



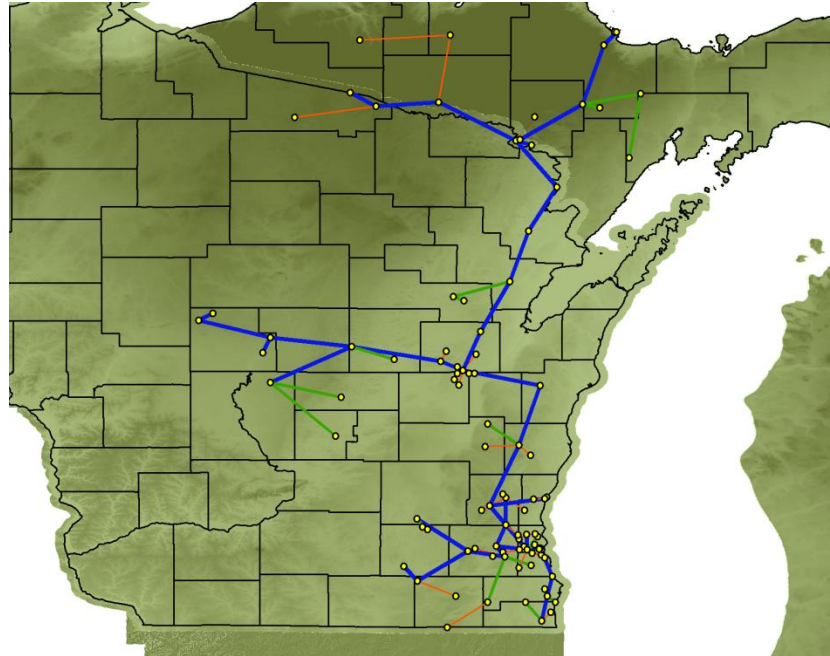
Building a Private IP/MPLS Network

Nathan Gotz <nathan.gotz@we-energies.com>

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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

TDM

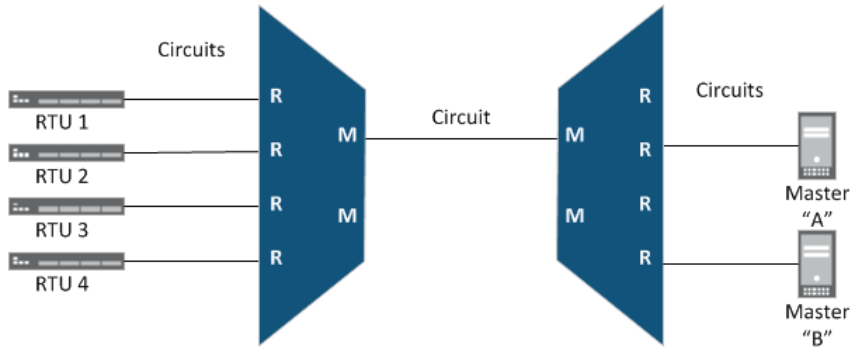
- DS3, DS1, DS0
- We have a lot of TDM equipment
 - Channel Banks, DACS, Microwave, Radios, etc
- We have a lot of TDM circuits
 - Paging, Two-way, Ring Downs, RTUs, Relays
- End Devices may have a 10-30 year lifecycle

SCADA Bridging

What is SCADA?

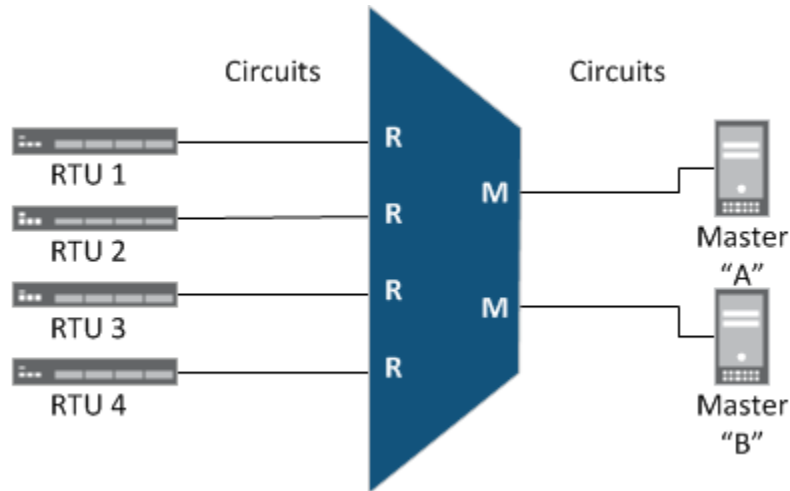
- Supervisory Control and Data Acquisition
- Industrial SNMP
- Monitor and Control Real Time Operations
 - Voltage, Amperage, Breaker Status, etc.
 - Head water and tail water
- Core function of a utility

