



Automatic Reporting for IEC61850 Performance Testing of Multi-Vendor Digital Substation Applications

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 - flowchart
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 - Get available variables
 - Poll data from buffer
 - Create temporary buffer
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- Reporting on CHIL test
- IEC61850
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 - GOOSE
 - Sample Value
 - Network
 - Performance
- Practical case
- Report creation for IEC61850



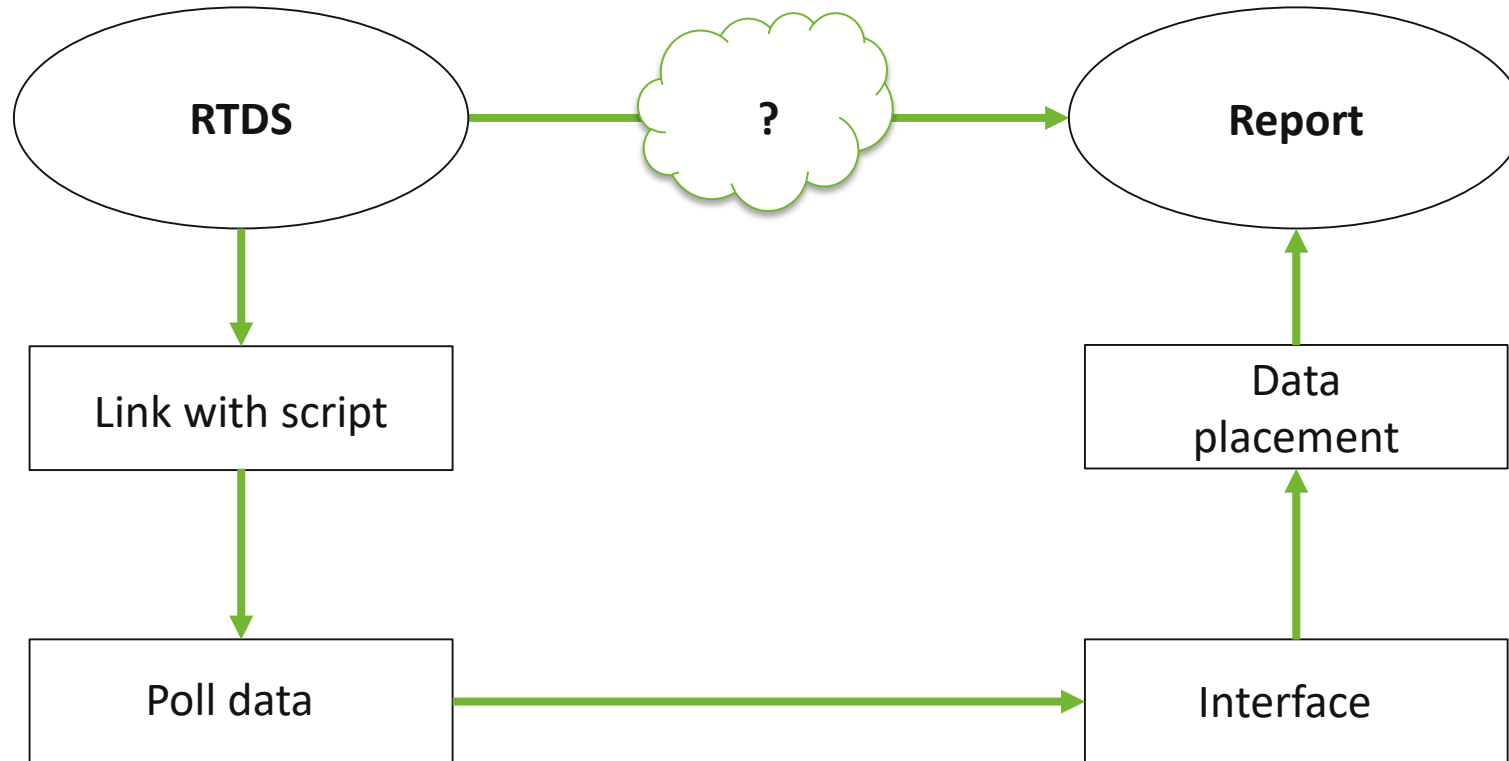
Reasoning

- Combine results from different tools
- Early identification of out of bound parameters
- Single tool for scripting and reporting



Report creation for RTDS

Flowchart



Report creation for RTDS

Link with script

- Scripting
 - Text-based
 - .scr-file
 - Matlab coding
 - Providing more functionalities
-
- Setup Link
 - Use existing functionality
 - ListenOnPort(portnum, true)
 - Netstat for portnum
 - Handshake and error handling
 - Java interface (jtcp.m)
 - Bi-directional 'client-server'
 - Read and write commands



Report creation for RTDS

Get available variables

- Scripting
 - Text-based
 - .scr-file
 - Other files
 - Information file (.Inf)
 - Runtime file (.sib)
 - Draft file (.dft)
- {
- Names of controls
 - Output names
 - e.g.:

```
Output Desc="S1) N1" Group="Subsystem #1|Node Voltages" Units="kV"  
Output Desc="S1) N2" Group="Subsystem #1|Node Voltages" Units="kV"  
Output Desc="S1) N3" Group="Subsystem #1|Node Voltages" Units="kV"  
Output Desc="S1) N4" Group="Subsystem #1|Node Voltages" Units="kV"  
Output Desc="S1) N5" Group="Subsystem #1|Node Voltages" Units="kV"  
Output Desc="S1) N6" Group="Subsystem #1|Node Voltages" Units="kV"
```

