Internet of Things (IoT) Interoperability Framework for Utility Industry

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About Duke Energy

• One of the Largest Electric Holding Companies in the United States

• Electric Utility operations in North and South Carolina, Indiana, Ohio, Kentucky and Florida serving 7.2 million customers

• 57,500 MW of regulated generation

• Renewable generation of 1500 MW of wind and 500 MW of solar located throughout the United States
Duke Energy’s Interoperability Vision

http://duke-energy.com/coalition/
# Key Drivers of Grid Transformation

## CURRENT STATE
- Centralized
- One-way Flow
- Stable Load
- Static/Reactive
- Analog/Electromechanical
- Single-Purpose
- Proprietary
- Silo-oriented
- Latent / Data Overload
- OT/IT Disconnected
- Limited Customer Interaction
- Data Center Security
- Fragile

## Why?
- Intermittent Renewables
- Energy Storage
- Microgrids
- Electric Vehicles
- Cyber-Security Threats
- Premise “Internet of Things”
- Aging Infrastructure
- Stranded Assets
- “Big Data” Complexity

## FUTURE STATE
- Distributed
- Multi-direction Flow
- Stochastic Load
- Dynamic/Proactive
- Digital/Automated
- Multi-function
- Open Standards/Modular
- Interoperable/Integrated
- Timely / Filtered Data
- OT/IT Convergence
- Virtual Hand-shake
- Enterprise-wide Security
- Resilient

## How?
1. Internet Connectivity
2. Translation
3. Common Dictionary
4. Security
5. Analytics

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DER Challenges with Traditional Centralized Solutions

Current State: Centralized Decisions
Slow, Raw, Stale, Unsecure Data

Key Observations:
1. Single-Purpose Functions
2. Proprietary & Silo’ed systems
3. Latent, Error-prone Data
4. OT/IT/Telecom Disconnected
5. No Field Interoperability!

Present Day Smart Grid
“Pass-Through”

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Why Interoperability is Important

• Distributed Energy Resources, Microgrids, and Advanced Demand Response require disparate field devices to work together remotely with little latency or delay.

• Key to more efficient, cost-effective, and secure grid
  – Leverage existing grid network infrastructure / underutilized assets
  – Reduces effort in device configuration, management, and commissioning
  – Improves Situational Awareness of Operational Technology (OT) and Information Technology (IT) systems

• Back office integration is expensive and time consuming
  – Hidden costs and inefficiencies with siloed, single-function solutions
  – “Big Data” complexity caused by lots of “Small Data” problems

• Open Standards does NOT mean interoperable
Unlocking data with an Open Field Message Bus (OpenFMB)

Key Observations:
1. Single-Purpose Functions
2. Proprietary & Siloed systems
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Future State: Distributed Decisions
Fast, Local, Actionable, Secure Data

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OpenFMB Operation: Federated Message Exchanges

- Readings - Pub each 2 secs or near-real-time
- Events – on status change in near-real-time

Readings
KW A/B/C
KVAR A/B/C
V A/B/C
I A/B/C
Phase Angle A/B/C
KWh
TimeStamp
State of Charge

Status, Events, Alarms, & Control
Trip / Open
TimeStamp

Microgrid optimization analytics
Expected Benefits of OpenFMB Framework

- Open, Observable, & Auditable interfaces for *Situational Awareness*
- Interoperability with existing assets for *No Rip-and-Replace*
- Fast Response when Centralized sites are *Too Far Away* to respond
- Resiliency when Portions of the Grid are Segmented
- Local intelligence with coordinated *Self-Optimization*
- Potential *Unified Backhaul* for reduced O&M, simplified management, and enhanced security
- Fostering innovative products & services
SGIP OpenFMB Overview Cartoon

https://www.youtube.com/watch?v=91HPyA8pol0
OpenFMB™: The Catalyst for Interoperability

• Open Field Message Bus (OpenFMB™) is a reference architecture and framework for distributed intelligence

• Leverages existing standards to federate data between field devices and harmonize them with centralized systems
  – IEC’s Common Information Model (CIM) for semantic data model
  – Internet of Things (IoT) publish/subscribe protocols
    • DDS: Data Distribution Service
    • MQTT: Message Queue Telemetry Transport
    • AMQP: Advanced Message Queue Protocol

• Scales operations independently, without a system-wide rollout
  – Flexible integration of renewables and storage with the existing grid
  – Accelerates ability to stack operational benefits

• OpenFMB™ standard ratified in March 2016 by the North American Energy Standards Board (NAESB)
OpenFMB Publications

