Duke Energy Emerging Technology Office

Unlocking new Grid Automation Use-Cases with Distributed Intelligence and Precision Timing

Stuart Laval

Different Control Paradigms and Data Models

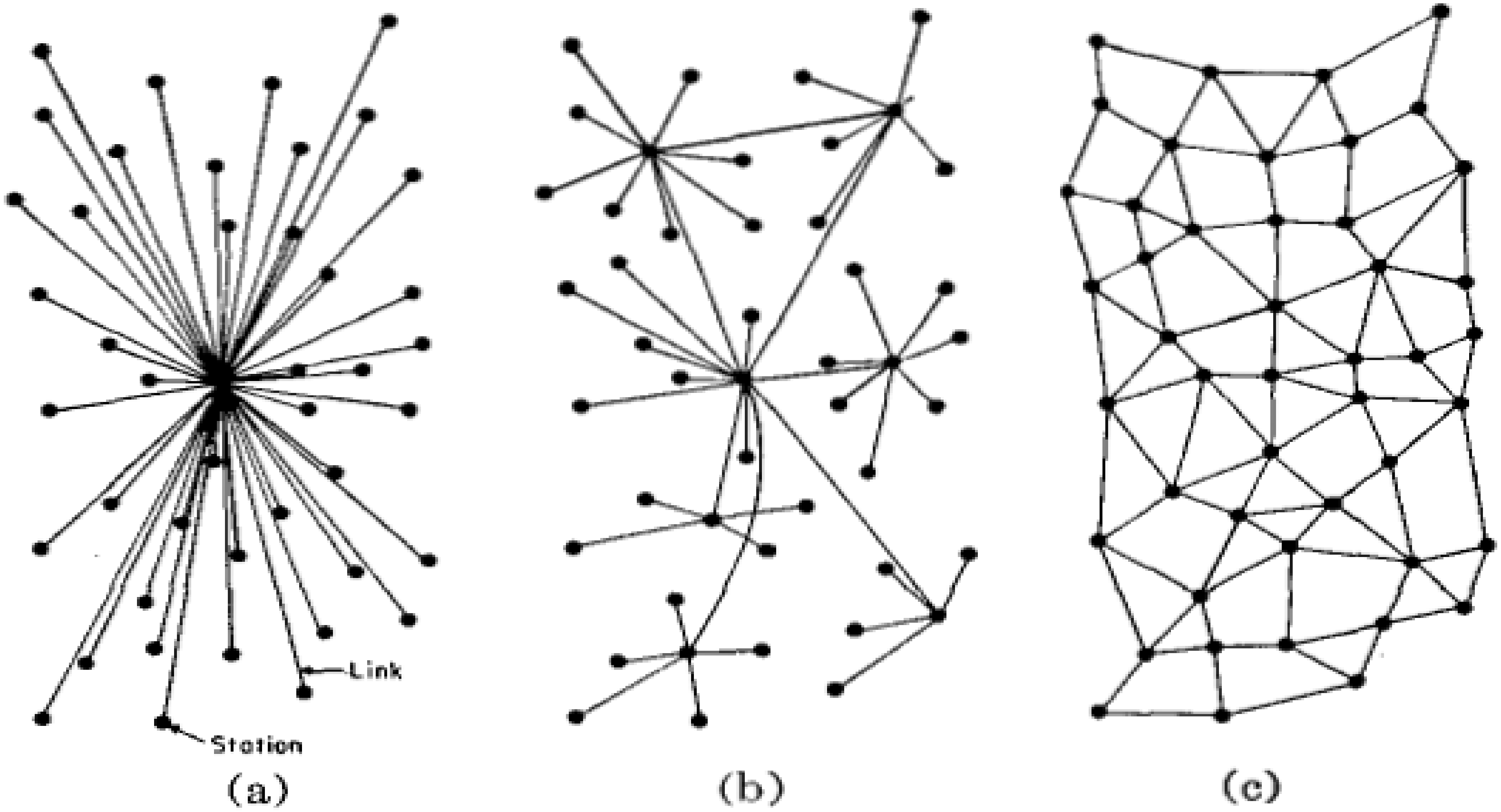


Fig. 1—(a) Centralized. (b) Decentralized. (c) Distributed networks.

