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Minimal cutsets-based reduction approach for the use of binary decision diagrams on probabilistic safety assessment fault tree models

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Abstract-

Binary decision diagrams (BDDs) are a well-known alternative to the minimal cutsets (MCS) approach to assess Boolean reliability models. While the application of fault tree analysis can be considered to be consolidated, its application to the event trees involved in the probabilistic safety assessment (PSA) studies of the nuclear industry require extended efforts. For many real PSA models the full conversion procedure remains out of reach in terms of computational resources owing to their size, non-coherency, redundancy, and complexity. A potential solution to improve the quality of assessment methods is to design hybrid algorithms that combine the information derived from the calculation of MCS with the BDD methodology. As a first step to develop this new approach, this paper explores various procedures and strategies based on this principle. First, a method is presented to reduce the fault tree model by considering only the domain of the most relevant MCS of the system prior to the BDD conversion and the impact on the final probability of the model is analysed. Second, several ordering heuristics derived from the MCS and the structural information of the model are proposed and compared, both in terms of their general performance and their sensitivity to the initial rewriting of the model. This preliminary study is applied on a set of fault tree models belonging to a real PSA study. The results obtained lead to some promising conclusions: it is shown that the topological information proves to be essential for the ordering and conversion procedures; it is also revealed that the rewriting strategies should be considered when designing variable ordering methods; and, finally, it is demonstrated that the reduction procedure provides a faster computation process without affecting the final probability. The long-term objective, which has motivated this work, is to apply this reduction procedure to quantify sequences of linked fault trees, both static and dynamic, a task for which further work is required.

Index Terms- Probabilistic safety assessment, fault tree analysis, binary cecision diagrams, minimal cutsets, variable ordering heuristics

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