the unit to keep its ability to function (i.e. not to have failures) throughout a specified period of time under specified conditions. A failure is the partial or total loss or modification of those properties of the units in such a way that their functioning is seriously impeded or completely stopped.

Another important concept in reliability theory is that of life. The lifetime of a unit means its capacity

for extended use under the necessary technological servicing, which may include various types of repairs and maintenances. The lifetime is classified either by time or the number of cycles or the volume of work performed. For certain units, the concepts of life and failure-free operation may coincide, but, in general, these are independent characteristics of reliability.

Also a very important and popular characteristic of reliability is that usually known as the failure rate, which is the probability of almost immediate failure of a system. In probability theory terms, it is the conditional probability density of failure at a given instant with the hypothesis that the system has been functioning without failure up to that instant.

Another basic characteristic of reliability of a system is the so-called pointwise availability (in other words availability coefficient) which is the probability that the system will be able to operate within the tolerances at given instant of time.

Standby redundancy is one of the basic methods of increasing reliability. In principle at least, it enables us to obtain a system reliability arbitrarily close to one. Standby redundancy consists in attaching to a unit

of a system one or more redundant units, which, when failures occur, take the place of a basic unit and fulfill its functions.

We refer to a set consisting of a basic unit and its standby unit as a redundant system. Depending on the state of the standby units before they are put into operation, the redundancy of a unit falls into one of several types, here we mention two only:

(i) Warm standby redundancy. The standby units are subject to the same rules as the basic unit or in a partially energized state and their reliabilities are independent of the instant at which they take the place of the basic unit.

(ii) Cold standby redundancy. The standby units are not initially hooked up and, by hypothesis, they cannot fail until they are put in place of the primary units.

Moreover to increase the effectiveness of standby systems, units that have failed are renewed. This renewal can assume various forms: it can be subjected to a repair facility or to a preventive maintenance facility or to both that completely restore all the original properties of the units. The repair of a unit may either start immediately upon failure or is subject to an administrative delay. Also the repair policy may assume various

forms such as first arrived, first served policy or pre-emptive repeat type.

To take out a unit that has failed or called for inspection and insert in its place in the system a stand-by unit, we need a device , which is known as a switch. Of course, the role of such a switch can be performed by a human being. However, when this is the case, it usually requires a considerable amount of time to find the place where the trouble is located and replace the unable unit. When such interruptions in the operation of a system are inadmissible or undesirable , we have automatic switches that instantaneously insert the stand-by unit when needed.

In calculating the reliability of some standby systems where the switches are absolutely reliable, no attention has been given to them. However,in some actual situations, the switches themselves can fail while they are still instantaneous. Such a switch device is known by an imperfect instantaneous switch device.

Moreover, in other actual situations, the switchover time is not instantaneous but is a random variable. For such situations , the switch may also be perfect or imperfect.

Another concept of switch is the concept of connect switching which plays an important role in system reliability. The basic role of a connect switch is to keep the system under consideration in good connection with other systems.

In this section, we have surveyed a brief introduction to reliability theory and the fundamental quantitative characteristics encountered in it.

1.2. DESCRIPTION OF THE CHAPTERS' CONTENTS

The interest in reliability theory currently exhibited by engineers, mathematicians, economists and industrial managers has stimulated the publication of many papers. Problems in reliability theory are extremely varied. Thus, it is natural that papers should appear expounding reliability theory from many points of view. In this thesis, we consider certain portions of the various problems in reliability theory.

The second chapter considers two models for a standby redundant system subject to a repair facility and an imperfect instantaneous switchover device. The first model consists of dissimilar units and one cold standby