NettedAutomation GmbH

Information & Communication Systems

IEC 61850 and IEC 61400-25

GLOBAL Standards for all Energy Systems

Generation, Transmission, Distribution, ... Smart Grids –
Design, Specification, Engineering, Configuration, Automation,
SCADA, Measuring, Condition Monitoring;
Information Modeling, Exchange and Management

Stack and API Integration
Embedded Controller, Software Support
Gateways (DNP3, Modbus, IEC 60870-104, ...)
Consultancy, Training

3,300+ Experts from 800+ Companies from 80+ Countries trained (2013-03)

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IEC 1906 AWARD

UCA International Users Group

USE61400-25
IEC 61400-25 user group

Dipl.-Ing. Karlheinz Schwarz, Karlsruhe/Germany
Editor of IEC 61850 and IEC 61400-25 (Wind Power Plants)
Member of IEC TC 57 WG 10, WG 17 (DER), WG 18 (Hydro Power Plants)
Member of IEC TC 88 PT 25 (IEC 61400-25, Wind Power Plants)
Convenor of IEC TC 88 IEC 61400-25-6 (Condition Monitoring)

You get comprehensive, first-hand, and neutral knowledge and experience

IEC 61850 & IEC 61400-25 SCC

Motivation: sustainable interoperability

The standards IEC 61850 „Communication networks and systems for power utility automation“ and IEC 61400-25 „Communications for monitoring and control of wind power plants“ provide support for **sustainable interoperability: Information Models, Information Exchange Methods, Protocol Mappings, and System Configuration Language (SCL)** for Power Systems (Generation, Transmission, and Distribution for HV, MV, and LV, ...).

Data Models

IEC 61850-7-4xx

Substations (7-4)
160 LN
900 DO

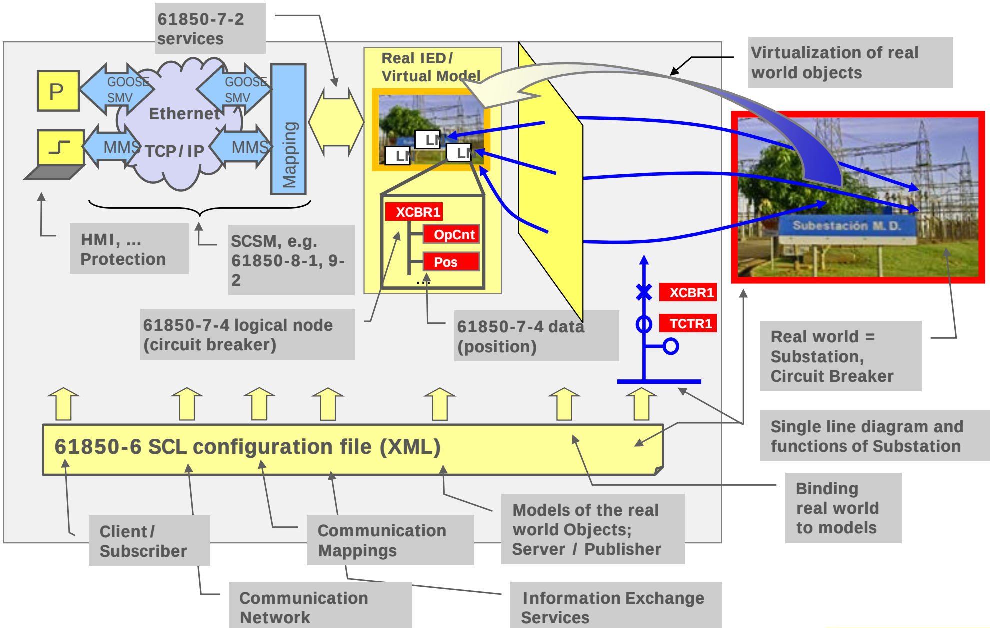
Hydro Power (410)
63 LN
350 DO

Decentralized Energy Res. (420)
50 LN
450 DO

IEC 61400-25-2

Wind Power
16 LN
250 DO

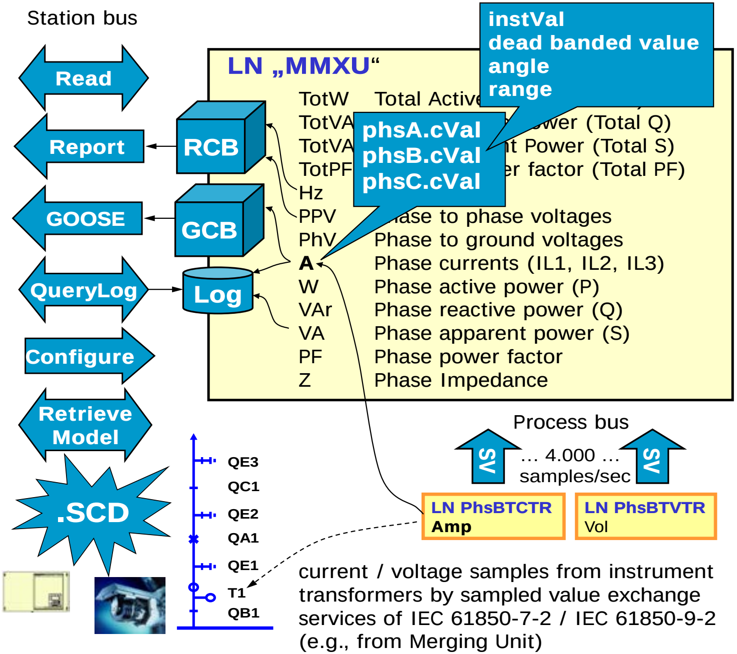
Logical Nodes (LN) represent real-world **Inputs, Outputs, Ratings, and Settings of functions** or **equipment**. A LN provides a list of named data objects (DO). The LN “XCBR” represents a real “circuit breaker” with the data object (DO) “Pos” (Position). IEC 61850-7-2 defines **Information Exchange Methods**, e.g., for the position (with Client/Server services, GOOSE, SMV). **Data flow** is specified by a **SCL** file (IEC 61850-6).



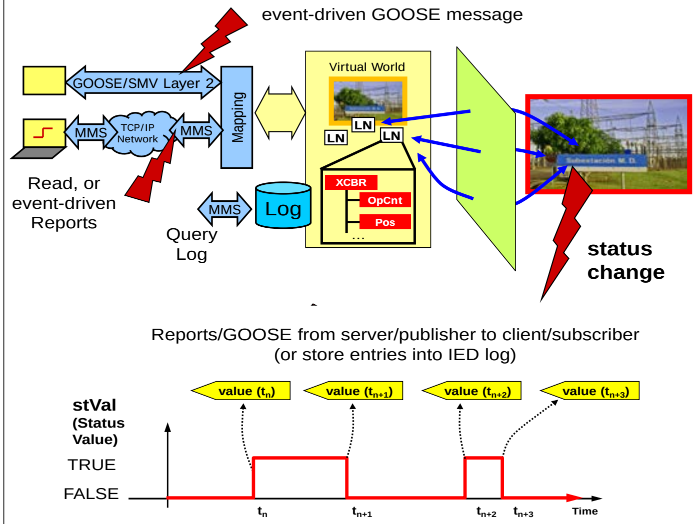
Example see reverse side

Example: Measurement LN “MMXU” represents power, voltages, currents, impedances, ... in a three-phase electrical system. The values can be communicated by various services. The LN “MMXU” comprises values for measurements, monitoring, configuration, settings, description, and substitution. These values can be communicated by various services like read (polling), reporting, GOOSE, logging and log query. Recording and logging are build upon monitored value changes. The SCL configuration file .SCD (System Configuration Description) specifies the single line diagram of the substation, the information model, the parameters of the control blocks for reporting and logging, GOOSE, SV, the binding to the process and the data flow.

LN and data objects



Information flow (example)



NettedAutomation GmbH

Information & Communication Systems

25+ Years of Excellence

International Standards for Power Systems

Generation, Transmission, Distribution, ..., Smart Grids; Design, Specification, Bidding, Engineering, Configuration, Automation, SCADA, Condition Monitoring, Information Management ...

We bring standards, smart people, intelligent devices, tools, and systems together to build Smarter Grids!

IEC 1906 AWARD

Supplier information, capabilities, and experience profile

Supplier information

Company	**NettedAutomation GmbH**
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Foundation	2000

Our knowledge and experience are asked all over – more and more!

3,000+ Experts from 750+ Companies from 75+ Countries trained (2012-08)

Ownership	Privately held by **Dipl.-Ing. Karlheinz Schwarz**	
Registered	Amtsgericht Karlsruhe HRB 8866	
General Manager	Ingeruth Schwarz	
Major Customers	Users:	AXPO, Bayernwerk, Badenwerk, Con Edison NYC, ENERGI E2, E.ON, Endessa, EdF, EdP, Energex, ETRANS, EVS, EWE, GdF, HEW, Manitoba Hydro, Hydro Quebec, Itaipu Binacional Hydro Power Plant Brazil, KEPCO, Mercedes Benz, PowerLink Australia, RWE, Stattkraft, TNB Malaysia, Terna, Transba, Transpower NZ, Vector, VEW, Vattenfall, ...
	Vendors:	AEG, Beck, Beckhoff, ABB, Alstom, AREVA, Bosch, BTC, Doble, E+H, IDS, Eberle, GE, Hirschmann, Kloeckner & Möller, LG, OMICRON, Pepperl & Fuchs, Phoenix Contact, PSI, Repas AEG, Schweitzer Engineering Labs, Siemens, TNB, VATECH SAT, SMA, VESTAS Wind, Voith Hydro, ...
	Consultants:	KEPRI, SKM, Teshmont, ...

More than 30 training sessions in 2011

Vendor independent, up-to-date, neutral, and experienced!

The primary service of NettedAutomation is to provide **consulting** services to all enterprises for feasibility studies, information modeling, system specification, implementation and use of devices and systems; **education and hands-on training** for users, system integrators and vendors in all aspects of Standards used for Power Systems; **support** for marketing, information dissemination, procurement for distributed systems, specifying procurement requirements; and **evaluation** of bidder proposals for devices, systems, tools, and open communications. The application domains cover generation, transmission, and distribution, Smart Grids, RTUs, SCADA and EMS systems, protection, automation and condition monitoring systems.

NettedAutomation has long-time experience in IEC 61850, IEC 61400-25, IEC 60870-5-10x, IEC 60870-6 TASE.2, IEC 62351, DNP3, IEC 61970 CIM, IEC 61968, IEC 61158, IEC 61499, IEEE 802.3, and ISO 9506 MMS to name just a few.

To keep abreast of the latest technical development, NettedAutomation is actively involved in workshops, seminars, hands-on training, task forces, and committees of various professional organizations such as ISO, IEC, IEEE, CEN, CENELEC, DKE, VDI, ZVEI, NIST SGIP, UCA IUG, and USE-IEC61400-25.

Curriculum vitae of Karlheinz Schwarz

Dipl.-Ing. **Karlheinz Schwarz** (58) received his diploma degree in Information and Automation Technology at the University of Siegen (Germany) in 1982. He is married and has four children and seven grandchildren.

As a manager with Siemens Automation & Drives (communication systems) he represented the positions of Siemens and the German national committee in the international standardization of MAP, MMS, MMS companion standards, Fieldbus, and other standardization projects from 1984 until 1997.

He is president of SCC (Schwarz Consulting Company), Karlsruhe (Germany) specializing in distributed automation systems. He is an independent consultant in the area of information modeling, systems and information integration, system and device engineering and configuration, open information exchange, and open communications since 1992. Mr. Schwarz has immense experience in the migration from proprietary or other solutions to standard compliant solutions.

He is involved in many standardization activities within IEC (TC 57, TC 65, and TC 88), ISO (TC 184), CENELEC (TC 65 CX), IEEE (SCC 36 "UCA", 802), and DIN since 1985. He is engaged in representing main industry branches in the global standardization and providing consulting services to users and vendors. Mr. Schwarz is a well-known authority in the application of mainstream information and communication technologies. He provides guidance in the migration from proprietary solutions to advanced seamless and standard-based solutions applicable in substations, and power generation units, and between these and with local, regional, and central SCADA systems. Specifically, his contributions to the publication of many standards are considered to be outstanding.

He has been awarded with the IEC 1906 Award in 2007 ***"For his strong involvement in the edition of the IEC 61850 series, its promotion inside and outside IEC, and specifically its adaptation for wind turbine plant control."***

http://www.nettedautomation.com/download/IEC1906-Award.pdf

Publications:

http://www.nettedautomation.com/marketing/scc_publications/index.html

NettedAutomation's Capabilities and Experience Profile

Learn firsthand what you need to know about these standards and products!

We assist companies in examining open communications and distributed systems technologies in substation automation, Smart Grids, and many other application areas outside the utility industry (for which IEC 61850 was originally designed). We support the design and implementation of IEDs compliant with IEC 61850 and other standards. Support for procurement requirements and evaluation of bidder proposals for IEC 61850 related devices, systems and tools can be provided. We have long term experience in implementing and organizing IEC 61850 and IEC 61850 based pilot projects.

Mr. Schwarz is the principal teacher and trainer of the seminars and training services offered and organized by NettedAutomation GmbH. We have given lectures all over

http://www.nettedautomation.com/seminars

We offers consulting services outlined above for a wide range of information and device modeling as well as standards-based configuration, communication systems and technical applications oriented to the automation of discrete and continuous automation related to:

- International Fieldbus standard, IEC 61158 (IEC TC 65)
- European Fieldbus, EN 50170 (CENELEC TC 65 CX)
- National Fieldbus standards like PROFIBUS, FIP, P-Net
- Actuator Sensor Interface (ASI) or IEEE 802 LAN/WAN
- Utility Comm. Architecture (UCA™), IEEE SCC 36
- Communication networks and systems for power utiliy automation, IEC 61850 (IEC TC 57)
- Telecontrol equipment and system, IEC 60870-5-10x
- Communications for monitoring & control of wind power plants, IEC 61400-25 (IEC TC 88) and IEC 61400-25-6 on Information models for condition monitoring systems (IEC TC 88)
- Communications Systems for Distributed Energy Resources (DER), IEC 62350 (IEC TC 57)
- Hydroelectric power plants – Communication for monitoring and control, IEC 62344 (IEC TC 57)
- Intercontrol Center Communications Protocol (ICCP), IEC 60870-6 TASE.2 (IEC TC 57)
- Common information models (CIM), IEC 61970 (IEC TC 57)
- Accreditation, Testing and Certification of IT products (DIN Test Lab Auditor), Quality Management
- Standard for the Exchange of Product Model Data (STEP)
- Application and Function block modeling IEC 61499 (IEC TC 65)
- Process Control Functionblocks and Device Description Language, IEC 61804 (IEC TC 65)
- Open Systems Application Frameworks, ISO 15745 (ISO TC 184 SC5)
- Manufacturing Automation Protocol (MAP), MiniMAP/FAIS
- Manufacturing Message Specification, MMS, ISO 9506 (ISO TC 184)

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Appendix: Personal education and qualifications of Karlheinz Schwarz

1. Education

1958 – 1962	Elementary School
1962 – 1965	Secondary School
1965 – 1967	Secondary School (Gymnasium)
1967 – 1969	Technical School
1969 – 1972	Apprenticeship as electrical mechanic and electronics (Siemens)
1973 – 1974	Service technician responsible for alarm systems (Siemens: fire alarm systems, burglar alarm systems, ...)
1975 – 1977	Academic high school (Hessenkolleg)
1977 – 1982	Study of electrical engineering and IT at University Siegen (degree: Dipl.-Ing.)
1981 – 1997	Employee at Siemens Automation (responsible for standardization of comms)
1992 – present	Consultant and trainer for communication and automation (see above and below)

2. Training experience since 2002

Mr. Schwarz has trained almost 3,000 experts all over. Most seminars have been conducted as in-house courses. Attendees from more than 700 companies have attended. Attendees from small, medium and big utilities and big vendors have attended. An excerpt is shown in the following table:

Year	**Training in Countries**	**Courses**	**Attendees**
2002	China	2	30
2003	Denmark, Spain	2	22
2004	Spain, Germany, France, USA, China, South Africa, Malaysia	8	199
2005	South Korea, Mexico, Denmark, Canada, Switzerland, Germany, South Africa, Australia, Israel	12	299
2006	Germany, Italy, Spain, India, Canada, UK, Portugal, France, Austria, USA	18	545
2007	Russia, Germany, Portugal, USA, France, Canada, South Korea, Australia, New Zealand	11	252
2008	Germany, Slovenia, Canada, USA, France, Malaysia, South Korea, Australia, New Zealand, Sweden	20	379
2009	Mexico, Russia, Italy, Germany, Malaysia, USA, Australia	15	220
2010	Iceland, Spain, Ireland, Argentina, Brazil, Germany, Japan, Denmark, USA, Philippines, Sweden, Australia, France	20	276
2011	France, UK, Germany, Australia, South Korea, Switzerland, Zimbabwe, Canada, Belgium, USA, China, Austria, Brazil	33	542
2012 (Sept)	Germany, India, Belgium, Israel, Italy, Sweden, USA, South Korea, China, Taiwan	18	262
		159	***3.026***

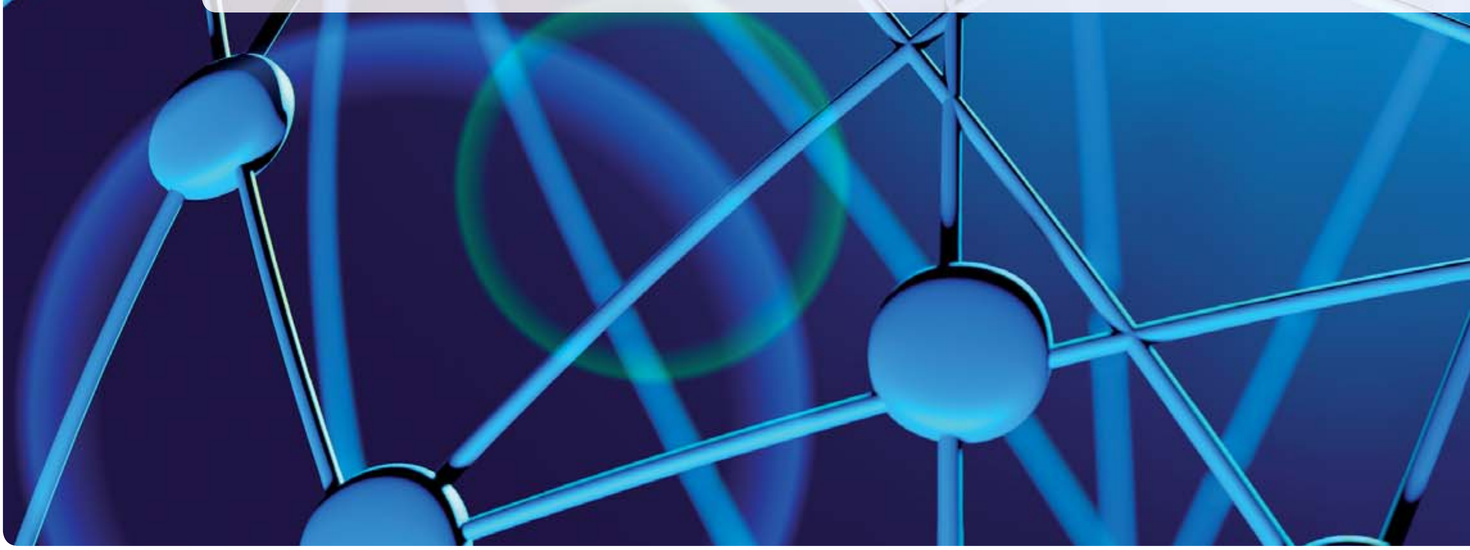
3. Standardization experience

Mr. Schwarz is (was) a principal contributor in the following standardization projects (either project member or as the technical lead), representing many German industries (users and vendors):

ISO	ISO TC 184/SC5	Architecture, Communications, Integration Frameworks	Member	1985-2012
	ISO TC 184/SC5/WG 5	Open Systems Application Frameworks	Member	1985-2005
	ISO TC 184/SC5/WG 2	Communications and interconnection (MMS, ...)	Mem-ber/Chairman	1985-2005/1998-2005
IEC	IEC TC 57	Power Systems Control and Associated Communications	Member	1992-2012
	IEC TC 57 SPAG	Strategic Policy Advisory Group	Invited Guest	
	IEC TC 57 WG 07	Protocols compatible with ISO/OSI and ITU	Member	1992-2000
	IEC TC 57 WG 10	Power system IED communication and associated data models / Communication and systems within Substations (IEC 61850)	Member/editor of 61850	1995-2012
	IEC TC 57 WG 17	Communications Systems for Distributed Energy Resources (DER) – based on IEC 61850	Member	2004-2012
	IEC TC 57 WG 18	Hydroelectric power plants – Communication for monitoring and control – based on IEC 61850	Member	2004-2012
	IEC TC 57 WG 19	Interoperability within TC 57 in the long term	Member	2005-2012
	IEC TC 65 WG 6	Functionblocks (IEC 61499)	Member	1990-2002
	IEC TC 65 PJWG	Device Profiles	Member	1998-2002
	IEC TC 65C WG 1	Message data format for information transferred on process and control data highways, Profiles	Member	1983-2006
	IEC TC 65C WG 6	Fieldbus (IEC 61158)	Member	1997-2000
	IEC TC 65C WG 7	Functionblocks and Data Descriptive Language (IEC 61804)	Member	1996-1999
	IEC TC 88 PT 25	Communications for monitoring and control of wind power plants (IEC 61400-25-1/-2/-3/-4/-5) – based on IEC 61850	Member/editor of 61400-25	2001-2012
	IEC TC 88 PT 25 / IEC 61400-6	Communications for monitoring and control of wind power plants (IEC 61400-25-6) – Logical node classes and data clas-ses for condition monitoring	Convenor	2006-2011
IEEE	IEEE 802.3 /.15	LAN, WAN	Member	1998-2001
	IEEE SCC 36	Utility Communication Architecture	Member	1996-2000
CENELEC	CENELEC TC 65 CX	Fieldbus Communication	Member	1992-2000
CEN	CEN TC 310/TG ICOM	Task Group on industrial communications	Member	1994-1996
MMS Forum	EPRI, Electric Power Research Institute	Communications and application modelling in the area of power utilities (UCA, ICCP)	Member	1992-1998
NAM	DKE/NAM/NI 96.5	Architektur und Kommunikation	Member	1985-1998
	DKE/NAM/NI GA 96.5.2	Kommunikation und Datenaustausch (MMS, ...)	Chairman	1985-2002
DKE	DKE FB 9 AK AP	FB 9 Arbeitskreis Arbeitsplanung	Member	1989-2003
	KG-ILT	Koordinierungsgruppe Industrielle Leittechnik	Member	1989-2003
	K 261	Mirror of IEC TC 8: System aspects of electrical energy supply	Member	2003-2008
	DKE K 950	Kommunikation und Informationslogistik	Member	1998-2001
	DKE AK 956.0.2	Kommunikationsdienste, Process Control	Member	1992-1997
	DKE K 956	Feldbus	Member	1986-2012
	DKE AK 956.3.1	Functionblocks and Data Descriptive Language	Chairman	1995-206
	DKE K 952	Netzleittechnik	Vice Chair-man/member	1992-2012
	DKE AK 952.0.7	Protocols compatible with ISO/OSI and ITU	Member	1992-2005
	DKE AK 952.0.10	Stationsleittechnik	Member	1995-2012
	DKE AK 952.0.17	Kommunikation für verteilte Energieversorgung (TC 57 WG 17)	Member	2005-2012
	DKE K 383.0.1	Kommunikation für Windenergieanlagen	Chairman	2001-2012
GMA	GMA AK 4.2	Kommunikation in verteilten Systemen	Member	1996-1998
VDMA	Fachverband InCom	Industrial Communications	Member	1990-1996
ZVEI	ZVEI GA IK	Gemeinschaftsausschuss Industrielle Kommunikation	Member	1986-2012

Smart Grids

Intelligent, safe electrical power distribution networks were invented at the start of electrification and have been further developed up to the present day. Electrical fuses, protective devices and monitoring devices have been phenomenal in the protection of life and technical installations for more than 100 years. Without these "smart" devices a fault-free, fail-safe electrical energy supply system would be inconceivable and the supply of electrical energy much too dangerous.



RELIABLE – ENERGY – DELIVERY

– A 19th century invention

Since the 19th century engineers have developed, tested, used on a large-scale and continuously improved suitable solutions for the safe and reliable operation of the rapidly growing supply of ever more applications with electrical energy. During the sustained further development of the supply systems, it is necessary to handle the available resources (energy sources, technical installations and individuals with experience) as well as the laws of physics both responsibly and in a "smart" manner.

Smart grids help to make it possible to use physics safely and reliably for the benefit of man – in the past, today and in the future

Smart energy supply

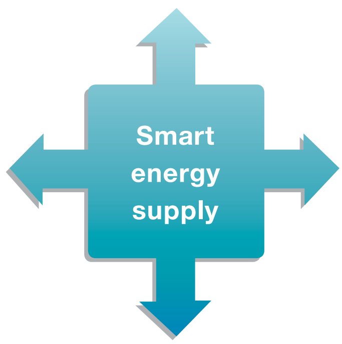
The system for the supply of electrical energy has been in construction for more than 130 years. Along with the high-availability provision of electrical energy, the protection of lives and technical installations has had a significant impact on the development of the supply system. Special concepts, processes and devices were "smart" from the start – the intelligent, selective shut down of a faulty electrical circuit or an intelligently planned redundant system topology result in minimal interruption in supply in the event of a malfunction.