RS232 SCADA



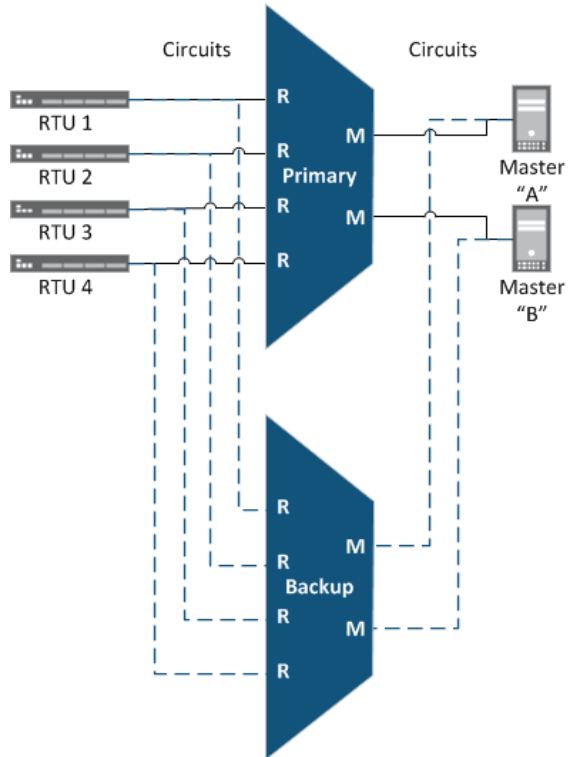
- Pros
 - Fewer ports needed on the master(s)
 - Multiple masters for redundancy
- Cons
 - Each circuit is a hard coded path

