NovaCor™

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IEC 61850 REPRESENTATION OF SWITCHGEAR, SWITCH CONTROLLER AND INTERLOCKING FUNCTIONS FOR REAL-TIME SIMULATIONS

RTDS Technologies

Outline

Introduction

Switchgear Modeling in IEC 61850

Development of the Simulation Model

Test Setup

Results and Discussion

Introduction

- **IEC 61850** has become the preferred standard for substation automation systems (**SAS**) around the world
- **Testing and validating** of control systems in a substation such as high voltage **switchgear controls** can be challenging due to the unavailability of an accurate **replica test system**
- Control systems can be tested in a virtual environment by modelling them inside a **real-time simulator**

Switchgear Control

- **High voltage switchgear** in an electrical substation operates in response to either a **trip** or a **switch** (opening and closing) command
- Typically, only protection and control intelligent electronic devices (IEDs) at **bay level** can trip circuit breakers
- A circuit breaker can either be switched **locally with manual control** or by a command from **bay**, **station** and/or **remote levels**
- **IEC 61850** defines **data models** for representing switchgear and their associated controls
- These data models can be read and controlled by **MMS** communication protocol

Control Models

- As different applications require different control behaviours, IEC 61850 defines **four** control models:
  - Direct control with normal security
  - SBO (select before operate) control with normal security
  - Direct control with enhanced security
  - SBO control with enhanced security

Originator Category (*orCat*)

- Originator category (*orCat*) indicates who/what requested the change of state of a controllable value

Values for orCat	Explanation
not-supported	That value shall not be used
bay-control	Control operation issued from an operator using a client located at bay level
station-control	Control operation issued from an operator using a client located at station level
remote-control	Control operation from a remote operator outside the substation (for example network control center)
automatic-bay	Control operation issued from an automatic function at bay level
automatic-station	Control operation issued from an automatic function at station level
automatic-remote	Control operation issued from a automatic function outside of the substation
maintenance	Control operation issued from a maintenance/service tool
process	Status change occurred without control action (for example external trip of a circuit breaker or failure inside the breaker)

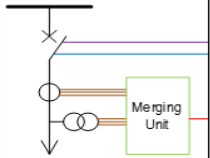
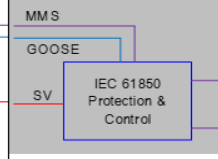
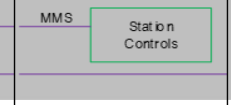
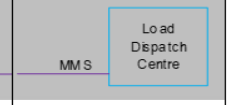
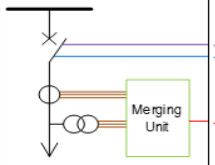
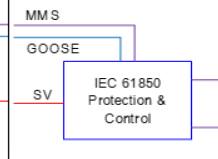
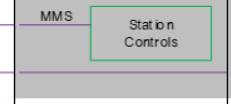
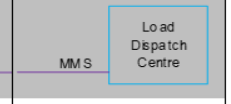
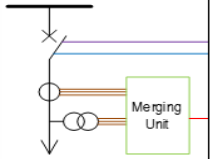
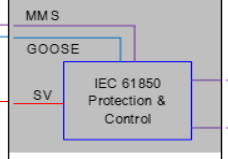
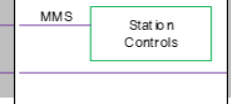
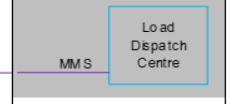
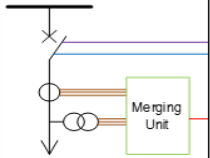
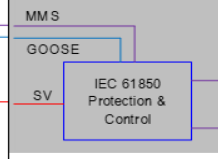
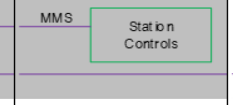
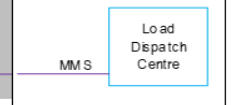
Control Parameters

- An originator's right to possess the control authority for a particular switch depends on a **prescribed set** of control parameters

Control Parameter	Description (as per IEC 61850-7-4)
XCBR/XSWI/CSWI.Loc	Shows the control behaviour of the logical node
LLN0.MltLev	Shows if more than one source of control commands is accepted at a certain level at the same time
CSWI.LocSta	Shows the switching authority at station level.

