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Optimizing IEC 61850 substation control systems with SMP Gateway

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Power systems consist of equipment from many manufacturers and getting equipment to work together seamlessly in an electrical substation can be a challenge. Utilities can advance cybersecurity, system function, redundancy and efficiency by adding gateway technology to support interoperability among substation equipment and unify modeling that enables new intelligence into system conditions.

IEC 61850 primer

Fundamentally, the International Electrotechnical Commission (IEC) 61850 standard is aimed at advancing interoperability between similar devices, regardless of the manufacturer, used in electrical substations across industries. Through an object-orientated approach to electrical and control systems, the standard helps to simplify configuration, testing and commissioning of control and protection systems.

The standard addresses hardware and software requirements in a substation including an abstract data model of each device. This abstract model can be mapped to communication protocols (like MMS, GOOSE, etc.), providing a high-level method of exchanging information between the devices within the substation and between the substation and control centers.

Technically, IEC 61850 protocol can be implemented over serial communication mediums. However, the standard has only been implemented on TCP/IP to date, supporting forward adaptability.

How do gateways fit within an IEC 61850 environment?

Substation environments adhering to IEC 61850 standard incorporate IP based devices that can be reached remotely. Devices can also interact with each other, without a translator per se. So, how does a gateway fit?

At first glance, a gateway may seem redundant. Yet, it can yield powerful benefits in terms of system efficiency, performance and cybersecurity. Users should run a cost versus benefit evaluation to account for the cost of hardware and installation compared to the extra features and functions in their system.

SMP Gateway features in an IEC 61850 environment

Efficient device management

While a SCADA system can directly communicate with all the devices in the field, this approach can be inefficient, especially in large systems with a high number of substations and devices. In other words, device management can easily get out of control. A far more practical approach would be to add an SMP Gateway in the substation to locally handle device addition, removal and configuration modifications. Using the SMP Gateway can drastically reduce the amount of necessary work in the control center as minor modifications will be hidden from upstream.

Further, with an SMP Gateway in the substation, it is possible to resolve differences among manufacturers' device models. The gateway provides flexibility for users to resolve conflicts at the substation level.

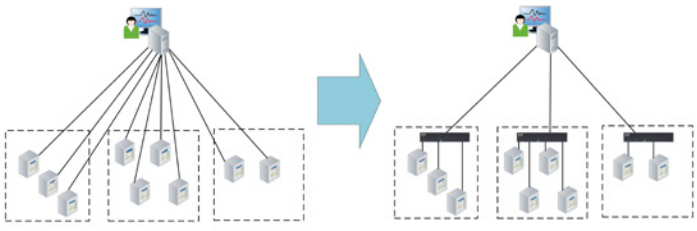

Figure 1. Data concentration with SMP Gateway.

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Uniform substation modeling

Beyond supporting more efficient device management, an SMP Gateway can simplify and expedite substation modifications and additions by unifying modeling. The gateway can create a uniform IEC 61850 substation model template and mask the differences among substation devices and architectures.

For example, device manufacturers try to model as much information as they can within their devices, even if the information is not required by the SCADA system. This extra data should be disabled or ignored at the control center level and an SMP Gateway can ensure that only necessary information is communicated—reducing SCADA system workload and required network bandwidth.

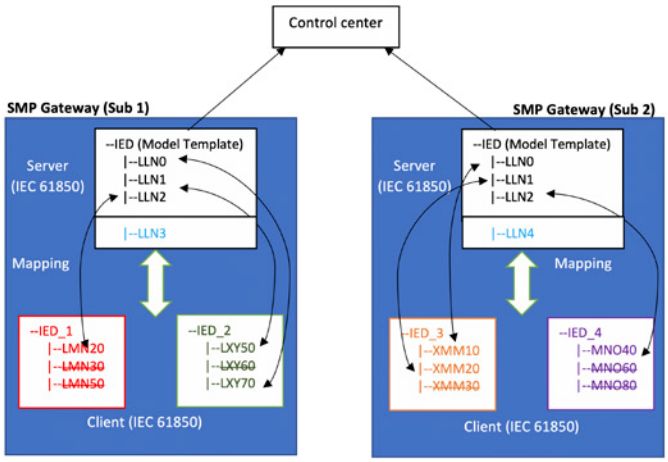

Figure 2. Making uniform models in SMP Gateway.

To make the model more flexible, SMP Gateway Automation Function logic processor can be used to generate new data points by applying some logics to the information received by the devices. These new data points can then be included in the uniform model and sent to the control center.

With its support for both Edition 1 and Edition 2 of the IEC 61850 standard, an SMP Gateway can also integrate devices that only support Edition 1 in an Edition 2 environment.

