World Academy of Science, Engineering and Technology
International Journal of Nuclear and Quantum Engineering
Vol:19, No:03, 2025

Advanced Combinatorial Method for Solving Complex Fault Trees

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Abstract : Combinatorial explosion is a common problem to both predominant methods for solving fault trees: Minimal Cut Set (MCS) approach and Binary Decision Diagram (BDD). High memory consumption impedes the complete solution of very complex fault trees. Only approximated non-conservative solutions are possible in these cases using truncation or other simplification techniques. The paper proposes a method (CSolv+) for solving complex fault trees, without any possibility of combinatorial explosion. Each individual MCS is immediately discarded after its contribution to the basic events importance measures and the Top gate Upper Bound Probability (TUBP) has been accounted. An estimation of the Top gate Exact Probability (TEP) is also provided. Therefore, running in a computer cluster, CSolv+ will guarantee the complete solution of complex fault trees. It was successfully applied to 40 fault trees from the Aralia fault trees database, performing the evaluation of the top gate probability, the 1000 Significant MCSs (SMCS), and the Fussell-Vesely, RRW and RAW importance measures for all basic events. The high complexity fault tree nus9601 was solved with truncation probabilities from 10^{-21} to 10^{-27} just to limit the execution time. The solution corresponding to 10^{-27} evaluated 3.530.592.796 MCSs in 3 hours and 15 minutes.

Keywords : system reliability analysis, probabilistic risk assessment, fault tree analysis, basic events importance measures
Conference Title : ICNE 2025 : International Conference on Nuclear Engineering
Conference Location : Miami, United States
Conference Dates : March 11-12, 2025