Foresight is 2020
NDOT building an ITS Network for the next Decade and Beyond

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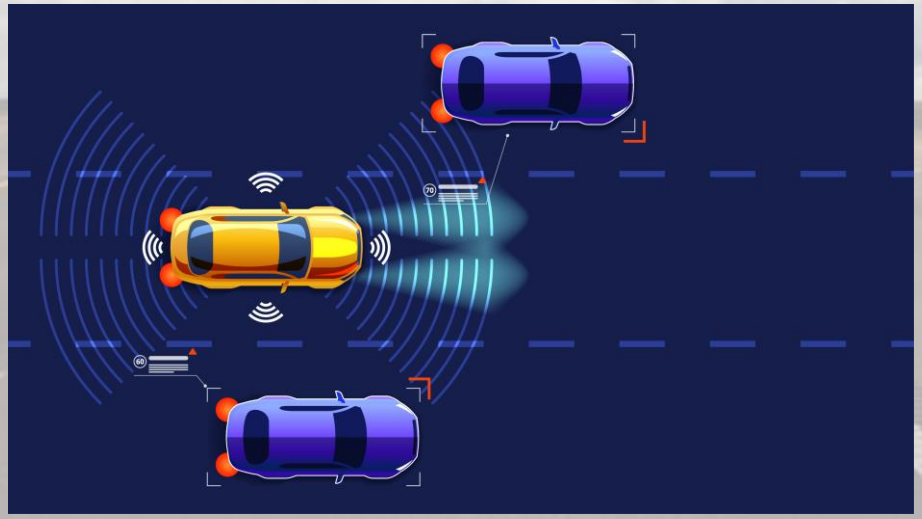
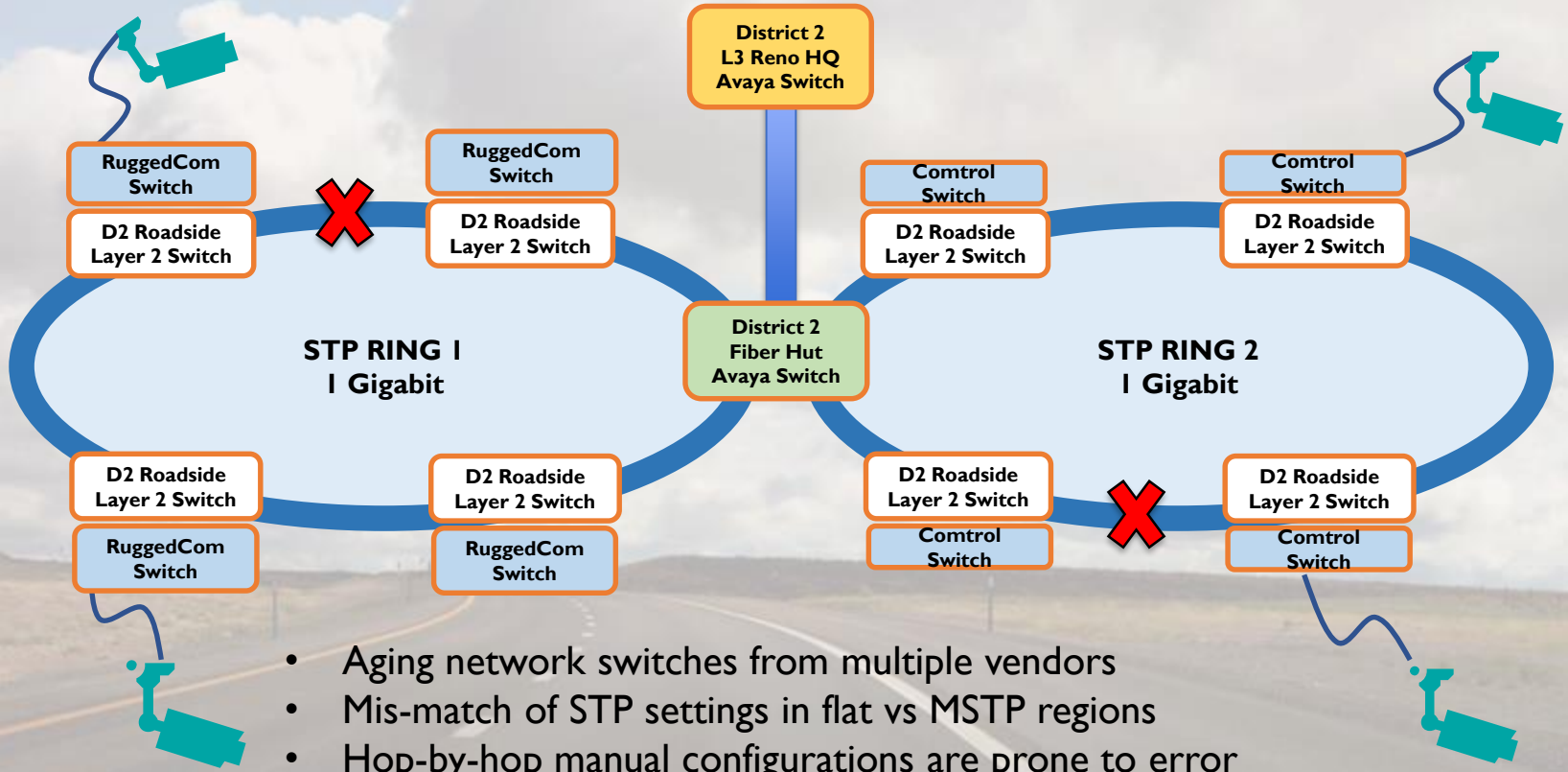
Vision for a Connected Future