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

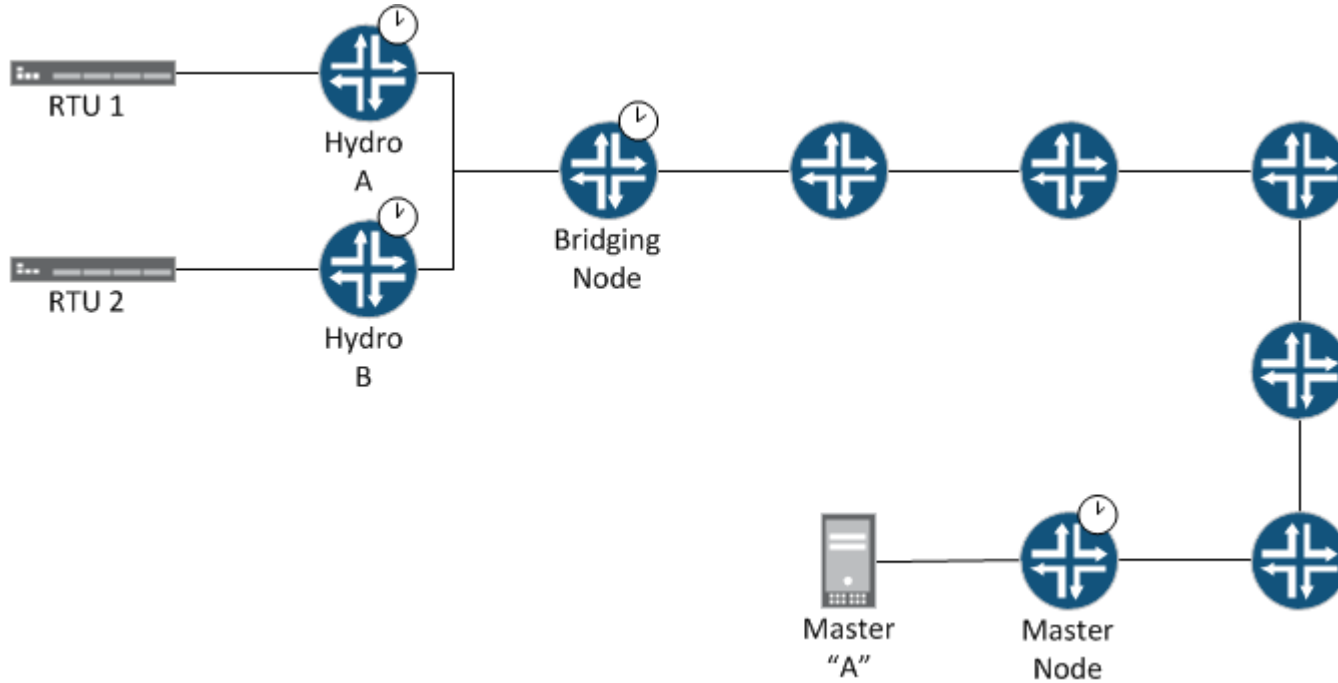


- Pros
 - Bridge Redundancy
 - Pseudowire Redundancy
 - Worked with the BERT Tester
- Cons
 - Complicated configuration
 - Hard to troubleshoot

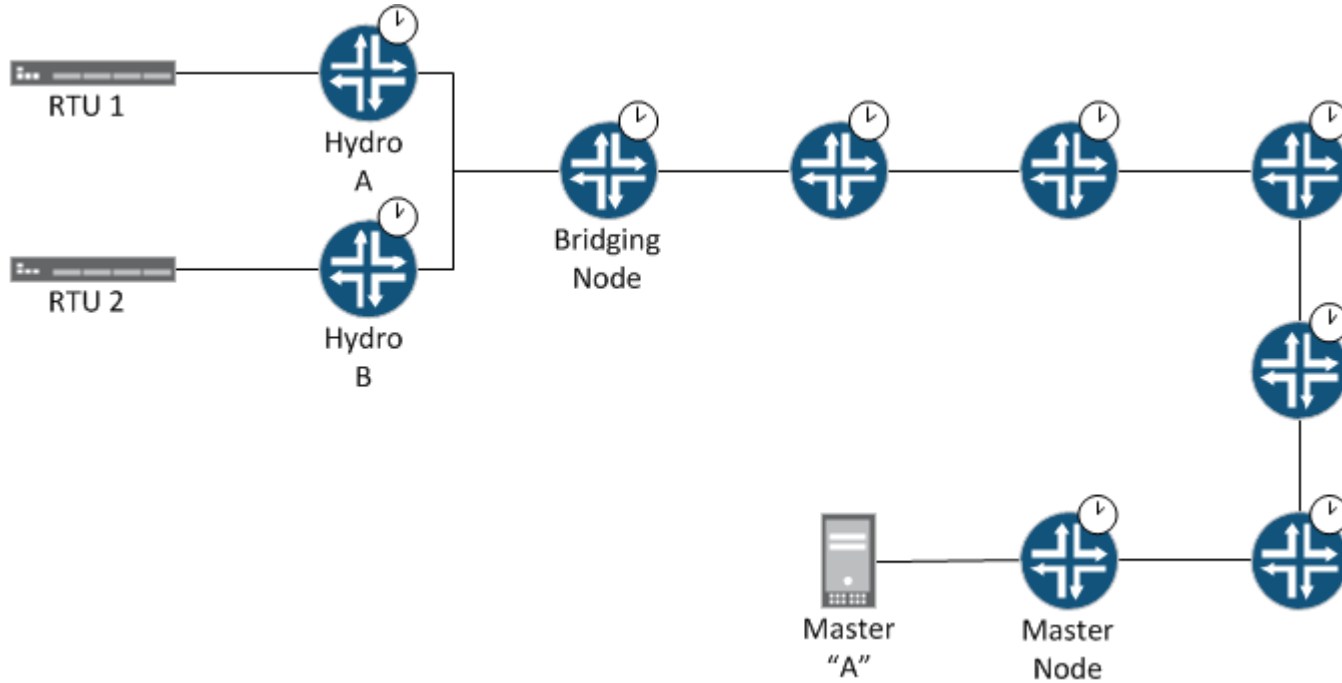
Where did it start going wrong?

