Substation automation migration strategies to IEC 61850 using Relion protection and control
The fact that The US National Institute of Standards and Technology (NIST) has advised the Federal Energy Regulatory Commission that it has identified IEC 61850 as one of five “foundational” sets of standards for Smart Grid interoperability and cyber security clearly shows that IEC 61850 is foreseeable in the future of all protection, automation, and control specialists around the world.
How to you get from?
Conventional SA system

Control Center

Station HMI

Interlocking logic

RTU

Hardwired with parallel Copper wires

Relay X1

Relay X2

Conventional Switchgear

Conventional CT / VT's

Relay X1

Relay X2

Conventional Switchgear

Conventional CT / VT's
To This
IEC 61850 station and process communications

- Control Center
- Station HMI
- Ethernet communication:
  - Elimination of wires
  - Access to information
  - Optimized functionality

- Gateway
- Station Ethernet Bus
- Process Bus

- Bay Controller
- Relay X1
- Relay X2
- Intelligent Switchgear
- Non conventional CT/VT
- Bay Controller
- Relay X1
- Relay X2
- Intelligent Switchgear
- Non conventional CT/VT
Let’s look at some 61850 concepts

- Logical node
- Physical Devices
Logical nodes

- IEC 61850 Definitions
  - A **logical node** is the smallest part of a function that exchanges data and represents a function within a physical device
  - A **logical connection** is the communication link between logical nodes
  - **PICOM** is a piece of information for communication describing an information transfer on a given logical connection with given communication attributes between two logical nodes
  - The IEC 61850 logical node, and the communications of data between them, are at the core of interoperability
Physical Devices

- Primary System Devices
  - Circuit breakers
  - Disconnect and grounding switches
  - Power transformers
  - Instrument transformers
  - Generators

- Secondary System Devices
  - Protection
  - Reclosers
  - Annunciators
  - Meters, sensors
  - Fault recorders
  - Control switches and interfaces
  - Etc.
Logical Nodes and Physical Devices

Station/Process Bus

Client Connections

Server

IED

Control Switch

I/O

LD0: Logical Device

CSWI:LN

DO  DO

LN

DO

PDIS:LN

DO  DO

LN

DO

Distance Protection

Client Connections
Logical Node Names

**xxx**XCBR1

- Optional Application Specific Prefix
- Logical Node Instance #
- Logical Node Name per IEC 61850-7-4 (breaker)
Basic Principle
Application Variances (retrofit)

Process Level

Bay Level

hardwired

GGIO1 → TCTR1 → TVTR1 → GXSWI3

GGIO1 → TCTR1 → TVTR1 → GXSWI3

GGIO2 → TCTR1 → TVTR1 → GXSWI3

Merging Unit

XSWI1 → XCBR1 → XSWI2 → GXSWI3

IED(S)
Application Variances (retrofit)

Process Level

- GGI01
- BGGI04
- GGI02
- GGGI03
- Merging Unit

Bay Level

- XSWI1
- XCBR1
- XSWI2
- GXSWI3
- IED(S)

AI Processing

hardwired
Basic line protection functions

- Distance protection
- Tripping in distributed systems
- Differential protection
- Autoreclosing
- Disturbance recording
Distance Protection

Substation A

- Several Distance zones
- PTOC1
- PDIS
- PTOC2
- PSCH1
- PSCH2
- PTRC
- XCBR

Substation B

- PTOC2
- PDIS
- PSCH2
- PSCH1
- PTRC
- XCBR

Communication

Trip conditioning

Tripping
Physical distribution examples

Conventional

Process bus

PISA & Prot. Redundancy
Differential Protection

Substation A

TCTR

MDIF

PDIF

PTRC

XCBR

Determines differences

Triggers trip

Substation B

TCTR

MDIF

PDIF

PTRC

XCBR
Autoreclosure and Control

Conventional

Distributed
Disturbance Recording

*Single Line*

*Logical Device Disturbance Recorder*

- **TCTR**
- **TVTR**
- **CBIO**
- **XCBR**
- **TVTR**
- **LLN0**

- **RADR**
  - N Instances of RADR
- **RDRE**
- **RBDR**
  - M Instances of RBDR

Channel numbers for example 1 \( \ldots \) N for analogue channels

1 LN for Common features and Co-ordination

Channel numbers for example N+1 \( \ldots \) N+M for binary channels
How do these concepts apply to our Relion series relays?
Logical Nodes applied to Relay