Lay the foundations for NDoT's next-generation Intelligent Transportation System (ITS), making it easier to connect and manage the growing mesh of Internet of Things (IoT) devices on the state's highways



Dated Network Infrastructure



- Aging network switches from multiple vendors
- Mis-match of STP settings in flat vs MSTP regions
- Hop-by-hop manual configurations are prone to error
- Power/Fiber Physical error events cause network flooding
- Inefficient IGMP snooping causing poor video quality
- High convergence time
- Limitation of 4096 VLAN IDs

Background

- Shortest Path Bridging (SPB IEE 802.1aq) was introduced to the NDOT IT Network Group & Traffic Operations Technology Section (TOTS) in 2012.
  - SPB features of interest to NDOT
    - Elimination of Spanning Tree (STP)
    - Ease of management for small network teams on each side
      - IT Network Group consisted of 3 Network Engineers and 1 Supervisor
      - TOTS consisted of 1 ITS Technical Planner, 1Network/Microwave Technician and 1 Network Manager.
    - Multi-tenant support
      - Ability to provide transparent transport for IT and other partner agencies
    - Rapid deployment of edge services to keep up with emerging needs

Background

- Conducted and completed comparison of vendors supporting SPB.
  - In 2013 Avaya & Alcatel Lucent Enterprise (ALE) were the only two vendors which supported SPB. The review was conducted by both IT and Traffic Operations personnel.
  - Review of Avaya found:
    - Avaya had no hardened switch to push SPB to the edge. This means Spanning Tree would not be eliminated and failover issues would continue.
    - Avaya implemented a proprietary mechanism which modifies the standard operations of IP multicast. Because of the proprietary mechanism Avaya is not compatible with ALE SPB switches, this is more impactful to users committed to an open architecture.
    - Avaya uses several Operating Systems (OS) to manage their complement of switching and routing equipment. This means more code versions to maintain and differing CLI command syntax to learn and master.

Background

- Review of ALE:
  - Supports both hardened and non-hardened switches.
  - Fully supports 802.1aq which is less impactful to users committed to an open architecture.
  - One OS for all switching and routing equipment in the OS6000 series.
  - Compatible with other vendors who support 802.1aq with no modifications.

❖ Dealing with internal opposition

- 2014, review results were shared with IT and TO Management.
- IT Network Manager & Chief IT Manager approve purchase of ALE Equipment for Traffic Ops use.
- IT Network Manager & Chief IT Manager then disapprove purchase of ALE Equipment.
  - IT proposed a SPB solution using Avaya equipment and proposed to meet TO requirements.
- 2014 Traffic Operation Management accepted IT's proposal and project kickoff started in fall of 2014.

