IEC 61850 meets Industrial^IT

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The international electrical engineering community is continuously creating new global standards. These are not only important but also mandatory for ABB's global business. Standards, however, are invariably a compromise, designed to benefit providers and customers alike. And they have a dedicated application domain.

ABB, by comparison, works continuously to develop advanced concepts, such as Industrial^IT, that provide a competitive edge and maximize benefit for our entire customer base. This raises the question: How do international standards interact with company-driven concepts? In the domain of substation automation, where a new international standard, IEC 61850, meets Industrial IT, the answer is as clear as it is promising.

Substations are the key nodes in an electrical power network. It is here that the power flow is controlled, and also where the power system can be accessed by the supervisory network management system. In addition, most of the power system's protection equipment is installed here. With all this functionality it is hardly surprising that the substation automation (SA) system has a more or less distributed structure, and that its reliability is such a key factor in successful power system management.

A typical SA system has the three levels (station, bay and process) shown in 1.

The interface to the process can be established either by conventional hardwiring or by serial communication links.

The importance of substation communication

The backbone of every SA system is communication. The creation of a new communication standard – IEC 61850 [1] – especially for substation automation is therefore an important event. The main goal of this standard, to which ABB made a major contribution, is interoperability, ie the provision of capability that will allow two or more intelligent electronic devices (IEDs), from one or several vendors, to exchange information and to use it in order to function correctly, individually as well as together. Such a goal obviously makes special demands on both the system design and the system engineering. But what makes the standard especially challenging, and worthwhile, for ABB is the way it fits in with the Groups' commitment to having all its systems comply with its IndustrialIT concept [2].

Both IEC 61850 and Industrial IT (IIT) are the fruit of advanced thinking about the direction industrial automation is taking. To understand their special significance for substation automation, it is worth taking a look first at their individual characteristics.

> Both IEC 61850 and ABB's IndustrialIT solutions are the fruit of advanced thinking about the direction industrial automation is taking.

IEC 61850: A new standard for a new era

A key feature of the new standard is that it separates the application from the communication by means of an abstract interface 2. A domain-specific, object-oriented function and device model describes the application data with all services needed. The functions can be allocated freely to different devices 3.

The stack, selected from mainstream communication technology, comprises MMS (Manufacturing Message Specification) over TCP/IP and Ethernet. The object model is mapped in a standardized way to the MMS application layer, but time-critical messages pass directly to the link layer of Ethernet. Extension rules allow the model to be expanded to accommodate future needs. Changing the communication technology requires only new mapping. All these features add up to a future-proof standard, designed to safeguard the investments of utilities and providers alike.

The substation configuration language

Interoperability also calls for a standardized way of describing the communication topology and its allocation to the substation structure. The new standard's answer to this is the XML-based substation configuration description language (SCL). All IEC 61850 compliant engineering tools are therefore also interoperable.