Common Information Model
(CIM)

IEC
61850

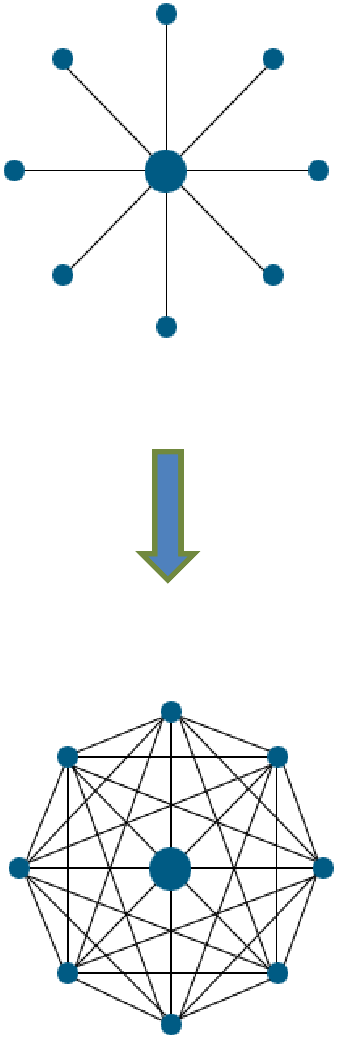
Open Field Message Bus
(OpenFMB)

CIM users group

IEC 61850 users group

OPEN FMB

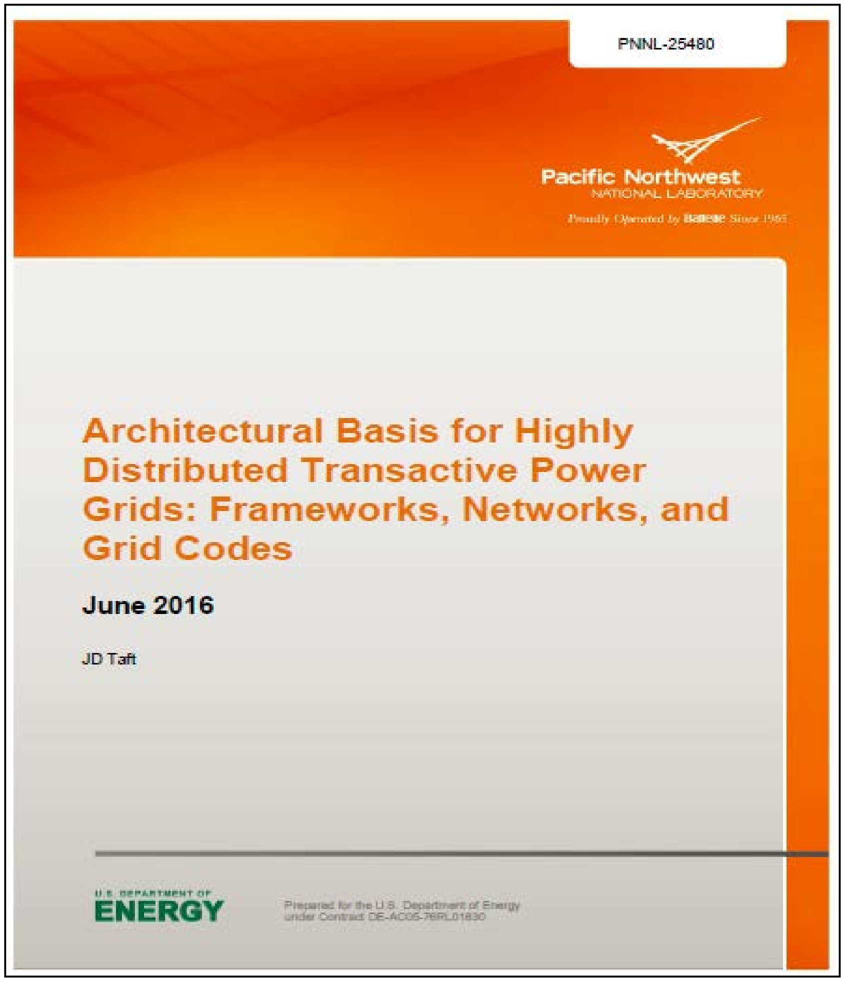
What is Distributed Intelligence?



- Distributed Intelligence (DI) is a multi-layer, federated architecture that supports active coordination between multiple devices/systems to solve a common problem.
    - DOE refers to as “Laminar Coordination”
    - Can occur at head-end, node, and grid-edge layers.
    - Location of decision can be optimized based on sensitivity, timeframe, system updates.
- Differences over traditional approaches
    - Supports stacked business use-cases
    - Enables edge interoperability and enhanced resiliency
    - Exception-based processing, distributed computing
    - Does not rely on back office connectivity
- DI standard: NAESB’s Open Field Message Bus (OpenFMB)

Viable Distributed Intelligence (DI) Frameworks

DOE PNNL’s Grid Architecture 2.0:
Laminar Coordination Framework (LCF)



PNNL-25480

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Architectural Basis for Highly Distributed Transactive Power Grids: Frameworks, Networks, and Grid Codes

June 2016

JD Taft

U.S. DEPARTMENT OF
ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

PNNL-25480 (Courtesy of JD Taft)
Available at http://gridarchitecture.pnnl.gov/

Open Field Message Bus (OpenFMB): Industrial
Internet of Things (IoT) Interoperability Framework