Background

- 2017 TO & IT close SPB project
  - IT did not meet requirements
    - Spanning Tree was not eliminated
    - SPB was not pushed to the edge
    - Proprietary system was installed using Avaya equipment
      - Avaya SPB implementation prevented the interoperability of their equipment with ruggedized ALE SPB equipment.
    - No hardened SPB-capable switches were identified which could interoperate with Avaya SPB

❖ Implementing the correct solution

- 2017 TOTS informed IT that they would move to their own network using ALE equipment throughout.
- June 2018 using ALE professional services TOTS kicked off the SPB Upgrade Project
- February 2019, ALE SPB Upgrade Project completed.
  - 221 switches installed including non-hardened and hardened switches
  - 802.1aq (no modifications) pushed to the cabinet level


Search for a Solution

ITS Network Requirements

Eliminate STP

- Using IEEE 802.1aq SPB-M end-to-end
- Provide end-to-end Layer 2 services throughout
- Bring regional VLANs directly to ITS Network Engineers desks for testing and troubleshooting purposes

Provide backward compatible with the legacy network

- IP Multicast Applications
- Legacy PIM routers

Multi-tenancy

- Enable edge-only provisioning
- Provide Layer 2 services for various departments / entities – T Uni
- Provide Layer 3 VPN services to various departments / entities

PoE everywhere

- Provide 802.3af and 802.3at PoE and PoE+ in all locations
- Allow for High Power PoE on multiple ports in all locations

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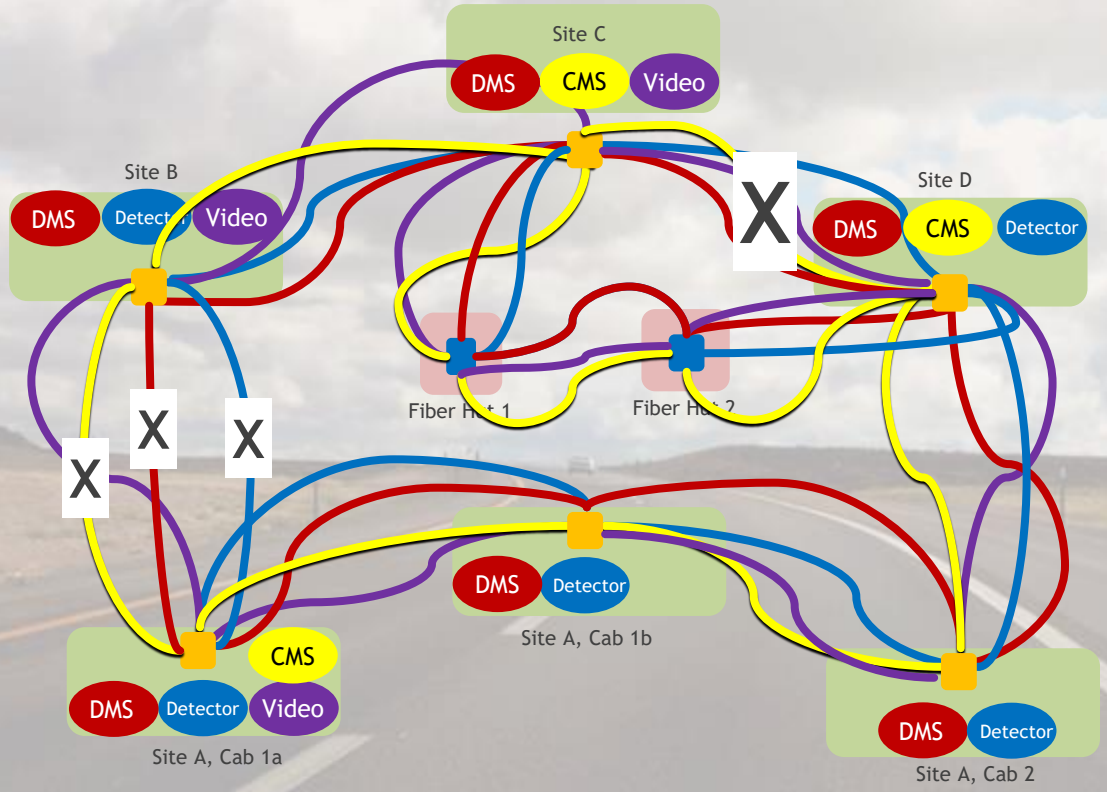
Why SPB?

