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THE BENEFITS OF THE COMING STANDARD IEC61850 FOR COMMUNICATION IN SUBSTATIONS

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ABSTRACT

The easy exchange of information between all devices in a power control and management system and the free access for all interested parties is a basic requirement for competitive power business today. Easy access to and data exchange within such heterogeneous systems claims for an international communication standard. - The communication in substations, i.e. for substation automation systems has to support the dedicated requirements of the involved functions. Strong real-time behaviour is requested and a high withstand-capability against harsh environmental conditions. The long lifetime of substations claims also for long life cycles of the communication standard. - An open system needs a communication standard not only open for interoperability but also for changes in technology (state-of-the-art) and operation philosophies. - Substation automation systems are widely accepted today but are mostly based on proprietary solutions or (de facto) standards not specifically designed for substations and its requirements. To fulfil all these requirements a new standard with a very advanced approach is requested. Such a standard is the coming IEC61850 common for the IEC and ANSI world. - How the standard fulfils all these requirements and what benefits it offers to the users in a unique way is shown by examples like the independence from actual technology, the support of free allocation of functions and of long-term system maintenance. - The standard consists of ten main parts. The most parts exist in draft form and some fine-tuning is needed, but first steps in the voting procedure have been already started. Therefore, the most parts will be ready and, hopefully accepted in 2001.

MOTIVATION

The motivation for a standard is based on the role of communication today. Communication appears as a global phenomenon today and is an important part of IT (information technology). All information has to be available in an understandable way where it is needed.

The communication network has to provide at least the connectivity of all communicating partners, to allow access to all data of interest, to use a common agreed syntax and semantics and to show a controlled time behaviour (Fig.1). The power system (primary system) is controlled by control and management systems (secondary system) with more and more numerical devices and advanced sensors for data acquisition. These secondary systems produce an increasing amount of data. Besides this *technical trend*, there is an operational *request* to get more and more data for running a competitive power business in deregulated markets. The communication has to provide this data everywhere it is needed.

More precisely, no data is needed but information. Information is a properly pre-processed set of all relevant data in the context of the process the system is build for. The full semantic meaning has to be supported by the communication.

All this information is used for decision making, either by *human beings* for system operation and business management, or by *automatics* for fast and safety-related decisions. Since such automatic decisions support a fail-safe running of the primary system, they contribute also to the competitive power business.

Large and historically grown systems like the power system consist of a heterogeneous set of data-producing and decision-making equipment. The request to include all data or information respectively for decision making calls for a common language for the data and information to be communicated, i.e. for an international communication standard.

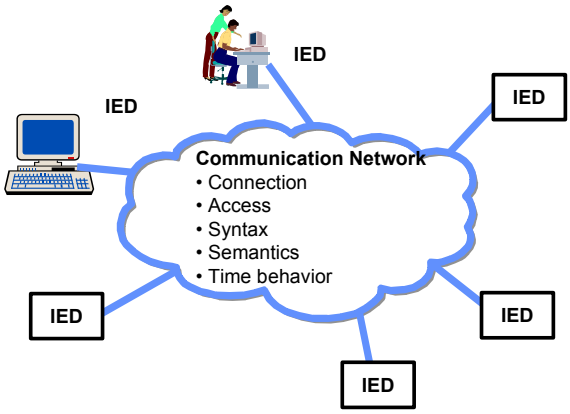

Fig.1 – Communication network with communicating intelligent electronic devices (IED)

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SPECIFICS OF THE APPLICATION DOMAIN

Same as we speak of industrial IT, also communication requirements are depending on the functionality to be supported, i.e. we have to look to the substation domain. The power system consists of nodes called substations. At this level, the control and management system is represented by a substation automation system including protection, monitoring, etc. A standard for communication in substations will not standardize the functions, but is depending on the functions to be performed in the substation.

Fig.2 shows a typical example of a substation automation system with its common three levels. At process level there are the process interfaces hard-wired in the past and serially linked by the process bus in the future. Protection and control at bay level may reside commonly in one device or in dedicated ones. These devices are connected in between and with the station level by the interbay/station bus. At station level, there is very often a station computer with HMI (human machine interface) and a gateway to the control at the higher network level. There exist a lot of variations of this example but all substation automation systems have to provide all or at least a subset of the following functions with some domain specific performance, heterogeneity and life-time conditions.

Important function groups and functions are given below.