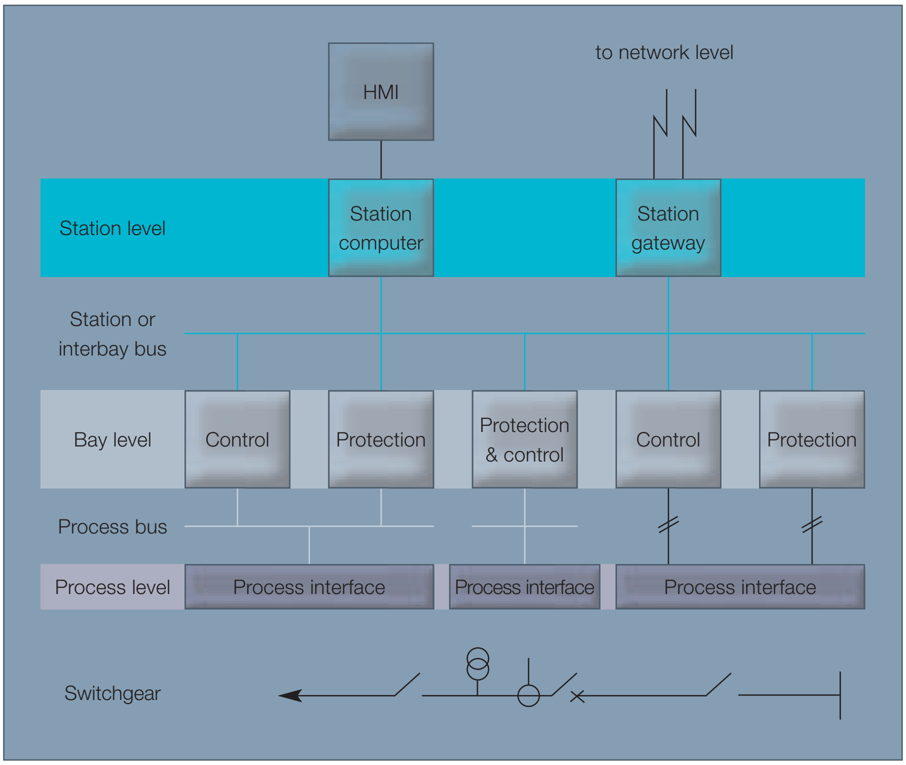
A common bus

IEC 61850 does not differentiate between the process bus (on which the current and voltage samples are transmitted) and the station bus (which transmits events, files and commands). Both functionalities can be realized on the same physical network, using a common bus. Nevertheless, performance and maintenance requirements may lead to designs with physically separated networks for the station and process buses 4.

Substation automation supported by IEC 61850

So far, substation automation has usually

1 The three levels of a typical substation automation system



been organized hierarchically, with separate station, bay and process levels. Client-server relations traditionally dominate the vertical communication across these levels. Within a level, peer-to-peer communication for automatic functions like interlocking is provided by GOOSE (Generic Object Oriented Substation Event) messages. The synchronous analog samples of voltage and current are transmitted cyclically. The new IEC 61850 standard supports all of this communication, at all levels of the substation.

Industrial[IT] – the new way of thinking

The IT revolution has produced an enormous, still-growing amount of data. This data is of varying interest to different users. For example, information from a substation automation system is useful not only for remote control but also for business purposes, such as asset management.

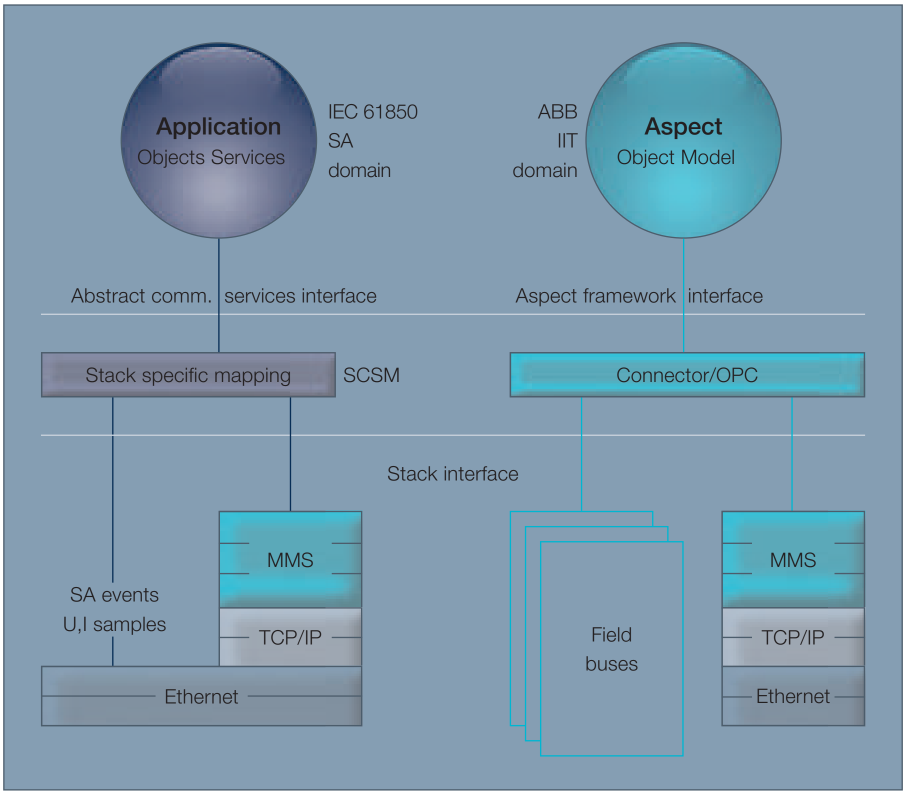
ABB supplies automation systems to customers in a very broad range of industrial sectors. Interconnecting these systems is a challenge in itself, but it can become even more complex, for instance when a network control system from ABB is to be connected to a business system from SAP. The customer's standpoint is clear: seamless communication is expected, from real-time information to business applications.

