When it was first announced, there was certain skepticism about the usefulness of IEC 61850. Could you comment on the extent to which it has gained acceptance globally and in the Middle East in particular?

Let us take a brief look at the background first: Utilities have long been seeking a standard for communication in substations to eliminate the need for costly conversions between the plethora of quasi-standard, but mostly proprietary, protocols. They also aimed at having a free choice of suppliers for different parts of their substation automation (SA) systems or extensions thereof and at easily combining equipment from different suppliers in fully integrated and interoperable systems.

Since its publication in 2004, the standard IEC 61850 has been accepted by utilities around the globe at an unexpectedly fast rate. The proof for this is as simple as it is impressive: The standard has now made its way into nearly all specifications for SA systems. Moreover, hundreds of such systems have already been delivered resulting in a vast amount of experience with new installations, retrofit and migration projects.

Some IEC 61850 SA systems are in service since the end of 2004 already. Amongst them is the world’s first multi-vendor system. This was implemented at the 380kV Laufenburg substation in Switzerland, where the special problem of varying life cycles of bay and station level equipment had to be addressed and the latter be kept for the time being. Therefore, ABB integrated its new IEC 61850 compliant bay control and protection IEDs (Intelligent Electronic Devices) with the existing third party station level. The transmission station belongs to the Swiss utility E GL and is one of the most important nodes in the European grid. In this context, it is noteworthy that E GL has recently entrusted ABB with the replacement of this third party system as well. This task will be done by fully re-using the engineering data from the original SCD (Substation Configuration Description) file, prepared by ABB on the basis of the Substation Configuration description Language (SCL) according to IEC 61850.

Most notably, Gulf customers were among the first to specify SA systems based on IEC 61850, soon after the only global standard for substation communication was published. Within their massive grid expansion projects including the Gulf link interconnection, dozens of new substations are needed. For their reliable operation, the utilities require future-proof secondary systems. High availability and most modern, yet proven technologies are also a must. Extending on past experiences and convinced of its strong commitment to the new standard, many customers entrusted ABB with their IEC 61850-based SA projects from the onset. The verified implementation of IEC 61850 throughout the portfolio as well as excellent system integration capabilities, afford customers all the benefits from state-of-the-art control, protection, and monitoring systems. Apart from higher flexibility, increased efficiency and safeguarded investments, these provide openness for future hardware and functional extensions, multi-vendor integration as well as high performance and availability. We are very proud to say that the present installed base in the Middle East region comprises more than 150 IEC 61850 SA systems and is continuously increasing.

What are the starting pains of working with 61850-compliant equipment?

The standard has an impact on all activities related to the field of protection, control and substation automation. How users in utilities and industry can specify protection and substation automation systems and how manufacturers can implement the standard in practice are main issues to be considered.

Experience has clearly shown that the key for specifying and ordering, designing and integrating, commissioning and maintaining powerful IEC 61850-based substations is reasonable knowledge of the standard. This is not only valid for suppliers but also for customers. Therefore, ABB started early to provide customer training on different levels in the ABB University or at the customer’s premises. The result is a mutual understanding to optimally exploit the benefits. An important aspect is also to learn what is fixed by the standard and should not be changed by any specification, as well as what has to be specified explicitly and may be directly influenced by the customer.

Specifications for SA systems should preferably be based on functionality rather than on specific devices to allow the system integrator to elaborate an optimal solution, taking further aspects into consideration such as performance and constraints.

Specifying systems in accordance with the standard IEC 61850 further means that the whole functionality is split into Logical Nodes with their corresponding data, i.e. with the established common naming of the function-related signal names. If this is not done by the customer, the system integrator has to do it.

It is also recommendable to check the “old” signal lists and to evaluate which signals are really needed, what purpose they have and which functions they belong to. This is especially important as they might not be mandatory data provided by all suppliers in their IEDs, but optional or even extended ones. Optional data are predefined but only provided as per the supplier’s choice, whilst extended data can additionally
be created by the suppliers according to strict rules ensuring interoperability.

The standard defines certain response times for various data exchange scenarios, but not the complete system performance. Users are therefore recommended to outline the system performance in the specification by defining the maximum response times for transmission of commands and receipt of process data. Especially for bigger systems, acceptable transmission times during a defined avalanche condition should be included as well. The design of the suitable system architecture is strongly influenced by the user's availability requirements. These should be specified either directly in figures or, perhaps more conveniently, by defining failure scenarios with accepted and non-accepted losses.