NAESB

North American Energy Standards Board
Retail Gas Quadrant
Retail Electric Quadrant
Model Business Practices

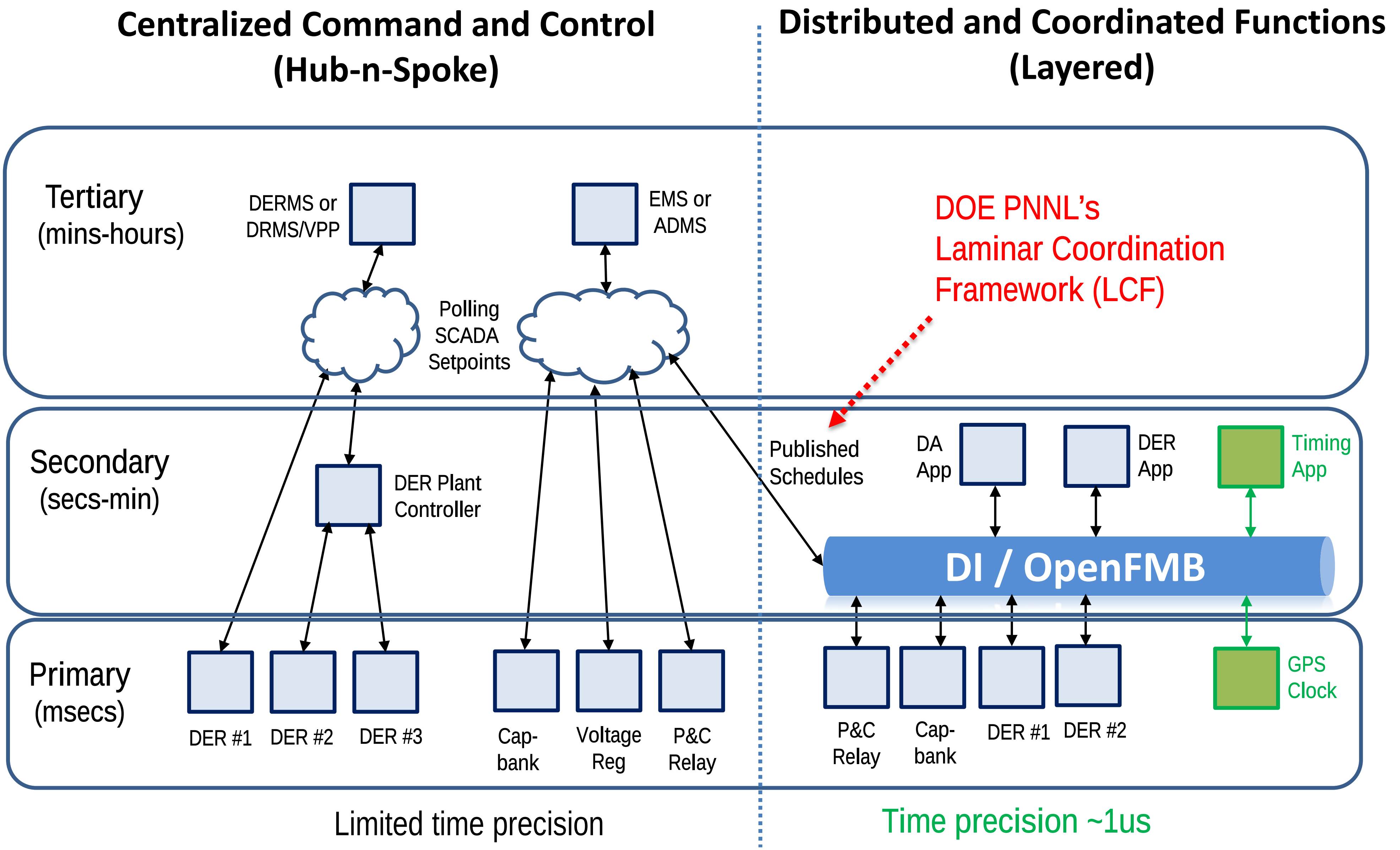
Open Field Message Bus (OpenFMB)

Version 3.1
March 31, 2016

Copyright © 2012-2016 North American Energy Standards Board, Inc.
All rights reserved.