This requires proper object modeling and an agreement on the communication structure, which in IIT is based on MMS and TCP/IP. Different field buses for remote I/Os, sensors, etc. are also supported 2.

The Aspect model approach

All real objects, like circuit-breakers or motors, are modeled in Industrial IT as Aspect Objects 5. Aspect Objects contain all the information required to manage the allocated real object in different Aspects. The IIT architecture provides the Aspect Integrator Platform (AIP), which enables devices to exchange real-time information. The AIP provides the execution environment for IIT-compliant applications and includes the Aspect framework (the functionality supporting the integration of Aspect Systems and connectivity components).

2 Separating application from communication: the IEC 61850 approach (left) and ABB's Industrial[IT] approach (right)



The structures

To keep track of all the plant and process objects at their different levels of detail, IIT organizes them into different *object structures*, for example according to the logical process flow, the physical plant layout or the control system network.

The *functional structure* shows where a particular object fits into the functional context.

The *location structure* shows where an object fits into the physical (geographical) context.

The *control system structure* shows where a software function or hardware device can be found in the particular control system.

User-specific structures are also easily designed.

Certification levels

ABB has a certification program in place called *Industrial IT enabling*. A product can be Industrial IT Enabled at one of four levels, each one building on the prior level to provide further value. In this way, existing facilities can gradually grow into the Industrial IT Enabled world:

Level 0 – Information: Products enabled at this level present basic Aspect information in common electronic formats. The information can be technical specifications, drawings, manuals, a product classification, coding information, etc.

Level 1 – Connectivity: Products at this level can be connected to other Industrial IT Enabled products and basic data can be exchanged.

Level 2 – Integration: Products certified to this level can exchange more sophisticated data (status, maintenance, etc) with other equipment.

Level 3 – Optimization: Level 3 certified products have extended Aspects that can interact with other components to optimize the system in which they are working.

Industrial IT enabling of products ensures access to all required information as well as their seamless integration into systems.

Getting it together: Industrial[IT] and IEC 61850

To see how well IEC 61850 and Industrial IT go together in the ABB substation automation domain, it is useful to compare their respective key elements – device types, communication characteristics, object model, engineering information and certification rules.

The communication network set out in IEC 61850 is a high-performance LAN with all the features of an IIT control network. For the purpose of the comparison, it is therefore assumed that the IEC 61850 is a certified Industrial IT control network. Furthermore, it is assumed that all ABB devices in the SA system meet the requirements of both IEC 61850 interoperability and Industrial IT certification level 3.

