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THE DUAL-DOMAINS OF IEC 61850
POWER VS INDUSTRIAL DOMAINS

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The intent of this paper is three-fold: first to provide a brief overview of IEC 61850 and its value-added features; second to discuss the various IEC 61850 use cases found within the industrial and power utility domains; and finally to provide design considerations that identify areas of overlap where common practices ought to be taken.

Despite the popular belief that the "power" domain and "industrial" domain have intrinsically unique principles, this paper suggests the gap is decreasing, and through the use of IEC 61850 we can adopt a single strategy that capitalizes on a **common technology platform.** This will ultimately streamline the specification, design and commissioning processes for power and industrial users alike. This will minimize the overhead by eliminating the need to build two sets of infrastructure in parallel, and provides greater reliability by avoiding common points of failure such as gateways, protocol converters, etc. IEC 61850 still provides users the flexibility to address the challenges found within each domain, which is indeed unique.

THREE W'S OF IEC 61850

WHEN?

IEC 61850 is synonymous with "innovation" and is often considered to be a state-of-the-art technology; however we must not forget that we'll be celebrating the standard's 20th birthday in 2015. It's fair to say that IEC 61850 is a mature standard that has continually evolved since its inception in 1995, and users ought to be confident in its ability to meet their functional requirements. The power and industrial domains should be rest-assured the foundations have been well thought out and widely deployed across the globe. Some aspects may very well be cutting-edge (e.g. process bus), while others (e.g. station bus) are well established to offer the low-lying fruit that can be easily exploited.

Today there are still soft points to the standard - such as the testing and commissioning aspects that are being addressed in Edition 2 - but this is not reason alone to reject the standard; it is the paradigm of any design. Without users - power and industrial - demanding additional requirements such as these, the standard will come to a deadlock.

The success of IEC 61850 has resulted in the standard spilling into other domains, such as hydropower, wind power, battery storage and other distributed energy resource (DER) applications. If it has proven worthy to support the bulk electric power system and DER domains, surely there's an argument to be made that it's suitable for industrial applications as well.

WHAT?

By definition, "IEC 61850 applies to Power Utility Automation Systems. It defines the communication between intelligent electronic devices (IED) in the power utility automation system and the related system requirements".

There are a number of ways to communicate data between IEDs; whether that is through hard-wired inputs and outputs; proprietary communication channels (e.g. Profibus); de-facto communication channels (e.g. Modbus); or non-proprietary communication channels (IEC 61850). If we use the analogy of a conversation between two individuals from across the globe, we can communicate via a hand-written letter; or via our native tongue

(French -Translator - English); or we can have both individuals learn the global language (e.g. English). IEC 61850 is the "global language" of power automation systems, and has the capability to be the same for industrial automation systems. The fundamental principle remains the same; maximize the amount of interoperability.

The scope of IEC 61850 includes the specification, design and commissioning aspects of substation automation systems (SAS), which explains why this standard - and its supporting technologies - are often referred to as a disruptive technology. It touches almost every aspect of the SAS supply chain, but all for good reason. This is a game changing technology, and a "bolt-on" approach is not an option. When adopting IEC 61850, one should be prepared to reconsider how they specify, design, and commission their automation systems.

IEC 61850 provides us with a standardized schema to model the power system's data and communication services. This so called "schema" defines the rules, that are analogous to the english language and its associated dictionary/grammar. Manufacturers must conform to this schema when implementing "english" within their products, which provides us with a consistent set of building blocks (data model) and the glue (communication services) to tie it all together.

In order to properly specify an IEC 61850 system - regardless of the domain - the user must have mechanisms to articulate their functional design requirements. This is done through IEC 61850's substation configuration language (SCL), which is an XML based format that captures these details. There are SCL files for:

1. Specifying the system requirements: System Specification Description (SSD)
2. Describing the IED's capabilities: IED Capability Description (ICD)
3. Describing the IED's configuration from the IED's perspective: Configured IED Description (CID)
4. Describing the IED's configuration from the system's perspective: Instantiated IED Description (IID)
5. Describing the entire substation: Substation Configuration Description (SCD)

There are other SCL files that have special applications (substation-substation), as well as new SCL files that are being considered for specification purposes.

WHY?

The primary goal of IEC 61850 is to maximize the interoperability of IEDs, which is a precursor to achieving interoperability; the quintessential solution. Interchangeability spawns both tangible and intangible cost savings. Many are familiar with the reduction in CAPEX costs via minimizing the amount of hard-wiring, which offers both material and labour savings. The SCL files allows for the SAS design to be easily replicated and tailored to other projects, which also offers substantial savings via minimizing the amount of re-engineering. The self-describing nature of IEC 61850 streamlines the configuration process, and eliminates the need for tedious look-up tables to translate meaningless point/index numbers. Wiring diagrams and cable schedules will drop away, and will be replaced with these XML based engineering files. Need to make a last minute design change or add I/O to a control scheme? Not an issue, this can easily be achieved by quickly configuring a GOOSE message, which doesn't require mark-ups to wiring diagrams, or changes to field wiring and all the associated as-built drawings, etc.

