Experiences with conformance test procedures for IEC 61850 Edition 2 System and IED configuration tools

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Summary

The standard IEC 61850 “Communication networks and systems for power utility automation” provides interoperability for all functions in substations.

Utilities and industries provided a lot of feedback to further improve and achieve true interoperability for all people dealing with specification, engineering and configuration, system integration, testing and maintenance of IEC 61850 based Substation Automation Systems.

One of the major requests was to improve the interoperability and quality of configuration data exchange within the IEC 61850 System Configuration Description Language (SCL) based engineering process. Therefore, the improved IEC 61850 Edition 2 was extended to define configuration tool related conformance testing. A set of abstract test cases are defined in part 10: Conformance testing. These test cases are based on the typical and real-life use cases substation automation engineers face during the IEC 61850 based engineering process. Interacting with System configuration tools (SCT) and IED configuration tools (ICT) does require import and export of configuration data.

This paper shares experiences of ABB as a vendor of substation automation products and system integrator together with DNV GL (former KEMA) as an accredited UCA International Users Group (UCAIug) level A test lab in working on the detailed UCAIug test procedures for tool conformance.

In 2016 the IEC 61850 standard was brought to the next level by formalizing independent test procedures for system and device engineering tools.

DNV GL was the first accredited company in the world to provide IEC 61850 Edition 2 certification service to ensure interoperability between configuration tools and to issue level A conformance test certificates on behalf of the UCAIug.

ABB was the first company in the world to receive level A certificates for both IEC 61850 System and IED configuration tools respectively.

Starting in 2014 both ABB and DNV GL worked closely together on pilot testing and refining test procedures in close cooperation with stakeholders in the UCAIug.

Keywords
IEC 61850, System Configuration Description Language, SCL, Engineering, Testing, Conformance, Interoperability

1. Introduction

Exchanging substation automation data is always problematic when proprietary formats are used. Traditionally a single automation system, delivered by one vendor was used resulting in a single proprietary data standard and format. With the deregulation of the power industry and the emergence of digital substations, there is now a greater need to share engineering data between different vendors of automation systems.

The increase in choice provided by the number of substation automation vendors and the different software packages and architectures available add to the challenge of data exchange. These issues point to a requirement for a single, open standard for describing power systems and to facilitate interoperability between systems.

IEC 61850 is the substation automation standard providing a unified engineering method, standardized communication within and outside the substation together with a comprehensive testing and verification program.

Based upon a dedicated part of IEC 61850 related to conformance testing the UCAIug has worked since 2005 on conformance testing for IEDs. Thanks to these efforts severe interoperability issues related to communication did not happen.

Despite the great efforts on conformance testing of IEDs, the true challenge for a successful multi-vendor implementation of IEC 61850 does not only depend on conformance tested devices such as IEDs and gateways, it depends as well on having conformance tested System and IED configuration tools.

In 2014 both ABB and DNV GL took initiative to bring the conformance test program to the next level by working on a set of conformance test procedures for both system and IED engineering tools. This work resulted in 2015 with the first release of the UCAIug test procedures and the first official conformance tested IED- and system engineering tools in 2016.

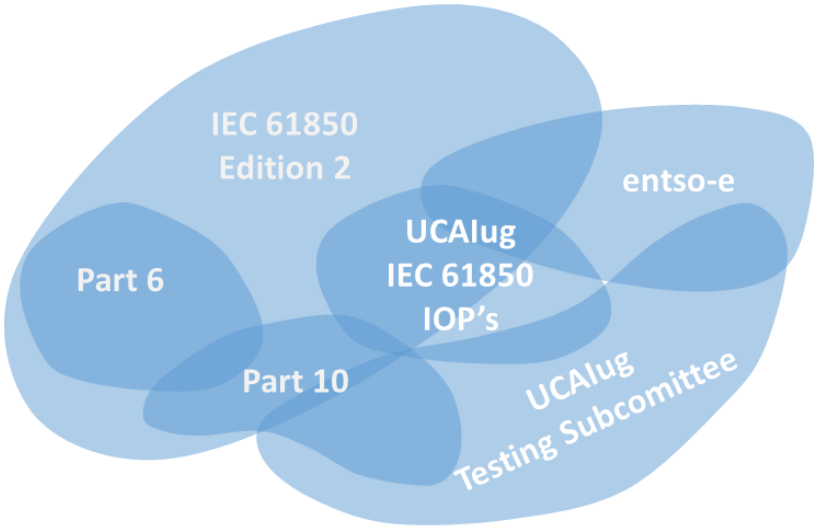
By using certified Edition 2 tools, users around the world are capable to seamlessly integrate different products and secures multi-vendor IED and system engineering including advantages of the latest features of IEC 61850 Edition 2.

