Reconfigurable and Dynamic Microgrids with Interdependencies between Cyber and Physical Networks

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Abstract

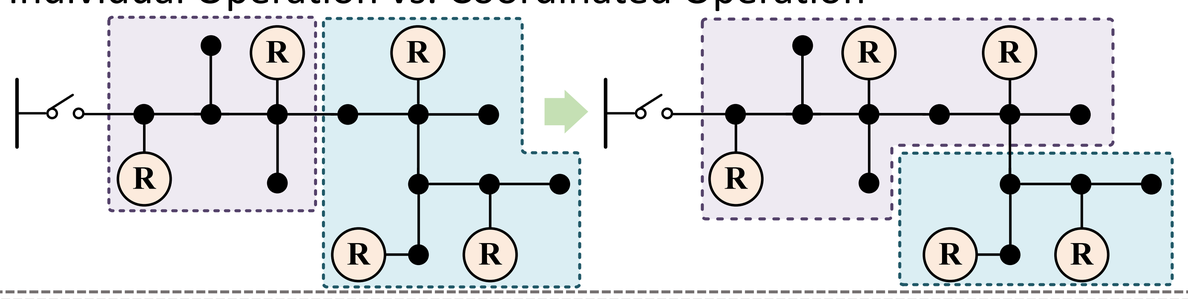
In this study, we develop a distribution system framework with reconfigurable and dynamic microgrids. In contrast to conventional static microgrids, dynamic microgrids feature flexible architecture and adjustable boundaries, which can be implemented surrounding distributed energy resources (DERs) to enhance grid resiliency at critical infrastructures. Furthermore, modeled and operated as cyber and physical systems (CPS) and given the cross-layer interdependencies between cyber and physical systems, a pinning consensus algorithm is designed to ensure resilient operation in steady and transient states. The proposed approach were verified using real-time simulation facilities.

Background

- Vulnerabilities in distribution grids or other energy systems
- Severe power outages: high-impact incidents covering a large footprint with strong stochastics
- Cascading consequences on interdependent infrastructures

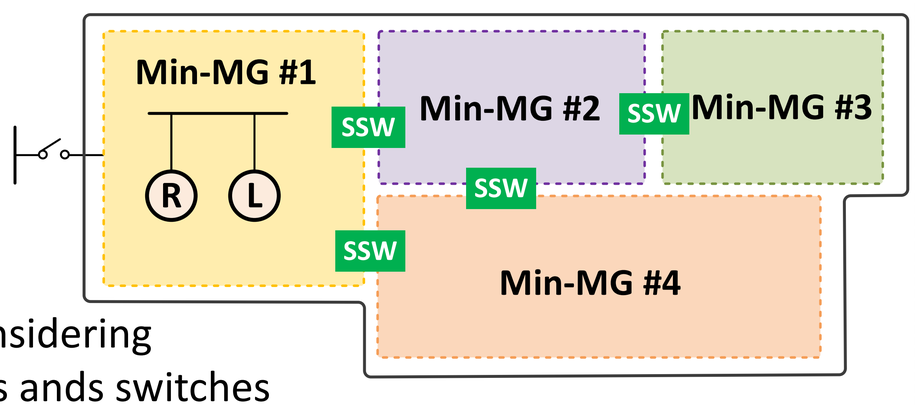
Static Microgrids vs. Dynamic Microgrids

- Static Boundary vs. Dynamic Boundary
- Individual Operation vs. Coordinated Operation



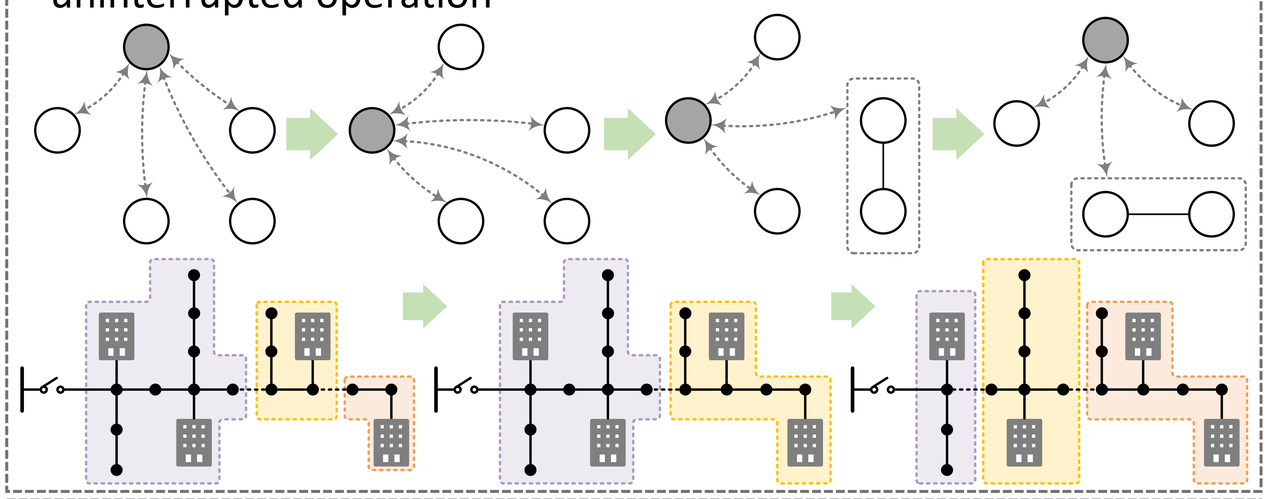
Min-Microgrids – Building Blocks

- Pre-grouped resources and loads
- Building blocks of dynamic microgrids
- Determined considering resources, loads ands switches