ENERGY COMMUNICATION AT THE FORUM "LIFE NEEDS POWER" AT THE HANNOVER MESSE

Electrical distribution network operator:
"We cannot change Ohm's or Kirchhoff's laws."

Lawyer:
"Objection! Every law can be changed.
Even the constitution with a 2/3 majority."

Such a smart energy supply system that strictly follows the laws of physics is increasing viewed by politics, commerce, science and the public in relation to the conservation of natural resources and the protection of the environment, as well as in relation to the aim of generating profits. Smart grids are viewed as an effective instrument to achieve these goals.



The energy revolution and the increasing interest in renewable energy sources and storage options (for instance pumped storage, gas or heat storage systems) are increasingly frequently viewed in conjunction with new technological capabilities for the quick and safe exchange of information – a core topic of smart grids.

The term "smart grid" as an intelligent energy supply system involves, according to the DKE and IEC smart grid road maps, "the networking, monitoring, control and regulation of intelligent energy producers, storage systems, power consumers and network equipment in energy transmission and distribution networks with the aid of information and communication technology (ICT). The objective is, based on transparent energy-efficient, cost-efficient, safe and reliable system operation, to achieve the sustainable and environmentally acceptable assurance of the supply of energy."

These days a differentiation is made between **smart markets** (in which the market participants who offer or require energy organise themselves) and **smart grids** (the technical installations and processes to be further developed that are needed for high availability, efficient and safe supply based on the laws of physics). Even though both are closely linked, they do provide some orientation in the maze of discussions.

Smart markets with the high volatility of renewable energy sources place comprehensive requirements on smart grids; meeting these requirements requires above all that the solutions are in harmony with the laws of physics for the electrical system. Controlling the volatility of the availability of water and sunlight in the supply of foodstuffs by means of storage, transport and distribution can be taken as an example for the smart supply of energy of the future. The volatile availability of solar and wind energy could contribute to a secure, high-availability, efficient supply by means of increasing storage.

How secure is our supply of energy?

The current raw materials for energy (gas, oil, coal, uranium, ...) and also the volatile sources of energy such as the sun, water and wind are only secure to a limited extent. This uncertainty preoccupies above all the future smart market – it is of lesser importance during the consideration of smart grids.

Smart measures to make the supply of electrical energy secure (in the context of high availability) have been developed and continuously improved since the 1880s. During network planning for the higher voltage networks, the so-called (n-1) and (n-2) criteria have been used for some time – these criteria state that in the event of one (or two) failures due to malfunctions in any item of equipment (generator, transformer, cable, ...) the network as a whole must safeguard the supply within the stipulated limits. Higher costs for their implementation are justified because, for instance, interruptions in the supply to large areas can be prevented by redundant cable routing or power stations.

The European transmission systems are coupled together into an integrated European network and some are also integrated into a grid control network so that, on the failure of a component in a system, or in case of an imbalance in the generation and consumption of power in a sub-system, help can be obtained from a neighbouring system. These transmission systems can quite rightly be termed high-voltage smart grids.

In distribution networks (medium voltage, low voltage) on the other hand the risk of an interruption in the supply for minutes or hours is accepted in the majority of cases. Here the distribution network is often not constructed based on the (n-1) criterion. Accordingly few or even no technical features are provided that could automatically compensate for the failure of a component or an imbalance between generation and consumption.

In the area of energy supply systems a large number of system-related limits and parameters (trigger current for circuit breakers, frequency, voltage, insulation on a cable, ...), secondary devices (measuring systems, controllers, regulators, ...) and primary devices (transformers, circuit breakers, inverters, ...) as well as in future many components at the integration levels (above all the communication infrastructure such as Ethernet switches, routers, backup power supplies) must be constantly monitored, and that mostly in real-time. In the case of developing malfunctions it may be necessary to intervene with control measures within milliseconds. If action is not taken until a component fails, then an entire system may easily collapse with unpredictable consequences for people and the environment if a fail-safe supply is imperative.

Since the start of electrification, particularly high value has been placed on the protection of individuals against physical contact with the electrical system. Worldwide it is state-of-the-art to protect people against the hazards of electrical power. A series of IEC standards and other standards define suitable measures that have made possible a high safety standard.

In relation to electromagnetic compatibility (EMC), electronic devices in the area of the supply of electrical energy must meet particularly high requirements that go way beyond the requirements in the office or industrial environment. The "IEC Smart Grid Standardization Roadmap" from 2010 clearly refers to these requirements. In the second version of the familiar American "NIST Framework and Roadmap for Smart Grid Interoperability Standards" (2012) these requirement were recently placed alongside the requirements for communication security. The availability of an automation or communication component must be much higher in an energy supply system than in the office or residential sector.

Furthermore physically extensive integration levels require high security in relation to the availability and vulnerability of the infrastructure and the supply systems, in the past the topic of security has been largely ignored during the implementation. In the future energy supply, this topic must be taken significantly more into account in the implementation and the solutions must be much more rigorously applied.

Smart solutions for a secure energy supply are required for generation, transport, distribution and the power consumers – in public distribution networks just as in public buildings and offices, as well as in other items of infrastructure such as transport systems or the Internet.

What will be new in the future?

The reliable and secure operation of the future electrical supply system places new challenges on engineers, businessmen and politicians, and has done so particularly since the turn of the century. Necessary changes are to be expected due to:

- → The rapidly growing number decentral feed points, the transition from central to more decentral electricity generation,
- → The development of renewable energy generation,
- → The development of the integration level and
- → The ageing distribution network infrastructure.

These changes must be made "open heart" (that is while providing supply) against the background of the following issues:

- → An increasingly ageing and therefore reducing technical expertise,
- → The demand for more energy efficiency,
- → The short time for implementation and
- → The high expectations on profitable investments in increasingly networked supply systems for electrical energy, gas, heat and transport.

The broad and intense discussion to be observed in recent times and the publication of comprehensive studies and opinions from politics, research institutes, associations, federations and industry is unprecedented in the construction of the electrical supply system. What is so interesting about the supply of electrical energy in the future? For many manufacturers who traditionally operate in the area of industrial automation, or in the area of network technology, the Internet or cloud computing, the increasingly necessary equipment for the integration infrastructure in distribution networks appears to be a massive new market.

Can Internet technologies and general automation solutions help?

„**Energy-on-demand** is considered by many to be solution for the efficient usage of energy."

Internet for energy

The BDI (Bundesverband der Deutschen Industrie e.V.) stated the following on the topic of the smart grid: "Information and communication technology will have a key role during the development of a supply of energy suitable for the future. It is the basis for the realisation of a future **energy internet**, that is the intelligent electronic networking **of all components in the energy system.** ... The biggest challenge here is to create an **integration level between business applications and the physical network** that makes possible the communication between complex IT components distributed across heterogeneous networks and organisational boundaries."

Is such an integration level primarily of service to the smart market or the smart grid at the distribution level, or both? The components installed today at the higher voltage levels are already effectively networked (CIM for grid control centre internal communication, telecontrol for communication with grid control centres and power generation systems as well as IEC 61850 for substations and power generation systems). With the need to integrate thousands of times more components in the lower voltage levels than in the higher voltage levels, it is still largely unclear which tasks they will have and how these can help also in the long-term to maintain the stability of the supply of electrical power at its current level.

Energy-on-demand is considered by many to be solution for the efficient usage of energy. In the context of social networks power consumers could suddenly develop volatile consumption behaviour and synchronously increase or reduce their consumption either in a limited area or over a large area, an event that could have unexpected effects on the systems and in some cases could result in the collapse of the system.

A key question for the realisation of future systems is knowledge of possible and probable failure scenarios. How many feed points

„**Development** must bee understood as continous "further" development of the existing systems with all their complex aspects."

and loads in the distribution networks can be controlled at which points using communication, and which regulation mechanisms could compensate for these effects adequately and quickly enough such that the distribution networks can be operated stably at all levels at all times?

Even under the assumption that all effects are known and corresponding mechanisms for stable system operation have been developed and tested, key questions remain unanswered: who is to finance this automation infrastructure and the related Internet-based integration levels foreseen and, above all, who is to implement, install, integrate, utilise and further develop it? ■

Dipl.-Ing Karlheinz Schwarz
NettedAutomation GmbH

CONCLUSION

The construction of automation infrastructures and integration levels for the supply of energy requires resources that go way beyond current notions and the resources that are available in the short-term. Financial aid for smart energy supply systems must not be primarily an "economic stimulus package" for the integration levels. The aspects such as the electrical safety, the high availability of the supply of energy, the ageing electrical and information technology infrastructure and above all the ageing personnel for the further development and operation of the electrical system must have a significantly higher priority.

The future supply of energy must be understood as a whole. Development must be understood as continuous "further" development of the existing systems with all their complex aspects. Only then can the familiar security of supply of the past also be ensured in the future. The scope and also the required short implementation period will overshadow all the experience of the past 130 years.

The energy revolution currently in planning and the concomitant development of a step-by-step structural change and a closer meshing of the energy networks for electricity, gas, heat and electric mobility, as well as the related necessary infrastructure will be more of a marathon than a sprint. Inter-disciplinary collaboration above all among the electrical engineers and power engineers must be significantly expanded. IEC standards and other standards can, above all against the background of limited development resources, make an important contribution to the simplification of solutions at the integration levels.

The smart grids that will result from the energy revolution will combine the inventions of several hundred years.

Monitoring and Control of
Power Systems and Communication Infrastructures
based on IEC 61850 and IEC 61400-25

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Monitoring of Power System and Communication Infrastructures based on IEC 61850 and IEC 61400-25

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1 Introduction

The focus of the first edition of IEC 61850 “Communication networks and systems in substations” was on substation operational aspects (mainly protection and control). Various groups have identified that IEC 61850 is the basis of further applications, e.g., monitoring of functions, processes, primary equipment, and the communication infrastructure in substations and other power system application domains. The second edition of the first 14 parts IEC 61850 (with the new title “Communication networks and systems for power utility automation“) and other extensions provide further definitions to keep the high quality and availability of power systems, to reduce commissioning time and life cycle costs.

Edition 2 of IEC 61850 provides new data objects for (condition) monitoring. Many new data objects are added for critical measurements like temperatures, oil levels, gas densities, maximum number of connections exceeded et cetera. Such extensions cover the monitoring of equipment like switchgear, transformers, on-load tap changers, automatic voltage regulation devices, gas compartments, and lines; generators, gearboxes, and towers in wind turbines; communication infrastructure like Ethernet switches and routers. Myriads of sensors are needed to monitor the condition of the wind power foundation, tower, rotors, gearboxes, generators to name just a few. The standard IEC 61400-25-2 extends IEC 61850 with condition monitoring data objects for wind turbines. IEC 61850-7-4 (core information models), IEC 61850-7-410 (extensions for hydro power plants), IEC 61850-7-420 (decentralized energy resources), and IEC 62351-7 (security) provide a huge list of new data objects for general monitoring purposes.

The abstract data objects are the basis for a sustainable interoperability in the power industry – abstract means, they can be mapped to more than protocol; sustainable means, they can be used “forever”. The abstract objects can be mapped to MMS as defined in IEC 61850-8-1 or (according to IEC 61400-25-4) to Web Services, OPC-XML, IEC 60870-5-10x, or DNP3.

The new extensions are a pivotal point for the interoperability of exchanging monitoring information in the future electric power systems – they can make the power systems smarter than they were in the past. This paper presents and discusses the benefits and challenges of the various model extensions in edition 2 of IEC 61850 and other related standards. Realizations in practical use in power utilities will be presented, too.

2 Information modeling in IEC 61850

Information models are one of the key elements of the standard series IEC 61850 and related standards. Information models represent measurements and status information taken at the process level, and other kinds of processed information like metering information. The information models are independent of any communication protocol and network solution. They are intended to have a “long life” – a Phase C Voltage in a 50 Hz system is a Phase C Voltage today, tomorrow, in 20 years, in Karlsruhe and in Reykjavik.

Figure 1 shows the different levels of standard definitions: from "long-life" at the top to "short-life" at the bottom.

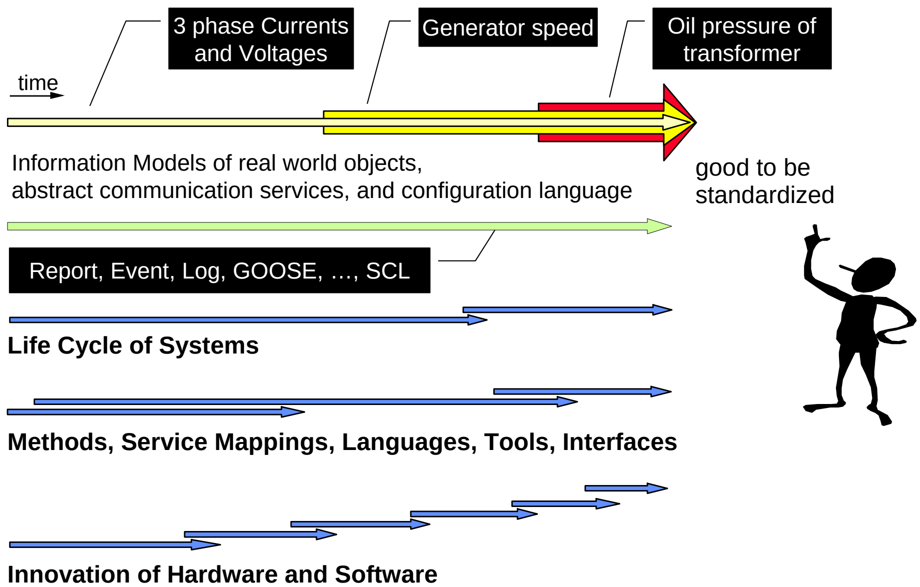

Figure 1: Information models and implementation issues

The models are organized in Logical Nodes containing Data Objects. A Logical Node is for example the "MMXU": The measurements and calculated values of a three phase electrical system. Figure 2 depicts the application of the standard Logical Node "MMXU" for different voltage levels.

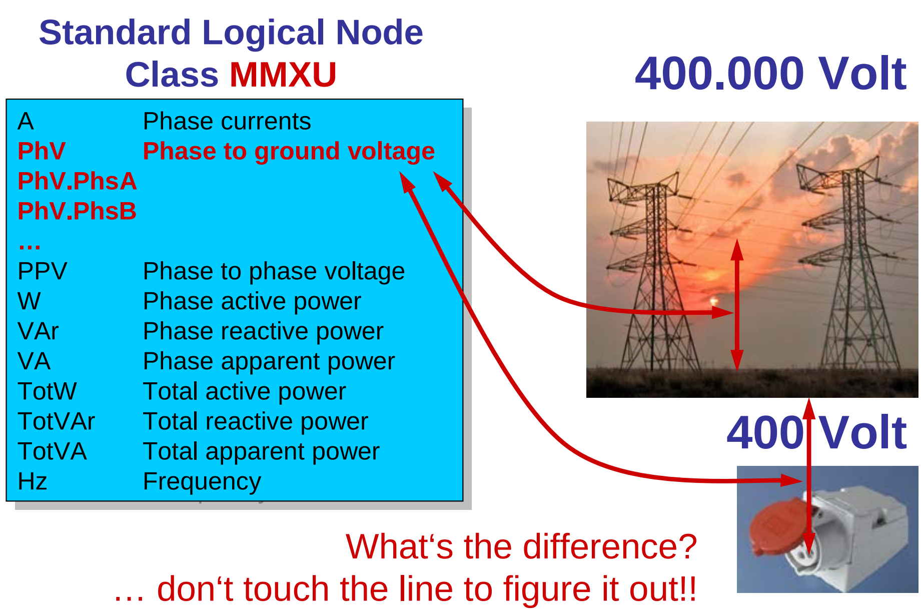

Figure 2: Information model of electrical values

IEC 61850 and related standards define thousands of "signals" as Data Objects organized in Logical Nodes. The list of more 280 standardized Logical Nodes can be found in the Annex.

3 Information models of IEC 61850-7-4 Edition 2

The first Edition of IEC 61850-7-4 “Compatible logical node classes and data classes” contained some 90 Logical Nodes and 500 Data Objects (see Figure 3). They mainly were intended to provide information for control and protection of substation equipment. A few years after the IEC TC 57 WG 10 defined the core document IEC 61850-7-4 Edition 1 several groups started to extend the models for additional application domains. One of the first crucial areas of extensions was the condition monitoring of wind turbines as well as circuit breakers.

Figure 3 shows the current status of the IEC 61850 documents that provide models. The Edition 2 of IEC 61850-7-4 is out for FDIS ballot until February 2010.

150 Logical Nodes (Ed2) – 90 (Ed 1)
800 Data Objects (Ed2) – 500 (Ed 1)

60 Logical Nodes
350 Data Objects

Document	Title	Publication	Edition 2
7-3	Basic communication structure – Common data classes	IS Ed1:2003-05	FDIS 2010-06
7-4	Basic communication structure – Compatible logical node classes and data classes	IS Ed1:2003-05	FDIS 2010-02
7-410	Hydroelectric power plants - Communication for monitoring and control	IS Ed1:2007-08	CD 20xx
7-420	Communications systems for distributed energy resources (DER) - Logical nodes	IS Ed1:2009-03	CD 20xx
7-5	Basic communication structure – Usage of information models for substation automation applications	DC 2010-08	
7-500	Use of logical nodes to model functions of a substation automation system	DC 2010-08	
7-510	Use of logical nodes to model functions of a hydro power plant	DC 2009-12	
7-520	Use of logical nodes to model functions of distributed energy resources	Draft 2010	
7-10	Web-based and structured access to the IEC 61850 information models	DC 2009-12	
		current work in 2009/2010	current work in 2009/2010

updated 2009-12-28

50 Logical Nodes (Draft 2008-05)
450 Data Objects (Draft 2008-05)

Figure 3: Information models in IEC 61850

The second edition specifies more than 150 Logical Nodes. The major technical changes with regard to the first edition are as follows:

- Corrections and clarifications according to information letter;
- Extensions for new logical nodes for the power quality domain;
- Extensions for the model for statistical and historical statistical data;
- Extensions regarding IEC 61850-90-1 (substation-substation communication);
- Extensions for new logical nodes for monitoring functions according to IEC 62271;
- New logical nodes from IEC 61850-7-410 and IEC 61850-7-420 of general interest.

Examples of new Logical Nodes in IEC 61850-7-4 Edition 2 are Logical Nodes for Functionblocks, for Transducers, and Monitoring and Supervision.

Logical Nodes for Functionblocks

The following Logical Nodes expose information used in Functionblock applications:

1. Counter – FCNT
2. Curve shape – FCSD
3. Generic filter – FFIL
4. Control function output limitation – FLIM
5. PID regulator – FPID
6. Ramp function – FRMP
7. Set-point control function – FSPT
8. Action at over threshold – FXOT
9. Action at under threshold – FXUT

An example of a PID loop control with a Logical Node "FPID" representing its attributes (or input and output signals) is shown in Figure 4.

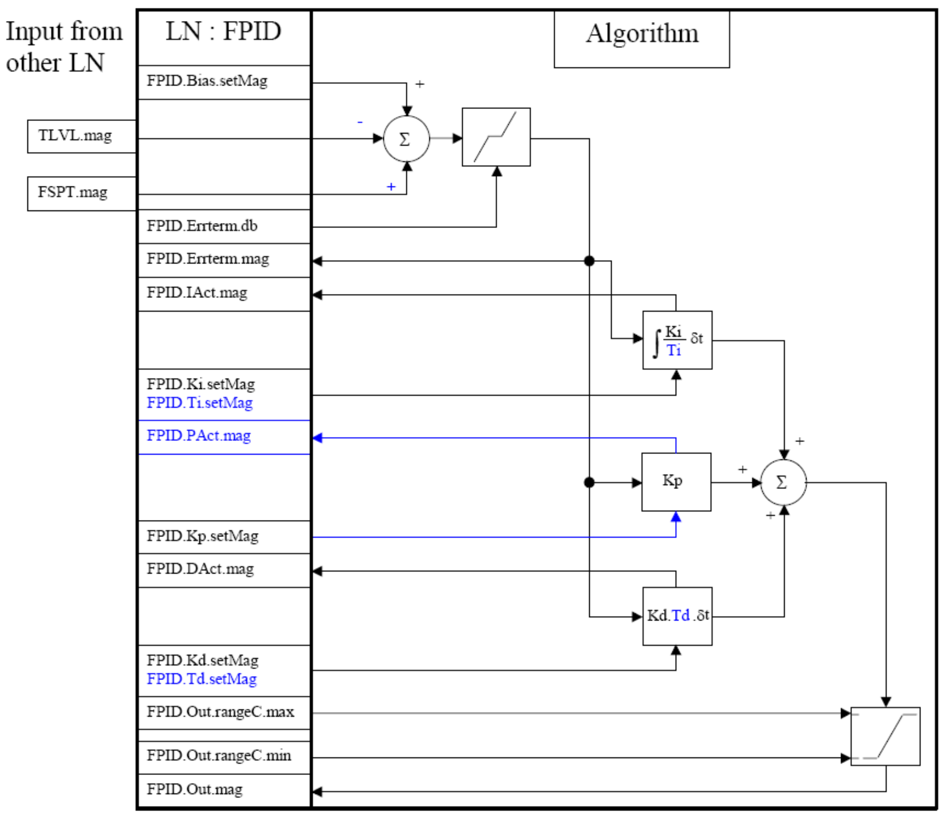

Figure 4: PID Logical Node

Note that IEC 61850 DOES NOT specify the PID loop control algorithm, logig, or function. IEC 61850-7-4 Logical Nodes provide the "interface" or the presentation of the signals, the configuration of the object models and the exchange of the values. The Data Object "KP" (Proportional gain) can be set by an ACSI service. Or the Data Object "DAct" (Derivative action) can be read, reported, logged, or sent by a GOOSE message. All Data Objects can be monitored by using the IEC 61850-7-2 service "Reporting" and "Logging".

Many other new Logical Nodes are included in the second edition of IEC 61850-7-4. There is one crucial area to mention: The new Logical Nodes for sensor (transducer) data. Several of these new and other Logical Nodes have been moved from the Edition 1 of IEC 61850-7-410 (Hydro) to IEC 61850-7-4 Edition 2.

Logical Nodes for Transducers (Sensors)

The following list contains 18 new “T” Logical Nodes for transducers; transducers more or less represent raw values from sensors:

1. Angle – TANG
2. Axial displacement – TAXD
3. Current transformer – TCTR
4. Distance – TDST
5. Liquid flow – TFLW
6. Frequency – TFRQ
7. Generic sensor – TGSN
8. Humidity – THUM
9. Media level – TLVL
10. Magnetic field – TMGF
11. Movement sensor – TMVM
12. Position indicator – TPOS
13. Pressure sensor – TPRS
14. Rotation transmitter – TRTN
15. Sound pressure sensor – TSND
16. Temperature sensor – TTMP
17. Mechanical tension / stress – TTNS
18. Vibration sensor – TVBR
19. Voltage transformer – TVTR
20. Water acidity – TWPH

Most of these Logical Nodes just represent the sampled values from a sensor. The Logical Node for Pressure sensor “TPRS” is shown as an example in Table 1.

Table 1: Logical Node for Pressure sensor

TPRS class			
Data object	**Explanation**		**M/O/C**
LNName	The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22.		
Data objects			
EEHealth	External equipment health		O
EEName	External equipment name plate		O
Measured values			
PresSv	Sampled value of pressure of media [Pa]		C
Settings			
SmpRte	Sampling rate setting		O
Condition C: The data object is mandatory if the data object is transmitted over a communication link and therefore it is visible.			

All “T” Logical Nodes have a Data Object “EEHealth” that provides a simple status information “green”, “yellow” or “red” of the real underlying sensor (called ExternalEquipment – EE). They have further a Data Object “EEName” which comprises a huge list of mainly optional information that provides general details about the sensor. The external equipment name plate exposes the following information (without further explanation): vendor, hwRev, swRev, serNum, model, location, name, owner, ePSName, role, primeOper, secondOper, latitude, longitude, altitude, and mrID.

Logical Nodes for Supervision and Monitoring

The Logical Nodes for supervision and monitoring of the Logical Node group “S” comprise also a lot of new models (seven new Logical Nodes):

1. Monitoring and diagnostics for arcs – SARC
2. Circuit breaker supervision – SCBR (new)
3. Insulation medium supervision (gas) – SIMG
4. Insulation medium supervision (liquid) – SIML
5. Tap changer Supervision – SLTC (new)
6. Supervision of Operating Mechanism – SOPM (new)
7. Monitoring and diagnostics for partial discharges – SPDC (new)
8. Power Transformer Supervision – SPTR (new)
9. Circuit Switch Supervision – SSWI (new)
10. Temperature supervision – STMP (new)
11. Vibration supervision – SVBR (new)

The new Logical Node “Circuit breaker supervision – SCBR” (see Table 2) for example comprises a huge number of new Data Objects that represent a more detailed status of circuit breakers than an “EEHealth” Data Object. These Data Objects of have been defined as part of a new Logical Node “SCBR” instead of adding them to the well know Logical Node “XCBR”. For a specific real circuit breaker only a subset of the Data Objects may be applicable. Or there may even be a need to define further Data Objects; this can be done easily according the name space concept of IEC 61850-7-1 (which is already defined in Edition 1).