Duke Energy Distributed Intelligence Platform

NAESB OpenFMB Standard

www.duke-energy.com/pdfs/distributedintelligenceplatformvol01.pdf

Please contact naesb@naesb.org
“Internet of Things” Platform for the Utility

Technology Approach
1. Internet Connectivity
2. Translation
3. Common Dictionary
4. Security
5. Analytics

Open Field Message Bus (OpenFMB)

DEMAND
- Smart Assets
  - Smart Meter
  - Transformer
  - Other Nodes
  - Line
  - Sensor
  - Distributed Energy Resources
  - Capacitor Bank
  - Intelligent Switch
  - Street Light

ELECTRIC GRID
- Distributed Energy Resources
  - Smart Generation
  - Continuous Emission Monitoring
  - Weather Sensor

SUPPLY

Open Standards Node
- Radio
- CPU
- Internet Connectivity
- Distributed Intelligence

Walking Through the Platform

DATA CENTER
- Network Router
- Data Center Message Bus
- Head End A
- Head End B
- Head End N

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"Internet of Things" Platform for the Utility

Technology Approach
1. Internet Connectivity
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Open Field Message Bus (OpenFMB)

Core OS

Virtual OS

Internet Connectivity

Distributed Intelligence

IP Network

UTILITY DATA CENTER

Data Center Message Bus

Network Router

Head End A

Head End B

Head End N
“Internet of Things” Platform for the Utility

Open Field Message Bus (OpenFMB)

Technology Approach
1. Internet Connectivity
2. Translation
3. Common Dictionary
4. Security
5. Analytics

Open Standards Node

Core OS
- Processor(s) + Memory
- Linux-based OS
- Open API Messaging
- 3rd Party Apps
- Security / Network Mgr

Internet Connectivity

Distributed Intelligence

IP Network

DEMAND
- Smart Assets
  - Smart Meter
  - Transformer
  - Other Nodes
  - Line Sensor
  - Distributed Energy Resources
  - Capacitor Bank
  - Intelligent Switch
  - Street Light

ELECTRIC GRID
- Smart Generation
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SUPPLY

UTILITY DATA CENTER
- Network Router
  - Head End A
  - Head End B
  - Head End N
- Data Center Message Bus

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SGIP’s OpenFMB Framework Life Cycle

- **Business Case**
  - Business-driven solutions

- **Use Case**
  - Profile of applicable, existing data model

- **UML**
  - Common software definitions and language

- **XSD and IDL**
  - Software tools to allow actors to interoperate

- **Apps and Adapters**
  - System integration and validation testing

- **Test and Field**
  - Updates and versioning

- **Maintenance**

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OpenFMB: SGIP Guiding Principles

• Agile and Evolving Architecture
  – No “one-size-fits-all” technology for DERs with existing T&D
  – Any Common Data Model with Any IoT Pub/Sub Protocol

• No reinventing wheel / No duplicating of standards effort

• Focus on quickly business value by solving real problems
• Flexibility, scalability, & backward-compatibility are critical
• Security & configuration built-in at the start
SGIP OpenFMB Microgrid Use-Case Cartoon

https://www.youtube.com/watch?v=QlcPN4ps9jY
Duke Energy Microgrid Test Site: Mount Holly, NC

- PV Installations
- Islanding Switch
- Battery & Load-bank
- Behind the meter and control room
- Grid Equipment
Mount Holly Microgrid Components

- 250kW/250kWh Battery Energy Storage System
- Padmount Recloser
- 1200A Disconnect
- 1000kVA Transformer
- Secondary Cabinet
- 275kVA Step-up Transformer
- 75kVA Transformer
- Meter Structure

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Mount Holly Microgrid Components, Cont.
Mount Holly IT Infrastructure

Verizon 4G LTE Small-Cell Base Station

Internet of Things OT User Interfaces
Key Lessons Learned

- Some technologies did not initially produce information to run distributed applications
- Distributed control sequences need to be choreographed to reflect latencies of communications and applications
- Microgrid operations require more precise performance
  - Time accuracy and synchronization are paramount
  - Granular and accurate sensor data is critical
- Most hardware challenges were resolved with OpenFMB
- Our partner’s skills and insights refined our final solution
Why is the OpenFMB Important for Duke Energy?

• **Accuracy**: Provides accurate control and alleviates intermittency of distributed energy resources

• **Scalability**: Provides the ability to scale independently, as needed, without needing a system wide rollout

• **Reduce Costs**: Takes cost out of the business by reducing integration time and effort

• **Security**: A distributed grid is more resilient and can be made more secure

• **Forefront**: Allows Duke to be at the forefront of developing new regulations and policies
Thank you!