Advancing cybersecurity

Concentrating field devices in an SMP Gateway instead of establishing direct communication links between each individual device and the SCADA system can help reducing the security risk.

Routers and firewalls are deployed in network infrastructure to enhance the security of the system. They typically work on the network and transport layers of the open systems interconnection (OSI) model. Extra security can be set up using an SMP Gateway to segregate the internal substation network from the outgoing network by blocking the packet routing between these two networks. Information exchange is done on the Application layer, where an SMP Gateway parses messages from one side to the other side.

In this setup, one SMP Gateway port is connected to the internal network. A second port can be connected to the outgoing network through the router and firewall. As SMP Gateway does not conduct packet routing between two separate ports; in-substation IEDs are separated from the outgoing network at the TCP/IP level. However, they can send information out through the SMP Gateway at the application level. The SMP Gateway can encrypt the communication with the control center using TLS for enhanced security.

To support secure remote access to devices in the field, transparent connections can be established. This approach enables remote operators to connect to devices for maintenance and programming purposes. These connections are logged, and users can be granted access based on the privileges defined by the system administrator. All access logs can also be sent to a syslog server for further processing.

When paired with Eaton's IED Manager Suite software (IMS), users can use their corporate credentials and privileges to access the devices. All logs are centrally stored for potential future auditing or troubleshooting. The Eaton's IMS software can also generate NERC-CIP compliancy reports based on collected information.

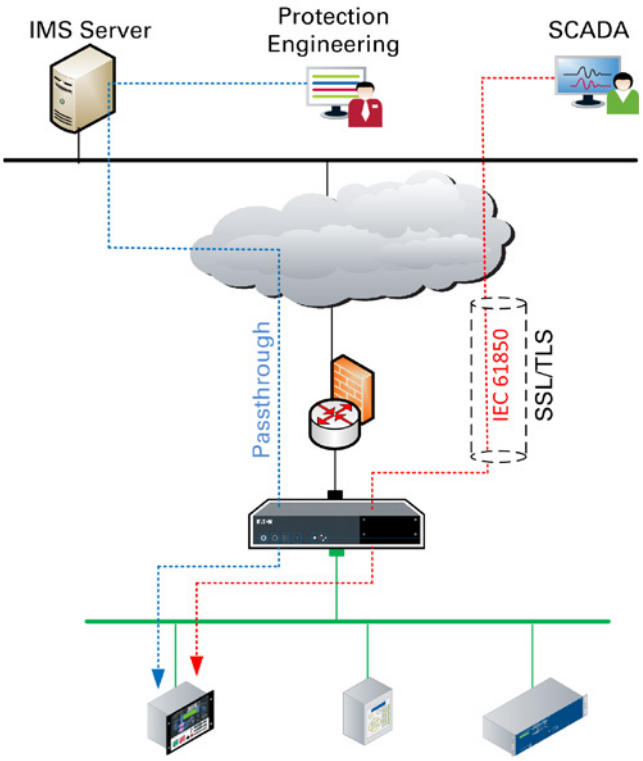

Figure 3. Passthrough connection architecture.

In addition to these cybersecurity mechanisms, SMP Gateway has an internal firewall that works based on whitelisting. All ports are blocked by default and only necessary ports are open to minimize the chance of unwanted inbound traffic. SMP Gateway also runs a malware detection code that only allows Eaton's digitally signed codes to run on the platform. If it detects suspicious code, it immediately blocks it and restarts in safe mode (no communication between the devices and the SMP Gateway).

Support for system redundancy

Device redundancy (e.g. A/B protection model) is essential to high availability systems and is widely used in critical infrastructure. The idea is to have an active and a backup device concurrently receiving information from the system. The backup device (even though fully functional) is not used unless the system detects the active device is not available anymore.

Device redundancy can be handled in SCADA, but it needs to constantly process and monitor two sets of data streams, which is not ideal especially in large systems. For optimization, the redundancy management task can be transferred to an SMP Gateway in the substation. The SMP Gateway can monitor both devices and decide which set of information should be sent out, while keeping it completely transparent to the control center.

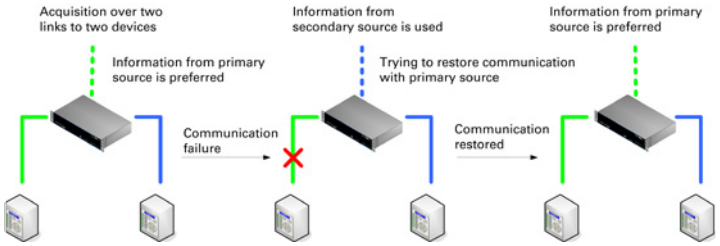

Figure 4. SMP Gateway redundancy.

