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INTEGRATED TESTING FOR IEC 61850 COMPATIBLE IEDS IN A SIMULATED SMART AUTOMATION SYSTEM

RTDS Technologies

Outline

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Introduction

- **IEC 61850** has become the preferred standard for substation automation systems (**SAS**) around the world
- **Testing and validating** of multi-function capable IEDs used in newly deployed integrated and complex smart automation systems can be challenging due to the unavailability of an accurate **replica test system**
- IEDs supporting testing features defined in IEC 61850 **Edition 2** can be tested in a virtual environment simulated by a **real-time simulator**

Testing Features Defined in IEC 61850

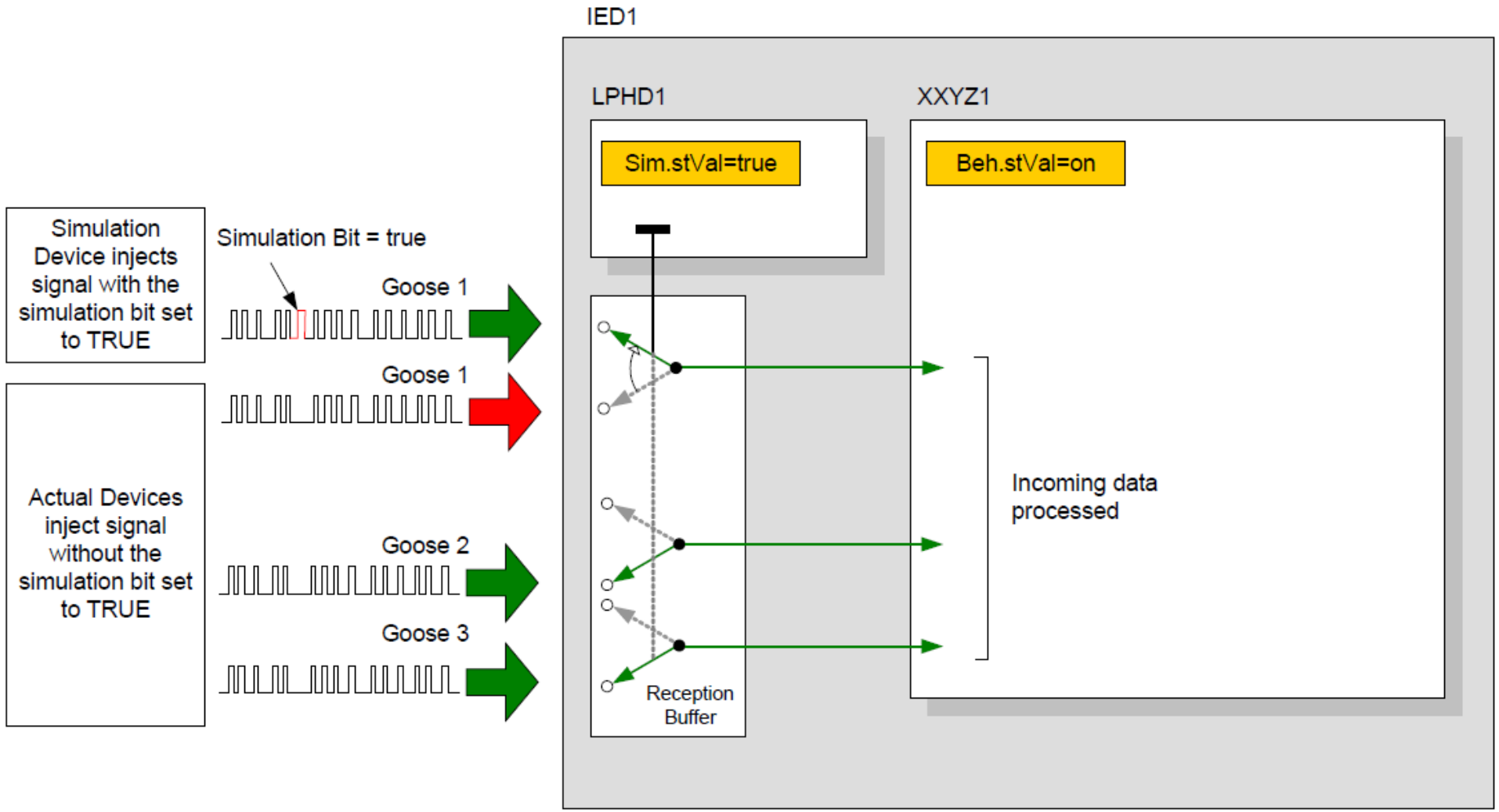
Some of the main testing features

- ❑ The **Simulation** of GOOSE and SMV telegrams
- ❑ GOOSE and SMV Supervision (**LGOS** / **LSVS**)
- ❑ **Mode** and **Behaviour** of functions
- ❑ MMS service parameter **Test**

Data Used for Testing - Simulation

- As described in IEC 61850-7-1 Edition2: in order to carry out functional, commissioning or maintenance tests, a communications network-based SAS that supports testing functions should offer some of the following facilities:
  - At the IED level, the option of receiving multicast **simulation** signals instead of **actual** signals
  - At the LN (function) level, the option of receiving test input signals instead of actual signal
  - At the LN (function) level, the option of setting a function or a group of functions of the system in test mode

