ELECTRIC POWER
RESEARCH INSTITUTE

# IEC 61850: More Than Meets the Eye

Utilities use dozens of protocols to communicate between devices and substations, within substations, between substations and control centers, and between control centers. When International Electrotechnical Commission (IEC) standard 61850 first arrived on the scene in 2003, it promised to standardize realtime communications within substations. It was adopted enthusiastically in Europe for this purpose and has seen slowly growing adoption in the U.S. But IEC 61850 is more than just another protocol; it has scope ambitions far beyond substations (or even the electric grid).

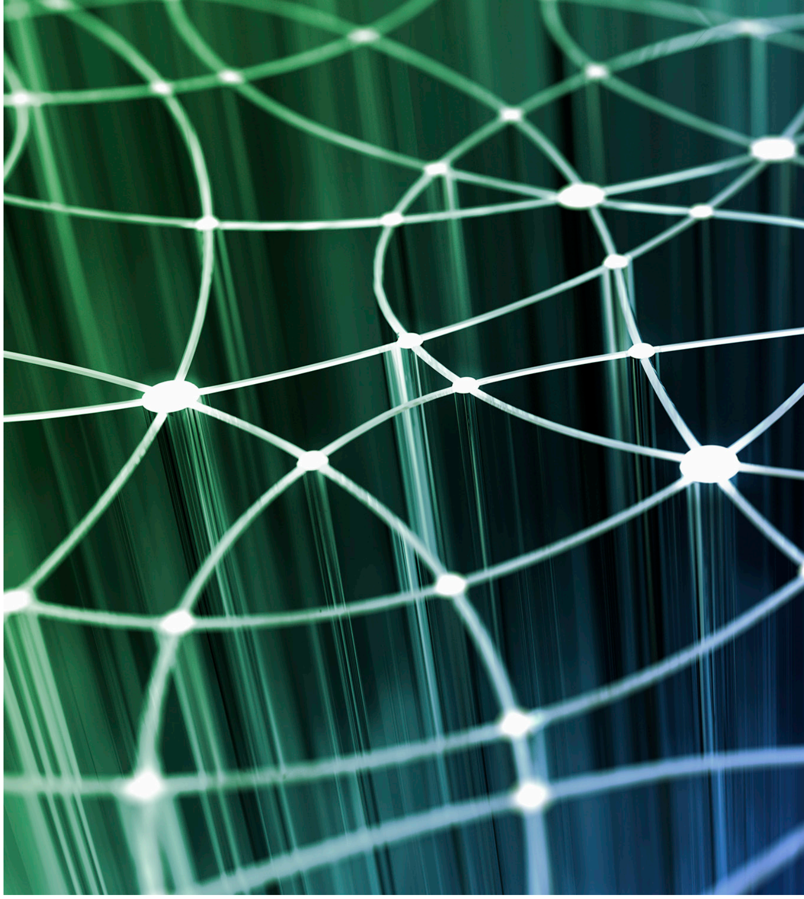
This paper outlines why IEC 61850 is likely to affect utilities and why they should pay attention to this standard.

# Breadth with Depth

Though the original version of IEC 61850 targeted "communication networks and systems in substations," this scope was limited for political reasons. In 2010 the description was changed to "communication networks and systems for power utility automation" but even with that expansion in scope the 61850 working group would have preferred it simply to say "…for automation." The IEC balked at this because "automation" seemed overly broad for a standard created by an organization focused on "electrotechnology." IEC 61850 proponents argue that it could be used for any sort of communication or control, in any application domain. After all, measurement and communication of temperature, for example, is not tied to a thermostat, transformer, or other electrical device; it could just as easily relate to a chemical process or a medical examination.

In addition to this broad potential scope, IEC 61850 is also much deeper than just another protocol. It includes device information models, a configuration language for describing substations, and a set of abstract services that facilitate porting to a range of communication protocols. In fact, it could be argued that the value of IEC 61850 is not in the protocols at all, but in some of its other features, particularly in the device models and configuration language. By way of contrast, a protocol such as Distributed Network Protocol 3 (DNP3) only defines the communication protocol: it provides no standardization of information models and no standardized configuration tools.

IEC 61850's original applications focused on support of realtime communications using the Generic Object-Oriented Substation Events (GOOSE) control model over Ethernet to provide high speed (sub-4 msec) communications within a substation. But even in this area, it has moved well beyond this specialized domain. IEC 61850 uses an abstract communication service layer, which has allowed it to be mapped to other messaging protocols, including both MMS (ISO/IEC 9506)[1] and DNP3 (IEEE 1815). Furthermore, by replacing the transport layers (GOOSE/Ethernet) with standard Transmission Control Protocol/Internet Protocol (TCP/IP) protocols, native IEC 61850 messages have become fully routable for use in wide-area networks. With these option available, IEC 61850 has moved out of the localized substation domain into the realm of Supervisory Control and Data Acquisition (SCADA) systems and control centers. And in 2016 a new substation-to-control center communication role was standardized with 61850-90-2. Extension of IEC 61850 to more abstract domains, such as asset lifecycle management, is also under discussion.



## The Value Proposition

IEC 61850 has seen widespread adoption in Europe and is growing in other parts of the world. Indeed, major utilities, including Electricité de France (EDF) and Southern California Edison (SCE), have made strong commitments to its use in the future. So, what makes IEC 61850 so attractive?