Almost all Data Objects of the “SCBR” are optional. Optional usually means that a vendor of an IEC 61850 compliant device can decide to implement only the mandatory Data Objects – in order to be fast on the market and having a standard conformant device (with the minimum of objects). Very often utility people or system integrators are surprised that a device has just a few objects – they would like to have more. It is up to the utilities to request from the vendors to implement more than just the minimum. This is – of course – completely outside the influence of the standardization groups. The Data Objects of the Logical Node “SCBR” are listed in Table 2. These Data Objects have been discussed by several groups of domain experts of switch gears prior to the inclusion into the Edition 2.

In addition to the features build into the measured value models (common data class “MV”; see also the communication services explained further down) there are some crucial Data Objects like “AbrAlm” (Contact abrasion alarm) and “AbrWrn” (Contact abrasion warning) that define a concrete semantic (meaning) of the object. An alarm may be communicated by a GOOSE message and a software at the subscriber side may act automatically on the receipt of this GOOSE message. The alarm and warning levels are defined in the settings “AbrAlmLev” (Abrasion sum threshold for alarm state) and “AbrWrnLev” (Abrasion sum threshold for warning state). The levels may be configured during device configuration or they may be configured by a communication service (SetDataValues) at runtime.

Table 2: Logical Node "Circuit breaker supervision – SCBR"

Status information	
OpCntRs	Resettable Operation Counter
ColOpn	Open command of trip coil
AbrAlm	Contact abrasion alarm
AbrWrn	Contact abrasion warning
MechHealth	Mechanical behavior alarm
OpTmAlm	Switch operating time exceeded
ColAlm	Coil alarm
OpCntAlm	Number of operations (modeled in the XCBR) has exceeded the alarm level for number of operations
OpCntWrn	Number of operations (modeled in the XCBR) exceeds the warning limit
OpTmWrn	Warning when operation time reaches the warning level
OpTmh	Time since installation or last maintenance in hours
Measured values	
AccAbr	Cumulated abrasion
SwA	Current that was interrupted during last open operation
ActAbr	Abrasion of last open operation
AuxSwTmOpn	Auxiliary switches timing Open
AuxSwTmCls	Auxiliary switches timing Close
RctTmOpn	Reaction time measurement Open
RctTmCls	Reaction time measurement
OpSpdOpn	Operation speed Open
OpSpdCls	Operation speed Close
OpTmOpn	Operation time Open
OpTmCls	Operation time Close
Stk	Contact Stroke
OvStkOpn	Overstroke Open
OvStkCls	Overstroke Close
ColA	Coil current
Tmp	Temperature e.g. inside drive mechanism
Settings	
AbrAlmLev	Abrasion sum threshold for alarm state
AbrWrnLev	Abrasion sum threshold for warning state
OpAlmTmh	Alarm level for operation time in hours
OpWrnTmh	Warning level for operation time in hours
OpAlmNum	Alarm level for number of operations
OpWrnNum	Warning level for number of operations

It is likely that new vendors of IEC 61850 conformant devices will specialize in the domain of condition monitoring and offer more possibilities than traditional vendors. The trend is quite obvious: There are a lot of new solutions for monitoring one or the other part of the process that will hid the road in 2010. The monitoring operation usually does not have a direct link to the automation and protection. It is lees critical than protection functions and devices. Most equipment in the electrical system (mainly at distribution level) is not monitored at all today – operators are quite "blind" on what's going on in distribution networks. With the event of Smart Grids (or Smarter Grids) this is likely to change dramatically.

4 Information models of IEC 61850-7-410 Edition 2 for Monitoring

The Standard IEC 61850-7-410 Edition 1 “Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Hydropower plant logical nodes” defines some 60 Logical Nodes and 350 Data Objects for various hydropower plant applications.

The Logical Nodes in IEC 61850-7-410 Edition 1, that where not specific to hydropower plants (mainly those that represent transducers, supervision and monitoring information), have been moved to Edition 2 of IEC 61850-7-4 and they will be removed from Edition 2 of IEC 61850-7-410. Most of the modeling examples and background information that was included in IEC-61850-7-410 Edition 1 will be transferred to a technical report TR 61850-7-510.

Edition 2 of IEC 61850-7-410 will include additional general-purpose and supervision and monitoring Logical Nodes, not included in IEC 61850-7-4 (Edition 2), but required in IEC 61850-7-410 in order to represent the complete control and monitoring system of a hydropower plant.

The following Logical Nodes for supervision and monitoring (Group “S”) have been specified for Edition 2 of IEC 61850-7-410:

1. Supervision of media flow – SFLW
2. Supervision of media level – SLEV
3. Supervision of the position of a device – SPOS
4. Supervision media pressure – SPRS

Each of these Logical Nodes comprises measured values, status information and settings.

Details are still under discussion in IEC TC 57 WG 18 which is responsible for the Edition 2 of IEC 61850-7-410.

5 Information models of IEC 61850-7-420 Edition 1 for Monitoring

The Standard IEC 61850-7-420 Edition 1 “Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes” defines some 50 Logical Nodes and 450 Data Objects for various DER domains.

Most Logical Nodes have some status information and measurements that can be used for monitoring. They are usually not defined in separate “S” Logical Nodes.

IEC 61850-7-420 defines the following specific Logical Nodes that are intended to provide special measurements for monitoring various physical processes:

1. Temperature measurements – STMP
2. Pressure measurements – MPRS
3. Heat measurement – MHET
4. Flow measurement – MFLW
5. Vibration conditions – SVBR

The details of the Logical Nodes could be found in IEC 61850-7-420. One example is shown in the following example.

The crucial Data Objects of the Logical Node “MFLW” (Flow measurement) are listed in Table 3. These models are more comprehensive than those that will be defined in IEC 61850-7-4 Edition 2; they may be used for any other application domain as well.

One of the crucial benefits of IEC 61850 is this: Which Data Object is ever missing in any Logical Node, it could be defined as an extension. IEC 61850-7-1 defines the rules for defining new Logical Nodes, new Data Objects or even new common data classes. The concept is called the “name space concept”.

Table 3: Logical Node “Flow measurement – MFLW”

Measured values	
FlwRte	Volume flow rate
FanSpd	Fan or other fluid driver speed
FlwHorDir	Flow horizontal direction
FlwVerDir	Flow vertical direction
MatDen	Material density
MatCndv	Material thermal conductivity
MatLev	Material level as percent of full
FlwVlvPct	Flow valve opening percent
Controls	
FlwVlvCtr	Set flow valve opening percent
FanSpdSet	Set fan (or other fluid driver) speed
Metered values	
MtrVol	Metered volume of fluid since last reset

6 Information models of IEC 61400-25 for Monitoring

Some Data Objects are already defined in the current published standard IEC 61400-25-2 “Communications for monitoring and control of wind power plants – Information models”. The Logical Node Wind turbine transmission information (WTRM) comprises the Data Objects that represent wind turbine (mechanical) transmission information. The data represent usual transmission topology, consisting of a slow speed shaft, multistage gearbox, a fast shaft and a (hydraulically driven) mechanical brake. In case of a divergent transmission topology (e.g. direct drive, single stage gearbox) or different mounted equipment (e.g. sensors, electromechanical brake), users are free to adapt or extend the data classes. Table 4 shows the Logical Node “WTRM” of the standard IEC 61400-25-2 published in January 2007. Most of the Data Objects of this Logical Node provide monitoring information of the transmission system.

Table 4**:** Logical Node “WTRM”

Data object	**Description**
Status information	
BrkOpMod	Status of shaft brake
LuSt	Status of gearbox lubrication system.
FtrSt	Status of filtration system
ClSt	Status of transmission cooling system
HtSt	Status of heating system
OilLevSt	Status of oil level in gearbox sump
OfFltSt	Status of offline filter
InlFltSt	Status of inline filter
Measured values	
TrmTmpShfBrg1	Measured temperature of shaft bearing 1
TrmTmpShfBrg2	Measured temperature of shaft bearing 2
TrmTmpGbxOil	Measured temperature of gearbox oil
TrmTmpShfBrk	Measured temperature of shaft brake (surface)
VibGbx1	Measured gearbox vibration of gearbox 1
VibGbx2	Measured gearbox vibration of gearbox 2
GsLev	Grease level for lubrication of main shaft bearing

GbxOilLev	Oil level in gearbox sump
GbxOilPres	Gear oil pressure
BrkHyPres	Hydraulic pressure for shaft brake
OfFlt	Offline filter contamination
InlFlt	Inline filter contamination

Several other Logical Nodes offer Data Objects that can be used for monitoring purposes.

The standard IEC 61400-25-6 “Communications for monitoring and control of wind power plants – Logical node classes and data classes for condition monitoring” is intended to provide more sophisticated Data Objects that can be used for higher level diagnosis.

IEC 61400-25 defines information models and information exchange models for monitoring and control of wind power plants. The modeling approach (for information models and information exchange models) of IEC 61400-25-2 and IEC 61400-25-3 uses abstract definitions of classes and services such that the specifications are independent of specific communication protocol stacks, implementations, and operating systems. The mappings of these abstract definitions to specific communication profiles are defined in IEC 61400-25-4 (see **Figure 5**). The definitions in parts IEC 61400-25-1 to IEC 61400-25-5 apply also for part 6.

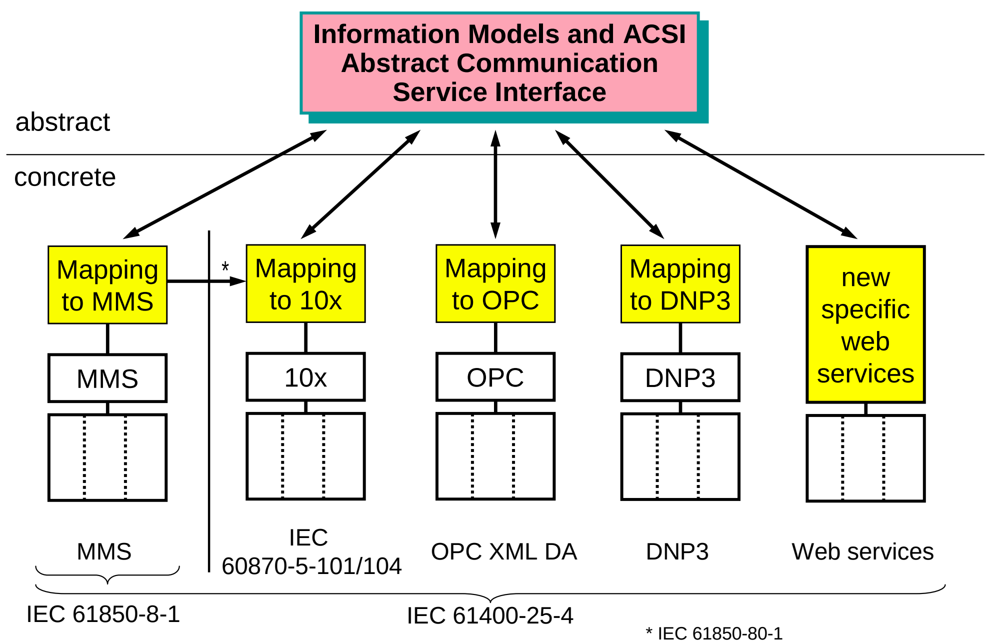

Figure 5: The mappings of IEC 61400-25-4

The purpose of part 6 is to define an information model for more specialized condition monitoring information and to define how to use the existing definitions of part IEC 61400-25-2 and to define the required extensions in order to describe and exchange information related to condition monitoring of wind turbines. The models of condition monitoring information defined in this standard may represent information provided by sensors or by calculation.

In the context of this standard condition monitoring means a process with the purpose of observing components or structures of a wind turbine or wind power plant for a period of time in order to evaluate the state of the components or structures and any changes to it, to detect early indications of impending failure.

Condition monitoring is most frequently used as a Predictive or Condition-Based Maintenance technique (CBM). However, there are other predictive maintenance techniques that can also be used, including the use of the Human Senses (look, listen, feel, smell) or Machine Performance Monitoring techniques. These could be considered to be part of the condition monitoring.

Condition monitoring techniques that generate information to be modeled include, but are not limited to techniques such as:

- Vibration measurements and analysis,
- Oil debris analysis,
- Temperature measurement, and
- Strain gauge measurement.

Components and structures can be monitored by using automatic instrumentation as well as using a manual process.

The condition monitoring functions may be located in different physical devices. Some information may be located in a turbine controller device (TCD) while other information may be located in an additional condition monitoring device (CMD). Various actors may request to exchange data located in the TCD or CMD. A SCADA device may request the information from a TCD or CMD; a CMD may request information from a TCD and vice versa. The information exchange between any two devices requires the use of information exchange services defined in IEC 61400-25-3 or added in part 6.

The use case of having the condition monitoring functions located in the turbine controller device is a special use case. That use case does not require information exchange services for the information exchange between the condition monitoring functions and the turbine controller functions. The case of having separate devices is the more comprehensive use case. This is used as the typical topology in this part of the standard. The special case of both functions in one device could be derived from the most general use case.

It may also be required to build a hierarchical model of automatic turbine controller and condition monitoring devices/functions. A simple condition monitoring device (CMD; providing measured values and status information and very basic monitoring capabilities). This CMD may retrieve information from the underlying CMD or TCD and may further process and analyze the measured values and status information.

In condition monitoring systems predefined triggers are applied to initiate a sequence of events, for example issuing an alarm to the local SCADA system or sending a message to a monitoring centre in order to prevent further damage on components or structures. In general such messages can be used by a Condition Monitoring Supervision function to generate actionable information which can be used by a service organization to create work orders and initiate actions. Figure 6 illustrates the information chain of a system using condition monitoring to perform condition based maintenance.

Figure 6 illustrates how data are refined and concentrated through the information chain, ending up with the ultimate goal of condition based maintenance – actions to be performed via issuing work orders to maintenance teams.

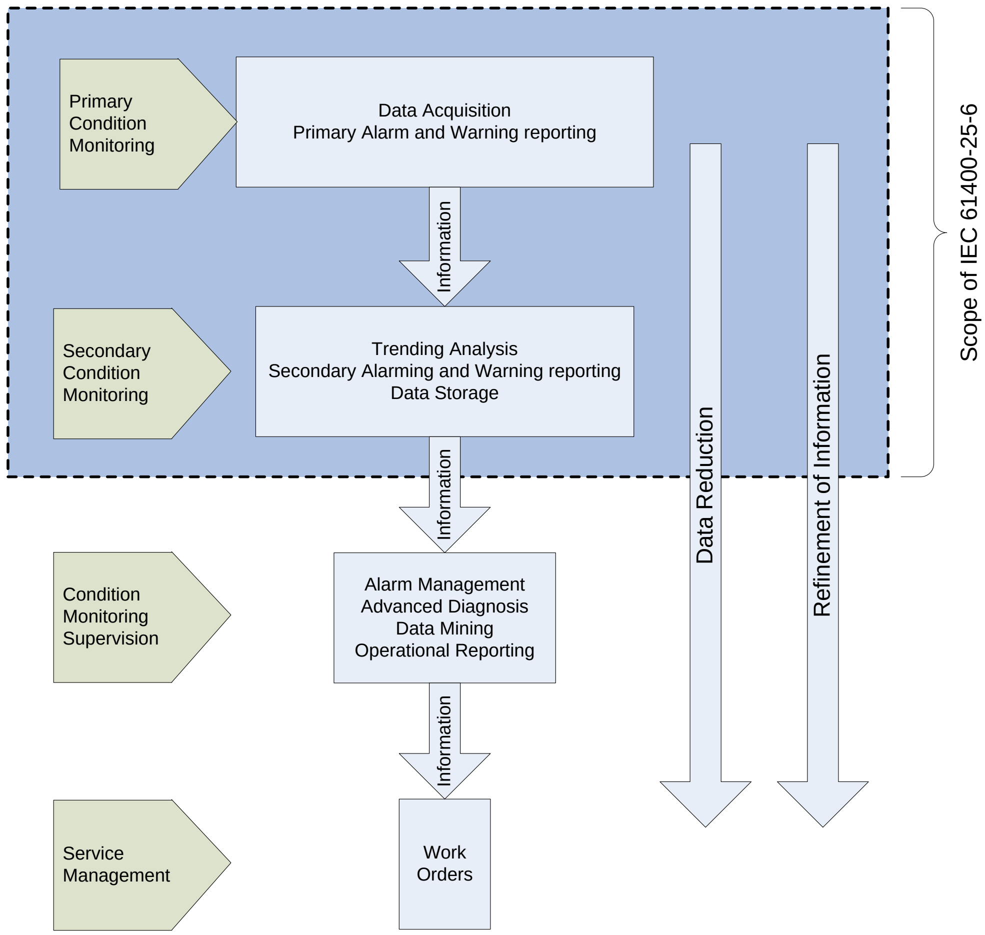

Figure 6: The information chain of condition based maintenance

Figure 6 shows the scope of IEC 61400-25-6 and the typical information chain of condition monitoring systems. The local (primary) part of the chain could be named as condition monitoring localized in the wind turbine and the wind farm SCADA system, but the local functionality can vary from system to system. The centralized (secondary) data retrieval performed by for example a control centre system is often named as a back-office system. The decreasing sizes of the boxes illustrate the data reduction and the transformation of data into more useful information with an enhanced value.

The FDIS (Final Draft International Standard) of part IEC 61400-25-6 is expected to be available in early 2010.

7 Communication services for monitoring

The part IEC 61850-7-2 (ACSI – Abstract communication service interface) and IEC 61400-25-3 define the basics for information models and services and part IEC 61850-7-4 and IEC 61400-25-2 (Logical Nodes and Data Objects) defines concrete information models (the Data Objects that represent the values to be monitored). It is crucial to understand that the standards IEC 61850 and IEC 61400-25 do not define new process data – the standards assign useful names and types to real-world data. These names are valid internationally.

The ACSI provides the following basic definitions we need for monitoring:

- Logical Nodes are used as containers of any information (Data Objects) to be monitored,
- Data Objects are used to designate useful information to be monitored,
- Retrieval (polling) of the values of Data Objects (GetDataObjectValues),
- Send events from a server device to a client (spontaneous Reporting),
- Store historical values of Data Objects (logging),
- Exchange sampled values (current, voltages and vibration values),
- Exchange simple status information (GOOSE), and
- Recording functions with COMTRADE files as output.

These basic definitions are explained in the following with regard to the use case “monitoring”.

Logical Nodes

Many Logical Nodes are explicitly defined to represent a list of Data Objects that relate to measurements like temperature, pressure, level, gas density, etc. Many other logical nodes are a mix of controllable Data Objects, objects for settings, protection, and so on.

An example of a Logical Node comprising only monitoring information is the Logical Node “Circuit breaker wear supervision” (SCBR) of the draft edition 2 of IEC 61850-7-4 is shown in Table 5 (this and the following Logical Node tables are just showing an excerpt of Data Objects).

Table 5**:** Circuit breaker wear supervision Logical Node (SCBR)

Data object	**Description**
Status information	
Col1Opn	Open command of trip coil 1
Col2Opn	Open command of trip coil 2 (usually as backup protection coil)
AbrAlm	Contact abrasion alarm
AbrWrn	Contact abrasion warning
Measured values	
AccAbr	Cumulated abrasion coefficients
TripA	Current that was interrupted during last open operation
ActAbrCoef	Abrasion coefficient of last open operation
Settings	
AbrAlmLev	Abrasion coefficient sum threshold for alarm state
AbrWrnLev	Abrasion coefficient sum threshold for warning state

Operating a breaker and especially tripping a short circuit causes always some abrasion (or erosion) of the breaker contacts. The supervision relates to a single phase since each phase has its own contact.

The first seven Data Objects can be used for monitoring purposes; the last two are used for settings limits. The communication services applicable are explained below.

Data Objects

There are several categories of Data Objects that provide various aspects of the monitoring process:

- Status information (single or double point information),
- Measured information (analogue values measured or calculated, and
- Settings (set ratings or limits for monitoring)

The standards related to IEC 61850 define hundreds of Data Objects of these categories.

Some basic aspects with regard to monitoring are explained in the following paragraphs:

Status information: In most cases there is a need to provide several details of the status. IEC 61850-7-3 provides these attributes by, e.g., the common data class SPS (single point status as defined in IEC 61850-7-3):

– stVal BOOLEAN TrgOp=dchg
– q Quality TrgOp=qchg
– t TimeStamp

Any change of the value of the status with the standard name “stVal” can be used to trigger a report (comprising the values for stVal, q and t) to be sent to clients or to trigger to log the values of stVal, q and t to one or multiple logs. It is also possible that a client reads these values (stVal, q and t) at any time to get the values of the last change or the current value.

These values may also be used to be sent as content of a GOOSE messages. GOOSE messages are sent by multicast to any IEDs (Intelligent Electronic Device) connected to the same subnetwork. Even a sampled value message may sent the values (stVal, q and t) continuously with the same rate (e.g. 4 kHz) as the current and voltage samples from CTs and VTs.

Independent of the use of reporting, logging, GOOSE, or sampled value exchange, the data to be exchanged has to be specified by a DataSet. A DataSet contains a list of references to Data Objects and parts of it (the so-called functionally constraint data, FCD, or data attributes, FCDA).

A DataSet may comprise several status information and a few measurements for example.

Measured values: IEC 61850-7-3 provides attributes for measured values. The most common class is the common data class MV (measured value) with the following attributes:

– instMag AnalogueValue
– mag AnalogueValue TrgOp=dchg
– range ENUMERATED TrgOp=dchg
– q Quality TrgOp=qchg
– t TimeStamp
– units Unit
– db INT32U
– zeroDb INT32U
– sVC ScaledValueConfig
– rangeC RangeConfig

Any change of the magnitude value (with the standard name “mag”) can be used to trigger a report (of mag, range, q and t) to be sent to clients or to trigger to log these values to one or multiple logs. It is also possible that a client reads these values at any time to get the last change. The values may also be used for other services like GOOSE.

The use of mag (a deadband or filtered value) and range in conjunction with reporting and logging is explained below.

The attribute units, db, sVC and rangeC are used to configure the engineering unit (e.g., V for Volt), the multiplier (M for Mega), the deadband value for filtering the analogue value, the scale factor and offset (for integer values) and the range configuration. Those attributes that have a impact on the monitoring of measured value are explained below.

Statistical and historical statistical information

Measurement Data Objects usually (in Edition 1) refer to RMS (root mean square) values or just current values, provided at the time when they have been measured. In many applications there is a need to refer also to statistical values of a measurement, e.g., maximum value of an hour or

15 minutes interval. The statistical values require some minor extensions of the first edition of IEC 61850-7-x. The standard IEC 61400-25-2 has already published the solution for statistical data.

In many application domains such as wind power plants, it is required to provide additional information of a basic analogue value:

- **Statistical information** (for example, minimum value calculated for a specified time period, for example, minimum value of last 1 hour)
- **Historical statistical information** (for example, log of minimum values of the sequence of values calculated above, for example, last 24 hourly values)

This additional information may be derived from the basic analogue values. It may be the only information provided – depending on the application requirements.

The models for the statistical and historical statistical data are explained conceptually in Figure 7.

On the left hand side are the basic data representing the cur-rent values (PRES), i.e. some instantaneous analogue (or integer) values that are contained in the logical node instance XXYZ.

The upper half depicts the method defined for statistical values. The first example is the instance XXYZ1 of the logical node class XXYZ. The analogue values represent the calcu-lated maximum values derived from the instance XXYZ. The logical node XXYZ1 has special setting data that indicate that the values are maximum values and that the calculation method is "periodic". The period starts after a start command or by local means. At the end of the period the calculated maximum values of the instance XXYZ1 are overwritten by the new values.

The maximum values can be used to calculate the minimum maximum values in – of course – a much longer period than for the maximum calculation in XXYZ1. The instance XXYZ2 may represent the minimum value of the max value of the last 10 days.

Setting parameters other than PERIOD may be used to specify calculation modes. A calculation mode set to TOTAL means that the calculated maximum values are calculated since the first start of the device or of the involved application. A calculation mode set to SLIDING means that the calculated maximum values are calculated over a sliding window whose width can be set by means of a special interval type setting (e.g. hour, day, week).

The lower part of the figure shows the conceptual model of the historical statistical data. In this model the calculated val-ues (in this case the maximum values with calculation mode set to PERIOD) are stored in sequence in a log. The calcula-tion in the example starts at midnight of 2004-10-03. The in-terval is 1 h. After that first hour the first log entry is written. After the second hour the second entry contains the value of the second hour. After five (5) hours the log contains the values of the last three hours (intervals 02-03, 03-04, 04-05).

