ABSTRACT OF THESIS

MODELING AND ANALYSIS OF SOFTWARE RELIABILITY AND AVAILABILITY USING MARKOVIAN APPROACH

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ABSTRACT

In the present thesis the analysis of reliability and availability of Web-based software system with three tier architecture, Application server software system, Router software system and Clustered architecture system has been presented using Markovian approach. These software systems are a part of almost all the software products developed and used in software industry. Due to the uncertainties associated with parameters like software failure and repair rates, which either cannot be accurately measured in limited time frames through testing, or may vary on different customer sites, reliability and availability analysis must be able to accommodate the uncertainties and produce meaningful results. The approach described in the thesis carries out fuzzy reliability and availability analysis to incorporate such uncertain parameters and these estimations can be easily done even if the values of the parameters are not exactly known.

The architecture of the systems and certain assumptions under which the system is working has been analyzed completely for finding their reliability and availability. The mathematical formulation of Chapman-Kolomogrov differential equation, determining the reliability and availability of the software systems, is then developed based on the Markov model of the systems. The behavior analysis is then carried out for various combinations of repair and failure rates of the sub-systems. The fuzzy reliability and availability of the system has been calculated for the different combinations of failure and repair rates. The lower bound and upper bounds of fuzzy availability has been calculated for different \( \alpha \)-cut levels. In transient state the governing differential equations are solved numerically to calculate the reliability of the system and sensitivity analysis is carried out in transient state by studying the effect of software repair and failure rates of various subsystems on the reliability of the system. In steady state the system of linear equations are solved recursively as well as analytically to calculate the availability of
the system and sensitivity analysis is carried out in steady state also. The present thesis consists of six chapters and chapter wise brief summary is given below:

Chapter I is introductory in nature. In this chapter we briefly discuss the significance of determining the reliability and availability of software systems. It also presents the fundamental definitions associated with reliability, availability and fuzzy logic. The membership functions used to calculate the parameters as fuzzy numbers have also been discussed. The chapter also presents a literature review and general considerations of software reliability models followed by the methodology used in the thesis to carry out reliability and availability by taking a general four state Markov model. A summary of the work presented in the succeeding chapters of the thesis are also given in this chapter.

In Chapter II the reliability and availability analysis of Web-based software system with three-tier architecture is carried out by taking actual repair and failure rates of various components of the system. A Markov model for the system is developed and mathematical formulation has been carried out using mnemonic rule for sub-systems. The Chapman-kolomogrov system of differential equations thus formed has been solved numerically to calculate the reliability and availability of the system. The sensitivity analysis has also been carried out in transient and steady state by studying the effect of failure and repair rates of various components on the reliability and availability of the system.

Modeling and analysis of reliability and availability for application server using fuzzy logic and Markov model is presented in Chapter III. A mathematical model of Sun Java System Application Server has been formulated using Markov method. The fuzzy reliability has been calculated for various combinations of failure and repair rates and fuzzy availability has also been calculated for different \( \alpha \)-cut levels. The sensitivity analysis of reliability to operating
system recovery time has been presented by taking variations in the values of operating system recovery time. The sensitivity analysis of availability to application server instance failure rate and operating system failure rate has also been presented. The conclusions based on the present study are finally drawn.

Chapter IV innovatively carries out the software reliability and availability analysis of router software system using fuzzy logic and Markov models. The uncertainty of the parameters has been easily incorporated in the fuzzy markov model by modeling the uncertain parameters as fuzzy numbers using triangular membership function. The behavior analysis of the system is carried out for various combinations of repair and failure rates of the sub-systems. The fuzzy reliability and availability has been calculated for various combinations of failure and repair rates. The sensitivity analysis has been carried out in both transient and steady state by studying the effect of software failure and repair rates, on the reliability and availability of the system.

Chapter V highlights the fuzzy reliability and availability modeling of a system with clustered architecture that allows uncertainty based parameters of markov model in the evaluation of reliability and availability evaluation. The fuzzy reliability and availability has been calculated for various combinations of failure and repair rates for different $\alpha$-cut levels. The sensitivity analysis has finally been carried out in both transient and steady state by studying the effect of software failure and repair rates, on the reliability and availability of the system.

Finally, Chapter VI summarizes the contribution of this thesis. The possible directions, along which further research work on the topic can be carried out, are also discussed in brief. The industrial significance and limitations of the present work are also presented in this chapter.