

GOOSE Auditor



GOOSE Auditor is a solution for engineers commissioning IEC 61850 substations. It consists of two components: a tap for filtering and capturing GOOSE packets and a protocol analysis application. A handheld tap captures the messages to GOOSE Monitor, which displays the topology of the installation, the configuration and status of each node, the messages between IEDs, the changes caused by the protocol, and reports any events that may occur.



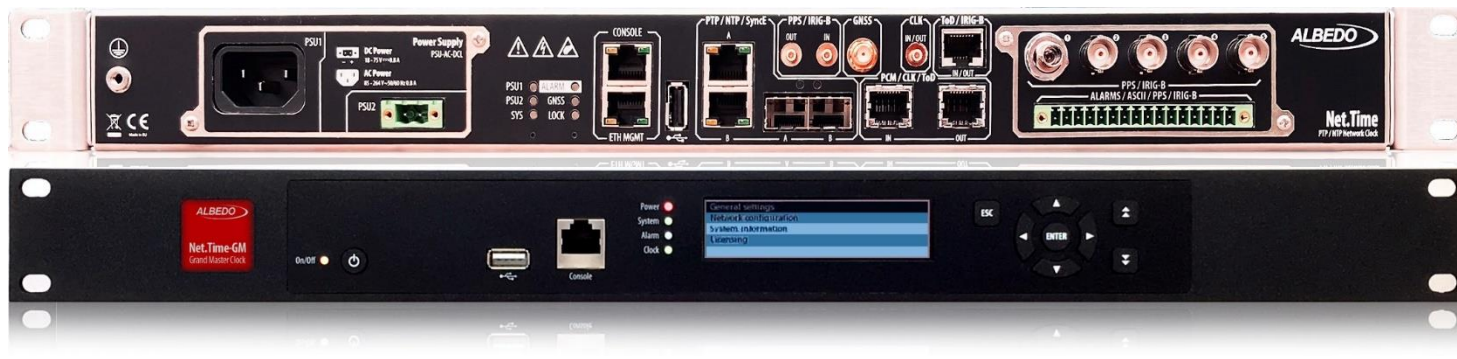
ALBEDO: a global player of **telecom** appliances



ICT electronics
(1983)



Trend Comms
(2001)



ALBEDO (2009-today)



GOOSE Auditor is the solution that allows engineers to quickly **deploy, commission, monitor** and **troubleshoot** the IEC 61850 GOOSE protocol ensuring the correct configuration of Publishers and Subscribers, as well as a reliable operation, detecting bad and inconsistent messages.

GOOSE Monitor - [SGMT]

File Edit View Tools Help

IEDs

Index	Name	Alerts	Publications	Subscriptions
1	SGMT_01	●	●	●
2	SGMT_02	●	●	●
3	SGMT_03	●	●	●
4	SGMT_04	●	●	●
5	SGMT_05	●	●	●
6	SGMT_06	●	●	●
7	SGMT_07	●	●	●
8	SGMT_08	●	●	●
9	SGMT_09	●	●	●
10	SGMT_10	●	●	●
11	SGMT_11	●	●	●

Publication States: ● All Seen ● Some Seen ● None Seen ● Some or All Simulated

Subscription States: ● All Active ● Some Active ● None Active ● No LGOS ● Connection Error

Alert States: ● No Alerts ● Alerts Latched ● Alerts Active LPHD In Simulation Mode

Details

- SGMT_01 (LGOS OK)
 - AP1
 - SGMT_01Device1
 - GOOSE Control Blocks
 - gocbG1
 - gocbR1
 - LGOS References
 - LGOS1
 - LGOS2
 - LGOS3
 - LGOS4

Displaying All IEDs Reset Graph

Node States: ● LGOS OK ● LGOS Not OK ● No LGOS ● Connection Error ● Simulation Processed

Edge TAL Unexpired: ● LGOS OK ● LGOS Not OK ● No LGOS ● Connection Error ● Data Quality

Edge TAL Expired: ● LGOS OK ● LGOS Not OK ● No LGOS ● Connection Error ● CB Problem

2020-05-20 09:52:14.173 Switching IED (SGMT_18) Publication_State from (Some GSEControl Blocks Seen) to (All GSEControl Blocks Seen)

GSEControl (gocbG1AP2) TAL Unexpired

GSEControl (gocbR1AP2) TAL Unexpired

GSEControl (gocbG1AP1) TAL Unexpired

GSEControl (gocbR1AP1) TAL Unexpired

2020-05-20 09:52:14.174 Switching IED (SGMT_18) Edge Publication GseControl (gocbG1AP1) Subscribing IED (SGMT_05) from (TAL Expired LGOS OK) to (TAL Unexpired LGOS OK)

● On
Blocked
Test
Test Blocked
Off

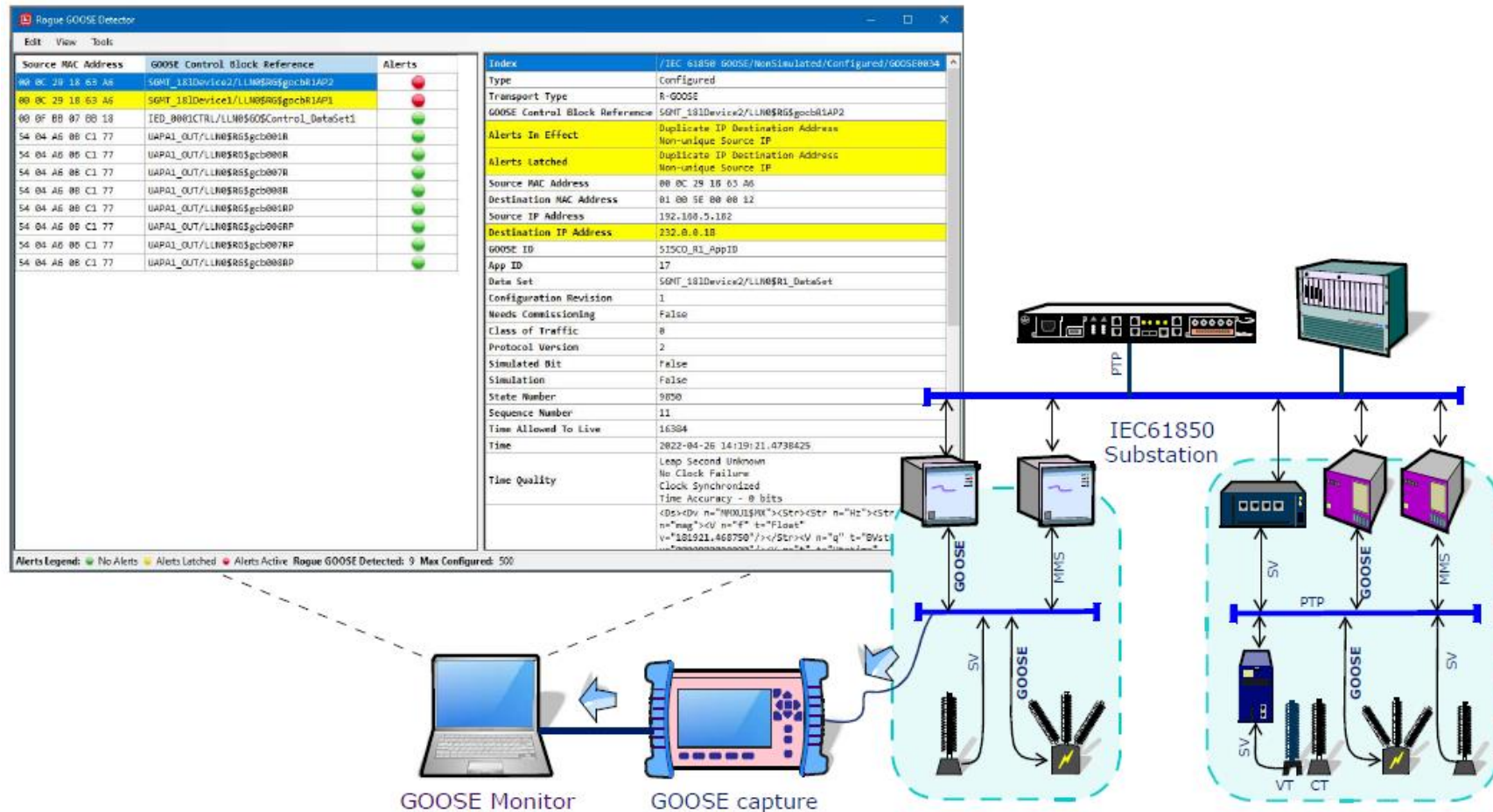
● Rogue GOOSE Detected GOOSE Interface is Running