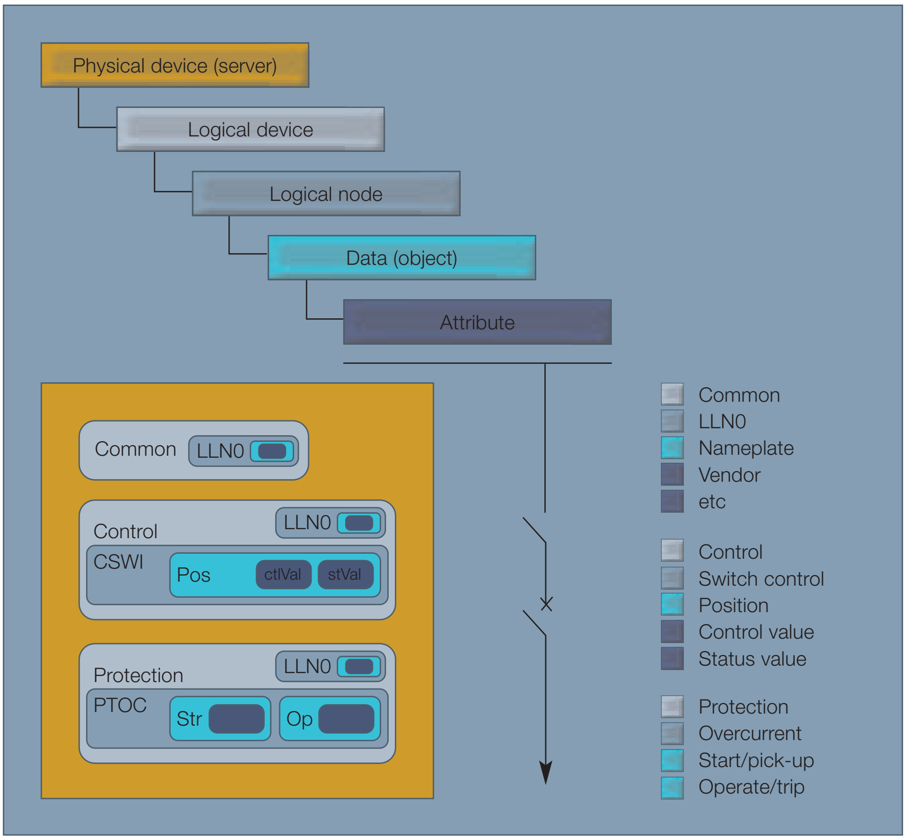
Device types

Protection, control and monitoring devices in the SA domain largely correspond to the control network devices in the IIT domain. Today, distributed protection systems, such as the busbar protection, tend to be mapped as a single control network device. In the future it will be possible to map each component of such a system, utilizing the IEC 61850 standard, as an individual control network device.