Data Used for Testing - Simulation



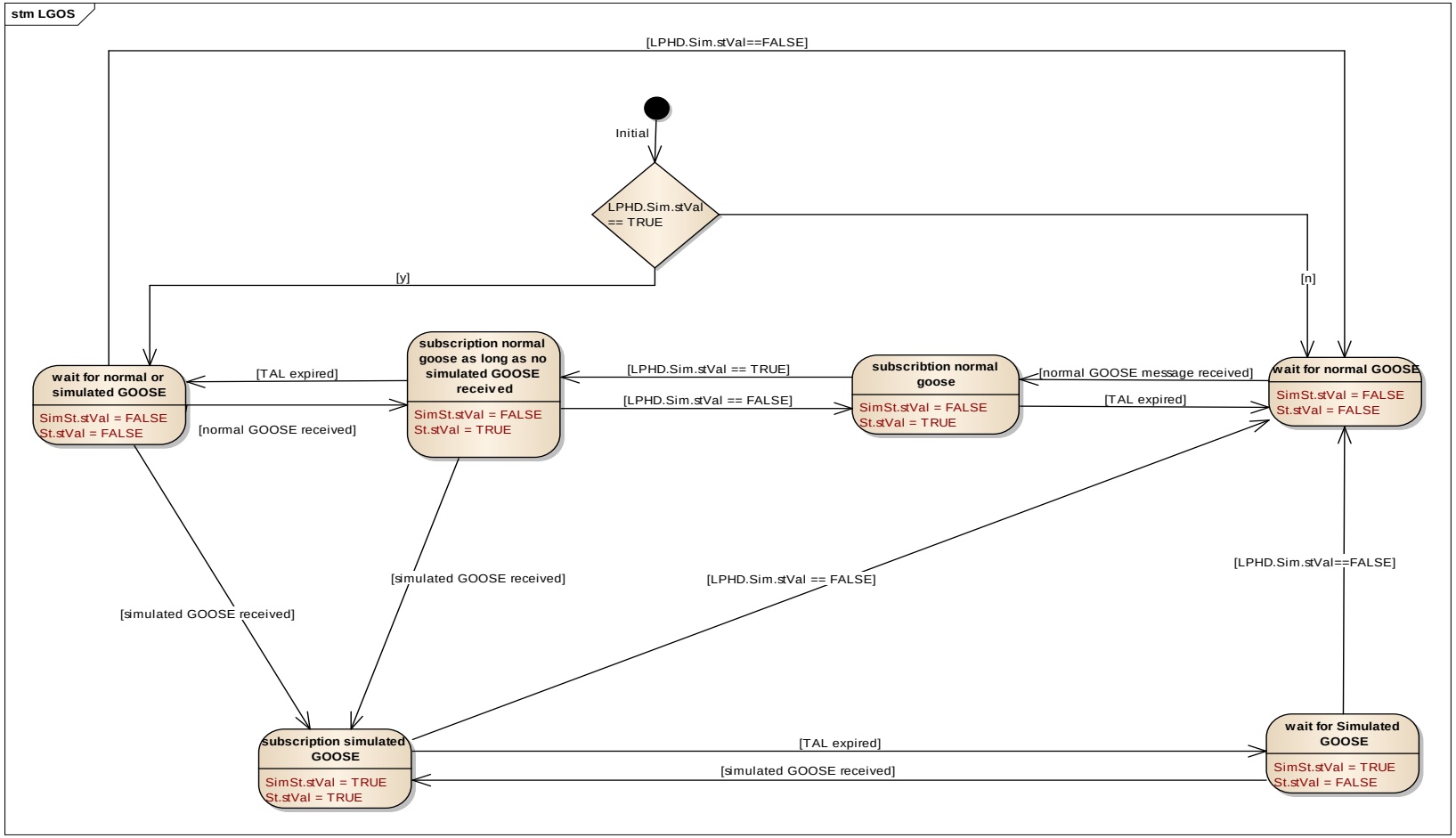
GOOSE and SMV Supervision

- The LGOS and LSVS logical nodes may be used to monitor subscription states to GOOSE or SMV signals. They contain mandatory information like status of the subscription (active, not active) and other optional information
- The subscriber's root LD LPHD.Sim.StVal is used to switch the ability of the DUT to accept real or simulated test signals, then LGOS or LSVS will indicate the state of the incoming signals

GOOSE and SMV Supervision

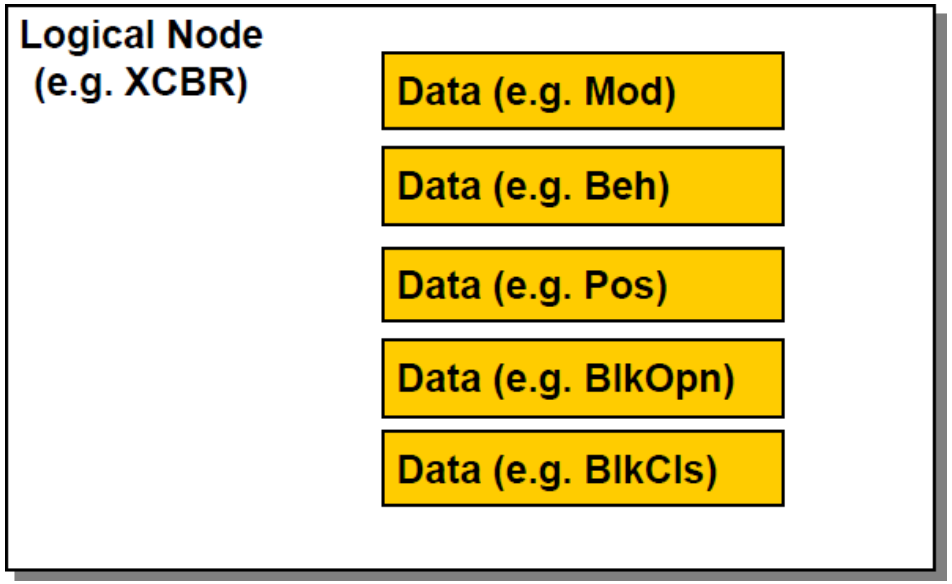
IEC 61850 Tissue 1151 -

Data Object	Status	Explanation
LSVS/LGOS.***St***	TRUE	Message are there and therefore forwarded to the application
	FALSE	No message received. Application does not get message
LSVS/LGOS.***SimSt***	TRUE	Subscription switched to simulated telegram only
	FALSE	Subscription switched to NOT simulated telegram



Mode & Behaviour

- IEC 61850-7-4 defines a list of logical nodes. Each logical node (e.g. a circuit breaker is abbreviated as "XCBR") is composed of several data that represent some application-specific meaning
- **Mod** is a **controllable** data representing the current operation mode of the circuit breaker logical node (**on**, **on-block**, **test**, **test/blocked**, **off**).
- **Beh** is a **non-controllable** data and has the same values as Mod. It represents the combination status of the mode of a logical node and the mode of the containing **logical device***



*A **logical device** is mainly a composition of logical nodes and additional services (e.g. GOOSE, sample value exchange, setting groups). The **logical node zero (LLN0)** represents common data of the logical device. For example, the **mode of LLN0** is used to control the mode of the whole logical device and, as a result, the mode of every logical node being part of the logical device.

