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IEC 61850 SCL기반 변전소 자동화 시스템의 구성방법

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Substation Automation System Design Process Based on IEC 61850 SCL

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Abstract - With the advent of the international standard IEC 61850 for communication networks and systems in substations, utilities are beginning to implement substation automation systems (SAS) that can give support to interoperability, interchangeability and self-description features. This paper describes with the SAS design accordance with this new standard. After a brief introduction of IEC 61850 SCL, this paper addresses some issues related to the specification of an IEC 61850 based SAS, and describes the Substation Configuration Language (SCL) based on Extensible Markup Language (XML). The SAS design process is explored with examples including the Intelligent Electronic Device (IED) selection, Logical Nodes (LN) allocation and the related services and the SAS communication architecture.

1. INTRODUCTION

Utilities have been undergoing significant changes that are motivating the application of the third generation automation system. Substation automation systems are evolving towards ubiquitous, diverse, broad, agile, autonomous and integrated large-scale real-time information systems [1]. The development of Substation Automation Systems requires significant engineering efforts related to the architecture of the substation and the communication system, as well as the configuration of numerous Intelligent Electronic Devices (IED) and communications equipment. The standard IEC 61850 "Communication networks and systems in Substation" will provide interoperability between IEDs for protection, monitoring, metering, control and automation in substation. Interoperability and free allocation of functions opens up a vast range of possible solutions. The Extensible Markup Language (XML) based IEC 61850 Substation Configuration description Language (SCL) is standardized for the interoperable exchange of engineering data between engineering tools. Its model based approach allows to be used to exchange IED capability descriptions, and SA system descriptions between IED engineering tools and the system engineering tools of different manufactures in a compatible way. In this paper a SCL based SAS design process is proposed, to explain a way in using IEC 61850 for optimal SAS design.

2. SCL BASED SAS DESIGN

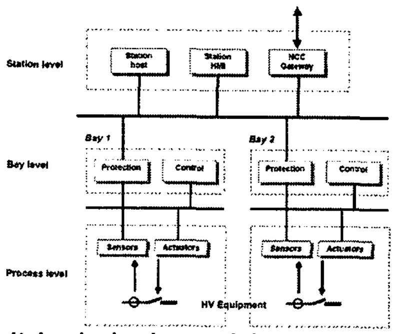
2.1 Substation automation system Configuration Language

To be able to exchange the device descriptions and system parameters between tools of different manufacturers in a compatible way, IEC 61850-6 defines a substation configuration language (SCL). This language itself is based on XML and it allows

- to describe the capabilities of an IED in terms of the models of IEC 61850-5 and IEC 61850-7-x for import to the system engineering tool.
- to describe all data needed to define system parameters for a single IED. This includes especially the binding of the IED and its functions to the substation itself, in terms of its single line diagram, and its place in the communication system.

2.2 Specifications

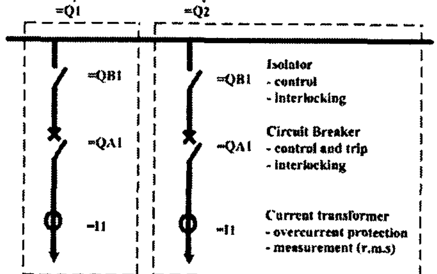
Substation automation (SA) is used for controlling, protecting and monitoring substations. At least from a logical point of view, SA systems comprise three levels, the station level with the substation host, the substation HMI and the gateway to the remote Network Control Center (NCC); the bay level with all the control and protection units; and the process level with more or less intelligent process interfaces to the switchgear (Figure 1). Extended implementations show all three levels equipped with IEDs, where for example a conventional RTU comprises all three levels in one unit. All implemented levels are interconnected by serial communication links. There is not only vertical communication between the levels (e.g. between bay and station level), but also horizontal communication within the level (e.g. in the bay level between bay units for functions like interlocking).



<Figure 1> Logical scheme of the three levels of a SAS

2.2.1 Single line diagram and SAS functionality

The single line diagram was up to now the basis of any SAS specification and mainly decided by the importance of the substation in the system but also by norms of environment protection, safety labor and security of installations. As an example, part of a single line diagram of a substation with two bays is shown in Figure 2. The topology, how the



<Figure 2> Single line diagram and allocated functions

power equipment is electrically connected, gives further information needed. The behavior and performance of the functions has to be specified as before. Specifying according to IEC 61850 means that the entire functionality is split into LNs with their corresponding data.