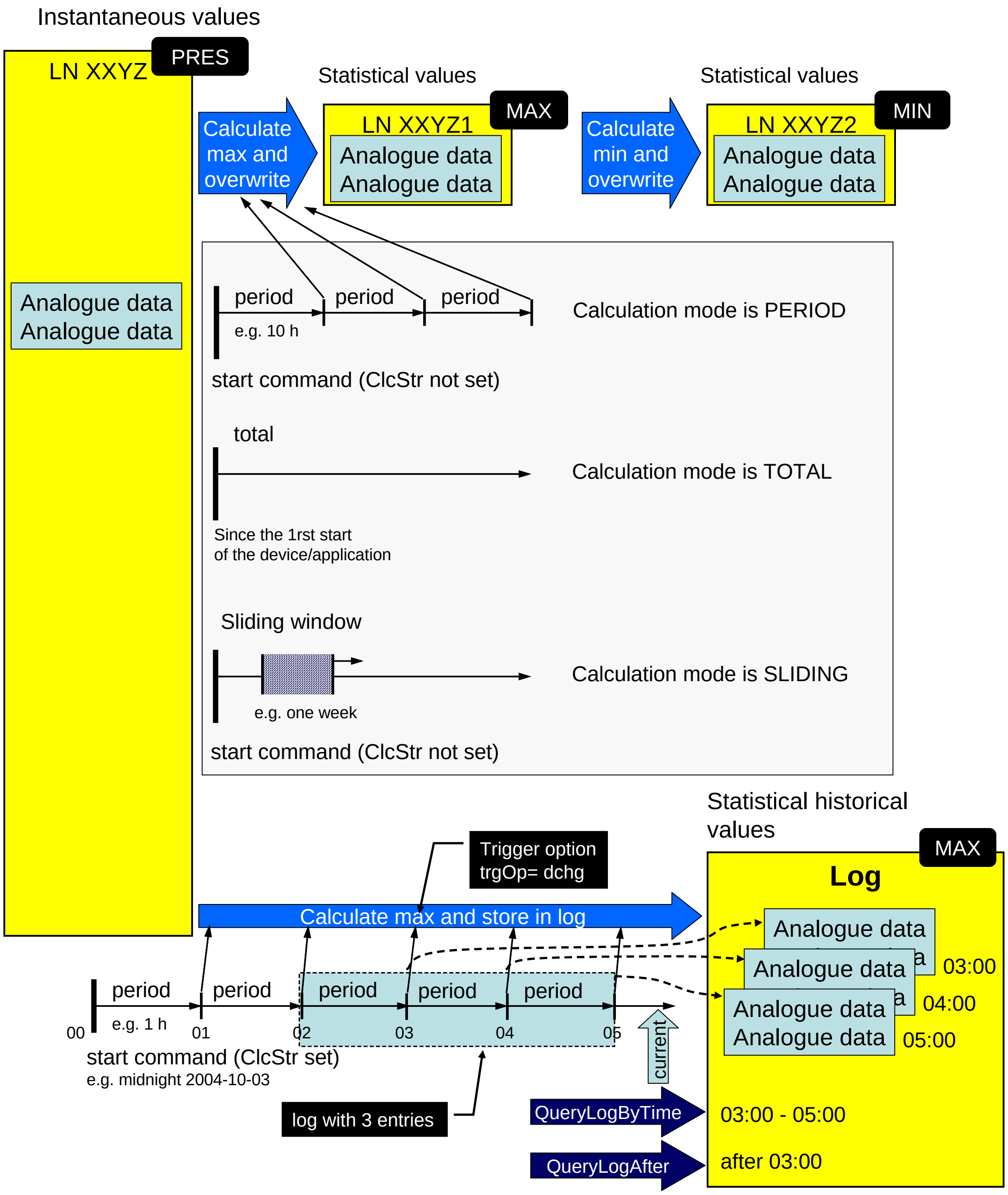

Figure 7: Statistical and Historical Statistical Data Objects (1)

The statistical data model is based on the calculation of analogue values contained in other logi-cal nodes. The top logical node LN XXYZ in Figure 2 refers to three technologi-cal logical nodes of the same Type (for example MMXU). The top logical node (LN XXYZ) represents the instanta-neous measured values. The second and third logical nodes are the statistical logical nodes, i.e., the logical nodes that represent the calculated values (LN XXYZ1 represents the MIN values, the LN XXYZ2 the MAX values).

The two logical nodes on the left of the bottom in Figure 2 (XXYZ1 and XXYZ2) represent mini-mum (MIN) and maxi-mum (MAX) values of the analogue data represented in the top logical node (XXYZ). The two logical nodes make use of the setting data ClcSrc (calculation source). The common data class of ClcSrc is ORG, “object reference setting group” and is used to reference the source logical node for the calculation. For both logical nodes, ClcSrc has the value XXYZ. Each logical node with analogue data can be used as a source. Addi-tionally, they have the data ClcStr (calculation start) and ClcExp (calculation expired) and the setting data ClcPerms (calculation period), ClcSrc (calculation source), and ClcMod (calculation mode).

With the settings ClcMod, ClcMthd, ClcPer and ClcSrc, the behavior of the logical node can be controlled. For periodic calculation, the “event” ClcExp set to TRUE can be used as an event to report the new value (the statistical value) by the re-port control block or it may be logged as historical statistical data for later retrieval.

The data names of the “Data” in all logical nodes shown **Figure 8** are the same, i.e., in all three logical nodes. The data are contained in different logical node instances (XXYZ, XXYZ1, and XXYZ2). These result in the following refer-ences: XXYZ.Data1, XXYZ1.Data1, and XXYZ2.Data1.

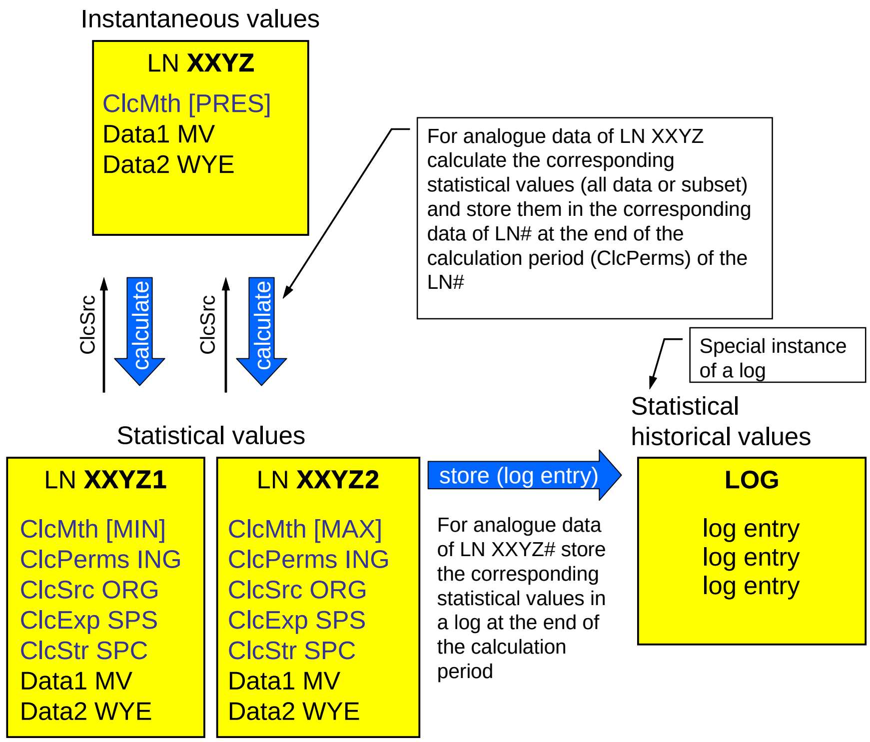

Figure 8: Statistical and Historical Statistical Data Objects (2)

Settings: Setting Data Objects are used to set specific val-ues for limits and other purposes. The purpose is usually de-fined with the semantic of a Data Object.

In the example of the Logical Node SCBR the two settings are used to monitor when to change status values of the warn-ing AbrWrn and the alarm Data Object AbrAlm. These Data Objects are single point status objects that can be used by the various communication services.

Retrieve (poll) the values of Data Objects

Any Data Object, any part of it and any group of them (optionally through a DataSet) can be read from a client. The corresponding services are GetDataValues and GetDataSetValues.

A DataSet may be defined by the service CreateDataSet (online), during configuration, or it may be built in.

Send events from a server device to a client (spontaneous Reporting)

Reporting is one of the most powerful service models in IEC 61850. It allows to configure the reporting behavior of the server device in a wide range of possibilities.

The basic concept of reporting is that values to be reported are specified by a DataSet object. The DataSet is a list of references to the objects to be reported; each referenced object is called a member of the DataSet. If a change of a value of one of the members happens the server creates a report message and sends the new value to the corresponding client. The change is also called a trigger – to trigger sending a report.

The trigger options are defined in the Data Objects (in Logical Nodes). There are, for example, two trigger options (data value change and quality value change) defined for each status Data Object derived from the common data class SPS:

SPS (single point status):

– stVal	BOOLEAN	TrgOp=dchg
– q	Quality	TrgOp=qchg
– t	TimeStamp	

The two Data Objects of the Logical Node SCBR (from above) are derived from the common data class SPS:

"AbrAlm" – Contact abrasion alarm and "AbrWrn" – Contact abrasion warning

If the cumulated abrasion coefficients "AccAbr" has reached the value of the "AbrWrnLev" (as configured by "AbrWrnLev" -abrasion coefficient sum threshold for warning state) the value of "AbrWrn" changes and can be reported if the object is a member of the corresponding DataSet.

Setting Data Objects are used to set specific values for limits and other purposes. The purpose is usually defined with the semantic of a Data Object.

In the example of the Logical Node "SCBR" the two settings are used to monitor when to change status values of the warning "AbrWrn" and the alarm Data Object "AbrAlm". These Data Objects are single point status objects that can be used by the various communication services.

The example has shown that any analog value (measurement or calculated value) can be monitored for limit violations. This approach of defining Data Objects for the analogue value "AccAbr", the limit configurations "AbrWrnLev" and "AbrAlm-Lev" and the warning "AbrWrn" and alarm "AbrAlm" is quite often used in the Logical Nodes in edition 2 of IEC 61850-7-4 and in other documents.

The measured value common data class "MV" contains already some mechanisms to monitor analogue values.

IEC 61850-7-3's common data class MV (measured value) has the following values with regard to reporting:

– mag	AnalogueValue	TrgOp=dchg
– range	ENUMERATED	TrgOp=dchg
– q	Quality	TrgOp=qchg
– t	TimeStamp	
– db	INT32U	
– rangeC	RangeConfig	

The use of the attributes mag and range are shown in Figure 9 and Figure 10.

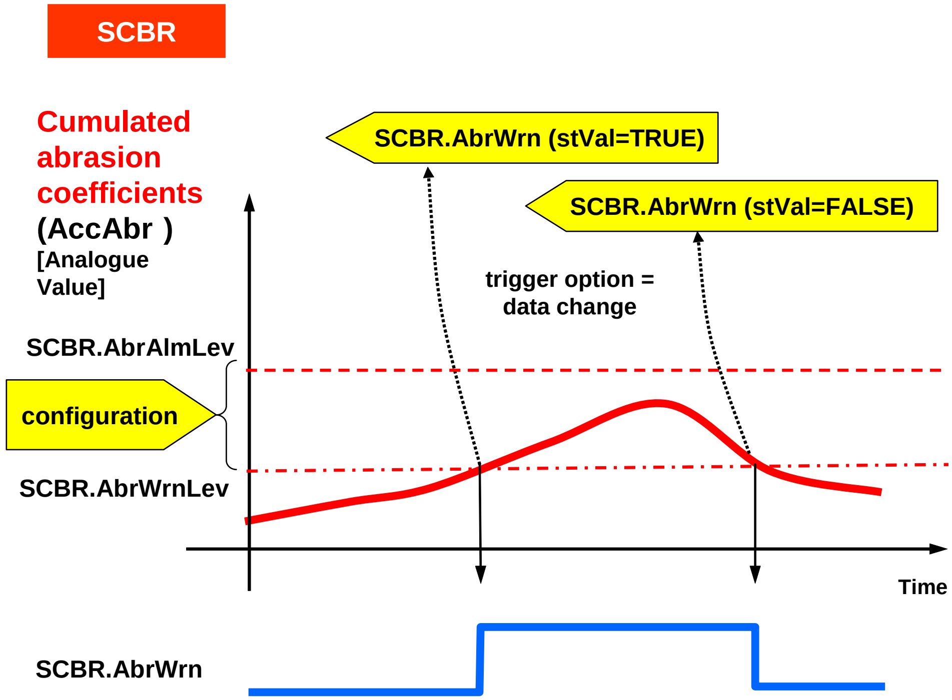

Figure 9**:** Deadband Filtering and Reporting (logging)

The analog value “AccAbr” is monitored for relative changes configured by “db” (deadband configuration). The deadband configuration specifies a relative change in per cent of the whole value range: Min to Max. In our case the value is 10 per cent. Any change of the value by +/10 per cent issues a trigger that can be used to report or log the new value.

The deadband configuration value can be configured during engineering, IED configuration, or online with the SetData-Value service. The smaller the value the more reports may be generated. It is up to the system integrator or operator (later on) to make sure that the whole system is configured in a way that not too many reports are generated. If for thousands of Data Objects the configuration parameter db is very small and the change rate of the values is high then it could happen that the IEDs and the network are flooded. Be aware everything is limited!

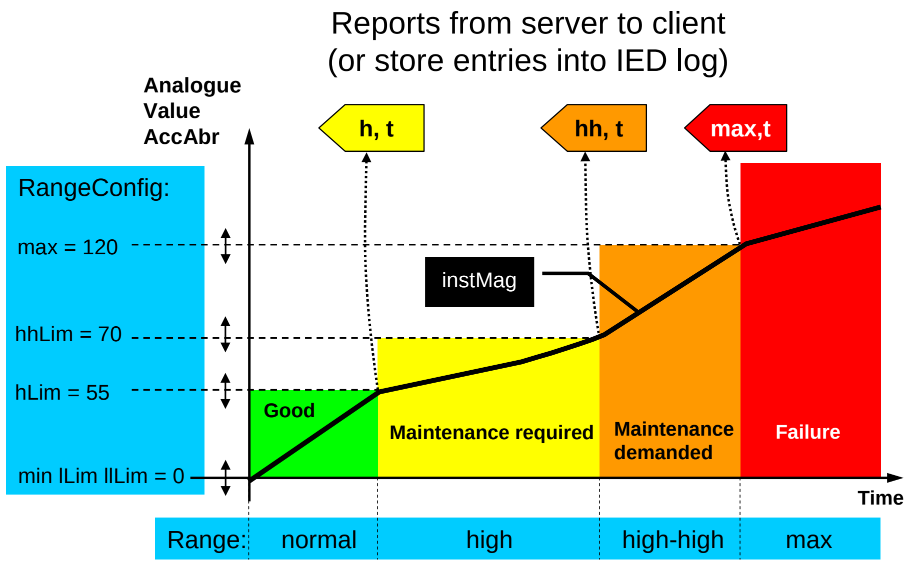

Figure 10**:** Range monitoring and reporting (logging)

The range monitoring uses the limits specified by the range configuration values for min, llLim, lLim, hLim, hhLim and max. Each time the analog value AccAbr crosses one of these limits a trigger is issued. The triggers can be used to report the analog value with the range value min, low-low, low, normal, high, high-high, and max. In addition to these two values the quality information q and timestamp t can be communicated with the report. Instead or in addition to the report the values may be placed into a log.

The meaning of the range values can de defined by the application. In the example it is defined as good, maintenance required, maintenance demanded, and failure. This approach (which is build-in in each analog value derived from the common data class "MV") is different to the approach discussed earlier with the warning and alarm Data Objects and the configuration of the two limits as Data Objects. There is one difference: the Data Objects "AbrAlm" (Contact abrasion alarm) and "AbrWrn" (Contact abrasion warning) represent already a semantic. The two Data Objects can easily be used for GOOSE messaging to trigger an automatic function, e.g. to block operation or to control something in the substation.

A comprehensive modeling approach for monitoring of analog values is expected to be written by IEC TC 57 WG 10. This could be used for modeling monitoring of analog values in future applications. It is the freedom of the modelers to model the monitoring function one way or the other. All possibilities defined in the various standards today are conformant to IEC 61850 in general.

Store historical values of Data Objects (logging)

The logging of values of members of a DataSet is exactly the same as the reporting – except that the values are stored in a local buffer (the log – a circular buffer) and that clients have to initiate queries to retrieve logged data values.

The query log service is simple and straight forward: A client specifies the log to be queried, a starting time and ending time, a start time, or an ending time. In the first case all values stored between the two times are transmitted, in the second case all values after the start time are provided and in the third case all values before the ending time will be sent to the client.

For different applications it is recommended to think about how to best configure the logging: one log or multiple logs. A DataSet which causes frequent changes that may be logged for a short period (e.g., one day) may use a separate log. Because other Data Objects (not frequently changing) in another DataSet may have to be logged for a year or more. Putting these two streams in one log would cause the low frequent values being overwritten by the high speed values.

Be aware that reporting and especially logging is now migrating from control center SCADA systems down to the IED level. The functions reporting and logging are providing are well known – but usually implemented in SCADA systems; often on top of RTUs (remote terminal units).

Exchange of sampled values (SV)

The sampled value exchange mechanism has been defined in IEC 61850-7-2 and IEC 61850-9-2 for replacing the many wires carrying analog signals of voltage and current measurements. The samples to be transmitted are defined by a DataSet. A DataSet may contain analog and any other type of data, e.g., status values.

For the use of sampled value exchange in so-called Merging Units (MU) the UCA IUG (UCA International Users Group) has defined an implementation guide "9-2LE". This guide provides a set of concrete settings for the DataSet and the control block. The DataSet comprises a fixed set of four currents and four voltages. Two sampling rates are defined: 80 samples/period for protection and 256 samples/period for metering. First Merging Units are available.

The sampled value exchange method can also be used for the high speed transmission of vibration data. Think of a huge hydro power plant with some 50 generators. Each and every set of generator and turbine has a lot of sensors that monitor the turbine, generator, and other components. There is now way to continuously record all samples of vibration sensors. The vibration sensor cold trigger a report sent to the maintenance department indicating a warning level. The maintenance people can now start a sampled value control block to send high speed samples from the field up to the office. At the subscriber of the sample stream there could be a analyzing tool that does some online analysis of the sample stream as it arrives. After some time of analysis the publisher may be disabled sending a high frequency stream of samples.

Exchange simple status information (GOOSE)

GOOSE (Generic Object Oriented Substation Event) is used to reliably distribute events very fast in the whole substation (subnetwork). The values to be sent are also specified by a DataSet. The DataSet members may be status information or any other values. After a change of any member of the DataSet the GOOSE message is sent immediately and repeated in a very high frequency. After several repetitions the frequency turns down to a low value (may be every 100 ms). Every 100 ms the receiver (subscriber) can expect new GOOSE message.

If the subscriber does no receive the message after 100 ms, it can expect that the sender (publisher) or the communication network have a serious problem. With that mechanism it is possible to monitor the publisher and communication system continuously. This is not possible in today's wire based exchange of status information.

Recording functions with COMTRADE files as output

The recording functions are defined in IEC 61850-7-4 by a set of Logical Nodes included in the group R – protection related Logical Nodes. They are used to model typical (and well known) recording functions in different devices that have (already!) recording capabilities. The recording mechanisms are NOT defined in IEC 61850.

RDRE is a Logical Node representing the acquisition functions for voltage and current wave forms from the sensors (CTs and VTs), and for position sensors (usually binary inputs). Calculated values such as frequency, power and calculated binary signals can also be recorded. “RDRE” is used also to define the trigger mode, pre-trigger time, post-trigger time, pre-fault, post-fault, etc. attributes of a disturbance-recording function.

The Logical Node “RADR” is used to represent a single analog channel, while “RBDR” is used for the binary channels. Thus the disturbance recording function is modeled as a logical device with as many instances of “RADR” and “RBDR” Logical Nodes as there are analog and binary channels of the real recorder function available.

8 RWE R&D Process Bus Project

The IEC Standard 61850 is usually used for station and bay level communication. The standard comprises also a digital communication with the process level. This allows to integrate primary substation equipment, in particular electronic instrument transformers in a standardized way into the digital communication of the substation automation system (SAS).

RWE (second biggest German utility) has launched a multi-vendor project with the objective of collecting experience with this new process bus technology in a real 380/110 kV substation environment. An already existing 380/110 kV power transformer and its related bays were equipped with the new process bus technology in parallel to the existing active SAS. Two non-conventional CTs and VTs have been added to the primary equipment. The digital interface of an instrument transformer is the so called “merging unit”. Samples from conventional instrument transformers using the 100V/1A interface can also communicate using a merging unit as a sample value publisher. Thus a merging unit operates as a decentralized A/D-converter.

The communication network consists of two fully redundant ring busses. Several devices are connected: merging units, protection devices, bay controllers, electronic circuit breaker devices, a voltage controller, a tap changer controller, power transformer monitoring, an HMI and the gateway to the existing SAS.

The topology is based on the so-called "9-2LE" (light edition) published by the UCA users group based on IEC 61850-9-2 Edition 1. According to the specification the data volume per merging unit is about 5 MBit/s for 50 Hz and about 6 MBit/s for 60 Hz comprising one set of 3-phase current and voltage samples. Other time critical data (e.g. GOOSE messages) and also non time critical data (e.g. file transfer) could be transmitted over the same architecture. Figure 11 shows the topology of the process bus and the substation.

One of the key requirements was the implementation of a transformer monitoring system based on appropriate Logical Nodes and Data Objects as well as a selection of crucial client-server communication services. Additional monitoring information is provided by circuit breaker IEDs.

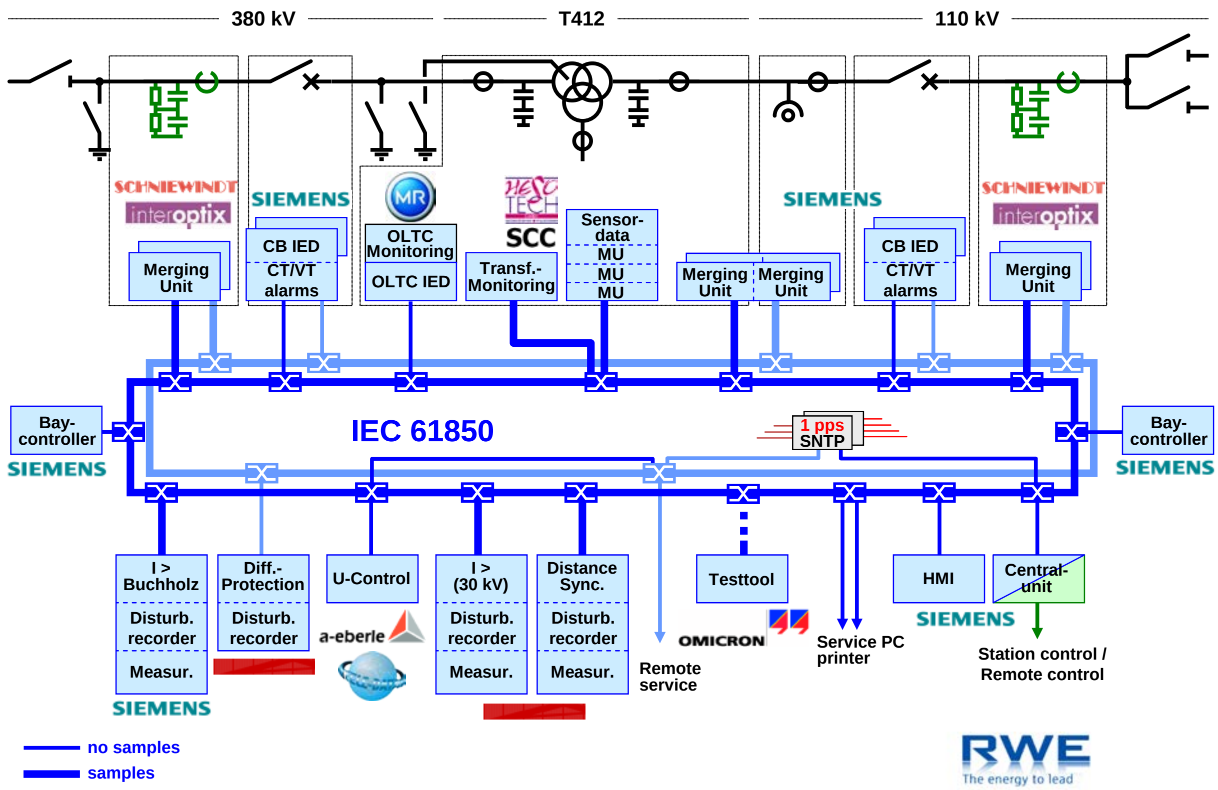

Figure 11: Topology of RWE Process Bus project

The Transformer and the load tap changer are monitored by two separate monitoring systems providing each an IEC 61850 server with the appropriate list of Logical Nodes and Data Objects. The transformer monitoring information models are listed in Table 6.

Table 6: Logical Nodes for Transformer Monitoring

LN	Data Object
MMXU1	Measurements 380 kV
MMXU2	Measurements 110 kV
MMXU3	Measurements 30 kV
YPTR1	Transformer
SIML1	Insulation measurement Transformer
SIML2	Insulation measurement circuit breaker
CCGR1	Transformer cooling group 1
CCGR2	Transformer cooling group 2
CCGR3	Transformer cooling group 3
CCGR4	Transformer cooling group 4
CALH1	Summary alarm
ZAXN1	Monitoring 3 phases of cooling group 1

ZAXN2	Monitoring 3 phases of cooling group 2
ZAXN3	Monitoring of cooling group 1
ZAXN4	Monitoring of cooling group 2

The process bus interface to the primary equipment provides all crucial information about their status. The key benefit is that all the information from the process level is communicated in a standardized way. Proprietary communication links – using may vendor specific solutions – are replaced by a single solution supported by multiple vendors.

