Experience in IEC 61850

And possible improvements of SCL Language

An overview of a substation automation project, based on the IEC 61850 standard, provides this paper.

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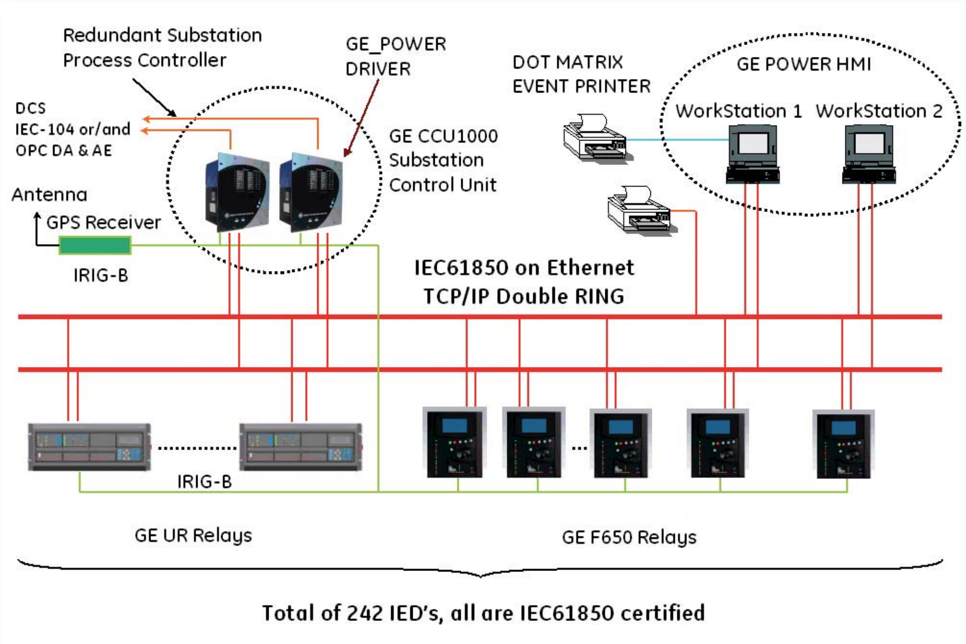

IEC 61850 communication architecture in Simeri Crichi project

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The system described in this paper has been designed in scope of a project of new 800 MW combined-cycle power plant in Calabria, southern Italy.

The paper includes the description of manufacturer's experience in the engineering process of an IEC 61850 project and the conclusions that helped to improve IEC 61850 tools and protocol implementation in IEDs.

Finally several open issues have been identified in SCL language (Substation Configuration Language) defined in part 6 of IEC 61850 and a possible scenario of further development in SCL language has been presented.

Introduction

IEC 61850, the recent international standard for communication within substations in electrical power systems, is being widely deployed in different parts of the world. It is almost two years since all parts of IEC 61850 obtained International Standard (IS) status from the IEC committee in Switzerland in 2005.

More than thirty devices have passed IEC 61850 conformance testing done by independent laboratories at KEMA, Netherlands and AEP Dolan Test Labs, USA. The standard is gaining maturity and currently new work is being held in order to extend IEC 61850 to other industries like Wind Power Systems (IEC 61400-25), Hydro Power Systems (IEC62344), Distributed Generation (IEC 61850-7-240 or IEC 62350), etc.

The evolution of the standard is driven by cooperation between different players in electrical power systems business. It is not only the standard committees and editors groups but also software companies that develop protocol stacks, protection and control equipment manufacturers, integrators and engineering companies, utilities and testing laboratories. Most important for the standard is its implementation in real life installations. Successful projects give the manufacturer the possibility to receive feedback from the integrator companies involved as well as from the end user utility.

Project description

One of the biggest installations with an automation system based on IEC 61850 that has already been commissioned is the Edison-Simeri Crichi project [3]. This installation comprises the combined-cycle power plant with a capacity of 800 MW, which is based on two gas turbines, two heat recovery steam generators with a single steam turbine, a seawater condenser and two desalination units.