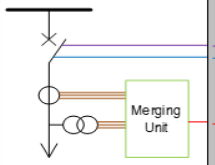
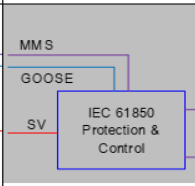
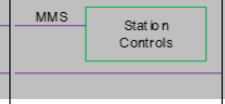
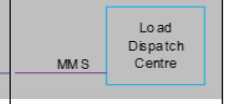
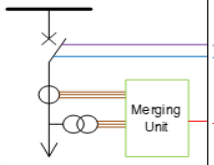
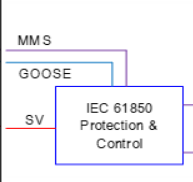
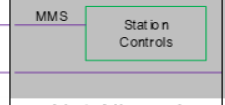
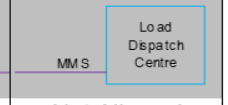
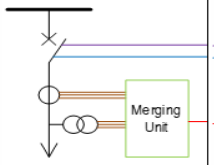
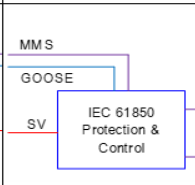
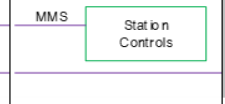
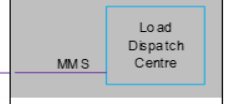
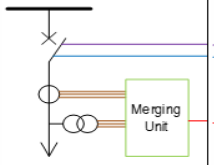
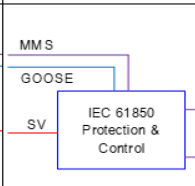
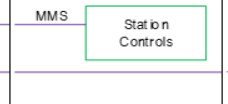
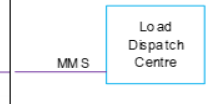
Control Parameters & Control Authority

