Article

Recovering Power Grids Using Strategies Based on Network Metrics and Greedy Algorithms

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Abstract: For this study, we investigated efficient strategies for the recovery of individual links in power grids governed by the direct current (DC) power flow model, under random link failures. Our primary objective was to explore the efficacy of recovering failed links based solely on topological network metrics. In total, we considered 13 recovery strategies, which encompassed 2 strategies based on link centrality values (link betweenness and link flow betweenness), 8 strategies based on the products of node centrality values at link endpoints (degree, eigenvector, weighted eigenvector, closeness, electrical closeness, weighted electrical closeness, zeta vector, and weighted zeta vector), and 2 heuristic strategies (greedy recovery and two-step greedy recovery), in addition to the random recovery strategy. To evaluate the performance of these proposed strategies, we conducted simulations on three distinct power systems: the IEEE 30, IEEE 39, and IEEE 118 systems. Our findings revealed several key insights: Firstly, there were notable variations in the performance of the recovery strategies based on topological network metrics across different power systems. Secondly, all such strategies exhibited inferior performance when compared to the heuristic recovery strategies. Thirdly, the two-step greedy recovery strategy consistently outperformed the others, with the greedy recovery strategy ranking second. Based on our results, we conclude that relying solely on a single metric for the development of a recovery strategy is insufficient when restoring power grids following link failures. By comparison, recovery strategies employing greedy algorithms prove to be more effective choices.

Keywords: power grids; network resilience; network recoverability

1. Introduction

The power grid system is vulnerable to disruptions caused by manufacturing defects, natural disasters, and human actions, such as terrorist attacks [1–3]. Even minor initial disturbances can lead to severe consequences, including economic and social instability [4–6]. To reduce the costs associated with the disruptions, one research direction is to enhance the robustness of the power grid to withstand perturbations. The other direction is to propose efficient restoration strategies.

The power grid can be represented as a complex network, where nodes represent generators and loads, and where links represent transmission lines and transformers. Analyzing the power grid's robustness from a network perspective has attracted significant attention. Network robustness is typically evaluated by assessing changes in network performance due to fluctuations such as node removals or link removals [7]. Identifying

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