WHITE PAPER

Using MMS and SNMP to Integrate IT Management for Substation Automation

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Electrical substations are time-critical systems that rely on highly precise automated monitoring and messaging to guarantee effective and safe control. The devices that comprise these systems must therefore be extremely reliable and efficient, providing real-time feedback with dependably prompt reaction times. However, different classes of substation approach these issues in different ways. For conformity's sake—and to future-proof their automation systems—the most up-to-date smart substations use intelligent electronic devices (IEDs) as defined by IEC 61850, to monitor and control their switchgear and transformers. Using IEC 61850, these systems may be consolidated using the Manufacturing Messaging Specification (MMS), Generic Object Oriented Substation Events (GOOSE), and sampled measurement values (SMV).

The monitoring and messaging protocol used for communications in IEC 61850 compliant systems is MMS. However, as IT networking devices have been increasingly applied in IEC 61850 systems, equipment that does not communicate using MMS—devices like industrial Ethernet switches and embedded computers—have also become important cornerstones for communication and control. In contrast to IEC 61850 devices, the protocol today used for managing IT equipment is SNMP, a protocol entirely distinct from MMS, comprised of a wholly different logical structure. Additionally, to complicate matters, some substations today exclusively use SNMP, without any implementation of MMS whatsoever, and for these stations SNMP is an indispensible requirement, with no alternative.

Within the substation automation industry, it's clear that SNMP and MMS must continue to exist side-by-side, and bridging the gap in systems that mix the two can sometimes be an expensive and time-consuming challenge. These divergent messaging interfaces thus form a bottom-line liability for substation operation, and in poorly planned systems negotiating their interoperability issues may increase overall operating costs as well as complicate or slow substation operators as they go about their daily work. To a designer of electrical substations, IT equipment that supports both MMS and SNMP is an ideal, one-size fits-all alternative that provides the best of every conceivable world.

Rapid Changes in the Electricity Industry

To achieve the highest level of interoperability and compatibility in IEC 61850 substations, engineers should be able to call upon IT equipment capable of supporting MMS communications. The upside offered by such devices is clear: a fully integrated management platform utilizing a single communications and networking paradigm. It is, of course, possible to use regular SNMP-capable IT equipment without MMS support, but the downside will be far more complex management architectures, with MMS and SNMP comprising distinct, incomplete subsystems within the station: SNMP for IT devices, and MMS for IEDs and everything else.

Released on May 22, 2013

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For the last ten years or so, the electrical substation industry has invested a great deal of time, money, and effort into establishing an industry-wide interoperability standard for substation automation. IEC 61850 defines data objects for all of the key services required by the substation domain. The IEC 61850 data models are the Manufacturing Messaging Specification (MMS), Generic Object-Oriented Substation Events (GOOSE), and real-time Sampled Measurement Values (SMV); together they form a comprehensive suite of protocol-independent (and thus future-proof) substation services to which all IEDs and other high-voltage monitoring and control hardware must conform. Unfortunately, the standard does not succeed in integrating all of the devices now commonly found in today's substations. Over the last twenty years, IT hardware has steadily advanced deeper and deeper into the electrical production and distribution process, forcing substation engineers into a rather sloppy situation: the devices that form the Ethernet communication network use IT technology, while proprietary IA protocols or the IEC 61850 suite is used for everything else. Each is an independent, incompatible system that is distinct from the other, with one for monitoring and control of the substation's IT hardware via NMS, and the other for monitoring and control of switchgear, IEDs, transformers, and other substation operations via MMS, GOOSE, and SMV. As a result, IEC 61850 substations are today suspended between two competing standards, leaving engineers coping with irrational, expensive, and time-consuming redundancies that would best be eliminated.