- LLN0.Mltlev = False

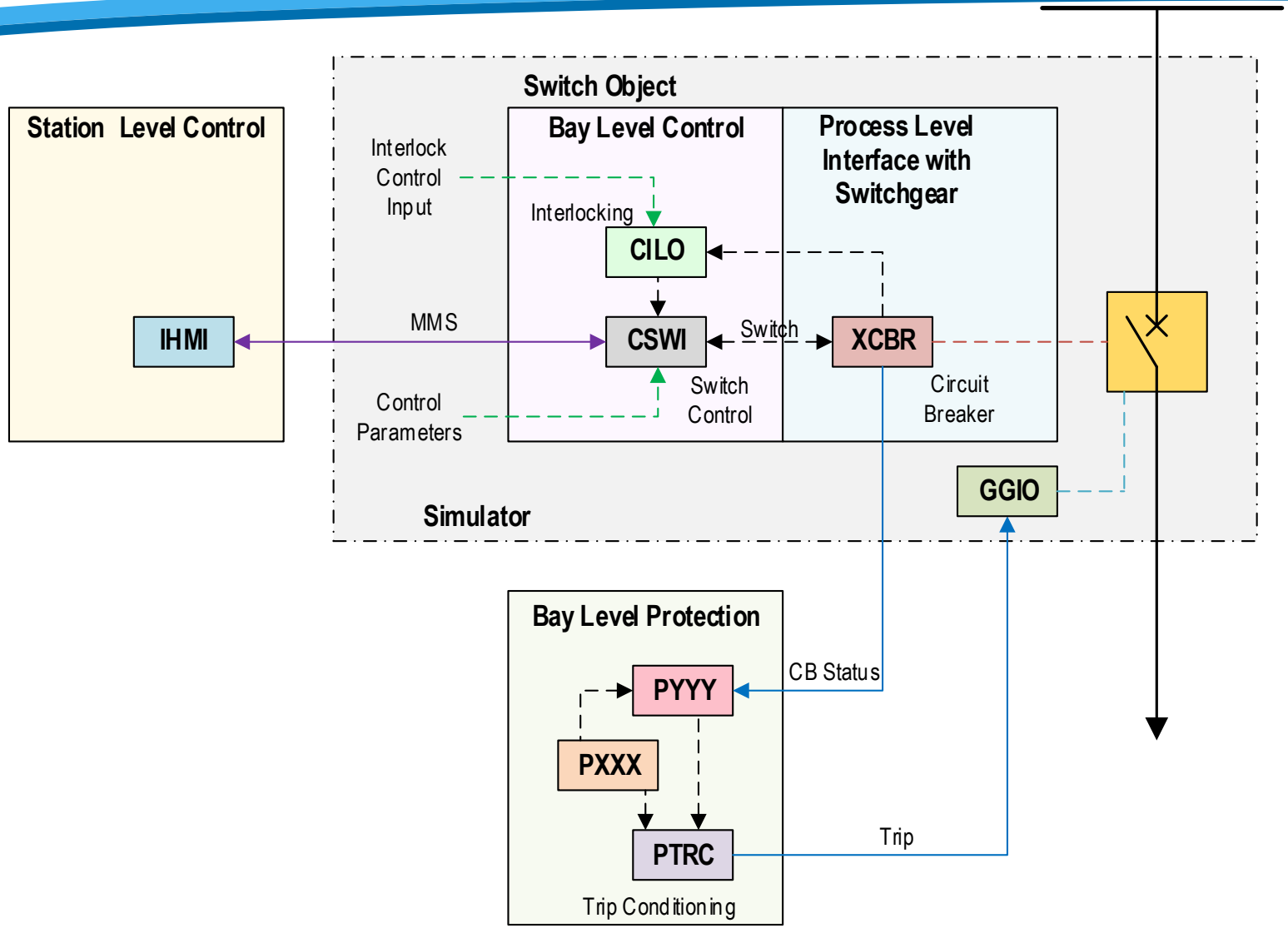
Control Parameters				Control Authority at each Level			
Switch	Bay Control			Manual Control	Originator Category (OrCat)		
XCBR.Loc XSWI.Loc	LLNO.MltLev	CSWI.Loc	CSWI.LocSta	Process	Bay	Station	Remote
 True	 False	Not Applicable	Not Applicable	 Always Allowed	 Not Allowed	 Not Allowed	 Not Allowed
 False	 False	 True	Not Applicable	 Always Allowed	 Always Allowed	 Not Allowed	 Not Allowed
 False	 False	 False	 True	 Always Allowed	 Not Allowed	 Always Allowed	 Not Allowed
 False	 False	 False	 False	 Always Allowed	 Not Allowed	 Not Allowed	 Always Allowed

Control Parameters & Control Authority

- LLN0.Mltlev = True

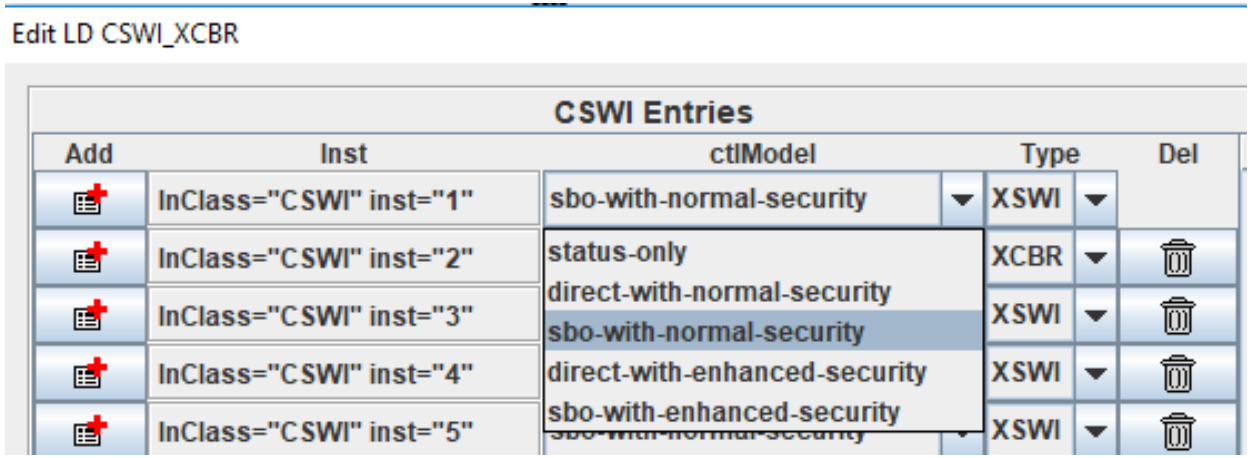
Control Parameters				Control Authority at each Level			
Switch	Bay Control			Manual Control	Originator Category (OrCat)		
XCBR.Loc XSWI.Loc	LLNO.MltLev	CSWI.Loc	CSWI.LocSta	Process	Bay	Station	Remote
 True	 True	Not Applicable	Not Applicable	 Always Allowed	 Not Allowed	 Not Allowed	 Not Allowed
 False	 True	 True	Not Applicable	 Always Allowed	 Always Allowed	 Not Allowed	 Not Allowed
 False	 True	 False	 True	 Always Allowed	 Always Allowed	 Always Allowed	 Not Allowed
 False	 True	 False	 False	 Always Allowed	 Always Allowed	 Always Allowed	 Always Allowed

