IEC61850 – IS IT WORTH THE TROUBLE?

Günther SENFTER
TIWAG-Netz AG / Austria
guenther.senfter@tiwag-netz.at

ABSTRACT

IEC61850 is the most discussed, but still less often implemented international standard for substation automation.
As TIWAG-Netz AG already implemented a remarkable number of substations with this new technology we want to describe our approach and introduce the 'lessons learned'. Furthermore this article will explain our solution for specific problems in substation automation and finally we give our assessment, what the most important risks and benefits of IEC61850 are.

INTRODUCTION

New technologies must yield obvious advantages versus established technologies to be implemented on a large scale. For power or gas companies the demands on new technologies are even more challenging because of the long-term life cycles of used equipment. Furthermore, the responsibility for the supply of the public with energy in a safe and reliable way leads to the fact, that in the energy sector new technical developments are implemented very carefully and - slowly.

A good example for the implementation of new technologies is the IEC61850, an international norm for substation automation systems, which defines the communication between devices in the substation. The IEC61850 has become a synonym for 'modern', 'fast', 'network technology in substations', but the number of actual implementations stayed surprisingly low.
As only a few companies have implemented substations with IEC61850-technology, the important questions still remain:

- Is it worth being used?
- What are the main advantages?
- Is the technology safe?
- Does IEC61850 really reduce costs in a mid- or long-term view?

This article wants to provide answers to these questions.

COMPANY BACKGROUND

TIWAG-Netz AG is part of the TIWAG group and operates the electric power grid in the state of Tyrol, Austria.
The operated voltage levels reach from the high-voltage 220kV/110kV to the low voltage grid.

TIWAG-Netz AG is also member of the UCTE and responsible for the reliable interconnected transmission system operation as a TSO (transmission system operator).

Technical staff at TIWAG normally carries out most of the engineering of substations.
Therefore the understanding for the technical matters and details is deeper than in other companies, where own personnel do not perform engineering.
Usually we only buy the components or devices for a solution and the engineering is performed completely in-house.

This approach to engineering was an obvious advantage when TIWAG-Netz decided to implement a new technology like IEC61850.

THE INITIAL POSITION

Before we made the decision to implement IEC61850 in our company's substations we already had miscellaneous communication standards in use in many different configurations:

- Various company-specific protocols like L&G 800, Indactic, …
- IEC60870-5-101 and -104 for remote control.
- IEC60870-5-103 for connection with protection and remote control devices.
- Parallel Interfaces for various devices.

The technical staffs are used to implement these interfaces and protocols in various configurations and many different protection/remote control devices.

TRIGGERS FOR A NEW PROTOCOL

The above-mentioned protocols have – although like IEC60870 worldwide used – some disadvantages in the respect of engineering:

a) All information is processed on a 1:1 basis. This means, logical connections between data, e.g. the command and indication for a specific breaker, cannot be easily mapped onto one another: communication protocols deal with information only as "signal", the "context"-aspect of information cannot be represented.
b) The engineering of one substation is divided into several parts: the data definition, the definition of logical functions, definition of protocols, testing, documentation…
Hence no automatically generated comprehensive technical description is available.
c) New equipments, like combined protection/control devices should be connected to the existing substation architecture. Many of the built-in functionality could not be called via the existing protocols.

d) The engineering of each substation is – at least slightly – different because of the large number of devices with different communications. The number of different communications between devices produces much complexity and costs; hence a system of a standard communication between all devices was much appreciated.

DECISION FOR IEC61850

As we examined the documents of the norm – in continuous coordination and discussion with our suppliers of protection and remote control devices – we identified solutions to most of the above-mentioned limitations of existing protocols.
In our opinion the following arguments are most important:

a) Most of the leading providers for protection/ control systems worldwide participated in the development of this norm. For this reason there is high confidence that the norm guarantees a long-term availability, also for future requirements.
b) The process of engineering substations can easily be standardized, thus reducing the effort in engineering.
c) For companies like TIWAG-Netz the implementation of the IEC61850 can bring enormous cost effects on a mid-term point of view.
d) The number of devices in the substation is dramatically reduced due to better integration in the protection devices.

The main development in comparison with older protocols is the availability of standardized tools, by which the engineering, testing, commissioning, and documentation processes are persistently described.
The substation configuration language SCL provides a description of the substation, ICD/IED-files hold the data for protection/control devices and even the functionalities implemented in the system are described in standard files. (SCD = substation configuration description).
The documentation of the substation and all of its parts is generated automatically.

INTRODUCTION OF IEC61850

We developed a strategy to introduce IEC61850 in our company. At the beginning of 2005 we started with the engineering of the first substation in IEC-technology.
Our suppliers for protection and remote control devices supported the implementation in a very committed way, maybe also motivated because we were the first who urged for an implementation in our region.
The IEC-tools provided at that time were sufficient for an integrated engineering process, although we determined some flaws that lead to a major improvement of the tools.

The actual implementation had to be very careful:

a) The high standard of availability and quality of the stations at TIWAG-Netz had to be guaranteed.
b) The estimated time to learn and operate the engineering tools had to be taken into account.
c) For the provider of telecontrol-devices this project was also the first IEC61850-project.