The electrical system is composed of a high voltage level of 380 kV and a medium voltage level of 10 kV. The end user of the project is Edison, the oldest Italian company in the energy sector with more than 6000MW of installed power. The integrator in this project was an Italian company called Saet S.p.A. The device and solution provider was GE Multilin, a division of General Electric Company.

Two substation control units communicate simultaneously with IEDs using IEC 61850. Protection and control IEDs from two manufacturers and automatic tap changers from another vendor were selected for the project. The total number of IEC 61850 capable IEDs is 242. The communication architecture is fibre optic Ethernet double ring with managed switches. Both substation control units communicate with the dispatch centre through the IEC-60870-5-104 protocol. The substation automation system (SAS) designed for the Simeri Crichi project contains two workstations running the HMI applications.

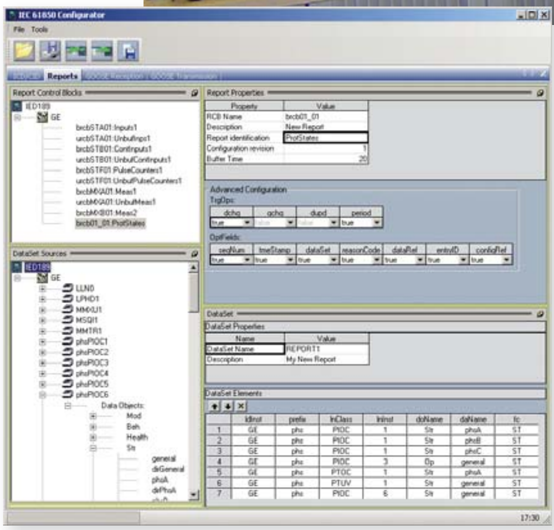
The substation control units acquire digital and analogue data from IEDs using IEC 61850 buffered and unbuffered reports. Direct control scheme is used for sending control operations. Oscillography files are obtained through IEC 61850 file services. GOOSE is used for peer-to-peer communications between IEDs. The figure on the left side shows the communication architecture designed for the project.

During the project development, performance tests had been executed under heavy traffic conditions in order to prove that each GE substation control unit could communicate via IEC 61850 simultaneously with a significant number of devices.

The testbeds were prepared with 120 devices installed in racks communicating simultaneously with the station control units. In order to save space in the laboratory a special rack was built which contained CPU boards with the Ethernet card used by the relays.

This test rack is depicted on figure above. Each CPU board was running the complete firmware of the relay and was maintaining two simultaneous TCP connections with the station control units. Apart from this rack a cabinet with 12 complete protection relays fully equipped with CT/VT module, I/O boards and front panel was connected to the same network. The complete devices mounted in the cabinet have been wired with digital inputs in order to simulate data exchange and interlocks and were wired to auxiliary relays to test switchgear operations.

Testbed for heavy traffic conditions based on a special rack with more than one hundred CPU boards equipped with Ethernet cards and connected through switches



Screenshot of GE Multilin IEC 61850 Configurator for the F650 family of protection relays

Experience from the project

The estimation of timesavings in man-hours of the engineering process has been calculated according to the performed tasks during project development and compared to the time spent in similar projects based on other communication protocols.

The conclusion was that IEC 61850 reduces the man hours required for the integration effort of the vendor's own IEDs by about 15 per cent as compared to other protocols like Modbus RTU, DNP 3.0, IEC 60870-5-104. The reduction in engineering effort for integration of third party devices was from 50 to 70 per cent depending on the complexity of the application. The limited benefit in engineering time of the vendor's own IEDs can be explained by the fact that application engineers typically have deep knowledge and experience integrating devices manufactured by their company.

Different stages of the project helped to identify the need to develop or to improve the IEC 61850 implementation in IEDs and also to improve SCL configuration tools. One of the conclusions that appeared during the project was that in order to mitigate the risk of interoperability problems between IEDs the IEC 61850 clients should implement a minimal subset of services and should allow certain features to be user-configurable.

By making the implementation user-configurable the vendor tries to avoid making customer or project-specific implementations. A good example is the availability of configurable data sets for Reports and for GOOSE communication. This permits the engineer to fully customize Reports and GOOSE applications with user-friendly tools using drag-and-drop technology. An example of such tool is shown on Figure above.