The communication services can be used to retrieve the crucial status information of the primary equipment.

The transformer monitoring system comprises the information models shown in Figure 12 and Figure 13.

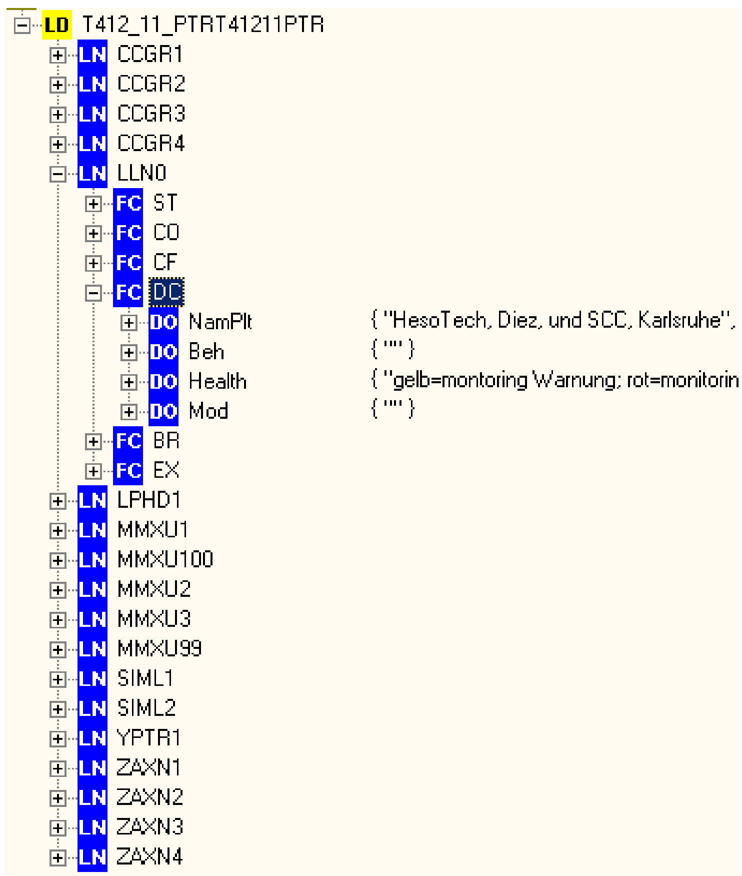

Figure 12**:** Transformer monitoring model for RWE R&D project (1)

Details, e.g., implemented in the SIML1 Logical Node are depicted in Figure 14.

Figure 13**:** Transformer monitoring model for RWE R&D project (2)

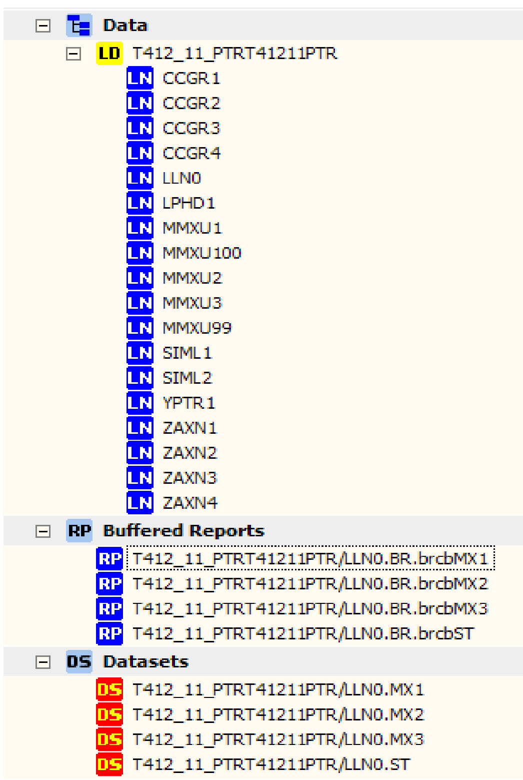

Figure 14**:** Transformer monitoring model for RWE R&D project (3)

The server for the transformer monitoring and the merging unit for the current and voltage samples of the transformer measurements are implemented in a standard PLC – Programmable Logic Controller (see Figure 15).

Figure 15**:** Transformer monitoring and merging unit IEDs

The whole transformer monitoring system is configured through an SCL file defining all needed objects, services, and the binding of the model to the real data of the monitor. The real data values are contained in a database. The binding of the model to the database is accomplished by the so-called <sAddr> attribute in SCL. The binding is automatically done by an interpreter in the IEC 61850 server software.

Once the pilot project is fully functional, protecting, controlling, and monitoring the substation , this is likely the first time where a comprehensive process bus is installed and operating.

9 Web-based and structured access to the IEC 61850 information models

With the use of IEC 61850 in domains outside the substation automation, the number of logical nodes and data objects published is increasing. Today, we have already more than 300 logical nodes defined in different parts of IEC 61850 and IEC 61400-25. There exist many associations between these different documents, but no easy hyperlinked browsing possibility exists. The maintenance of the defined information models always needs to be linked to a new complete document with a large collection of information models.

When experts of new application domains start to use the concepts of IEC 61850 and the existing information models as a base, the domain experts first need to easily identify what already exists. Therefore, it would be preferable to find and browse all information models at one place (preferably at the IEC website).

IEC is supporting the publication of standards as databases – the procedure of the standardization of the information models is defined in Annex J “Procedures for the maintenance of the IEC standards in database format” of the IEC Supplement to ISO/IEC Directives.

It is intended to convert the publication of Logical Nodes and common data classes as being published today in different parts of IEC 61850 and IEC 61400-25 into a web based and structured access solution.

IEC 61850-6, Edition 2 has included in Annex C.2 a XML schema based on SCL type template definitions for the purpose of formally describing IEC 61850 information models as a base to formally document and maintain the models of different IEC 61850 application domains, and facilitate automatic checking of IED data models against these definitions. It is foreseen to describe in the future the standard IEC 61850 information models using that schema. So, in the future, XML documents shall replace the word documents of the parts IEC 61850-7-3 and IEC 61850-7-4xx as well as IEC 61400-25-2 as the normative documents.

Based on these XML documents, several web-based access possibilities can be implemented. Different users need to be able to access the models through a web-based interface:

- Editors of the standard and working group members need to be able to browse existing models, to add new models and to maintain the existing models.
- National committees need to be able to review the draft models and to comment and vote on the models.
- Any interested people shall be able to browse the semantic and details of the models and to download the formal XML documents of the models.

Note that it will still be possible to automatically derive other representations like pdf and html from the XML files.

An example of a Web-based interface to an IEC standard is the Database for IEC 61360:

http://std.iec.ch/iec61360

As part of that work in a first step a Technical Report IEC 61850-7-10 will be prepared that describes the requirements of the different users and the possible approaches for its implementation.

The web-based access and the procedures involved in maintaining the models shall be described in the report and shall be based on Annex J “Procedures for the maintenance of the IEC standards in database format” of the IEC Supplement to ISO/IEC Directives.

10 Conclusions

In highly automated substations and power plants, almost no limitations exist with regard to make the information from the process (status values, measurements, events on limit violations, any monitoring data) available to any entity that needs the information for controlling, monitoring, service, diagnosis, network analyzing, testing, or asset management. The acquisition of any needed process information increases the stability of the system because any failure or trend that may lead to a failure can be made visible.

The electric power delivery system is using IEC 61850, IEC 61400-25, and its extensions in substations, for power quality monitoring applications, for the control and monitoring of wind power plants, control and monitoring of distributed energy resources (DER), and the control and monitoring of hydro power plants.

The condition monitoring possibilities rely on four aspects (standardized in IEC 61850 and IEC 61400-25):

- Standard Data Objects for values to be monitored,
- Standard communication services,
- Fast and reliable communication protocols, and
- Standard configuration language to specify or document the huge amount of information

It is very likely that especially the monitoring applications will be the focus for the next couple of years. Protection and automation of substations is well understood, implemented and used. Many physical aspects are not yet sensed by advanced or even simple sensors.

The standards are providing more and more condition monitoring Data Objects. The services allow for the exchange of these values in real-time (sampled values and GOOSE) as well in client/server relations.

11 References

[1] IEC 61850-1, Communication networks and systems in substations – Part 1: Introduction and overview

[2] IEC 61850-2, Communication networks and systems in substations – Part 2: Glossary

[3] IEC 61850-3, Communication networks and systems in substations – Part 3: General requirements

[4] IEC 61850-4, Communication networks and systems in substations –- Part 4: System and project management

[5] IEC 61850-5, Communication networks and systems in substations – Part 5: Communication requirements for functions and devices models

[6] IEC 61850-6, Communication networks and systems in substations – Part 6: Configuration description language for communication in electrical substations related to IEDs

[7] IEC 61850-7-1, Communication networks and systems in substations – Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models

[8] IEC 61850-7-2, Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)

[9] IEC 61850-7-3, Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes

[10] IEC 61850-7-4, Communication networks and systems in substations – Part 7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes

[11] IEC 61850-8-1, Communication networks and systems in substations – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO/IEC 9506-1 and ISO/IEC 9506-2) and to ISO/IEC 8802-3

[12] IEC 61850-9-1, Communication networks and systems in substations –- Part 9-1: Specific communication service mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link

[13] IEC 61850-9-2, Communication networks and systems in substations – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3

Easy, Affordable and Fast Integration of IEC 61850 in Small Power System Devices

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August 2012

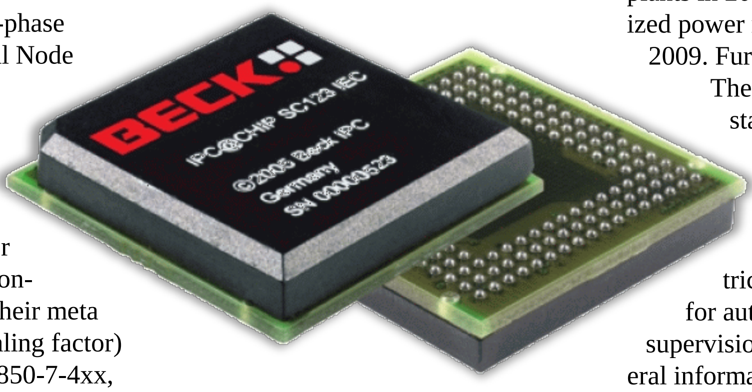
High financial and time expenditures for the implementation of IEC 61850 in control systems and other devices prevented so far a broad market penetration of the standard in the lower voltage levels and in distributed power generation. A reasonable and cost effective solution is now available with the Beck IPC@CHIP. The development of IEC 61850 conformant interfaces in power delivery systems – particularly renewable and decentralized power producers and consumers – can now be realized within very short time to market.

The standard series IEC 61850 [1] defines comprehensive information models, mechanisms for information exchange, a configuration language and a mapping to general communication protocols. It offers a unique and common architecture for many application domains [2,3]. The aspects are mainly the following:

General and user-specific information models like measured values of the voltage of the three-phase electrical network (Logical Node MMXU), rotor speed of a wind turbine (WTUR), switching position of the circuit-breaker (XCBR), temperature measured value (STMP) or the values of a PID loop controller (FPID) as well as their meta data (like SI-Units and scaling factor) are in the focus of IEC 61850-7-4xx, IEC 61850-7-3 and IEC 61400-25-2) [4-7].

Abstract methods for the change of information (ACSI - abstract communication service interface, according to IEC 61850-7-2) offer the most crucial services for the direct access (Read, Write, and Control), Reporting (spontaneous and cyclic; with monitoring of limits and changes), sequences of events (SoE: Sequence OF events), event archives in the devices (Logging), control, configuring and retrieving the self-description of the devices (IEC 61850-7-2 and IEC 61400-25-3) [8,9]. In addition two methods are defined for the transmission of critical information in real time: for the fast exchange of sensor data (typical several thousand sampled values per second of currents and voltages) and the fast exchange of critical information within the millisecond range.

Mapping of the abstract information and exchange methods to the application layer protocols as defined



in IEC 61850-8-1, IEC 61850-9-1, IEC 61850-9-2, and IEC 61400-25-4 [10-13]. The communication stacks for transferring the messages use among other protocols mainly TCP/IP and Ethernet (IEC 61850-8-1 and IEC 61400-25-4).

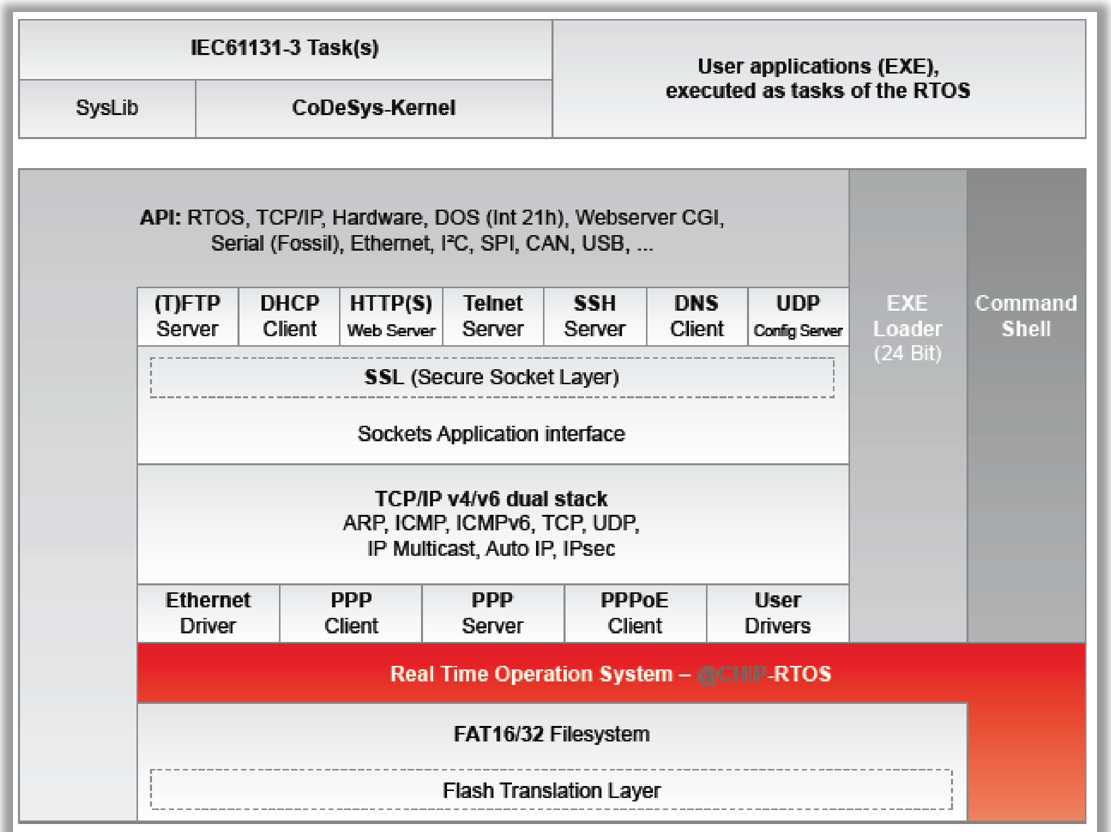
XML based configuration language for the complete description of a plant (IEC 61850-6) and a single device: Description of the plant topology, communication, information models, linkage of sources of information to destinations, and the binding of the models to the process and to internal equipment structures [14].

Toolbox for Multivendor systems

The standard series consists of 14 parts; published between 2003 and 2005. It is a tool box for building multivendor systems for substation protection and automation. The first extensions were published in 2007 in IEC TC 88 (Wind Turbines) with IEC 61400-25-4 for wind power plants. Extensions for hydro-electric power plants in 2007 and for the decentralized power resources followed in 2009. Further parts are in process.

The first fourteen parts of the standard series and the extensions (above all the information models) cover crucial information needed in the electrical power supply network for automation, protection and supervision. Meanwhile many general information models for the applications in general automation domains are defined in the second edition of part IEC 61850-7-4. One of the most crucial and interesting parts is part IEC 61850-90-7 (IEC 61850 object models for inverters in distributed energy resources (DER) systems).

The issue of the information exchange by means of MMS (Manufacturing Message Specification - ISO 9506) and ASN.1 (Abstract Syntax Notation 1 - ISO 8824/8825) – although it is required in the communication stacks of devices – however it is of subordinated importance, if it concerns the contents of the standards. With the realization of standard-



IPC@CHIP® RTOS architecture

conformant products MMS is key because before two devices can communicate in the client-server relation there is a need of an MMS stack on each end of the communication channel – a server and a client.

Applications of IEC 61850

IEC 61850 is used globally in many thousand plants of medium and high voltage networks. All large manufacturers of substations such as ABB, AREVA, GE, Siemens, Toshiba and many smaller manufacturers use IEC 61850 as the preferred solution. In the context of many Smart Grid projects in North America, in Asia and Europe IEC 61850 is regarded as the most important protocol standard. Beyond that, IEC 61850 – particularly because of the uniform and recently defined general information models – is used increasingly also in industrial and process automation systems.

In the contrast to the fieldbus standard IEC 61158 with (too) many standardized solutions in a single standard with almost 100 parts, IEC 61850 has only one protocol stack for TCP/IP-based client-server communication and two simple protocols using native switched Ethernet for real time communication. In many enterprises IP networks are very common. This allows directly and without special modifications to directly employ MMS based client-server communication. All information models of all devices can be accessed this way, fast and without detours from everywhere – also safely with TLS (Transport Layer Security). TLS is required by IEC 61850-8-1 and selected in IEC 62351 – the sister standard of IEC 61850.

These solutions could be achieved so far mostly just by very high financial and temporal expenditures. The implementation of the MMS client-server stack was usually realized by purchasing extensive and relatively expensive licensed software packages. The expected expenditures for porting the licensed MMS software and/or the development of MMS software were estimated so high that in many cases the application of IEC 61850 was questioned – especially when it comes to small devices.

Although the focus of the application of the standard series clearly is on the models and configuration language (which are independent of MMS), the implementation mainly depends on the acceptance of MMS. This is especially true for the use of IEC 61850 in simpler applications. MMS is however necessary for standard-conformant information exchange between clients and servers – no question. IEC 61850 does not support alternative protocols fortunately! The question is now, are there alternative MMS implementations – above all – for the application of IEC 61850 for simple applications? Yes! Thanks to the efforts taken by SystemCorp (Bentley, Western Australia) [15] and Beck IPC (Pohlheim, Germany) [16] to implement IEC 61850 on a small footprint of a simple embedded controller: IEC61850@CHIP.

Chip based solution

At the Hanover fair 2010 Beck IPC presented the integrated solution for IEC 61850 successfully in co-operation with SystemCORP Pty Ltd. (Bentley, Western Australia) at the Beck IPC booth. The embedded controller demonstrated was an industrial proven component that is on the market for five years in industrial automa-

tion systems. It is a modular controller chip (IPC@CHIP). The resonance of the many hundred booth visitors exceeded expectations of all involved people of Beck and SystemCorp by far. In the meantime there are many applications all over that use the Beck IPC controller.

The substantial advantage of the embedded controller based solution is its high efficiency, performance, and the minimum expenditure needed for the implementation of IEC61850-based interfaces for clients and servers. This platform is very economical. From a programming point of view it is a PC and a PLC (programmable logic controller) – it can be programmed with C/C++ as well as with IEC 61131-3 (CoDeSys). All license costs for the compilers and the IEC 61850 communication stack and API (application program interface) are already included in the chip price. Products based on other stacks may require a run-time license fee for the IEC

61850 stack per device that is more expensive than the complete chip. Not to speak about the needed efforts of porting the stack software to your platform (HW and SW). This may take many months and even years – the author has been contacted by many companies that complained that IEC 61850 is quite complex and too expensive to implement (even when using available third party software).

The IPC@CHIP SC123 and SC143 are equipped with the real-time and multitasking operating system IPC@CHIP-RTOS. The following software functions are integrated in the RTOS of the SC123/SC143: IEC 61850, IEC 61400-25, TCP/IPv6/IPv4, SSL, SSH, IPSec, PPPoE, API for CAN, IEC 61131-3 (CoDeSys, PLC), and C/C++

The software architecture is very comprehensive, compact and extremely efficient (Figure above).

The technical specification of the Chips (SC123 und SC143) could be found in the attached document.

For different applications regarding simple integration, mass production and performance three packages are offered.

IEC 61850 lite implementation

All crucial data models, communication services and the device configuration language (SCL) are realized in the stack and API running on the chip. All models from the applications protection and automation substations of any voltage level including power generation and distribution, monitoring of the power quality, automation and monitoring of hydro-electric power plants, wind turbines, decentralized energy generation such as photovoltaic, combined heat and power, diesel generators, battery storage stations, car charging stations to name just a few. The models of the new part IEC 61850-90-7 [17] are supported. The models for PV inverter have already been implemented on the SC143 by major PV inverter vendors in 2010 and 2011.

All models needed for the applications can be uploaded by a standardized SCL files by ftp on the chip. Thus the model and communication configuration is entirely accomplished by a standardized IEC 61850-6 file (SCL – system configuration language).

The IEC 61850 software stack and API can be started by the application easily as client or as server. Both applications can co-exist on the IPC@CHIP at the same time. The stack supports IEC 61850 services inclusive GOOSE and transmission of sampled values.

The SystemCorp IEC 61850 stack and API offers a very simple interface to the application software in the form of a few calls (and call-backs) like for example "Read", "Write", "Update", and "Control". Only a binding table must be defined, with which the real values of the process or of the application are bound (linked to) the information models according IEC 61850. This table is used, in order to describe the appropriate relations between model and the real world. That relation is implemented in the SCL file by private XML elements, which are interpreted by the IEC 61850 stack and API software as well as by the application software. This model (SCL file) is used for the configuration of the server **and** the client. The API documentation is available online [18]. A video explaining the use of the API function calls and the models at the server and the client side is available [19].

All services like Read, Write, Reporting, GOOSE, data sets and so on are completely configured by a SCL file. Using the same application data, one can configure at any time further logical devices, control blocks and data records simply by an extended or new SCL file transferred to the chip.

Ready to go devices

Beside the chips Beck IPC offers also ready to go modules (com.tom) – the only need is to let your application code understand the few API calls and call-backs – that's all you need to communicate your data values with IEC 61850 models and services. The development of different gateways to, for example, CAN, IEC 60870-5-10x,

Profibus, DNP3 or Modbus can be realized in short time. This reduces the time to marked tremendously. The modules can be equipped with a data base system which implements the binding of different protocols by configuration software which is based on a Windows configuration tool. Protocol stacks for IEC 60870-5-101/104/103 and DNP3.0 are likewise available.

The com.tom solution for telecontrol is suitable for applications with existing WAN connectivity and existing process control and monitoring applications. Communication of the com.tom BASIC solutions can also directly communicate with a dedicated Web portal. The com.tom communicates with Ethernet and other existing network infrastructures like WiFi, Bluetooth, or GPRS.

The communication with the process can be realized over a serial interface or over digital inputs or outputs. The digital inputs and outputs can be processed additionally with simple PLC functions.

The integrated Web server on the com.tom BASIC provides also a simple WEB based editor for a Web PLC that can be used to for simple control algorithms.

Development Kit Beck IPC DK61

For a cost effective and fast start into the world of IEC 61850 the development kit DK61 is likely the best approach.

The IPC@CHIP DK61 development kit is a complete development system for the embedded controller IPC@CHIP SC123 and SC143.

It contains the Paradigm C/C++ compiler with IPC@CHIP RTOS debugger and many further tools, which can be applied for the simplified development of C/C++ and IEC 61131-3 (CoDeSys) applications on the Embedded controller SC123 and SC143.

Despite the comprehensive hardware of the development board, which makes all interfaces of the SC123 and SC143 available, a start-up is possible within minutes rather than hours or days. This is due to the installed RTOS, the „Getting Started“ manuals and the examples that come with the DK61 development kit.

The extensive hard and software equipment allow a fast and efficient development of customized applications within hours and days.

All aspects of the IEC 61850 Solution on the IPC@CHIP, described above, are available and directly applicable also on the development kit. An extensive example of use with a model for process values (inputs and outputs), with reporting and GOOSE is contained in the kit. The source code of the C application program is likewise provided. C programmers can immediately begin with the programming of their application and – as described in the example – communicate their data values within a short time by IEC 61850.

Special knowledge of MMS and ASN.1 is not necessary – applications can directly use the simple API. The development of an extensive protocol stack and a user interface are not needed – the focus is now on the application of the standard series for the realization of smarter power delivery systems.

The SystemCorp stack and API is available on various embedded controller platforms, e.g., Arm 9 or Arm 11 controllers that run on Linux. The stack and API could be ported to all major platforms; DLLs and libraries for Windows and PCs are also available.