The SMP Gateway itself can function in a redundant configuration to support high available systems. In this architecture, the active SMP Gateway receives information from the IEDs in the field and sends it to the control center. It also updates the internal database of the standby SMP Gateway to always keep it up to date. In case of a failure on the active SMP Gateway, the standby SMP Gateway is ready to take over the control and keep sending information out.

In addition to device redundancy and gateway redundancy, SMP Gateway supports other forms of redundancy (network redundancy, control center redundancy and device link redundancy) that can be useful in an IEC 61850 environment. Both Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR) for network redundancy are supported by SMP Gateway as recommended by IEC 61850 standard.

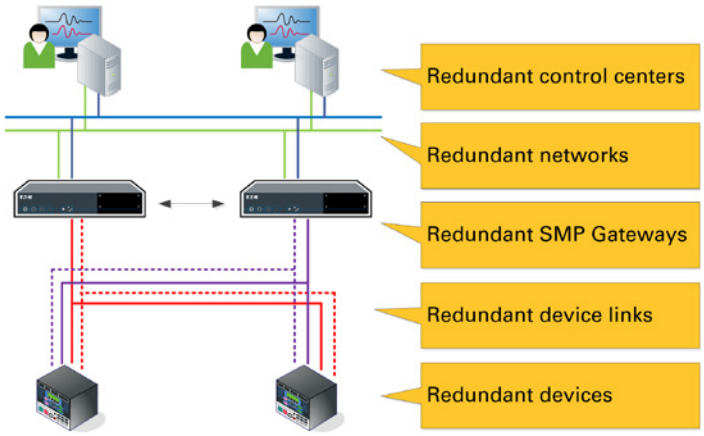

Figure 5. Redundancy options.

Integrating legacy devices in the IEC 61850 environment

Except for greenfield projects, there are always some legacy devices that either cannot communicate in IEC 61850 or support edition 1. To control the costs, clients prefer to gradually move toward a fully IEC 61850-based systems. In such cases, protocol translation capability from older protocols to IEC 61850 is crucial.

With its support for more than 80 different proprietary and standard protocols, SMP Gateway can convert legacy protocols into IEC 61850. An important advantage of this approach is the future ability to map the nodes from the new devices on the client side to existing nodes on the server side, so from the point of view of the control center, no changes would be necessary.

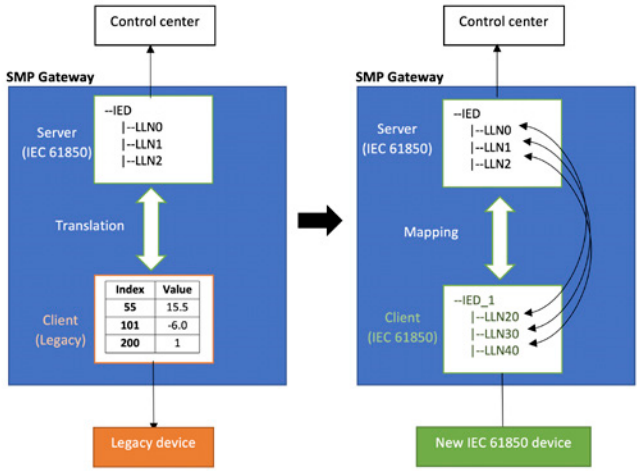

Figure 6. Using legacy devices.

Efficient testing, commissioning and simulations

SMP Gateway comes with a set of powerful diagnostic tools including SMP Trace, SMP log and SMP Stats. Users can trace real-time information exchanges between different devices and the SMP Gateway from the link layer up to the application layer. These tools help operators to test, troubleshoot, isolate and identify problems faster and more easily.

SMP Commissioning Tools, which is accessible via a web interface, enables users to verify real-time value of the data points as well as simulating points and devices to study the effect of certain changes in the system in order to test different scenarios before installing the SMP Gateway in an operational environment.

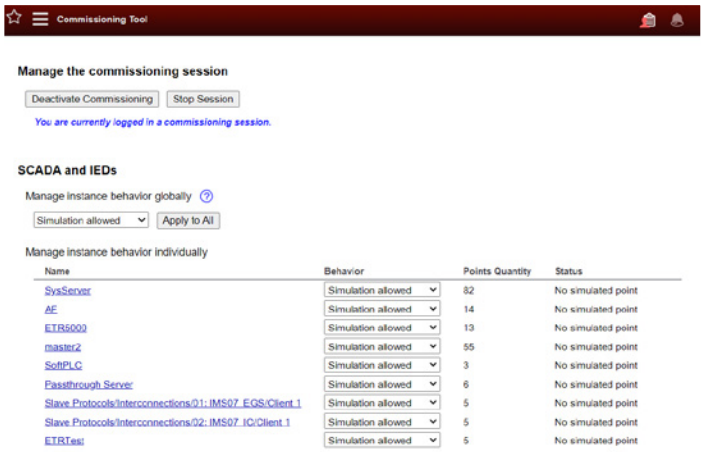

Figure 7. SMP Gateway commissioning tools.

