GE VERNOVA

THE ENERGY TO CHANGE THE WORLD

Digital Substation Monitoring – Classical Approach

- **MMS Monitoring:**
  - Pooling each device LGOS, LSVS, LTMS.

- **Short comings:**
  - **Modeling** - Not every device **implement** those **LNs**.
  - **PTP** - not possible to monitor missing **path-delay-request,** missing **Sync/Announce.**
  - **PRP-** not possible to monitor duplicated messages or link absence.
  - **GOOSE** - it's not possible to get signal's **quality** changes and **stNum/sqNum wrong sequence**.
  - **SV** - it's not possible to monitor measures **quality** changes, **missing smpCnt.**

Process Bus Monitoring

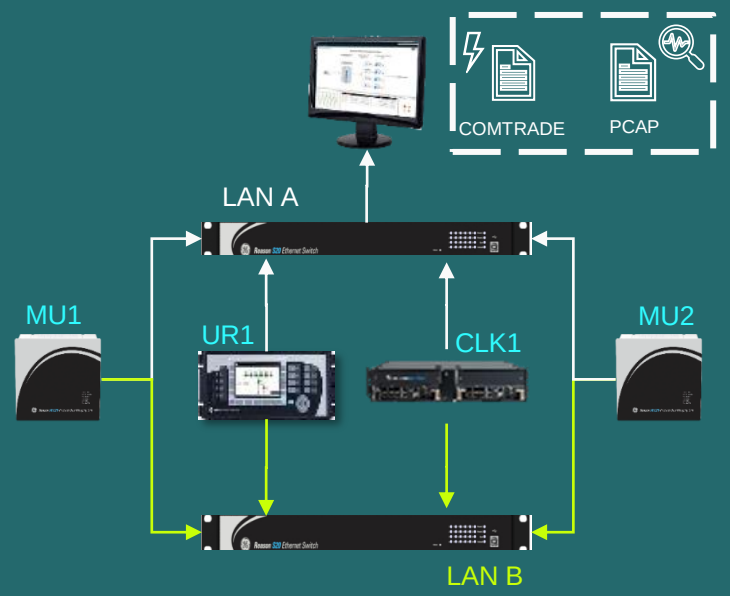
- Reduced configuration set-up (based on SCD)
- Independent of Modelling (Just sniffing)

- Capable to capture detailed registers for each traffic

- Associate Digital and Electrical registers for the DSS event

- Online and Offline event analysis
- Use standard files to investigate event

Test Architecture and Monitoring Tools



These tools are the result of more than 10 years developing products for DSS. Used within our R&D and V&V process.

OFF-LINE Tools

tt-prp-checker

- Detect messages published without PRP trailer
- Detect package from LANB sent at LANA

tt-ptp-checker

- Detect missing Sync/Announce.
- Identify missing Path-Delay-Req/Res

tt-goose-checker

- Detect changes in any signal status
- Detec messages that exceed its TTL

tt-pcap2comtrade

- Use the recorded PCAP file, extract SV and convert it to COMTRADE format.