When it comes to refurbishment projects, not only the strategy needs to be specified, i.e. retrofit in one step with interruption of service or step-by-step supporting migration with almost no service interruption. It is also important to outline the needs for adaptation resp. interfacing to parts of existing equipment, which are retained. In an optimal solution, all these factors have to be considered.

With one of its main goals being interoperability between IEDs and tools independent of the vendors, IEC 61850 has enabled a multi-vendor environment and brought about a new role, namely that of a system integrator. When a SA system is to be built from IEDs and/or subsystems from various suppliers, one party has to assume the responsibility for ensuring that it all comes together in a properly integrated system. Apart from warranting, that the customer gets the ordered system as specified, the integrator shall also supply one common SCD (Substation Configuration Description) file based on SCL according to IEC 61850. The SCD file describes the entire SA system as built, belongs to the system documentation and is the basis for any future maintenance, update and extension.

You also asked which issues arise out of non-deployment of IEC 61850. The wide acceptance of IEC 61850 caused practically all suppliers to implement the standard in their portfolios and abandon further development of equipment using proprietary protocols. Since these do neither offer interoperability and free functional allocation nor use standardised data models, communication mechanisms and configuration descriptions like the SCL central data exchange format provided by IEC 61850, they restrict the user's flexibility in many ways. For any user wanting to freely choose the system architecture and equipment, have a truly interoperable system that is also future-proof and open for hardware as well as functional extensions, there is no way around IEC 61850. Since the standard is being extended to other domains such as power generation, communication between substations and to network control centers, it will eventually enable truly enterprise-wide data integration for efficient power system management, i.e. the "smart grid". Who would truly want his or her organisation to be excluded from all these current and future perspectives and benefits?

### IEC 61850 in brief

**Communication systems and networks in substations essentially defines standardised data models and sets, communication mechanisms as well as the system configuration language SCL and facilitates e.g. the**

- Interoperability of system components and software tools
- Free allocation of functions as well as choice of different system architectures
- Reuse of system configuration data
- Understandability of the system description and functionality

**Retrofit is very similar to a new project. If the retrofit is done stepwise we talk about migration.**

Migration is a retrofit where the old equipment – which might also include the switchgear – is replaced step-by-step. The main reason for such a procedure is to keep the substation in operation with the exception of the bay being retrofitted. For the SA system, this means the parallel operation of old and new equipment whereby a subsystem with IEC 61850 has to communicate with a legacy or hardwired one. Since for such a migration the boundary between the subsystems is moving with each retrofit step and the substation is in operation, migration is a big challenge both for the system integrator and the project manager.

Especially in developed countries with many stations being in their forties, fifties and even sixties, retrofit becomes increasingly important and also more economically viable owing to advances in technology such as hybrid switchgear and IEC 61850 substation automation and protection. ABB has comprehensive experience in performing retrofits in live substations with minimal interruptions. One example, the Laufenburg 380kV substation has already been mentioned.

Whenever existing devices are retained, they have to be integrated into the IEC 61850 SA system using external converters or gateways. This conversion not only involves a change of the coding of telegrams running over the wire or fiber, but also the mapping of legacy data to the object-oriented data model of IEC 61850. In addition, even the best conversion from a slower legacy protocol to the 100 Mbit/s of IEC 61850 has some performance limits by definition, e.g. for fast GOOSE (Generic Object Oriented Substation Event) messages.

These GOOSE messages can replace all wires and contacts between IEDs and...
offer a high potential for the realisation of any kind of distributed functions. Thus they are worth considering, even in stepwise retrofit projects, where ensuring proper performance of station-wide functions such as interlocking is a critical issue. An example for such a migration is the 380kV substation Sils, a challenging project ABB is realising for the Swiss utility KHR (Kraftwerke Hinterhein AG). For station interlocking using GOOSE messages, the auxiliary contacts of all disconnectors and breakers are being connected to the new control IEDs in parallel to the existing electromechanical relays. The latter will be taken out of operation at the end of the migration.

Any tools enabling the integration of IEC 61850 SA systems shall, of course, also facilitate the proper handling of migration projects. Whilst the system integration tools must support incremental engineering to allow selective refurbishment of components, a second important category of tools is required to perform system testing and commissioning, simulating the parts not yet refurbished or available.

Thus, powerful tools using the strongly formal Substation Configuration description Language (SCL) as per IEC 61850 are an important issue for the system integrator. Tool development or, at least the skilled use of such powerful tools is an absolute prerequisite for proper system integration. Owing to its excellent tools environment, ABB can handle large systems and demanding refurbishment projects, seamlessly integrate compliant third party IEDs and build a homogeneous system.