Possible improvements in SCL language

The development process of a project based on IEC 61850 depends on the availability of software tools that make use of the SCL language. SCL, defined in part 6 of the IEC 61850 standard, is the configuration description language for communication in electrical substations related to IEDs.

It specifies a common file format for describing IED capabilities, a system specification that can be viewed in terms of a single line diagram, and a substation automation system description. Part 6 of IEC 61850 introduces four types of common files. These files are the IED capability description (ICD), configured IED description (CID), substation configuration description (SCD) and system specification description (SSD) files. The figure below depicts the complete engineering process envisioned by SCL.

However the SCL language does not cover all features of today's IEDs. In fact it was not the intention of the editors of IEC 61850 standard to standardize all aspects of IEDs. This is because of the wide variety of functionality provided by each manufacturer. In addition to the configuration information specified by part 6 of IEC 61850 the complete configuration of an IED should be completed with a proprietary IED configuration tool provided by the manufacturer. The following list shows examples of features that can only be set-up with a vendor's tool:

- PLC logic equations
- content of graphical display on an IED's front panel (e.g. single-line diagram displayed by the IED, etc.)
- internal mappings
- non-IEC 61850 and vendor-specific parameters

The final configuration done by the proprietary tool is individualized per IED and can have either a proprietary format or a standard CID format. In fact the CID file is optional in IEC 61850 standard.

Nowadays many vendors have decided to have a CID file using a proprietary format while a few vendors create the CID file in a similar way as the ICD file. Also, the download process of putting the final configuration into the IED has not been strictly standardized by IEC 61850. Manufacturers use one of the following ways to load the configuration file to their devices:

- IEC 61850 file services
- FTP protocol
- Other standard or proprietary protocols designed for file transfer

It is important to know that for the complete engineering process of an IEC 61850 project it is currently necessary to use vendor specific tools for IEDs from each manufacturer. In the situation where settings of an IED need to be modified or if the IED has to be replaced by new hardware a vendor specific tool has to be used for configuration. This is not new, as maintenance has always been done this way where IEDs from every manufacturer needed their own configuration software.

The IEC 61850 standard is all about interoperability specifying a common data model and the format of data communication. The benefits of IEC 61850 are clearly visible in the substation engineering process and the increased interoperability of communications between devices. However, there is still a lot of work to do in order to maximize the benefits of IEC 61850 related to maintenance and reusability of existing projects.

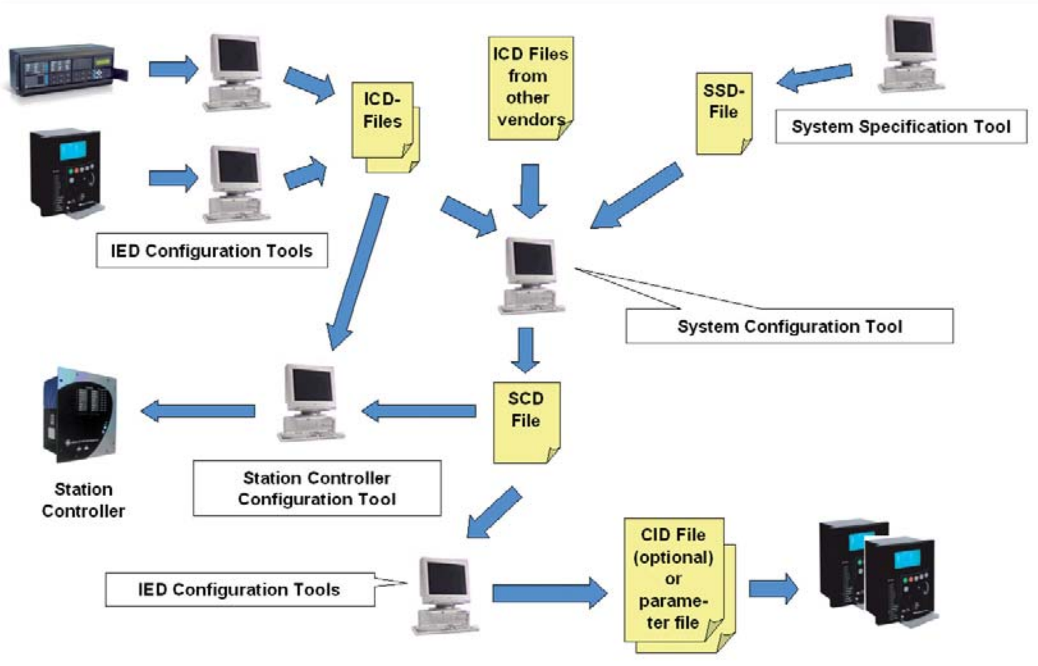
In the IEC 61850 standard many features were left out of scope of the standard. Nevertheless, the experience in IEC 61850 projects, where IEDs from multiple vendors have been used, have shown that the standard can be extended and improved.