ON-Line Tools

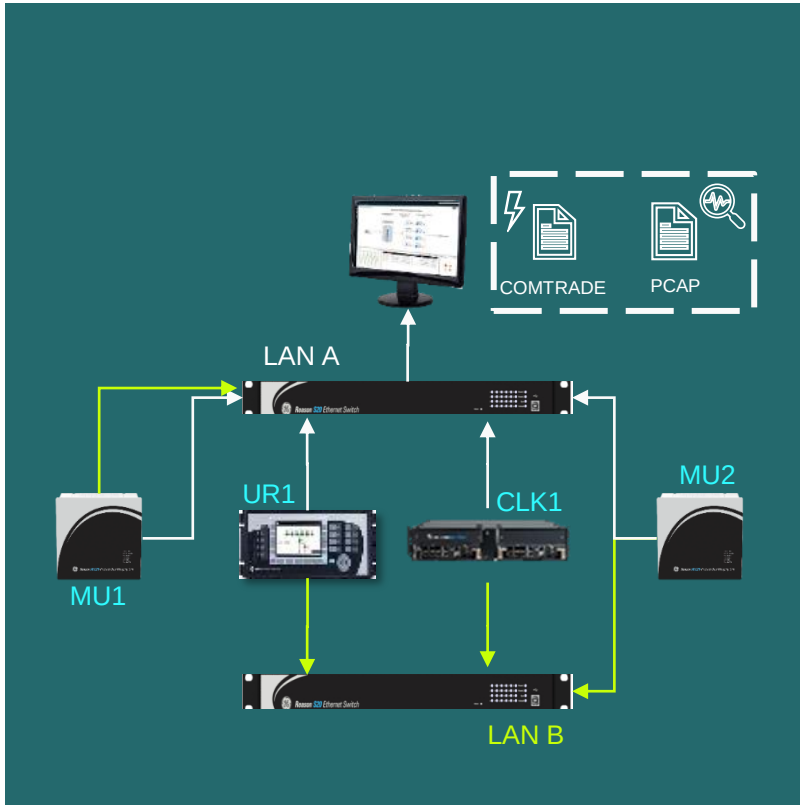
tt-sv-phasor-calc

- Calculate 1 phasor per SV stream in the network
- Detect Sync loss.
- Support IEC-61869-9 Profiles

tt-sv-analyzer-live-mult

- Detect Sync loss
- Detect missing SmpCnt per SV Stream.
- Support IEC-61869-9 Profiles

tt-prp-checker



Test Case

1. MU1 was configured to publish PRP messages
2. Both Ethernet ports were connected at the same LAN (A)
3. GOOSE messages from other IED was configured to be transmitted without PRP.
4. PCAP messages were recorded

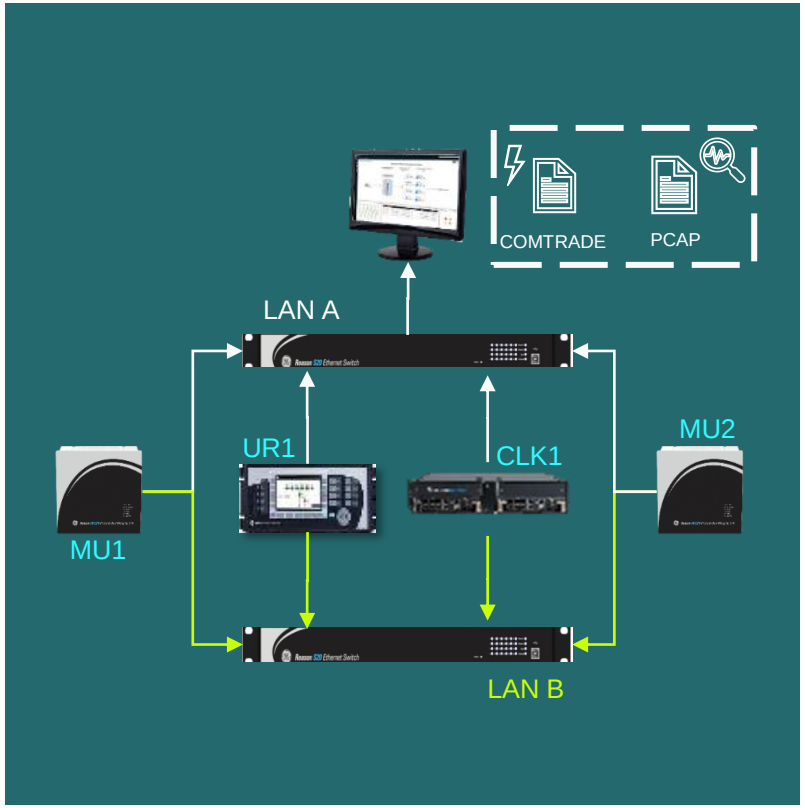
Results

26514 Duplicated messages were detected

28 messages **without PRP** trailer were detected by the tool

```
PS C:\Dev\ReasonProducts\Tools\tt-prp_rct_checker> py .\prp_rct_checker.py --pcap '..\PACOTES DUPLICADOS.pcapng'
------------------------------------------------------------
Number of packets without PRP Trailer: 28
Number of duplicates packets : 26514
Number of packets with wrong RCT: 0
```