Reduce time to market

Using the approaches of SystemCorp (Lite Implementation and API) and Beck IPC (embedded controller with everything ready-to-go) will help you **control**, **predict** and **reduce** your **time to market**. If the market requires IEC 61850 integrated, e.g., into your PV converter or other devices for controlling or monitoring the electrical system (or other applications) there are several approaches (depending on the time to deliver the device to the customer) you could choose from:

Very short time to market
(week(s) up to a very few months):
Recommended to use the Beck IPC com.tom ready-to-go box with Beck IPC chip as external or internal module.

Short time to market
(few months):
to use the Beck IPC Chip on a small printed circuit board as internal module.

Longer time to market
(several months):
to use the SystemCorp software on the controller of an available design or design a new HW with a new powerful embedded controller, e.g., from Beck (running RTOS) or TQ (running Linux).

In the attachment there is a description of the path to a short time to market using the SystemCorp stack and API.

Further information

More information on the IPC@CHIP can be found in English and German:
http://www.beck-ipc.com

Details of the IEC 61850 Stack and API implemented on the IPC@CHIP are available at:
http://systemcorp.com.au/PIS10API

General information, trends and news on IEC 61850:
http://blog.iec61850.com

Monitoring and Control of Power Systems and Communication Infrastructures based on IEC 61850 and IEC 61400-25 (English):
http://www.nettedautomation.com/download/pub/DT-Tampa-Paper_2010-03-24.pdf

User Groups:
http://www.iec61850.ucaiug.org
http://www.USE61400-25.com

[1] IEC 61850: Communication networks and systems for power system automation. Some 20 parts by end of 2011:
http://blog.iec61850.com/2012/01/status-of-parts-of-iec-61850-series.html

[2] IEC 61850 on a page (English):
http://www.nettedautomation.com/standardization/IEC_TC57/WG10-12/iec61850/What-is-IEC61850.pdf

[3] Video on the basics of IEC 61850:
http://blog.iec61850.com/2012/02/video-with-brief-introduction-to-iec.html

[4] IEC 61850-7-410: Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control.

[5] IEC 61850-7-420: Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes.

[6] IEC 61850-7-3: Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes.

[7] IEC 61400-25-2: Wind turbines – Part 25-2: Communications for monitoring and control of wind power plants – Information models.

[8] IEC 61850-7-2: Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI).

[9] IEC 61400-25-3: Wind turbines – Part 25-3: Communications for monitoring and control of wind power plants – Information exchange models.

[10] IEC 61850-8-1: Communication networks and systems in substations – Part 8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3.

[11] IEC 61850-9-1: Communication networks and systems in substations – Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link.

[12] IEC 61850-9-2: Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3

[13] IEC 61400-25-4: Wind turbines – Part 25-4: Communications for monitoring and control of wind power plants – Mapping to communication profile.

[14] IEC 61850-6: Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs.

[15] System Corp Pty Ltd, Bentley, Western Australia: http://systemcorp.com.au

[16] Beck IPC GmbH, Pohlheim: www.beck-ipc.com

[17] IEC 61850-90-7: IEC 61850 object models for inverters in distributed energy resources (DER) systems (to be published early 2012) http://blog.iec61850.com/2011/08/pv-power-to-destabilize-european-power.html

[18] API online documentation: http://systemcorp.com.au/PIS10API

[19] Video on the use of SCL files for configuration of a server and a client: http://blog.iec61850.com/2012/02/video-on-use-of-iec-61850-6-scl-to.html

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Dipl.-Ing. Karlheinz Schwarz (president of Schwarz Consulting Company, SCC, and owner of NettedAutomation GmbH; Karlsruhe/Germany) specializing in distributed automation systems. He is involved in many international standardization projects (IEC 61850 – utility automation, DER, hydro power, IEC 61400-25 – wind power, IEC 61158 - Fieldbus, ISO 9506 – MMS, …) since 1984. He is engaged in representing main industry branches in the international standardization of real-time information modeling, configuration, and exchange systems. Core services are consulting and training of utility personal, system integrators, consultants, and vendors. He has educated more than 2,750 experts from more than 700 companies and more than 70 countries. The training courses are considered to be outstanding. Mr. Schwarz is a well-known authority on the application of mainstream information and communication technologies in the utility industry and general automation domain.

NettedAutomation GmbH
Information & Communication Systems

Annex

What does IEC 61850-90-7 (IEC 61850 object models for inverters in distributed energy resources (DER) systems) provide?

The following is based on IEC 61850-90-7 (final draft 2012-02)

The main purpose of the document is to define **information models** of the known functions of PV inverters. These functions are those that are **already implemented** in today's controllers of inverters installed all over. The information models defined in IEC 61850-90-7 just define **standard names** of the "signals" found in most PV inverters – the standard just follows the market. The standard also provides a **common way to access and distribute the information** needed to configure, control, and monitor real inverters. Due to the single model and communication profile (independent of the vendors) it is easy to communicate with the inverters of many different vendors with one single standard.

The advent of decentralized electric power production is a reality in the majority of the power systems of the world, driven by the need for new types of energy converters to mitigate the heavy reliance on non-renewable fossil fuels, by the increased demand for electrical energy, by the development of new technologies of small power production, by the deregulation of energy markets, and by increasing environmental constraints.

These pressures have greatly increased the demand for Distributed Energy Resources (DER) systems which are interconnected with distribution power systems, leading to high penetrations of these variable and often unmanaged sources of power. No longer can they be viewed only as "negative load". Their large numbers, their unplanned locations, their variable capabilities, and their fluctuating responses to both environmental and power situations make them difficult to manage, particularly as greater efficiency and reliability of the power system is being demanded.

This paradigm shift in management of power systems can be characterized by the following issues:

The numbers of interconnected DER systems are increasing rapidly. The advent of decentralized electric power production is a reality in the majority of power systems all over the world, driven by many factors:

- The need for new sources of energy to mitigate the heavy reliance on externally-produced fossil fuels.
- The requirements in many countries and US states for renewable portfolios that have spurred the movement toward renewable energy sources such as solar and wind, including tax breaks and other incentives for utilities and their customers.
- The development of new technologies of small power production that have made, and are continuing to improve, the cost-effectiveness of small energy devices.
- The trend in deregulation down to the retail level, thus incentivizing energy service providers to combine load management with generation and energy storage management.
- The increased demand for electrical energy, particularly in developing countries, but also in developed countries for new requirements such as Electric Vehicles (EVs).
- The constraints on building new transmission facilities and increasing environmental concerns that make urban-based generation more attractive.

These pressures have greatly increased the demand for Distributed Energy Resources (DER) systems which consist of both generation and energy storage systems that are interconnected with the distribution power systems.

DER systems challenge traditional power system management. These increasing numbers of DER systems are also leading to pockets of high penetrations of these variable and often unmanaged sources of power which impact the stability, reliability, and efficiency of the power grid. No longer can DER systems be viewed only as "negative load" and therefore insignificant in power system planning and operations. Their unplanned locations, their variable sizes and capabilities, and their fluctuating responses to both environmental and power situations make them difficult to manage, particularly as greater efficiency and reliability of the power system is being demanded.

At the same time, DER devices could become very powerful tools in managing the power system for reliability and efficiency. The majority of DER devices use inverters to convert their primary electrical form (often direct current (dc) or non-standard frequency) to the utility power grid standard electrical interconnection requirements of 60Hz or 50Hz and alternating current (ac). Not only can inverters provide these basic conversions, but inverters are also very powerful devices that can readily modify many of their electrical characteristics through software settings and commands, so long as they remain within the capabilities of the DER device that they are managing and within the standard requirements for interconnecting the DER to the power system.

DER systems are becoming quite "smart" and can perform "autonomously" most of the time according to pre-established settings or "operating modes", while still responding to occasional commands to override or modify their autonomous actions by utilities and/or energy service providers (ESPs). DER systems can "sense" local conditions of voltage levels, frequency deviations, and temperature, and can receive emergency commands and pricing signals, which allow them to modify their power and reactive power output. These autonomous settings can be updated as needed. To better coordinate these DER autonomous capabilities while minimizing the need for constant communications, utilities and ESPs can also send schedules of modes and commands for the DER systems to follow on daily, weekly, and/or seasonal timeframes.

Given these ever more sophisticated capabilities, utilities and energy service providers (ESPs) are increasingly desirous (and even mandated by some regulations) to make use of these capabilities to improve power system reliability and efficiency.

Inverter configurations and interactions

Bulk power generation is generally managed directly, one-on-one, by utilities. This approach is not feasible for managing thousands if not millions of DER systems.

DER systems cannot and should not be managed in the same way as bulk power generation. New methods for handling these dispersed sources of generation and storage must be developed, including both new power system functions and new communication capabilities. In particular, the "smart" capabilities of inverter-based DER systems must be utilized to allow this power system management to take place at the lowest levels possible, while still being coordinated from region-wide and system-wide utility perspectives.

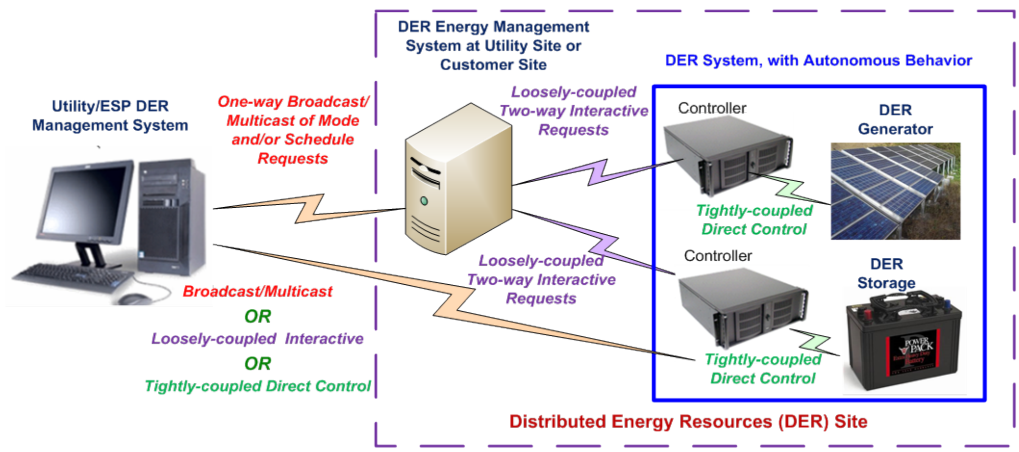
This "dispersed, but coordinated intelligence" approach permits far greater efficiencies, reliability, and safety through rapid, autonomous DER responses to local conditions, while still allowing the necessary coordination as broader requirements can be addressed through communications on an as-needed basis. Communications, therefore, play an integral role in managing the power system, but are not expected or capable of continuous monitoring and control. Therefore the role of communications must be modified to reflect this reality.

Inverter-based DER functions range from the simple (turn on/off, limit maximum output) to the quite sophisticated (volt-var control, frequency/watt control, and low-voltage ride-through). They also can utilize varying degrees of autonomous capabilities to help cope with the sophistication.

At least **three levels of information exchanges** are envisioned:

- **Tightly-coupled interactions** focused on direct monitoring and control of the DERs with responses expected in "real-time".
- **Loosely-coupled interactions** which request actions or "modes" that are interpreted by intelligent DER systems for undertaking **autonomous reactions** to local conditions or externally provided information. Information is then sent back on what actions they actually performed.
- **Broadcast/multicast** essentially one-way requests for actions or "modes", without directly communicated responses by large numbers of DERs.

These different DER management interactions are shown in the following figure.



DER Management: Interactions between Components

Inverter functions

Inverter functions range from the simple to the complex. Most inverter functions are based on settings or curves that allow them to respond autonomously to local conditions, while some require direct control commands:

- **Immediate control functions** for inverters
  - Function INV1: connect / disconnect from grid
  - Function INV2: adjust maximum generation level up/down
  - Function INV3: adjust power factor
  - Function INV4: request active power (charge or discharge storage)
  - Function INV5: request action through a pricing signal
- **Volt-var management modes**
  - Volt-var mode VV11: available vars mode with no impact on watts
  - Volt-var mode VV12: maximum var support mode based on maximum watts
  - Volt-var mode VV13: static inverter mode based on settings
  - Volt-var mode VV14: passive mode with no var support
- **Frequency-watt management modes**
  - Frequency-watt mode FW21: high frequency reduces active power or low frequency reduces charging
  - Frequency-watt mode FW22: constraining generating/charging by frequency
  - Frequency-watt mode FW23: watt generation/absorption counteractions to frequency deviations
- **Dynamic reactive current support during abnormally high or low voltage levels**
  - Dynamic reactive current support TV31: volt-var support during abnormally high or low voltage levels
- **Functions for “must disconnect” and “must stay connected”**
  - “Must disconnect” MD curve
  - “Must stay connected” MSC curve
  - Reconnect settings
- **Watt-power factor management modes**
  - Watt-power factor WP41: feed-in power controls power factor (parameters)
  - Watt-power factor WP42: feed-in power controls power factor (curves)
- **Voltage-watt management modes**
  - Voltage-watt mode VW51: smoothing voltage deviations by watt management
  - Voltage-watt mode VW52: charging by voltage
- **Non-power-related modes**
  - Temperature-function mode TMP: ambient temperature indicates function
  - Pricing signal-function mode PS: pricing signal indicates function to execute
- **Parameter setting and reporting**
  - Function DS91: modify inverter-based DER settings
  - Function DS92: event/history logging
  - Function DS93: status reporting
  - Function DS94: time synchronization

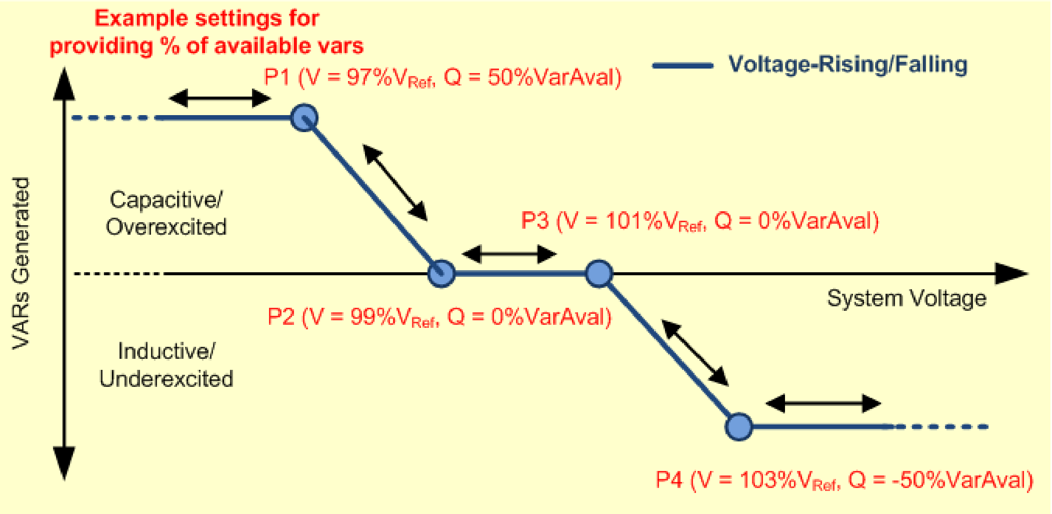
It is expected that additional functions will be added in the future, for instance for handling intentional and unintentional islanding.

The following figure provides an example of volt-var settings for this mode. It is assumed that the var value between VMin and V1 is the same as for V1 (shown as 50% VArAval, in this example). The equivalent is true for the var value between V4 and VMax (which is assumed to be 50% VArAval in this example).

Example Settings

Voltage Array (% VRef)		VAr Array (% VArAval)	
V1	97	Q1	50
V2	99	Q2	0
V3	101	Q3	0
V4	103	Q4	-50

VAr Ramp Rate Limit – fastest allowed decrease in VAR output in response to either power or voltage changes	50 [%VArAval/second]
VAr Ramp Rate Limit – fastest allowed increase in VAR output in response to either power or voltage changes	50 [%VArAval/second]
The time of the PT1 in seconds (time to accomplish a change of 95%).	10 seconds
Randomization Interval – time window over which mode or setting changes are to be made effective	60 seconds



The information needed for this application is defined in corresponding Logical Nodes of IEC 61850-90-7 and IEC 61850-7-4. From an implementation point of view the standard just provides an external view of the inverter internal information and information exchange (**for the inverter functions, e.g., volt-var control**). It could be assumed that the functions are **already implemented in the existing inverter controller**.

Italian Norm about to Require IEC 61850 for almost all PV Inverters

The CEI (Comitato Elettrotecnico Italiano) has published in December 2011 a norm that strongly proposes to use IEC 61850 to connect PV inverters (>1kV and >6 kW) to external systems (grid operator, …):

CEI 0-21 “Regola tecnica di riferimento per la connessione di Utenti attivi e passivi alle reti BT delle imprese distributrici di energia elettrica”.

“Reference technical rules for the connection of active and passive users to the LV electrical Utilities”

The document IEC 61850-90-7 “IEC 61850 object models for inverters in distributed energy resources (DER) systems” is about to published in a few months. This document is a perfect fit for the needs of PV inverters.

The Information Model defined in IEC 61850-90-4 has been implemented on the Beck IPC SC 143 controller by a well-known inverter company.

Training modules for public and in-house training courses

IEC 61850, IEC 61400-25, IEC 60870-5/-6, IEC 61968/70 CIM, DNP3, ...

The following list contains the most asked modules of our training services with regard to standards related to power system automation. Depending on the needs of our customers we select the modules to provide the most crucial information for the experts of the customers. Other topics can be added as needed. The modules are used for public training courses as well as for in-house training sessions.

[S-00] – General		
00	Welcome and opening	Welcome, opening, roll call of attendees, expectations of attendees, Title and scope of IEC 61850 (IEC TC 57), Power Delivery System, What does IEC 61850 provide?, Motivation for the new standards, IEC 61850 in brief, Re-use of IEC 61850, Tools and System Integration, Standardization and projects, General observations.
01	Summary	Summary and next steps
[S-01] – Management and automation of the power system (basics)		
00	Power system automation basics	Basics of power system information integration and automation covering control centers, substations, power generation; Elements of the power system: Substations, Power Generation, Transmission, Distribution, System architecture, Functions, Communications, System engineering, and device configuration
01	Standardization	IEC activities related to power system standardization, IEC TC 57 and TC 88, International organizations for the power industry, IEC organization and standardization work, IEC activities related to the power industry, CIGRE, IEEE, UCA Users Group, IEC 61400 User Group, activities related to the power industry; international fieldbus
02	System design and specification	Introduction Substation automation system specification, Product requirements for communication equipment from IEC 61850-4, product requirements from IEC 61850-3, substation automation system design
03	System migration aspects and role of system integrator	Stepwise migration from existing systems to solutions compliant to standards, project and migration planning, ...; roles of users, vendors and system integrators
04	Security	Secure communication (data on travel and data stored) (IEC 62351), IED security (IEEE 1686), IEC/TS 62443-1, NERC CIP (critical infrastructure protection), VDE Guideline, NIST SGIP
05	System management	Revision control and asset management with IEC 61850
06	Testing devices and systems	Test coverage and steps towards system testing and simulation (from devices to systems)
07	Power Delivery System Basics	Brief Introduction to Power Delivery System and relations to standards from IEC TC 57 and TC 88; mainly intended to give an overview of the power delivery system and power system automation for non-utility experts.
[S-02] – IEC 61850 (and IEC 61400-25) basics		
00	IEC 61850 series – overview	Communication networks and systems for power system automation: general introduction on whole series. Design objectives and scope IEC 61850, Content and structure of IEC 61850, Features of IEC 61850, Application modeling, Information exchange and communication services, the 20+ parts of the standard
01	IEC 61850 Application modeling principles	Modeling protection, substation automation, other applications (Logical nodes, data and data attributes, function modeling, extension of the models, monitoring). The elements of the data model, Acquisition of measured information, Controlling of switchgear equipment, Protection functions, Edition 2 updates, Example of a model.
02	IEC 61850-6 engineering process	Engineering process using the configuration language: from IEDs and single line diagram to configured substation automation system Systems specification (Single line diagram and functions), IED specification (IED

		capability description), System engineering, IED engineering and configuration, Use of SCL (summary), Edition 2.
03	Communication services of IEC 61850	Information exchange with the ACSI according to IEC 61850-7-2 Basics, Information flow through IEDs, ACSI in detail (IEC 61850-7-2), Server, Logical Device, Logical Node, Data, DataSet, Control Blocks (Reporting, Logging, GOOSE, SV), Control, Conformance statement, Recording (IEC 61850-7-4).
04	Implementation of IEC 61850 conformant devices and tools	Device models, design of advanced IEDs, software and hardware architectures, OEM software
05	Device conformance testing	Conformance testing of devices according to IEC 61850-10
06	Extension rules IEC 61850	The extension rules for Logical Nodes, Data, and Common Data Classes, the name space concept. Scope, Instantiation of existing information model classes, New information models, Name space concept.
07	Substation configuration language (SCL)	System configuration language: basics and details; Engineering process and SCL, SCL object model, SCL syntax (IEC 61850-6 (SCL)), SCL edition 2. The object model and content of the SCL files, Examples, Binding models to real world, inputs, and to outputs, the data flow engineering; File extensions: SSD, SCD, ICD, CID, IID, … including examples; configuring servers and clients.
08	Common Data Classes (Ed2)	What is new in part IEC 61850-7-3 Edition 2? New possibilities for information modelers.
50	Mapping of Common Data Classes (CDC) to IEC 60870-5-101/104 according to IEC 61850-80-1	Introduction and details of IEC 61850-80-1. The Technical Specification IEC 61850-80-1 gives a guideline on how to exchange information from a CDC based data model (IEC 61850) using IEC 60870-5-101 or IEC 60870-5-104 protocols between substation(s) and control center(s).
[S-03] – Substation automation and protection		
00	IEC 61850 modeling details	Modeling of protection, switchgear, metering and power quality equipment and other substation automation applications. Basic principles, Protection functions, Protection related functions, Control, Example
01	Applying IEC 61850 for power system automation – use cases	Use cases from power system automation like measuring of current and voltage, protection, operating a switch, creation of a sequence of events, SCADA. Use case 1 – measuring current and voltage Use case 2 – operate switchgear
02	Product specifications for substation equipment	Implementation guideline IEC 61850-9-2 "LE", Product standard for switchgear with integrated IEC 61850 interface (IEC 62271-003)
03	Substation automation system architecture	Communication architecture and topology, device architecture, impact of new technologies; redundancy concepts for switched Ethernet network. Communication architecture, Device modeling, Availability considerations
04	Substation to substation communication for protection and control with IEC 61850	What does the standard IEC 61850-90-1 (Use of IEC 61850 for the communication between substations) provide? Introduction and current status of work. Interlocking between substations, Distance line protection, Current differential line protection, Out-of-step detection, etc.
[S-04] – Power generation		
00	Wind power plants	Overview and introduction of the standard for Communications for monitoring and control of wind power plants – IEC 61400-25
01	Hydro power plants	Overview and introduction of the standard for Communications for monitoring and control of hydro power plants – IEC 61850-7-410
02	Distributed Energy Resources	Overview and introduction of the standard for Communications for monitoring and control of Distributed Energy Resources (DER) – IEC 61850-7-420
03	Application modeling for hydro power plants	Overview and introduction of the standard for IEC 61850-7-410 modeling details; New common data classes for hydro power plants
[S-05] – Communication between field devices and system level and at system level		
00	Telecontrol protocols IEC 60870-5-101/-104 and DNP3	Fundamentals of Telecontrol standards IEC 60870-5-101, IEC 60870-5-104, and DNP3. What is the market relevance in the future (comprehensive set of slides available if information is needed for the attendees; several slides are added for the attendees convenience – to take home). Is IEC 61850 competing with Telecontrol Protocols? What are the use cases for Telecontrol Protocols and IEC 61850?
01	Telecontrol protocols details	Fundamentals of DNP3; comparison with IEC 60870-5-101/104
02	Substation to control center communication with IEC 61850	What will the standard IEC 61850-90-2 (Using IEC 61850 for the communication between substations and control centres) provide? Introduction and current status of work.