Simulation Model



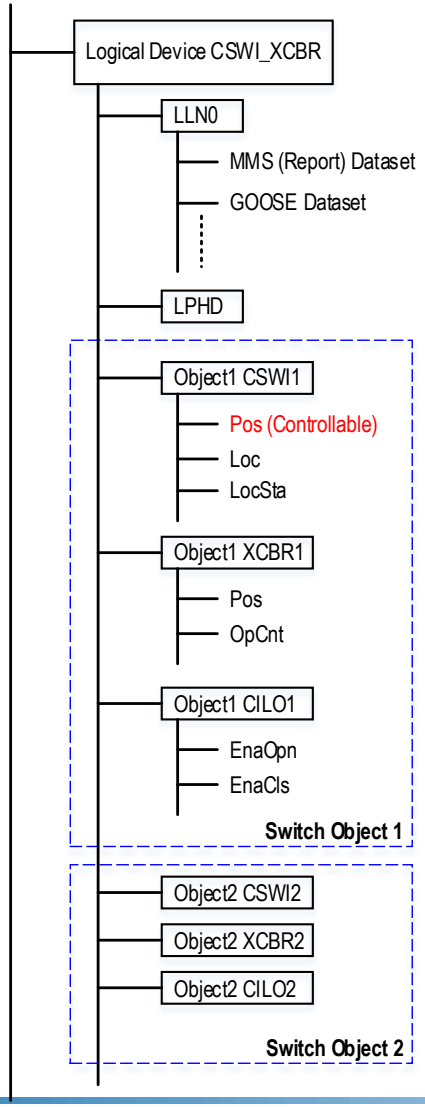
Initialization of Switch Objects

- All four control models are implemented with an additional “status only” option
- Control model type is chosen when LN instances are first created using the **IED configuration tool**
- Type of the switch (XCBR or XSWI) is also chosen at this point
- All three LN instances (XCBR/XSWI, CSWI, CILO) are created simultaneously and locally interlinked