tt-goose-checker



Test Case

Results

```
PS C:\Dev\ReasonProducts\Tools\tt-goose_checker> py .\goose_checker.py --pcap '..\Falha_MU-GE1.pcapng'
..\Falha_MU-GE1.pcapng is a pcapng file!
At time 2014-01-14 00:46:58.000000, New GOOSE Message detected in the network: RL1
At time 2014-01-14 00:46:58.000000, New GOOSE Message detected in the network: MU2
At time 2014-01-14 00:46:58.000000, New GOOSE Message detected in the network: GOID
At time 2014-01-14 00:46:58.000000, New GOOSE Message detected in the network: Switch
At time 2014-01-14 00:46:58.000000, New GOOSE Message detected in the network: MU1
At time 2014-01-14 00:46:58.000000, New GOOSE Message detected in the network: 52C
At time 2014-01-14 00:47:00.000000, New GOOSE Message detected in the network: 52A
At time 2014-01-14 00:47:02.000000, New GOOSE Message detected in the network: TxGOOSE1
At time 2014-01-14 00:47:02.000000, Frame number 117675, GOOSE ID Switch had a time-out.
 TTL = 2000
 Delay = 2999.856948852539 ms

At time 2014-01-14 00:47:03.000000, New GOOSE Message detected in the network: TxGOOSE2
At time 2014-01-14 00:47:04.000000, Frame number 158318, GOOSE ID 52A had a time-out.
 TTL = 2000
 Delay = 2999.9051094055176 ms

At time 2014-01-14 00:47:08.000000, Frame number 263993, GOOSE ID 52A had a time-out.
 TTL = 2000
 Delay = 2999.9160766601562 ms

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----- GOOSE Checker Results --------
Total APDU decode failures: 0
Total Timeouts : 3
```
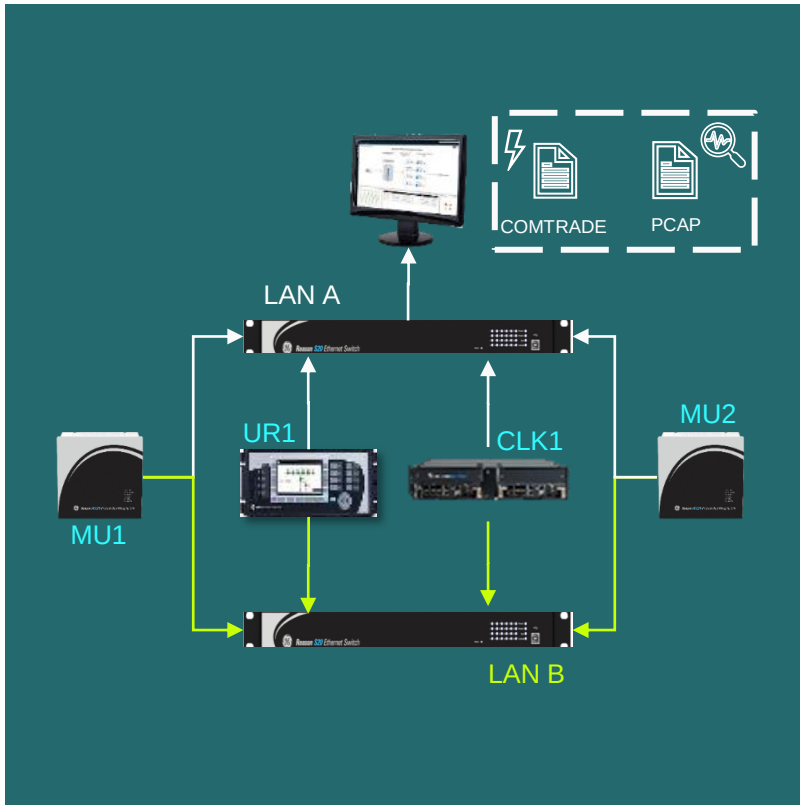