- 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

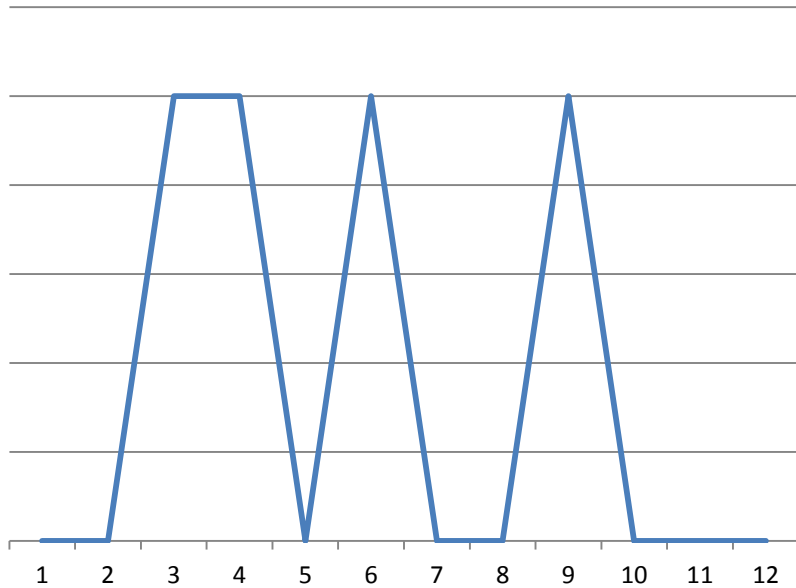


Adding clock source (PTP)

