How to Navigate the Backbone Telecommunications Fiber Versus Microwave Business Case Decision Tree
A Case Study of Dakota Electric Association

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About the Presenter: Craig has worked for several utilities, in both distribution and transmission operations and planning. He has worked at IOU’s, G&T’s and distribution cooperatives. His experience has been with many areas in both Transmission and Distribution. He has worked on transmission planning and operations areas and distribution SCADA, protection, maintenance and substation design. He is graduate of the University of Minnesota in electrical engineering and a professional engineer in the State of Minnesota.
About the Presenter: Charles currently leads a team of communication experts facilitating the strategic planning, evaluation, procurement, and deployment of mission critical communications infrastructure for PSE utility clients following smart grid technology roadmaps. He has been working in the electrical utility industry for over 20 years in various communications and application technologies. Mr. Plummer earned a Bachelor of Science degree in Electrical Engineering from the University of Wisconsin - Madison.
Session Objectives

• Discuss the drivers that make utilities consider new private backbone communications for their field assets.

• Learn the basics of fiber optics terminology, technology and standards.

• Learn the latest microwave technology trends.

• Discuss a case study of a strategic communications study at Dakota Electric Association and their technology decisions.

• Understand the economics and tradeoffs of installing fiber versus leasing dark fiber.

• Determine a method to navigate the business case decision tree comparing fiber to microwave technologies.
Private Utility Communication
System Drivers
Current Trends in Commercial TELCO Services

• Commercial frame relay and T1 circuits are going away
  – It is hard to find tech support for these services

• Dedicated Telco copper lines are going away
  – One utility reported $20k/year lease costs last year

• Telephone companies are not maintaining copper plant
  – Connections to home not replaced after the Super-storm Sandy
    • Homes given wireless modems to connect to phone network
  – Phone companies are asking regulators to be allowed to abandon copper phone plant
TDM Equipment Vendor Facts

- Ethernet is the overwhelming standard for communications worldwide in almost all industries.
- The equipment vendor pool for TDM equipment is shrinking every day.
- It has become difficult to buy computers with serial ports.
- There are rarely any new greenfield TDM backbone communications systems being deployed outside of the electrical utility industry.
- The Electrical Utility Industry does not control the communication vendors’ decisions in what technologies to support for growth in their markets.
  - IP is coming to your OT networks if you like it or not.
Current Trends in Utility Communications

• Smart Grid initiatives are driving communications needs
  – More need for backbone communications across the service territory
  – Comm need has been driven by the deployment of wireless AMI, DA, and DG initiatives

• Licensed microwave costs have come down significantly
  – Now seeing microwave to substations as a affordable solution

• Private fiber to the substations is becoming much more common
  – Either as private fiber plant or as leased plant
Why Utilities are Considering Fiber or Microwave to Subs

• As frame relay and dedicated copper pairs are being eliminated by local Telco's, commercial bandwidth communication choices can have high OpEx costs
  – Utilities often doing strategic communications plans to unearth all options for replacement of the commercial services
  – Relay protection still using circuit-switched technologies. This will need to be considered in any plans….for now

• Many utilities have been adding OPGW fiber to transmission lines as they are being rebuilt so fiber plant may be available for leveraging plant costs

• Often local 3rd party dark fiber options are available within your territory
The Substation PMP Wireless Communications Dilemma

- Substations have become a network node for utilities:
  - Traditional SCADA Communications
  - Take-out points for PLC and wireless AMI and DA masters
  - Utilities are interested in remote access to IEDs for event data analysis and metrics
  - Often a hot-spot for mobile data exchange and enterprise services
  - Streaming video for security monitoring
    - This can be the needle mover to drive bandwidth needs at subs well beyond the typical Kbps limit of PTMP radios
  - Relay protection is difficult to impossible using PMP radios
  - Substation bandwidth requirements can reach higher than one Mbps
Why Utilities are Considering Fiber or Microwave to Subs

- Substation communication bandwidth needs are becoming difficult for point-to-multipoint radio communications.
- If a utility wants a private network for substation communications, these applications often require point-to-point technologies.
Fiber Optics Primer
Fiber Optics Benefits

• Fiber Optics is often viewed as the best communications media for utilities:
  – Most utilities would put in fiber nearly everywhere if costs were not an issue.
  – Fiber is immune to ground potential rise and EMI.
  – Very long life cycle
    • 30-40+ years for fiber plant.
  – Bandwidth currently easily 40 Gbps using a single wavelength and growing
Fiber Cable Types & Features

• Common cable types for utilities:
  – OPGW = Optical Ground Wire
  – ADSS = All-Dielectric Self-Supporting
  – Lashed = Fiber is lashed to a carrier wire in the communications space

• Cable features:
  – Armor – none, single, double, triple
  – Gel-filled or gel-free
  – Loose-tube or ribbon cable
Fiber Cable Pathway Construction Methods