Report creation for RTDS

Poll data from buffer

- Scripting
 - Text-based
 - .scr-file
 - Other files
 - Information file (.Inf)
 - Runtime file (.sib)
 - Draft file (.dft)
- {
- Array for external variable
 - Poll data from designated buffer of HMI plot
- {
- Save image
 - SavePlotToCSV “Name”
 - Time + variable

Report creation for RTDS

Create temporary buffer

- Scripting
 - Text-based
 - .scr-file
 - Other files
 - Information file (.Inf)
 - Runtime file (.sib)
 - Draft file (.dft)
- SavePlotToCSV “Name”
 - Create Placeholder
 - Position
 - Name
 - Variable details
 - Delete afterwards

```
COMPONENT: PLOT
  BOX AT (0,5580), DIMENSIONS 400 x 400
  NAME: TEST
  ICON: EXISTS
  ICON AT: (227,280)
  GROUP: (NONE)
  MIN: 0.0
  MAX: 1.0
  UNLOCKED
  NUMBER OF GRAPHS: 1
    GRAPH 1: 1 CURVE
      Y MIN: 0.0
      Y MAX: 1.0
      ...
      CURVE 1:
        GROUP: Subsystem #1 | Branch Currents
        DESC: IBRKB
        COLOR: RED
        LABEL: IBRKB

  PAGE HEIGHT: 0.0
  ...
```



Report creation for RTDS

Designate data with GUI

- Plot
 - Define x and y axis
 - Save figure
- Values
 - Define report condition

GENERAL

Name1; Name2; ...

Project Name; Location

1. Extract Data files

Get Get rscad folder

2. Set Desired Variables

Get Get variable ADD

X - value:

PLOT variable x1

Multi plot

Y - value:

variable y1

VALUE

write condition

3. Link with RSCAD

Start Stop

Report creation for RTDS

Excel interface

- Matlab opens actxserver
 - Full acces to excel functions
- Data placement
 - Placeholders
 - Copy format

Results:

< TITLE 1 >	
< subtitle 1 >	< subtitle 2 >
< PLOT 1 >	< VAR 1 >
	< VALUE 1 >

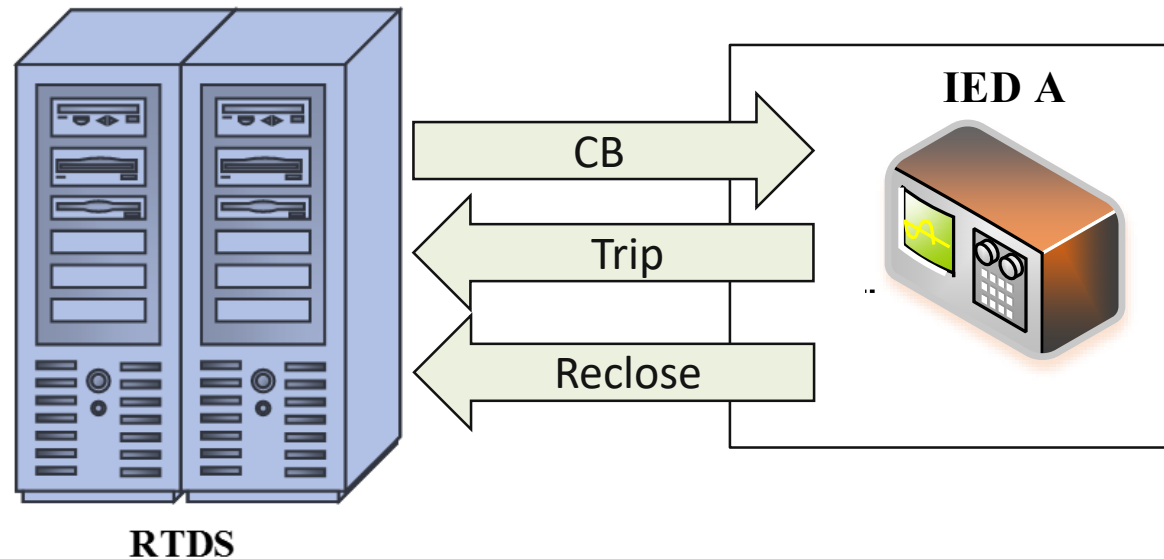
IEC61850	
< network details 1 >	< network details 2 >



Reporting on CHIL test

Functionality testing

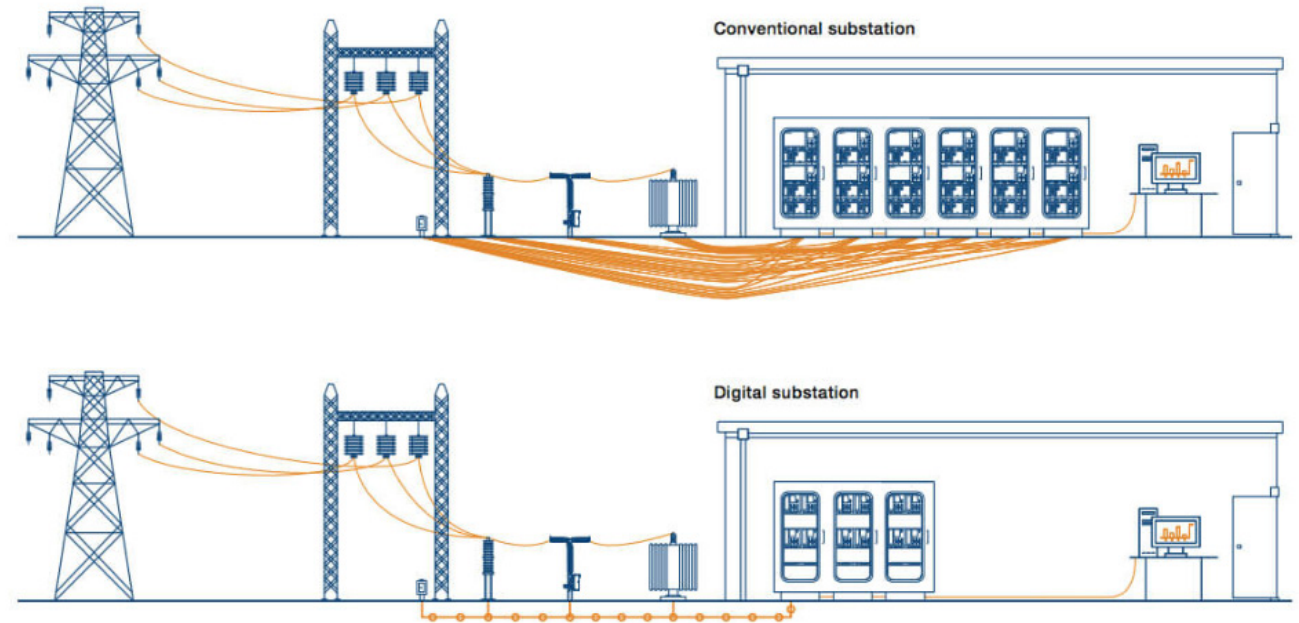
- Trip
- Circuit Breaker
- Reclosure
- Tele-communication
- Alarms



