This webinar brought to you by the Relion® product family

Advanced protection and control from ABB

Relion. Thinking beyond the box.

Designed to seamlessly consolidate functions, Relion relays are smarter, more flexible and more adaptable. Easy to integrate and with an extensive function library, the Relion family of protection and control delivers advanced functionality and improved performance.

ABB Protective Relay School Webinar Series

Disclaimer

ABB is pleased to provide you with technical information regarding protective relays. The material included is not intended to be a complete presentation of all potential problems and solutions related to this topic. The content is generic and may not be applicable for circumstances or equipment at any specific facility. By participating in ABB's web-based Protective Relay School, you agree that ABB is providing this information to you on an informational basis only and makes no warranties, representations or guarantees as to the efficacy or commercial utility of the information for any specific application or purpose, and ABB is not responsible for any action taken in reliance on the information contained herein. ABB consultants and service representatives are available to study specific operations and make recommendations on improving safety, efficiency and profitability. Contact an ABB sales representative for further information.

ABB Protective Relay School Webinar Series

Overview of IEC 61850

Howard Self

October 8, 2015

Presenter
Howard Self, P.E.

Howard is a 1987 Graduate of Clemson University, where he received his Bachelors of Science in Electrical Engineering. He has over 28 years experience in protection, control and automation in utility transmission and distribution systems.

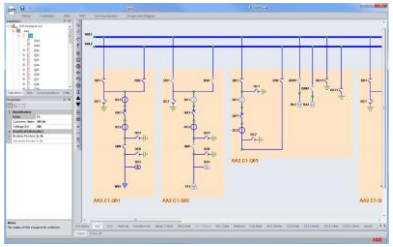
He spent his first 12 years of his career as a Substation Relay, Protection and Control Engineer for Santee Cooper. Howard was involved in Engineering, Operations, maintenance and Design of Transmission, Distribution, and Generation substations while there. Howard has worked the next 15 years as both an Engineering Manager for Substation Automation Systems and Product Manager for Transmission and Distribution Automation Products.

Howard has experience in delivery of systems using both DNP and IEC61850. He has been active in CUEPRA, IEEE, UCA, and DNP users groups.. Howard is presently a member of SGIP.

Howard joined ABB in 2011. He is currently the Program Manager for ABB's Distribution Automation Smart Grid Center of Excellence. Howard is responsible for helping close the product gaps through R&D and product development in ABB's DA Smart Grid Portfolio,as well as, leading the NAM Distribution Automation Verification Center(DAVC).

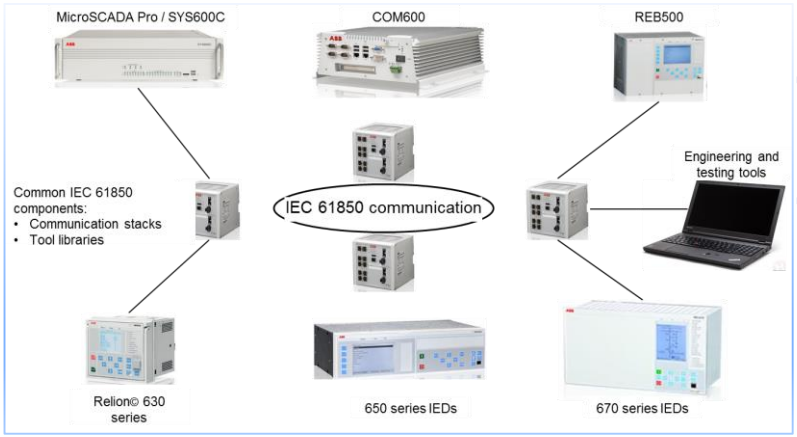
ABB Protective Relay School Webinar Series
Contents

IEC 61850 in ABB Products
ABB IEC 61850 System Solutions



- ABB IED products offer native IEC 61850 features with high performance functionality
- Since 2005, ABB has been delivering products with IEC 61850 as a standard
- ABB has products and solutions to accommodate from small to very large Substation Automation IEC 61850 systems
  - Relion© IEDs
  - Remote I/O RIO600
  - MicroSCADA, RTU560, COM600, 800xA
- ABB IEC 61850 tools:
  - One common IED tool, PCM600
  - IET600, system configuration tool
  - ITT600, testing tool

IEC 61850 in DA Products
ABB Native IEC 61850 Solution

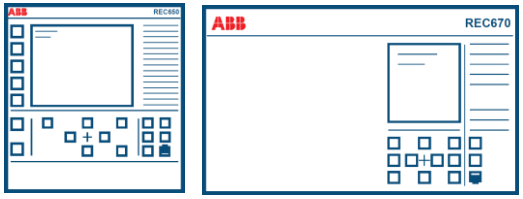


Supported ABB Solutions

- MicroSCADA Pro SYS600
- RTU560
- Grid Automation controller COM600
- System 800xA

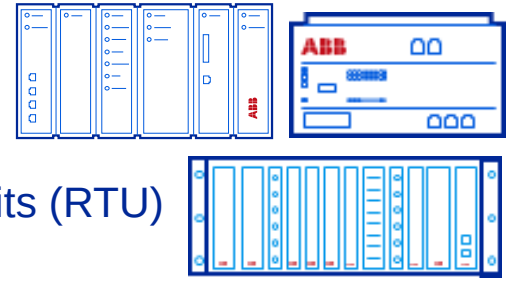
- **The ABB products constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems**
- **The native IEC 61850 support offer**:
  - High communication performance
  - Continuous supervision of the integrity of the protection and communication system
  - Integration to 3rd party systems with standard application modeling
- **ABB's Connectivity Package concept enables**:
  - Streamlining of the IEC 61850 system engineering and IED configuration
  - Enables easy integration with RTU560, COM600 and MicroSCADA Pro
  - Helps automating the engineering part, e.g. event lists and single line diagram
  - Shortens the system engineering time

Substation Automation Products
Proven reliability across our technology



+250,000

Relion® Series IEDs
Installed Worldwide



+100,000

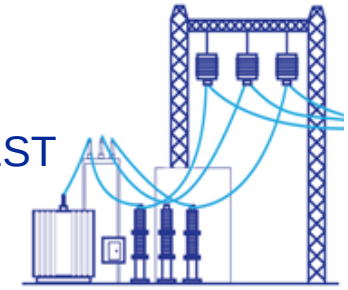
Remote Terminal Units (RTU)
Installed Worldwide

+10,000

MicroSCADA Pro Licenses
Delivered Worldwide

+8 million

COMBIFLEX/COMBITEST modules
Installed Worldwide



Substation automation
ABBs brief history with IEC61850

1994-2003
- Active IEC work with up to 13 permanent delegates in all key working groups
- Extensive interoperability test amongst key suppliers

2004
- Finalization and release of IEC 61850
- 1st project delivered by ABB, EGL 380kV in Switzerland
- 1st IEC61850-8-1 multi-vendor project world wide

2005
- UCA certification for the ABB System Verification Center

2008
- 1st ABB pilot IEC61850-9-2 process bus installation

2010
- 1st UCA certification for IEC61850-9-2 Merging Unit world wide

2012
- 1st UCA GOOSE performance certificate

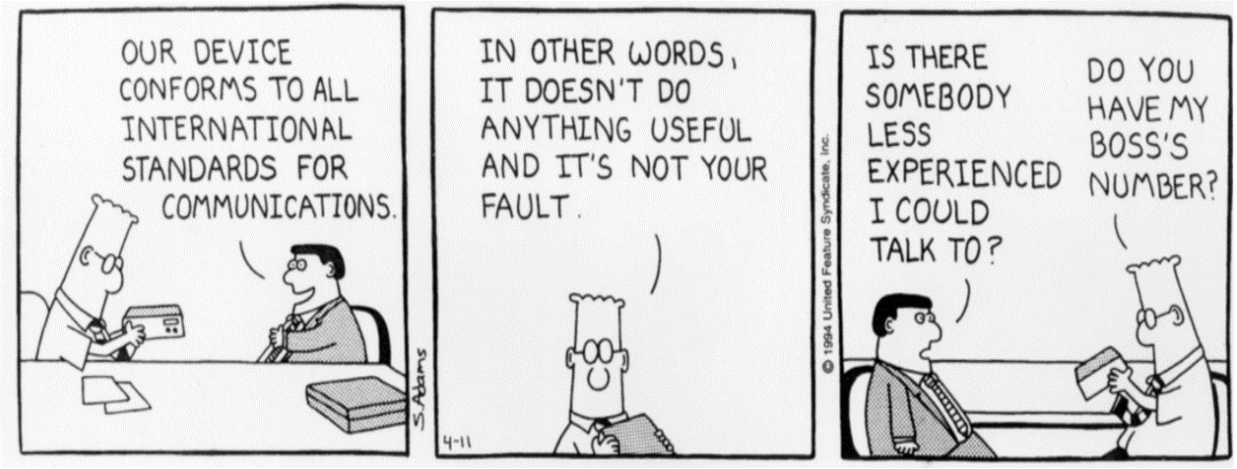
2014
- Globally > 3000 ABB SA Systems Based on IEC 61850 delivered

IEC 61850 Overview

IEC 61850

- The goal of the IEC 61850 series is to provide interoperability between the IEDs from different suppliers or, more precisely, between functions to be performed by systems for power utility automation but residing in equipment (physical devices) from different suppliers.
- Interoperable functions may be those functions that represent interfaces to the process (for example, circuit breakers) or substation automation functions such as protection functions.

61850-7-1 © IEC:2011



A breakthrough for substation automation

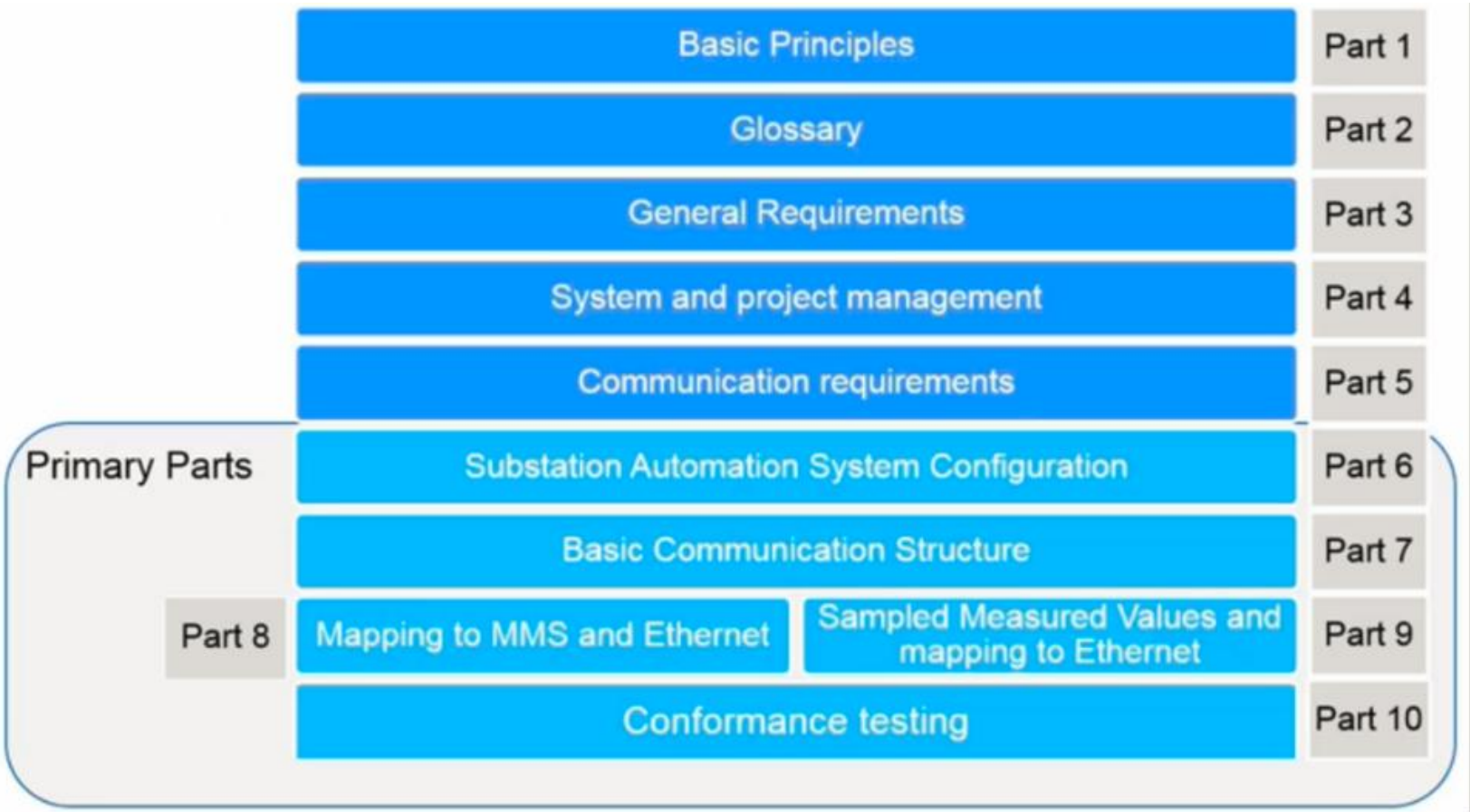
Basics:

- Fast ethernet (100 MBps to 1 GBps)
- Station bus 61850 8-1
- Process bus 61850 9-2
- Data model
- Substation configuration language

Much more than a protocol:

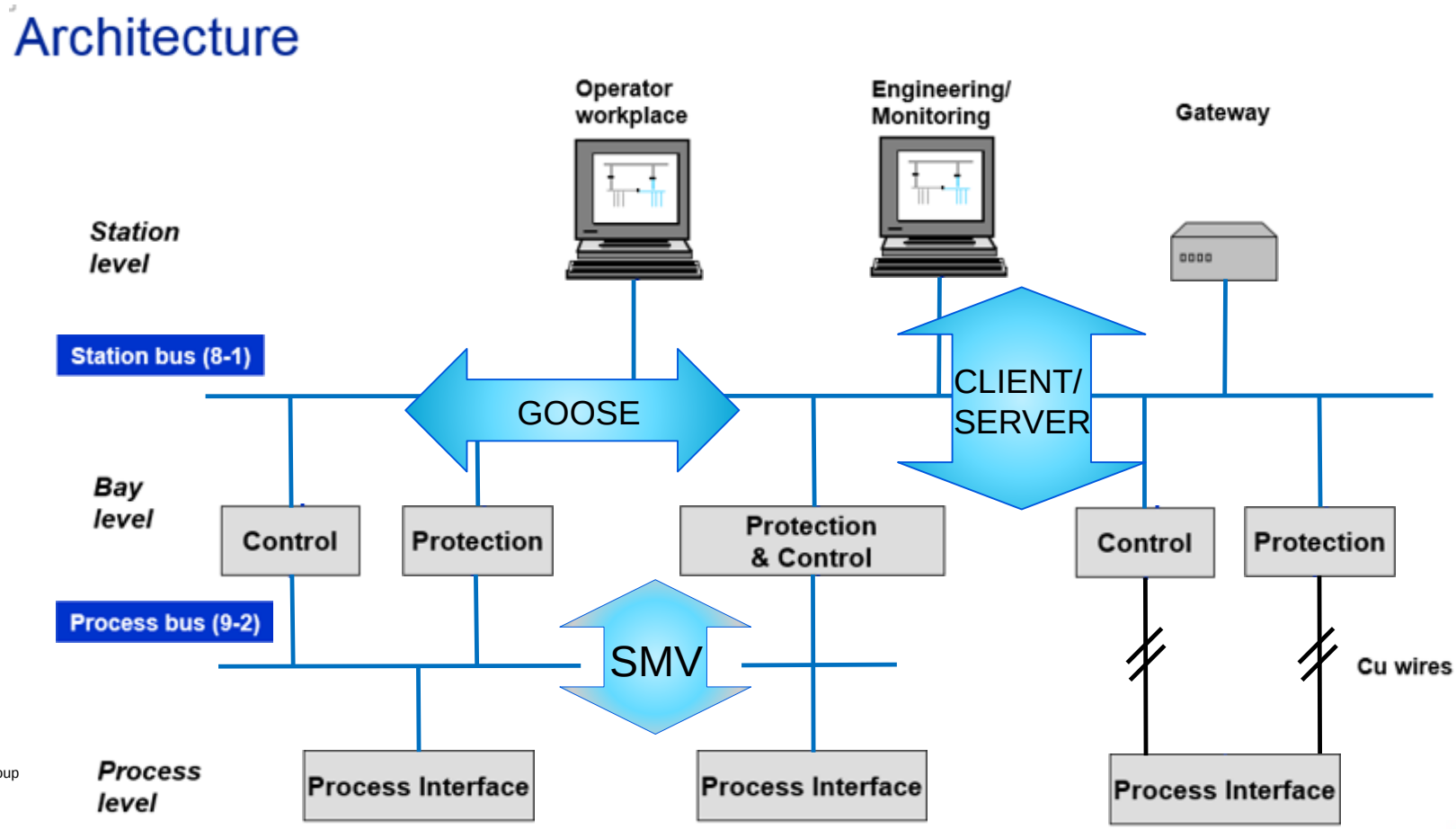
- Modularization and structuring of data
- On-line meaningful information
- Free allocation of functions in IEDs
- Complete description of configuration
- Structured engineering & services
- Testing, validation, and certification

IEC61850 Overview
Structure of Standard

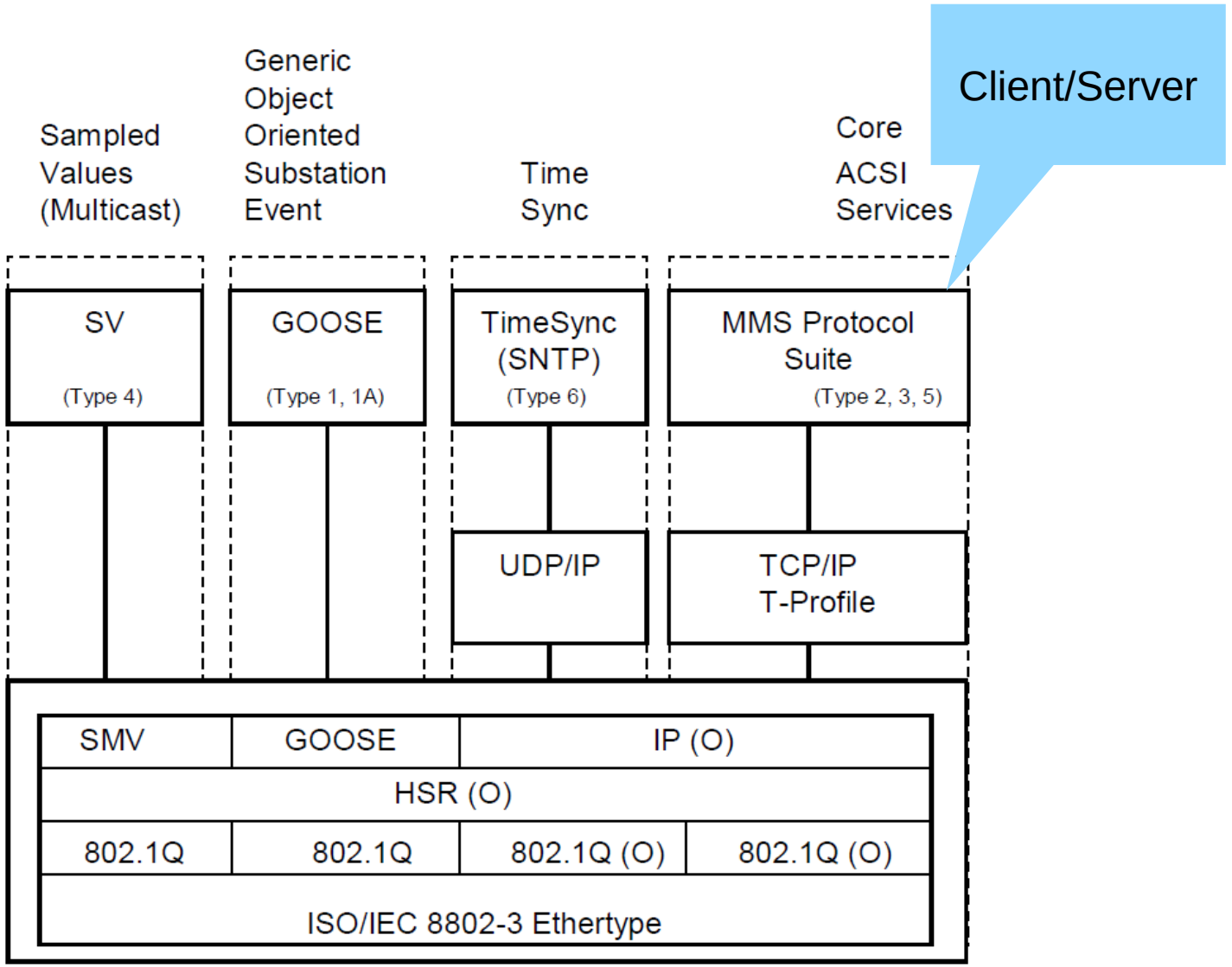


IEC 61850 – What is it?

IEC 61850 is the international standard for substation automation systems. It defines the communication between devices in the substation and the related system requirements.