GOOSE Auditor is an essential tool for **substation automation** and **protection systems** using GOOSE. It provides an intuitive visualisation of the IED topology with the flows of GOOSE messages in order to assist engineers in the identification of issues displaying the data contents and status in real time to monitor every change. The result is a solution that facilitates a consistent management of GOOSE.

2 x Components



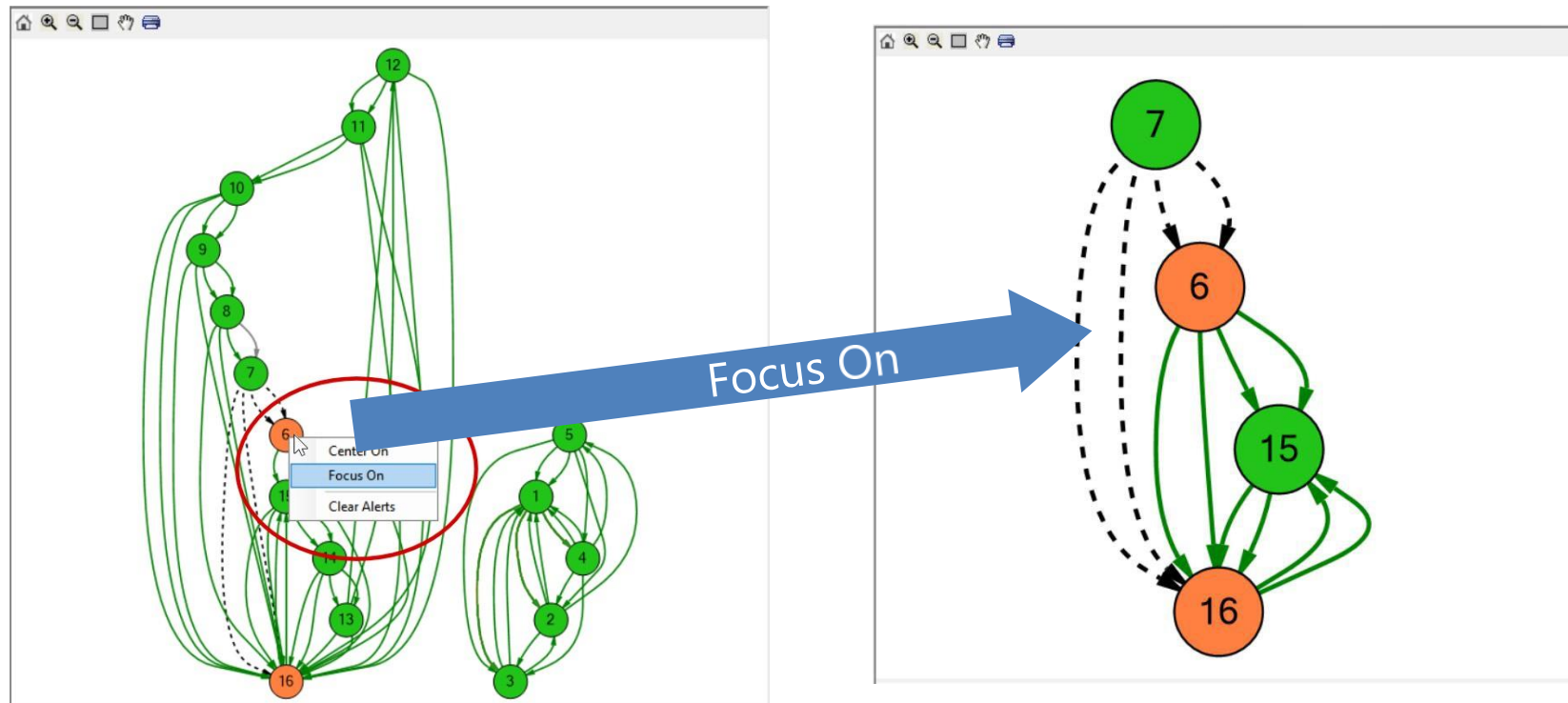
- ◆ GOOSE Auditor is a software made of component, a hand-held tap and a laptop with the application:
 - The laptop executes GOOSE Monitor application that represents the GOOSE interactions in several level of details displaying, in real-time, all data structures and the device status.
 - The laptop is the hand-held tap designed to easy capture of GOOSE messages ensuring none will be lost nor cause impairments to the rest of the IEC-61850 traffic.