The Function Block

IEC 61850
The Function Block

Discrete Function Relay (made smart) + IEC 61850
Basic Function Block Description

- **Function**
  - Tasks or logic performed

- **I/O Connections to other FBs**
  - Analog
  - Binary
  - Data

- **Computation resources**
  - Instance – N\textsuperscript{TH} time used
  - Sequence of execution
  - Computation Interval

- **Background Operations**
  - Settings
Basic Design Process for IED

- Application Function Library
- Application Configuration
  - Combine discrete application functions to meet P&C requirements
- Download IED
- Test configuration
- Create ICD
  - Defines the IED capabilities to the rest of the IEC 61850 substation
- Substation configuration process
Application Configuration

- Virtual Analog Inputs
- Virtual Binary Inputs
- Breaker Control
- 50/51
- OR
- Trip
- Virtual Goos Inputs
- Virtual Goos Outputs
- Logical Node
- IEC 61850 Communications

I/O in Application are Hardware Independent

Physical Inputs

Physical Outputs

Virtual Interfaces
IED & SCD Configuration Descriptions

- Function blocks that are logical nodes provide data with ICD file that describes it to other substation IEDs.
- SCD file defines the substation.
- ICD and SCD are written with the defined Substation Configuration Language (SCL).
- The SCD file is used by all substation IEDs and station HMI with tools to make appropriate interfaces.
Analog Input Function Block

- **Input**
  - Block (True / False)
  - Group and signal names for signal matrix mapping
  - Type (Current / Voltage)

- **Output**
  - AI3P
    - Data for measurement and computations
  - AI A, …, N
    - Sampled data for DFR
  - Logic Names
    - V3P, …, VN

<table>
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<th>Block</th>
<th>Type</th>
<th>Signal Names</th>
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<td>V3P</td>
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</tr>
<tr>
<td>FALSE</td>
<td>I</td>
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</tbody>
</table>

Diagram:
- Transformer Inputs: VA, VB, VC
- Signal Matrix
- Virtual Transformers
- Background Operations
Binary Output Function Block

- **Inputs:**
  - Logic signals to be output to physical outputs
    - Contacts
    - LEDs
  - Group and signal names for signal matrix mapping
Impedance Function Block

- Detect phase and ground faults on transmission lines

**Inputs**
- Supervision
- Analog data

**Outputs**
- Single and three pole tripping
- Single and three pole starting
- Logical node
Disturbance Reporting Function Blocks

Disturbance Report

A1RADR

RDRE

LMBRFLO

TRIP VALUE RECORDER

FAULT LOCATOR

DISTURBANCE RECORDER

EVENT RECORDER

B1RBDR

INDICATIONS (HMI)

SEQ. OF EVENTS LIST

ANALOG SIGNALS

BINARY SIGNALS

40/rec

96/rec

150/rec

96/rec

1000, Continuous

40/rec

96/rec

150/rec

96/rec

1000, Continuous
Generic GOOSE Output Function Blocks

- **SPGGIO**
  - Single point GOOSE
  - Binary
  - 1 / 0
- **DPGGIO**
  - Double point control GOOSE
  - Integer
  - 1/0, 0/1, 0/0, 1/1
  - Valid

**Inputs**
- Logic signals to sent to other station IEDs

Mapped to other Network IED via Substation Configuration Description File
Control Function Blocks

- Function blocks (IEC 61850 logical nodes) for IEDs at process level
  - XCBR – circuit breaker
  - XSWI – MOD

- Function blocks (IEC 61850 logical nodes) for IEDs at bay level
  - CSWI – switch controller
  - CILO – Interlocking
  - PDIS – distance protection
  - PTOC – TOC protection
  - Many more defined in IEC 61850 to provide secure substation control

- Operator places that provide control through function blocks (logical nodes)
  - Station HMI
  - IED (front panel)
Benefits to This Design Method

- Versatile Applications
- Simplify settings
- Design documentation
- Testing
Relion series relays for your current and future needs

- 61850 Logical Node concept used in Relion design
- Don’t see need to implement 61850 design at this time??
- There for future use without having to modify relays
- Can implement in stages
- Future Proofing your substation protection and control design process
QUESTIONS ?