IEC 61850 Communication Profiles



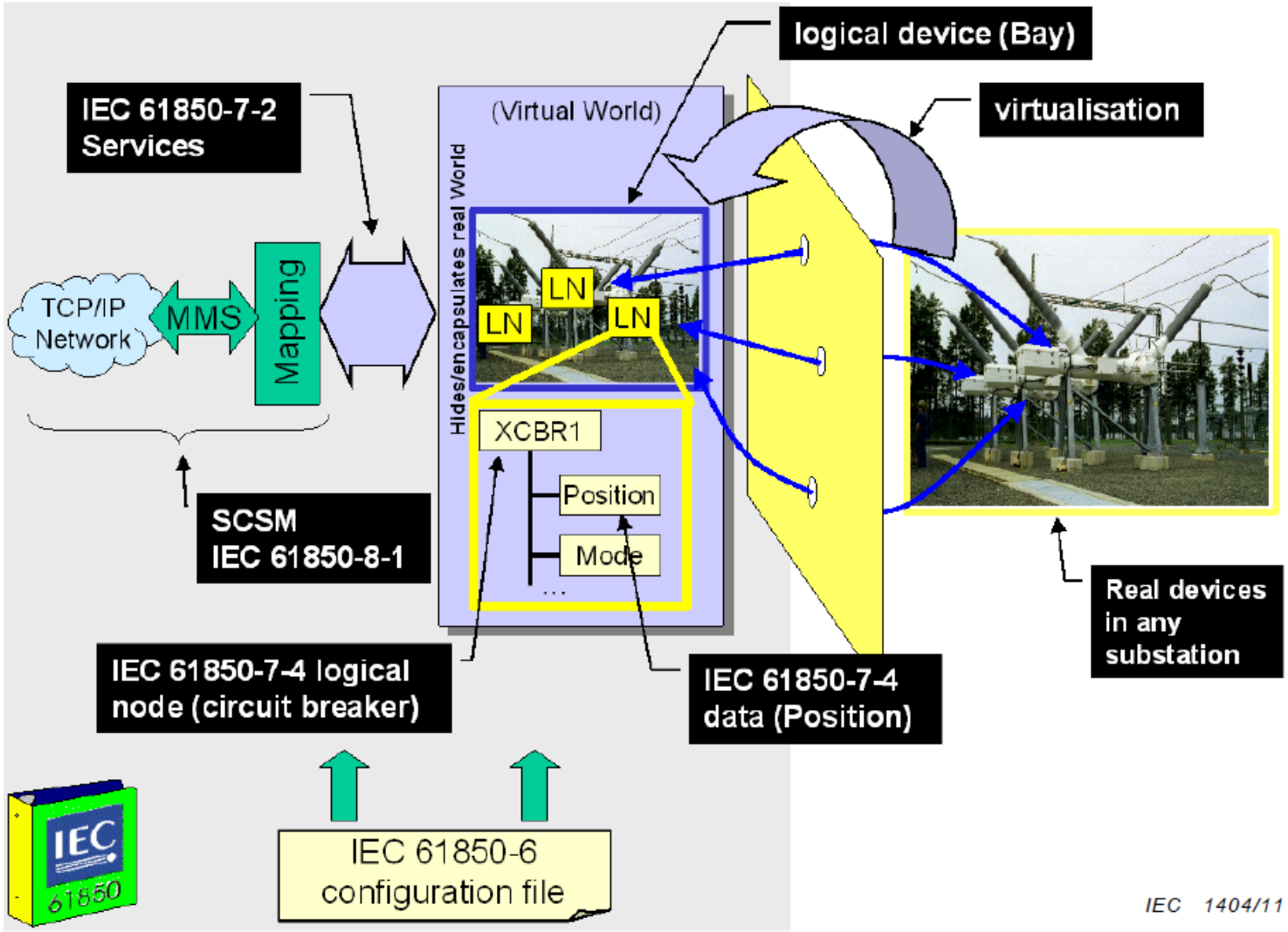
(Type x) is the Message type and performance class defined in IEC 61850-5

IEC 811/11

Figure 1 – Overview of functionality and profiles

IEC61850 Data model

The core of 61850 is the standard representation of functions and equipment, its attributes, and its location within a system



IEC61850 Data model
Logical Node

Table 1 – LN groups

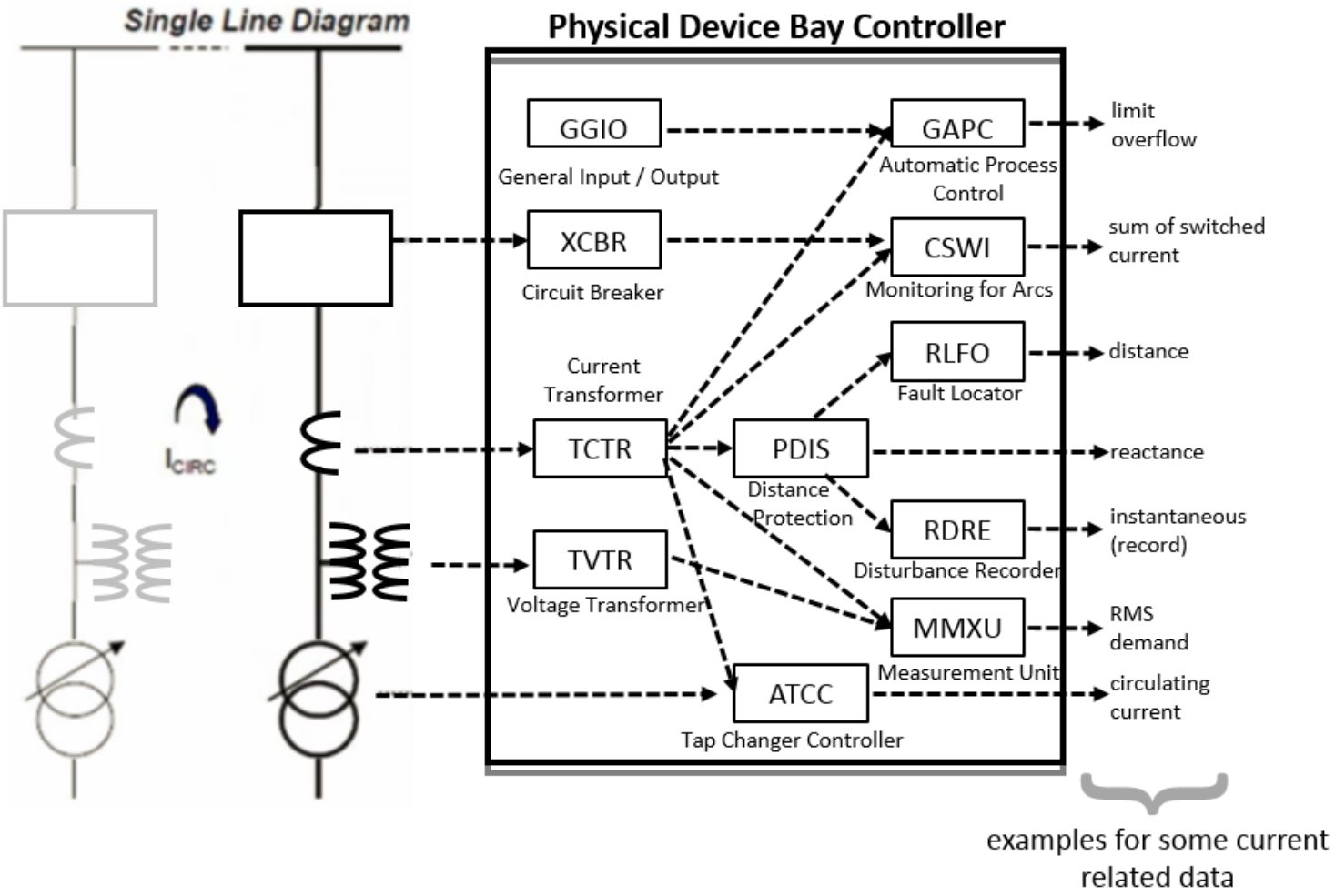
Group indicator	Logical node groups
A	Automatic control
C	Supervisory control
D	DER (Distributed Energy Resources)
F	Functional blocks
G	Generic function references
H	Hydro power
I	Interfacing and archiving
K	Mechanical and non-electrical primary equipment
L	System logical nodes
M	Metering and measurement
P	Protection functions
Q	Power quality events detection related
R	Protection related functions
S	Supervision and monitoring
T	Instrument transformer and sensors
W	Wind power
X	Switchgear
Y	Power transformer and related functions
Z	Further (power system) equipment

MMXU	Three-phase measurement
MMDC	DC-related measurement
MMTR	Three-phase metering
MHAI	Three-phase harmonics and inter-harmonics

PDIR	Directional element
PHAR	Harmonic restraint
PSCH	Protection scheme
PTEF	Transient earth fault
PZSU	Zero speed or underspeed
PDIS	Distance protection
PVPH	Volts per Hz relay
PTUV	Undervoltage
PDOP	Directional over power
…more	

XCBR	Circuit Breaker
XSWI	Circuit Switch

IEC 61850 Overview
Functional Modeling, LN Relations



Substation Information - Typical

IED/Relay

IED Reports information to Master via Polling Methods

Remote Terminal Unit (RTU)

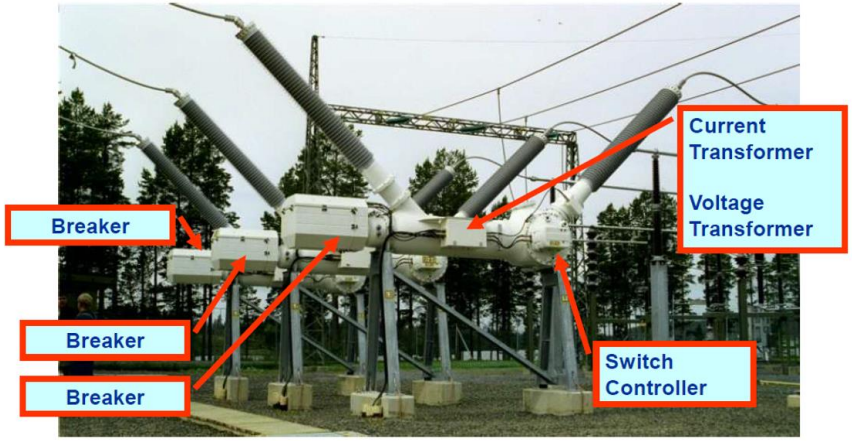
Slave

Master

Data

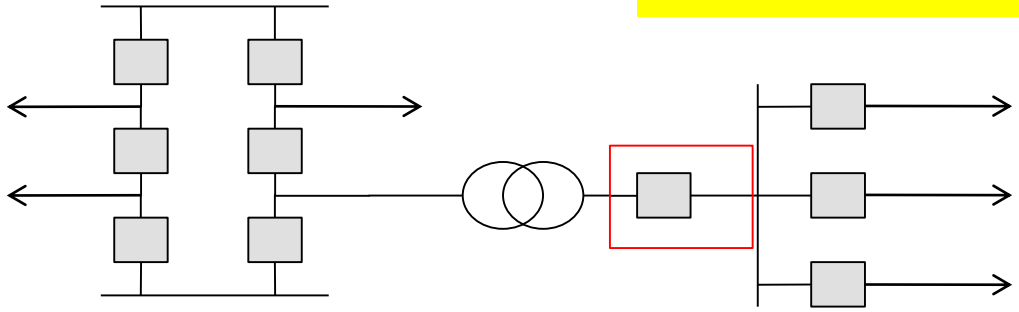
Measurements
- Ia (Amps)
- Va (Volts)
- P (Watts)

Status
- 52a,52b(Pos),50PU,51Trip



Substation Data
DNP Protocol

Function / Equipment	Protocol Specific Addresses
Position of Breaker1	
52A = Device 5,	DNP – Obj. 1, index 0
52B = Device 5,	DNP – Obj. 1, index 1
Breaker1 Current	
PhA = Device 5,	DNP – Obj. 30, index 0
PhB = Device 5,	DNP – Obj. 30, index 1
PhC = Device 5,	DNP – Obj. 30, index 2
Breaker 1 51P and 50P targets	
51P = Device 5,	DNP – Obj. 1, index 35
50P = Device 5,	DNP – Obj. 1, index 36