2. Test Procedure Development

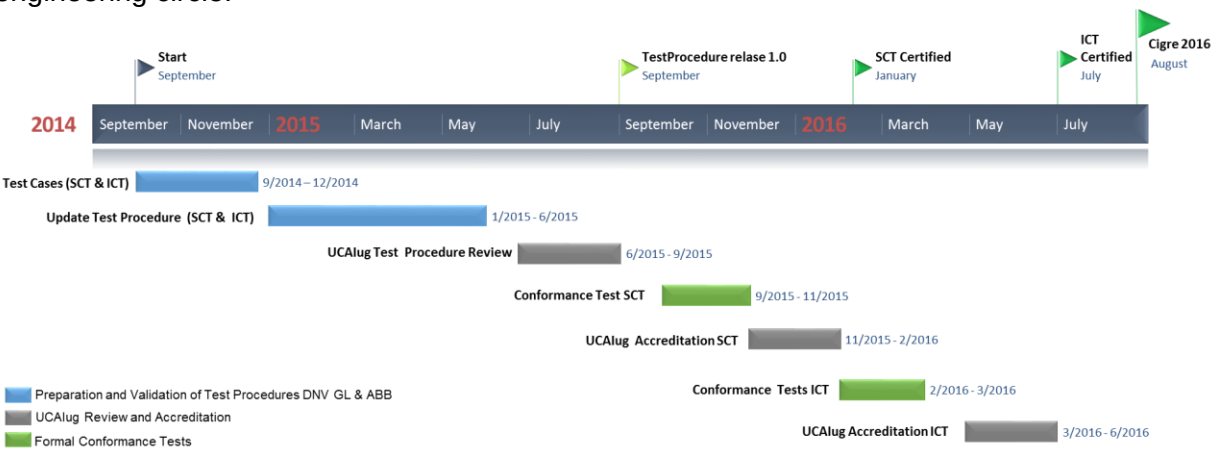
The base for the IEC 61850 conformance test procedures is the IEC 61850 standard, especially part 10 which defines the abstract test cases and the structure for the test procedures. IEC 61850 Edition 2 introduces conformance tests for configuration tools in addition to the already defined conformance tests for IEDs.

Results from the UCAIug IEC 61850 interoperability tests and feedback from the users, such as entso-e, are influencing factors to either improve the IEC 61850 standard or the affected test procedures.

The UCAIug Testing Subcommittee is responsible for developing detailed testing procedures for IEC 61850 conformance tests. These detailed test procedures are based upon the abstract test cases defined in IEC 61850-10.



Throughout 2015 both ABB and DNV GL worked closely together on pilot testing and refining the test procedures in close cooperation with stakeholders in the UCAIug. The final testing of IET600 Integrated Engineering Tool as SCT took place in less than one year, followed by the approval of the UCA International Users Group in the beginning of 2016. The level A certificate for the IED configuration tool PCM600 has been granted in July 2016 and completes the engineering circle.



In September 2014, the journey started by refining the abstract test cases to concrete test cases and preparing the first draft of the tool conformance test procedure by grouping the abstract test cases together related to functionality.

During spring 2015 several test sessions in the ABB System Verification and Validation Center (SVC) were conducted on a real system and real-life engineering scenarios to improve the test procedures, the related test environment, as well as the development of "golden" SCL files, which are needed as a reference and solid foundation to execute the tests. In addition, the current state of ABB's engineering tools was verified.

During the first half of 2015 feedback to IEC TC 57 WG 10 was provided to further improve the IEC 61850 standard, specifically the SCL Implementation Conformance Statement (SICS). The SICS is the configuration tool equivalent of the Protocol Implementation Conformance Statements (PICS) for IEDs.

In summer 2015 the review process in the UCAIug started and input from the stakeholders was incorporated in the test procedures. During this time DNV GL worked on further improving the reference SCL files while ABB resolved issues detected during testing and further improved the engineering tools by adding functionality.

In September DNV GL executed the formal conformance test on the SCT (IET600) and after successful completion of the conformance test the gained experience and results were used to obtain the formal level A accreditation of the UCAIug. When the UCAIug issued the official accreditation the conformance test was formally closed and the first level A certificate for SCT was issued by the UCAIug in January 2016.

In February 2016, the conformance test for ICT (PCM600) was executed at SVC by DNV GL engineers. Testing of an ICT requires presence of real IEDs to verify the outcome of the configuration tool, while testing an SCT can be done without interaction with IEDs.