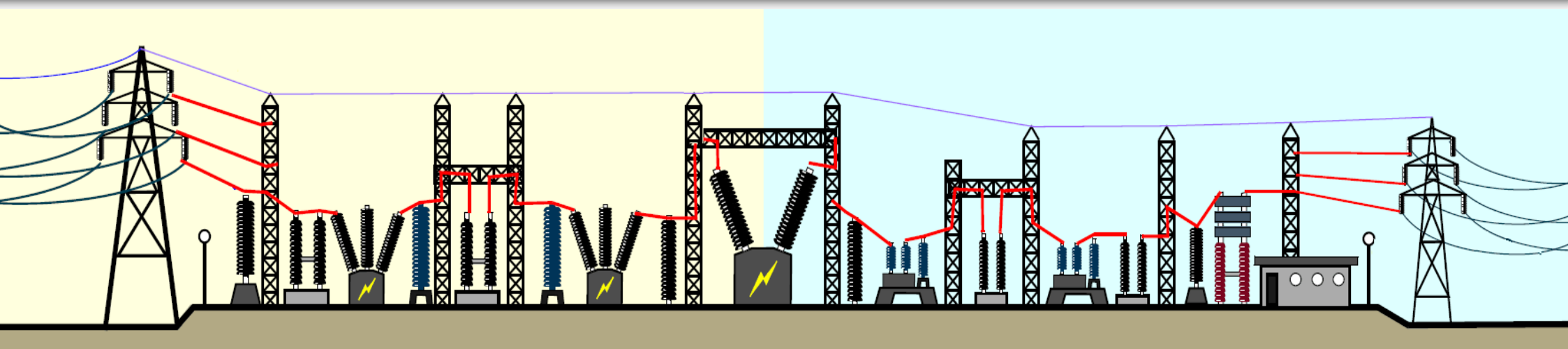


Substations using GOOSE have to deal with thousands of messages constantly being exchanged between IEDs. Trying to determine whether a particular protocol sequence is correct is a tedious task because GOOSE messages are cryptic, difficult to decode and difficult to correlate.

GOOSE Auditor helps to discover the topology, assist with configuration, display protocol flows, IED relationships, detect alarms... everything needed to commission and troubleshoot the IEC-61850 installation.

- GOOSE Auditor captures GOOSE/R-GOOSE packets using Net.Hunter or a PC/Laptop
- Captures and displays publication and subscription status for all the GOOSE messages in a real-time
- Provides the substation engineer with the ability to see at a glance if there are problems and the source of the problem
- Uses graphical visualisation to help engineers quickly identify where problems are occurring





- **Automatic configuration**, visualisation and communications in a single step using SCL files
- **Subscriber** information from Logical Nodes (LGOS) to indicate which IEDs are not receiving the expected data
- GOOSE data extracted from the **Publishers**
- Details are displayed, including data set values, device mode, LGOS subscriptions, quality, timestamps...
- Detection of **Rogue messages**, unconfigured, error conditions, including duplicate publishers, out of sequence messages, mismatched ConfRevNum
- **Syslog client** so that all error conditions can be monitored locally or remotely for security purposes

The screenshot shows the Packet Monitor application interface. At the top, there is a menu bar with 'File', 'Capture', and 'Tools'. Below it is a toolbar with icons for refresh, filter, and zoom. The main area is a table titled 'Packet List' with columns: No., Time, Source, Destination, Protocol, IED, CB Ref, Network Interface Index, Network Interface Name, Network Adapter Name, and Network Interface IP Addresses. The table contains 25 rows of data, with row 256 highlighted in blue. Below the table, there is a section titled 'Frame 256:' which shows the details of the selected packet. This section includes 'Arrival Time: Sep 21, 2021 12:17:10.1128270', 'GOOSE' protocol details, and 'Packet Contents' which lists various parameters like AppID, Message Type, Control Block Reference, Time Allowed To Live, Dataset Reference, GOOSEID, Event Timestamp, State Number, Sequence Number, and Simulation Bit. At the bottom, there is a section titled 'Raw Packet Data' showing a hex dump of the packet bytes.

No.	Time	Source	Destination	Protocol	IED	CB Ref	Network Interface Index	Network Interface Name	Network Adapter Name	Network Interface IP Addresses
251	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
252	2021-09-21 12:17...	192.168.5.45	192.168.66.34	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
253	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
254	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
255	2021-09-21 12:17...	192.168.5.45	192.168.66.34	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
256	2021-09-21 12:17...	00:0F:BB:07:BB:18	01:0C:CD:01:00:45	GOOSE	IED_0001CTRL/...		3	Ethernet0	\Device\NPF_{4...	192.168.5.45
257	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
258	2021-09-21 12:17...	192.168.2.81	192.168.1.135	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
259	2021-09-21 12:17...	192.168.1.135	192.168.2.81	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
260	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
261	2021-09-21 12:17...	192.168.5.45	192.168.66.34	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
262	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
263	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
264	2021-09-21 12:17...	192.168.5.45	192.168.66.34	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
265	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
266	2021-09-21 12:17...	192.168.66.34	192.168.5.45	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45
267	2021-09-21 12:17...	192.168.5.45	192.168.66.34	TCP			3	Ethernet0	\Device\NPF_{4...	192.168.5.45

Frame 256:
 Arrival Time: Sep 21, 2021 12:17:10.1128270
 GOOSE
 AppID: 0
 GOOSE Message Type: Goose
 Control Block Reference: IED_0001CTRL/LLN0\$go\$control_DataSet1
 Time Allowed To Live: 2000 ms
 Dataset Reference: IED_0001CTRL/LLN0\$DataSet1
 GOOSEID: 1
 Event Timestamp: 2021-09-12 07:11:12.4677735
 State Number: 2
 Sequence Number: 609309
 Simulation Bit: FALSE

Raw Packet Data

```

0000 01 0c cd 01 00 45 00 0f bb 07 bb 18 88 b8 00 00 .....E.....
0010 00 7c 00 00 00 00 61 72 80 25 49 45 44 5f 30 30 .l...af.%IED_00
0020 30 31 43 54 52 4c 2f 4c 4c 4e 30 24 47 4f 24 43 01CTRL/L LN0$GO$C
0030 6f 6e 74 72 6f 6c 5f 44 61 74 61 53 65 74 31 81 ontrol_D ataSet1.
0040 02 07 d0 82 1a 49 45 44 5f 30 30 30 31 43 54 52 .....IED_0001CTR
0050 4c 2f 4c 4c 4e 30 24 44 61 74 61 53 65 74 31 83 L/LLN0$D ataSet1.
0060 01 31 84 08 61 3d e0 50 77 c0 00 0a 85 01 02 86 .l..a=.P w.....
0070 03 09 4c 1d 87 01 00 88 01 01 89 01 00 8a 01 02 ..L.....
0080 ab 08 84 03 03 c1 00 83 01 00 .....
    
```