Note: Functional testing tools should not only test the performance of the system, but also observe the exchanges between the different components of a distributed function being integrated into a system

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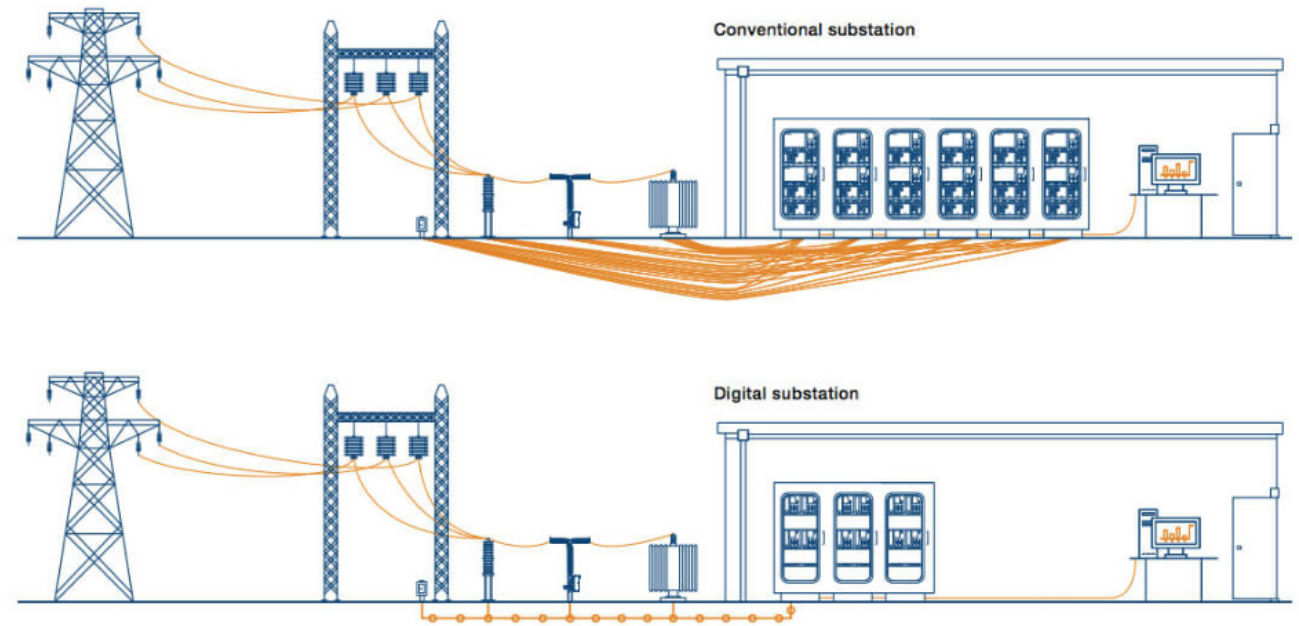
- General
 - Communication standard
 - Protection and control
 - models to organize data
- Advantages
 - Reduce wiring
 - Less complex
 - More dynamic
- Interoperability
- Future-proof



Source: *Digital Substations – Enabling a stronger, smarter and greener grid*, ABB, Brochure

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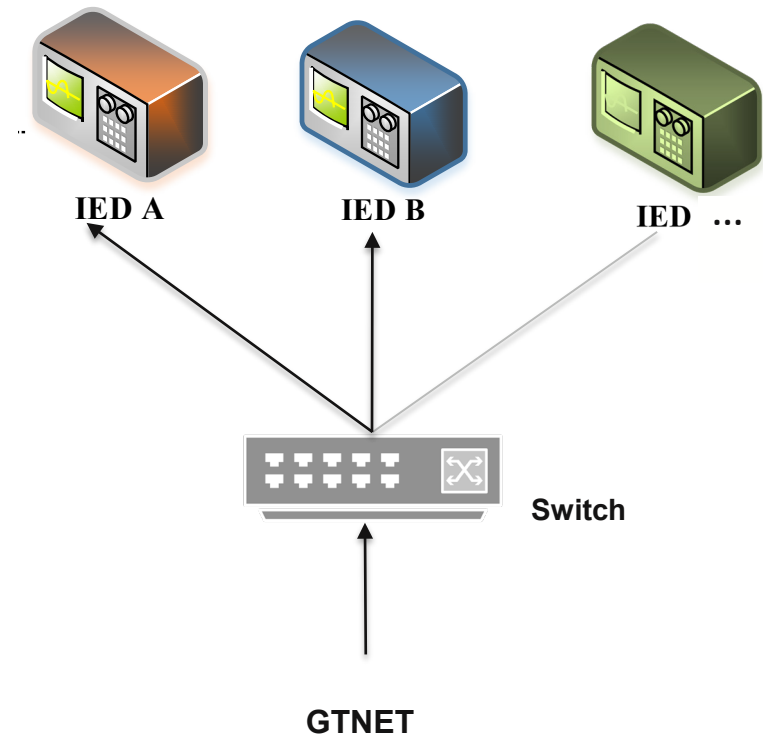
- Reason to test
 - Hesitant transition
 - Change of traditional system
 - Reliability concern
 - Interoperability issues
 - Test procedure
 - Standard not clear
 - Assumptions
 - Lack of test procedures