We commissioned small substations in the 30kV-grid in autumn 2005. In 2006 we engineered some other substations in the 30kV-grid, after then we accepted the challenge to project 110kV/30kV-transformer stations.
For one important 110kV/30kV-station we did a partial refurbishment using IEC61850.
Meanwhile we have started the engineering process for a large 220kV/110kV-station.

Up to now we implemented ten systems in important transformer stations (3 installations), various substations (5) and small power plants (2).

As we perform a lot of engineering in-house, we got a deep insight into the actual level of IEC61850 in the systems of our suppliers for protection, telecontrol and network systems.
We combined two suppliers in the installations, one for protection/control and one for telecontrol interfaces, thus confronting us with one of the main goals of IEC61850, the so-called 'interoperability'.
Interoperability suggests, that systems of different providers can co-operate in IEC61850, because all the important date, definitions and functions are standardised.
This is the goal for each standard protocol, but in IEC61850 it is more than a 1:1-interconnection, "interoperability" means the standardization of the "context" (= the complete functionality) of the system has to be implemented in different systems according to the norm.

After about two years of experience we can now present an estimation of the benefits and risks of IEC61850.

DESCRIPTION OF AUTOMATION CONCEPT

Figure "TIWAG-Netz IEC61850-Implementation standard" shows our actual implementation of IEC61850 in large stations. This system is the basis of the implementations up to now. There are two redundant network-switches, where all the other components are connected forming the station-bus.

In the following the main issues of the implementation are discussed:

Protection/Control devices

The used equipments are combined protection and control devices with touch-screen for supervision and control. Each device has two interconnections to the station-bus. Only one is active at a time. If a device cannot reach other devices via a communication port, the ports are switched.

Telecontrol device
The Telecontrol device is connected to the station-bus via one communication port. Any further parts of the station can be connected to the telecontrol device via other protocols than IEC61850, a feature necessary for refurbishments. The telecontrol device works as a server to provide correct time information to all devices connected to the bus.

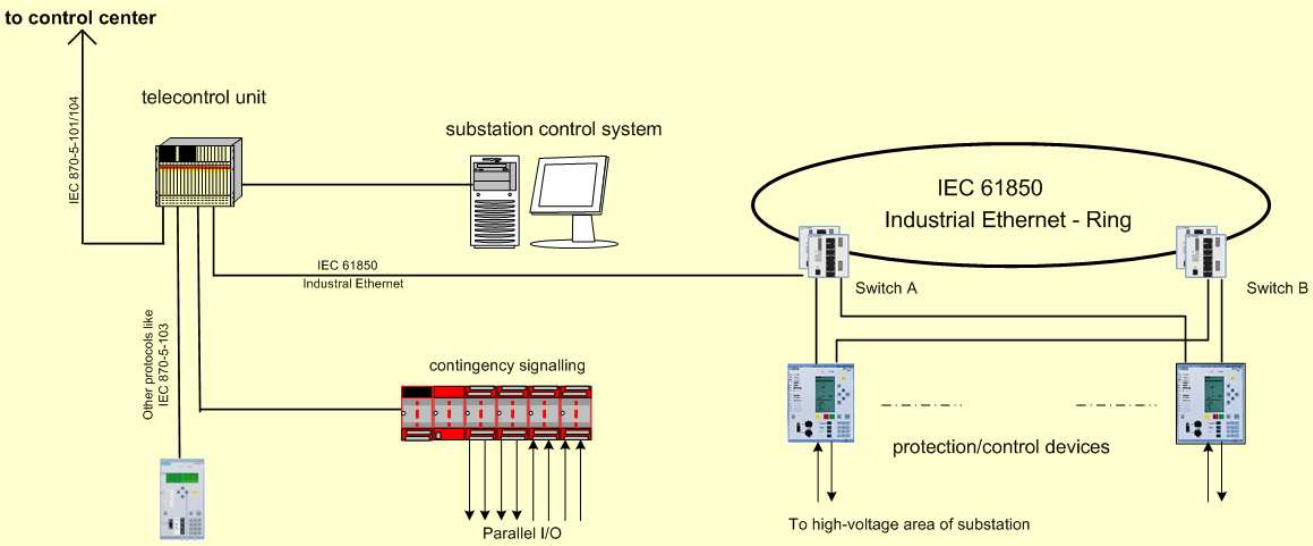

Figure:"TIWAG-Netz IEC61850-Implementation standard"

Network
We use two independently powered 100Mbit-switches. All interconnections are redundant; the switches are continuously checked for errors via life-contact and internal errors.
If switch A fails, switch B guarantees that all local functions operate as normal. The connection to the network-control is not vital for local operation.