IEC61850 Standard
Use of a Standard Data Model

Function / Equipment

Position of Breaker1

52A = Device 5,

52B = Device 5,

Breaker1 Current

PhA = Device 5,

PhB = Device 5,

PhC = Device 5,

Breaker 1 51P and 50P targets

51P = Device 5,

50P = Device 5,

Logical Node

Breaker = XCBR

Position = XCBR.Pos.stVal

Measurements = MMXU

Current PhA = MMXU.A.phsA

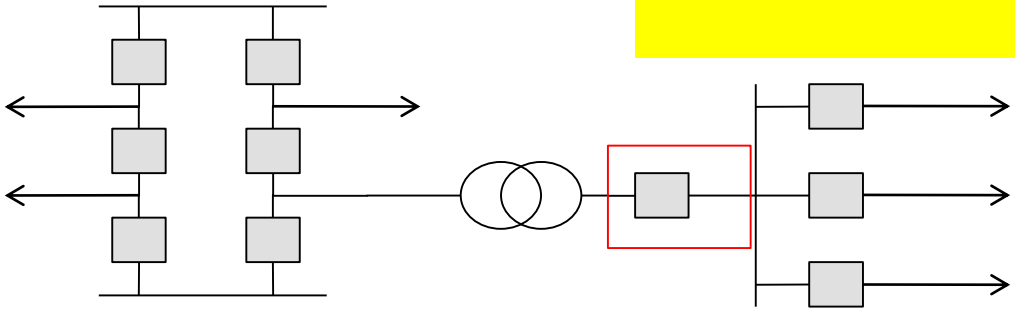
Current PhB = MMXU.A.phsB

Current PhC = MMXU.A.phsC

51P Target

51P = PTOC.Op.general

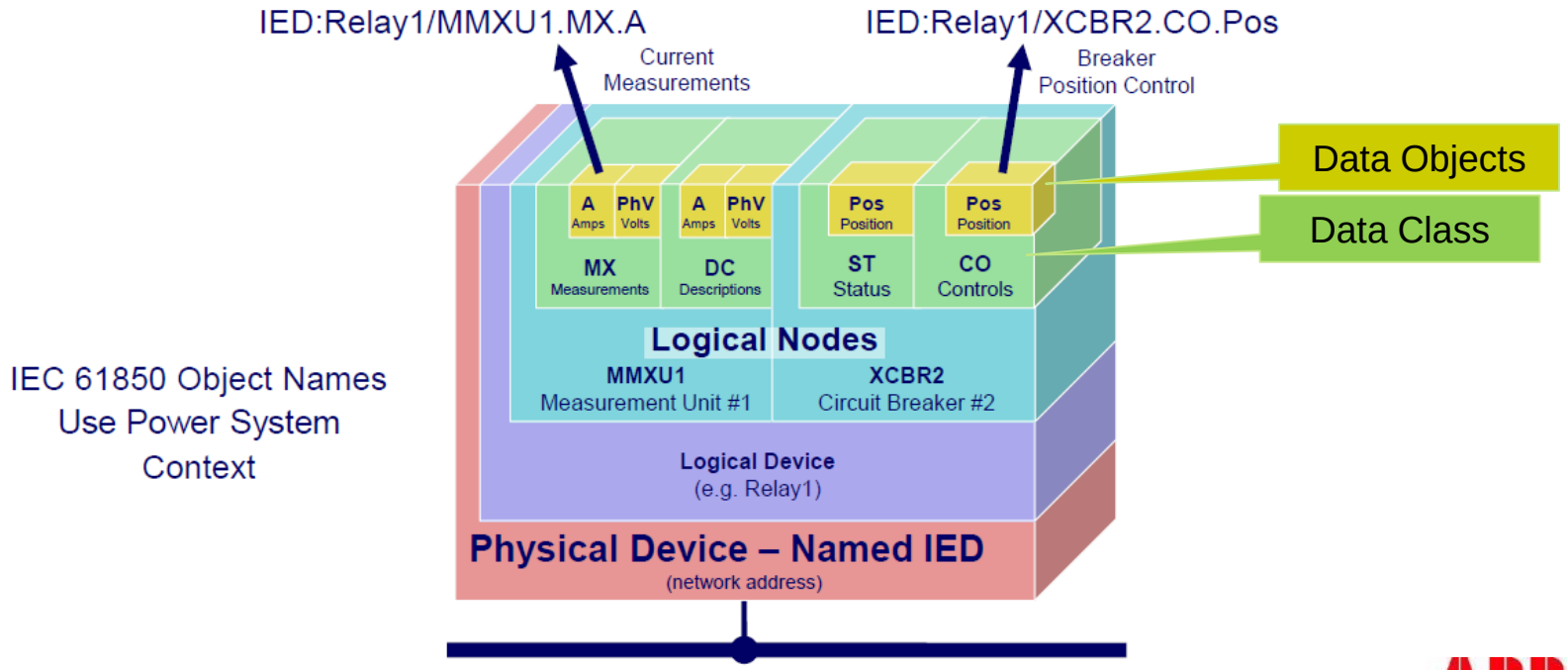
50P = PIOC.Op.general



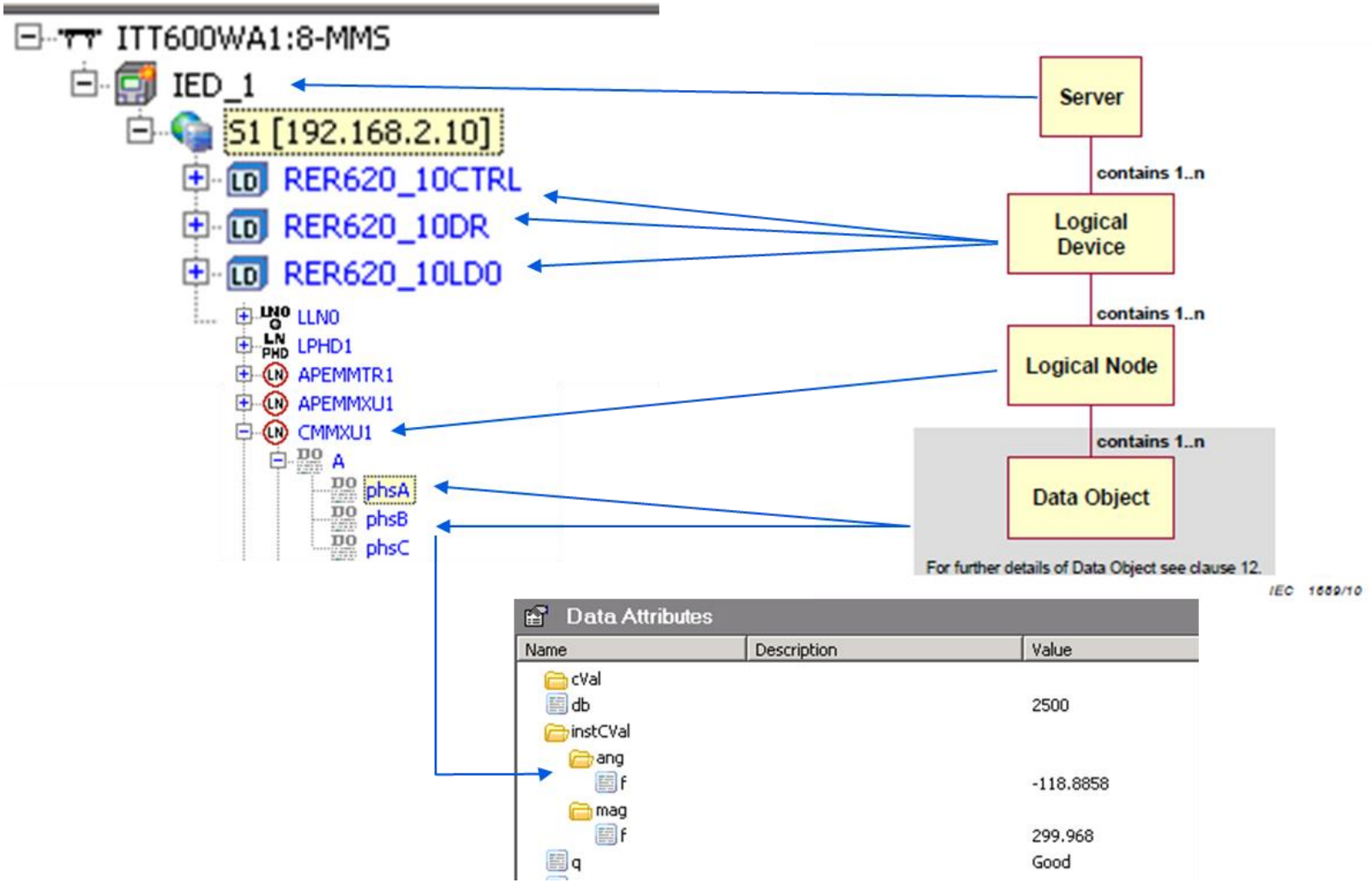
IEC61850 Data model
Logical Node(LN)

- A named grouping of data and associated services that is logically related to some power system function
- Consists of one or more attributes each of a type defined by a Common Data Class (CDC)

IEC61850 Object Model



IEC 61850
Expanding the Data Model - Example



IEC 61850 Client/Server

Report information from IED to master

Server

Client

Data

Measurements
- Ia (Amps)
- Va (Volts)
- P (Watts)

Status
- 52a,52b(Pos),50PU,51Trip

Named and Grouped

Data Sets

Organizes the Data into Groups

ICD

Reporting Parameters

Report Control Blocks

Allows reporting data for changes in: data, quality, etc.

IEC 61850 Client/Server

IED/Relay

Server

Data placed into data sets which are then associated with Report Control Blocks (RCBs)

Remote Terminal Unit (RTU)

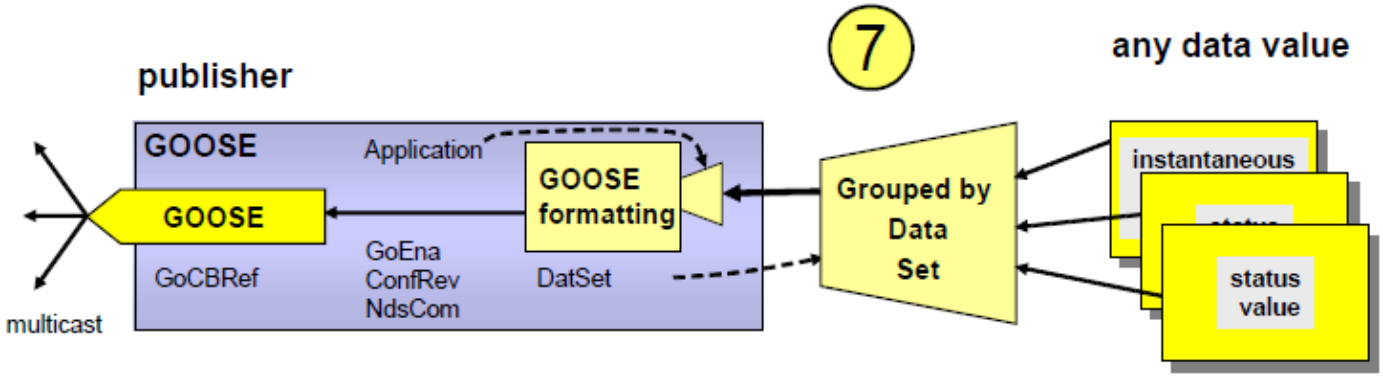
Client

3 steps for the client

1. Connect to server
2. Enable the RCB
3. Receive the data

What is a GOOSE message?

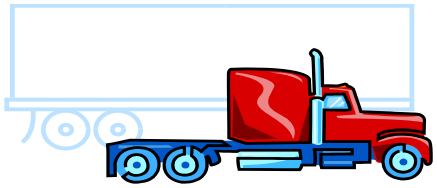
- Generic Object Oriented Substation Event
- Fast and reliable distribution of information
  - Status (breaker position, trip, pickup, alarms, etc.)
  - Analog (counter values, etc.)
- Performance
  - Fast messages Type 1A (Class P2/P3) received within 3ms.
  - This includes transmission time into the other IEDs (similar to an output to input connection between 2 relays)



What is a GOOSE message?