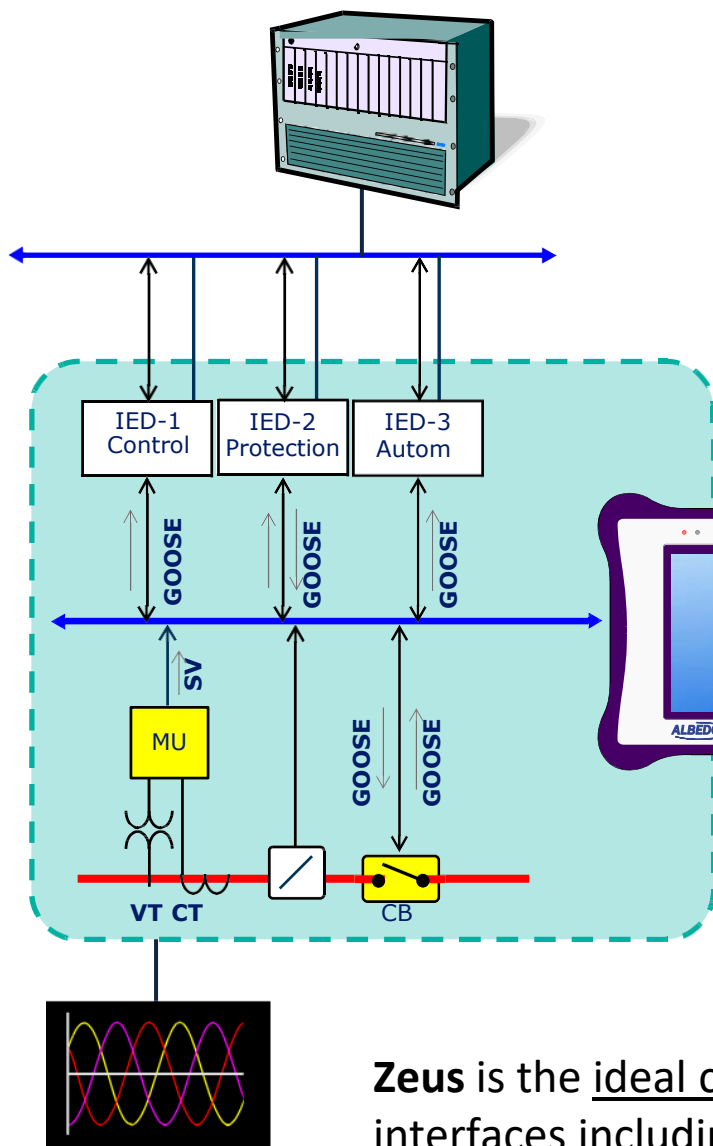
Capture Completed Captured Packets Count: 388

Packet Monitor is the application that provides an intuitive way to capture, view, store and replay GOOSE network traffic from one or more interfaces.

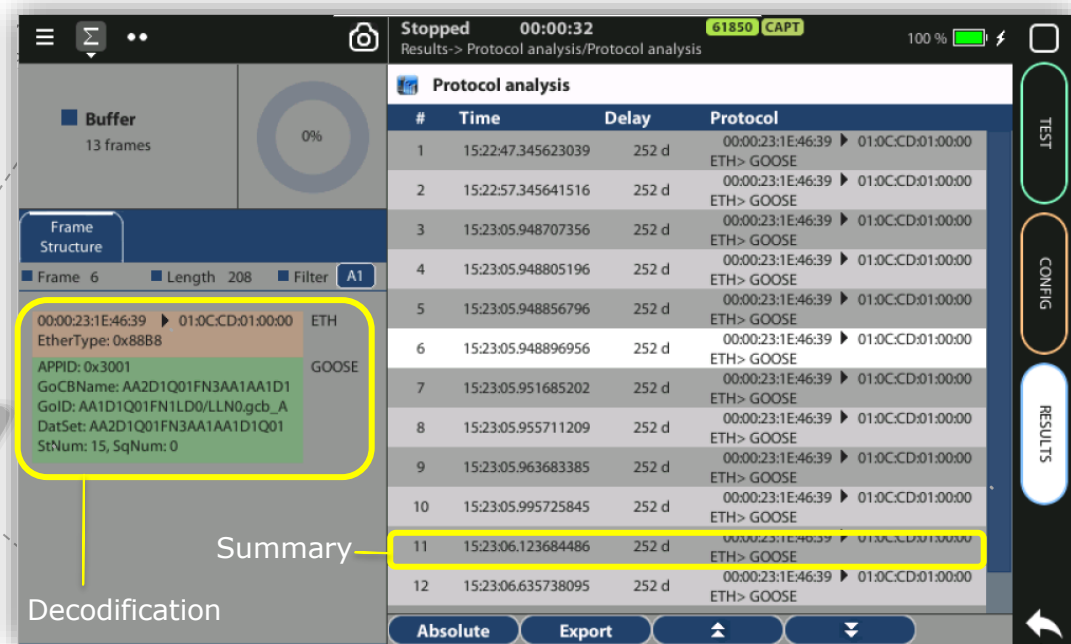
Captures can be filtered by:

- IED
- Control Block Reference
- Protocol types
- Date/Time
- Ignored retransmissions

Messages can be saved to disc for later analysis. It can also read GOOSE messages captured by other devices and stored in PCAP.



Packet Monitor can read GOOSE messages captured and saved in PCAP format by **Zeus** which a tester designed for the **installation & maintenance** of communications in the energy industry.



Zeus is the ideal complement to **GOOSE Auditor** as it supports legacy and IEC-61850 interfaces including Ethernet / IP, MPLS, PTP, SyncE, ToD, IRIG-B, T1 / E1, C37.94, G703, RS-232, GOOSE... used in the infrastructures of the utility substation.

Unauthorised messages are called **Rogue messages** because they can be disruptive and potentially dangerous to the substation. GOOSE Auditor alerts, captures and logs them according to several criteria:

The screenshot shows the 'Rogue GOOSE Detector' application window. It is divided into three main sections:

- Rogue GOOSE List:** A table listing detected messages with columns for Source MAC Address, GOOSE Control Block Reference, and Alerts. Two messages are highlighted in yellow, indicating they are active alerts.
- Rogue GOOSE Details:** A detailed view of a specific message, showing fields like Index, Type, Transport Type, Alerts In Effect, Alerts Latched, Source MAC Address, Destination MAC Address, Source IP Address, Destination IP Address, GOOSE ID, App ID, Data Set, Configuration Revision, Needs Commissioning, Class of Traffic, Protocol Version, Simulated Bit, Simulation, State Number, Sequence Number, Time Allowed To Live, Time, and Time Quality.
- Alerts Legend:** A legend at the bottom left showing 'No Alerts' (green circle), 'Alerts Latched' (yellow circle), and 'Alerts Active' (red circle). It also displays 'Rogue GOOSE Detected: 9' and 'Max Configured: 500'.