NAESB RMQ.26 Version 3.1
Please contact naesb@naesb.org

Co-Existence of Legacy and Future Controls



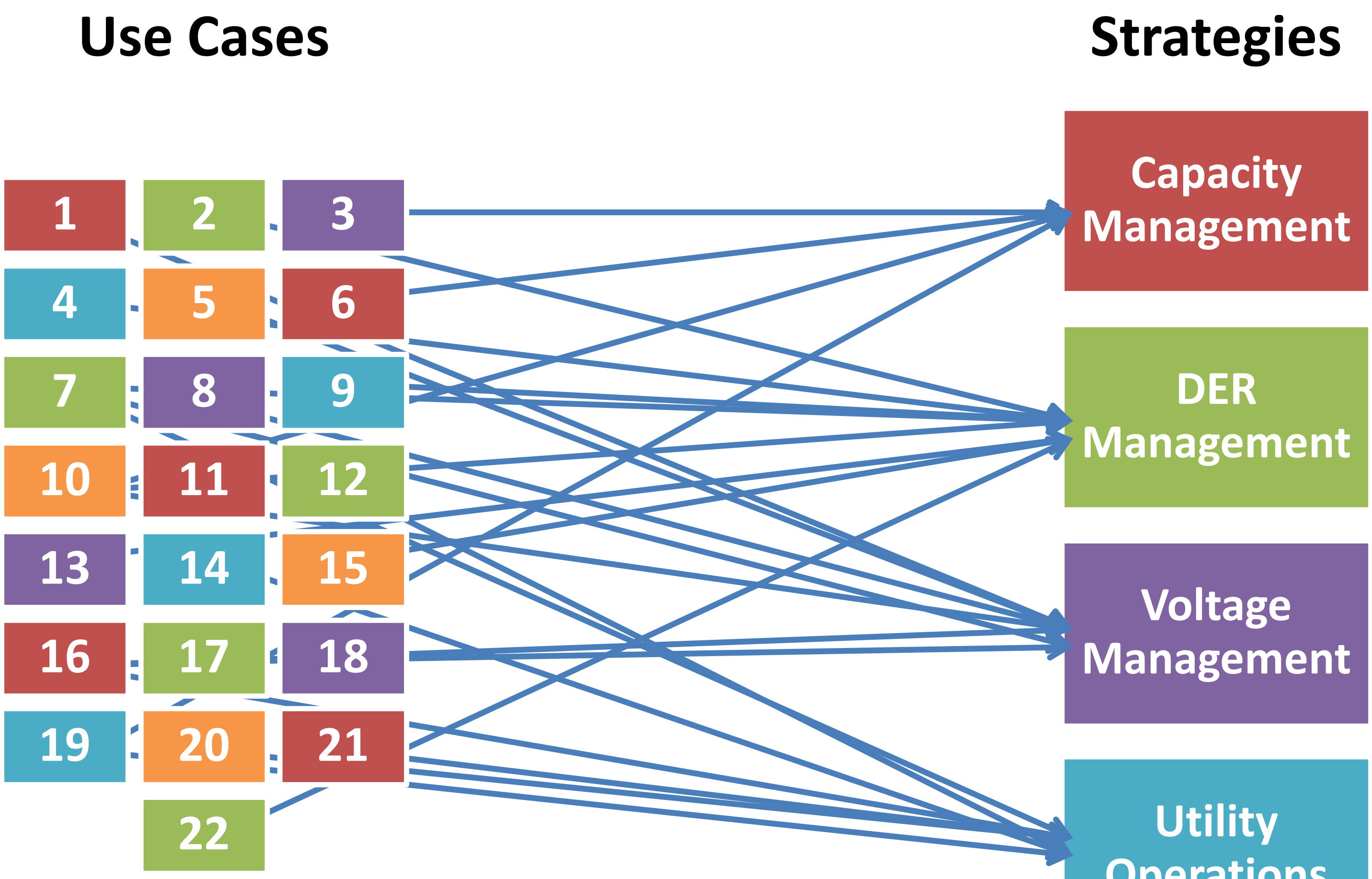
Traditional Approach

Conventional deployed assets support a single use case and outcome

Use Cases	Strategies
Demand Response	Capacity Management
DER Forecasting	DER Management
Volt-Var Management	Voltage Management
Remote Device Configuration	Utility Operations

Future Approach

Distributed Intelligence (DI) deployed assets support multiple use cases and outcomes leading to stacked benefits