Values of Mode & Behaviour

- Switching between the modes (Mod.stVal) should only happen as a result of an operator command to the data object Mod
- Mod and Beh are always accessible by the services
- The communication services for the data object Mod do not care about the status of the Beh of the LN

Table A.1 – Values of mode and behaviour

Value	Mode	
1	on	The application represented by the LN works. All communication services work and get updated values
2	on-blocked	The application represented by the LN works. No output data (digital by relays or analogue setting) will be issued to the process. All communication services work and get updated values. Data objects will be transmitted with quality "operatorBlocked". Control commands will be rejected. See note below Table A.1.
3	test	The application represented by the LN works. All communication services work and get updated values. Data objects will be transmitted with quality "test". Control commands with quality test will be accepted only by LNs in "test" or "test-blocked" mode. "Processed as valid" means that the application should react in the manner what is foreseen for "test".
4	test/blocked	The application represented by the LN works. No output data (digital by relays or analogue setting) will be issued to the process. All communication services work and get updated values. Data objects will be transmitted with quality "test". Control commands with quality test will be accepted only by LNs in TEST or TEST-Blocked mode.
5	off	The application represented by the LN doesn't work. No process output is possible. No control command should be acknowledged (negative response). Only the data object Mod and Beh should be accessible by the services.
NOTE	The Mod ="blocked" from edition 1 is changed in edition 2 to "on-blocked".	

Definition of Mode & Behaviour

Table A.2 – Definition of mode and behaviour

MODE/BEHAVIOUR	on	on-blocked	test	test/blocked	off
Function behind LN	ON	ON	ON	ON	OFF
Output to the Process (Switchgear) via a non-IEC 61850 link for example wire (typical for X...,Y... and GGIO LNs)	YES	NO	YES	NO	NO
Output of FC ST, MX (issued independently from Beh)	value is relevant q is relevant	value is relevant q = operatorBlocked	value is relevant q = test	value is relevant q = test +operator-Blocked	value is irrelevant q = invalid
Response to (Normal) Command from Client (a+ / a- acknowledgement)	a+ pos. ack.	a- neg. ack.	a- neg. ack.	a- neg. ack.	a- neg. ack.
Response to TEST Command from Client (a+ / a- acknowledgement)	a- neg. ack.	a- neg. ack.	a+ pos. ack.	a+ pos. ack.	a- neg. ack.
Incoming data with q=normal	Processed as valid	Processed as valid	Processed as valid	Processed as valid	Not Processed
Incoming data with q=operatorBlocked	Processed as blocked	Processed as blocked	Processed as blocked	Processed as blocked	Not Processed
Incoming data with q=test	Processed as valid	Processed as invalid	Processed as valid	Processed as valid	Not Processed
Incoming data with q=test+operatorBlocked	Processed as invalid	Processed as invalid	Processed as blocked	Processed as blocked	Not Processed
Incoming data with q=invalid	Processed as invalid	Processed as invalid	Processed as invalid	Processed as invalid	Not Processed
Non-IEC 61850 binary (relay, contact) inputs and analogue (instrument transformer) inputs	Processed	Processed	Processed	Processed	Not Processed