What type of skills sets will be required to develop IEC 61850 compliant power systems?
As mentioned earlier, utilities need to have a reasonable know-how of the standard and an understanding of its object-oriented data model. Also certain knowledge of the application of switched Ethernet technology is required to understand the various SA architectures with their respective implications, e.g. in terms of availability.

A system integrator, in turn, needs to have long experience with SA systems and applications, comprehensive expertise in IEC 61850 and solid system integration capabilities. Furthermore, skilled resources are needed to develop IEC 61850-compliant devices and tools as well as innovative applications such as GOOSE-based and distributed functions. These kinds of functions gain increasing acceptance and are not only needed on the transmission level but also on the distribution level.

The use of third party devices e.g. for main 2 protection in projects necessitates the know-how, skills and tools to integrate multi-vendor systems.

Independent of the manufacturer of the IED to be used, i.e. ABB or a third party supplier, it always has a product configuration tool and – according to the standard – an ICD (IED capability description) file. The grammar of all entries in these description files is defined by the standard. As said before, there are mandatory and optional data as well as extensions. Therefore, also compliant devices differ from supplier to supplier both in the functions that are not standardised by IEC 61850 and in the provision of data. System integration tools must therefore not only integrate all information from the IEDs and define the data flow between them, but must also compensate for these differences. A professional system integrator will be able to provide one common SCD (Substation Configuration Description) file based on SCL according to IEC 61850 also for a multi-vendor system. This file describes the entire SA system as built, belongs to the system documentation and is the basis for any future maintenance, update and extension.

Last, but not least a system integrator needs to bridge the gap between compliant and certified products and full systems. For this reason, ABB has installed a system verification center (SVC) which tests all IED types under consideration in a real system environment. The SVC is also qualified by UCA International since 2006 to officially verify the compliance of IEDs to IEC 61850.

What are the basic advantages of using IEC 61850? How should we calculate the Return on Investment (ROI)?
The domain-specific data model of IEC 61850 provides information for various parties within the utility and is continuously being updated according to the users’ needs. Through the client-server structure, all data may be made available to every interested party within the organisation, i.e. to operators, protection as well as maintenance engineers and even to the asset management. The mainstream communication technology used
i.e. Ethernet allows authorised access to data from any point in the communication network and makes the system future-proof by allowing to follow the progress in communication technology without any impact on the databases, algorithms, etc.

The strongly formal Substation Configuration description Language (SCL) and the use of the object-oriented data model with its semantics warrants user-understandable data irrespective of the vendor as well as data consistency through single data entry.

In addition, the comprehensive system description (SCD file) as per the standard can be reused for any future system extension or upgrade.

All these features render IEC 61850 future-proof and safeguard investments.

The standard also supports the free allocation of functions to devices on all levels and spanning from centralised (e.g. RTU type solutions) to fully decentralised configurations (e.g. intelligent sensors and actuators). This allows tailored designs of SA system architectures to meet the specific needs and operational philosophies of the users with the standard system components available from vendors.

The interoperability facilitated by the standard allows two or more IEDs from one or several vendors to exchange information and to use it in the performance of their functions and for correct cooperation. Similarly, it allows tools to be interoperable and directly use the engineering data provided in SCL-based files such as ICD and SCD files. Thus, users have a free choice of suppliers for different parts of their SA system.

Despite the coverage of a wide range of system aspects by the standard, it does not facilitate plug & play systems. The freedom given to vendors, e.g. in terms of the provision of data and non-standardised functions, creates the necessity for a system integrator, who shall take on the responsibility to realise a fully integrated SA system. This role implies vast know-how of the standard, long experience in substation automation, a powerful tool environment as well as excellent quality assurance as can be provided by a qualified system verification center.

The detailed ROI calculation depends very much on the actual situation on site and within the utility’s organisation. A reasonable ROI can, however, be assumed over the entire life cycle of the substation and its automation system. Replacement of obsolete components and extensions are common events during an installation’s lifetime. This is where the adoption of the IEC 61850 standard proves to be a wise investment, especially. Its SCD file always reflects the actual as-built status of the installation. Only incremental engineering is required to cater for the above mentioned events. This saves both money and downtime. In other words, it not only enhances life cycle management, but also results in a reduction of the life cycle cost.

For more information please refer to the responsible ABB sales engineer for your country or to the address mentioned below.

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