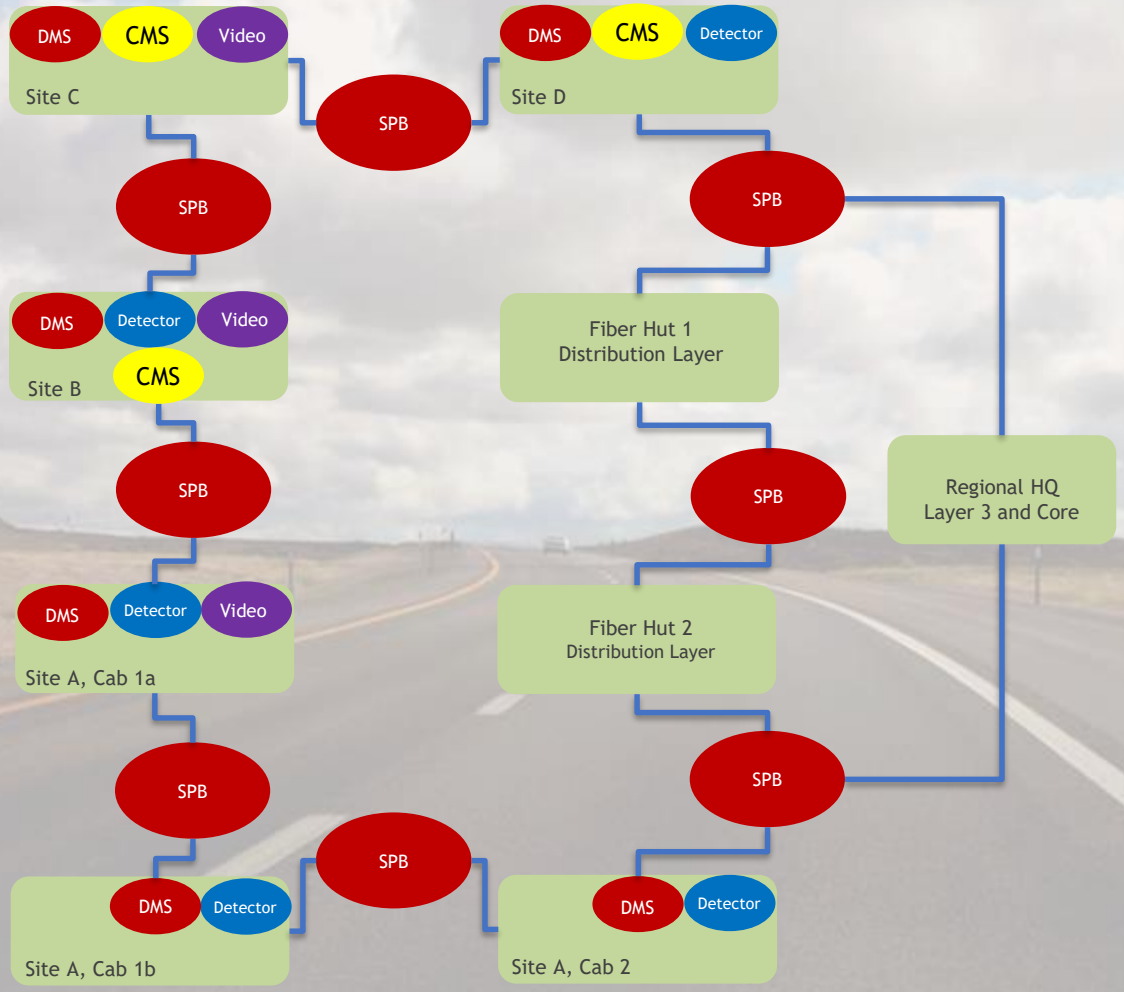
Traditional VLAN Delivery



STP/RSTP/MSTP

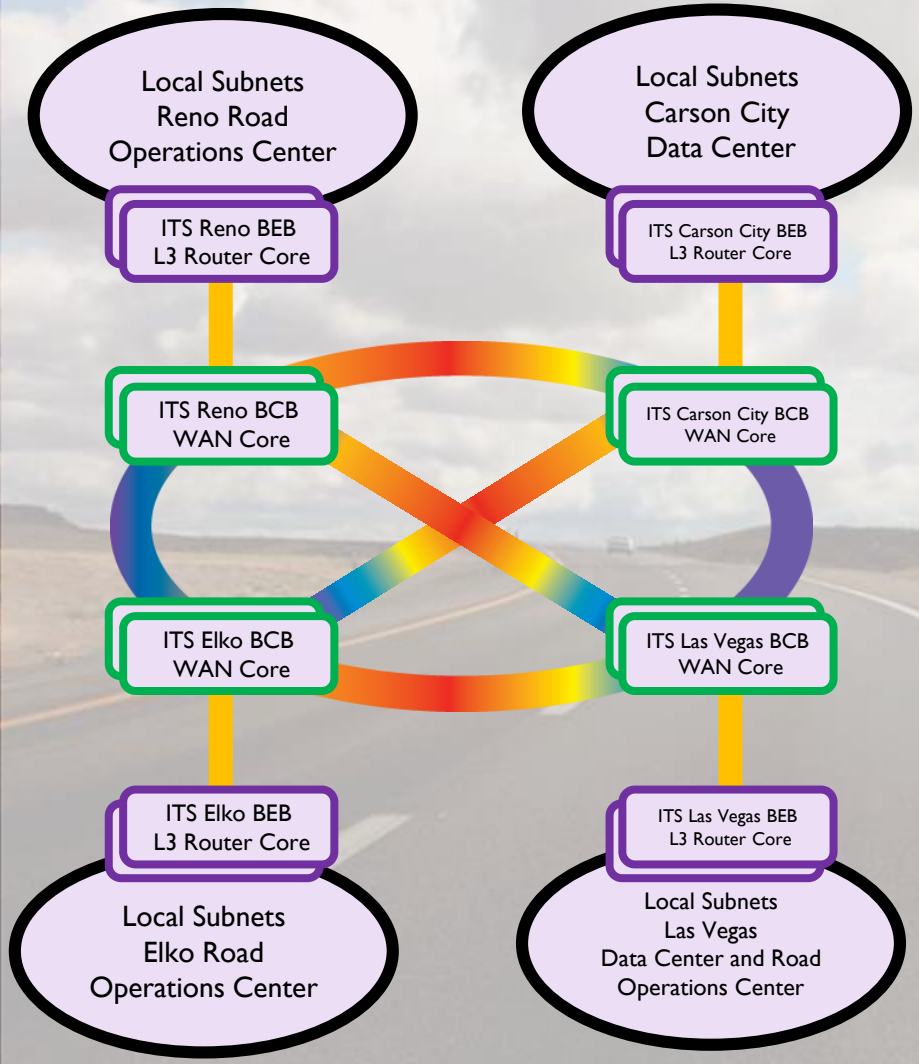
1. When an enterprise deploys a service, it generally limits that service exclusively to locations that need it
2. The usual mechanism for doing this is to create a virtual LAN
3. The use of VLANs requires the use of Spanning Tree
4. Add a new service, add a new VLAN
5. Adding a new service means configuring every switch involved in the service, edge and core
6. Add a location, extend the VLANs
7. Inefficient link utilization
8. Does not necessarily use the shortest path
9. Low scalability – max of 40 hops
10. High convergence times in large Layer 2 networks
11. Tedious, error-prone, hop-by-hop configuration

With an SPB Architecture:



- No more spanning tree: each service determines the Shortest path
- No blocking of ports and no loops present
- Mesh topologies can be fully utilized
- More efficient use of all network links
- Edge-only provisioning
- Adding a new location means making a simple configuration change
  at the edge of the network
- Scale up to 1000 nodes
- Ensures loop prevention by using IS-IS routing between nodes
- Sub-second convergence time in the event of node or link failure
- Ethernet as a service provisioning only at edge – no more hop-by-hop – 16M ISIDs
- Enables mapping of services from anywhere to anywhere, including to the ITS Helpdesk
- Utilizes any type of topology: ring, partial or full meshed
- Shortest path calculations are conducted by each node during the ISIS adjacency process in the Control Plane
  - Shortest path for each service is calculated and stored in the Forwarding Database (FDB) of each BEB