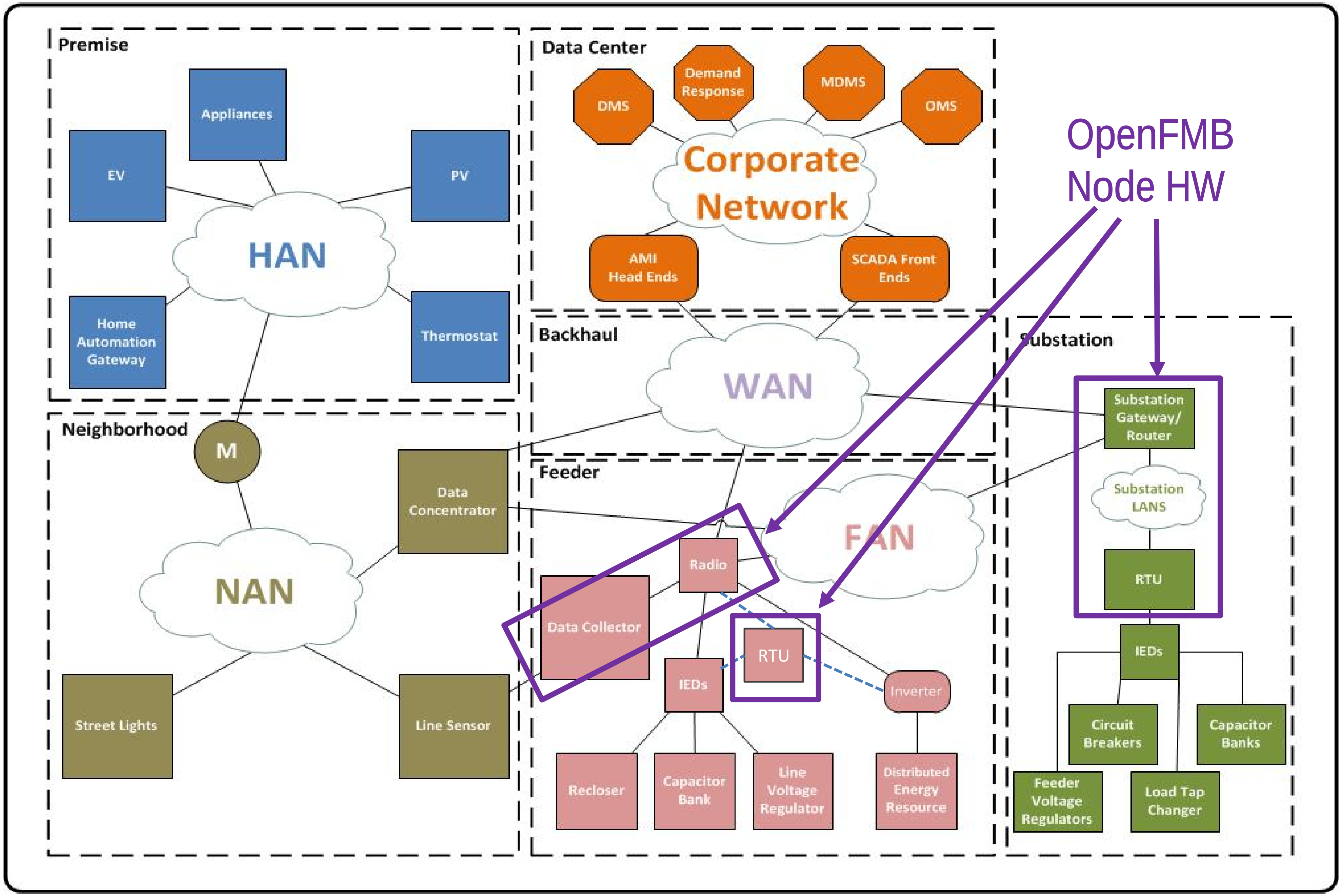


Stacking of Distributed Intelligence (DI) Use-cases

Of the 51 identified DI use-cases, 22 could be associated with a set of four deployment scenarios.

Use Case	Capacity Management	Voltage Management	DER Management	Utility Operations
DER Circuit Segment Management	✓	✓	✓	✓
Baseload Storage Monitoring/Mgmt.	✓		✓	
Peak Power Management	✓		✓	
DER Forecasting w/ Meters	✓		✓	
DER Forecasting w/ Weather Stations	✓		✓	
DER Optimization (Cust. Inverter)	✓		✓	
DER Optimization (Utility Inverter)	✓		✓	
Demand Response Optimization	✓			
PCC Mgmt/Optimization (Utility µgrid)	✓	✓	✓	
PCC Mgmt/Optimization (Cust. µgrid)	✓	✓	✓	
Volt/VAR Management	✓	✓	✓	✓
Grid Connectivity Discovery				✓
Remote Device Configuration			✓	✓
SCADA Point Aggregation			✓	✓
Enhanced COMS Network Ops. Status				✓
Improve Asset Maint. Practices				✓
Localized Protection Alarms & Events			✓	✓
Self Healing Radial Network			✓	✓
Solar Smoothing		✓	✓	
Solar Smoothing (+Battery)		✓	✓	
Inadvertent Island Detection			✓	
DER Integration & Interconnection			✓	