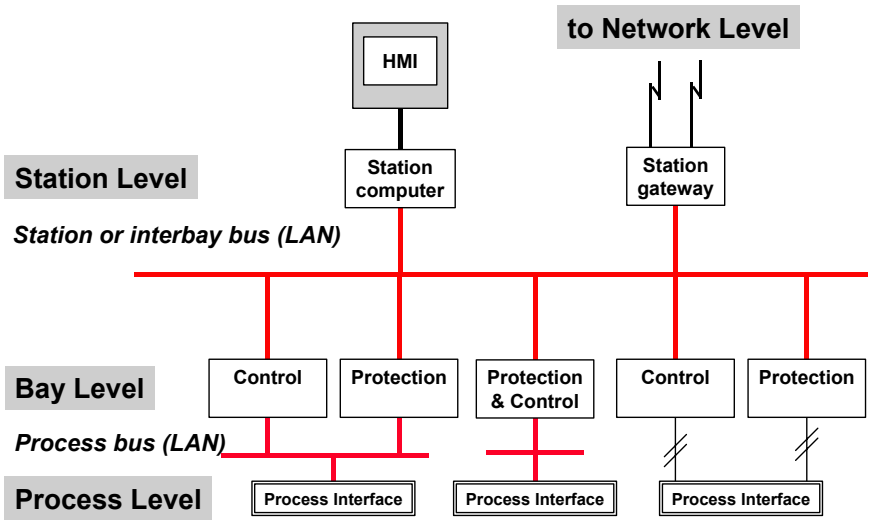

Fig.2 – Example of Substation Automation system architecture

Functions

System management functions
- Self-supervision, communication checking, time synchronization

Operational and control functions
- Access security management
- Switchgear operation
- Measurement (rms, power, etc.)
- Event and alarm handling

Parameter handling
- Data/disturbance records retrieval
- Logging and archiving

Local and distributed automation functions
- Protection and busbar protection (remote phasors)
- Protection adaptation
- Interlocking
- Local/distributed synchrocheck & synchronised switching
- Sequences
- Load shedding
- Voltage control

Network control functions
- In addition, the substation automation system has to provide all relevant information automatically or on request to the overall control and management system and to perform commands received from it locally.

Performance

The communication system in the substation has to support all functions with the requested performance. The most importance performance figures are
- data throughput,
- response times
- time synchronisation
  both for event logging and phasor calculation.

Heterogeneous systems

In addition, the communication system has to allow the mixture of devices from different suppliers. Traditionally, this request came by the wish for independent back-up functions, especially for protection. Today, the independence from suppliers is a strong argument in general.

Lifetime

Substations have a long lifetime (at least 40 years) and, therefore, their automation and protection system has to guarantee a reasonable long lifetime (at least 15 years) also. This holds same for the communication system and any related standard to safeguard the investments in the secondary system.

REQUEST FOR OPEN SYSTEMS

For systems with free exchange of data the term Open system is very common. In the past, substation automation systems had been open by standardized voltage and current levels used at the device interfaces, e.g. 110/220 V, 1/5A, 20 mA, 10 V, etc. Today, the serial communication has to be open. As seen in Fig.3 systems may be open to different directions.

Different kinds of openness

Open to free information exchange between devices form different suppliers. Not only the free terminal based access of human beings is requested but also the exchange of understandable information between devices and the mutual use for its own or common purposes. Functions from devices of different supplies may be combined to common modes of operation like sequences. This feature is called *global interoperability* and is the basic requirement for any kind of open systems and, therefore, the key for any modern communication standard. The term global refers to the requirement that there shall be one common standard world wide for the global business emerging today, i.e. no split between the IEC and ANSI world is accepted.

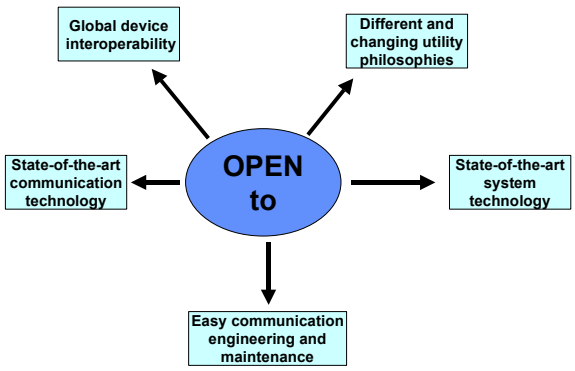

Fig.3 – The multiple meaning of the Open System requirement

Open to follow the state-of-the-art in communication. Despite the requested long-term stability of the communication system, advantageous developments in communication technology may result in favour to use a more modern one. To safeguard all the costly applications the standard has to be *future-proof* by approach. Any technological update shall have no impact on the application.

Open to support different and changing system philosophies. There are different philosophies, what functions are allocated to which devices. Some utilities prefer decentralized solutions, other ones more centralized ones, some prefer to have a high level of integration of functions in one box, other ones prefer dedicated devices for any function. Therefore, the communication standard has to support the *free allocation* of functions.