- GOOSE messages are based on change event
- GOOSE messages include diagnostic functions (a “heart beat” to all devices subscribed is sent periodically)
- GOOSE messages are managed by GCBs (GOOSE control block) inside IEDs
- GOOSE messages send “Data Sets” upon changes of state

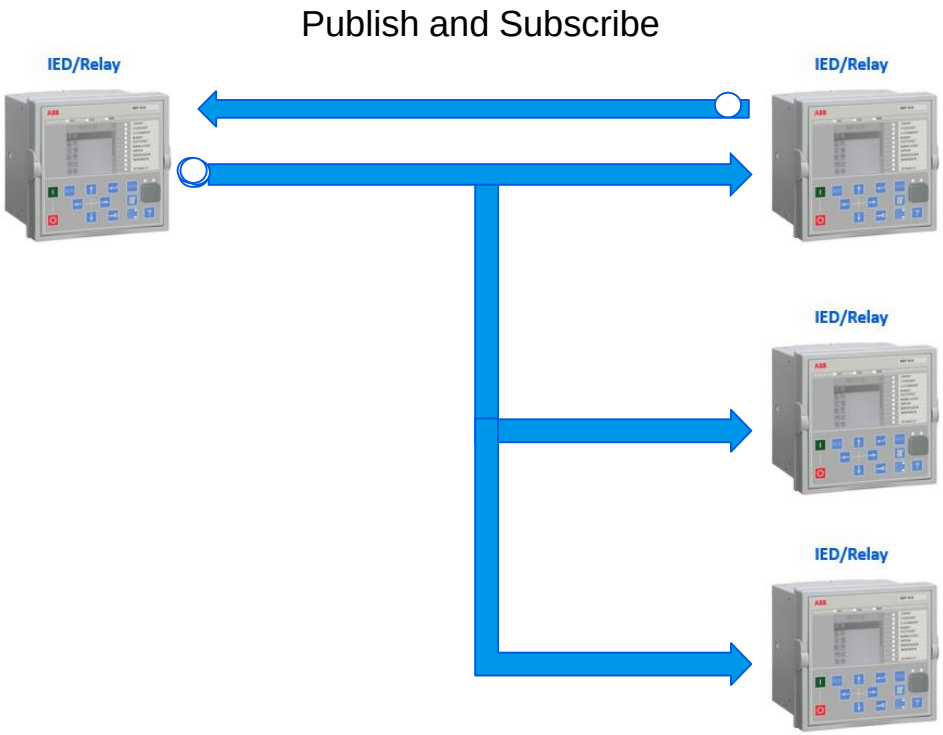
Data set



GCB

Network

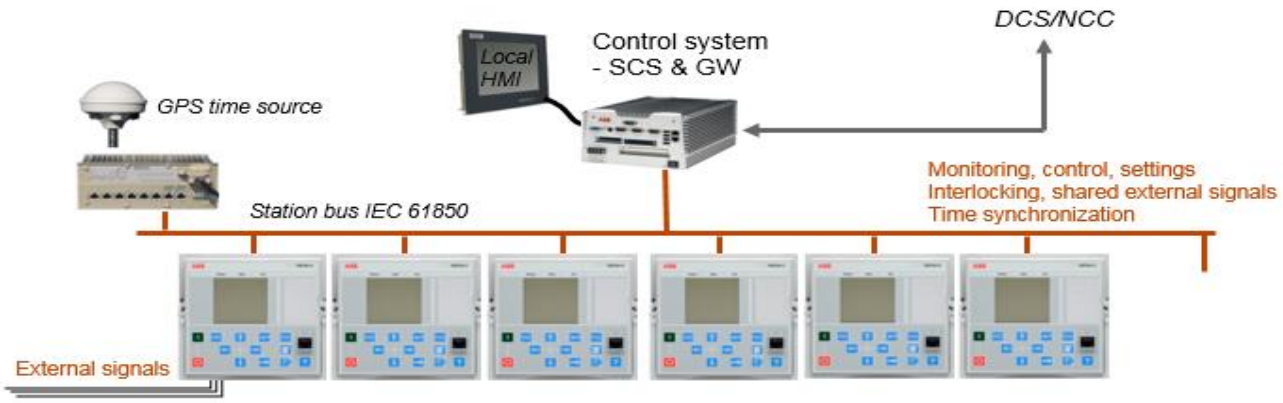
Multicast goose messaging



Protection and control applications
What can we do with GOOSE?

Inside the substation

- Breaker failure protection
- Station arc flash protection
- Blocking based bus protection
- Loss or source – high speed transfer
- Load shedding
  - Analog GOOSE inputs
  - Binary GOOSE outputs



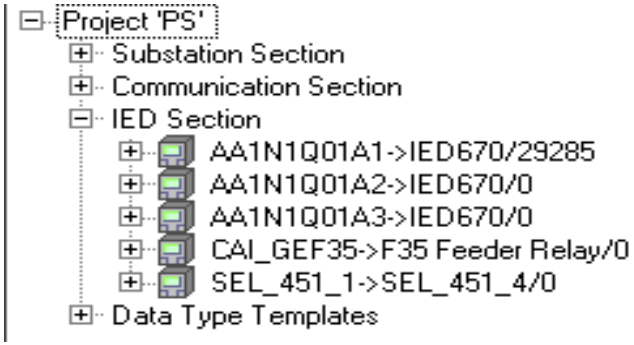
- Inter-bay signals using IEC 61850 and GOOSE
- SNTP time synchronization utilising station communication

Horizontal GOOSE communication
Benefits

- Automatically supervised connections
  - Connection failures are always detected
  - Data quality sent to peer IEDs along with event to enable data validation
- More I/O without hardware changes or additions
- Performance
- The standard includes a concept for signal testing
- Expandability
  - IED retrofit installations with just small wiring changes
  - New functionality can be introduced
- Flexibility
  - Possibility to easily add functionality afterwards
  - IEDs can share unused I/O
- Reduces wiring between IEDs

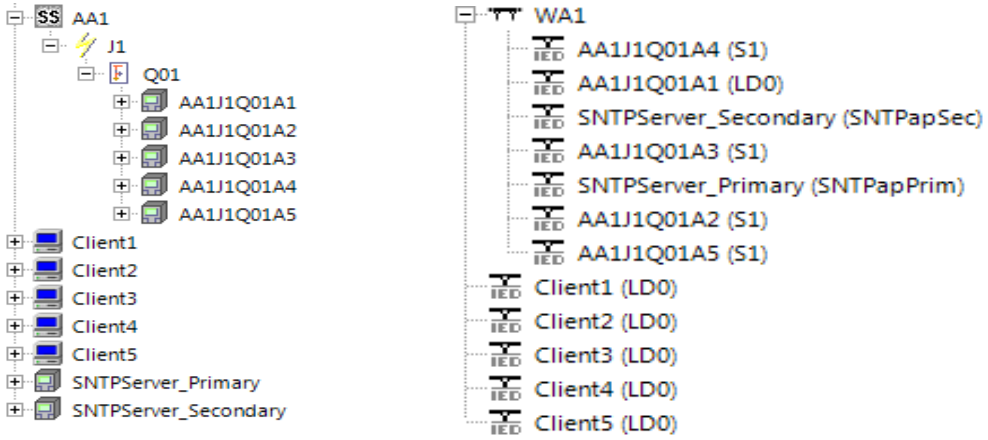
SCL and modeling in 61850

- 61850 defines a common language where all compliant manufacturers can exchange information regarding the “functions” (Logical Nodes) and related data available inside their equipment.
- Substation Configuration Language
- Offers 4 file formats (Ed. 1)(SCL)
  - SSD: Substation Specification Description
  - ICD: IED Capabilities Description
  - CID: Configured IED Description
  - SCD: Substation Configuration Description



SCL and modeling in 61850

- Documenting complete projects in SCD file
  - IEDs and their connection to the application
  - Functions and their connection to the application
  - Communication network
  - Connections between IEDs
  - Reporting mechanism

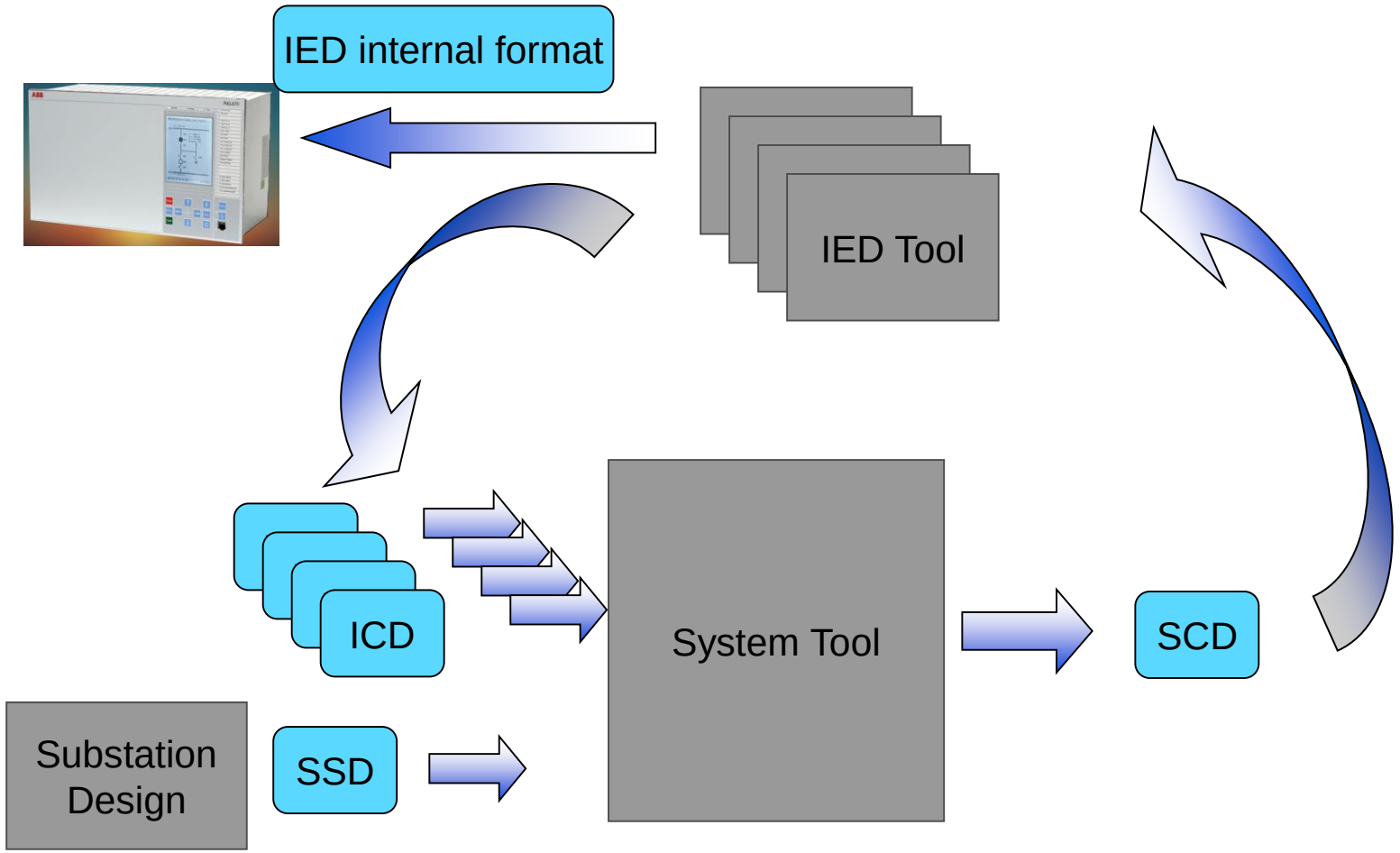


Engineering with SCL

System tool approach

- Thanks to common file format engineering of the SAS system can be performed under a single tool
- This provides a single point of interaction with the configuration files of all devices regardless of manufacturer
- End result (SCD file) must be part of the final system documentation just like DC and AC elementary are