Physical Topology Core/Data Center Design



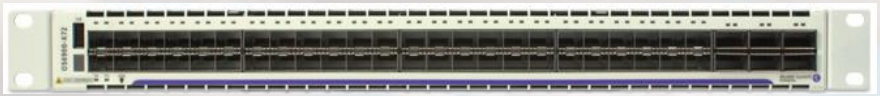
- Take advantage of Partner Optical DWDM statewide backbone to simplify WAN Core layer
- Full-mesh at the core for shortest path/redundancy between Regions, as well as to the regional Data Centers
- Physical redundancy using Virtual Chassis at the Core/Distribution Layers to simplify configuration, improve convergence, offer In-Service Software Upgrades
- Core Layer will be configured as Backbone Core Bridge (BCB) elements, focusing only on backbone bridging
- Regional Core Layers will be providing Layer 3 services (OSPF/PIM)


The Building Blocks

ALE Network Building Blocks

- Alcatel-Lucent Enterprise family of non-hardened and hardened Ethernet switches
- All switches share the same operating system, CLI, and network management
- PoE is provided in all locations, including Core, Distribution, and Access (Edge) Layers
- Edge to Distribution Layer connectivity is provisioned at 1G today with built-in migration option for 10G without requiring an equipment forklift
- Distribution to Core Layer connectivity is provisioned at 1G and in some cases 10G - built-in migration option for 10G everywhere or 40G without requiring an equipment forklift
- ALE models of choice include:
  - Core/Distribution: OS6900-X72
  - Access in environmentally-controlled locations: OS6860E-P48
  - Access in roadside locations: OS6865-P16X

Core, Layer 3 and Distribution Switch ALE Omniswitch OS6900-X72 Features



Member of the OS6900 family

OS6900-X72 fixed form factor
- 6x40G QSFP+ fixed ports
- 48x10G SFP+ ports

Low latency ~500 ns

Can operate in a virtual chassis up to 6 units
- Any combination of OS6900 models is supported in this mode

Data center positioned as a spine layer or Top of Rack (ToR)

Positioned as a multipurpose fundamental platform to serve as:
- Core interconnect switch between core sites
- Core Layer 3 Router
- High-density aggregation Distribution Layer switch
- High-density, high-speed (10G) server access layer switch

