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A managerial tool for reliability analysis using a novel Markov System Dynamics (MSD) approach

Meesala Srinivasa Rao* , V. N. A. Naikan

Reliability Engineering Centre, Indian Institute of Technology, Kharagpur 55351, India

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Abstract. System reliability is considered as an important performance index. Performance of engineering systems can be assessed by various techniques. In the traditional analytical techniques a mathematical model is developed to represent the system and to evaluate its reliability indices. There have been attempts in the literature to evolve more realistic techniques using simulation approach for reliability analysis of systems. This paper proposes a hybrid approach called as Markov System Dynamics (MSD) approach which combines the Markov approach with system dynamics simulation approach for reliability analysis and to study the dynamic behavior of systems. This approach will have the advantages of both Markov as well as System dynamics methodologies. The proposed framework is illustrated for a single component system with a numerical example. The results of the simulation when compared with that obtained by traditional Markov analysis clearly validate the Markov System Dynamics (MSD) approach as an alternative approach for reliability analysis.

Keywords: reliability analysis, simulation approach, dynamic implications of systems, Markov analysis, traditional analytical techniques, system dynamics

1 Introduction

Currently many reliability analysis procedures employ large number of unrealistic assumptions leading to over simplification of systems resulting in huge errors of evaluation. Traditional analytical techniques represent the system by a mathematical model and evaluate the reliability indices from this model using direct mathematical solutions. These techniques become very complicated and unrealistic especially for modern complex systems. The disadvantage with the analytical approach is that the model used in the analysis is usually a simplification of the system; sometimes to an extent it becomes totally unrealistic. In addition, the output of the analytical methods is usually limited to expected values only. The complexity of the modern engineering systems besides the need for realistic considerations when modeling their availability/reliability renders analytical methods very difficult to be used. Many researchers have been searching for alternate methodologies for more practical and realistic reliability analysis. Simulation has been used as a powerful tool for modeling and analysis of system reliability. It is used to represent the dynamic behavior of systems in the most realistic sense.

A system dynamics representation of Markov models opens up the possibility of numerical solution and of avoiding the tedium of analytical solution. Another advantage of system dynamics modeling is that it is easy to experiment with alternative values of parameters. Hence sensitivity analysis can be performed easily during reliability estimation and prediction. Finally, the steady state solutions for these problems can be obtained easily only by visual inspection of the flow diagrams and by making use of the fact that the net flow into a level is zero in the steady state.

* Corresponding author. Tel.: 9932573142; fax: +913222 255303; *E-mail address*: s_r_meesala@yahoo.co.in.