- Expired TAL
- Invalid StNum
- Missed StNum
- Out of Range StNum
- Out of Range SqNum
- Duplicate Frame
- Switched Simulation Mode
- Mismatched GOID
- Mismatched Dataset
- Unexpected ConfRev
- Bad Data
- Multiple Publishers
- Duplicate MAC/IP Address
- Non-unique Source IP

Utility Substations



Automation + Protection



Troubleshooting

Monitoring

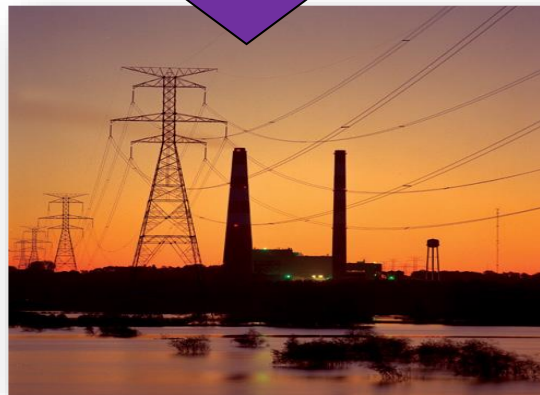
GOOSE Auditor

Commissioning

Configuration



IEC-61850 deployments



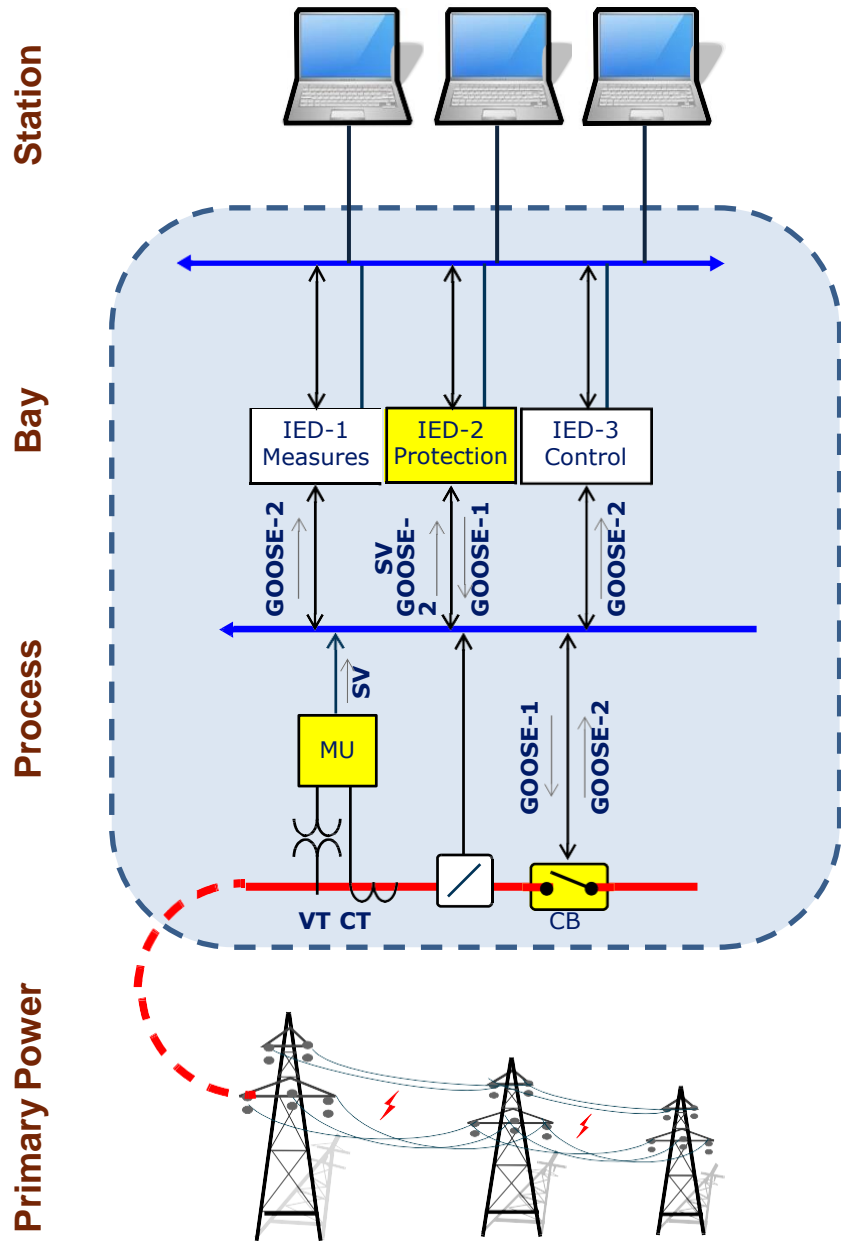
IEDs & Relays



GOOSE Auditor facilitates the design of substations, the IEDs configuration and monitors the operation providing information on data structure, traffic, status and alerts:

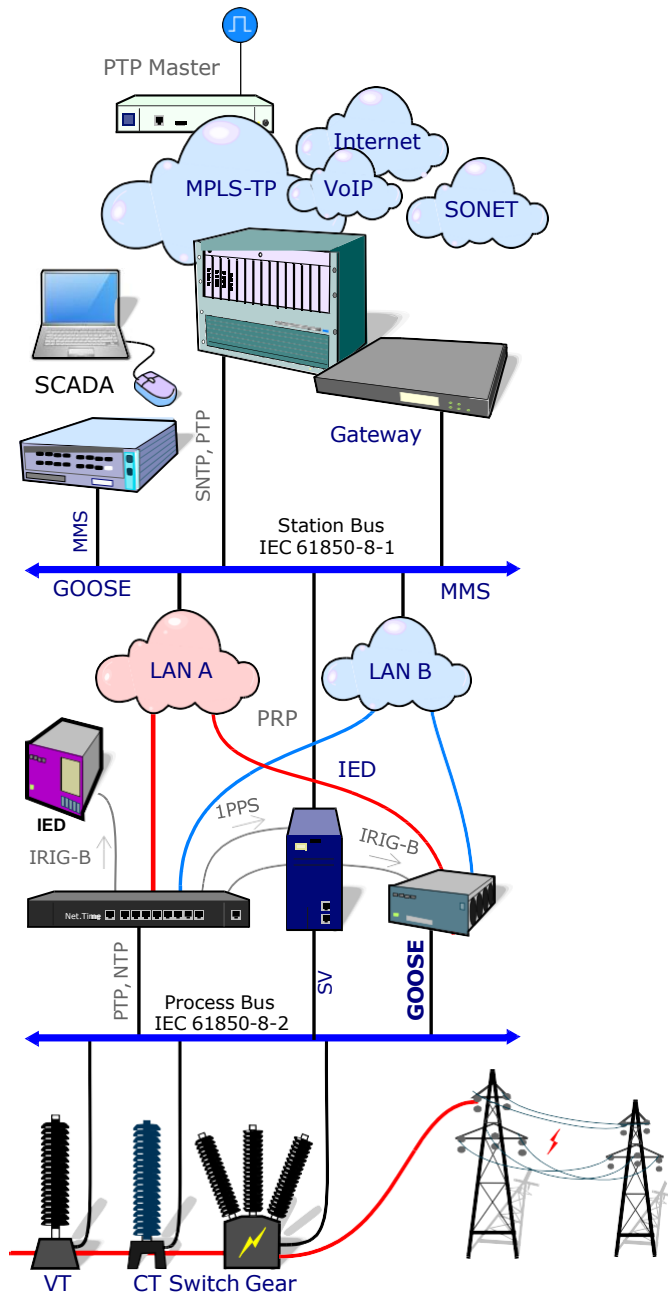
- Unrecognised message
- Configuration error
- Invalid source or destination address
- Unpaired message due to invalid ID
- Block does not match definitions
- Message published from multiple sources
- Message out of range
- Missing message

All the messages and events can be reported in the log.