SMP Gateway as an HMI

The SMP Gateway supports HMI functionality that can be accessed remotely (via web browser) or locally (with a touchscreen that connects directly to the box) to support testing, troubleshooting and day-to-day substation operations. Additionally, the SMP Gateway provides diagram functions that can be custom designed to monitor and control the points received by SMP Gateway using IEC 61850 protocols.

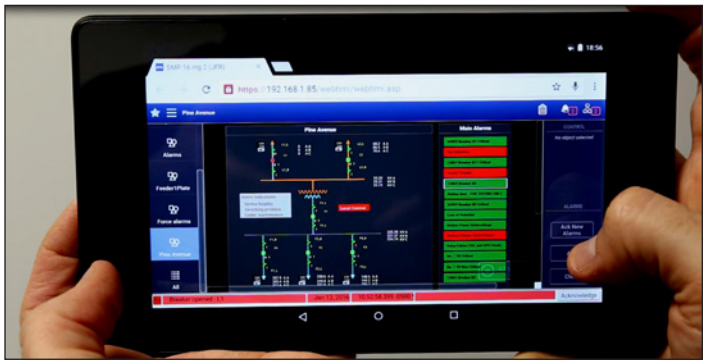

Figure 8. SMP Gateway Web HMI.

The SMP Gateway HMI also supports alarm management functionality. Alarms can be defined on various points based on threshold or on/off criteria, so visual and audio notification can be raised when an alarm becomes active.

Figure 9. SMP Gateway HMI alarm management.

IEC 61850 logic processing via SMP Gateway.

The SMP gateway supports logic processing engine based on IEC 16131-3. Information read using IEC 61850 protocol can be fed into this engine for preprocessing or to generate new data that can be used locally or sent out to the control system. As SMP Gateway concentrates datapoints from the devices in the substation, it is the ideal place for centralizing the logic implementation.

For example, a cause and effect algorithm can be implemented based on the status of circuit breakers and other system parameters to send load shedding commands and notify the control center about system updates.

Using a logic processor at the substation level can reduce the calculation load of the control center by distributing the pre-processing jobs to the substations. Generated data can be used for additional purposes like providing extra automatic prevention measures in case the communication between the substation and control center is temporarily lost.

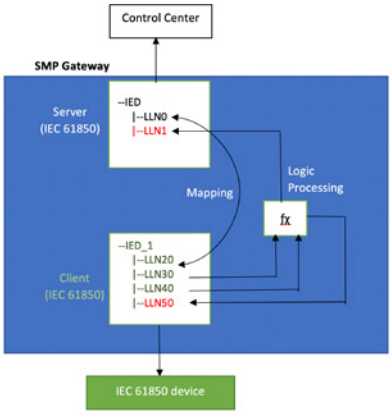

Figure 10. SMP Gateway logic processing.

Automatic file acquisition

Although IEC 61850 protocol supports file transfer features, the SMP Gateway can be used as a local repository to collect, compress and save the files for short- to mid-term time periods to reduce the necessary communication bandwidth. This repository can later be transferred to a corporate repository file server by polling the SMP Gateway using IEC 61850 or any other supported protocol.

Using Eaton's IED Manager Suite (IMS), locally stored files can periodically be polled and saved in the IMS central server. Once the files are transferred, IMS can send notification to the predefined users, so users won't need to periodically check the devices for new files.

What's the upshot?

Eaton's powerful SMP Gateway technology used at the substation level helps utilities improve their system architecture at multiple levels by transferring some configuration and bandwidth load from the control center to the substations and by concentrating data points and optimizing the substation IEC 61850 model. This approach offers advanced cybersecurity by exposing less devices to the corporate network and offers additional functionality that is necessary for a well operated and maintained modern substation.

About Eaton

Eaton's mission is to improve the quality of life and the environment through the use of power management technologies and services. We provide sustainable solutions that help our customers effectively manage electrical, hydraulic, and mechanical power – more safely, more efficiently, and more reliably. Eaton's 2020 revenues were $17.9 billion, and we sell products to customers in more than 175 countries.

About the author

Reza Dehghan is an electrical engineer with a master's degree in computer science from Concordia University in Montreal, QC. With 20 years of experience in the industry, Reza has mainly worked on electrical power and automation systems during his career. Reza joined Eaton's Substation Automation group in 2012 as a field application engineer and he has been involved in various communication/automation projects in North America, Europe and South Asia.

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