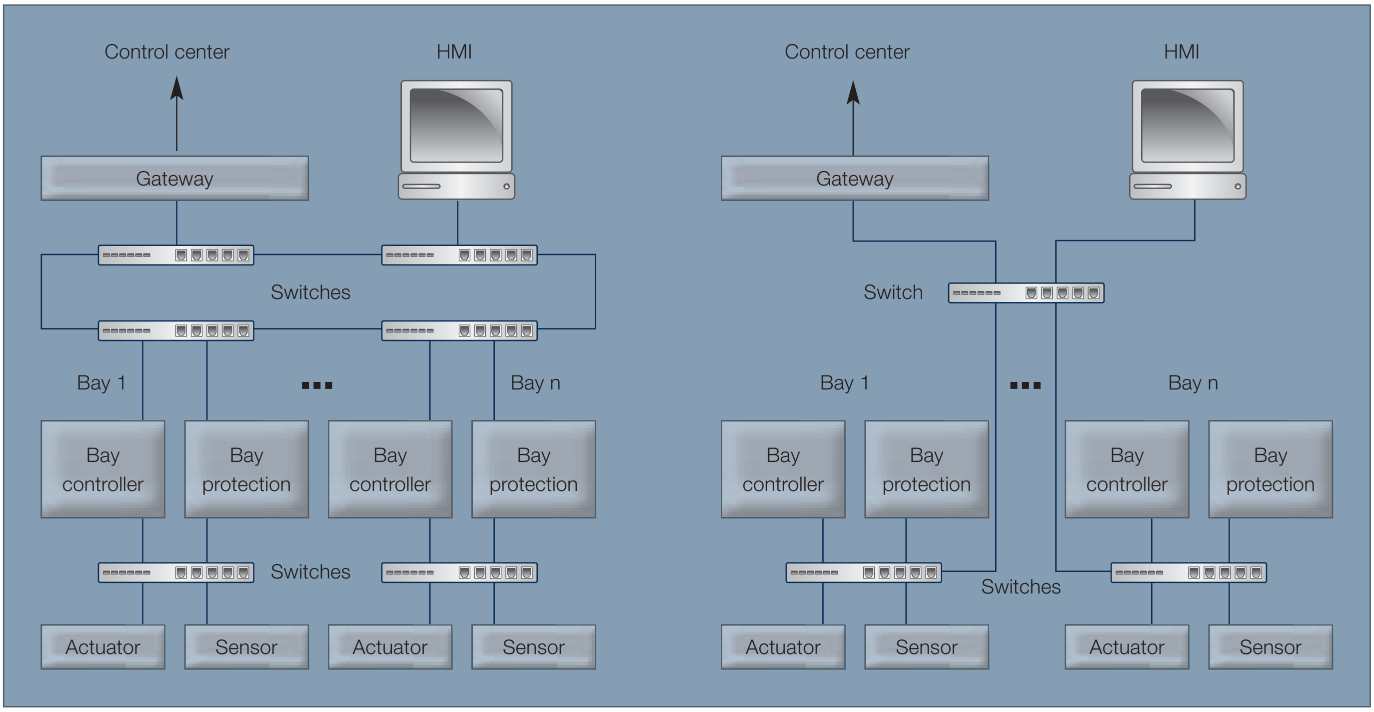
Communication structure and services

IIT defines a hierarchy of communication networks, from field buses through the control network and server network to the plant network. The

3 Data and device model of IEC 61850



4 Examples of bus structures according to IEC 61850
Separate or common networks for the process and station bus



IEC 61850 communication can be seen as a two-level network comprising the process and the station level communication. Both concepts allow the networks to be combined, ie the IIT server and control networks may be the same physical LAN, just as the station and process level networks may be the same station-wide network. (Note that, since IEC 61850 covers the interoperable communication for the entire substation, it does not define the integration of field buses in any way.)

The communication structures of IEC 61850 and the IIT control network are a good fit. The stacks are identical up to layer seven, both being based on TCP/IP over Ethernet, with MMS on top. The additional, reduced stack of IEC 61850, mapped directly to the Ethernet link layer, is needed for hard real-time data access to the sampled analog values and system-wide events. This data cannot be passed through the Aspect framework for performance reasons. If the data is required by the Aspect Integrator Platform, it must be collected and made available by a control network device. The data will then be transferred to AIP as bulk data.

Above stack layer seven there is an abstract interface and adaptation layer separating the communication from the application. In IEC 61850, the interface is the ACSI (Abstract Communications Services Interface) and the adaptation layer is the SCSM (Specific Communication Services Mapping). In the IIT domain, the interface is the Aspect framework interface, and the adaptation layer corresponds to the OPC (Object link embedded for Process Control) server/connector. These interfaces guarantee that changes and/or additions to communication will not affect the applications. They also ensure that IEC 61850 and the IIT communication are well integrated.

The solution created by integrating the new IEC 61850 standard with Industrial^IT has clear benefits for system integration in substation automation.

Application object models

IEC 61850 defines an application model with physical devices, logical devices, logical nodes, data objects and data attributes. The model is strongly supported by the Aspect Object model of IIT since, with this Aspect Object model, the entire ‘logical node’ model from IEC 61850 can be created and consequently re-used to model system implementations.