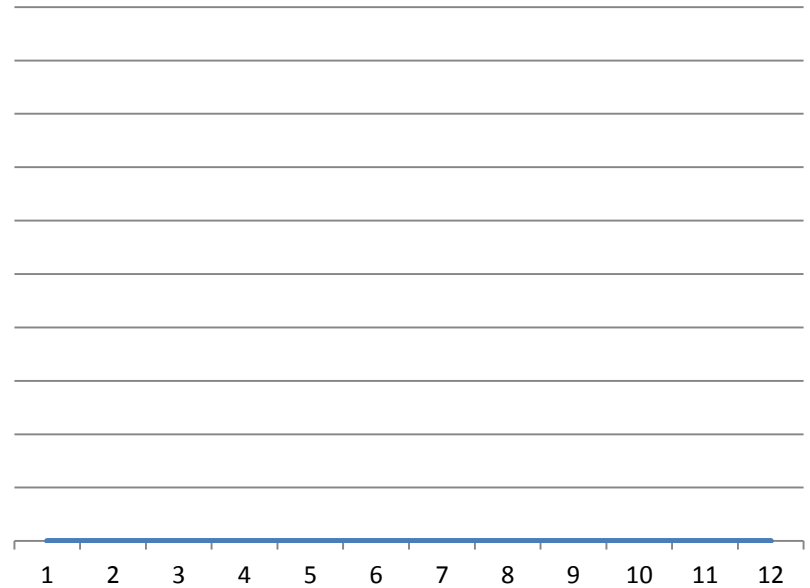


Error Report – Before and After Timing

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

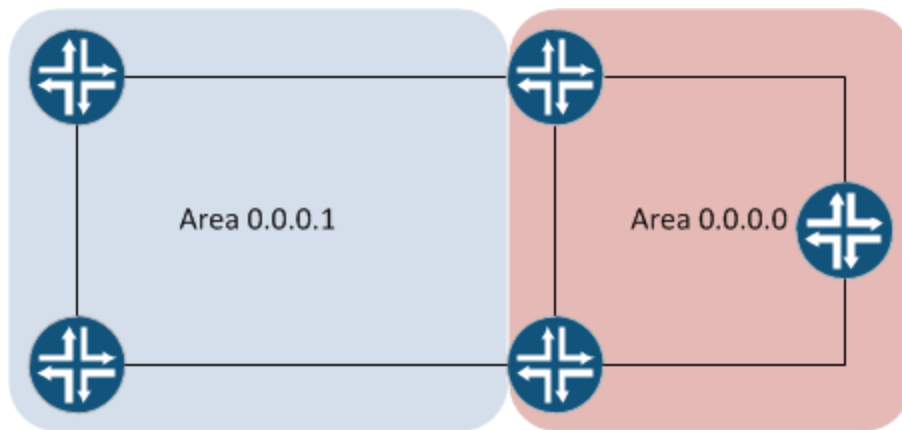
Not a fun hike



Routing Issues

OSPF is great

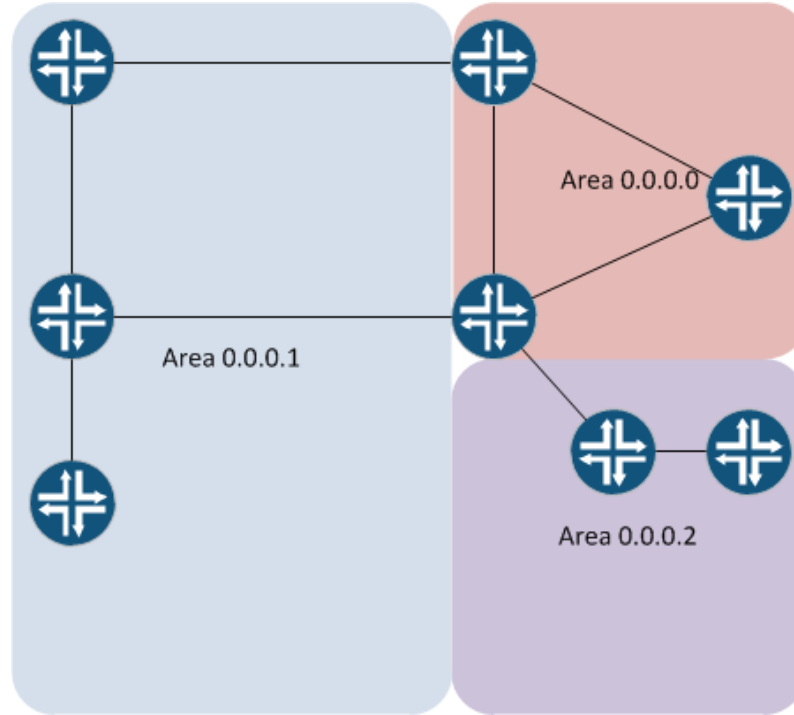
- Original implementation was multi-area OSPF



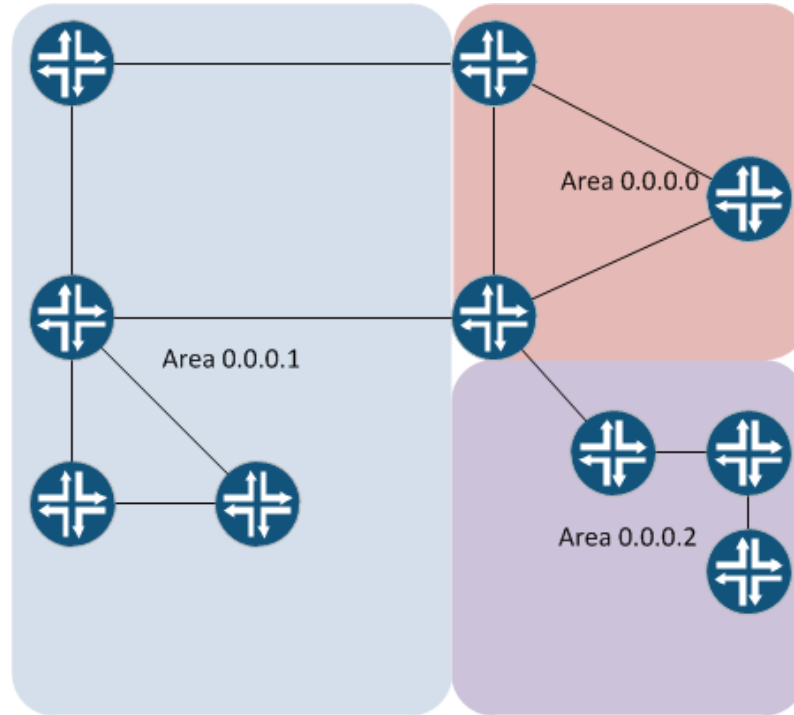
Issues with this setup

- Even though we had multiple areas, there was no summarization between the areas
- Multiple areas makes traffic engineering MPLS services much more difficult