Access Switch
ALE OmniSwitch OS6860E-P48 Features

OS6860E-P48

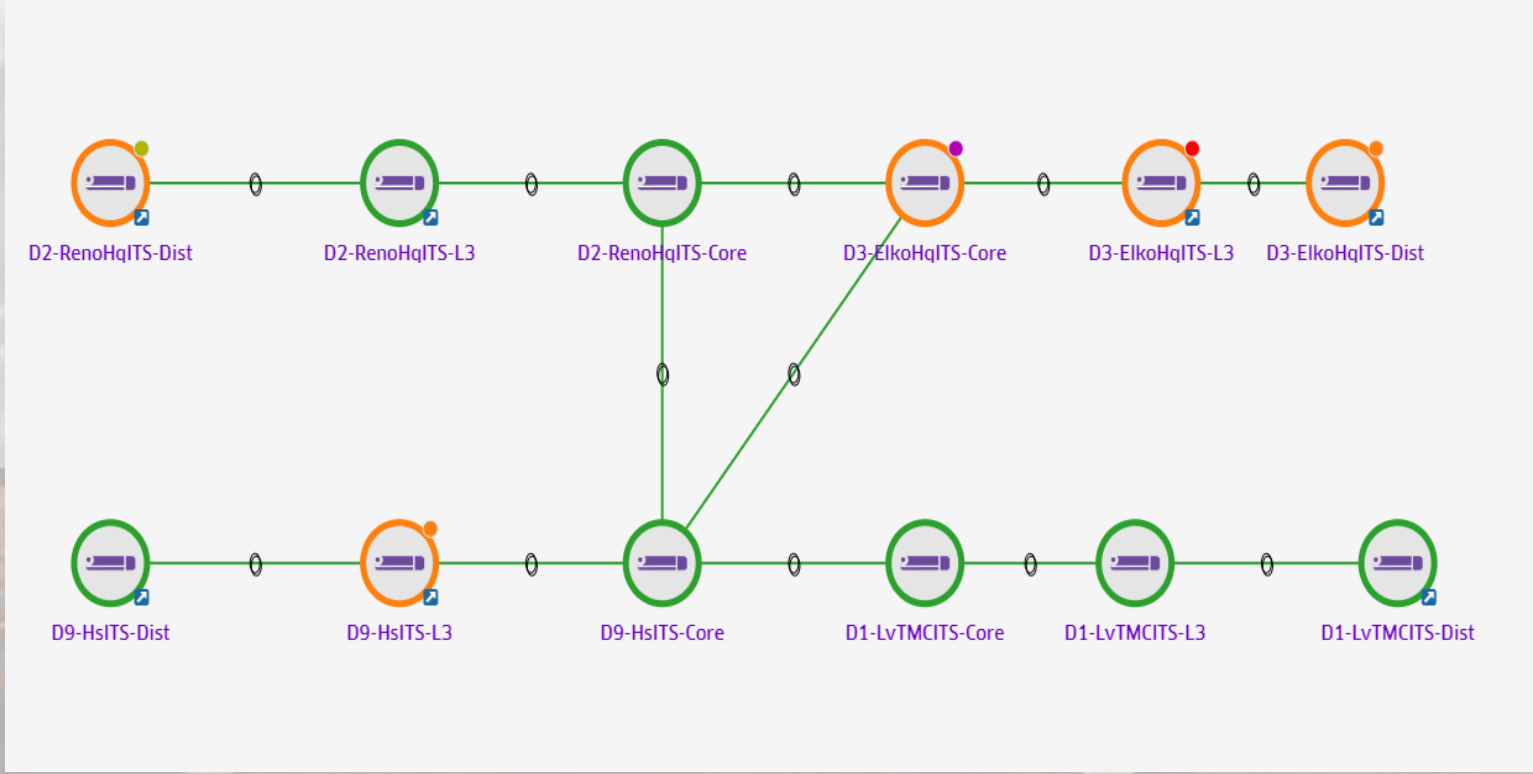
- 48 RJ-45 10/100/1000 BaseT POE ports,
- 4 fixed SFP+ (1G/10G); 2 VFL QSFP+ ports (20G each)
- 920W AC power supply

- All models have four built-in 10Gig SFP+ ports
- All models have two VFL ports (20G each)
- Support for PoE+ (up to 30W per port) on all ports
- Support for PoE++ (up to 60W per port) four ports per unit
- Common power supplies (hot-swappable)
- Connection to the Backup Power Shelf (BPS)
- Can be mixed in Virtual Chassis (VC) configuration
- Seven segment LED for VC numbering
- USB for file management and Bluetooth connection
- Micro-USB to USB console; Micro-USB – RS232
- Energy Efficient Ethernet supported on all copper models
- Deep Packet Inspection (DPI) in hardware
- Run the same AOS version and optional software packages