Contingency signalling
This equipment provides an independent means of overview over the substation. In the future this will be directly connected to the station-bus

Interlocking
Traditionally interlocking of signals is instantiated by wire. IEC61850 supports the GOOSE-mechanism to distribute important interlocking information very fast via the station-bus. GOOSE-messages are sent to all devices connected to the bus, thus ensuring information transfer in time-critical applications like interlocking.
We use the GOOSE under the following conditions:

a) Network components are doubled: failures of network devices (switches or ports of protection device) could cause an error situation, where the GOOSE-messages cannot be transferred.
b) Interlocking is implemented in a way that the missing of a GOOSE-message can never result in a faulty operation. The approach is that in case of a failure those breakers that have not all interlocking-information to be sure that they are safe cannot be operated. Damage to equipments is prohibited; in case of network-errors some breakers cannot be operated.

LESSONS LEARNED

Engineering, testing, commissioning and permanent supervision of a remarkable number of substations provided an insight into the risks and benefits of IEC61850.
These are the most important results and consequences:

Know-how

The amount of necessary know-how must not be under-estimated.
We experienced for the first small substation with three feeders that we had a large effort like for a much bigger station in conventional engineering. This fact may be deterrent to some potential buyers, but in the long term we count ourselves lucky to have the know-how available:
By the time the necessary know-how about the norm and engineering is available, the engineering-times decrease as a matter of course.

Tools

There are enormous differences in the quality of provided tools: Engineering of IEC61850-substations can be performed on a 1:1-basis like in other protocols, but the main advantages of IEC61850 – the "context"-based engineering with inherent documentation – are brought out only in high-sophisticated all-in-one tools.
Prospective customers should be aware of the quality of engineering-tools.

Moreover, we detected that there is "no way back" when you depend on tools: Any change of a data point or function that affects more than one protection device results in newly generated IED-files. These files are in XML-format and must be loaded into the protection devices. At the moment there is no easy way in the tools to compare IED-files with one another to ensure, that only the volitional differences between two versions are in the file - one has to trust in the tools.
This is a quite important difference to former tools, where the changes of data are performed directly in the files.

Station-bus, network components

The introduction of Ethernet to the station-bus was a piece of news for us. The station-bus is very different from a well-known company network: the network-structure is easy, there are only few components, but:
The stability and reliability of the network must be extraordinarily high, as the network will work without any re-configuration for many years. The network components should therefore be of the highest possible quality.
We analyzed components from different suppliers: as a result we use switches that are directly powered by the station's auxiliary power (110V). The switches are supplied with integrated self-checks and an integrated protocol-function. The protocols can be read from the switches via an extra-port during maintenance-cycles and provide counters for any disturbances of the network, irregular telegrams, port-checks …

Since the commissioning of the first substations in 2005 we realized no problems or failures in the IEC61850-stations based on network components.

Protection/control-devices

It is vital to ensure that in the protection devices the network-functionality is strictly separated from the protection-functionality: if a network-port is damaged e.g. by overvoltage, this must not affect the protection of equipment.

Interoperability

IEC61850 was developed in a detailed level to ensure that components and devices of different suppliers can work together without any further definitions or necessity for adaptations.
Although we didn't use many different suppliers in our implementations, we discovered that interoperability seems to stay an challenging goal: for many informations there were not sufficient 'logical nodes' defined in the norm, so we had to use "GGIOs", free additions to the pre-defined logical-nodes.
We see that the customers will have to invest much effort in the persuasion of suppliers to keep close to the norm and to enhance the norm where necessary.

Documentation

The IEC61850 engineering-tools provide comprehensive documentation of all used data and functionality. There is no extra effort to describe a function, because the definition in the engineering-tool IS the documentation.
This feature is a major advantage in comparison with older tools – out-dated documentation is a thing of the past.

Reusability of Engineering

The tasks in different substations are very much the same. IEC61850 enables to copy parts of substation-engineering into other substations. E.g. the interlocking of feeders with the coupling can be easily copied.
What a difference to a hardware-solution, where the hardware has to be built, tested and commissioned individually for each station – in the IEC61850-environment the engineering- and test-time are substantially reduced in comparison with older techniques.

Costs

The cost analysis for a substation is a challenging task, because the hardware and engineering has to be taken into account just as well as the efforts for maintenance and the lifecycle-costs of the facility.
We have compared engineering and hardware costs between conventional and IEC61850-systems and give a rough estimation – it would be unreliable to state absolute figures for the total costs of lifetime.
Hardware-costs for IEC61850 are obviously higher than for conventional systems, especially because of network equipment. After the above mentioned advantages seems to be clear that the engineering costs are much lower and therefore the total costs of a substation should be at least not higher than for conventional systems.
This is not the case for smaller stations without special functionality like interlocking, because there engineering is not if prime importance.

SUMMARY

Like all new technologies IEC61850 has to meet some problems and restrictions. Because TIWAG-Netz has implemented this technology in many substations, we are sure that the norm has opened a new era in engineering, because it supports a comprehensive look on the processes of engineering, testing, commissioning and documentation.
Companies that intend to implement IEC61850-substations and want to do the engineering in-house should be aware of the effort to spend to enter the technology, but they will earn much as the advantages like reusability become visible.
The tools for IEC61850 will be developed further and hopefully the interoperability between systems of different suppliers will become reality, as the customers insist in it.