Enabling Resilient Microgrid Through Programmable Network

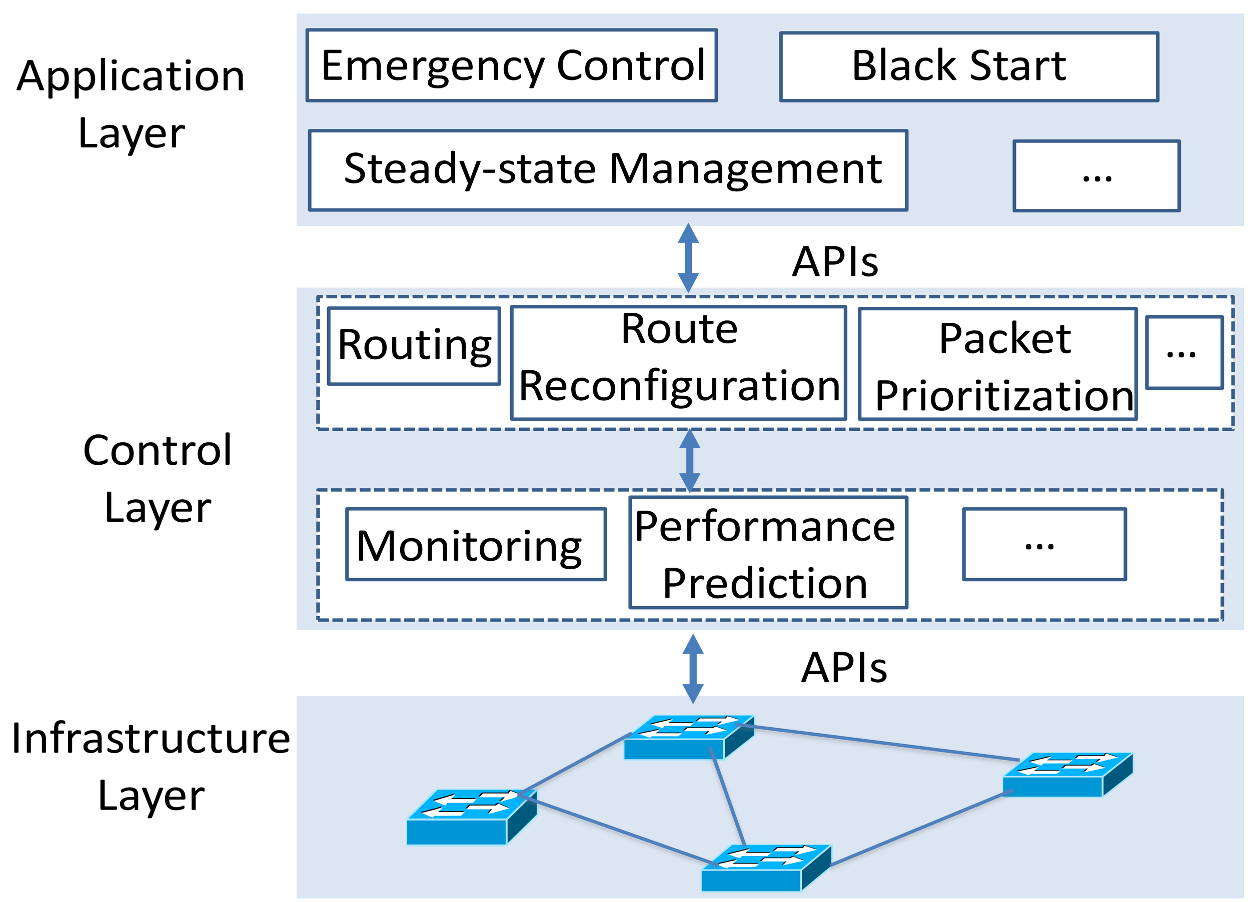
Lingyu Ren, Yanyuan Qin, Bing Wang, Peng Zhang, Peter Luh

University of Connecticut

Motivation

- Microgrid
  - Small-scale, low-voltage power network;
  - Emerging & promising paradigm for improving resilience of distribution system;
  - Enhance power supply quality.
- Communication infrastructure
  - Critical for microgrid with smaller inertia renewable energy sources;
  - Challenges: low latency for time stringent packet (e.g. 4ms), resilience to communication network failures, diverse QoS requirements.
- Software Defined Networking
  - Ultra-fast programmable network;
  - Flexible, dynamic network monitoring and management;
  - Diverse QoS support.