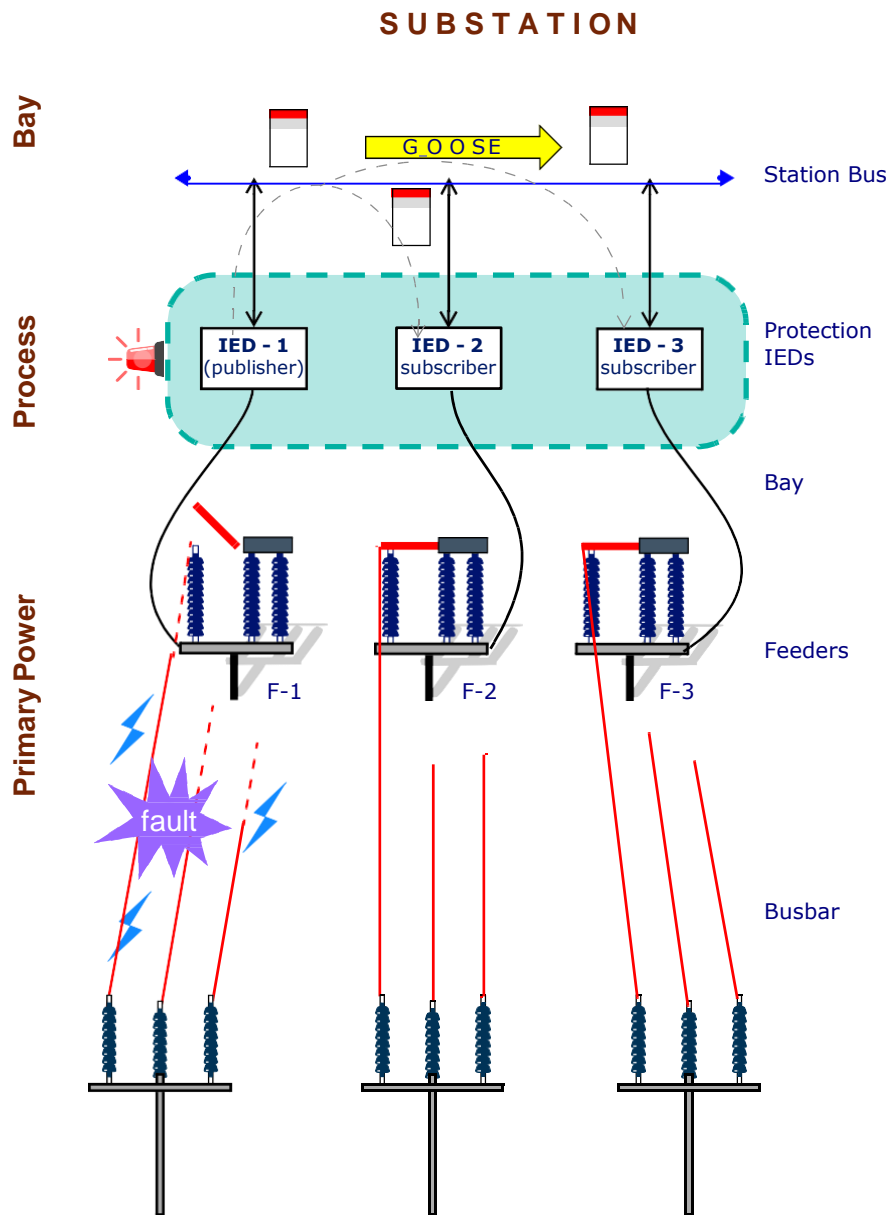
GOOSE Auditor can support GOOSE deployment by decoding messages, checking latencies, detecting rogue and invalid messages, generating special commands that are key factors to consider when verifying:

- 1. Device Compatibility:** Ensure that all devices are compatible and support the GOOSE standard.
- 2. Network Topology:** Determine the requirements such as bandwidth, latency, redundancy required by GOOSE.
- 3. Message Configuration:** Configure the messages with the appropriate data attributes and types of events that will trigger the transmission of GOOSE messages.
- 4. Security:** Ensure protection against unauthorised access, hacking, or other security breaches.

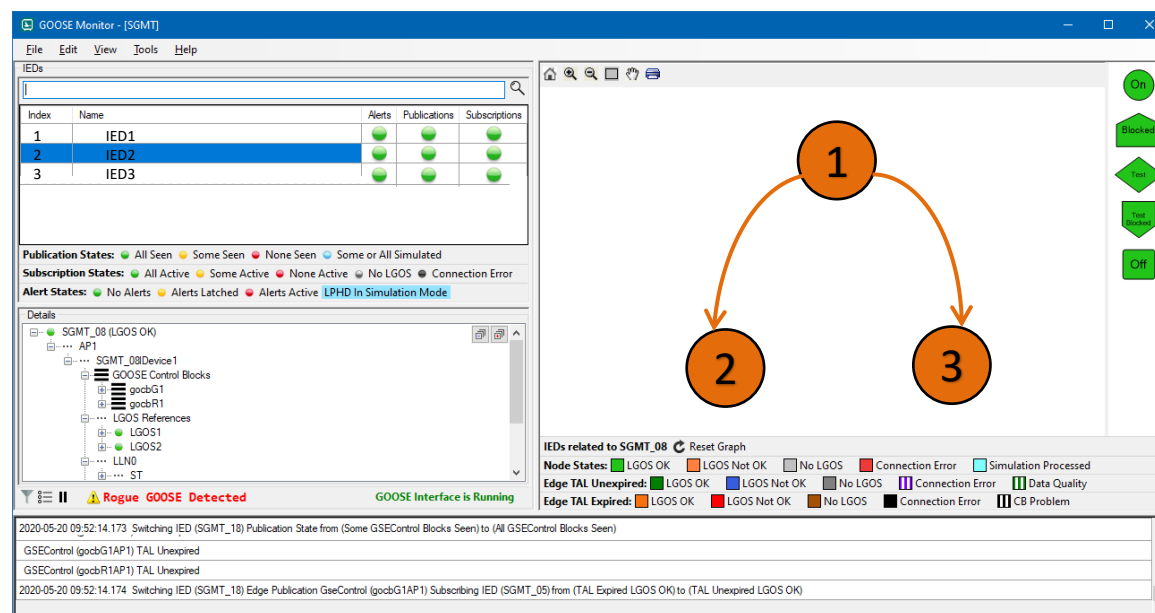


IEC-61850 acceptance and commissioning requires a detailed and rigorous testing process using GOOSE Auditor:

- 1. Documentation:** Verify details and ensure that all required documentation, including manuals, datasheets and test reports are available and complete.
- 2. Configuration:** Verify that the IED is correctly configured, including GOOSE messages (data attributes, data type, data length, etc).
- 3. Test:** Verify that the IED is functioning correctly and that the GOOSE is functioning as intended. Perform functional, interoperability and performance tests.
- 4. Communication:** Verify that the topology is appropriate and then ensure that the Publisher and Subscriber IEDs communicate properly.
- 5. Security:** Apply security measures to prevent unauthorised access and detect rogue messages.
- 6. Commissioning:** Verify that all connections are secure, and that settings are well configured.