03	Inter control center communication (ICCP)	Fundamentals of the use of IEC 60870-6-TASE.2 (ICCP); a comprehensive stand-alone seminar is available as well, ask for details.
04	Webservices	Fundamentals of the definition of Webservices for IEC 61400-25-3 (and IEC 61850-7-2) as specified in IEC 61400-25-4.
05	Comparison of protocols	Detailed comparison of the protocol suites IEC 60870-5, DNP3, ICCP (TASE.2), IEC 61850
[S-06] – Power system level applications		
00	IEC 61970 / 61968 series	Energy management system application program interface (EMS-API) / System interfaces for distribution management – introduction
01	IEC 61970-301 CIM	Energy management system application program interface (EMS-API); focus on Part 301: Common Information Model (CIM) and harmonization with IEC 61850
02	Dynamic and static use of the CIM Model	Component Interfaces for information exchange, use cases for the CIM: GID, EAI, Network models
03	Tooling for the Common Information Model CIM	Available tools, platforms, experiences with power delivery systems Overview of existing OS tools: CIMTool, Xpetal, CIMVT, CIMValidate, CIMSpy; Available commercial tools; Flaws and future tools
04	UML Modeling basics	Introduction of the modeling basics required for CIM
05	UML demonstration of the CIM	Using the free viewer of the Spax Enterprise Architect Modeling and Design Tool to visualize the current CIM (IEC 61970-301 Edition 2009). Free viewer will be provided for all attendees.
06	CIM Users Group	Activities of the CIM Users Group
07	Application examples and projects	Presentation of implemented and planned applications; projects
08	Harmonization CIM – IEC 61850	Present the current status and potential issues of the harmonization of the two models
[S-07] – Communication and SCADA aspects and protocol implementations		
00	Extracting data from field devices	General SCADA services – configuration of control blocks (IEC 61850-7-2). Overview, Reporting, Logging, GOOSE, Sampled values
01	Monitoring for SCADA applications	Fundamentals of special SCADA services (IEC 61850-7-2): model basics for monitoring, event reporting, event logging. IEC 61850 aspects of monitoring, SCADA services, Alarm handling
02	Communication technologies	Fundamentals of Industrial Ethernet used for substations and beyond Industrial Ethernet features, Ethernet Requirements for IEC 61850, Shared Ethernet, Switched Ethernet, Ethernet frames, Ethertypes used in IEC 61850, Priority tagging, 802.1Q / 802.1p
03	Information presentation and encoding	Fundamentals of UML, XML, ASN.1, ... Presentation of IEC 61850 Domain in UML Notation (Status of WG 10Task Force: 2010-09; Enterprise Architect)
04	Protocol details	Fundamentals of ISO 9506 (MMS), Webservices, IEC 60870-5, DNP3, ICCP
05	Protocol implementations and Mappings for IEC 61850-7-2	Details on how to implement protocols and information models? MMS, ASN.1 BER, Web services, ..., simple MMS clients; IEC 60870-5, ICCP, DNP3
06	Demonstration of compliant software	Demonstration of IEC 61850 compliant client and server software. Server (software-only, hardware version), API between existing data and „standard world", Existing data, DER model, and mapping of existing data to the DER model, Clients (MS Internet Explorer, Tamarack test client, Tamarack Client), Demonstrate information exchange
07	MMS client and server implementation – the basis for IEC 61850	Comprehensive training on the implementation of MMS clients and servers for all basic services required by TC 57 standards: Association, NamedVariable, NamedVariableList, Read, Write, Information Report, ... This module usually requires a 2 day course
08	ICCP (IEC 60870-6 TASE.2 Protocol)	Use of MMS for realizing the TASE.2 services
09	Network Engineering Guidelines (IEC 61850-11)	Recovery protocols (RSTP, PRP, etc); different approaches to network topology, redundancy, time synchronization, etc.; status of standardization
[S-08] – Products and projects		
00	Practical experience	IEC 61850 devices, tools, and projects in reality; penetration of IEC 61850 (61400-25) in the global market. Equipment, IEDs, Tools, Substations, Industrial applications
01	Tool support	Tools for IEC 61850, SCL, IEC 61400-25, Ethernet, TCP/IP, MMS, ASN.1 MS Internet Explorer, XML, SCL browser from ABB, Use of SCL for automatic building IED data bases of servers, Validation of models of a server IEDs, Network analyzers (Ethereal, KEMA UNICA, …)

02	User support	UCA international users group, quality measures and TISSUE process, why to join the users group?
03	Current and future standardization	Introduction of current and future application domains using and extending IEC 61850; Update on ongoing and planned standardization activities, Coordination and harmonization of information models, Maintenance of IEC 61850 base documents, Data and communication security, Power quality monitoring, Statistical and historical statistical data, Wind power plants, Hydro power plants, Decentralized energy resources, Substation to control center communication, Substation to substation communication, Product standards: switch gear and merging units, Monitoring, asset management, and maintenance (various groups), Condition monitoring.
04	SCL demo with compliant software	Use of SCL files for building data model in an IED, extension of model (new data); including live demonstration.
05	Products offered by major vendors	What is the situation on the market? What products are offered by the major vendors (ABB, Areva, GE, Siemens, … Doble, Omicron, … Beckhoff, Phoenix Contact, … RuggedCom, Hirschmann, …)
06	Multivendor projects and turn key projects of single vendor	Experiences after two years substation automation and protection with IEC 61850; turn key projects, ... User's view and requirements. Are the users' expectations met?
07	IEC 61850 Network Analyzer and SCL	Presentation and demonstration of the use of SCL files for the interpretation of messages: Connect IED Scout to QNE Measurement IED, Generate SCL for QNE with IED Scout, KEMA UNICA trace without SCL, KEMA UNICA trace with SCL, Ethereal Trace and interpretation of ASN.1 BER
10	Tools for the engineering of IEC 61850 conformant systems	The engineering process of IEC 61850 requires several tools for the various aspects of engineering: system design, IED design, system engineering, IED configuration, testing, ... The presentation introduces the typical engineering process using tools. More details can be found in the hands-on training [H-0104]
11	Second edition of IEC 61850 and other extensions	The first edition of IEC 61850 had 14 parts and was published between 2002 to 2005. In the meantime many extensions have been defined and published as standards or draft standards. This presentations presents the many new definitions in information models, services, configuration, mappings, and applications.
50	Quality process and user group	The UCA international users group represents all major vendors, many utilities, system integrators and consultants to support the various standards. The crucial objective is the support of the quality assurance process for testing, certification and lab accreditations.
[S-09] – Real-time information exchange with GOOSE and Sampled Values		
00	Network Infrastructure for Real-time information exchange	Required Ethernet communication infrastructure (Ethertype, Multicasting, Multicast filtering, … Redundancy). Non Ethernet communication solutions. Basics on PRP, HSR, and IEEE 1588. Draft IEC 61850-90-4
01	GOOSE (Generic Object Oriented System Event)	GOOSE Control Blocks and dynamic behavior of GOOSE message exchange. Required Ethernet communication infrastructure (Ethertype, Multicasting, Multicast filtering, …) . GOSSE message syntax (flexible and fixed encoding). Configuration of GOOSE control using SCL. GOOSE application examples. Demonstration of GOOSE messaging and network traffic analysis.
02	Sampled Measured Values	SMV Control Blocks and dynamic behavior of SMV message exchange. Required Ethernet communication infrastructure (Ethertype, Multicasting, Multicast filtering, …). SMV message syntax. Configuration of SMV control using SCL. SMV application examples.
[S-10] – Functional Testing		
00	Basics of functional testing. NEW	The functional elements in system testing. Status of standardization work in IEC TC 57 and CIGRÉ
02	Details of functional testing. NEW	How to use services and Model contents (various data objects) and IEDs like Merging Units for functional testing. Testing of servers, clients and system aspects.
[S-11] – Edition 1, Edition 2, Edition 3, …		
00	Basics of the various Editions in the series IEC 61850 and IEC 61400-25. NEW	The standard series IEC 61850 and IEC 61400-25 comprise more than 25 different parts. Each part has its own designation: "Edition 1", "Edition 2", … To reduce the confusion and to learn the right terminology of Editions the basic structures will be explained.
01	Basic comparisons of the Edition 1 and Edition 2 of the core documents. NEW	The crucial differences between Edition 1 and Edition 2 of the following documents will be explained: IEC 61850-5, IEC 61850-6, IEC 61850-7-1, IEC 61850-7-2, IEC 61850-7-3, IEC 61850-7-4, IEC 61850-8-1, IEC 61850-7-410
02	Detailed comparisons of the Edition 1 and Edition 2 of the core documents. NEW	The many differences between Edition 1 and Edition 2 of the following documents will be explained: IEC 61850-5, IEC 61850-6, IEC 61850-7-1, IEC 61850-7-2, IEC 61850-7-3, IEC 61850-7-4, IEC 61850-8-1, IEC 61850-7-410

Special hands-on Training opportunities for IEC 61850

[H-00] – General IEC 61850 hands-on training for in-house courses

00	Extended modeling of non-standardized information	Build your own extended model. The use of the extension rules of IEC 61850 to model application information outside standards
01	Design and engineering of a substation	Engineering of substations, IEDs and other systems using SCL tools
02	Real models	Analysis of existing real models; design of the model for your application
03	IED communication	Hands-on training of the use of communication services (ACSI) using an IED Simulator and common IED Browsers. The communication comprises all ACSI services except Sampled Values; communication with real IEDs (if IEDs are available and accessible); Network infrastructure and PCs are required; one PC per two attendees; training software will be provided in advance
04	Analyzing the communication	Analyzing the communication according to IEC 61850: client-server, GOOSE, SV; communication testing
05	H-0005-Client-Server-Demos-Hands-on_reviced-2010-10-25.ppt	

[H-01] – IEC 61850 IED and Engineering tools hands-on training in cooperation with STRI, Ludvika/Sweden

This hands-on training is offered as public or in-house events. The duration is usually 4 days. Contact NettedAutomation for details, dates and locations.

00	Module 1	Gives an introduction to the IEC 61850 standard together with a summary with real applications and the demonstration of STRI facilities for multivendor interoperability testing. Introduction to IEC 61850, the basics of the standard series, updates and other extensions. Presentation of the STRI multivendor application with ABB, Areva and Siemens IEDs for a typical substation. Demonstration of compliant IEC 61850 software, devices and test procedures in STRI's Independent IEC 61850 laboratory.
01	Module 2	Gives an independent and more detailed update on the IEC 61850 standard for substation and device modeling as well as communication principles with real examples. IEC 61850 substation and device modeling and communication principles (GOOSE, Sample Values, Client/Server applications). What you need to know for specification, evaluation, verification and maintenance of IEC 61850 systems (whole substations and IEDs).
02	Module 3	Presents possible functional allocation and architecture of a typical substation with state of the art IEDs from different manufacturers (ABB, Areva, Siemens) as well as available test sets (Omicron, Doble, Programma) with group sessions on how to optimize the solution. Review of available functions and possible architectures for substation automation. Optimized application of IEC 61850 in power utilities with examples based on the STRI multivendor application with ABB, Areva and Siemens IEDs for a typical substation. Morning session with theory and afternoon with group workshop to design and specify typical substation functions.
03	Module 4A IED interoperability workshop	IEC 61850 hands-on workshop demonstrating inter-operability of protection and control devices from ABB, Areva and Siemens. The intention is to create a small system demonstrating interoperability of protection and control devices from ABB, Areva and Siemens. The participants will be divided in three subgroups with the task of browsing the IED model of each device (using self-description, validation of model and SCL file) and creating outgoing GOOSE messages from their relay. After lunch the network traffic is jointly analyzed and the reception of GOOSE messages will be configured in smaller groups. Finally the system is tested through e.g. simple multi-protection tripping schemes and the use of IEC 61850 compatible test devices. Participant gets hands-on experience of at least two vendors IEC 61850 implementation in IEDs and tools. Experience in system debugging and network traffic analysis using third party and open source tools is gained.
04	Module 4B Substation Configuration Language	Substation Configuration Language (SCL) hands-on workshop. Learn what you need to know for specification, evaluation, verification, and maintenance of IEC 61850

	(SCL) workshop	substations and IEDs. The workshop focuses on the design of typical substation functions and the engineering of the substation and IEDs according to the engineering process described in edition 2 of IEC 61850-6 (SCL). The participants will use third-party functional specification, design and engineering tools to design ICD files, substation sections, communication sections, IED sections and DataTypeTemplates. The participants will create a SCD file that is used to generate a fully functional IED (IEC 61850) server simulator. The SCD file is also used as import file for an IED configuration tool to configure a real IED (data model, server and GOOSE message). During the last hour of the workshop the two groups join for the IED configuration by use of the SCD file created by the SCL group. This workshop 4B requires participants to bring their own notebooks (at least one for two attendees). The demo tools (from third parties) required will be provided by NettedAutomation prior to the beginning of the event.

Special hands-on Training opportunities for IEC 61850

[H-02] – General CIM (IEC 61968) hands-on training for in-house courses		
00	Hands-on training with available CIM tool demonstration software	The attendees will be guided through several sample tools. The students will learn how to use CIM compliant tools for sample applications.

Date and locations for public events:	http://www.nettedautomation.com/seminars/uca/sem.html#standardpublic
In-house courses:	http://www.nettedautomation.com/seminars/uca/sem.html#inhouse
Contact:	karlheinz.schwarz@nettedautomation.com
IEC 61850 Blog:	http://blog.iec61850.com

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2013 Public Seminars and Training Courses

11.-13. March 2013 Atlanta (GA USA)
06.-08. May 2013 Frankfurt (Germany)
16.-18. October 2013 Frankfurt (Germany)

Most asked help is for in-house courses and hands-on training

Details and Registration:
http://www.nettedautomation.com/seminars/uca/sem.html

Other subjects, locations and dates for public and in-house training courses need be negotiated according to your requirements. Please contact us.

Program

IEC 61850 Seminar and Hands-on Training

Frankfurt (Germany)

09.–11. May 2012

Notes:

1. Questions and discussions during and after each presentation are expected and welcome.
2. Breaks may be shifted and added if required.
3. If required some presentations may be reduced or extended.
4. The given durations may vary.
5. Page numbers Pxxx refer to the printed slides for the attendees

Wednesday, 09. May 2012 – Day 1

#	Modul	Topic	Description	Min	Time
01	S-0000 P007	Welcome and opening	Welcome, opening, roll call of attendees, expectations of attendees, Title and scope of IEC 61850 (IEC TC 57), Power Delivery System, What does IEC 61850 provide?, Motivation for the new standards, IEC 61850 in brief, Re-use of IEC 61850, Tools and System Integration, Standardization and projects, General observations.	150	10:00 – 12:30
Lunch					12:30 – 13:30
02	S-0100 P038	Power system automation basics	Basics of power system information integration and automation covering control centers, substations, power generation; Elements of the power system: Substations, Power Generation, Transmission, Distribution, System architecture, Functions, Communications, System engineering, and device configuration	45	13:30 – 14:15
03	S-0101 P050	Standardization	IEC activities related to power system standardization, IEC TC 57 and TC 88, International organizations for the power industry, IEC organization and standardization work, IEC activities related to the power industry, CIGRE, IEEE, UCA Users Group, IEC 61400 User Group, activities related to the power industry; international fieldbus	30	14:15 – 14:45
Break					14:45 – 15:05

#	Modul	Topic	Description	Min	Time
04	S-0200 P062	IEC 61850 series – overview	Communication networks and systems for power system automation: general introduction on whole series. Design objectives and scope IEC 61850, Content and structure of IEC 61850, Features of IEC 61850, Application modeling, Information exchange and communication services, the 16 parts of the standard	100	15:05 – 16:45
Break					16:45 – 16:55
05	S-0202 P088	IEC 61850-6 engineering process	Engineering process using the configuration language: from IEDs and single line diagram to configured substation automation system Systems specification (Single line diagram and functions), IED specification (IED capability description), System engineering, IED engineering and configuration, Use of SCL (summary), Edition 2.	45	16:55 – 17:40
06		Q&A		20	17:40 – 18:00

Thursday, 10. May 2012 – Day 2

#	Modul	Topic	Description	Min	Time
07	S-0201 P095	IEC 61850 Application modeling principles	Modeling protection, substation automation, other applications (Logical nodes, data and data attributes, function modeling, extension of the models, monitoring). The elements of the data model, Acquisition of measured information, Controlling of switchgear equipment, Protection functions, Edition 2 updates, Example of a model.	60	08:30 – 09:30
08	S-0203 P111	Communication	Information exchange with the ACSI according to IEC 61850-7-2 Basics, Information flow through IEDs, ACSI in detail (IEC 61850-7-2), Server, Logical Device, Logical Node, Data, DataSet, Control Blocks (Reporting, Logging, GOOSE, SV), Control, Conformance statement, Recording (IEC 61850-7-4).	90	09:30 – 10:30
Break					10:30 – 10:50
		cont.			10:50 – 11:20
09	S-0204 P143	Implementation of IEC 61850 conformant devices and tools	Device models, design of advanced IEDs, software and hardware architectures, OEM software	40	11:20 – 12:00
10	S-0800 P154	Practical experience	IEC 61850 devices, tools, and projects in reality; penetration of IEC 61850 (61400-25) in the global market. Equipment, IEDs, Tools, Substations, Industrial applications	30	12:00 – 12:30

#	Modul	Topic	Description	Min	Time
Lunch					12:30 – 13:30
11	S-0205 P169	Device conformance testing	Conformance testing of devices according to IEC 61850-10	20	13:30 – 13:50
12	S-0206 P177	Extension rules IEC 61850	The extension rules for Logical Nodes, Data, and Common Data Classes, the name space concept. Scope, Instantiation of existing information model classes, New information mod-els, Name space concept.	25	13:50 – 14:15
13	S-0207 P187	Substation configuration language (SCL)	System configuration language: basics and details; Engineering process and SCL, SCL object model, SCL syntax (IEC 61850-6 (SCL))	60	14:15 – 14:45
Break					14:45 – 15:05
		cont.			15:05 – 15:35
14	S-0301 P214	Applying IEC 61850 for substation automation – use cases	Use cases from substation automation like measuring of current and voltage, protection, operating a switch, creation of a sequence of events	25	15:35 – 16:00
15	S-0302 P223	Product specifications for substation equipment	Implementation guideline IEC 61850-9-2 “LE”, Product standard for switchgear with integrated IEC 61850 interface (IEC 62271-003)	20	16:00 – 16:20
Break					16:20 – 16:30
16	S-0400 P231	Wind power plants	Overview and introduction of the standard for Communications for monitoring and control of wind power plants – IEC 61400-25	10	16:30 – 16:40
17	S-0401 P250	Hydro power plants	Overview and introduction of the standard for Communications for monitoring and control of hydro power plants – IEC 61850-7-410	10	16:40 – 16:50
18	S-0402 P255	Distributed Energy Resources	Overview and introduction of the standard for Communications for monitoring and control of Distributed Energy Resources (DER) – IEC 61850-7-420	10	16:50 – 17:00
19	S-0700 P264	Extracting data from field devices	General SCADA services – configuration of control blocks (IEC 61850-7-2). Overview, Reporting, Logging, GOOSE, Sampled values	40	17:00 – 17:40
20	S-0701 P274	Monitoring for SCADA applications	Fundamentals of special SCADA services (IEC 61850-7-2): model basics for monitoring, event reporting, event logging. IEC 61850 aspects of monitoring, SCADA services, Alarm handling	20	17:40 – 18:00

Friday, 11. May 2012 – Day 3

21	S-0807 P284	IEC 61850 Network Analyzer and SCL	Presentation and demonstration of the use of SCL files for the interpretation of messages: Connect IED Scout to QNE Measurement IED, Generate SCL for QNE with IED Scout, KEMA UNICA trace without SCL, KEMA UNICA trace with SCL, Ethereal Trace and interpretation of ASN.1 BER	15	08:30 – 08:45
22	S-0900 P296	Network Infrastructure for Real-time information exchange	Required Ethernet communication infrastructure (Ethertype, Multicasting, Multicast filtering, ... Redundancy). Non Ethernet communication solutions.	30	08:45 – 09:15
23	S-0901 P308	GOOSE (Generic Object Oriented System Event)	GOOSE Control Blocks and dynamic behavior of GOOSE message exchange. Required Ethernet communication infrastructure (Ethertype, Multicasting, Multicast filtering, ...) . GOSSE message syntax. Configuration of GOOSE control using SCL. GOOSE application examples. Demonstration of GOOSE messaging and network traffic analysis.	30	09:15 – 09:45
24	S-0705 P319	Protocol implementations and Mappings for IEC 61850-7-2	Details on how to implement protocols and information models? MMS, ASN.1 BER, Web services, ..., simple MMS clients	45	09:45 – 10:30
Break					10:30 – 10:50
25	H-03 P335	IED communication	Hands-on training of the use of communication services (ACSI) using an IED Simulator and common IED Browsers. The communication comprises all ACSI services except Sampled Values; communication with real IEDs (Measurement IED); Network infrastructure will be provided; two attendees each with a PC will be connected 1:1 by a cross-over cable; training software will be provided in advance.	180	10:50 – 12:30
Lunch					12:30 – 13:30
		cont.			13.30 – 14:50
Break					14:50 – 15:10
26	H-04	Analyzing the communication	Analyzing the communication according to IEC 61850: client-server, GOOSE, SV (if available); communication testing	60	15:10 – 16:10
27		Question & Answers	Final questions and answers	20	16:10 – 16:30

Feedback from attendees and pictures
of IEC 61850/61400-25 Seminars and Training Workshops

NettedAutomation GmbH

http://nettedautomation.com

http://blog.iec61850.com

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Version 2013-01-25

Summary of courses (seminars and training courses)

	Event	*Days*	*Att.*
1.	Shanghai (China) 2002-10		13
2.	Xian (China) 2002-10		17
3.	Rødkærsbro (Denmark) 2003-03		8
4.	Barcelona (Spain) 2003-04		14
5.	Madrid (Spain) 2004-03		22
6.	Frankfurt (Germany)2004-05		40
7.	Paris (France) 2004-08		25
8.	Chicago (USA) 2004-10		12
9.	Beijing (China) 2004-11		32
10.	Johannesburg (South Africa) 2004-11		23
11.	Kuala Lumpur (Malaysia) 2004-11		27
12.	Frankfurt (Germany) 2004-12		18
13.	Daejeon (South Korea) 2005-02		30
14.	Torréon (Mexico) 2005-04		22
15.	Copenhagen (Denmark) 2005-05		18
16.	Berlin (Germany) 2006-06		15
17.	Frankfurt (Germany) 2006-06		15
18.	Toronto (Canada) 2005-09		16
19.	Ottawa (Canada) 2005-09		15
20.	Baden (Switzerland) 2005-09		21
21.	Berlin (Germany) 2005-10		20
22.	Cape Town (South Africa) 2005-10		35
23.	Zurich (Switzerland) 2005-10		22
24.	Melbourne (Australia) 2005-11		22
25.	Brisbane (Australia) 2005-11		43
26.	Haifa (Israel) 2005-12		31
27.	[redacted] (Italien) 2006-01		16
28.	[redacted] Dortmund (Germany)2006-02		15
29.	[redacted]. (Germany) 2006-02		10
30.	[redacted] Rostock (Germany) 2006-03		6
31.	Frankfurt (Germany) 2006-03		7
32.	Madrid (Spain) 2006-03		11
33.	Bangalore (India) 2006-04	3	350
34.	[redacted] Berlin (Germany) 2006-05	3	22
35.	Calgary (Canada)	3	17
36.	London (UK) 2006-07	2	15
37.	[redacted] Lisboa (Portugal), 2006-07	3	8
38.	Paris (France) 2006-08	3	7
39.	[redacted] Klaus (Austria) 2006-08	3	7
40.	[redacted] Allentown (USA) 2006-11	4	10
41.	[redacted] Barcelona (Spain) 2006-11	3	8
42.	Frankfurt (Germany) 2006-12	3	6
43.	Cheboksary (Russia) 2007-04	4	16
44.	[redacted] Grenoble (France) 2007-04	2	70
45.	[redacted] Oldenburg (Germany) 2007-04	3	14
46.	[redacted] Blomberg (Germany) 2007-05	2	10
47.	Itaipu (Brazil) 2007-05		15
48.	Doha (Qatar) 2007-05		15
49.	Frankfurt (Germany) 2007-07		5
50.	[redacted] Lissabon (Portugal) 2007-07		10
51.	[redacted] Aschaffenburg (Germany) 2007-08		10
52.	[redacted] Raleigh (NC, USA) 2007-08		5
53.	Frankfurt (Germany) 2007-09		5

	Event	Days	Att.
54.	[redacted] Paris (France) 2007-09		18
55.	[redacted] Regina (Canada) 2007-10		6
56.	[redacted] Corp Seoul (Rep. Korea) 2007-10		9
57.	Melbourne (Australia) 2007-11		15
58.	Sydney (Australia) 2007-11		9
59.	[redacted] Wellington (New Zealand) 2007-11		20
60.	[redacted] Dortmund (Germany) 2008-01		11
61.	Frankfurt (Germany) 2008-01		11
62.	[redacted] (Germany) 2008-02		29
63.	[redacted] Oldenburg (Germany) 2008-03		10
64.	[redacted] Ljublijana (Slovenia) 2008-03		28
65.	Frankfurt (Germany) 2008-04		15
66.	[redacted] Winnipeg (Canada)		25
67.	Atlanta (USA) 2008-07		12
68.	Paris (France) 2008-08		10
69.	[redacted] Kuala Lumpur (Malaysia) 2008-09		16
70.	Seoul (Rep. Korea) 2008-10		20
71.	[redacted] Minden (Germany) 2008-10	2	5
72.	[redacted] New York City (USA) 2008-10	3	55
73.	[redacted] Brisbane (Australia) 2008-10	3	23
74.	[redacted] Auckland (New Zealand) 2008-11	2	15
75.	[redacted] Hamilton (New Zealand) 2008-11	3	10
76.	[redacted] Christchurch (New Zealand) 2008-11	3	30
77.	STRI Ludvika (Sweden) 2008-11	4	35
78.	[redacted], Berlin (Germany) 2008-12	2	7
79.	[redacted], Detmold (Germany) 2008-12	2	12
80.	Mexico City (Mexico) 2009-01	1	21
81.	Frankfurt (Germany) 2009-03	4	23
82.	Moscow (Russia) 2009-03	3	22
83.	[redacted] Italy) 2009-03/05/07 11 days	11	12
84.	[redacted], Berlin (Germany) 2009-04	2	7
85.	Kuala Lumpur (Malaysia) 2009-05	1	22
86.	Ifak, Magdeburg (Germany) 2009-06	2	6
87.	Moscow (Russia) 2009-09	3	10
88.	[redacted] (Germany) 2009-10	4	14
89.	Frankfurt (Germany) 2009-10	4	19
90.	San Antonio (TX, USA) 2009-10	2	16