The attraction of IEC 61850 depends on the perspective from which the question is examined:

[1] When the Manufacturing Message Specification (MMS) was originally released (in 1990), it was designed to run in an ISO/OSI network. In 1990, Boeing implemented MMS over TCP/IP, which has been key to its success.

- **Communications** – The underlying MMS messaging system has been around for nearly thirty years and is globally accepted. GOOSE messaging, though new with IEC 61850, provides a unique realtime communications capability for high-speed data transfer and is becoming widely accepted for substations.
- **Device Models** – The standardized information models created for IEC 61850 are both widely accepted and influential beyond their use with IEC 61850 itself (more on this below). Having uniform models that expose their information in a standardized way is crucial to interoperability issues.
- **Configuration Language** – The Substation Configuration Language (SCL) provides a modeling tool for specifying substation devices and interconnections using a common language. It allows specification of the capabilities of logical and physical devices and stores them in a standard SCL file (called a Substation Specification Description or "SSD").

Any of these features can provide significant value to a utility, particularly to the extent that they facilitate greater opportunity for interoperability among devices.

## Interoperability, Interchangeability, and Plug-and-Play

Does the adoption by manufacturers of IEC 61850 help with interoperability of devices from different vendors? Does it allow utilities to replace devices from one supplier with those of another with little effort? Or can new 61850-compliant devices be added to a system without reconfiguration?

While IEC 61850 facilitates steps in these directions, the answers today are likely to be "some," "maybe," and "not really."

### *Interoperability*

This case depends on what we mean by interoperability: physical, logical, functional, and so on. Interoperability requires (among other things) that the distribution of the (application) functionality between the devices be specified exactly. And although IEC 61850 contains a set of mandatory requirements, they are not sufficiently comprehensive to cover all implementation options. Two nominally conforming devices therefore may or may not interoperate because the functions and the services they supply or consume may differ.

### *Interchangeability*

Once a device has been successfully defined in the system, its replacement by another device (perhaps from a different manufacturer) may or may not succeed. Even though the functional behavior of the two devices match, the way in which data messages and flows are defined are not standardized and therefore may not allow successful 1-for-1 swapping to occur.

### *Plug and Play*

The widespread adoption of IEC 61850 by manufacturers does not mean that compliant devices may simply be installed and connected and then interoperate without further configuration. IEC 61850 describes an entire suite of capabilities that contains a lot of options. The selection of the appropriate options depends on the use to which the utility intends to put the equipment. Therefore, the devices cannot be "self-configuring" in any sense, and cannot provide a plug-and-play deployment.

## The Deeper Impact of IEC 61850

While IEC 61850 itself is on the rise and its deployment broadening, it is also making inroads and having impacts through other paths. For example, the device models defined in 61850 have been influential in shaping several other communications and control schemes, including SunSpec Modbus, ASHRAE 201, and IEEE 2030.5.

- **SunSpec Modbus** – The SunSpec Alliance Modbus interface description makes use of definitions from the IEC 61850 inverter information model. For example, electrical measurements defined in the IEC 61850 MMXU logical node have been used to name point IDs mapped to the Modbus registers. Thus, we find "PPV.phsCA" (61850) called "PPVphCA" (SunSpec) while "A.phsA" (61850) is called "AphA" (SunSpec).
- **ASHRAE 201** – This standard, for a "Facility Smart-Grid Information Model," also mines the IEC 61850 definitions. The purpose of this standard is "to define an abstract, object-oriented information model to enable appliances and control systems in homes, buildings, and industrial facilities." It "builds upon" the IEC's work on 61850 but, like SunSpec Modbus, makes some minor changes in the point names. For example, what ASHRAE 201 calls "OperationalModeConstantW" is equivalent to IEC 61850's "OpModConW" and "OperationModeConstantPowerFactor" (ASHRAE) is equivalent to "OpModConPF" (61850).
- **IEEE 2030.5 (SEP 2)** – This standard, which is the default protocol selected for DER integration under California's Rule 21, is based in part on a subset of IEC 61850's information models, which provide the basis for the communications required for Phase 1 and Phase 3 functionality in the rule. The abstract information models of IEC 61850-7-420 are used to support general data exchanges, while the specific device models of IEC 61850-90-7 describe most of the actual DER functionality.

## IEC 61850: Unavoidable and Inevitable

Whether a utility chooses to make a major commitment to IEC 61850 or approach it incrementally, its impact will be felt. Substation equipment manufacturers are designing IEC 61850 into their devices and proponents say it "just makes sense" to consider its use in substations. Whether IEC 61850 will displace DNP3 for SCADA communications anytime soon is less certain. The emerging protocols associated with DER control and monitoring (such as SunSpec Modbus and 2030.5) have adopted IEC 61850 data models as the basis for defining the devices and signals with which they communicate. Even less traditional load equipment, such as HVAC devices, are moving in the direction of employing IEC 61850 models.

With this movement and pervasive influence, there is no doubt that IEC 61850 will have at least an indirect impact on every utility. Gaining a good understanding of this pervasive standard will serve the interest of utility engineers now and for many years to come.

3002012056 November 2017

**Electric Power Research Institute**
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com