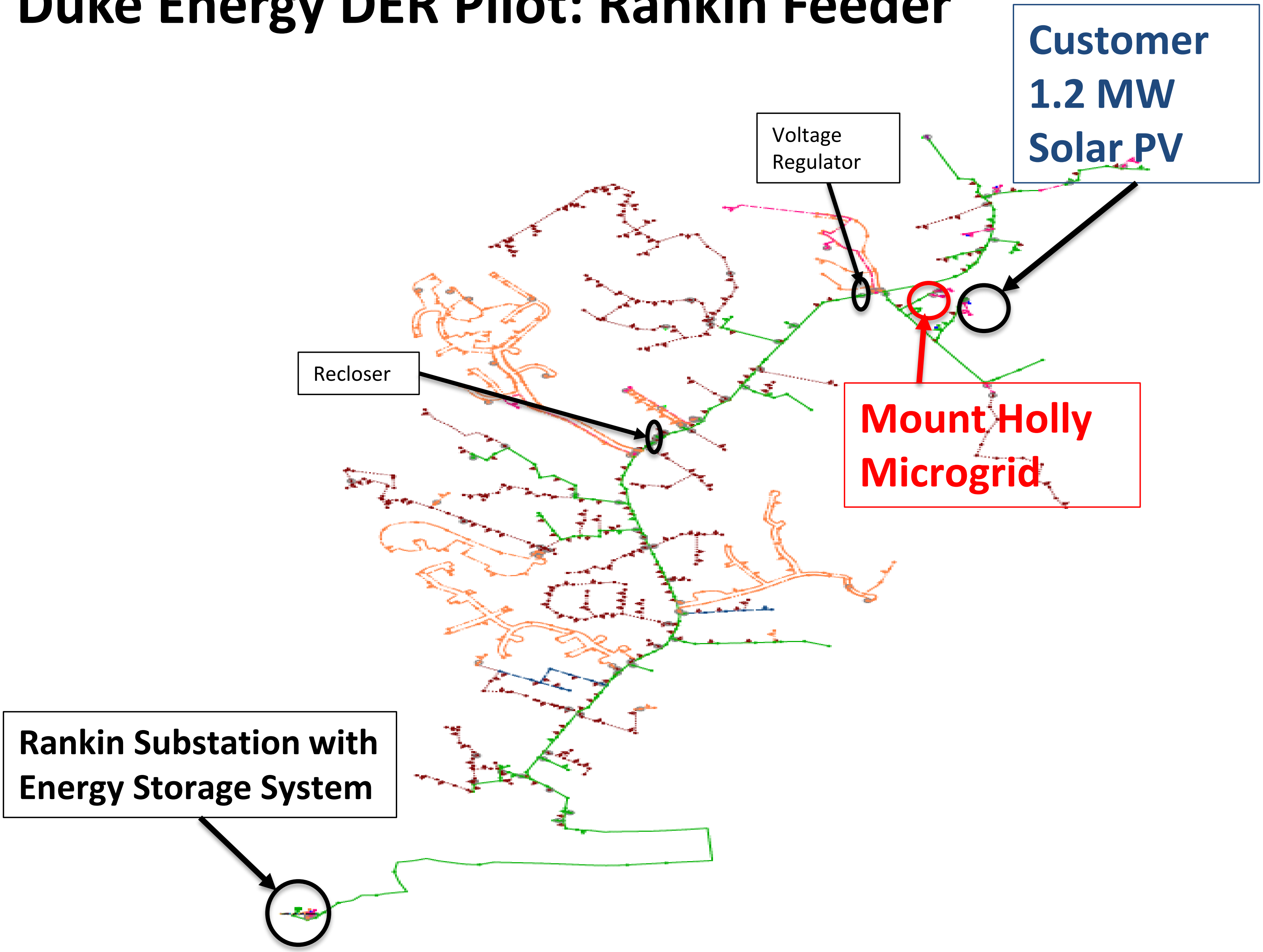
DI Node Location: Network Connectivity Domains



In-Flight DI/OpenFMB Industry Efforts:

- 5+ Investor-Owned Utilities initiating OpenFMB pilots
    - Microgrid islanding operation & optimization
    - Integration of DERs (grid-scale PV/Storage) into Distribution system
    - Voltage & Outage Management with High-Penetration DERs
    - Decentralized FLISR with DERs/Microgrids & centralized DMS
- OpenFMB Adoption by Leading Utility Technology Providers
    - Distribution automation (DA) manufacturers
    - 4G LTE gateway supplier
    - OT/IT Integrators & Middleware providers
    - DOE National Labs
- New Open-source DI Capabilities
    - VM/Container Platforms (e.g. Docker, Kubernetes)
    - Protocol translators to legacy SCADA (e.g. DNP3, Modbus, GOOSE, etc)
    - High-precision (<1us) time synchronization (e.g. GPS/PTP)
    - Local Historians (e.g. Time-series Databases)