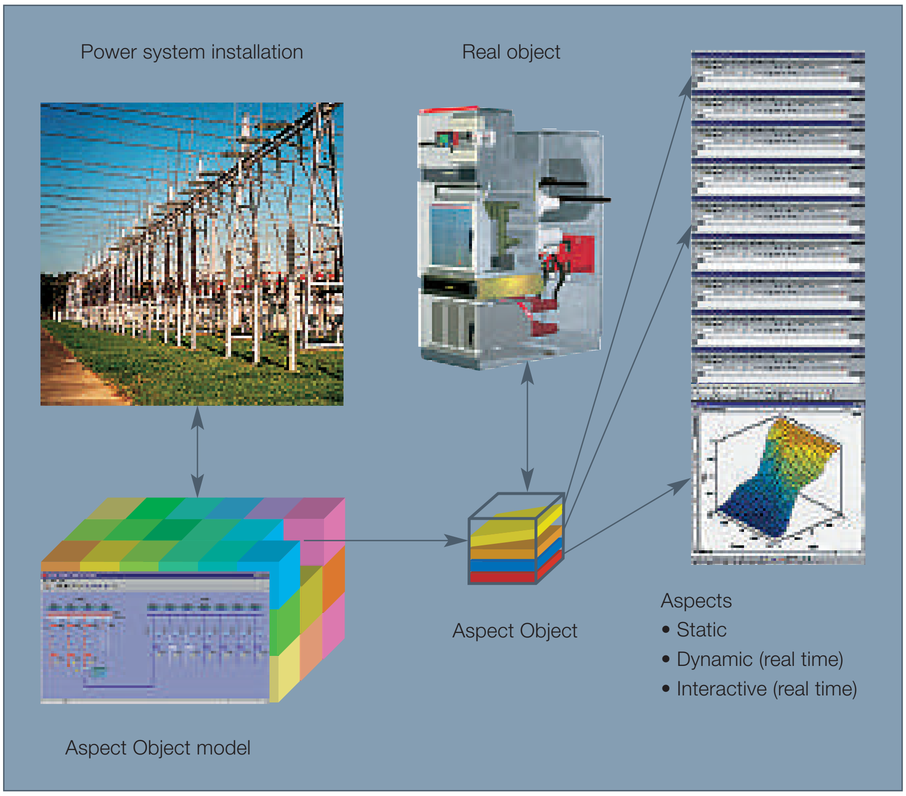
Engineering information

At the device level both concepts provide dedicated tools for creating and configuring the application functionality. In IIT this tool is the control builder, whereas in the SA domain several dedicated tools are in use today. The control builder can be used in the SA domain once SA systems have been integrated in IIT, but dedicated tools for individual devices in the SA domain will still be required, since these devices will also be integrated into third-party systems. The same is true for third-party devices integrated in ABB systems.

For the system engineering support, the IEC 61850 defines the SCL consisting of capability description files for both IEDs and the substation. These files contain all communication-relevant descriptions of devices and the station. Extensions are possible to provide enhanced support for ABB system engineering. Most of the definitions necessary for the Aspect System can be extracted from these files. As an example, the IED capability file defines not only the entire functionality contained in a device but also those Aspect Objects and Aspect Systems required for the system. The substation capability file contains the information necessary to define most of the hierarchical IIT structures required for the SA domain, such as functional, product and communication structures. The engineering information in these files can be used to configure the Aspect Systems more or less automatically.

For efficient engineering and to ensure consistency, all tools at the system and device levels must be able to exchange engineering information. This exchange has to be based on SCL, as defined in IEC 61850, since it must be possible to integrate third-party devices into the system.

5 Examples of Aspects for substation objects



Certification levels

The four-level certification described earlier ensures that products comply with the Industrial IT concept. IEC 61850 foresees conformance testing for the SA domain devices as a guarantee of compliance with the standard. ABB SA domain devices require both. The IEC 61850 conformance test must form an integral part of the IIT certification, extending the certification checklists as follows:

Level 0 – Information: The data object 'nameplate' in IEC 61850 supports Level 0 information, being stored either directly or by reference (links). Checklists must ensure that all this information can be derived from the 'nameplate' of the SA device.

Level 1 – Connectivity: Certain IEC 61850 conformance tests must be passed to provide this level of interoperability defined in Industrial IT.