Engineering



IEC 61850 Edition 2

IEC 61850 Edition 2
Why Edition 2 is required

- Remedying various shortcomings identified during first installations
- Enhance the applications range / new applications
  - Automation of wind power systems, Hydro power systems
  - Distributed energy resources, Combined heating and power systems
  - Photovoltaic plants
- Beyond the switch yard
  - Communication between substations
  - Communication between substations and network control centers
- Remaining challenges from Edition 1
- Complete process bus between primary and secondary equipment (analog samples and switch positions and commands)

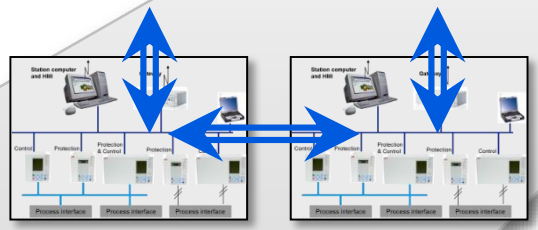
IEC 61850 Edition 2
The standard continues...

IEC 61850 Edition 1
From proprietary protocols towards a global communication standard **for substation automation**

Data model for water and wind application

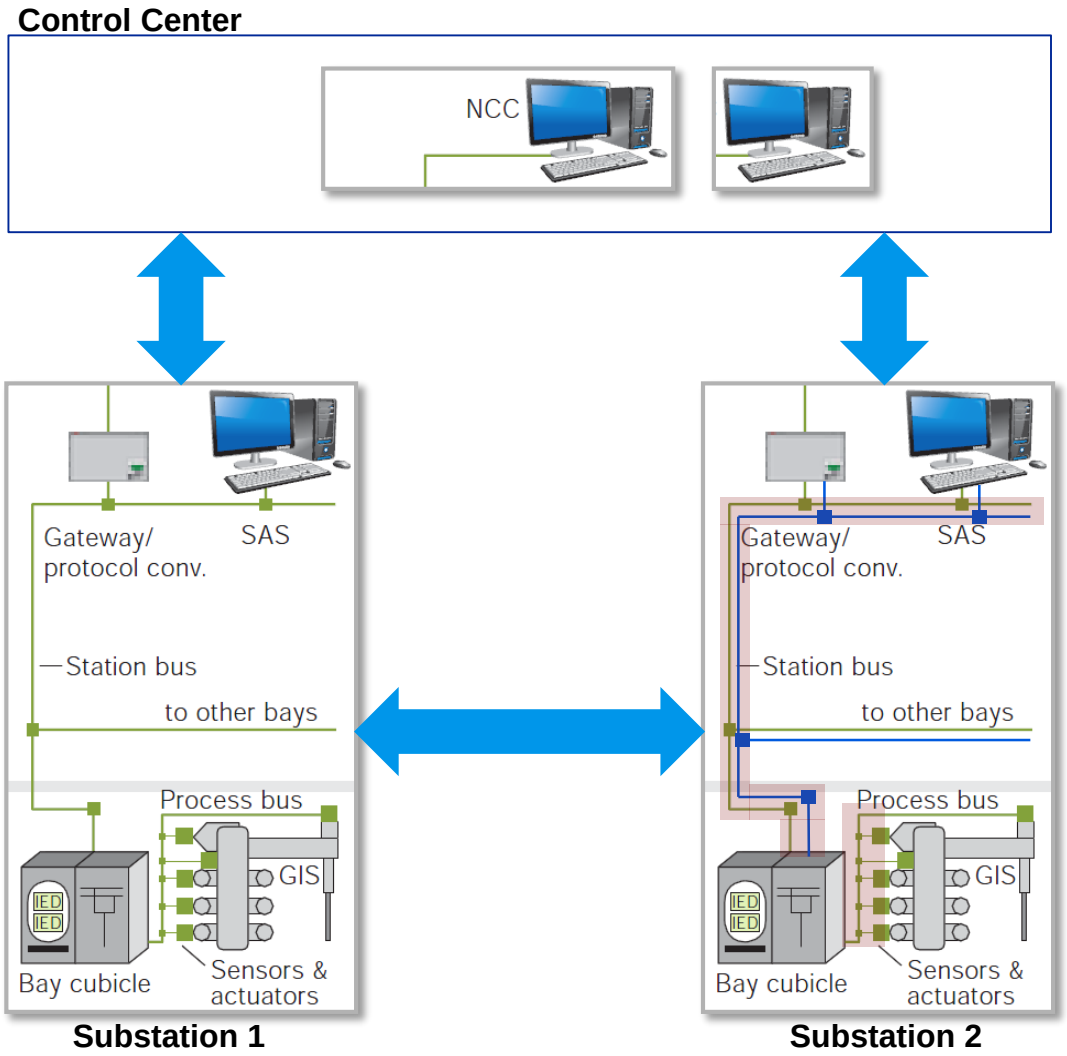
IEC 61850 Edition 2
A broad, encompassing standard for communication networks and systems **beyond substation automation**

TODAY



Many new Extensions in work for additional (smart grid) applications

IEC 61850 Edition 2
Solidify existing parts, extension for new applications



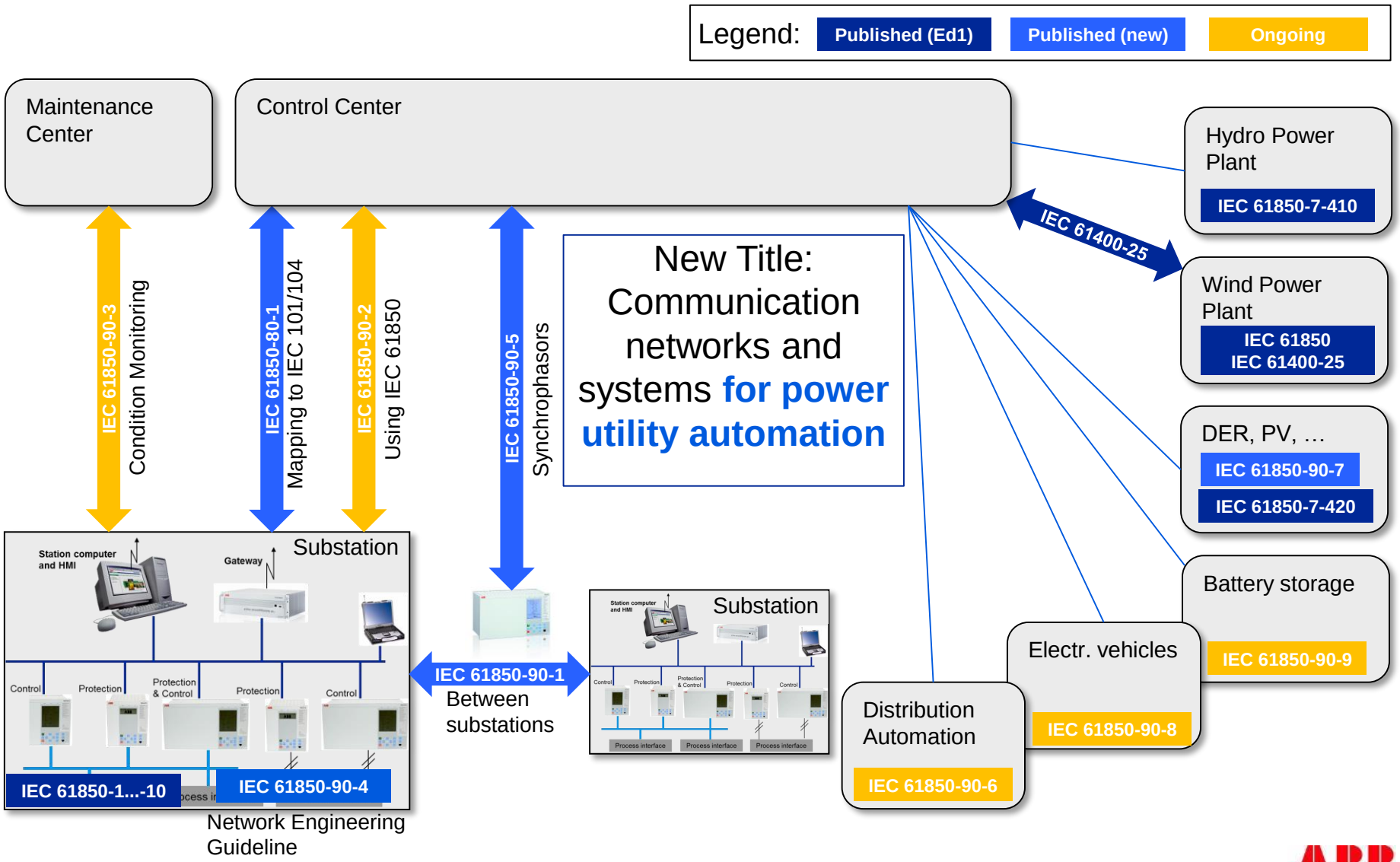
Improve interoperability
- Error corrections
- Compatibility of Edition 1 and Edition 2
- IED and system tools conformance statement

Increase system availability
- Bumpless link redundancy for end devices
- No single point of failure

Communication beyond substation
- Substation to substation
- Substation to control center (not released yet)

More flexible engineering process
- Top down ,Bottom up, modifications
- Multiple projects
- Substation to substation

IEC 61850 Edition 2
Scope mapped to system architecture



IEC 61850 Edition 2
Overview of new main features

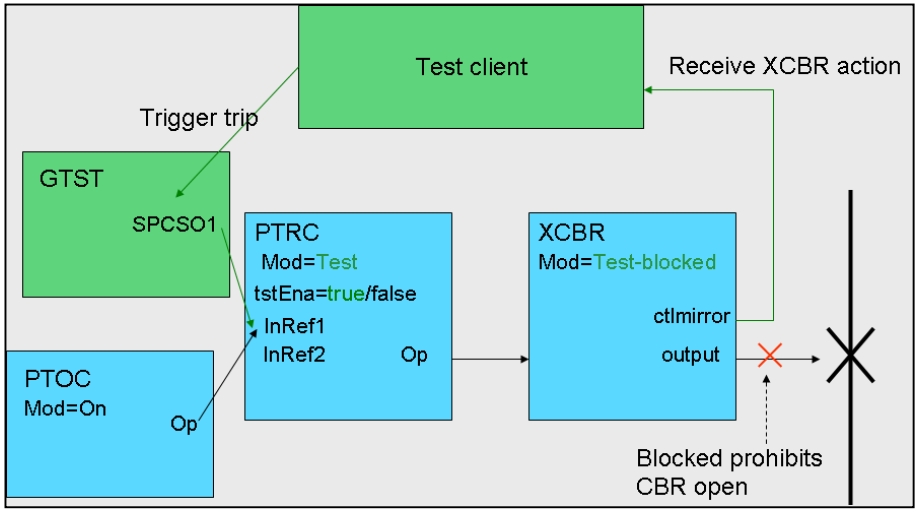
Feature	Benefit	Impact	m/o
Correction of errors and many small details	Ensure interoperabilty	Mainly on tools	M
Data model extension	Modeling for hydro, wind, DER and power quality	IEDs (servers and clients)	O
Longer LD names / prefixes	Object names extended from 64 to 128 characters	IEDs, Tools (IED and system)	M
SCL extension	Allow bottom-up system design and multiple projects	Tools (IED and system)	O
SCL implementation conformance statement SICS	Clarity on tool capability	Tools (IED and system)	M
Parameter and configuration Data revision and value change	Better version handling and reporting	IEDs (servers)	O
Defined named enumarations distinct from countable integers	Easier understandable, no interpretation needed	Clients, Tools (IED and system)	M
Link redundancy	Higher availability and interoperable solutions	IEDs (servers and clients)	O
Mechanisms for testing, simulation, maintenance	Support for efficient and automatic ‘in system’ testing	IEDs	O