**Aerial:** Electric space

- **OPGW**
  - Incremental costs of $10,000/mile when constructing or re-conductor upgrade
  - $5,000 incremental for OPGW vs. static + $5,000 labor and hardware
  - $50k/mile or more if retrofitting

- **Distribution lines – ADSS or lashed**
  - 5,000 - $30,000 per cable mile depending on make ready needs

**Buried:** Trenched or directional bored

- In conduit or direct buried
- $15,000 - $100,000 depending if rural or urban, percent trenched vs. bored, etc.
Wave Division Multiplexing (WDM) Scalability

- Multiple optical carrier signals on single strand of fiber using different light wavelengths (or lambdas)
  - Analogous to frequency division multiplexing on radios

- Coarse WDM (CWDM) uses up to 18 defined channels from 1270 nm to 1610 nm

- Dense WDM (DWDM) uses 40 channels or more
  - Heading towards 100 lambdas
Private Fiber Optic Network Options

• Build a private fiber network taking advantage of utility transmission and distribution right-of-ways
  – You may be require updating easements for communications

• Long-term dark fiber lease:
  – IRU (indefeasible right of use) for 20 years for example
  – Typically paid in a lump lease sum (CapEx) plus annual operating and maintenance expenses
  – Priced per strand mile ($1,000 to $4,000 typical)
  – Harder to find, telecom providers preferring selling “lit” services

• Wavelength IRU (fiber capacity lease)
  – Exclusive use of a wavelength on third-party fiber plant
  – Typically for shorter lease periods
  – Requires network to support DWDM technology
Identify Potential Fiber Partners in your Territory

• Share costs, lease existing fiber, trade fiber miles
• Public-Private Partnerships, State & Local Government
  – versus working individually
• Typical Fiber Potential Partners
  – Rural telephone cooperatives
  – Fiber transport providers
  – Winners of BB Grants
Microwave Technology Update
Microwave Costs Have Reduced Significantly

• Link costs have dropped over 50% in less than 10 years
  – Traditional carrier class TDM microwave companies have competition from TCP/IP microwave companies
  – Driven by the Telco move to VoIP technologies and data using packet-switched technologies
  – Native IP technologies have improved quality and native T1 capability
  – Now seeing licensed split-mount microwave link costs nearing unlicensed microwave link costs

• Licensed point-to-point microwave to the substation now can show a positive business case
  – Substation bandwidth needs are at awkward levels between point-to-multipoint radios and microwave
Microwave Costs Have Reduced Significantly

- IP-based communications allow for bandwidth efficiency
- Adaptive Modulation allows for a microwave design culture change
  - Allows for smaller dishes on towers and still have great link reliability
  - Tower loading is greatly reduced. Towers still can be expensive.
  - FCC approved this feature for licensed microwave in the last couple of years
  - Would not be possible if using circuit-switched technology only - the circuit would collapse due to timing synching errors
Adaptive Modulation Link Budget Design Concept

• Can now design link for bandwidth not fade margin
  – Dish sized for sunny weather reliability target
  – Dish does not need to be sized for worst case weather scenario
  – As weather issues occur, link throttles down modulation (bandwidth) to maintain link reliability
Adaptive Modulation with Ethernet and TDM

TDM interfaces, when enabled, always have higher priority than Ethernet
Why is Microwave Dish Size So Important?

Licensed Microwave Cost Breakdown

- Antenna, Mount, Feed Line, etc. 13%
- System Engineering 10%
- 6 GHz OC-3 Microwave Equipment 7%
- 100' tower - Installed 52%
- Towers are often over 50% of link costs
- 10’ tower - Installed 30%
- Antenna & Feed Line Installation 3%
- Acceptance Testing 3%
- Licensing 3%
- Path Alignments 3%
- Project Mgmt 3%
- Design & Procurement 3%
Dakota Electric Association
Strategic Communications Plan
Case Study
About Dakota Electric Association (DEA)

• DEA is a distribution cooperative headquartered in Farmington, Minnesota.

• It was founded in 1937 by a group of farmers

• DEA is located southeast of Minneapolis / St. Paul

• Service area is both suburban and rural and covers 500 sq. miles

• Over 103,000 members and 200 employees, with 500 MW peak
DEA is a combination of:

1/3 heavily populated urban/suburban territory

2/3 rural locations in the southern portion of the territory.
Dakota Electric SCADA & Load Management

• All of our substations are SCADA monitored
• Over 125 Member owned generators are SCADA Controlled (>100MW’s of load control with gens)
• 55,000 Load Control Receivers
• About 20% of load is controlled at billing peak!!
• Also many down-line remote controlled devices
  – Regulators
  – Air Break Switches
  – Auto-transfer PMH’s

• THERE IS A LOT RIDING ON
  THE COMMUNICATION SYSTEM!
Control of the 100 MW of member-owned generators is extremely critical.