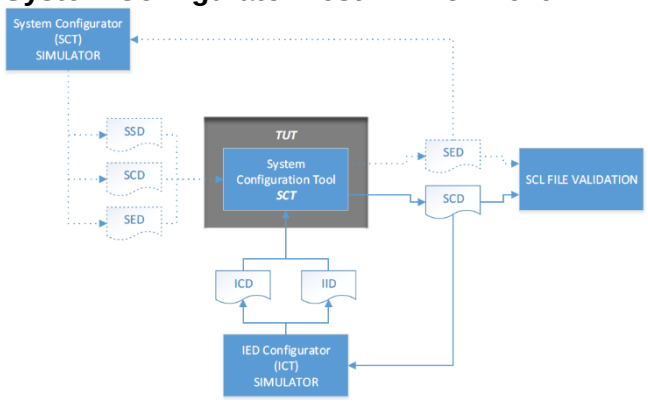
After successful conformance testing of the ICT the level A accreditation was updated to include conformance testing of IED configuration tools and the level A UCAIug certificate for the ICT was issued in July 2016.

At Cigré 2016 ABB was recognized for the world's first IED and System configuration tools certified against IEC 61850 Edition 2. This milestone was celebrated with an official handover of both tool conformance certificates.

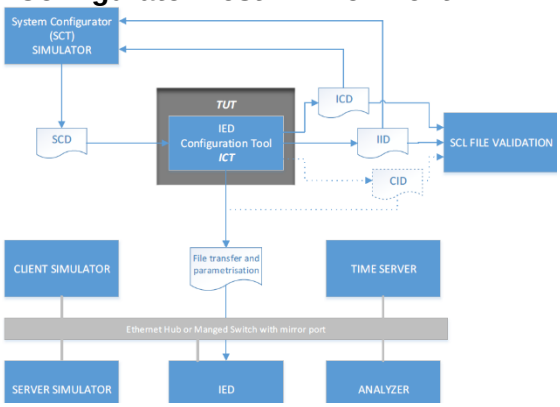
3. Structure of test procedure

The test procedure is structured in a section dedicated for the SCT and one for the ICT. The test setup is described below:

System Configurator Test Environment



IED Configurator Test Environment



Dotted lines indicate conditional environment (usage depends on the capabilities of the tool under test)

The sections for SCT and ICT are further divided in conformance blocks based upon tool functionality such as the SCD import for the ICT or the IID import for the SCT. The conformance blocks contain then several test cases covering the different engineering use cases and scenarios identified.

4. Execution of Tests

To execute conformance tests on the SCT a set of various reference SCL files is needed. These reference files are called the Golden SCL files. These represent a diverse collection of devices and functions, modeled in ICD and IID files. To verify the correct handling of different system configuration tasks including importing the substation configuration description and substation exchange description a reference SCT is required.

For the execution of the ICT conformance tests a reference SCT is required to simulate the system engineering steps. As well one or more IEDs are required to verify that the configuration

described in SCL is successfully loaded to the IED and the IED behaves accordingly. The transfer of SCL files to these IEDs is outside the scope of the conformance testing due to the openness of the standard.

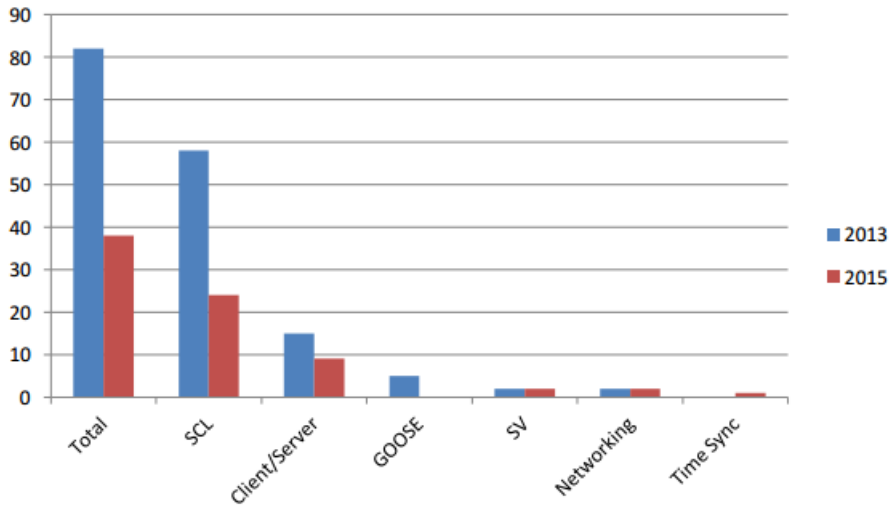
The SICS is describing the supported capabilities of the configuration tools and is therefore the starting point of the conformance test defining the applicable test cases.