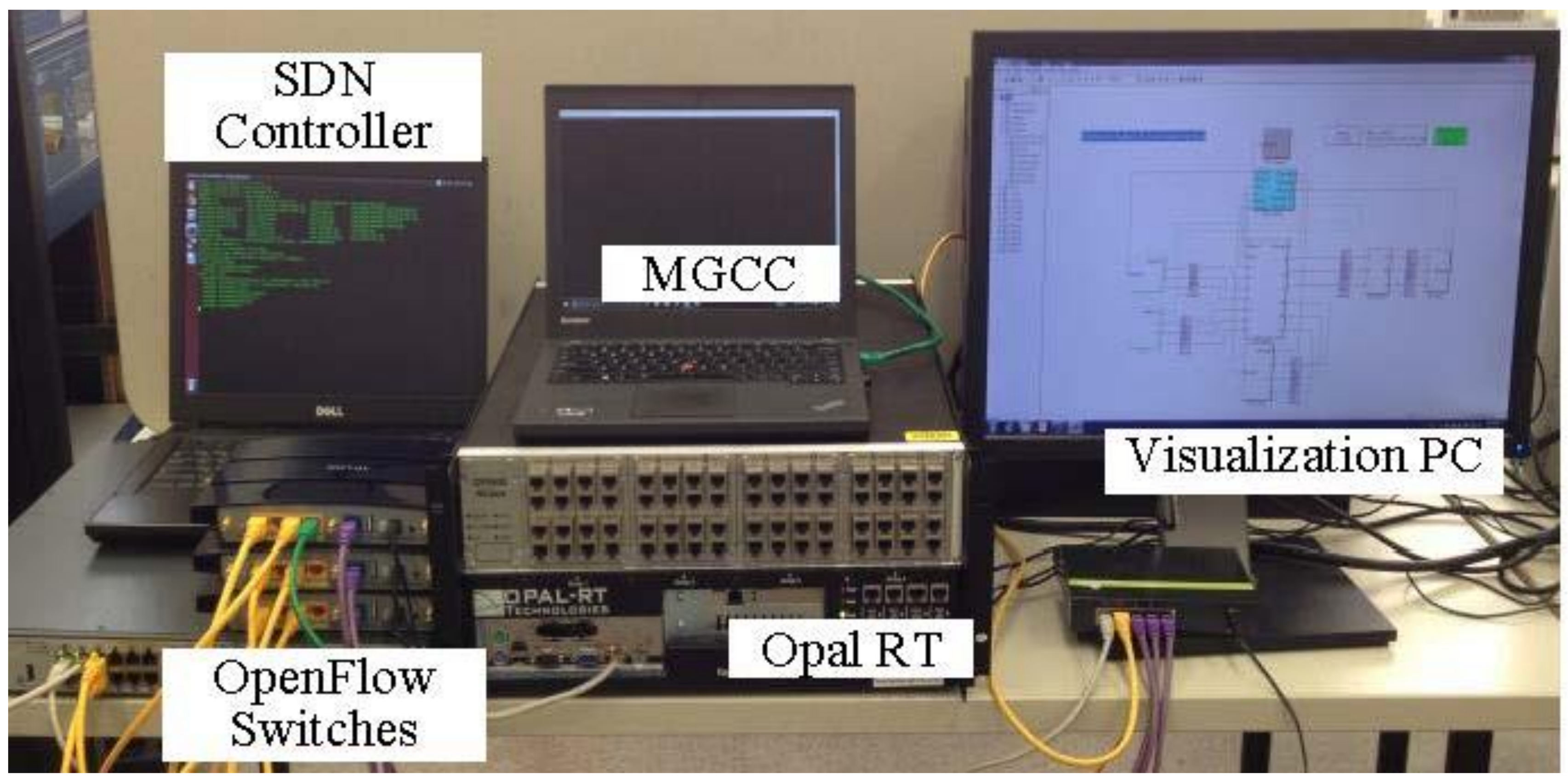
SDN-based Microgrid Communication Architecture