tt-sv-analyzer-live-mult

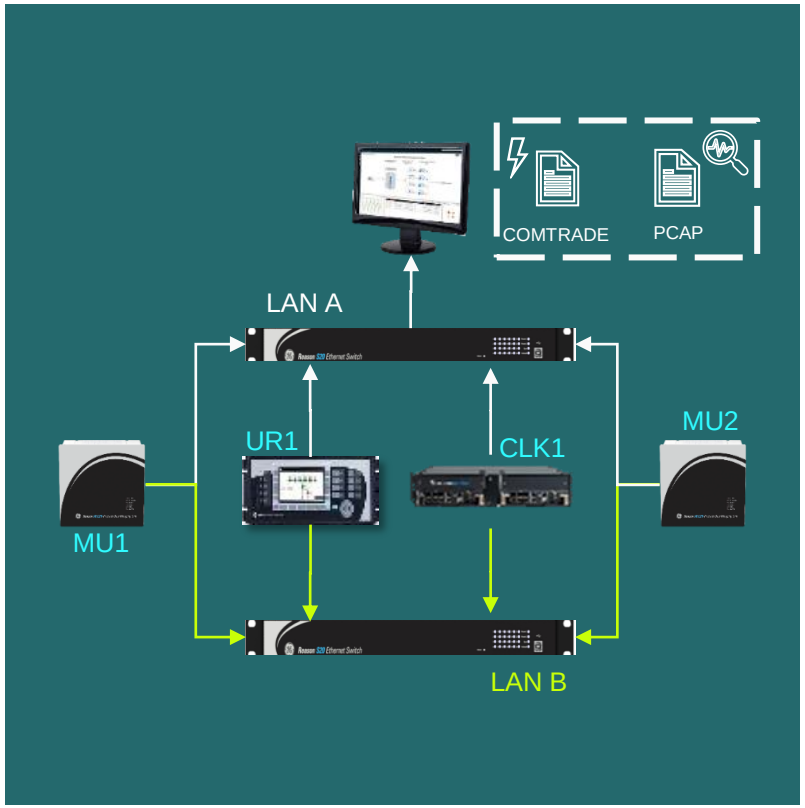


Test Case

Results

```
************************************************************
************************************************************
----- Statistics for SV stream with SVID 4013, Destination MAC Address 0x0030a717bde5 and APPID 0x4013 --------
First packet timestamp: 2014-01-14 00:39:09.000000
Total SV packets: 126104
Minimum time between SV packets: 9.989738464355469e-05
Maximum time between SV packets: 0.0003261566162109375
Average time between SV packets: 0.00020832466317035375
Total missed smpCnts: 0
Shortest sequence of missed smpCnt: 0
Longest sequence of missed smpCnt: 0
Average sequence of missed smpCnt: 0
Valid PPS count: 26
Minimum time between PPS: 0.9999349117279053
Maximum time between PPS: 0.9999809265136719
Average time between PPS: 0.9999585151672363
************************************************************
************************************************************
----- Statistics for SV stream with SVID MU52A, Destination MAC Address 0xf8027781068e5 and APPID 0x4020 --------
First packet timestamp: 2014-01-14 00:39:09.000000
Total SV packets: 114646
Minimum time between SV packets: 7.200241088867188e-05
Maximum time between SV packets: 0.0023419857025146484
Average time between SV packets: 0.00022914355671188992
Total missed smpCnts: 266
Shortest sequence of missed smpCnt: 9
Longest sequence of missed smpCnt: 10
Average sequence of missed smpCnt: 9.851851851851851
Valid PPS count: 23
Minimum time between PPS: 0.9999539852142334
Maximum time between PPS: 1.9999208450317383
Average time between PPS: 1.136316548694264
************************************************************
```