Source: *Digital Substations – Enabling a stronger, smarter and greener grid*, ABB, Brochure

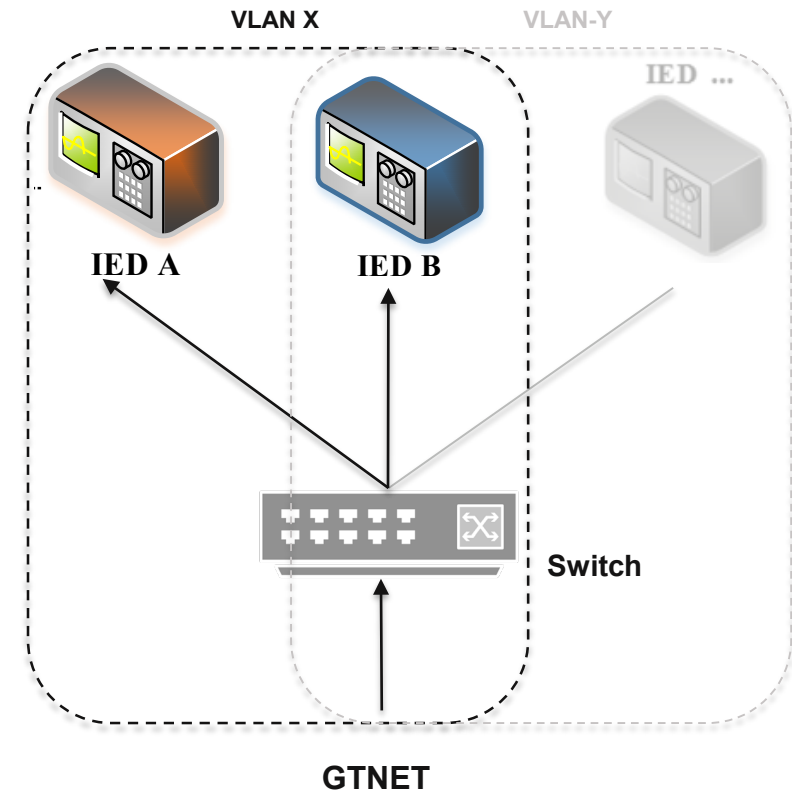
IEC61850: Network

- Multicast
 - No session, transport and network layer
 - No IP, No acknowledgement
 - Multicast mac-adress
 - APPID, goID
- Managing
 - VLAN priority
- Station configuration
 - Rscad creates SCD-file



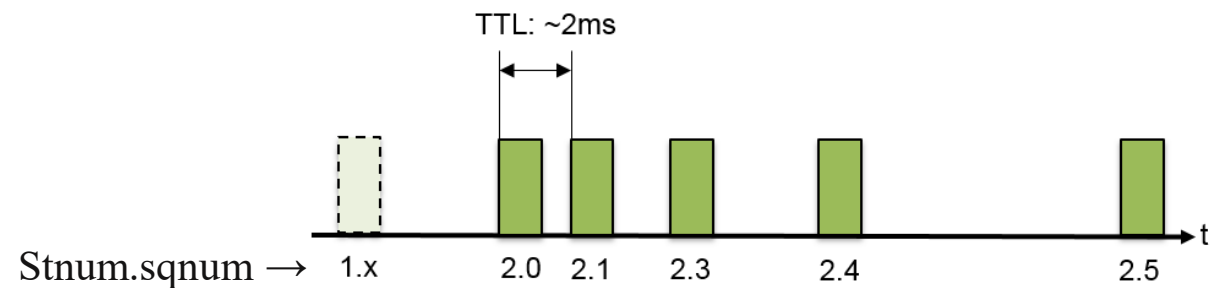
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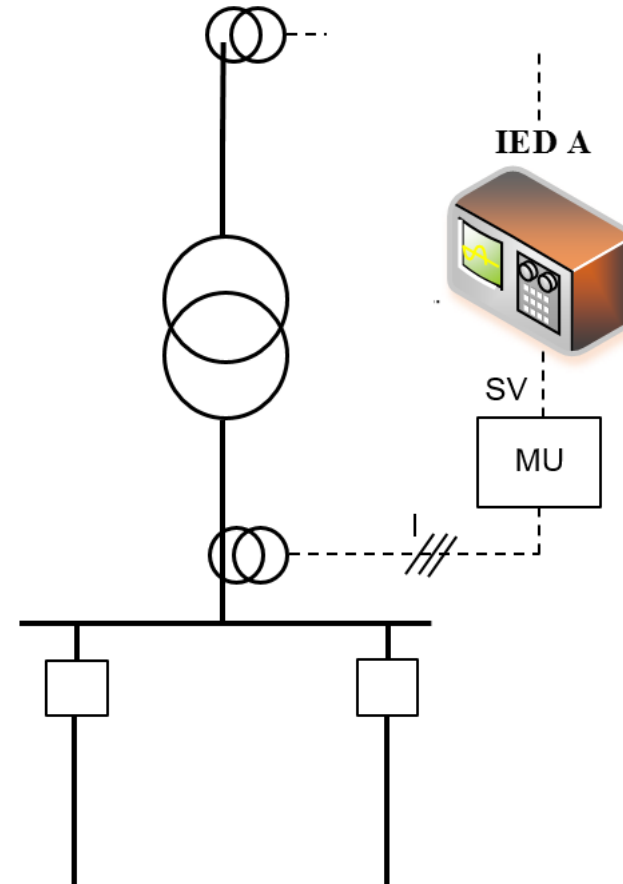
IEC61850: GOOSE