Duke Energy DER Pilot: Rankin Feeder



Customer 1.2 MW Solar PV

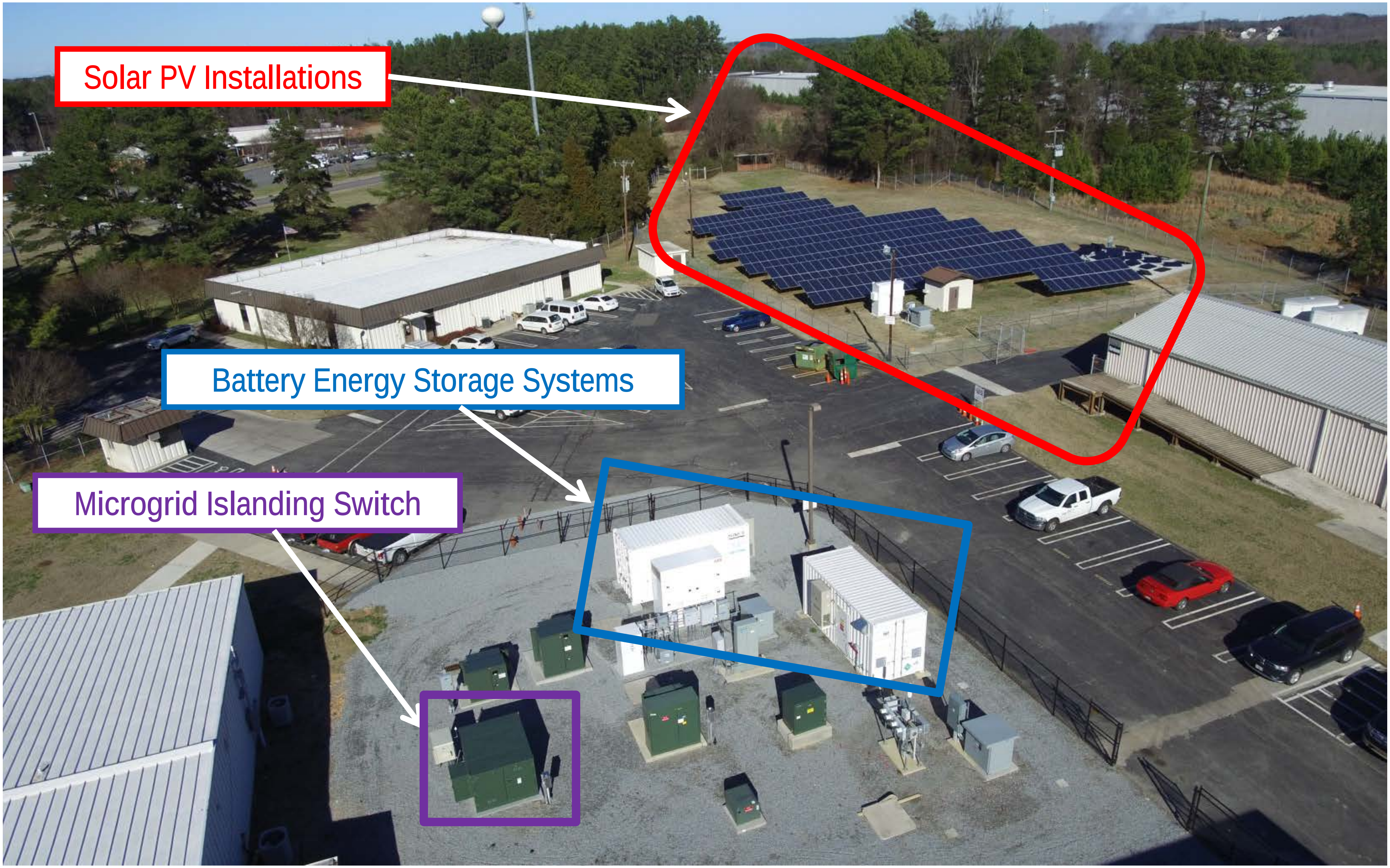
Voltage Regulator

Recloser

Mount Holly Microgrid

Rankin Substation with Energy Storage System

Duke Energy Microgrid Test Site: Mount Holly, NC



Duke Energy Microgrid T&D World Publications

T&D World March 2016 issue

SubstationAutomation

Duke Develops True Interoperability

An Open Field Message Bus framework enables a more robust energy Internet of Things platform.

By **Stuart Laval**, *Duke Energy, and* **Wade P. Malcolm**, *OMNETRIC Group*

An overall objective of an electric utility is to provide a more efficient, reliable and maintainable electric power system. To facilitate this, the development of enhanced information management systems is a prerequisite. Interoperability is the key to helping utilities operate the electric power system more simply and cost-effectively while also providing better service to customers. Historically, the back-office integration of information systems to achieve interoperability has been expensive and time-consuming.

The electric power system of the future will need to exchange information with different devices from many manufacturers locally in the field (outside of the central office) to achieve enhanced operational capabilities. In addition, traditional utility technologies and the associated data are often siloed, because they typically use proprietary, prepackaged hardware, telecommunications and software platforms that backhaul data to a centralized hub.