CIGRE Working Group B5.11 summarizes the benefits best in their report "The Introduction of IEC 61850 and Its Impact on Protection and Automation Within Substation":

1. Lower installation and maintenance costs through self-describing devices that reduce manual configuration
2. Reduction in engineering and commissioning with standardized object models and naming conventions for all devices that eliminates manual configuration and mapping of I/O signals to power system variables
3. Less time needed to configure and deploy new and updated devices through standardized configuration files
4. Lower wiring costs while enabling more advanced protection capabilities via the use of peer-to- peer messaging for direct exchange of data between devices and a high speed process bus that enables sharing of instrumentation signals between devices
5. Lower communication infrastructure costs by using readily available TCP/IP and Ethernet technology
6. A complete set of services for reporting, data access, event logging, and control sufficient for most applications
7. Maximum flexibility for users to choose among an increasing number of compliant products to be used as interoperable system components

IEC 61850 USE CASES

PROCESS VS POWER AUTOMATION

We should differentiate between the two flavours of "automation" and clarify the verbiage used in each domain. In the past these two domains were considered to be worlds apart, and treated as two independent systems with full autonomy between the two.

Power automation generally applies to the utility domain that is deployed within substation applications and are collectively referred to as substation automation systems, or as some refer to it as power management systems. The types of IEDs found within SAS schemes can range from protection relays, bay controllers, metering devices, merging units, fault recorders, etc. Due to stringent requirements imposed by utility regulators, there is typically a higher level of redundancy and availability requirements found within these applications, with many requiring a multi-vendor solution that further complicates the task.

Process automation is generally applied at lower voltage applications with IEDs such as programmable logic controllers (PLC), variable speed drives, motor controllers, etc. Today many process orientated plants have a distributed control system(s) (DCS) along with a collection of PLCs to gather and process the required I/O. The DCSs generally control and manage the core processes (e.g oil, gas, mining, food, pharmaceutical processes) that are responsible for the plant's production. The PLCs are meant to control non-core process functions, such as conveyor belts, drive controls, air compressor controls, cooling valves, and other balance of plant type processes. The PLCs are often a subsystem to the DCS, which creates yet another interface point in the process automation world.

Regardless of the domain, there are common denominators that can be found. Whether it's the SAS, DCS or PLC applications, these all share a common goal of collecting, processing, distributing and visualizing the data. The question now becomes where do we define the interface points? Currently these interface points are defined by the manufacturer's proprietary and/or de-facto standards, however this is not the way of the future. Hardware and software manufacturer's are being driven to adopt standardized communication interfaces, thereby decreasing the number of interface points and the associated equipment to do the conversions. Some manufacturers are more ambitious than others, but it is the users who are to benefit; so the onus lies with them to specify these standards.

Albeit each domain has a unique set of challenges and there are areas of overlap between the two. For example both the power and industrial domains require visualization at the local and enterprise levels, which is typically achieved through the HMI and EMS/DMS/DCS respectively. As previously discussed, a single, integrated HMI is an attractive solution from both the engineering and operational perspective. It allows for a single set of I/O mappings that streamline the engineering process, and provides operators with a single point of control and visibility for the entire plant. Whether it's controlling the voltage stability through automatic voltage regulators and transformer tap changers, or controlling valves to dispatch the flow of material in a production process; the fundamentals are the same. This also applies to condition based monitoring and asset management schemes.

Some applications are almost identical. Load shedding and black start generator schemes for example have very similar requirements. There is no value in trying to emulate the same set of requirements across two technology platforms. The logic and I/O may vary, but the vehicle to communicate the logic and I/O should be consistent.

JOINT CONSIDERATIONS

We'll start with the specification phase. There is lots of overlap in how and what we specify when procuring our IEDs. In both domains we specify the number of I/O, types of power supply, logic capabilities, along with the various type tests for immunity to EMF, operating temperatures, etc. These may not necessarily be impacted by IEC 61850 - although IEC 61850-3 covers this - the specification of the network interface and logic capabilities may share some commonalities. IEC 61850 will eventually eliminate the need to order separate communication cards for each type of legacy protocol, such as Foundation Fieldbus, ARCnet, DeviceNet, CANbus, etc. Not only do these lower-level standards lack the performance capabilities that IEC 61850 can offer (Transfer Time < 3ms for Type 1A messages), but they lack the ability to support cyber security services, among other value-added features.

