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# EFFECTS OF TOPOLOGY ON WATER DISTRIBUTION SYSTEMS RESILIENCE

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Water Distribution Systems (WDSs) are critical infrastructures for providing water to sustain life and human activities. Some recent trends, such as climate change, urbanization, and increasing system interdependence, have led to more frequent threats, with detrimental effects on WDSs. In recent years, resilience has been considered an effective approach to address those threats, for which it is difficult to estimate the likelihood and consequences (Henry and Ramirez-Marquez, 2012). In the literature, two approaches were used to assess WDS resilience. On the one hand, performance-based metrics were used to quantify the impacts of disruptions on the WDS. Specifically, recovery functions were developed to model the time-continuous system response following a disruption, during periods of loss and restoration of performance (Cassottana et al., 2019). On the other hand, indexes based on system attributes were developed to classify WDSs and identify structural vulnerabilities. For example, algebraic connectivity, clustering coefficient, and average path length were used as proxies for robustness, redundancy, and efficiency, respectively (Yazdani et al., 2011). However, those approaches were applied separately, and the relationship between the performance of WDSs and their attributes is still unknown. Hence, the question arises from the above analysis on how to identify the key structural factors determining the resilience of a WDS.

The goal of this research is to understand how and to what extent different network topologies determine different performance losses and recovery behaviors given increasing magnitude of disruption, i.e., pipe breakdown. To this end, we consider different network topologies as case studies and vary their structural attributes, e.g., water source head and tank capacity. We then simulate disruption scenarios of increasing magnitude and model the resulting system performance by means of recovery functions for the assessment of resilience. The estimated parameters of these functions are useful for characterizing different system responses, including severe or limited performance losses and fast or slow recoveries. By systematically varying the network topologies and the structural attributes, the function parameters could be in turn associated with key structural factors. We find that, while increasing the WDS supply capacity results in limited performance loss in terms of satisfied demand for water, increasing the reserve capacity improves the robustness of the system by delaying the loss of performance. This analysis will inform the design of resilient water networks based on their topology and unique attributes.

*Keywords*: Resilience, Topology, Recovery Functions, Water Distribution System, pipe failure.

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