Lessons from the field: Dominion

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Challenges from a Project Management perspective:

- Understanding the technology and what is required for installation
- Educating the workforce on the technology
- Developing full project scopes and accurate estimates
- Coordinating work across multiple business units and disciplines
- Performing IT architectural assessments

Synchrophasor Data Flow

- PMUs in substations
- ↓
- Local PDCs in substations (optional)
- ↓
- Central PDC in TO's operation center
- ↓
- PDCs at RTOs & Neighboring Utilities

  - Two groups of PMU data users
    - The TO (owner of the PMUs)
    - RTOs & Neighboring Utilities

Each group needs data named in specific way for acceptance of data in daily operations activities

- The TO (owner of PMUs)

  PMU data should be named in relation to the TO's system, following the same conventions used in operating center

  Ex: C37.118 station name – *Dooms_11-1PMU*

  C37.118 channel name – *Line555 VA Ang*

- RTOs & Neighboring Utilities

  PMU data should be named in relation to the RTO's wide-area system, or a neighboring utility's system

  ISO Ex: C37.118 station name – *VP 8DOOMS 01*

  C37.118 channel name – *L5008SUFFOLK VAA*

Must implement a way to perform name translations

C37.118 Element	TO's PMU Naming	RTO's PMU Naming
PMU ID	2	19851
Station Name	Dooms_11-1PMU	VP 8DOOMS 01
Channel Name	Line555 VA Ang	L5008SUFFOLK VAA

- **Must be able to perform this translation without adding significant latency**
- **Not all of today's PDCs can perform name translations**
  - **Limited # of PDCs that can be used to complete this today**
- **Required to keep this translation table up-to-date as network changes, new PMUs added, etc.**

Additional synchrophasor naming issues

- Not all of today's PMUs allow every C37.118 element custom named

  Example with SEL PMUs:

  C37.118 ID code – *Customizable*

  C37.118 station name – *Customizable*

  C37.118 channel name – *Not customizable; name is set internal to the relay based on input terminals → 'VAVPM'*

C37.118 Element	Relay PMU Naming	TO's PMU Naming	RTO's PMU Naming
PMU ID	2	2	19851
Station Name	Dooms_11-1PMU	Dooms_11-1PMU	VP 8DOOMS 01
Channel Name	VAVPM	Line555 VA Ang	L5008SUFFOLK VAA

- Adds another translation to perform and maintain

Vendor-provided bandwidth calculators

- The bandwidth calculators had formula errors, which resulted in incorrect bandwidth calculations.
- The bandwidth calculators where limited in scope (calculated Ethernet bandwidth only) and had to be modified to also estimate WAN bandwidth (this required knowledge of WAN link protocol overhead and VPN tunnel protocol overhead).
- The bandwidth calculators do not take into account whether IP multicasting or multiple unicasts will be used to delivery synchrophasor traffic to the head-end systems.
- Several planning factors need to be known or resolved in order to use the bandwidth calculators. They include:
  - Which network protocol will be used (TCP vs. UDP)?
  - Number of phasors that will be measured at each substation
  - The sample measurement rate (30 phasors per second, 60 per second, etc.)
  - Which data format will be used for phasor measurements (integer vs. floating point)?
  - Will a PDC be used at the substation to aggregate phasor measurements prior to uploading phasor data to the head-end system?
  - Will the substation PDC “down rate” the phasor measurements that are sent to the head-end system (say from 60 phasors per second to 30)?

VPN-encrypted substation WAN links

- VPN encryption can impact how synchrophasor traffic is supported on existing substation WAN links that carry other substation WAN applications.
- Using QoS to ensure the isochronous delivery of synchrophasor traffic over the WAN while minimizing performance impacts to the other substation WAN applications is not an option when IPsec VPNs are used to encrypt the WAN traffic. The IPsec protocol masks which applications are flowing through the VPN tunnel, so the WAN routers are not able to apply QoS handling for the WAN traffic.

VPN-encrypted substation WAN links (cont'd)

- Alternatives Include:
  - Provision additional bandwidth on the affected WAN links as required to mitigate performance issues,
  - Implement QoS controls in the VPN anchor points (firewalls), which can be complex and problematic, and
  - Use another VPN protocol that doesn't encrypt the synchrophasor IP packet headers, such as Cisco's Group Encrypted Transport VPN (GETVPN), which could require an expensive change out of your WAN and/or security equipment.
- The use of VPN tunnels and/or firewalls can also inhibit the use of IP multicasting to deliver synchrophasor traffic to two or more head-end systems ("super" PDCs). An alternative is to use individual unicast streams to direct synchrophasor traffic to each head-end system.

Sharing Synchrophasor Measurements

- Careful planning with your RTO and your system architect is critical in determining how best to architect the synchrophasor head-end system, especially when configuration and site redundancy are key requirements. The factors that need to be considered are:
  - Will you have separate primary and secondary head-end systems located at different sites (say at your SOC and ESOC)?
  - How will the RTO configure the WAN connections to your primary and secondary sites?
  - What operational response will be taken in the event the RTO's primary WAN link goes down? Does the RTO require you to reroute traffic from your primary synchrophasor head-end system through the secondary WAN link (i.e. via the secondary site) or will the RTO manually control which head-end system to obtain the shared phasor data from?