IED-1, which protects Feeder-1, detects a fault and then sends a GOOSE message to indicate that an inrush condition will occur as a result of a voltage recovery. On receiving the message, IED-2 and IED-3 adjust their settings in anticipation of the inrush.



During the test of this procedure, GOOSE Auditor displays the IED and the sequence of messages and changes of the IED to block the sensitive overcurrent. It will also display any events that may eventually occur.

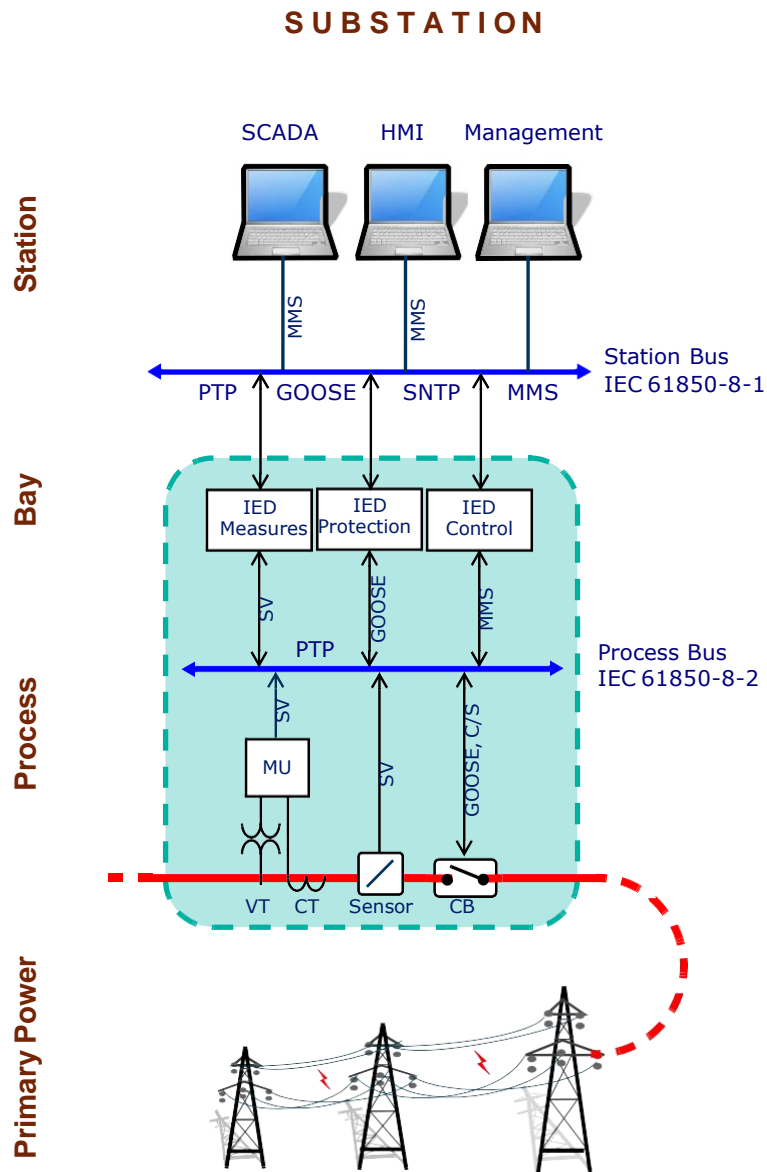


◆ Comprehensive tool

- Supports local or remote monitoring of faults and potentially harmful conditions, enabling proactive maintenance of the protection system.
- Flexible configuration environment supports a variety of configuration methods, enabling use in any IEC 61850 system, even with incomplete or missing Substation Configuration Language (SCL) files.
- Support for Ethernet GOOSE and Routable GOOSE (R-GOOSE) enables use in both LAN and WAN.
- Hand-held, battery-powered tap for filtering and capturing in hard-to-reach locations without losing messages or affecting IEC 61850 traffic.