	Event	Days	Att.
91.	Nürnberg (Germany) 2009-11	1	10
92.	Brisbane (Australia) 2009-11	3	21
93.	Sydney (Australia) 2009-12	3	17
94.	Reykjavik (Iceland) 2010-01	3	29
95.	[redacted], Madrid (Spain) 2010-01	5	23
96.	[redacted], Dublin (Ireland) 2010-01	4	8
97.	Buenos Aires (Argentina) 2010-04	3	26
98.	Sao Paulo (Brazil) 2010-04	3	10
99.	Frankfurt (Germany) 2010-05	3	9
100.	[redacted] Tokyo (Japan) 2010-05	4	7
101.	[redacted] DK 2010-06	4	32
102.	[redacted] Bethlehem (USA) 2010-07	4	24
103.	National Instruments 2010-07	3	1
104.	Frankfurt (Germany) 2010-09	3	7
105.	[redacted] (Germany) 2010-10	1	7
106.	Remote Dallas (TX) 2010-10	2	7
107.	[redacted] Manila (Phil) 2010-10	4	25
108.	STRI Stockholm (Sweden) 2010-11	4	19
109.	[redacted] (Germany) 2010-11-10	2	16
110.	[redacted] (Germany) 2010-11-19	1	8
111.	[redacted] Sydney (Australia) 2010-12-06	5	15
112.	EdF Paris (France) 2010-12-14	1	3
113.	[redacted] (Germany) 2010-12-21	1	7
114.	[redacted] (France) 2011-01-06	2	9
115.	[redacted] Knaresborough (UK) 2011-01-10	3	6
116.	[redacted] Karlsruhe Crashkurs 2011-02-17	1	2
117.	5 Guru Sydney (Australia) 2011-03-07	3	49
118.	Myong Ji University Yongin (Korea) 2011-03-13	1	45
119.	[redacted] (Germany) 2011-03-14	1	6
120.	[redacted] Baden (Schweiz) 2011-04-26	2	6
121.	SAPP Power Pool ICCP Harare (Zimbabwe) 2011-04-04	3	22
122.	[redacted] Ashby (UK) 2011-04-18	3	5
123.	Frankfurt (Germany) 2011-05-04	3	6
124.	[redacted] Karlsruhe (Germany) 2011-05-12	1	7
125.	BCIT Vancouver (Canada) 2011-05-16	3	46

	Event	*Days*	*Att.*
126.	TQ Seefeld (Germany) 2011-06-01	1	7
127.	TÜV SÜD München (Germany) 2011-06-03	1	6
128.	[redacted] (Germany) 2011-06-17	1	5
129.	TÜV SÜD München (Germany) 2011-06-27	2	6
130.	[redacted] (Germany) 2011-06-29	3	15
131.	[redacted] (Germany) 2011-07-05	1	13
132.	[redacted] Fürth (Germany) 2011-07-13	1	6
133.	[redacted] (Germany) 2011-07-14	1	6
134.	[redacted] Hannover (Germany) 2011-07-21	1	2
135.	[redacted] Brussels (Belgium) 2011-08-22	3	9
136.	[redacted] Emden (Germany) 2011-08-30	3	6
137.	Shanghai (China) 2011-09-05	1	110
138.	[redacted] (Austria) 2011-09-12	2	6
139.	Remote Nashville (TN, USA) 2011-09-20	2	11
140.	[redacted] (Austria) 2011-09-27	3	14
141.	Frankfurt (Germany) 2011-10-05	3	7
142.	[redacted] (France) 2011-10-17	6	19
143.	[redacted] (France) 2011-11-02	6	20
144.	Sao Paulo (Brazil) 2011-11-21	3	23
145.	[redacted] Shanghai (China) 2011-11-28	10	26
146.	TQ Systems Seefeld (Germany) 2011-12-14	1	16
147.	[redacted] München 2012-01-26	1	6
148.	[redacted] (Germany) 2012-02-15	1	6
149.	[redacted] (Germany) 2012-02-22	1	29
150.	[redacted] München 2012-03-16	1	5
151.	[redacted] New Delhi 2012-03-19/21	3	28
152.	HAW Hamburg 2012-03-28	2	55

	Event	*Days*	*Att.*
153.	[redacted] Brüssel 2012-03-11/13	3	8
154.	[redacted] (Israel) 2012-04-30	4	15
155.	Uni Peninsula Capetown 2012-05-02	3	2
156.	Frankfurt 2012-05-09	3	2
157.	[redacted] (Germany) 2012-05-14	1	45
158.	[redacted] (Germany) 2012-05-15	1	7
159.	[redacted] Italien 2012-05-29	3	15
160.	KTH Stockholm 2012-06-11	1	16
161.	[redacted] (Germany) 2012-06-19	2	6
162.	[redacted] (Germany) 2012-07-03	1	9
163.	[redacted] (MA), 2012-07-16/19	3	4
164.	TÜV SÜD München (Germany). 2012-07-23	1	4
165.	TÜV-SÜD Seoul, 2012-09-04	1	60
166.	TÜV-SÜD Beijing,2012-09-06	1	30
167.	TÜV-SÜD Taipei, 2012-09-11	1	45
168.	Frankfurt 2012-10-17	3	15
169.	Remote, Denver (CO), 2012-09-18	1	5
170.	[redacted] (WA, Australia), 2012-10-25	7	2
171.	[redacted] Los Angeles (CA), 2012-10-05	2	13
172.	[redacted] (GA), 2012-10-06	3	2
173.	[redacted] Berlin, 2012-12-11	1	15
174.	TÜV SÜD, 2012-12-13	1	7
175.	[redacted], Quebec City, Canada; 2013-01-07/11	5	15
176.	[redacted], Erlangen, 2013-01.21/23	3	33
177.			
178.			
179.			
180.			
181.			
	Total (by 2013-01-25)		*3.271*

Some personal responses:

1. Again thank you for all wise words and information.

   My knowledge of 61850 is extremely improved. It is always nice to see how experts show their knowledge. Also the location (Frankfurt) was excellent

2. I would like to thank you very much for the CD you gave me in Paris at the Cigré exhibition.

   It is very interesting for us to be informed like this about all the improvements done for the IEC 61850 and to realise how much work you had for all the presentations you made during the workshop in Paris. Congratulation !

   I was very pleased to see you once more and I hope it will not last too long since we meat again.

3. Excellent course ….thought provoking. I think it will be a matter of seeing if demand from the user community is high enough to encourage vendors to adopt 61850. Or visa versa. Another chicken before the egg scenario. I intend to pursue corporate membership in the UCA User's group.

4. Hi Karlheinz,

   You and Mr. Brunner speak very good today. Thank you very much.

5. You've done very well. Thanks for your hard work!

6. Thanks for your evaluation and your help. I would admire your hard working greately. I would like to cooperate with you in the future.

7. Friends,

   We had an IEC61850 seminar in Kuala Lumpur last week for 3 days. Needless to say, it was a rewarding experience to listen to Karlheinz Schwarz (Nettedautomation, Germany) and Christoph Brunner (ABB, Switzerland). I was informed by Karlheinz that there is an intent to have a IEC61850 seminar in India early next year.

   The standard is in the early stages of pilot implementations (in Europe). All leading players like ABB, Siemens, VATECH SAT, Areva etc besides the utilities in Europe are supporting this standard strongly.

   I am sure this seminar will go a long way in your understanding of the new standard. Please make the best use of the opportunity.

8. One of my colleagues (Gary T.) has attended Netted Automation courses in the past and his feedback has been very positive.

9. The seminar on the implementation of IEC 61850 based solutions is some kind of unique. As far as I know, there have not been such events in Russian Federation before. The lecturer is highly qualified professional who is involved in the development of IEC 61850 series and other standards. The program of the seminar included as well as the overview of all parts of the standard as the questions of its practical application. That is why the seminar gave a chance to capture a great portion of information and to learn the experience of foreign companies who are already implementing the standard in their systems.

   It was very useful to talk to other participants of the seminar – those professionals who work on its implementation, those who work in the area of SAS development, development of microprocessor based relays, testing equipment and in the utilities.

   The only drawback of the seminar is the limits of time that we had – three days is not enough for such an event – there is a will to get into the aspects of the standard more deeply.

10. "The seminar has delivered all the goods that I expected and brought even more. It was once more confirmed that IEC 61850 standard is the main track for the development of automation systems in power engineering and other related areas. One of the most useful aspects of the seminar was revealing of the aspects of the second edition of the standard.

If there is something to add I would only say that there is a need for organizing separate and more specialized seminars for programmers, engineers and top-managers of organizations."

11. "It was a very useful seminar. Karlheinz Schwarz is highly qualified professional in the field. I must say that we got the information from first hands and he was able to answer every question almost at once and if not - knew where to look for the answer. It is great that we had such an opportunity to attend such a seminar.

    If to compare this seminar with those provided by vendors I must state that vendors have a different approach – the approach that states that IEC 61850 standard is going to solve all the existing problems. And it is not like that at the moment. What is true here is that we need to have skills and a higher level of competence in the field – either way the standard is not going to bring benefits. It was mentioned by Karlheinz Schwarz during the seminar and it is right. It was very good to know about the existing problems. Nobody before mentioned about those things we should take care of to use the possibilities of IEC 61850 with the highest efficiency. And we can understand why the vendors do not talk about such things – because every need to acquire new knowledge and get the higher level of competence would require more investments from the utilities. It is important for the utilities to know about that."

12. Attendee of the Sydney course (02-04 December 2009):

    "Well organized and very well run. The presenters were well on top of the subject and could explain the subject matter. There was a huge amount of material to cover and they did it well. Being independent, the subject was presented objectively. Karlheinz was very strong on the background and the detail of the specification, including the interaction with related specifications. Andrea was excellent on the implementation and configuration. Had a very practical approach and committed to making it work in the real world. I certainly gained much more than I expected from the seminar. Excellent value."

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www.blog.iec61850.com

Shanghai (China), 2002-10

Xian (China), 2002-10

Daejeon (South Korea), 2005-02

Torréon (Mexico), 2005-04

Bangalore (India), 2006-04

Terna, Turin (Italy), 2009-07

Successful IEC 61850 Hands-On Training Courses in Australia

NettedAutomation GmbH and STRI conducted two 3 day IEC 61850 Hands-On Training courses in Australia: in Brisbane on November 30 - December 02 and Sydney on December 02-04, 2009.

Brisbane course (attendees from 7 organizations)

Sydney course (attendees from 10 organizations)

Andrea Bonetti (STRI) in action
... actions speak louder than words!

The attendees reported that there are many concrete plans to apply IEC 61850 in Substations of Australian transmission and distribution utilities in 2010 and 2011. Also substations outside of utilities (e.g., in the mining industry) are being build with IEC 61850 compliant automation and protection systems.

The plans to implement a huge Smart Grid project in Australia are an additional opportunity for IEC 61850 being applied for distribution networks - to make the Grids smarter.

Feedback from an attendee of the Sydney course:
"Well organized and very well run. The presenters were well on top of the subject and could explain the subject matter. There was a huge amount of material to cover and they did it well. Being independent, the subject was presented objectively. Karlheinz was very strong on the background and the detail of the specification, including the interaction with related specifications. Andrea was excellent on the implementation and configuration. Had a very practical approach and committed to making it work in the real world. **I certainly gained much more than I expected from the seminar. Excellent value.**"

110 Young People attended the Shanghai IEC 61850 and IEC 61400-25 Workshop

The workshop on IEC 61850 and IEC 61400-25 organized by the State Energy Smart Grid R&D Center (Shanghai) hosted at Shanghai Jiao Tong University on Monday, 05 September 2011, was very successful.

The **110 young attendees** from 37 organizations came to the event to get up-to-date information about the standards, market acceptance, challenges with the new standards, experience, and implementation hints.

One of the students of the workshop and the teacher at the entrance:

The 110 attendees (mostly young people):

Professor Peichao Zhang and his colleague Professor Dong Liu organized the event:

According to a report given during the IEC TC 57 Plenary meeting in Shanghai (6.-7. September 2011), one substation per day and one wind power turbine per hour are installed in China. So, there is a huge demand for solutions according to IEC 61850 and IEC 61400-25.

The young people are eager to learn how to use the standards for the various products and applications. The workshop has helped them a lot to get the basics of the standard.

IEC 61850, IEC 61400-25, IEC 61970 CIM, ...

Comprehensive Seminar &Training: IEC Standards for Automation, Protection, Monitoring, Engineering (SCL), SCADA, Smart Grids, RTU, Gateways,... for Smart(er) Grids and other domains

You'll get up-to-date, first-hand & neutral knowledge, experience, Do's and Don't's and guidance from the editors ... the fastest start in application and implementation

NettedAutomation GmbH
Information & Communication Systems

... the most successful vendor-independent education to help you like we did in India and Australia recently and all over:

Implementations and applications based on IEC Standards like IEC 61850 (Communication networks and systems for power utility automation), IEC 61400-25 (Wind turbines), IEC 61970 (CIM), ... **grow faster than expected** in many application domains like power generation, high voltage transmission, medium voltage power distribution, ... all over! To handle the exploding demands for products based on these IEC standards we offer courses for the best possible, up-to-date, first-hand & neutral knowledge, experience, and **most efficient start in the development and use** of IEC standard conformant products for substations, wind power plants, condition monitoring, decentralized energy resources, SmartGrids, SCADA, Engineering (SCL) substation to control center links, RTUs etc. We advice in all crucial **Do's and Don't's to reach interoperability**!

IEC 61850 is the backbone for substation automation and many other application domains, e. g., wind power plants, DER (decentralized energy resources), hydro power plants, power quality monitoring, condition monitoring of any power system equipment etc. Thousands of IEC 61850 compliant substations with several ten thousand IEDs have already been sold and will be in operation by end of 2010. Many products have already been field proven. Utilities and other industries like oil and gas companies all over trust the new technology “IEC 61850 inside” for substations and many other applications. IEC has published further standards for in the utility and non-utility application domain.

Many vendors and users all over have been challenged by the new IEC standard interfaces for intelligent devices and tools. Vendors, users and system integrators need more information to reach interoperable systems and devices. **The system integration has become THE crucial issue!** Many utilities have learnt this lesson: The benefit of the new standard depends on a comprehensive knowledge about IEC 61850. You may seek for efficient help for the application, implementation and system integration. We help to “understand” the many products and vendors! Here is what we offer today:

3 day comprehensive public seminar and hands-on training with Measurement IED and many demo software (fully functional) on Automation, Protection, Monitoring, Engineering, Configuration (SCL), SCADA, SmartGrids, RTU, ...

We provide all the necessary training to reach interoperable IEDs and Tools. 2,600+ experts from 600+ companies from more than 70 countries have attended our 140+ excellent training courses all over. The training courses are hold by Dipl.-Ing. Karlheinz Schwarz – an experts that really knows about the needs for the application and implementation of the standards: IEC 61850, IEC 61400-25, IEC 61970 (CIM), ISO 9506 (MMS), ISO 8824/25 (ASN.1), Web services, ...

Karlheinz Schwarz, Karlsruhe/Germany
Editor of IEC 61850 and IEC 61400-25 (Communications for wind power plants)
Member of IEC TC 57 WG 10, WG 17 (DER), and WG 18 (Hydro power plants),
Member of IEC TC 88 PT 25 (IEC 61400-25)
Convenor of IEC TC 88 PT 25-6 (Information models for Condition Monitoring Systems)

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UCA International Users Group
USE61400-25 IEC 61400-25 user group
IEC 1906 AWARD

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2012-10-01

3 day comprehensive public seminar and hands-on training with real IEDs (embedded controllers) and many demo software (most are fully functional) for Automation, Protection, Monitoring, Engineering, Configuration (SCL), SCADA, Smart Grids, RTU, Gateways, ...

NettedAutomation GmbH
Information & Communication Systems

The following crucial modules will be presented and discussed among other topics:

Modules		Topics	Title / description
Preparation		Get prepared in some crucial topics in order to run more efficiently during the event	In preparation for the training we send selected material to all registered people some three weeks prior to the event. What is a model, a protocol, MMS, an interface, ASN.1, XML, ... Ethernet?
0. General	S-0000	Welcome and opening	Welcome, opening, roll call of attendees, expectations of attendees, Title and scope of IEC 61850 (IEC TC 57), Power Delivery System, What does IEC 61850 provide?, Motivation for the new standards, IEC 61850 in brief, Re-use of IEC 61850, Tools and System Integration, Standardization and projects, General observations.
1. Management and automation of the power system (basics)	S-0100	Power system automation basics	Basics of power system information integration and automation covering control centers, substations, power generation; Elements of the power system: Substations, Power Generation, Transmission, Distribution, System architecture, Functions, Communications, System engineering, and device configuration
	S-0101	Standardization	IEC activities related to power system standardization, IEC TC 57 and TC 88, International organizations for the power industry, IEC organization and standardization work, IEC activities related to the power industry, CIGRE, IEEE, UCA Users Group, IEC 61400 User Group, activities related to the power industry; international fieldbus
2. IEC 61850 (and IEC 61400-25) basics	S-0200	IEC 61850 series – overview	Communication networks and systems for power system automation: general introduction on whole series. Design objectives and scope IEC 61850, Content and structure of IEC 61850, Features of IEC 61850, Application modeling, Information exchange and communication services, the 16 parts of the standard
	S-0201	IEC 61850 Application modeling principles	Modeling protection, substation automation, other applications (Logical nodes, data and data attributes, function modeling, extension of the models, monitoring). The elements of the data model, Acquisition of measured information, Controlling of switchgear equipment, Protection functions, Edition 2 updates, Example of a model.
	S-0202	IEC 61850-6 engineering process	Engineering process using the configuration language: from IEDs and single line diagram to configured substation automation system Systems specification (Single line diagram and functions), IED specification (IED capability description), System engineering, IED engineering and configuration, Use of SCL (summary), Edition 2.
	S-0203	Communication	Information exchange with the ACSI according to IEC 61850-7-2 Basics, Information flow through IEDs, ACSI in detail (IEC 61850-7-2), Server, Logical Device, Logical Node, Data, DataSet, Control Blocks (Reporting, Logging, GOOSE, SV), Control, Conformance statement, Recording (IEC 61850-7-4).
	S-0204	Implementation of IEC 61850 conformant devices and tools	Device models, design of advanced IEDs, software and hardware architectures, OEM software
	S-0205	Device conformance testing	Conformance testing of devices according to IEC 61850-10
	S-0206	Extension rules IEC 61850	The extension rules for Logical Nodes, Data, and Common Data Classes, the name space concept. Scope, Instantiation of existing information model classes, New information models, Name space concept.
	S-0207	Substation configuration language (SCL)	System configuration language: basics and details; Engineering process and SCL, SCL object model, SCL syntax (IEC 61850-6 (SCL)), SCL edition 2. The object model and content of the SCL files, Examples, Binding models to real world, inputs, and to outputs, the data flow engineering
3. Substation automation and protection	S-0301	Applying IEC 61850 for power system automation – use cases	Use cases from power system automation like measuring of current and voltage, protection, operating a switch, creation of a sequence of events, SCADA. Use case 1 – measuring current and voltage Use case 2 – operate switchgear
	S-0302	Product specifications for substation equipment	Implementation guideline IEC 61850-9-2 "LE", Product standard for switchgear with integrated IEC 61850 interface (IEC 62271-003)
4. Power generation	S-040x	Introduction	Wind power plants, Hydro power plants, Distributed Energy Resources
...	...	...	...
7. Communication and SCADA aspects and protocol implementations	S-0700	Extracting data from field devices	General SCADA services – configuration of control blocks (IEC 61850-7-2). Overview, Reporting, Logging, GOOSE, Sampled values
	S-0701	Monitoring for SCADA applications	Fundamentals of special SCADA services (IEC 61850-7-2): model basics for monitoring, event reporting, event logging. IEC 61850 aspects of monitoring, SCADA services, Alarm handling

Modules		Topics	Title / description
	S-0702	Communication technologies	Fundamentals of Industrial Ethernet used for substations and beyond Industrial Ethernet features, Ethernet Requirements for IEC 61850, Shared Ethernet, Switched Ethernet, Ethernet frames, Ethertypes used in IEC 61850, Priority tagging, 802.1Q / 802.1p
	0709	Network Engineering Guidelines (IEC 61850-11)	Recovery protocols (RSTP, PRP, etc); different approaches to network topology, redundancy, time synchronization, etc.; status of standardization
8. Products and projects	S-0800	Practical experience	IEC 61850 devices, tools, and projects in reality; penetration of IEC 61850 (61400-25) in the global market. Equipment, IEDs, Tools, Substations, Industrial applications
	S-0807	IEC 61850 Network Analyzer and SCL	Presentation and demonstration of the use of SCL files for the interpretation of messages: Connect IED Scout to QNE Measurement IED, Generate SCL for QNE with IED Scout, KEMA UNICA trace without SCL, KEMA UNICA trace with SCL, Ethereal Trace and interpretation of ASN.1 BER
9. Real-time information exchange with GOOSE and Sampled Values	S-0901	GOOSE (Generic Object Oriented System Event)	GOOSE Control Blocks and dynamic behavior of GOOSE message exchange. Required Ethernet communication infrastructure (Ethertype, Multicasting, Multicast filtering, ...) . GOSSE message syntax. Configuration of GOOSE control using SCL. GOOSE application examples. Demonstration of GOOSE messaging and network traffic analysis.
H. General IEC 61850 hands-on training	H-05	IED communication	Hands-on training of the use of communication services (ACSI) using an IED Simulator and common IED Browsers. The communication comprises all ACSI services except Sampled Values; communication with real IEDs (Measurement IED); Network infrastructure will be provided; two attendees each with a PC will be connected 1:1 by a cross-over cable; training software will be provided in advance.
	H-04	Analyzing the communication	Analyzing the communication according to IEC 61850: client-server, GOOSE, SV (if available); communication testing
Q & A		Question & Answers	All attendees are requested to provide questions some two weeks prior to the event. Questions will be answered and discussed during the course.

These topics may be updated. The final program for the events listed on the next page will be provided in due time.

Who should attend?

- Substation automation and protection experts and decision makers
- System and device designer and implementers
- Automation, IT and communication experts from utilities, power system planners
- System integrators, engineering personal, SCADA experts
- Control center experts
- Experts from operators, aggregators, power plants (hydro, wind, DER, ...), virtual power plants
- Asset manager, maintenance and service personal, Field application engineers
- Consultants and technical advisors
- ...

... best price - best advice

Dates and registration form See back page

Fee 1.950 EURO
(A discount of 20 per cent will be granted if more than one person per organization attends; for any other discount please contact us seminars@nettedautomation.com)

Attendees will receive all slides as paper copy and a CD ROM with all slides and other material like demo software etc.

Many other topics for advanced courses and in-house training can be found under:

http://www.nettedautomation.com/seminars

A current list of modules for seminars and hands-on training can be downloaded:

http://www.nettedautomation.com/download/Sem/prog/Training-Modules-2010-02-01.pdf [pdf, 150 KB]

registration form ►

Registration Form

(fill in form interactively or print it out first)

I would like to register for the following event on **IEC 61850 and related standards**:

3 day General Seminar/Hands-on Training with Real IEDs (embedded controller with RTOS, ...), Starter Kit (Windows DLL), and several Demo Software (Client/Server and GOOSE messaging)

Fee for 3 days: € 1,950 (with DK61*)/€ 1,150 (without DK61)

**Fee for 1 day: € 1,150 (with DK61*)/€ 220 (without DK61)

☐	**17.-19. October 2012**	**Frankfurt (Germany)**
☐	**11. February 2013**	**Cape Town (SA)****
☐	**06.-08. March 2013**	**Atlanta, GA, (USA)**
☐	**11.-13. March 2013**	**Phoenix, AZ (USA)**
☐	**06.-08. May 2013**	**Frankfurt (Germany)**
☐	**16.-18. October 2013**	**Frankfurt (Germany)**

(A discount of 20 per cent on fees (without DK61) will be granted if more than one person per organization attends; for any other discount please contact us seminars@nettedautomation.com); * DK61 – Beck IPC IEC 61850 Development Kit 61 http://www.beck-ipc.com/en/products/sc1x3/dk61.asp

All prices are in EURO (**excluding** costs for transportation and accommodation for attendees and **excluding** applicable Tax and **excluding** shipping of DK61 (if required). Course fee include lunch and breaks. Participants will be notified of the exact training location in due time.

Registration Information:

First & Family Name - (Dr) (Mr) (Mrs) (Ms) ______________________________

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NettedAutomation takes precautions (including administrative, technical, and physical measures) to safeguard your personal information against loss, theft, and misuse, as well as unauthorized access, disclosure, alteration, and destruction.

Cancellation Policy:
Cancellations received **up to 10** business days prior to the start of the event will be fully refunded. Cancellations **within 9** business days to the start of the workshop are subject to the entire event fee. If you don't cancel and don't attend, you are still responsible for payment.
Substitutions can be made at any time.

Signature:

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Please fax/email the signed form OR your company's purchase order to:

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