tt-sv-phasor-calc



Test Case

Results

```
************************************************************
************************************************************
----- Statistics for SV stream with SVID 4011, Destination MAC Address 0x0030a717cbeb and APPID 0x4011 --------
First packet timestamp: 2023-08-04 16:30:11.000000
Channel 0 ----
Module: 1466.33          Phase: 180.00    Frequency: 0.00
Channel 1 ----
Module: 2184.97          Phase: 180.00    Frequency: 0.00
Channel 2 ----
Module: 2454.46          Phase: 180.00    Frequency: 0.00
Channel 3 ----
Module: 6105.77          Phase: 180.00    Frequency: 0.00
Channel 4 ----
Module: 1507.77          Phase: 180.00    Frequency: 0.00
Channel 5 ----
Module: 1037.59          Phase: 180.00    Frequency: 0.00
Channel 6 ----
Module: 3456.10          Phase: 180.00    Frequency: 0.00
Channel 7 ----
Module: 6001.47          Phase: 180.00    Frequency: 0.00
Total Samples: 9362
************************************************************
************************************************************
----- Statistics for SV stream with SVID 4013, Destination MAC Address 0x0030a717bde5 and APPID 0x4013 --------
First packet timestamp: 2023-08-04 16:30:11.000000
Channel 0 ----
Module: 2723.28          Phase: 180.00    Frequency: 0.00
Channel 1 ----
Module: 1135.38          Phase: 180.00    Frequency: 0.00
Channel 2 ----
Module: 2430.82          Phase: 180.00    Frequency: 0.00
Channel 3 ----
Module: 6289.48          Phase: 180.00    Frequency: 0.00
Channel 4 ----
Module: 929.95    Phase: 6.49     Frequency: 599.00
Channel 5 ----
Module: 1048.89          Phase: 13.73     Frequency: 599.00
Channel 6 ----
Module: 2039.48          Phase: 180.00    Frequency: 0.00
Channel 7 ----
Module: 3352.04          Phase: 180.00    Frequency: 0.00
Total Samples: 9362
************************************************************
```

Conclusions

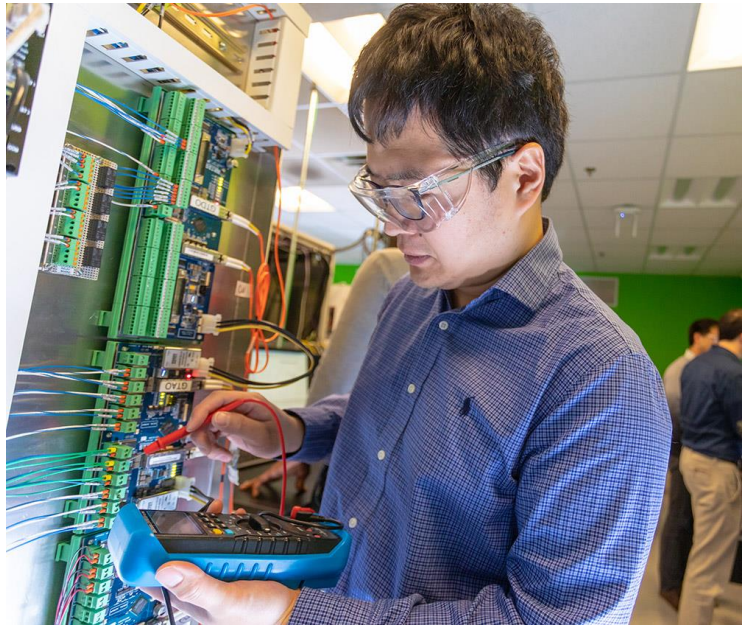
The discussions about the DSS Network Fault Recorder (D-NFR) are in its preliminary stages.

GE's approach considers that by monitoring directly the PB we'll bring more value to the user.

This event allowed us to test the concept, its strenghts and chanllenges.

Up coming next:

- Continue investing in the D-NFR technology
- Surpass the PoC stage
- Cross-Compile the developed tools so they can run in a purpose specific HW.



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Q+A