2.2.2 Services and signal list

The interfaces between hardware and parameter documentation are the signal lists. They are the base for the further process parameter lists. The reporting is a client-server service mainly between a bay unit and a station level client (substation host, HMI or gateway). In addition, there is a communication service between the bays, or more general, between IEDs called Generic Object Oriented Substation Events services (GOOSE), mostly used for peer-to-peer communication between IEDs. There is a problem regarding the services defined in IEC 61850 since these services

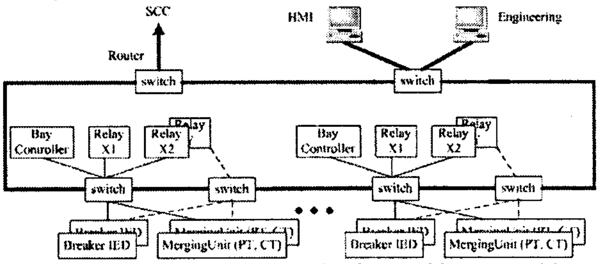
<Table 1> Example for the relation between service activities and signal list entries

OPEN sequence	Command service steps	Object	Status
Select breaker	SelVal_req	QA1_1XCBR.Pos.stSeld	UNSELECTED (FALSE)
Breaker successfully selected	Select_rsp+	QA1_1XCBR.Pos.stSeld	SELECTED (TRUE)
Command for breaker opening	Oper_req(off)	QA1_1XCBR.Pos.ctVal	OFF (FALSE)
Command successfully issued	Oper_rsp+	QA1_1XCBR.Pos.ctVal	OFF (FALSE)
Breaker has opened	Report_req(off)	QA1_1XCBR.Pos.stVal	ON>INTERMEDIATE>OFF
CLOSE sequence			
Select breaker	SelVal_req	QA1_1XCBR.Pos.stSeld	UNSELECTED (FALSE)
Breaker successfully selected	Select_rsp+	QA1_1XCBR.Pos.stSeld	SELECTED (TRUE)
Command for breaker closing	Oper_req(on)	QA1_1XCBR.Pos.ctVal	ON (TRUE)
Command successfully issued	Oper_rsp+	QA1_1XCBR.Pos.ctVal	ON (TRUE)
Breaker has closed	Report_req(on)	QA1_1XCBR.Pos.stVal	OFF>INTERMEDIATE>ON

provide entries in the signal list, witch are not seen directly in the data model or refer again and again to the same data object. So what has to be explained is that steps of one service with different parameters may produce signal list entries acting at the same data object or on different attributes of this data object. Service data exchange and signals from conventional signal lists of the customers can be compared in table 1.

2.2.3 SAS integration and Communication architecture

SAS integration is a tool that helps utilities to reduce installation, maintenance and operation costs. To achieve this goal exchange of signals among various IEDs is a must and this rise the problem of substation network and protocol definition. Definition of the network should contain enough information to understand the requirement but not too details as to limit the possible solutions. The mainstream communication basis for IEC 61850 based SAS is Ethernet. Two major topologies are mainly investigated: the ring and star network. Figure 3



<Figure 3> Example communication architecture with one network only

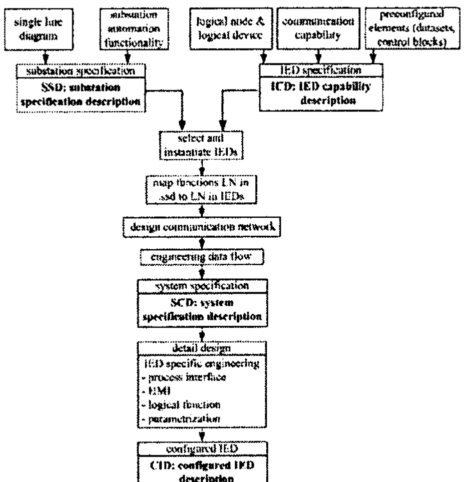
shows an example of the SAS communication architecture with one network only. This is not a new feature in substation automation.