Expansion

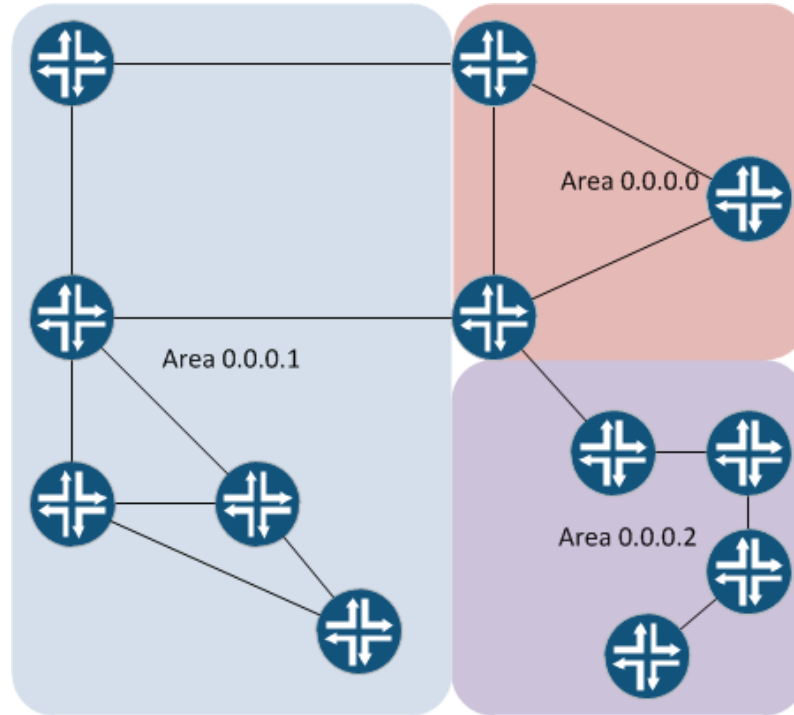


More Substations

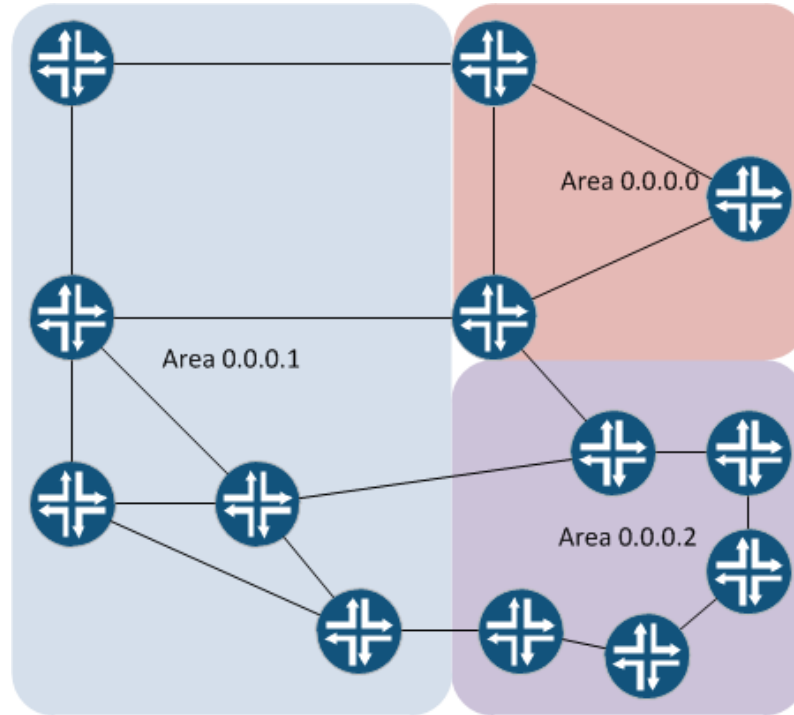


Another Round

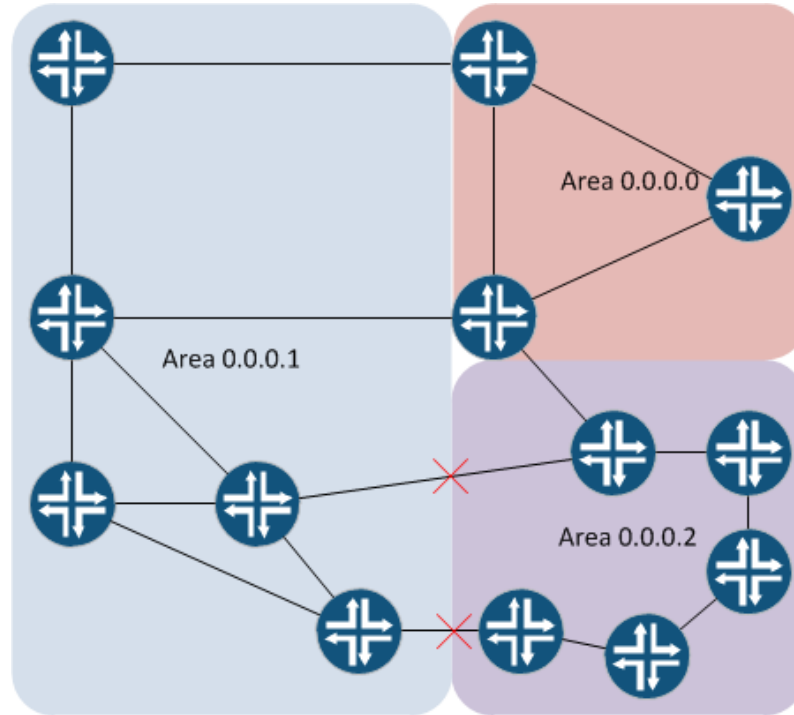
(Can you see where we're headed?)