Open to support state-of-the-art system technology. Depending on the state-of-the-art in system technology of the application domain preferred system structures may change. For example, some sensor technologies prefer passive fibres, other ones full serial communications resulting in different places for process interfaces. New functions may emerge over the time. Therefore, the communication standard has to support not only the *free allocation* of functions but also to provide *extension rules*.

Open to easy communication engineering and maintenance. A device is defined by its allocated functions. A system is defined by its devices and the connections in between. Therefore, a communication standard has to have some *means* to describe these properties. If such a description is part of the standard the system may be extended and modified over the complete life cycle with any tool using this formal description, also by different suppliers

Long-term perspective of open systems

The request for open systems is driven not only for freedom to select system components now but to get supply and support over its complete life-time independently from a dedicated supplier. There is not only a compatibility problem between devices from different suppliers but may be also between devices from the same supplier over some longer time period regarding the fast development in electronics and IT.

Impact of open system requirements on communication

For a common implementation of an open system, a communication standard is needed. Regarding the long-

time perspective, the communication standard has to have a long-term stability despite the fast development, especially in communication technology. This stability has to be assured by the basic approach of such a standard.

NEED FOR A NEW STANDARD

Existing systems are running well with proprietary protocols, standards and de facto standards e.g.
- DNP3.0
- IEC60870-5-103
- IEC60870-5-101
- UCA2.0
- LON

but do these solutions support…
… global business
… fast technology changes
… high reliability
… different user philosophies?

Global business. Existing solutions i.e. existing international, national and industry standards suffer from one of two major drawbacks for the global business. Either they are local (tied to a community of utilities or manufacturers, supported mainly by only one of the IEC and ANSI bodies) or the functional scope was reduced in order to gain acceptance by a larger community.

Fast technology changes. Many of the existing solutions have defined communication also on levels that are sensitive to changes and advances in technology e.g. physical and link layer levels.

High reliability. Few of the existing solutions have addressed the approach to testing in a uniform was. This may cause costly cross testing (between vendors) and delays of projects.

Free to apply different control and protection philosophies. Some of todays solutions makes firm assumptions about on which level in the substation a function is allocated and sometimes also in what type of device.

The present solutions violate at least one of the above requirements and this is the reason why a new standard is needed i.e. a standard that covers not only today's requirements but also supports the *substation automation solutions of tomorrow*.

EXAMPLES OF APPROACH AND BENEFITS

Independence of actual technology

State-of-the-art communication is described today by the 7-layer ISO/OSI model. In the approach of the IEC61850 (Fig.4) the domain specific application (object model, services) is decoupled from the communication stack. This allows the standard to follow the state-of-the-art in communication; i.e. today the stack with MMS/TCP/IP/Ethernet with optical physical layer is selected. In the future this could be a wireless physical layer or a multi Gigabit link layer as an example. The benefit from the decoupling is that all money invested in the application is safeguarded, since the object model and the related services have not to be changed but only the mapping has to be adopted.

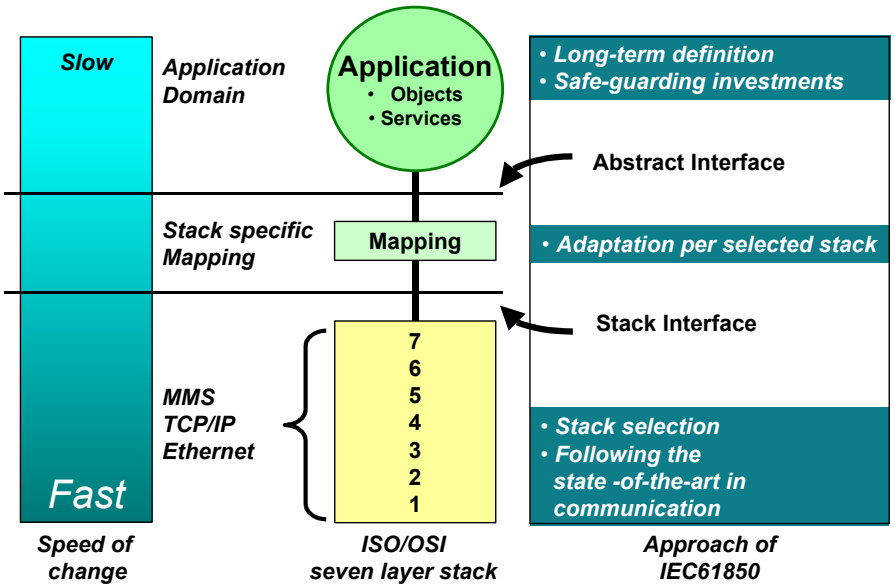

Fig.4 – The modelling of communication in order to decouple the long-term application from the fast changing technology

Support of free allocation of functions

Three examples of different philosophies in allocation of functions to devices and levels can be seen in Fig. 5. All kind of allocations is supported by the IEC61850 since the functions are split in communicating sub-parts called Logical Nodes, which are objects with data and related services. When allocating these logical nodes to different devices, the related communication features are also allocated automatically.

