THE FAN
AN INTRODUCTION TO FIELD AREA NETWORKS

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PRESENTATION AGENDA

• Introduction
• Building the Next Generation Network
• Field Area Network Technology
• Current Status of the Project
• Q&A
INTRODUCTION
A **Field Area Network (FAN)** provides connectivity to a large number of devices spread throughout a given geographic area.

**What is a “FAN”?**

Usually, Field Area Networks:

- Are enabled with wireless technologies to maximize “reach”.
- Offer Ethernet and IP connectivity to endpoints.
- Enable bi-directional data flows with various classes and quality of service (QoS) options.
• Both an internal (Xcel) visioning paper and Accenture’s 2012 Network Strategy Study identified the need for a comprehensive Field Area Network.
• The FAN Team was established in 2013.
• The FAN Limited Deployment Project
  – Goal is to Prove Out Technology and Process for Full Scale FAN Deployment
  – Team Recommended Two-Tier Solution
  – Phases of the Limited Deployment:
    • Demonstration
    • Bench Test
    • Integration Test
    • Deployment
    • Evaluation
• Existing “FANs” are disparate and purpose-built.
• Field devices requiring communication are increasing year-over-year.
• Equipment exists that would benefit from (but does not require) connectivity.
• Several upcoming applications will require substantial investment in field communications.
  – Advanced Distribution Management System (ADMS), Integrated Volt-Var Optimization (IVVO), Distribution Voltage Optimization (DVO)
• Current “standard” for connecting field devices is cellular modems.
• Advanced Metering Infrastructure (AMI) is being investigated for broader deployment across the company.
  – Desire to increase functionality at the meter beyond simple reads.
• Meter Reading contracts with 3rd parties are soon expiring.
1. Leverage Xcel Energy-Owned Backbone where possible.

2. Leverage Xcel Energy-Owned property, towers, and building assets for radio coverage where possible.

3. Design to capitalize equipment where Xcel Energy has full control of use, operations, and maintenance of the facility and equipment.

4. Unify equipment and service across the Operating Companies.

5. Follow and embrace industry standards for all tiers of network.
   – Deploy equipment that interoperates with other 3rd party equipment.

6. Carefully integrate and coordinate network control and monitoring systems.
1. Meet the necessary technical and operational requirements of all anticipated applications and traffic flows.
   – This includes, but is not limited to; bandwidth, packet loss, latency, and jitter.

2. Maintain a simplified architecture that minimizes equipment and services.

3. Employ a flexible architecture that can grow and evolve to meet ever-changing requirements from both the applications and the technological environment.

4. Optimize equipment utility by embracing advanced technologies.
   – Software defined radios, cognitive radios, link adaptation.

5. Design with expectation of change of wireless technology.

6. Be compliant to regulations, known and expected.

7. Consider and include security components in all aspects and tiers of FAN networking.
• A Far Reaching Network Capable of Deliver Wide Area Connectivity to Field Devices.

• Flexible Network Which Streamlines Process of Adding Additional Devices

• Helps Xcel Energy to Meet Strategic Goals:
  – *Increased customer satisfaction through increased service reliability*
  – *Increased service performance*
  – *Increased internal efficiencies through enhanced monitoring, control, and grid modernization.*

• Provides Means to Enable:
  – *Enhanced in-field performance monitoring (AMI, SCADA monitoring)*
  – *Enhanced switching options (switchgear, reclosers, IntelliTeam)*
  – *Improved control and performance mechanisms (IVVO, DVO)*
  – *Enhanced monitoring and response (ADMS)*
PRIMARY XCEL ENERGY SITES

Control Centers

Substations

Service Centers

Generating Stations

Offices
BUILDING THE BACKBONE

High-Capacity Backbone

Lower Capacity Access Ring
THE FIELD AREA NETWORK

High-Capacity Backbone

Lower Capacity Access Ring

Lower Capacity Access Ring
THE FIELD AREA NETWORK
FIELD AREA NETWORK TECHNOLOGY
WHAT IS MESH NETWORKING?

- **Take-Out Node (Access Point)**
- **End-Point Node (DA, Meter, etc)**
- **Relay Node (Repeater => Router)**
• IEEE 802.15.4 – “Low Rate Wireless Personal Area Networks”
  – 802.15.4g – “PHY Amendment for Smart Utility Networking (SUN)”
  – Wi-SUN Alliance

• Enables device-to-device and device-to-headend communication.

• Operates in ISM 900 MHz Band

• IPv6 Addressed Nodes

• Mesh Cluster is approximately ½ Mile Radius
  – Up to 5000 devices per cluster.

• Extensive Certificate-based authentication and Over-the-Air (OTA) encryption techniques.

• Network is easily expandable.
WHAT DOES THIS STUFF LOOK LIKE?
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Mesh-enabled Meters

Mesh Bridge

Mesh Repeater
POINT-TO-MULTIPOINT

Base Station

Sector Antenna

Needed Coverage

Sector Coverage

f1

f2

f3
• Worldwide Interoperability for Microwave Access
  — Interoperable implementation of standards from IEEE 802.16 — “Working Group on Broadband Wireless Access Standards”

• Cellular Data
  — 4G Mobile Broadband Technology
  — Defined Data Rates up to 100MBps Mobile, 1GBps fixed.

• Utilizes the 3.65GHz “Lightly Licensed Band”
  — Consumers are not allowed in this band.
  — Interference management falls to users, not FCC.
  — With max EIRP, Base Stations Cover Approx. 3-5 Mile Radius Fixed, 1-2 Mobile

• Spectrally Efficient and Operationally Robust
  — MIMO, AAS, OFDMA, QAM, FFR

• Customer Premise Equipment (CPE) is of Small-Form Factor
WHAT DOES THIS STUFF LOOK LIKE?
TECHNOLOGY COMPARISON

**WiMAX Point-to-Multipoint**
- Higher Bandwidth (>1.5Mbps)
- Lower Latency (<100ms)
- LoS; Links Must Be Engineered
- Height!!!
- Requires Additional Backup Connection

- Summation:
  - Best used for low-latency or high bandwidth applications.

**WiSUN Mesh**
- Lower Bandwidth (<300kbps)
- Higher Latency (>1s)
- Omni; Simplified Deployment
- Minimal Height Required
- Individual Devices Share Cluster’s Backup Connection

- Summation:
  - Best used for reporting-only or latency-tolerant applications.
LIMITED DEPLOYMENT SCOPE

- 3 WiMAX Base Stations
- 1 WiMAX Repeater
- 40 WiMAX Endpoints
- 2 P2P Ethernet Extensions
- 500 AMI Mesh Meters
- 20 Mesh Endpoints
- Street Lighting Connection
- Fiber Optic Backhaul
- Operational Applications
Current Progress
• Passed traffic back and forth from machine, through WiMAX, into Mesh, and onto another machine. This validated our architecture.
• Demonstrated traffic separation via VLANs across WiMAX and WiMAX’s ability to pass on VLAN tags.
• Implemented a simple QoS structure on WiMAX to prove prioritization utilizing one High Priority and one Low Priority queue; showed that High Priority will maintain low-latency characteristics even when the Low Priority queue is saturated with traffic.
• Verified performance of Mesh RF link across multiple hops.
• Successfully configured additional vendor CPEs to interoperate

Next Steps
• Quantify impacts on performance from signal attenuation, adjacent-channel interference, and noise.
• Test Security mechanisms to ensure over-the-air encryption.
THANK YOU