The task force behind IEC 61850-90-11is working hard to model the IED's internal logic using existing IEC 61850 mechanisms. IEC 61850 is no longer just the gate keeper to the IED - controlling only what goes in/out - but will soon provide the means to model the "guts" of the IEDs. This technical report will explain the methodologies for modelling IED's logic for IEC 61850 based applications in power utility automation applications, however the principle is the same for industrial applications. In particular, it includes:

1. The functional view of logic based on existing logical nodes for generic process automation and the operational modes of the logic.

2. The specification of the standard language (IEC 61131-3) to be applied to the specific logic
3. The related data exchange format between engineering tools and their application, as well as the mapping of logic elements to IEC 61850 data types.

IEC 61131-3 logic is commonly used within many PLC applications, and is a good example of how IEC 61850 is seeking to take advantage of existing standards, rather than trying to re-invent logic modelling principles. Another good example is IEC 61850-80-5, which is a guideline that is tasked to map IEC 61158-6 (Modbus) to IEC 61850. These two collaborative initiatives have a direct correlation to the industrial domain, and will help salvage the work already completed from IEC 61131 and Modbus users.

From a design perspective, IEC 61850 will have an equal impact to both the power and industrial domain, as neither currently use an XML based process. In other words, both domains will need to reconsider their design and workflow processes. System integration firms commonly implement both types of applications (power/industrial), which is testament to the fact there are common skill-sets that spread across both domains; those skill sets being network design, data communications, IEC 61131-3 logic programming, HMI configurations, etc. Granted we'll still need knowledge experts for the protection and production aspects.

The million dollar question is how can IEC 61850 accommodate the unique particularities and requirements of each domain, while still utilizing a common technology platform? The answer is profiles.

A profile specifies the use of a particular standard (IEC 61850) to support a specific:

1. Domain (e.g. Power vs. Industrial)
2. Application (e.g. Transmission Operator vs. Steel Refinery)
3. Function (e.g. Distance Protection vs. Rolling Mill Process)

A profile selects a minimum set of mandatory/optional data objects, attributes and services of IEC 61850 that are required to achieve the functionalities defined by the domain/application/function. In other words IEC 61850 provides us with a comprehensive library (superset) of models and services, and a profile defines a common denominator (subset) for each type of domain, application and function.

The profile provides a specification for manufacturers to build towards, so their resulting products will interoperate for that respective domain/application/function. This also streamlines the user's specification process as they can easily specify a IEC 61850 profile tailored to their needs. For example an industrial user may specify "the support of the industrial domain as it pertains to an oil refinery application, for the purposes of a load-shedding function." In contrast, a power user may specify "the support of the power domain as it pertains to a transmission service operator, for the purpose of a load shedding function." In this example the domain and application profiles will vary, but the functional profile should be the same. Remember, the profile defines the minimum set of requirements so users still have the flexibility to customize their schemes. For example defining parameters for stage 1 vs stage 2 load shedding, or frequency vs voltage based load shedding, etc. The intent is not to create canned schemes, but rather fast-track the engineer's starting point when commencing their design. Engineers and designers ought to be focused on achieving their functionalities, and should not be distracted with having to worry about interoperability issues, and profiles will help achieve this.

CONCLUSIONS

Every user unique has requirements, and they are all special in their own right. We're not suggesting that all IEC 61850 users must have identical implementations, instead we're suggesting there are some fundamental practices (e.g. tripping a breaker, communicating a sequence of event via buffered report control block, etc) that can be taken across many domains, and IEC 61850 is the ideal mechanism to facilitate these applications. It's likely that many are already using common practices within - and across - different domains, and it's just a matter of articulating these fundamental practices into a common technology platform (e.g. IEC 61850). In the event a user is an outlier (e.g. 1% of the norm), this may beg the question whether they should reconsider how they implement that particular scheme.

IEC 61850 was initially developed for the power domain, and because of its success it is creeping into other applications, such as distributed energy resources. IEC 61850's mechanisms are mature and have the flexibility to adapt to process and power automation applications. Recent trends such as the adoption of IEC 61131 and the creation of a Modbus mapping are good indicators of its future success in the industrial domain. The concept of profiles will help with this migration and with a bit of pressure from the industrial community, the gap between "power automation" and "process automation" will quickly disappear. This common technology platform will increase the competitive landscape within the industrial domain - which is currently dependent on proprietary protocols - and will ultimately benefit the user's bottom line. The power and industrial communities can share design philosophies, products, as well as the cost savings that come along with having a common technology platform. No longer is the day where we ask, "Is this an industrial product or a utility product?, and the same applies to system integration services. IEC 61850 may have been designed for the power domain, but it won't be long before we see it revolutionize the industrial domain.