2.2.4 SAS Constrains

System constrains include some specifications for process interface, interface to NCC control system, including the remote protection maintenance center but also some limitations due to the existing buildings and structures in the substation. Connections to the secondary windings of the CT, PTs and DC power supply impose the protection and control equipment analogue interface characteristics and decide on the power supply features. And due to the preserve of the existing control room building, local field constrains are encountered to influence the equipment location. This is a normal process that is independent from the use of IEC 61850.

2.3 SAS Design Process

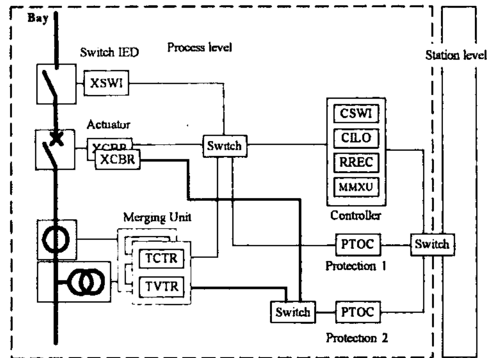
The SAS design process from specification to final system design is principally independent from any standard but some features of IEC 61850 influence and facilitate this process. However, applying such concepts allows the reduction of errors, due to the integrated handling of unambiguous models, and the reduction of the engineering effort by automating low value-adding activities.



<Figure 4> Proposed SAS design process using SCL

According to the proposed design process, the specification stage consideration is the first stage, in case of IEC 61850 preferably with a System Specification Description (SSD) file. The SSD is used to describe the single line diagram, the allocated function (feeder block diagram) and the optional data that need to be supported. Based on the SSD the required IEDs are also determined, with the available function on them. This can be done by IED capability description (ICD), which is used to describe the capabilities of an IEC 61850 compliant IED. Any substation, in which this ICD shall be used, must match an appropriate substation topology part, typically a switch control LN of class CSWI is attached to the switching device, while a measurement LN of class MMXU, or a protection function LN of class PTOC (time overcurrent function) are allocated to the bay. This means that the semantic meaning of a function within the SAS is determined by the LN class (CSWI, MMXU) as well as by the switch yard part to which it is allocated. And the data of all IEDs represented by the ICD files have to fit with the data in the SSD file. This should be supplied by the vendor, except for the paper documentation like a data sheet. With the use of a system configuration tool and from merging of the SSD and ICD files, the result of the design process for IEC 61850 based SA system can formally be described in a SCD file. The SCD file contains the switch yard naming and topology description, IED configuration description, communication network description, relation between switchyard and IED functions and the configuration value. The resulting SCD file contains individualized IED descriptions for the system under design.

Either the reliability calculations or given constraints may request main 1 and main 2 for protection. The example in Figure 5 does not cover this case. To avoid single point of failures, there have to be two process



<Figure 5> The process interface with redundant protection

bus segments, which connect the Merging Unit IED with the protection and Breaker IED (Figure 5). Each segment may contain an external or embedded switch. If any component of one segment fails, the protection of only this segment is out of order, and at least the other one is operating well.

And an SCD file can contain values of configuration attributes as well as setting parameters inside and outside of setting groups. This allows to use SCL as a standardized data exchange format for applications needing protection parameters, like

- Initial loading of configuration and parameter values into the IED either according to IEC 61850 by means of the IED tool, or optionally directly with a CID file.
- Export / Import of parameter values from tools checking consistency or generating consistent parameter sets for the whole power network.
- Export / Import of parameter set values from / to protection test tools.
- Protection parameter set version handling and archiving.

After the detail design of the SAS, the determined IEDs in SAS could be imported with the CID files, which contains the IED address in the network, and he name values assigned according to the SAS.

3. CONCLUSIONS

The paper discusses an IEC 61850 SCL based approach for the substation automation system design. The complete design information of substation automation system can be described using the language, including but not limited to: functions, devices, user interface, function distributiveness, etc. The communication system has been proven to be scalable supporting the requested availability. It was also shown that the availability is not only a communication issue but also a matter of redundant functions in separated IEDs.

ACKNOWLEDGEMENT

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