As such, development work is shifting away from the traditional centralized proprietary systems and evolving to support distributed intelligence, interoperability and the energy Internet of Things (IoT). Based in Charlotte, North Carolina, U.S., Duke Energy's efforts to develop its smart grid have resulted in the enablement of these concepts through what the industry calls OpenFMB (Open Field Message Bus). It was showcased in a collaborative demonstration at the DistribuTECH 2016 meeting in Orlando, Florida, U.S.

First-Generation Deployment

Duke Energy's initial smart grid efforts took hold in 2007 with a focus on establishing machine-to-machine connectivity to multiple grid devices with a 3G cellular backhaul. This led to the development and deployment of an Internet protocol (IP)-based node solution with multiple radios to facilitate use of the 3G backbone. As a result, the power line carrier (PLC) advanced metering infrastructure (AMI) and 900-MHz radio-frequency-based automated meter reading (AMR) systems being deployed were integrated into the node solution. In addition, the IP-based node solution also supported Wi-Fi-based medium-voltage sensors and serial devices used to improve distribution automation.

This first phase of Duke Energy's smart grid technology resulted in the deployment of approximately 150,000 nodes equipped with 3G cellular, PLC, Wi-Fi and 900-MHz radios attached to approximately 500,000 PLC meters and 10,000 Wi-Fi-based medium-voltage line sensors.

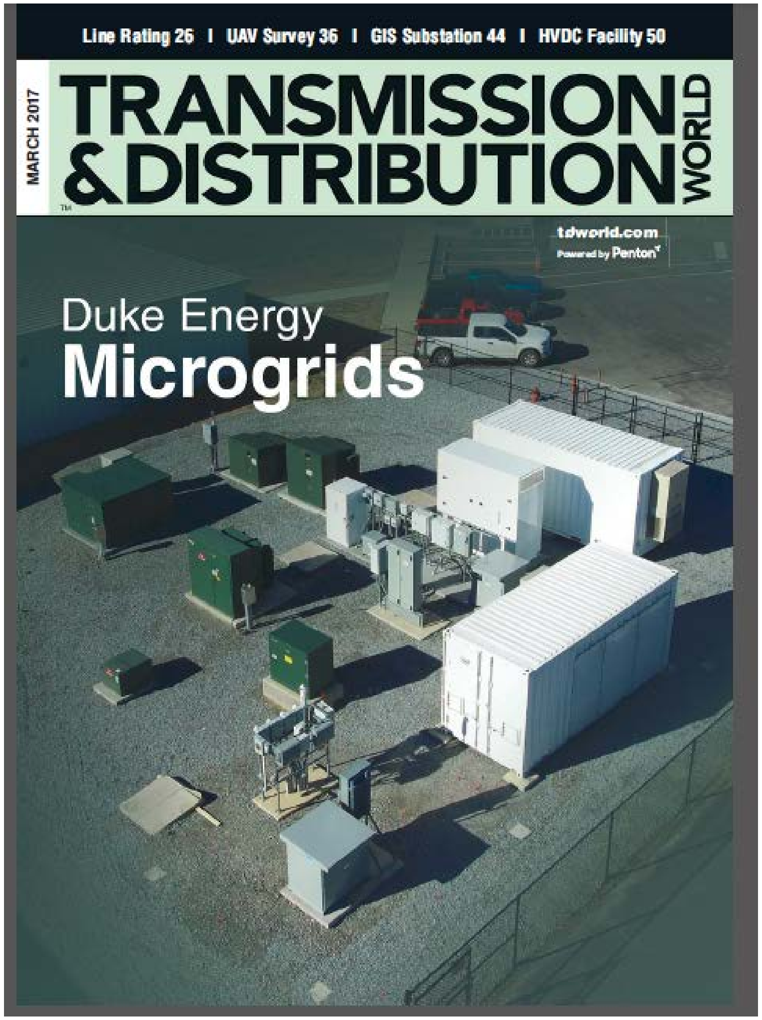
Circa 2010, the first-generation equipment was expanded with the addition of integrated streetlight control. LTE or 4G cellular technology was retrofitted to the node to operate capacitor banks. Weather sensors were also integrated with the upgraded LTE-based nodes. Partial discharge and secondary load-monitoring capability were added to the node-based

Duke Energy engineers inspect a meter structure and uninterruptible power supply that provide microgrid communications equipment support for the interoperability demonstration.

70 *March 2016* | *www.tdworld.com*

tdworld.com/grid-opt-smart-grid/duke-develops-true-interoperability/

T&D World March 2017 issue



Line Rating 26 I UAV Survey 36 I GIS Substation 44 I HVDC Facility 50

MARCH 2017

TRANSMISSION & DISTRIBUTION WORLD™

tdworld.com

Powered by Penton®

Duke Energy

Microgrids

tdworld.com/march-2017

Thank You!

For more information contact:

Stuart Laval, Duke Energy
Stuart.Laval@duke-energy.com