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Original Articles

An availability-based system with general repair via Bayesian aspect

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Highlights

- We study an availability system using Bayesian approach.
- Lognormal and Erlang distributions are used as the repair-time distributions.
- Simulation results are presented to evaluate the procedures.

Abstract

We study the Bayesian inferences of an availability system with reboot delay and standby switching failures, in which the system consists of one active component and one warm standby. The system is studied under the assumption that the time-to-failure and the time-to-repair are assumed to follow an exponential and a general distribution. The reboot time is assumed to be exponentially distributed with parameter β. There is always the failure possibility c during the switching process from standby-component state to the active-component state. To implement the simulation inference for the system availability, two repair-time distributions, namely, the lognormal and Erlang distributions characterized by their shape parameters are considered. Finally, all simulation results are displayed by appropriate tables and curves to analyze the performance of the statistical inference procedures.

Keywords: Availability; Distribution-free; Reboot delay; Standby switching failure; Simulation

1. Introduction

The availability of a repairable system plays an increasingly important issue in the power plants, manufacturing system, etc. Managers/engineers often require a higher availability/reliability system for maintaining production/service machinery operations. The concept of standby switching failures in the reliability with standby system has been

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introduced by Lewis [5]. Trivedi [9] introduced the concept of reboot delay and its effect on the reliability or availability model of a repairable system.

Statistical inference can be used to estimate the system parameters/characteristics by using experimental data or simulation. However, the statistical inferences for the availability/reliability systems are seldom addressed in the literature, in which general repair time and imperfect switch of failed component are considered. Confidence limits for availability of the two-unit redundant system were investigated by Masters et al. [6] and Sridharan and Mohanavadivu [8]. Yadavalli et al. [10] considered asymptotic confidence limits for the steady state availability of a two-unit parallel system with the introduction of preparation time for the service station and exponential repair time. Chandrasekhar et al. [1] derived a consistent asymptotically normal estimator and an asymptotic confidence interval for the steady-state availability of a two-unit cold standby system in which the failure rate of the unit while online is a constant and the repair time distribution is a two-stage Erlangian. Recently, Chien et al. [2] studied asymptotic confidence limits for performance measures of a repairable system with multiple unreliable service stations in which the repair time of failed components and service stations are assumed to exponential. Hsu et al. [4] examined Bayesian inferences of system characteristics for a redundant repairable system with exponential repair time, in which the system consists of one active component and one standby component.

Existing research works, including those mentioned above, mainly focused on interval estimations of system characteristics when the repair distributions are specified. The main reason is that system characteristics expressed in terms of Laplace–Stieltjes transform (LST) forms are not a convenient tool for statistical inferences and simulation analyses. Moreover, the failure time and repair time of components are assumed to follow certain probability distributions with known parameters, however, in practice, the parameters are usually unknown or the distribution of the repairable system might not be known in advance. Thus, it would be interesting to investigate a repair system with a general distribution. To the best of our knowledge, no one has derived the statistical inferences on system characteristics for a repairable system with a general repair distribution. This motivates us to explore statistical inferences for the system availability of a repairable system with distribution-free repair time. Moreover, in many practical situations, the availability of system is often improved by adding standby components or using reconfiguration mechanisms. For instance, in the internet reliability model, we might be concerned with evaluating the availability of an internetworking (router) system composed of independent identical switches; one is on operating (active component), and the other is on standby [3]. When the active component fails, it may be immediately replaced by a standby, which might fail during the switching process from standby state to operating state. After this switching, reboot delay takes places with a random time interval for a standby component. In this paper, we overcome the simulation difficulty of LST and successfully generate random sample from the posterior density function using the Metropolis–Hastings algorithm. We will select an appropriate estimation method to estimate the parameters of failure time distribution and repair time distribution. In Bayesian estimation approach, the prior probability density function is used to represent the relevant prior knowledge, including judgment regarding the characteristics of the parameter and its distribution. When the prior knowledge is combined with other observed information, a posterior distribution is obtained, which better represents the parameter of interest. O'Hagan and Forster [7] pointed out many benefits of the Bayesian approach. That is, it can provide more intuitive and meaningful inferences, can answer complex questions clearly and exactly, can make use of all available information, and is particularly well suited for decision making.

This article is organized as follows. In Section 2, we describe the problem statements and develop the system availability, A_v. Section 3 deduces an estimator of system availability from statistical standpoint. Using the estimator and its estimated variance, the asymptotical confidence interval of the availability is obtained. In Section 4, we explore the performance for the estimator for system availability according to simulation results. In the simulation study, we evaluate the accuracy of confidence interval of system availability by computing their coverage percentage. For concreteness, we consider two different distributions, namely, lognormal and Erlang distribution with three different shape parameters. Finally, we draw some conclusions based on the study.

2. Model description

We consider a redundant repairable system which consists of one active component and one standby component. The standby component is allowed to fail while inactive before it is put into full operation, and that the standby is continuously monitored by a fault detecting device in order to identify if it fail or not. Furthermore, there is a possibility of failure during the switching from standby-unit state to primary-unit state. The state transition diagram is given in Fig. 1. A significant probability c of a switching failure is considered. Primary units and warm standby units