Technical Approaches

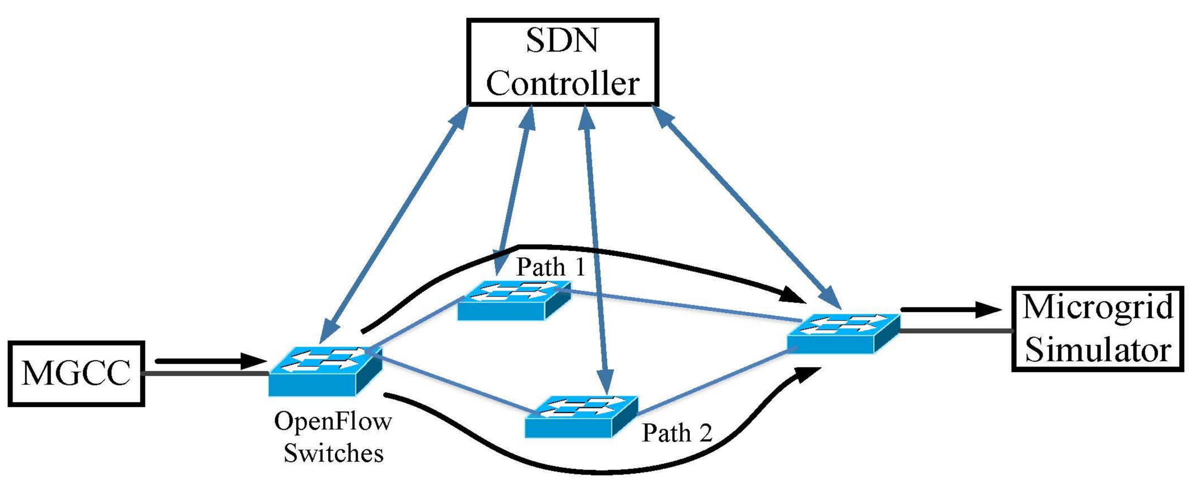
- **Microgrid emergency control**
  The Microgrid Central Controller (MGCC) monitors microgrid status, generates control signals and sends them to the local controllers.
- **Network delay guarantee**
  The SDN controller will measure the latency in real time and reconfigure the routes if any latency violates the predefined latency threshold.
- **Automatic failover**
  The SDN-capable switches will send port down message to the SDN controller when link failure occurs. The SDN controller will automatically reroute the network to bypass the failure.
- **Traffic prioritization**
  SDN supports different techniques for packet prioritization for various QoS requirements. Bandwidth allocation is one of them.

