# On the Applications of the Recursive Property of the Zero-Suppressed Binary Decision Diagram

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Abstract: The zero-suppressed binary decision diagram (ZDD) is a powerful data structure for the compact representation of sparse combinatorial families. Its recursive structure and effective reduction rules enable efficient diagram manipulation, family operations, and extraction of basic family information, making it widely applicable in discrete optimization. Given its utility and unique properties, this dissertation explores novel applications of the recursive property of the ZDD. Specifically, a framework bridging statistical moments and the ZDD is first introduced, facilitating the extraction of distributional properties from arbitrary families. A corresponding recursive algorithm is then developed and validated against three classical combinatorial problems, demonstrating orders of magnitude improvements in computational efficiency over conventional approaches. The recursive framework is further adapted to reliability engineering by introducing moment-based network reliability measures, called path survival reliabilities, which are efficiently calculated using the ZDD. Through theoretical discussions and experimental validation on three real-world water distribution networks, the new measures are demonstrated to be well-grounded in engineering principles, offering a more nuanced characterization of network reliability compared to conventional measures. Overall, the utility of the ZDD is extended by introducing efficient recursive algorithms for extracting non-trivial family information.