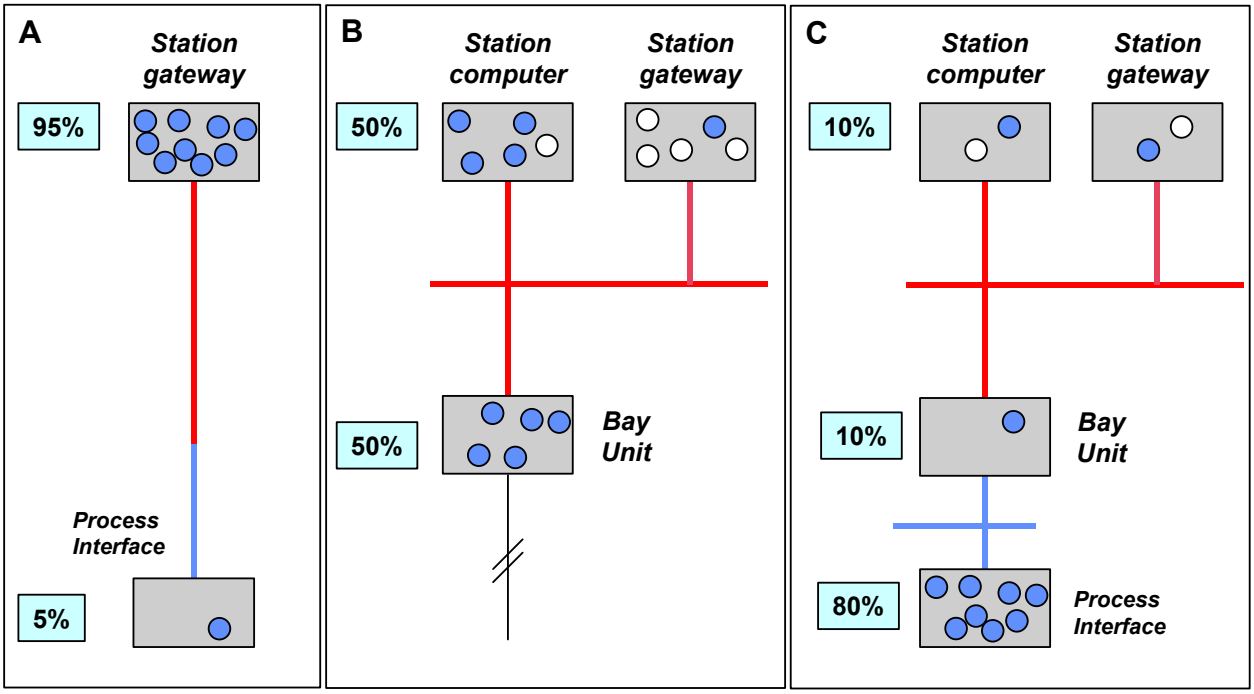

Fig.5 - Different allocations (A, B, C) of functions depending on system structure. The distribution of system functionality is shown in %, the filled dots represent function modules (logical nodes, i.e. objects with data), the empty dots redundant modules not included in the % figures.

Support of long-term system maintenance

Long term maintenance requires a possibility to extend a substation for example. It is not necessarily possible or wanted to use the same type of equipment in the extension. The standard supports these requirements with the Substation Configuration Language.

All devices from any supplier deliver all stand-alone configuration data relevant for communication in the formal description standardised as Substation Configuration Language (SCL). Also the overall system configuration is described in SCL. Therefore, these data are understandable for any system configuration tool compliant with IEC61850 (Fig.6). The output of such a tool can be configuration files for the devices including all relevant system interaction and functionality. The output is used in minimum for device specific configuration tools, e.g. per supplier. With the SCL all information exchanged in a sub stations communication network can be described. If all this formal information is stored for system documentation over the life cycle of the system, any IEC61850 compliant tool in the future easily handles any extension.