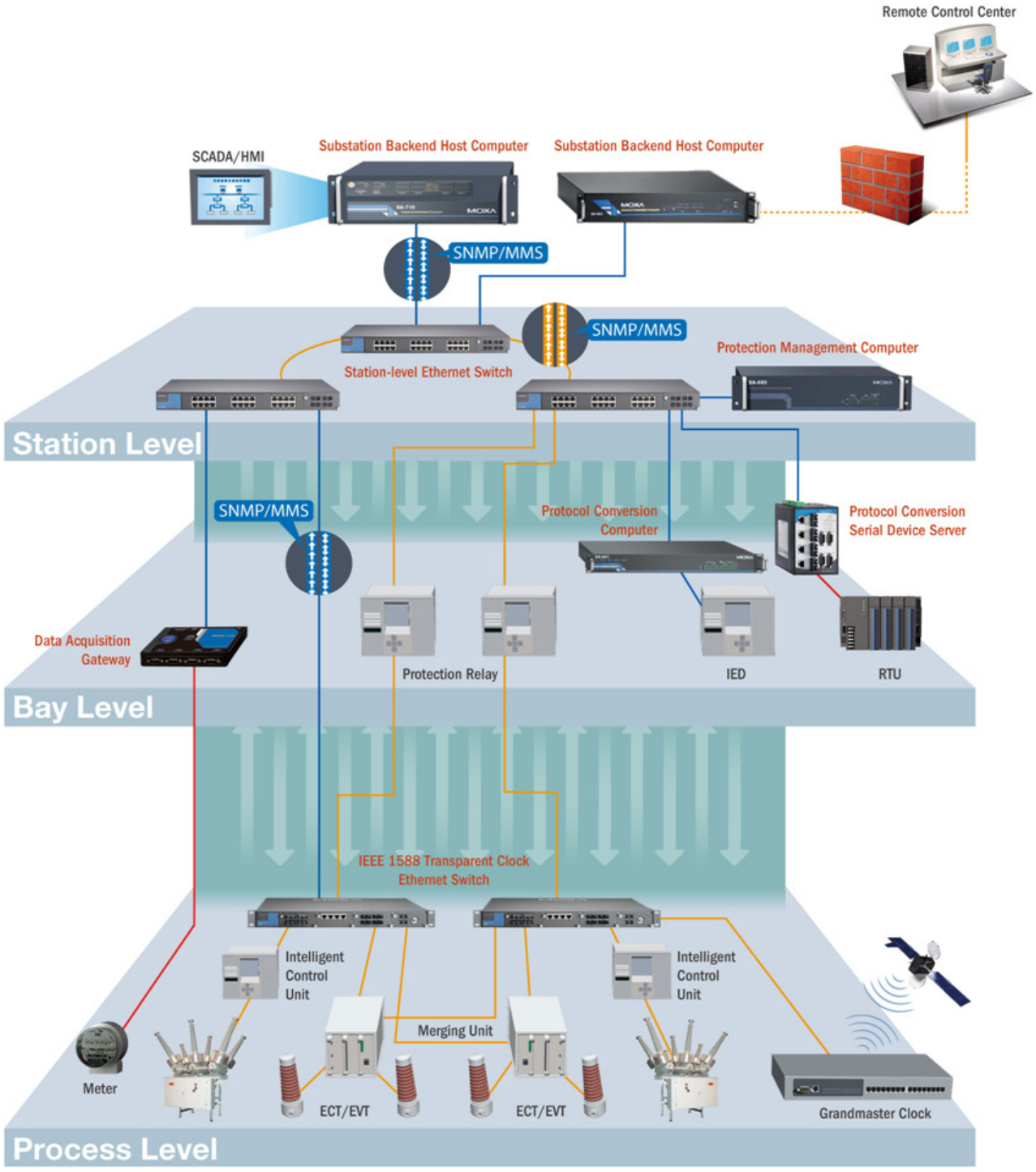
Yet the problem doesn't end there. Substations operating on a smaller budget, or which have no need of IEC full 61850 compliance, often choose not to fit their systems with these expensive and complex technologies. Instead, many smaller downstream stations have been content to stick with traditional mechanical switchgear and automation, and have adapted IT technology like SNMP (or IA tech like Modbus) for internal monitoring and alarms. This is understandable, because SNMP and NMS are established, mature, reliable technologies that are easily adapted to a wide variety of monitoring needs. Putting these proven services to work automating substation processes is only a matter of applying simple scripts to well-understood sensors and hardware.