Pinning-Consensus-Based Stabilization

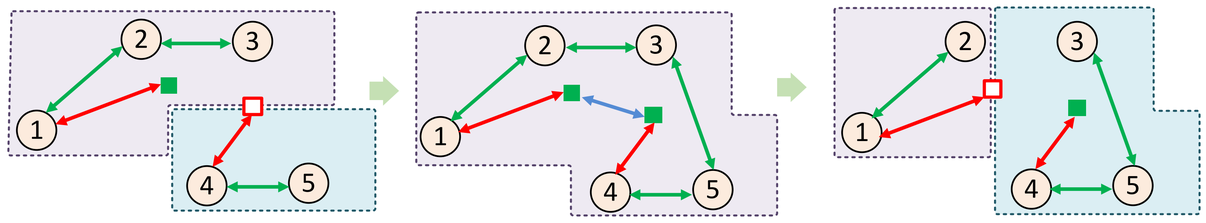
- Pinning consensus algorithm with both grid-forming and grid-following operation
- Topology transition to isolate the areas under faults and ensure uninterrupted operation



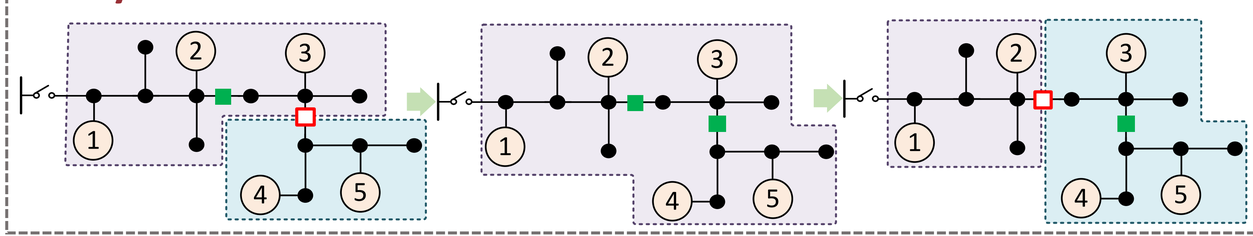
Interdependencies in Cyber and Physical Networks

- Communication among DERs and smart switches
- Interdependent sectionalization in cyber and physical networks
- Performance guarantee in both steady and transient states

Cyber Network:

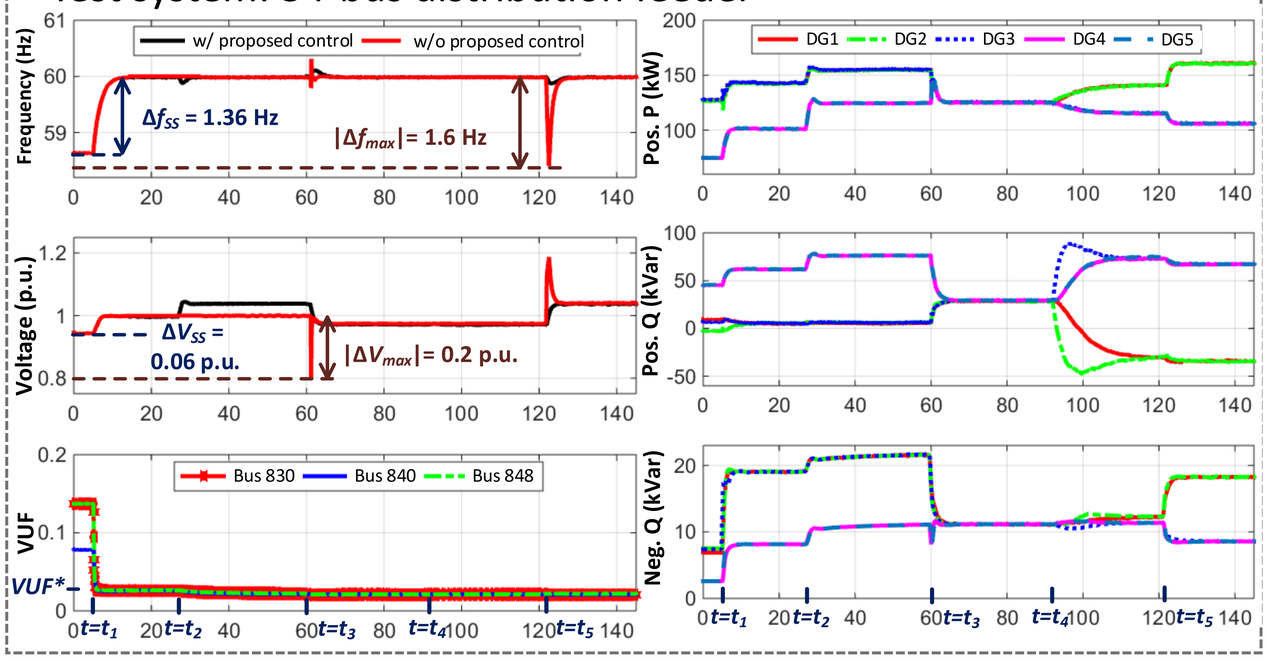


Physical Network:



Real-Time Testing Results

- Test system: 34-bus distribution feeder



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