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

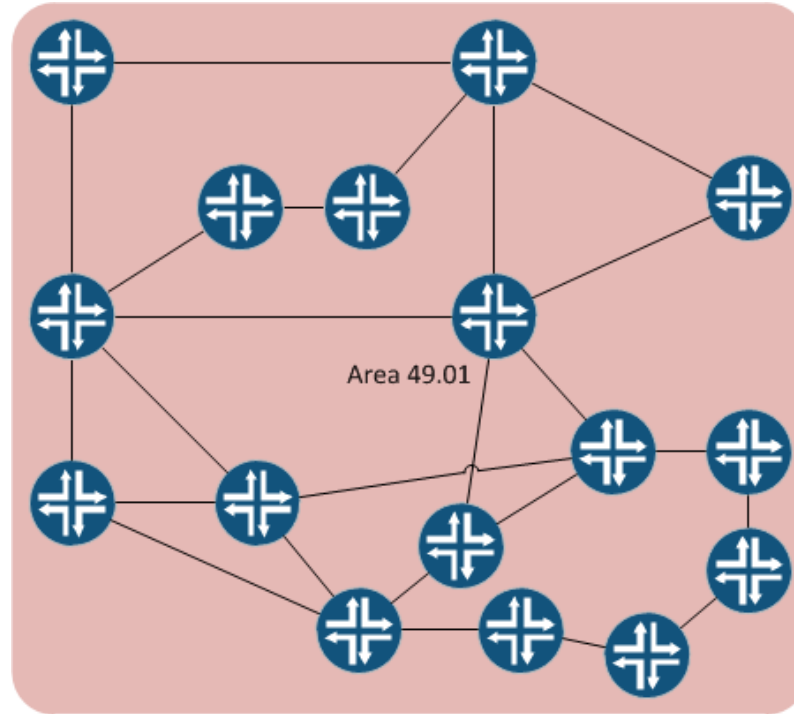
Plan to migrate to IS-IS

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?