Service Parameter Test

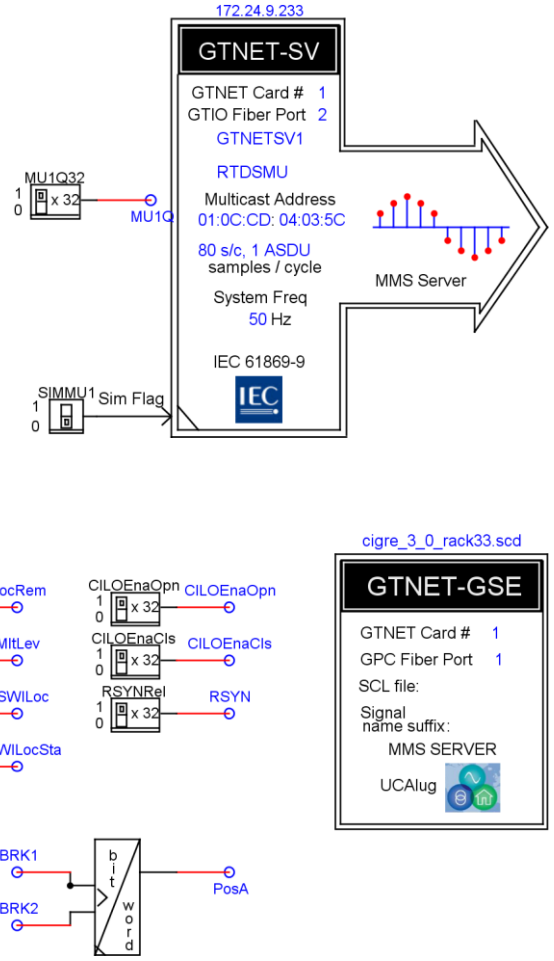
- The MMS service parameter **Test** shall be the test status of the control service
- It shall determine if the client sends a control service for the test purpose or not
- All service primitives belonging to one control sequence shall carry the same test status

Table 50 – Test definition

Test status type		
Service parameter name	**Parameter type**	**Value/value range/explanation**
Test	BOOLEAN	no-test (FALSE) | test (TRUE)