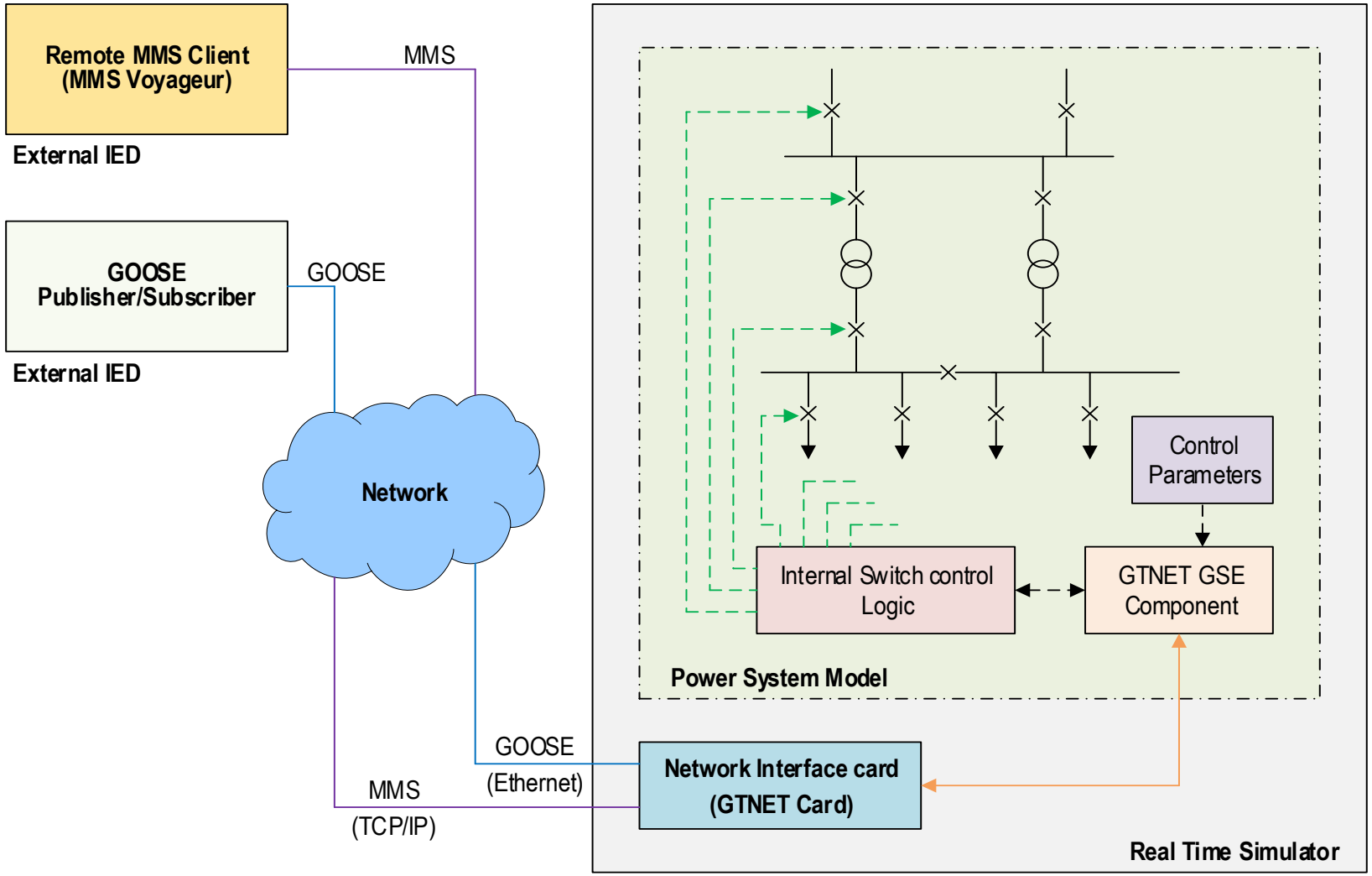


Data Model Structure

- All related LN instances are grouped into a separate Logical Device (LD)



Test Setup


Remote MMS Client
(MMS Voyageur)
External IED
MMS
GOOSE
Publisher/Subscriber
External IED
GOOSE
Network
GOOSE
(Ethernet)
MMS
(TCP/IP)
Control
Parameters
Internal Switch control
Logic
GTNET GSE
Component
Power System Model
Network Interface card
(GTNET Card)
Real Time Simulator

Test Setup

- A MMS client program (**MMS Voyageur**) available in RSCAD was used as the MMS client for testing
- Testing was carried out in **two phases**
- Firstly, **functional aspects** of the developed simulation model were tested to confirm its correct operation
- Under functional testing:
  - All eight scenarios were tested (as per 7-4 Annex B)
  - Tests were repeated for interlock checks
  - Tests were repeated for each control model
  - Operation was tested according to state machines

Test Setup

- Secondly, the model was used in a simulation of a substation to evaluate its performance under **realistic scenarios**
- Operation switch objects ware tested according to a **test plan** considering practical consideration in a SAS
- All switching operations during **functional testing** and **integrated testing** with the example substation exhibited expected performances

Results and Discussion

The simulation model presented enables:

- Producing a **testing environment** for real switch controllers (operators) in a SAS to be tested, individually as well as a group
- Testing and verification of the **electrical interlocks** in the SAS
- Interfacing switch objects in the simulation with **actual circuit breakers** via hardwired I/O connections of the simulator
- Integration of switchgear controls into the **coordinated operation** of the entire SAS, including both protection and control systems

Questions