Before the conformance test certificate is issued, the UCAIug performs a final check on the conformance test results provided by the test lab.

5. Results and Experience

IEC 61850-6 Edition 2 was officially released in 2009, and was the reference in the 2013 interoperability test organized by the UCAIug. After this event 60 issues related to SCL and interoperability between configuration tools were identified. The obtained results triggered the community to improve interoperability and compliance to IEC 61850.

The developments of the detailed test procedures and the feedback from the UCAIug resulted in an improved test procedure, taking additional functionality into account, a visible improvement, only 24 open issues were identified after the 2015 interoperability test was finished.



Since 2015 improvements to the IEC 61850 standard and SICS have been made resolving remaining issues.

It is our expectation that the number of issues will decrease over time when more conformance tested configuration tools are available, and further improvements to the IEC 61850 standard and test procedures are available.

Users are encouraged to verify if conformance tested devices and configuration tools meet their requirements by validation of the supplied PICS and SICS documents.

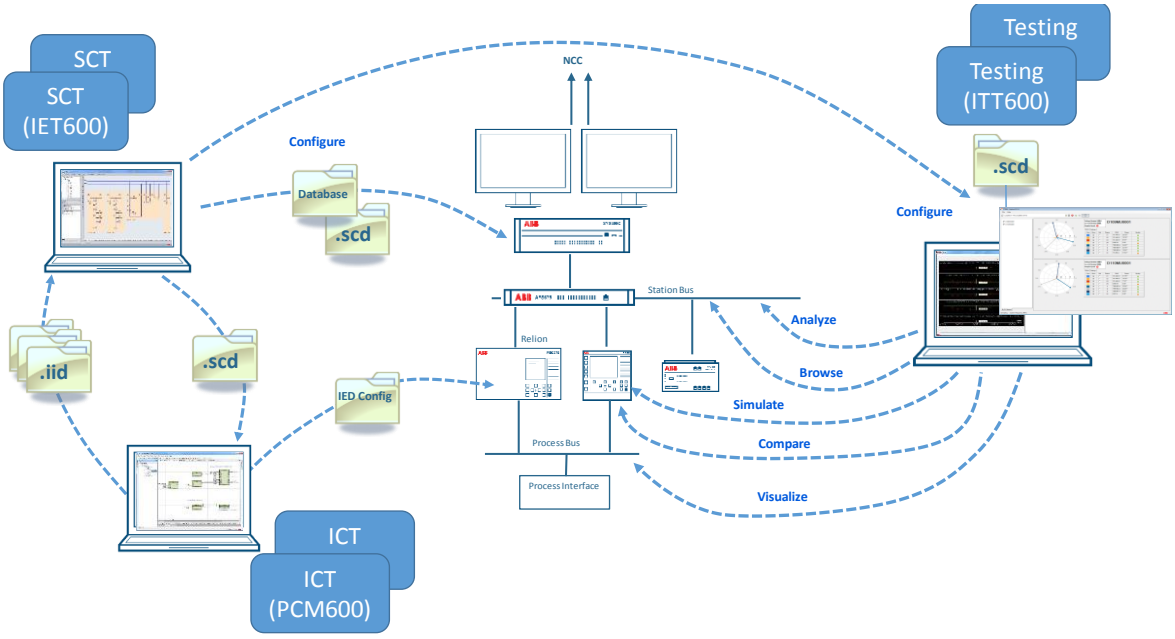
6. Conclusions

The IEC 61850 is the backbone for a truly digital and interoperable grid. Its high semantic level of data model and data exchange provide nearly unlimited extendibility for many applications in the power grid today and in the future.

Edition 2 is a major step in its evolution considering the user feedback throughout the complete value chain of a power utility automation system to further improve interoperability.

The new SCL Implementation Conformance Statement (SICS) of IEC 61850 Edition 2 is a very important step to improve the quality of interoperability and allows the end user of products judging the degree of interoperability between different engineering tools, system tools as well as IED tools. Finally, this will reduce the challenges end users have in integrating and maintaining IEC 61850 automation systems.

This leads us to a truly interoperable multivendor IEC 61850 engineering and testing tool suite supporting the complete life cycle from specification, design, and implementation, to integration, testing and maintenance. The figure below shows an example of how the different multivendor tools in engineering and testing are interacting with the substation automation system in its entire life cycle.



This concept will continue to be improved in the evolution of the standard with collaboration of all bodies, i.e. manufacturers, utilities, the UCAIug and IEC TC 57 WG 10.

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