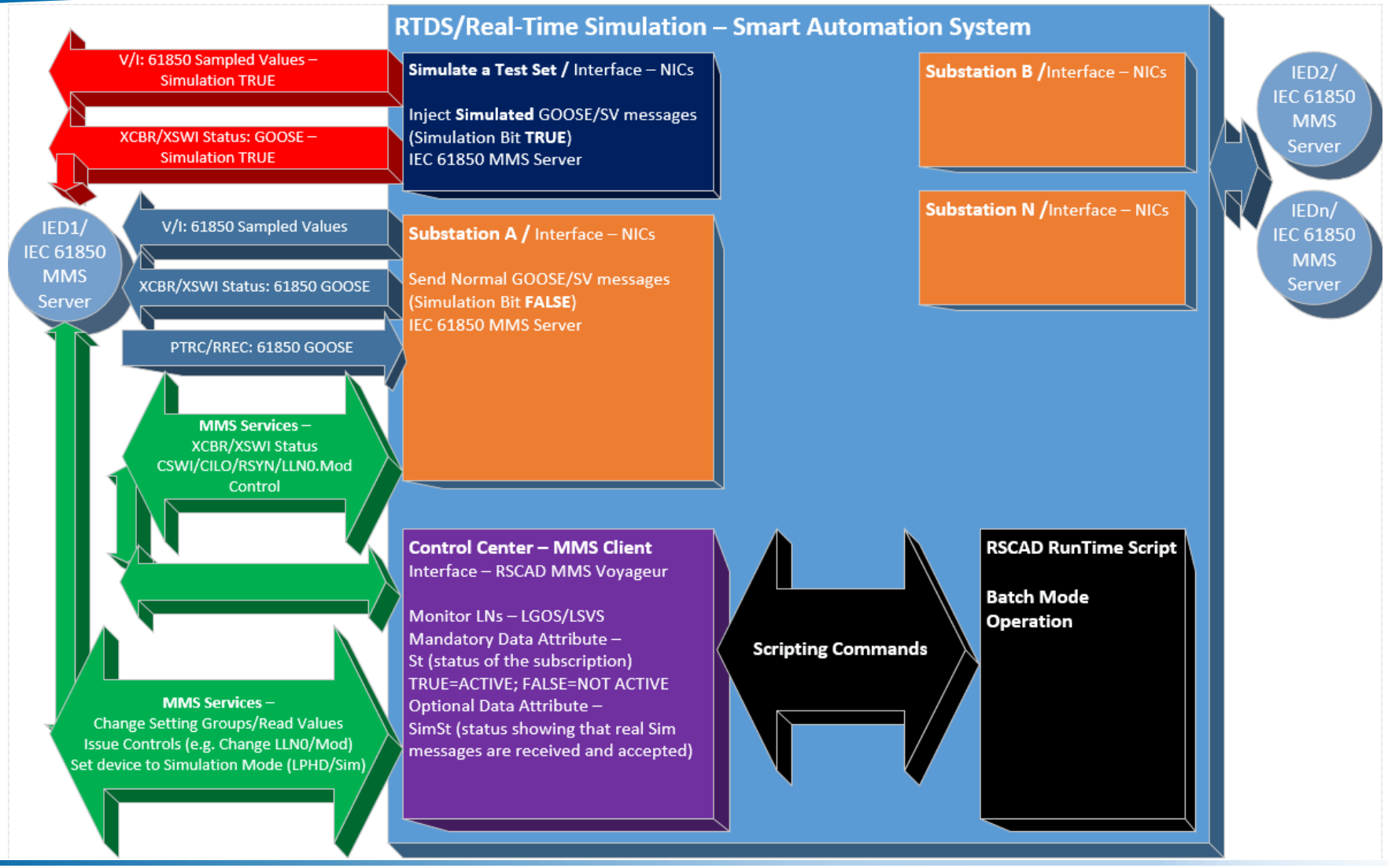
Simulation Models

- Simulation models were developed in the Real-Time Digital Simulator to provide testing functions
- The information exchange between the virtual environment simulated by the simulator and external physical IEDs under test is through the Network Interface Card (NIC)
- Testing functions provided by the simulation models and the NIC –
  - Simulation of GOOSE/SMV with configurable Simulation flag
  - Subscription of GOOSE/SMV with the support of supervision logical nodes (LGOS/LSVS)
  - The NIC serves as a MMS server to provide Client-Server monitoring/control related services