STRUCTURE AND STATUS OF IEC61850

The structure of the standard as shown in Fig.7 reflects the mentioned benefits. Part 3 summarises the general requirements, part 4 shows recommendations for system and project management to provide a trustfully interaction between suppliers and users. The communications requirements based on the application domain "substation" are defined in part 5 and transformed into a comprehensive application model for objects and services in part 7 to provide interoperability. Part 6 facilitates engineering and life cycle maintenance by the standardisation of the Substation Configuration Language (SCL). Part 10 assures common conformance testing worldwide. Part 8 and part 9 provide a clear selection of stack, according to the state-of-the-art, and the mapping of the application model to this stack.

The most parts of IEC61850 are in or near the status of CDV. These parts will be ready at least as FDIS (final draft international standard) in 2001. (Updated information will be presented at the conference.)

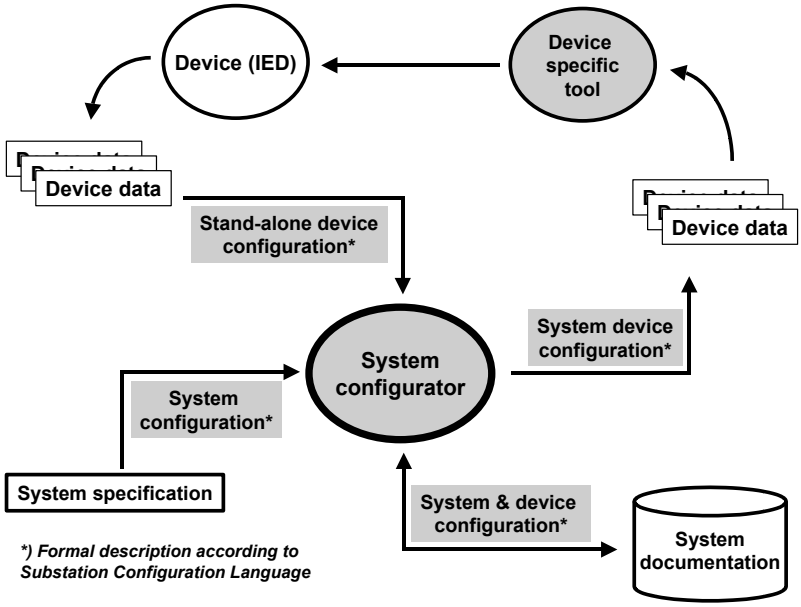

Fig.6 – The use of the Substation Configuration Language (SCL) for exchange of information between devices and tools

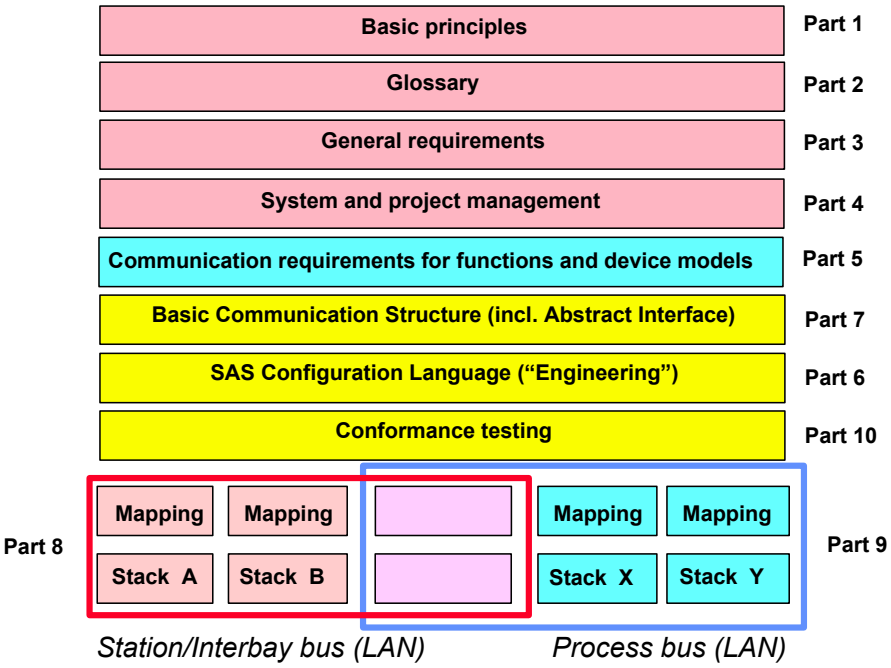

Fig.7 – Structure of the Standard IEC61850 "Communication networks and systems in substations"

CONCLUSIONS

Business today and tomorrow generate more requirements on the sub station communication than was the case yesterday. This has called for a new approach in the standardisation of communication. IEC has responded to this with the new standard. Therefore the IEC61850 is the most beneficial solution for future communication networks in sub station automation.