- Generic Object Orientated Substation Event
 - Event-driven dataset supporting multiple datatypes
- Retransmission
 - Time allowed To Live (TTL)
 - Packet numbering
 - Sequence number (sqnum)
 - State of Change (stnum)



IEC61850: Sampled Value

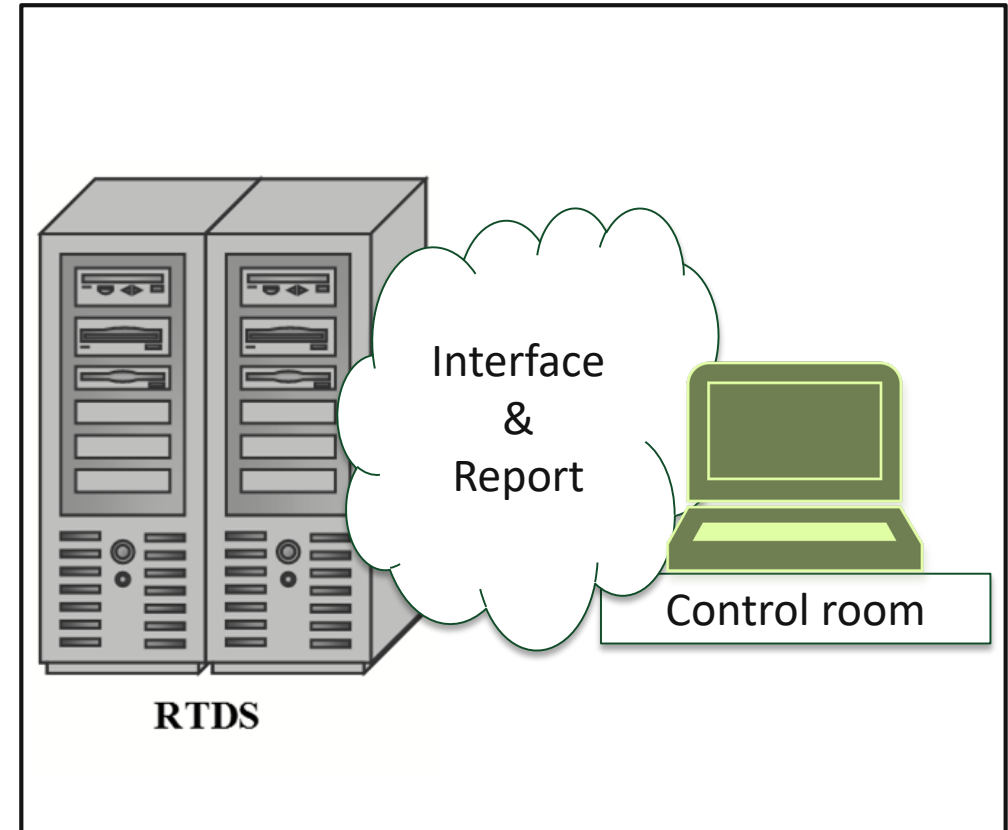
- Replacing secondary values
- Merging unit (MU)
 - Traditional CT/PT
 - NCIT (e.g. Rogowski)
- Similar to GOOSE
 - No retransmission
 - Continuous stream (sample count)
 - Synchronization more stringent: $1\mu\text{s}$
- 80 sample per cycle (4 Mbps \sim 4% of 100Mbps)



Report creation for IEC61850

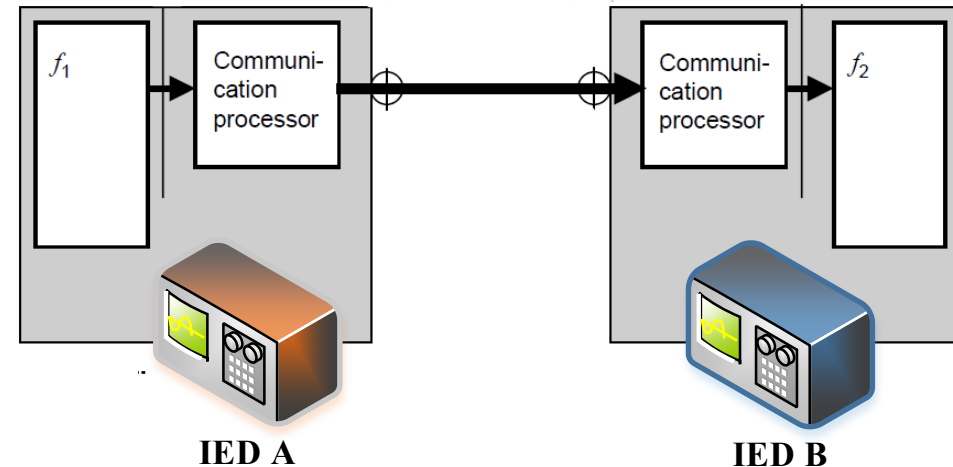
Network monitoring

- WireShark
 - PDU
 - timestamp
- Create Batch file
 - Capture filter
 - Data fields
 - Ethernet identifiers
 - Mac-address
 - Vlan/priority
 - ID numbers