IEC 61850 Edition 2 – New features
Data model extension

Group Indicator	Logical Nodes Group
A	Automatic control
C	Control
D	Distributed Energy Resources (DER)
F	Functional Blocks
G	Generic
H	Hydro
I	Interfacing and archiving
K	Mechanical and non-electrical primary equipment
L	System LN
M	Metering and measurement
P	Protection
Q	PQ events detection related
R	Protection related
S	Sensor and monitoring
T	Instrument transformers
X	Switchgear
Y	Power transformers
Z	Further power system equipment

- Logical nodes
  - Edition 1: Approx. 90
  - Edition 2: More than 150
- New LN groups
  - F Group: FCNT: Counter, FPID: PID regulator, FSPT: Set-point control function, …
  - K Group: KFAN: Fan, KFIL: Filter, KPMP: Pump, …
  - Q Group: QVVR: Voltage Variation, QFVR: Frequency Variation, QVTR Voltage Transient, …
- Other new LN:
  - LTRK: Service tracking, …

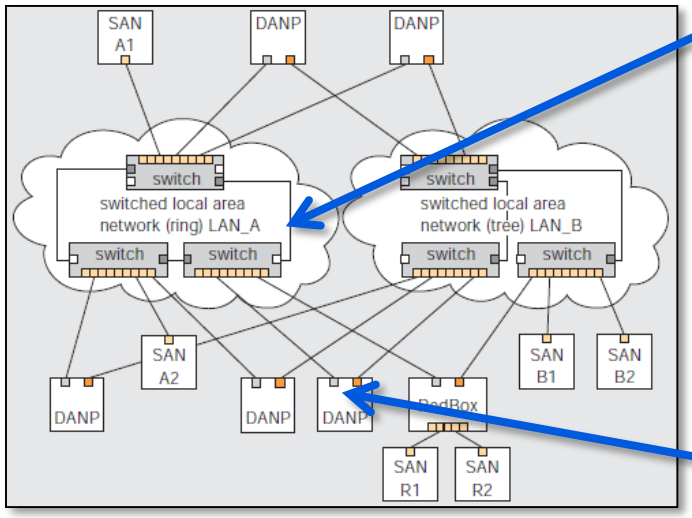
IEC 61850 Edition 2 – New features
Mechanisms for testing, simulation, maintenance

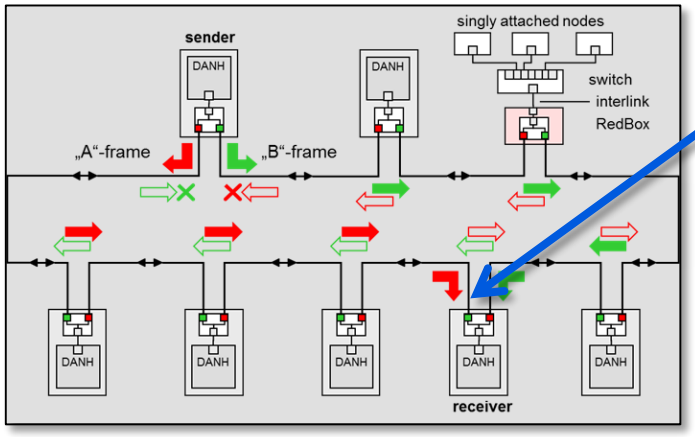


- New data objects and concepts for testing
  - Testing of function parts in the running system
  - Allows a standardized application of the test and test-blocked mode
- Enables more efficient testing and maintenance

Easier testing and maintenance

IEC 61850 Edition 2 – New features
Link Redundancy





- Redundancy within the network
  - **RSTP**, IEEE 802.1D
  - (n-1) criteria
  - With recovery time upon failure
- Redundancy in the end nodes
  - **PRP**, IEC 62439-3 Parallel Redundancy Protocol
  - **HSR**, IEC 62439-3 High-available Seamless Redundancy
  - (n-1) criteria
  - Zero recovery time upon failure

PRP/HSR is a patent of ABB Corporate Research. ABB has assured the IED to provide licenses throughout the world free of charge under reasonable and non-discriminatory terms.

Recovery delay demands as shown in IEC 61850-5

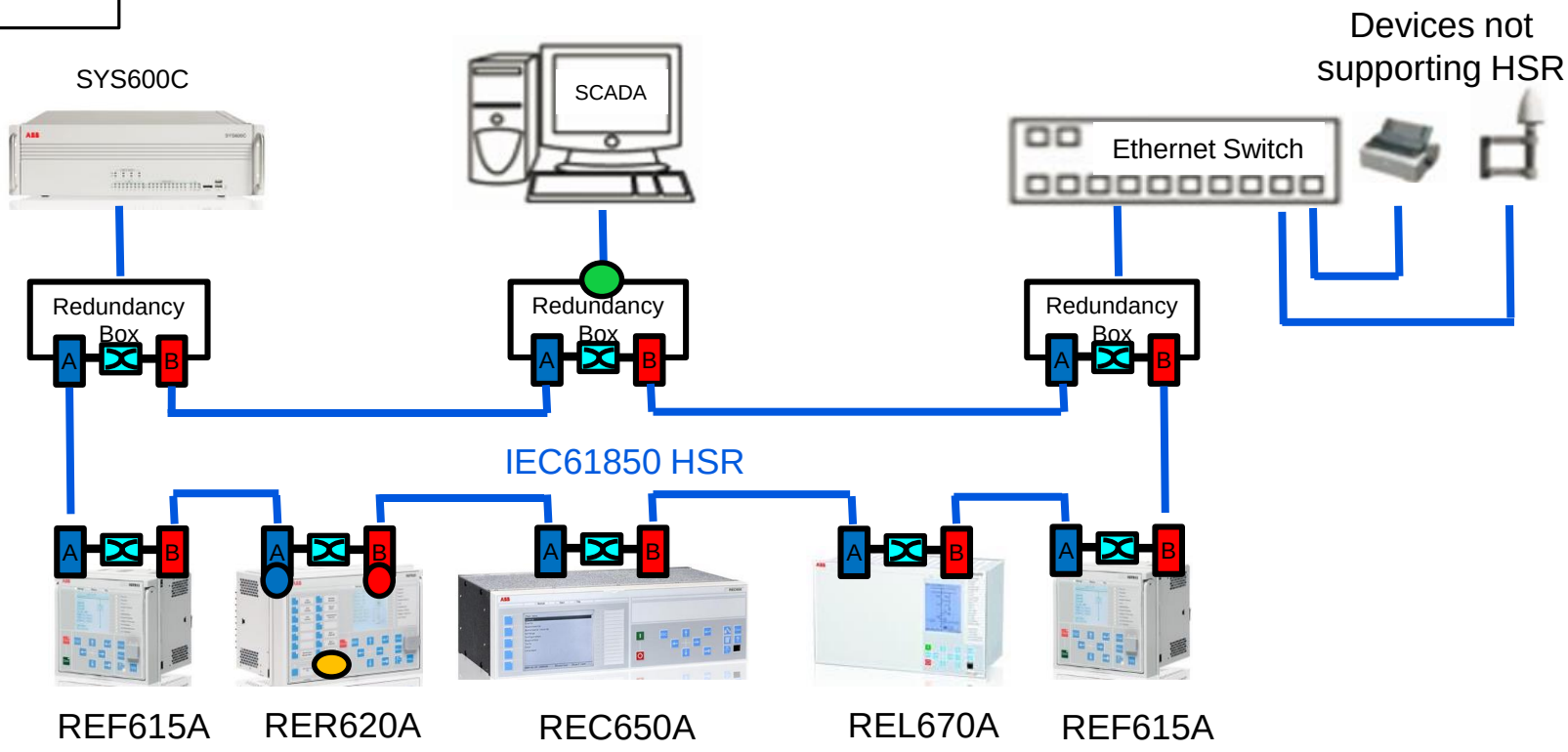
Communicating partners	Service	Application recovery tolerated delay	Required Communication Recovery Time
SCADA to IED, client-server	IEC 61850-8-1	800 ms	400 ms
IED to IED interlocking	IEC 61850-8-1	12 ms (with Tmin set to 4 ms)	4 ms
IED to IED, reverse blocking	IEC 61850-8-1	12 ms (with Tmin set to 4 ms)	4 ms
Protection trip excluding Bus Bar protection	IEC 61850-8-1	8 ms	4 ms
Busbar protection	IEC 61850-9-2 on station bus	< 1 ms	Bumpless
Sampled Values	IEC 61850-9-2 on process bus	Less than two consecutive samples	Bumpless

To fulfill these requirements, IEC 61850-8-1 and -9-2 uses redundancy solutions standardized for Industrial Ethernet by IEC 62439-3.