An example of an effort to improve the IEC 61850 standard is a working group in Spain formed by manufacturers, utilities and integrators. The leader of the group is Iberinco [1], which is the engineering and construction firm in Spain that forms part of the Iberdrola Group, a utility in Spain.

The purpose of the working group is the collaboration of different companies in order to share experience in IEC 61850 projects and identify the requirements for products which include IEC 61850 IEDs, IEC 61850 clients, software tools, etc. that would complete the specification of protection and control systems based entirely on the IEC 61850 standard.

One of the goals established by Iberinco is that manufacturers of IEDs should implement the CID file in SCL format and should include the device's complete configuration. This means that all parameters, even those not specified by current revision of IEC 61850 standard, should be included in the file using a compatible XML format. Several approaches are being discussed by the working group members, among them are:

- encapsulation of non-IEC 61850 data in <private> sections within CID files
- extension of the SCL language to be able to define as much configuration data as possible in a standard way using a SCL-similar style



Conceptual substation engineering process using SCL

The first solution is already implemented by some manufacturers as SCL already permits private sections to include private data in the SCL files. The advantage of this solution is that complete configuration information is available in one file, the CID file. However private sections can only be understood by the software or a device of a particular vendor and may have no meaning for third party tools.

The second solution tries to use the SCL language to define features not covered by the current state of IEC 61850 in a compatible XML format. The possibility of adding new definitions to the SCL language is under consideration. It would require definition in the XML language of an IED's logic equations and configuration of an IED's graphical display.

This is a complex task as there are many differences between manufacturers in the way they implement similar functionality. An example of the complexity is that display screens used by different vendors on the front panels of their devices have different hardware, different resolution, computing power, etc.

It is important to notice that the working group in Spain led by Iberinco is not trying to compete in any manner with Technical Committee 57 (TC57), Working Group 10 (WG10), of IEC which is responsible for the IEC 61850 standard. The Iberinco working group of companies, in which GE Multilin is an active member, is only trying to gather experience, identify difficulties, and specify requirements for IEC 61850 implementations. The result of the working group will be presented in the future to the standardization committee as contribution for further development of IEC 61850.

Conclusions

The lessons learnt prove that IEC 61850 eases the integration process of substation networks formed by devices from different vendors. The use of a communication standard that unifies the information model and the set of common services related to substation automation saves time for system configuration and interoperability tests.

Another advantage of IEC 61850 for substation automation is GOOSE messaging which provides faster performance [2] than traditional wiring and means less cabling in substation as all devices are connected via Ethernet.

The SCL language defines a standard file format for the device and substation configuration files. This helps to lower costs greatly during the process of engineering and integrating devices from different vendors into the SAS. Having complete data models of devices in digital format permits some offline configuration without having all devices physically available.

The SCL language should also ease the re-usability of the work performed in previously implemented projects. Nevertheless, some work should still be done to extend and improve the SCL language.

Refereces

1) Iberinco, at www.iberinco.com

2) B. Kasztenny, J. Whatley, E.A. Udren, J. Burger, D. Finney, M. Adamiak, "A Practical Application Primer for Protection Engineers", 60th Annual Georgia Tech Protective Relaying Conference, Atlanta, USA, 2006

3) M. Goraj, „Substation Automation System Based on IEC 61850 Architecture", Proceeding of the 15th International Conference on Power System Protection, PSP 2006, Bled, Slovenia, 2006.