Applying IEC 61850 to Distributed Energy Resources (DER)
Utility Industry is in Transition

TRADITIONAL
- Unidirectional power flow
- Large centralized energy resources
- Tag based Operational applications

TRANSFORMED
- Multi-directional power flow
- Numerous Distributed Energy Resources (DER)
- Model based Operational applications
Expanding Number of Data Sources and Data Quality Affects the Scope of Utility Applications

The growth of data requires a new approach for OT applications:

Model based integration using CIM and IEC 61850

- $+10^6$ Customer Usage Points
- $+10^7$ Utility Potential points
- $+10^4$ Waveform Samples
- $+10^x$ Social Media Clicks
Drivers for the DER Project

• A large number of small distributed energy resource (DER) projects are being developed and must be connected to the distribution grid:
  – Utility developed and owned solar and wind
  – Outside investor owned solar and wind

• The utility is required to connect and control both utility and third party DER in a neutral manner using existing systems

• The utility is resource constrained to undertake the engineering to interconnect so many different projects
Complexity

• A common complaint is that IEC 61850 is big, complex and requires a long learning curve. Other protocols are simpler. Simple is better (KISS principle).

• **The complexity of a system is not based on how the bytes are sent on the wire are organized**

• Product implementation complexity does not result in application complexity

• Even though user configuration using numbered tags is understandable (simple) overall system complexity is increased
Renewable Integration - Solar

• Sun Spec Alliance has developed a Modbus based communication protocol for grid connected inverters

• At a 2010 industry event a Sun Spec representative told me:
  – IEC 61850 was too complex for grid connected inverters
  – Modbus was simple and easy to implement

• Let’s look at how “simple” grid connected inverters are using Modbus
### Sun Spec Protocol Implementation Conformance Statement

There are **75** tabs on this spreadsheet.
Renewable Integration - Solar

• In California:
  – In 2014 there were 2,164 different models of inverters from 151 different manufacturers that were approved for grid connection of solar panels.
• Sun Spec Alliance:
  – 37 manufacturers with 127 models of Sun Spec certified Modbus interfaces.
• According to public sources:
  – There are > 626,000 solar homes in California

• Will it be “simple” to integrate 600K homes with utility scale applications and build an intelligent grid leveraging solar resources using Modbus?

• Good news: Standards like IEC 61850-7-420 are being improved to address these needs
Why Does This Happen?

• Assuming product implementation complexity results in application complexity

• Assuming that technology constraints today will be valid over the life of the system

• Assumption that user configuration is reasonable because it is understandable

• User effort costs less than development
Where should the complexity be handled?

Power System Functions

- Measurement
  - Phase A Voltage
  - Phase B Voltage
  - Phase C Voltage
- Controls
  - Local/Remote Status
  - Breaker Position
  - Blocked Open
- Protection
  - Activate Phase A
  - Activate Phase B
  - Activate Phase C

Modbus

- R400040
- R400041
- R400042
- R400043
- R400044
- R400045
- R400046
- R400047
- R400048
- R400049
- R40004A
- R40004B

Applications

626,000 mappings developed by USERS

Devices

151 mappings developed by VENDORS

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The Key Element of IEC 61850 to Address Complexity

**Semantics**

- Semantics to implement an engineering process based on standardized configuration language (Substation Configuration Language – SCL)
- Semantics to eliminate manual mappings and automate configuration
- Semantics to manage the complexity of very large systems that are changing constantly
- How data is sent/received on the wire is not what makes a system complex
The Utility Dilemma

• The utility needs to implement complex systems

• Because of the number of project coming on line and complexity of the data they don’t have the resources to do much manual configuration

• They don’t have budget to replace their communications architecture or to purchase large-scale specialized systems for DER integration
The Solution: Use IEC 61850 and DNP3 Together

• All system design and naming standards will be done using IEC 68150 engineering tools and data models
• All communications will be through a DNP3 gateway
• Each project owner is required to provide a DNP3 gateway that conforms to a standardized template that conforms to IEC 61850-7-420 and the IEEE 1815 DER profile under development
• SISCO is developing the tooling to support the project
Using IEC 61850 Semantics and Engineering with DNP3

- **Utility Requirements**
- **Device Template Spreadsheet**
- **ICD Creator**
  - **ICD File (Device Template)**
- **Substation Design Tool (SCT)**
- **IEC 61850 Model Files**
- **SCL to CIM**
- **PI DNP3 Interface Configurator**
- **Generic Tag Configuration Generation**
- **IEEE 1815.1 (or IEC 61850-80-1 for -104) XML Mapping File**
- **Other DNP3/101/104 Interfaces**
- **OSIsoft PI System**
- **SISCO Software**
- **ADMS System**
- **CIM XML**
- **For Topology Information**

**SISCO Software**
Status of Standards

• IEEE 1547 – Grid connected smart inverter standard for the US
• IEC 61850-7-420 – Logical nodes for DER
• DNP Application Note AN2013-001
IEEE 1547

- IEEE 1547-2013 specified how grid connected inverters operate assuming a low penetration rate of DER
  - Did not support numerous critical features like voltage, frequency ride-through, VAR support, etc.

- Critical standard in the US to meet regulatory requirements
- 2013 version was insufficient for modern DER
- IEEE 1547-2018 addresses these with descriptions and requirements of all DER functions
IEC 61850-7-420

• IEC 61850-7-420 Ed.1 was insufficient for current DER
• Ed.2 under development to be compatible with IEEE 1547-2018 and other updated standards
• Ed.2 is currently only at CD2 stage but is being used for the project (less incompatibility than using Ed.1)
• Project implementation has identified some inconsistencies and have been incorporated into the next CD
DNP Application Note AN2013-001
Profile for Advanced Photovoltaic Generation and Storage

- Specifies mappings between DNP3 and IEC 161850-7-420
- Existing version uses Ed.1 of 7-420
- Project is using in development new version of DNP3 mapping based on Ed.2 of 7-420 and IEEE 1547-2018
- Project usage has helped identify some inconsistencies in the new DNP3 profile
Project Summary

- IEC 61850 IED Capability Description (ICD) files are used to describe the inverter interfaces for the DER project.
- IEC 61850 engineering process using a System Configuration Tool (SCT) is used to configure all the DNP3 communications and mappings for all DER operations.
- Result is automated generation of all tag naming, DNP3 interface configuration and DER topology information.
- Dramatic reduction in configuration complexity for the utility.
- Can be applied to other technologies like IEC 60870-5-10X, etc.
Thank You