DEA also has over 55k LM switches in service.
Current iNet backbone radio system

- Star Configuration (Headquarters is the hub)
- Many single points of failure where we can lose communication to several substations and MAS radios.
- Looking to add more applications to the communication system
- It works very well but……..

- We needed a long range plan!
DEA Strategic Communications Plan

• In 2014, DEA commissioned PSE to complete a Strategic Communications Plan (SCP) to help determine the following:
  
  – How to replace an aging iNet radio backbone system with a more robust system to communicate between the office and substations.
    • Backbone is bandwidth limited.
    • iNet radios are nearing end of life announcement from manufacturer
    • Backbone also backhauls several MAS radio networks that control a many customer owned generators used for load shaving.
  
  – How to plan for future planned AMI, DA and LM initiatives
    • Determine bandwidth requirements for the backbone to accommodate the addition of these new applications and others
    • Look at possible wireless technologies to backhaul feeder located assets to the new backbone
  
  – Review the risks of other private and commercial communication systems currently used by DEA
Basic Steps Taken for the SCP

- Current State of the Utility Systems
- Requirements Gathering for Future Applications
- Bandwidth Requirements by Tier Development
- Gap Analysis of Present to Future State
- Build GIS database with utility assets for Analysis
- Create Several Solution Alternatives for each Tier
- Solution Refinement Stage – Focusing on Chosen Alternatives
- Deployment Roadmap by Years and Budget
- Today we are going to discuss the Tier 1 Backbone Solution Alternatives and Final Solution Choice
Backbone Solution Requirements

• DEA wants more bandwidth to the substations than current point-to-multipoint radio technologies can provide.

• The Requirements Analysis determined that DEA has two technology options moving forward:
  – Microwave Point-to-point radios
  – Fiber Plant
  – Or a combination of the both

• Good news was that we discovered that there is a fair amount of dark fiber available in the DEA territory
  – Great River Energy and Xcel Energy (Transmission Shield Wire OPGW)
  – Local Commercial Fiber Leases through Zayo or Arvig
  – The Dakota County and State Governments have a lot of installed fiber
Some Discovered Installed Fiber in DEA’s Territory

Installed dark fiber runs near a majority of the DEA substations.

Some solution options are shown in the following slides.
Option 1: GRE/DEA Fiber Solution Alternative for Tier 1

Use OPGW fiber currently installed by GRE

DEA installing the rest of the fiber backbone on distribution lines or URD
Option 2: GRE/DEA Fiber Microwave Hybrid Solution

Use OPGW fiber currently installed by GRE DEA installing less fiber and completing backbone with microwave links in the southern part of the territory.
Option 3: GRE/DEA/County Fiber Solution for Tier 1

Use OPGW fiber currently installed by GRE

DEA partnering with the county, and DEA installing the rest of the fiber on distribution line laterals.
Final Solution Alternative Chosen by DEA

• After careful review of the costs, benefits and risk assessment, DEA decided to move forward with a partnership with Dakota County.
  – It was the lowest cost solution for Tier 1!

• There are some issues to resolve but we are currently negotiating a memorandum of understanding with the county.
  – Need to create maintenance agreement
  – Have to work through lateral fiber builds and each party’s wishes for lateral usage.

• Creating IP Network Topology right now as well
Building a Business Case to Compare Microwave to Fiber
Example Fiber Conceptual Design Process

Cost of fiber >> cost of microwave
Final Hybrid Fiber-Microwave Conceptual Design
Fiber vs Microwave vs Commercial Services Economics

- Compare cost of fiber to cost of private wireless and telecom bandwidth services.
  - Microwave equipment life ~ 10 years.
  - Towers similar to fiber infrastructure in life.
  - 20 year PV of upfront and recurring costs including equipment replacement.
- Evaluate each path to determine technology fit.
- Simplified cost example (replacing electronics after 10 years).

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<th>Microwave</th>
<th>Managed BW Services</th>
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<td>Towers</td>
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<th>Fiber</th>
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<td><strong>Distance that costs compare</strong></td>
<td><strong>4 miles</strong></td>
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<tr>
<td><strong>Total</strong></td>
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In this business case, fiber is the most economical solution up to 4 miles in distance.
Conclusions

• Many mainstay Telco TDM services are in sunset
  – Affected utilities should consider all of their options before moving forward with changes
  – Recommend doing a Strategic Communications Plan to confirm business cases for different communications technologies

• Private fiber and microwave may be viable backbone options
  – Costs are coming down significantly for microwave
  – Often local partnering for fiber plant is available
    • Dark fiber or wavelengths can be economical 3rd party fiber solutions

• DEA found a unique business partner during SCP

• When doing business cases remember fiber plant life cycle
  – There is not an apples-to-apples financial comparison between microwave and fiber
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Questions?