Thus, when considering the current state of electrical substation automation the technological situation is rather tangled. For substations which are interested in future-proofing their equipment and maintaining the most efficient, cutting-edge system available, the way forward is clear: MMS is clearly intended to serve as the monitoring standard for IEC 61850-compliant electrical production and distribution, and in that environment SNMP is a de jure subordinate. Yet currently, few (if any) IT devices support MMS. Meanwhile, for downstream substations operating on constrained budgets or relying on conventional mechanical switching and automation, IEC 61850 equipment is often unnecessary and irrelevant; for these systems SNMP is an effective, even indispensible automation alternative that forms the bedrock of the internal monitoring, alarm, and (to some extent) control systems.

SNMP, MMS and Substation Architectures

IEC 61850 conceptually separates substation architecture into three layers that correspond rather closely to basic machinery (switchgear and transformers); channels and devices for messaging, automation, and real-time communications (the process layer); and data collation, analysis, and system controls (the station layer). Depending on the sophistication of the primary equipment, the advancement of its automation, and which layer is being equipped,

SNMP or MMS may be more or less applicable. The decision about which one of these approaches is used coincides with how great an investment the substation owners want to make in future-proofing the facilities, and how important cutting-edge technology is to the purposes served by the station.



The station layer of nearly every substation—whether one within a utility grid or a localized downstream facility—will be equipped almost entirely with IT hardware (switches, routers, and computers serving SCADAs, HMIs, databases, and other IT functions), and consequently all or nearly all of these machines will have SNMP available. Lower down, however, things diverge: at the bay layer, utility stations will be a hybrid system that is equipped with IEC 61850

compliant merging units and IEDs (MMS) installed alongside a few IT switches and device gateways (SNMP); the process layer, on the other hand, will feature advanced IEDs and GIS machinery (smart transformers and switchgear) that is already engineered for integration with intelligent IEC 61850 devices that utilize MMS, SMV, and GOOSE. However, in addition to these advanced IEC 61850 systems, there exist many other substations that do not feature such advanced intelligence, nor even feature a distinct process bus; instead, these rely on conventional mechanical switchgear and transformers kitted out to return regular feedback for predictive maintenance and emergency alarms, all linked over simple Ethernet. For these conventional systems, MMS/GSE/SMV technology is beyond their means, and largely irrelevant.

The Coming Changes to IEC 61850:

MMS (Almost) Everywhere

With only this slight bit of mechanical overlap between the station layer and the bay and process layers, engineers working in advanced IEC 61850 substations have so far been able to sidestep full device integration with few inconveniences or worry. Yet these deployments are not quite fully integrated and interoperable, particularly at the process layer, where IT technology and IEC 61850 most overlap.