HSR
Normal operation

Operation description:

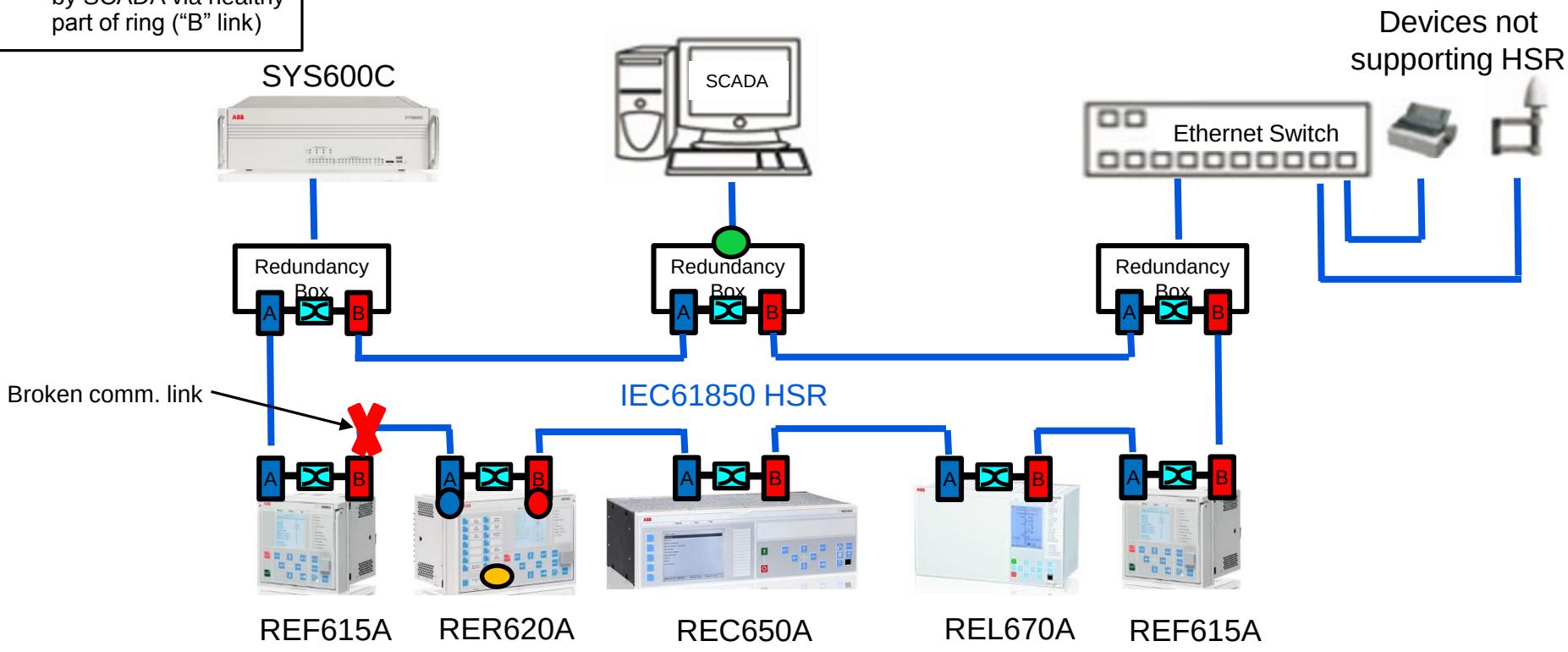
1. Message from IED is sent via both links (“A” and “B”) to the SCADA via HSR ring



HSR
Operation under failure condition

Operation description:

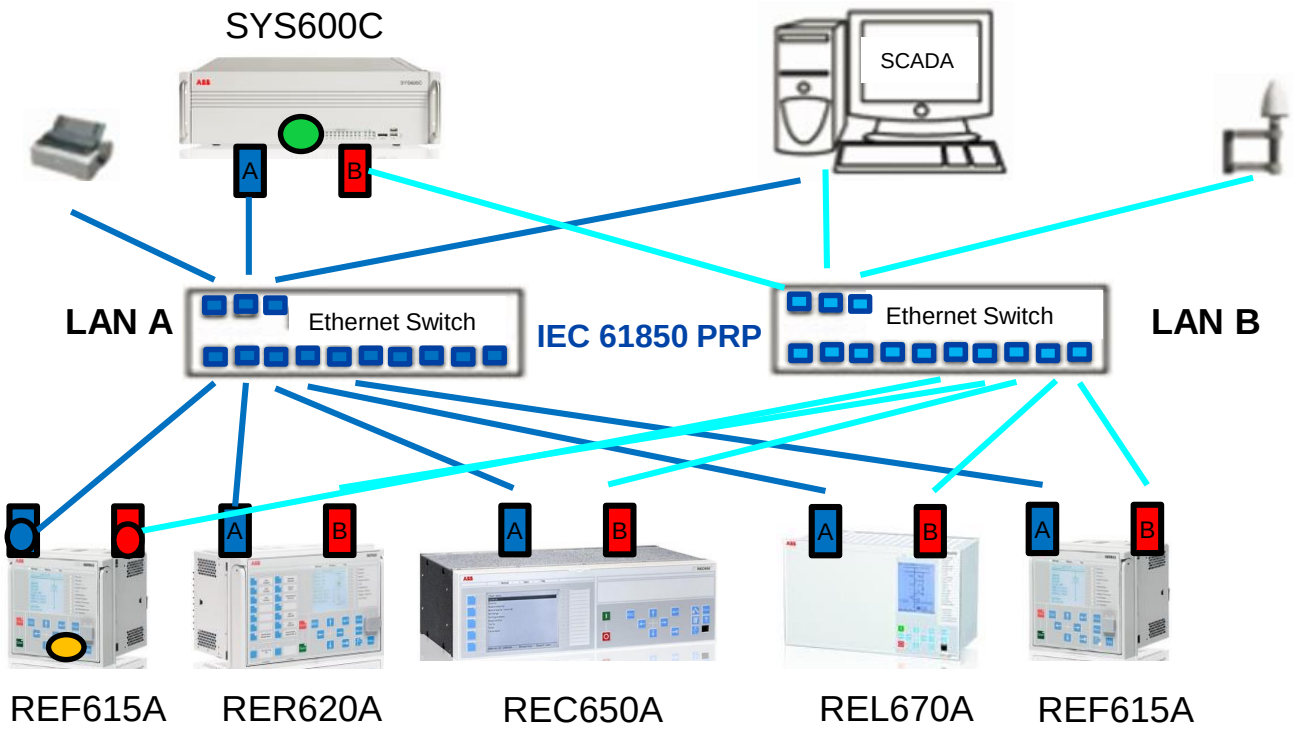
1. Failure recognized in HSR ring (“A” link)
2. Message is received by SCADA via healthy part of ring (“B” link)



PRP
Normal operation

Operation description:

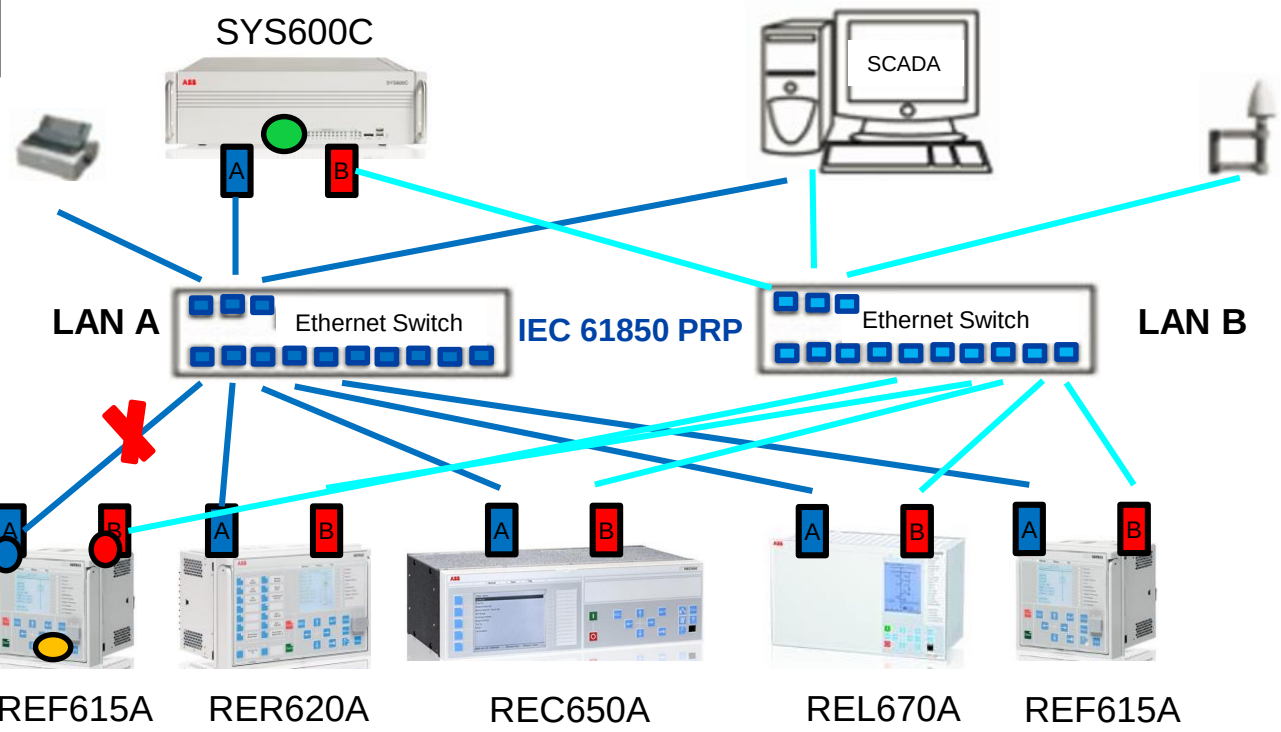
1. Message is received in SYS600C via both parallel links (LAN “A” and LAN “B”



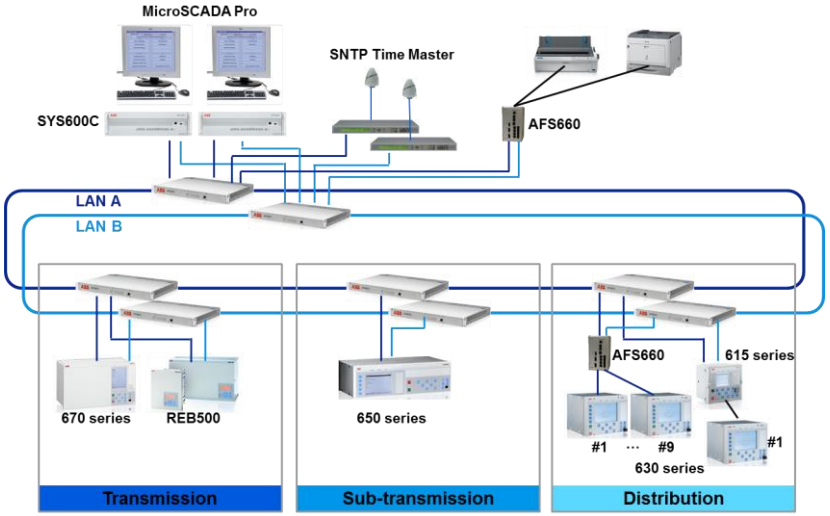
PRP
Operation under failure condition

Operation description:

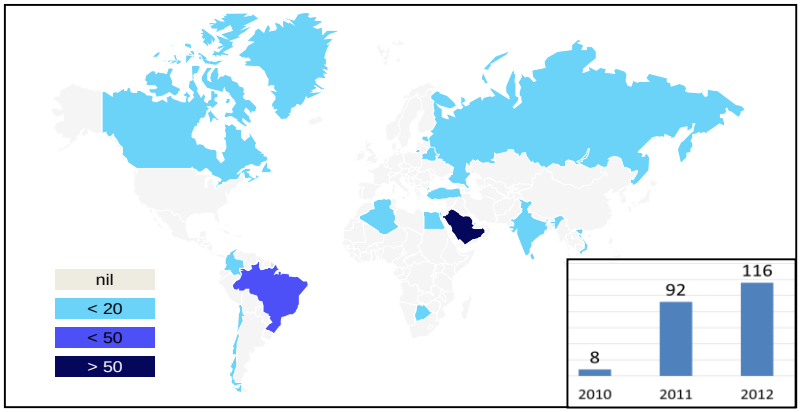
1. Failure recognized in PRP network (LAN “A”)
2. Message is received in SYS600C via healthy link (LAN “B”)



IEC 61850 Edition 2 – New features
Communication – Link redundancy



Delivered MicroSCADA Pro with PRP



- Link redundancy for end devices
  - PRP: Parallel Redundancy Protocol
  - HSR: Highly reliable Seamless Ring
  - Red Box to connect single port IEDs
- Customer Benefits
  - Higher system availability, No single point of failure
  - **Zero** recovery time upon failure
  - Guaranteed interoperability
- ABBs offering (today):
  - SA Solutions and products with PRP
  - Large # of delivered systems, experience

Thank you for your participation

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