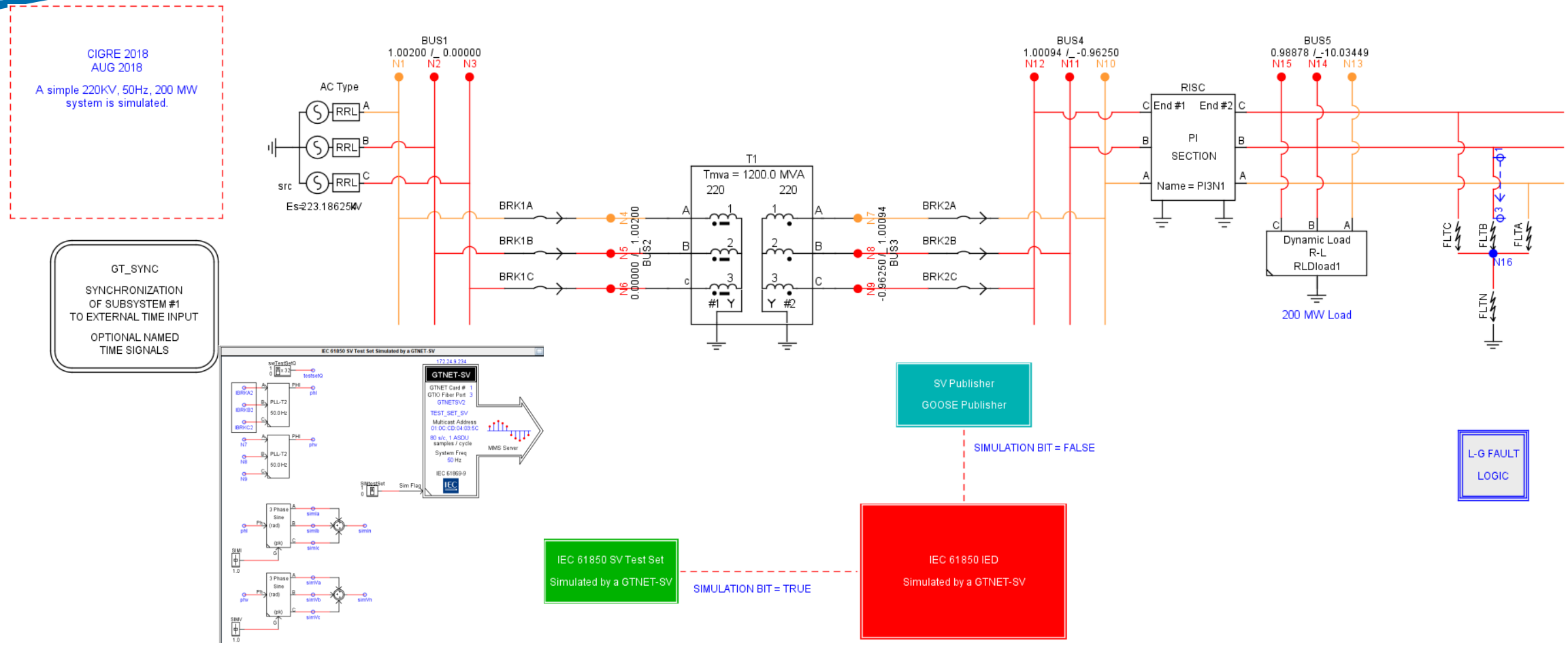


Integrated Testing

- The integrated testing can be automated using the **Scripting** utility available in the simulator



A Simple Test Demo



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File Sequencer Racks Help

Rack: 33 3PH: 100 all SS:

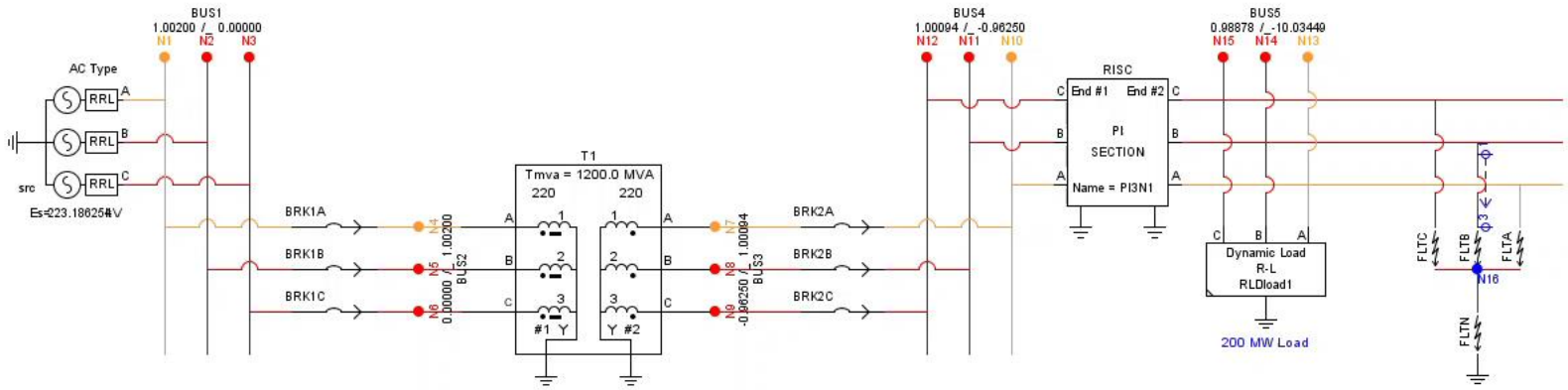
C:\RTDS_USER\fileman\Eric\Conferences\CIGRE_2018_Paris\cigre_2018_demo\Integrated_demo\Integrated_demo_v0.dft

SS #1

CIGRE 2018
AUG 2018

A simple 220KV, 50Hz, 200 MW system is simulated.

To be added
To be added
To be added



SV Publisher
GOOSE Publisher

SIMULATION BIT = FALSE

IEC 61850 SV Test Set
Simulated by a GTNET-SV

SIMULATION BIT = TRUE

IEC 61850 IED
Simulated by a GTNET-SV

L-G FAULT
LOGIC

Message Area

Copy Clear View All

At Line Number: 9921 of file C:\RTDS_SWMLIB\COMMON\GPCdefault.lib
WARNING - Unknown variable "scl" found in draft file for component "rtds_sharc_1phbkr".
At Line Number: 9922 of file C:\RTDS_SWMLIB\COMMON\GPCdefault.lib

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Questions