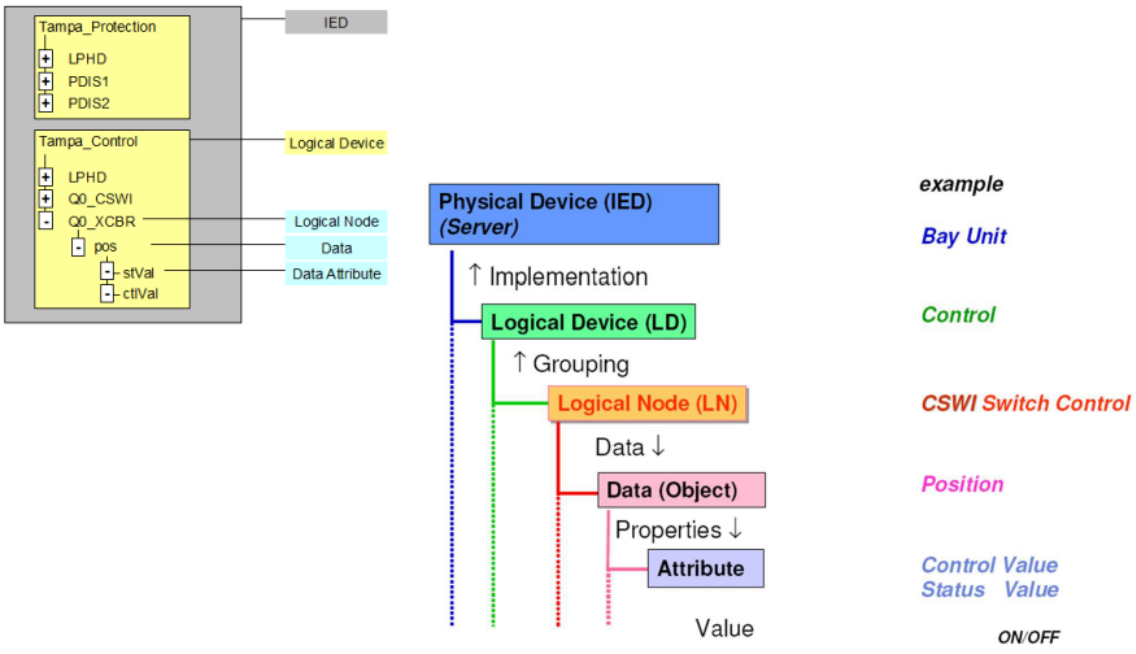
Currently, SNMP and MMS reports are separated into two independent, mutually exclusive software views. Presumably this is because Power SCADA systems basically employ two independent SCADA for supervisory controls: one that uses NMS to oversee SNMP-compatible IT subsystems (HMI and SCADA servers, databases, IT switches, etc), and the other using MMS for everything else. Yet as the process bus becomes more and more established within substation systems, IT switching and computational hardware (panel computers, HMIs, databases, and device servers) are moving ever more deeply into the bay and process layers, making this arrangement unwieldy and expensive, whether in terms of deployment, maintenance, or workflow. With two separate systems, it is often hard for engineers to keep track of where switches and computers within the IT/NMS subsystem are located relative to the GSE/MMS subsystem, and vice versa. Additionally, without customized software adaptation, warnings within either of the messaging systems will not be automatically reflected in the other. Automation engineers working to build IEC 61850 compliant systems thus have a strong motivation to see these two systems consolidated under a single standard.

For IEC 61850, the momentum is clearly towards getting every device to communicate using MMS. Its next draft, IEC TR 61850-90-4, will likely be released in late 2013 or early 2014, and IT switches are already included as part of the new revision. Future versions will likely expand this to include embedded computers and station-layer servers, as well. The trend appears to be leading electrical utility providers towards eliminating SNMP/MMS incompatibilities by building real time messaging and control communications in all devices, using MMS and GOOSE over TCP/IP.

With these changes to IEC 61850 already in the pipeline, it is clear that the next generation of specialized substation IT switches would best be engineered not only with SNMP, but also with full MMS capabilities. This will allow substation engineers to include IT switches within the same SCADA/HMI overview, right alongside the station's IEDs. Following switches, the next

obvious step is to include MMS communications on substation computers. Ideally, once these changes reach their logical endpoint IEC 61850-compliant substations will be able to eliminate an entire software layer, consolidating all internal messaging for every device under a single model. This will improve communications, cut deployment costs, and eliminate a huge swath of maintenance issues and costs. Further, because substation engineers will only need to focus on a single set of tools and skills, operations efficiency and maintenance execution (and the associated costs) will improve, as well.

This presents a challenge to suppliers of IT switches for power substations: how best to implement a rational, integrated MMS data model for IT equipment, one that has yet to be fully defined but still remains compatible with other IEC 61850 equipment. Since the ultimate goal is full interoperability with any IEC 61850-compatible device, constructing a precise, successful, suitably responsive, and fully interoperable MMS data model for IT devices means a lot of research, careful debugging, and extensive testing for compatibility and reliability. However, all this work delivers one big benefit to the early-adopter IT suppliers who dare to take it on: having succeeded in bringing MMS to one class of IT devices, porting it to other IT devices (like embedded computers, wireless access points, or other IT networking components) is a relatively quick and simple process.



