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Quantitative Analysis of Dynamic Fault Trees Using Improved Sequential Binary Decision Diagrams

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Abstract: Dynamic fault trees (DFTs) are powerful in modeling systems with sequence- and function dependent failure behaviors. The key point lies in how to quantify complex DFTs analytically and efficiently. Unfortunately, the existing methods for analyzing DFTs all have their own disadvantages. They either suffer from the problem of combinatorial explosion or need a long computation time to obtain an accurate solution. Sequential Binary Decision Diagrams (SBDDs) are regarded as novel and efficient approaches to deal with DFTs, but their two apparent shortcomings remain to be handled: That is, SBDDs probably generate invalid nodes when given an unpleasant variable index and the scale of the resultant cut sequences greatly relies on the chosen variable index. An improved SBDD method is proposed in this paper to deal with the two mentioned problems. It uses an improved ite (If-Then-Else) algorithm to avoid generating invalid nodes when building SBDDs, and a heuristic variable index to keep the scale of resultant cut sequences as small as possible. To confirm the applicability and merits of the proposed method, several benchmark examples are demonstrated, and the results indicate this approach is efficient as well as reasonable.

Keywords: Dynamic fault tree; Quantitative analysis; Improved Sequential Binary Decision Diagram; Heuristic variable index

1. Introduction

Dynamic fault trees (DFTs) [1-2] as the extensions of the traditional static fault trees are widely used to model dynamic systems with sequence- and function-dependent failure behaviors. In fact, such DFTs are often highly coupled because of dynamic gates that either share basic events or are directly interacted. To the former ones, we name them the I-type highly coupled DFTs, and for the latter ones, the II-type coupled DFTs. Both types are illustrated in Fig.1.

In I-type DFTs, the contained dynamic gates or modules are located at lower or bottom level of DFTs and interacted by repeated basic events. Such cases are very common in real-life industrial systems and have attracted more attention for their reliability evaluations [2-4]. Therefore, in the paper, we are focused on quantitative analysis of the I-type coupled DFTs.

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