Hardware-in-the-loop Testing Environment



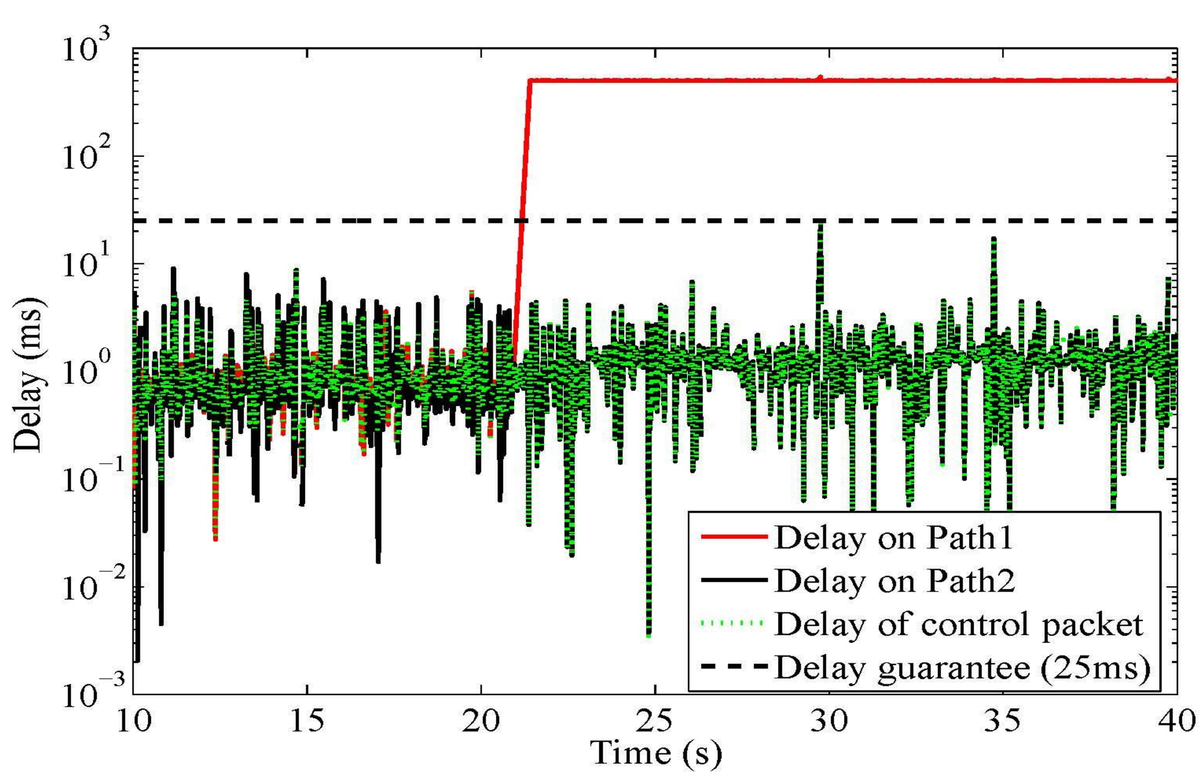
Experimental Results

- UCONN Depot Campus Microgrid:
  One 100 kW PV array, one 200 kW Fuel Cell, four 125 kW Synchronous Generators and 16 buildings.

