# Optimizing vital nodes detection in complex distribution networks with a global structural model

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**Abstract**

The identification of vulnerabilities within distribution networks, impacted by complex factors such as ring configurations and the integration of distributed energy resources, remains a significant challenge. This study presents a novel enhanced hierarchical analysis fault chain comprehensive assessment model to address this issue. The proposed model develops four new weak indicators of assessing the nodes of a distribution network based on complex network theory: an improved indicator of node degree, improved indicator of node PageRank, power flow increment impact indicator, and node voltage stability indicator. It introduces the weighting method with the binomial coefficient for optimal distribution of weight in the fault chain framework to further enhance effectiveness in refined hierarchical analysis, aimed at improving objectivity and precision. Besides, it employs an Integrated Analytic Hierarchy Process in which system indicators and operational parameters under various conditions can be integrated and dynamically calculate the fault rate of a weak link in the network. These further enhance the adaptability and precision of the model in solving inherent complexities within modern distribution networks. Simulation case studies performed using IEEE-69 node complex active distribution network have demonstrated the efficacy and superiority of the proposed method for correct identification of weak nodes.

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