IEC61850: Performance

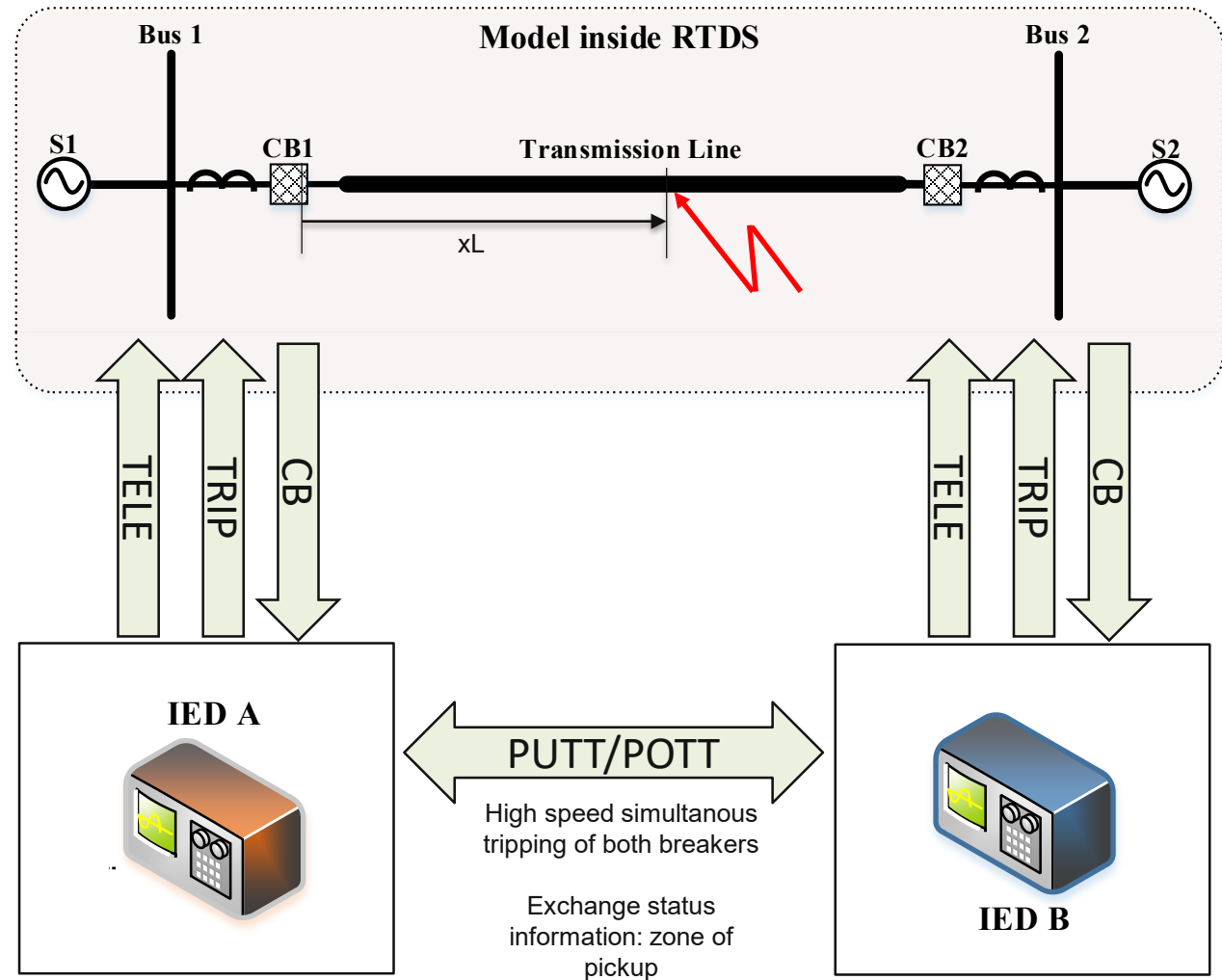
- Faster?
 - Signals from (GOOSE) message bits are sent and read directly between relay processors with microsecond Ethernet delays.
 - Delays:
 - Transmission delay
 - Propagation delay
 - Ethernet devices (e.g. switches)
 - Traffic on the network
 - Recovery times
 - Loss of data
- Transfer time: trip ($\leq 3\text{ms}$) and other ($\leq 20\text{ms}$)





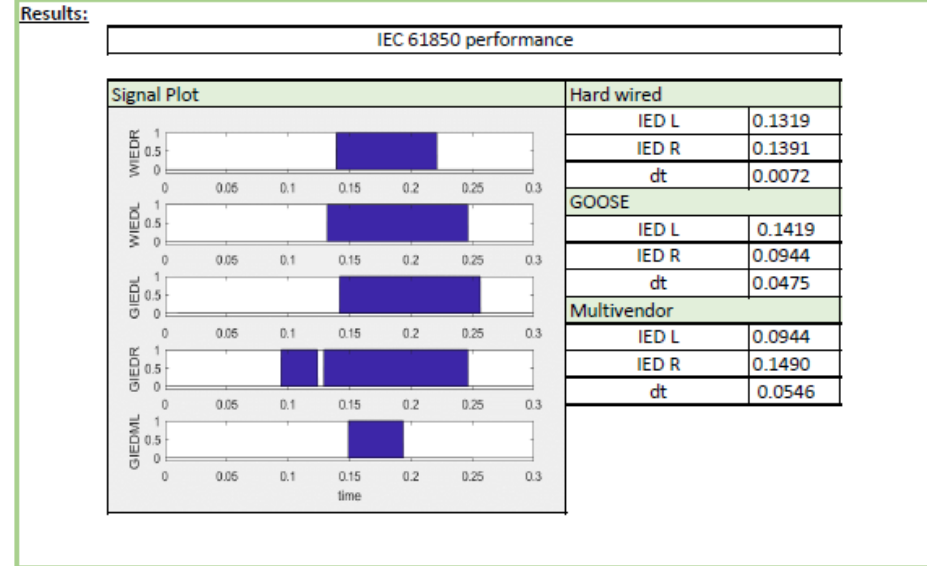
Functional test: Practical case

- Function performed by
 - Wired signals
 - GOOSE-messages
 - Multi-vendor system
 - (Sampled Value)
- Compare deterioration of the function ('tripping')

