Building a Private IP/MPLS Network

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We Energies RF/Microwave Transport

• Responsible for getting data between sites
  – Microwave
  – Optical
  – TDM
  – Two-way radios
  – Paging
  – MAS
  – IP/MPLS
Our Start into IP/MPLS - 2013

• 33 site migration from SONET to IP/MPLS
  – Service Centers
  – Power Plants
  – Substations
  – Radio Towers
  – Underground Vaults
Why IP/MPLS?

• Future Proof
• Converged networks
  – TDM and IP with a common transport
• Migration Path from TDM to IP
• TDM path redundancy
• DS3, DS1, DS0
• We have a lot of TDM equipment
  – Channel Banks, DACS, Microwave, Radios, etc
• We have a lot of TDM circuits
  – Paging, Two-way, Ring Downs, RTUs, Relays
• End Devices may have a 10-30 year lifecycle
What is SCADA?

- Supervisory Control and Data Acquisition
- Industrial SNMP
- Monitor and Control Real Time Operations
  - Voltage, Amperage, Breaker Status, etc.
  - Head water and tail water
- Core function of a utility
RS232 SCADA

• **Pros**
  – Fewer ports needed on the master(s)
  – Multiple masters for redundancy

• **Cons**
  – Each circuit is a hard coded path
Migrating TDM to IP/MPLS Transport

**Pros**
- Only 1 bridge needed
- Circuits can take any network path
- Easy to add test ports on either remote or master side

**Cons**
- Still have Single Points of Failure
Redundant IP/MPLS SCADA Bridging

**Pros**
- Bridge Redundancy
- Pseudowire Redundancy
- Worked with the BERT Tester

**Cons**
- Complicated configuration
- Hard to troubleshoot
Where did it start going wrong?

- Hydro Plants
- RTU monitors head and tail water levels
- Control Center kept losing connectivity to 2 IP/MPLS connected hydro plants
- Dispatch Hydro Operations to plant to monitor water levels when RTU is down
Clocks
Adding clock source (PTP)
Error Report – Before and After Timing

RTU Down Before

RTU Down After
Hydro Plant RTU Issue Resolution

• No timing on intermediate nodes caused the TDM circuits to get out of sync
• Out of sync means traffic isn’t lining up properly
• This lead to the RTUs going down
• Once clock sources added on the intermediate nodes, issues went away
What other issues have we run into?
Lack of IP/MPLS and vendor knowledge

• We didn’t know IP/MPLS and how to implement it
• Didn’t understand the layering aspects
• Solutions:
  – Onsite vendor support
  – Training and studying
  – Lab
Lab

• Test services and configurations
• No Virtual TDM test equipment
MTU Issues

• Equipment couldn’t go above 1500 MTU
  – Microwave or MPLS Ethernet ports

• Solutions:
  – Lifecycle older radios
  – Use DS1s on the radios to connect IP/MPLS nodes
  – Test new transport equipment for compatibility
  – Replace Ethernet cards
Not a fun hike
Routing Issues
OSPF is great

- Original implementation was multi-area OSPF
Issues with this setup

- Even though we had multiple areas, there was no summarization between the areas.
- Multiple areas makes traffic engineering MPLS services much more difficult.
Expansion
More Substations
Another Round
(Can you see where we’re headed?)
Adding More sites
Can’t bring up some links
Options

• Create Virtual Links

• Move all routers to Area 0
  – Too many nodes to convert to OSPF Area 0 and too much downtime

• Use another IGP
Decision: IS-IS for the IGP

• Less preferred in Route Table than OSPF
• Scaling issues with OSPF (for our vendor)
  – 255 in an OSPF area vs 1024 in IS-IS
Plan to migrate to IS-IS

0. Let IT Security know that IS-IS is a routing protocol and you’re doing research
1. Configure IS-IS on all routers
2. Check IS-IS database to make sure routes are showing up properly
Plan Continued

3. Install nodes with only IS-IS
4. Shutdown OSPF on a handful of test/low impact nodes
5. Shutdown and remove OSPF everywhere
There’s so much room for connectivity
Results

• Minor outage per site
  – Dropped 0-4 pings per site
• No client/user impact
• Able to bring up links we couldn’t use
• Able to start using traffic engineering features
Emerging IP/MPLS Use Cases for Utilities
Emerging Services

- IP Based
- SCADA over IP
- Root Cause Analysis for substation events
More Emerging Services

• Distribution Automation
• Increased safety and reliability for employees and customers
What we learned

• Automate configuration generation
• Clock Synchronization is important for TDM services
• Don’t limit yourself with routing protocol choices
• Work with the business units
• IP/MPLS doesn’t work everywhere
Issues we’re still dealing with

• TDM over MPLS over IP radio
• Node/Circuit/Service Documentation
  – IP/MPLS and TDM transport mix
  – Capacity planning
• Training and getting people more comfortable with IP/MPLS
Our IP/MPLS Future

• More expansion
• More clocks
• More redundant paths
• Start retiring TDM circuits
Thank you! Questions?