Rejuvenating Conventional Systems with SNMP

In contrast to the cutting edge of IEC 61850, some downstream substations take a very different approach to automation. These stations are typically automated with mechanical switches and transformers, and use conventional switchgear and transformers with only a minimum of intelligent devices. Moxa specialist Alan Harris, our Field Applications Engineer in substation automation, explains: "These automation networks are rigged up on small budgets, using whatever is immediately available. SNMP is often used for messaging, as is Modbus. Basically, it's whatever the engineer is most familiar with." For these setups, compact embedded computers may be used to serve and monitor local sensors and other I/O devices

that are linked directly to the basic equipment. In this way, SNMP can be adapted to provide extensive, customizable monitoring and alarms for non-IEC 61850 systems.

For these downstream stations, full automation of the entire stepdown, concentration, or delivery process is beyond their budgetary means. Yet monitoring and alarms remain critical objectives, aiding in daily operations, predictive maintenance, and emergency response. According to Mr. Harris, "The three key points that must be monitored are relay temperatures, the contact make and break times for those relays, and transformer oil temperature." By keeping these critical points under constant observation and subjecting them to around-the-clock statistical analysis, effective monitoring of a substation's local system with uncanny accuracy in failure prediction can be reliably achieved. Additionally, some system integrators are taking small embedded computers and combining them with other off-the-shelf components to assemble economical, alternative IEDs; by bringing MMS support to these embedded computers, these alternative IEDs may be configured to use either SNMP or MMS as the substation's primary messaging interface, giving substation designers a lot more leeway when building substation automation systems.

The main advantage to deploying these kinds of systems is that they are cheap and relatively simple to build; the hardware involved is basically nothing more than the right sensors at the right points all connected to a compact computer that supports serial, digital I/O, and Ethernet LAN interfaces. With SNMP, a custom MIB file must be created to serve the information in the intended fashion, and automation scripts authored to integrate and deliver the traps and reports to the remote NMS—simple tasks for any experienced IT engineer. With MMS, the data models would already be built in, but configuring the scripts would be a much more labor-intensive task. Still, with the right experience and enough time and effort, there is really no limit to what can be done.

Dual MMS/SNMP for Comprehensive Messaging Capabilities

By integrating MMS into Ethernet switches and other IT hardware (like embedded computers and other station-level servers), substation SIs and automation engineers will be able to use MMS to a render a full accounting of the entire network of IEC 61850 and IT automation within a single power SCADA view. Because substation systems will no longer need to resort to installing and configuring separate software for IT devices station, operators will win the opportunity for more thorough integration with tangible management efficiency and savings on deployment costs. Yet because full-scale integration of the entire array of devices currently requires significant customization to particular SCADA environments, substation operators may still choose to implement this transformation in a step-by-step manner, shifting their IT hardware over to the MMS network according as specified by IEC 61850. Additionally, some substation operators may opt to completely forego IEC 61850 integration, and instead apply SNMP, Modbus, or other workarounds to achieve their automated messaging goals.

Thus, for the foreseeable future, SNMP remains a critical communications technology that substation operators and engineers continue to demand. IT devices that feature dual MMS and SNMP communications are thus a powerful, exciting tool for future-proofing electrical substations against the rapid advances promoted by the ongoing enhancements to the IEC 61850 standard. Easily integrated into any existing system, but offering the potential for unlimited integration into IEC 61850 compliant systems—whether planned or already here—

dual MMS/SNMP functionality is the new must-have feature for anyone tasked with installing new substation hardware, whether for new systems or simple upgrades.

Moxa's new line of PowerTrans IEC 61850 switches now come with full MMS compatibility, with a complete implementation of IEC 61850 data modeling and a built-in MMS server. Our entire line of substation computers, switches, and other associated hardware all still feature our own enhanced SNMP support (with custom MIB files), but Moxa welcomes any inquiry into further customizing our switches, embedded computers, and other substation IT hardware with full or enhanced MMS support, made to your order.