Operation time acceptable if both relays have tripped the breakers within a time interval of 150 ms



Author: Rick Loenders Co-Author Researcher(s): ... Assistantce: ... Date: 01/06/2018 Project: Performance testing Location: EnergyVille - RTDS lab Supervisor: ...	General note remark: This is a demo																								
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IEC61850	
Eth.Mac	APPID
RTDS	IED R
IED R	IED M
IED M	IED L
IED L	RTDS



* Some squares are automated, pass alterations in a different colour

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 Co-Author
 Researcher(s): ...
 Assistantce: ...
 Date: 01/06/2018
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 Supervisor: ...

General note
 remark:
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Review:

Score:

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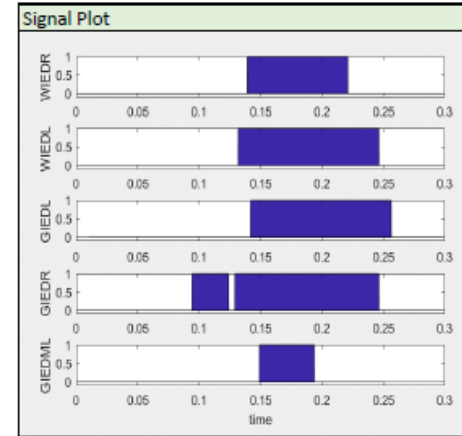
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Results:



IEC 61850 performance

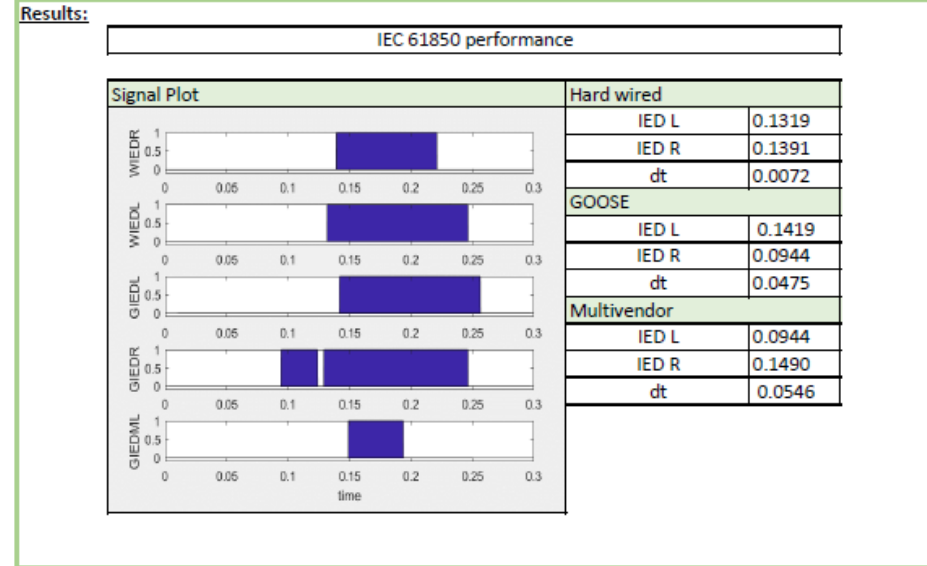


Hard wired	
IED L	0.1319
IED R	0.1391
dt	0.0072
GOOSE	
IED L	0.1419
IED R	0.0944
dt	0.0475
Multivendor	
IED L	0.0944
IED R	0.1490
dt	0.0546