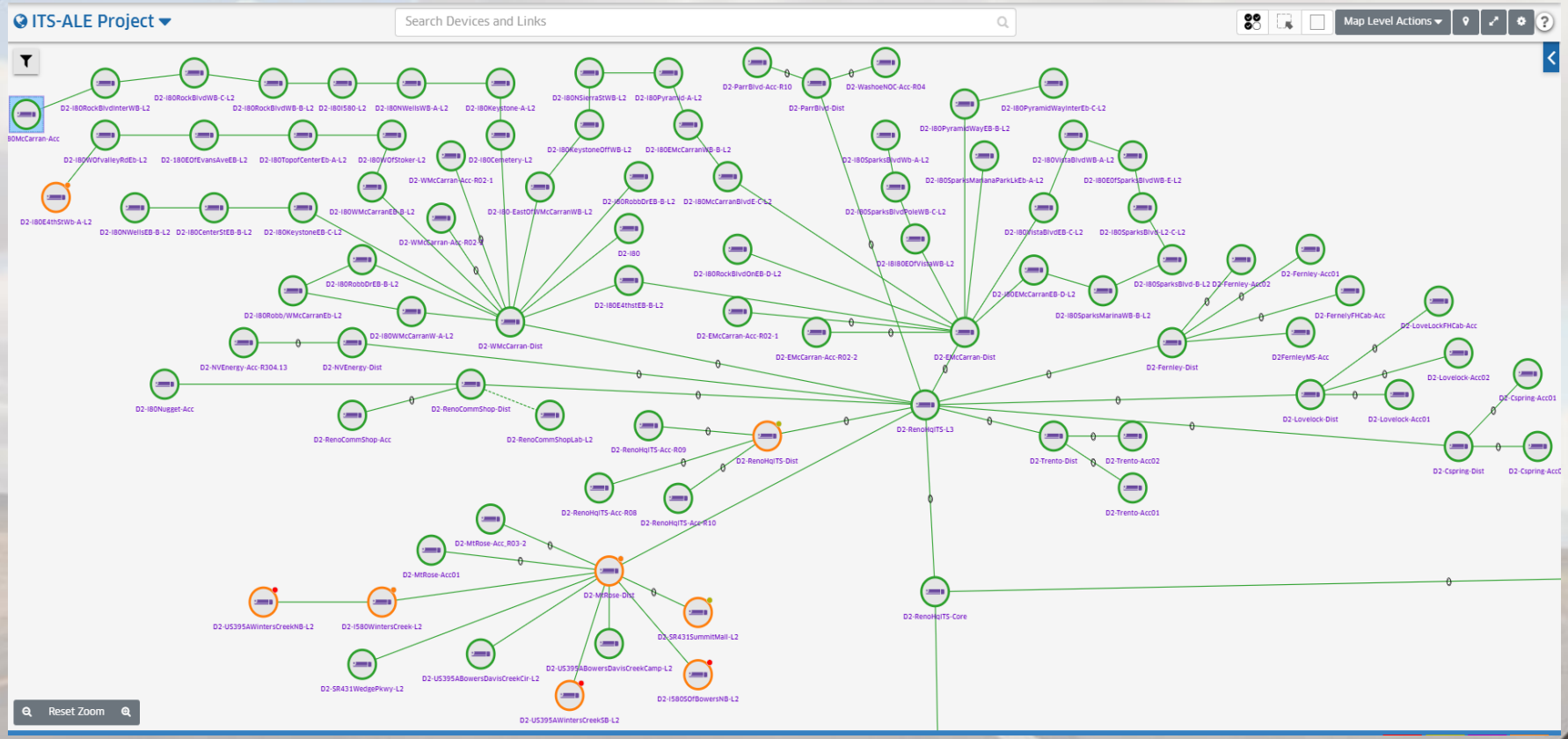
OmniSwitch 6865-P16X

- Half rack (19") wide
- 10.2" deep (excluding Power Supplies
- DIN, 19" Rack, Wall Mount
- Dual power supply connectors in the back
- External power supplies
  - 180W AC – 140W POE budget
  - 180W DC – POE budget – 140W @48V, 100W @24V

NDOT Network Core, Layer 3 and Distribution Layers



NDOT Regional SPB Network Deployment



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Benefits and Lessons Learned

Benefits

Technical

- Support for future technology
- Reduced new device, service, and application roll out time

Financial

- Increased staff availability to work on mission-critical projects

User Experience

- Real-time travel information provided to drivers
- Increased safety and improved traffic flow

Lessons Learned

Identify specific goals of the project

- What is the main problem to be eliminated through this?
- What additional capabilities will we achieve?
- What is the timetable for execution and completion?

Exercise due diligence in evaluating options

- Technology alternatives
- Vendor alternatives

Enroll stakeholders in the vision

- Secure buy in from our whole team
- Secure buy in from our customers
- Secure buy in from management

Prepare for the unexpected

- It's always more complicated than all the planning reveals
- Contingency plans and being nimble are essential
- Communicate, communicate and communicate!

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Questions?


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