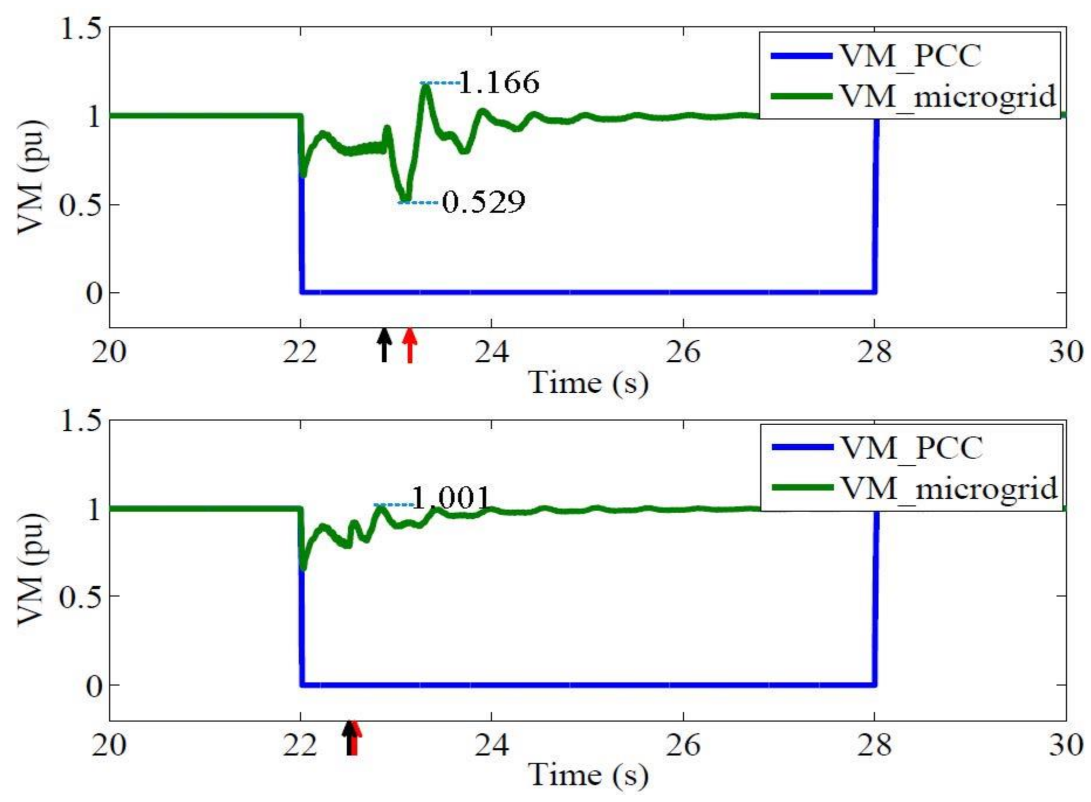


Network topology for microgrid testbed

- Test 1: Network delay guarantee

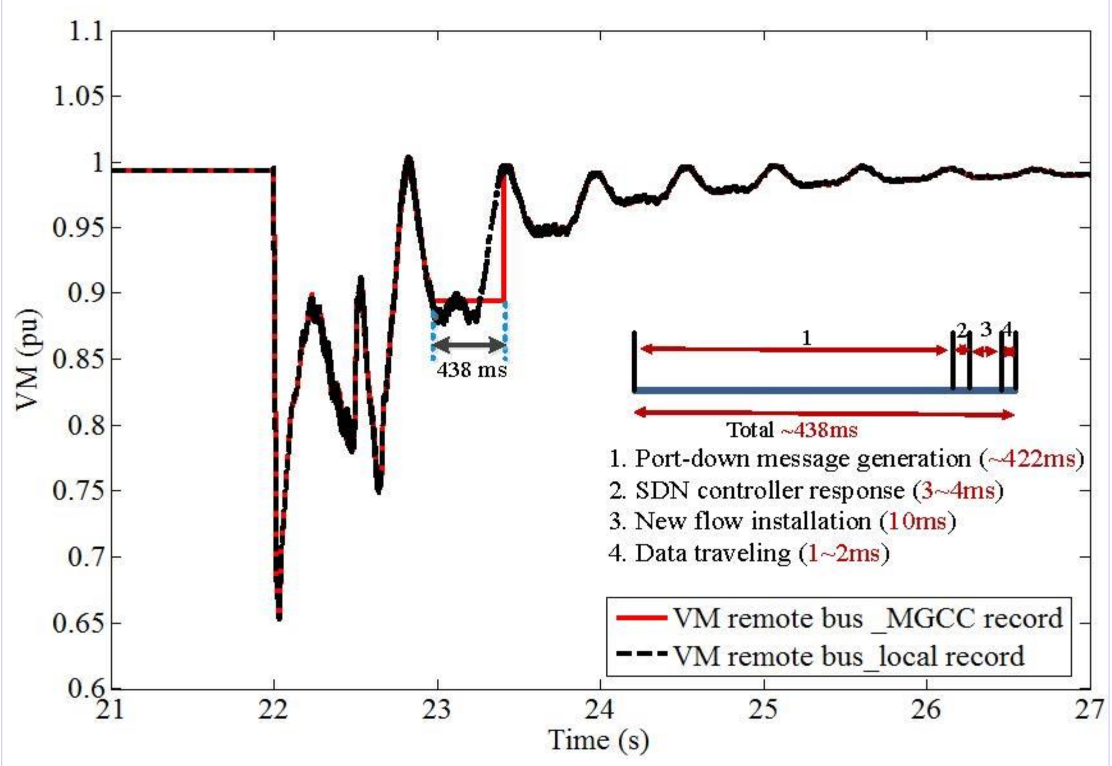


Rerouting for network delay guarantee



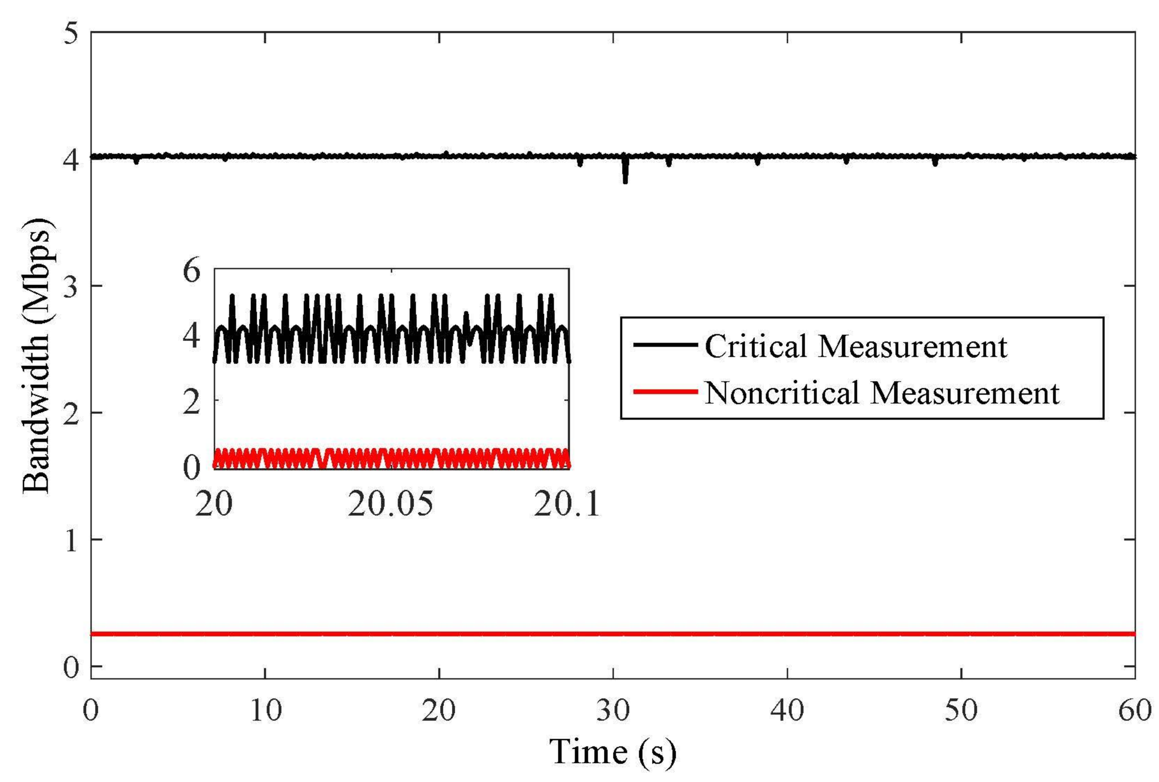
System response to time delay guarantee

- Test 2: Automatic failover



Voltage Magnitude during failover

- Test 3: Packet prioritization



Rate limit for QoS support

Conclusion

- Network delay guarantee enhanced microgrid resilience by shortening the transient period with smoother voltage curves.
- Automatic failover enables fast network recovery (milliseconds) which is critical during emergency.
- Packet prioritization benefits the microgrid by dynamically managing the data traffic and supporting various QoS.
- SDN architecture provides fast speed and high reliability data communication thus to stabilize microgrids under emergency.