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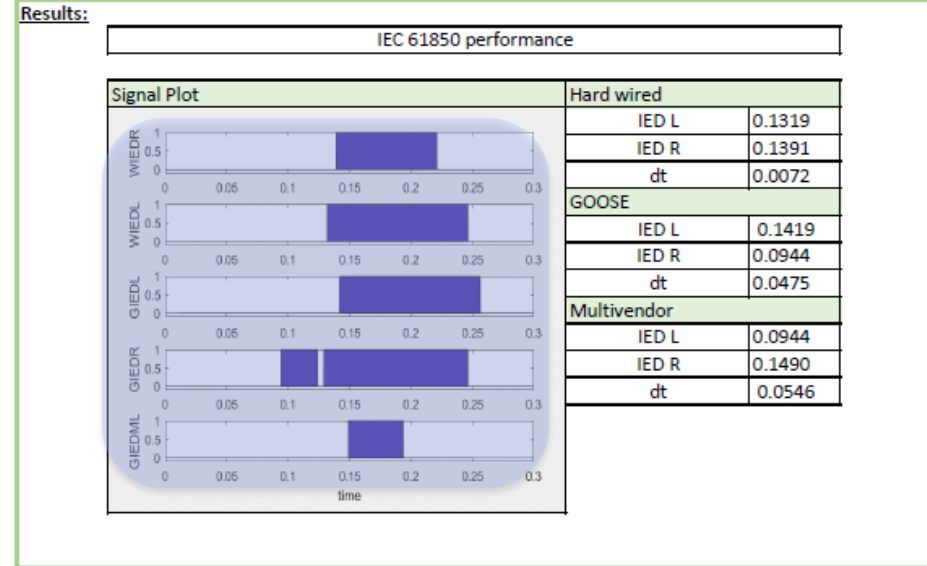
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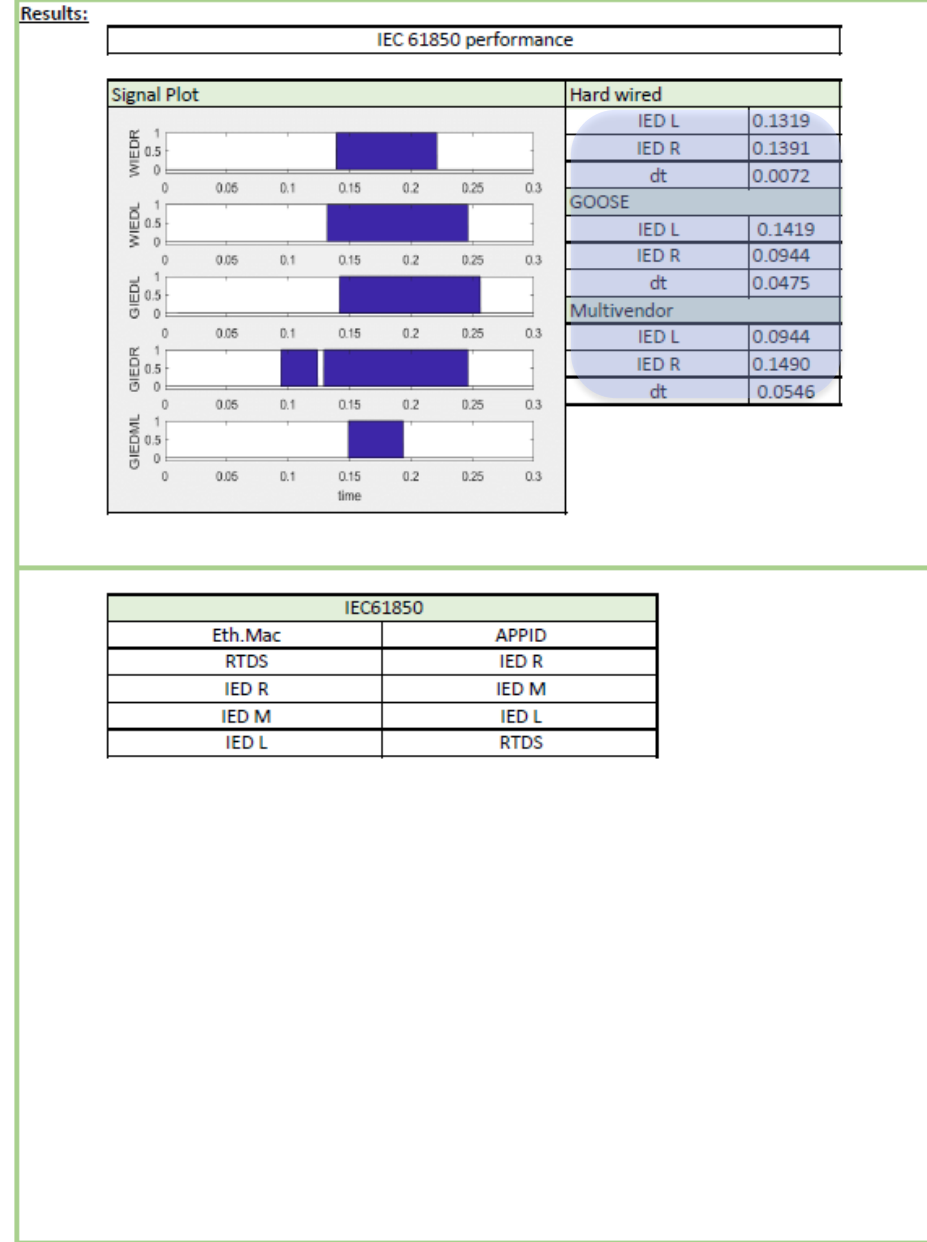
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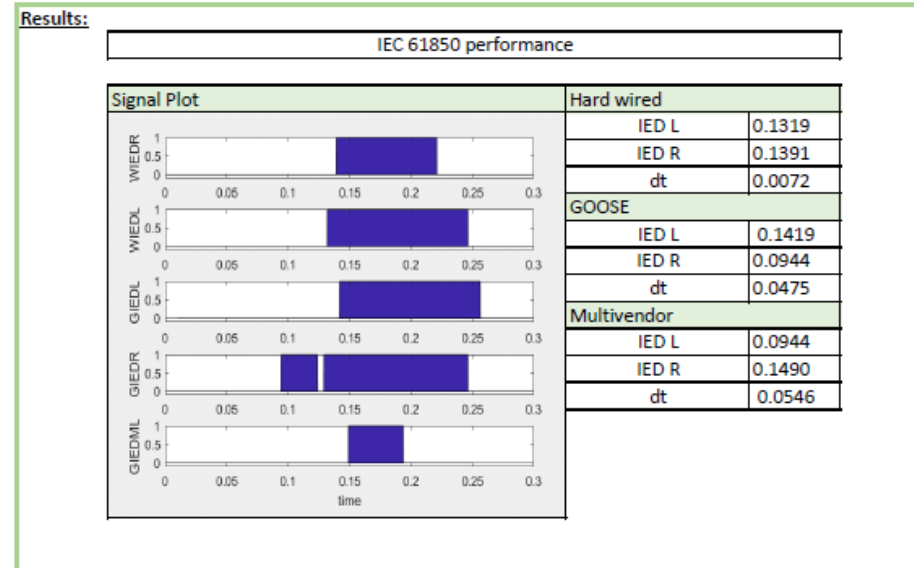
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Questions