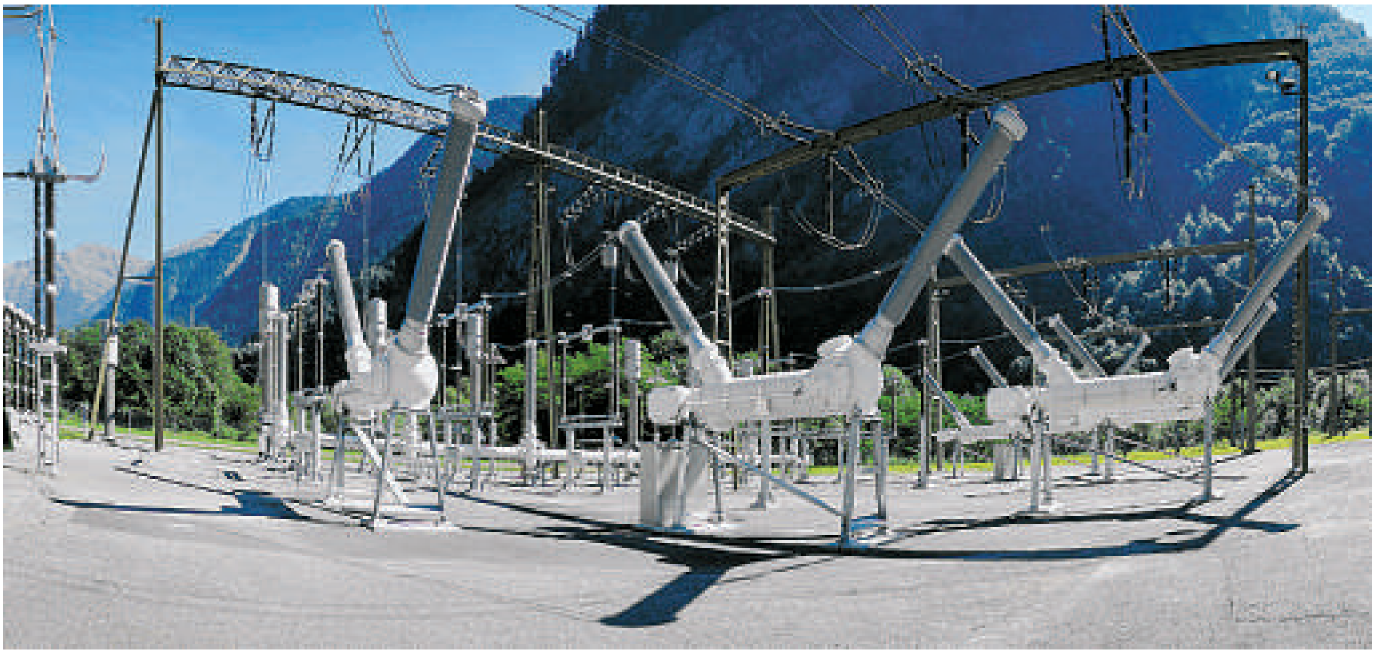
Level 2 – Integration: Additional IEC 61850 conformance tests must be passed. Also, engineering support based on the SCL of IEC 61850 must be partly available.

Level 3 – Optimization: All IEC 61850 conformance tests must be passed and all of the available engineering support must be provided to fulfill all requirements for 'plug & produce' in the SA domain.

A solid match

It can be stated without reservation that all the key elements of IEC 61850 and Industrial IT fit well together. No obstacles to the certification of an IEC 61850-compliant device in IIT are evident anywhere. In those areas requiring some amendments, both concepts offer a basis for their implementation.

Any requirements of IIT that go beyond IEC 61850 are relevant to ABB devices



only. Non-ABB devices that comply with IEC 61850 may be easily integrated into IIT via the IEC 61850 network and any missing Level 0 information provided, eg by a system server.

There are three areas in which some further work is needed:

- Use of the SCL definition to cover all engineering support required for Industrial IT and providing Aspect Object types for all SCL object types.
- Introducing and automating SCL handling in the Industrial IT tools.
- Amending all relevant certification checklists so that all IEC 61850 requirements are also covered.

The solution created by integrating the new IEC 61850 standard with Industrial IT has clear benefits for system integration in substation automation. For example, IIT enhances IEC 61850 in terms of interconnectivity across domains. IEC 61850, in turn, enhances IIT in terms of third-party product integration in the SA domain. In particular, the engineering support given by the two concepts facilitates very efficient engineering of ABB SA systems. Both ABB, as a system integrator, and our utility customers, as system users, stand to benefit from this in the SA domain, where experience shows that there is a need for many systems to have third-party products integrated.

The question asked in the introduction to this article can now be answered: Industrial IT provides customers with extended capability that enables them to make the most of international standards. In the SA domain, as we have seen, it is not only a case of selecting and combining elements of IEC 61850 and ABB's Industrial IT solutions. More importantly, the two concepts enhance each other in the key areas to make the whole greater than the sum of its parts.

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