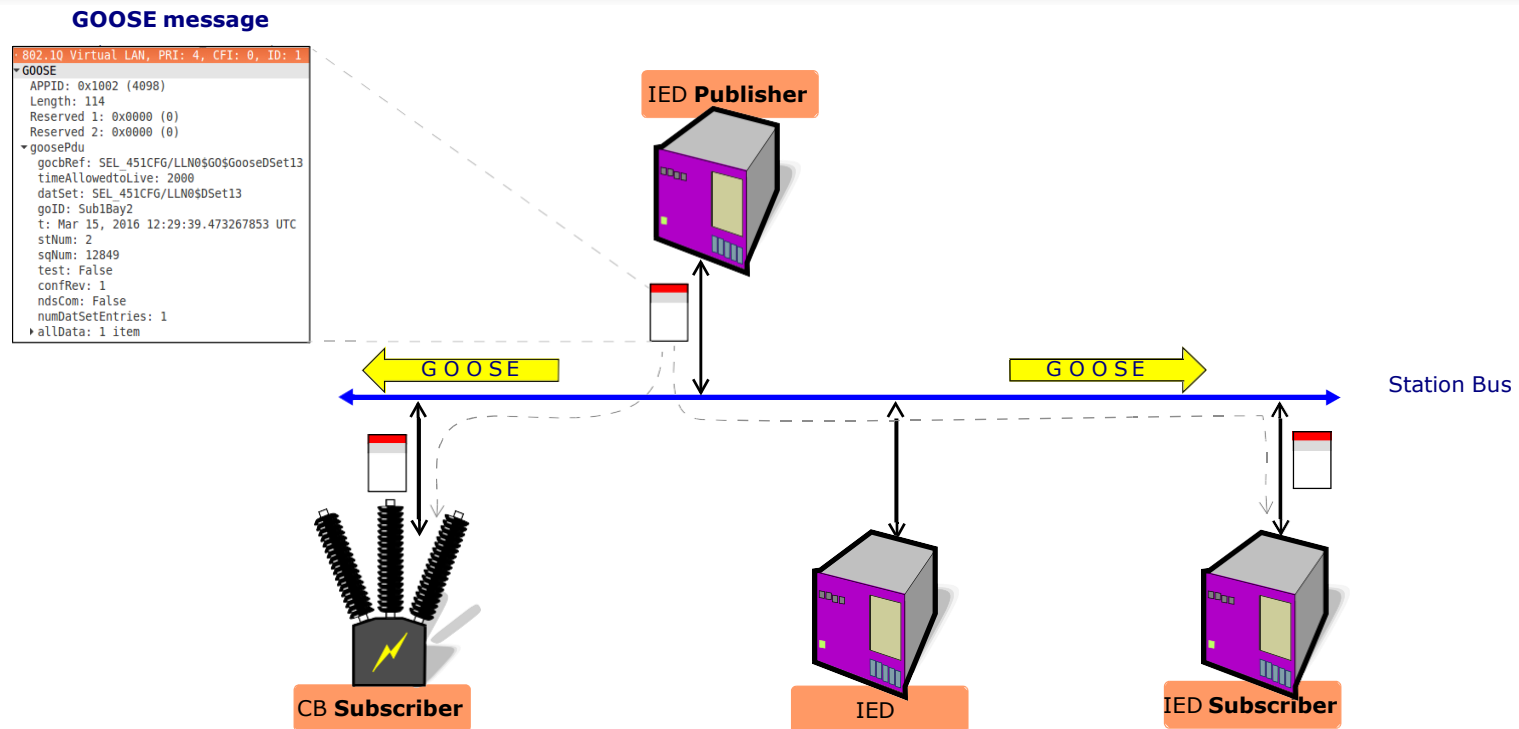
◆ Advanced Graphical Interface

- Visualisation enables substation engineers view the complete architecture of the network
- Instantly representation of the events, errors or alarms that may occur
- Display of the messages flows and state changes of devices

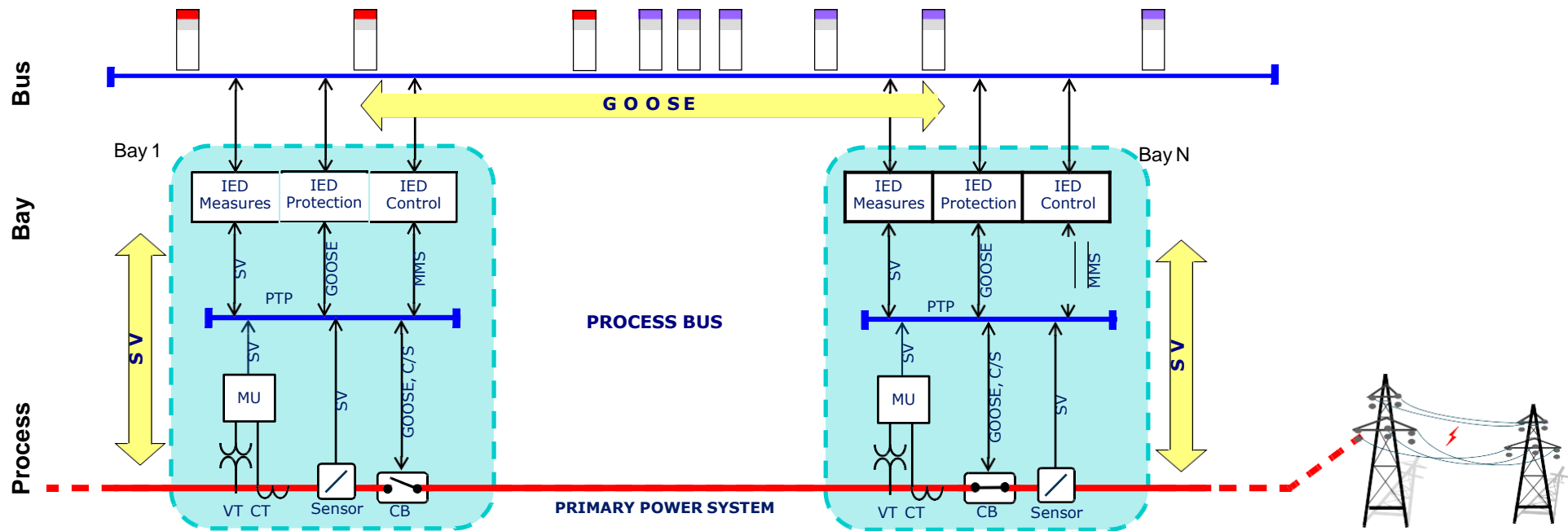


GOOSE is a messaging system used by IEDs and mission critical applications to communicate substation events such as commands, alarms, indications and measurements:

- Applications include switchgear tripping, disturbance recorder starting, interlocking position indication and teleprotection.
- As an L2 protocol, GOOSE operates in a real-time Ethernet context and is used for fast / reliable data distribution.
- The publisher/subscriber method is used: an IED sends a message that can be read by N receivers.
- The response of each receiver depends on its functionality and configuration. For example, a message indicates the position of the circuit breaker (open, closed, intermediate).
- No ACK mechanism, but messages are repeated cyclically for a certain time, even if there are no changes. The idea is to stay connected as a polling.
- Simplifies cabling, while the use of fibre optics unifies the traffic, dramatically reducing metallic cables.
- GOOSE is vendor interoperable and scalable.



- GOOSE mapped directly to Ethernet for real-time communication
- Point-to-Multipoint connection or Multicast Application Association (MCAA)
- This method provides efficient information exchange between IEDs
- Circuit breaker tripping: short information that must be sent without loss within msec
- The Publisher IED sends a message that only the subscribers receive; the reaction of each receiver depends on its configuration and functionality



Under normal operating conditions, the IED transmits and retransmits GOOSE messages cyclically - this is the heartbeat of the substation. The health of the GOOSE messages is closely monitored to ensure timely delivery. A missing message is an indication to subscribers that communication from the publisher has been disrupted.

GOOSE messages are repeated to account for possible lost datagrams due to congestion or failure scenarios. The IEC 61850 architecture prioritises GOOSE and SV traffic to guarantee high speed and avoid degradation of Layer 3 traffic used for normal Ethernet LAN traffic.

```

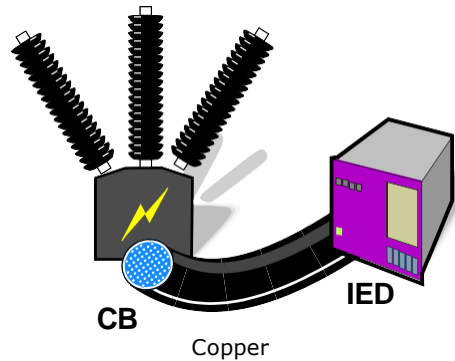
802.1Q Virtual LAN, PRI: 4, CFI: 0, ID: 1
└─ GOOSE
  APPID: 0x1002 (4098)
  Length: 114
  Reserved 1: 0x0000 (0)
  Reserved 2: 0x0000 (0)
  └─ goosePdu
    gocbRef: SEL_451CFG/LLN0$G0$GooseDataSet13
    timeAllowedtoLive: 2000
    dataSet: SEL_451CFG/LLN0$DataSet13
    goID: Sub1Bay2
    t: Mar 15, 2016 12:29:39.473267853 UTC
    stNum: 2
    sqNum: 12849
    test: False
    confRev: 1
    ndsCom: False
    numDataSetEntries: 1
    └─ allData: 1 item

```

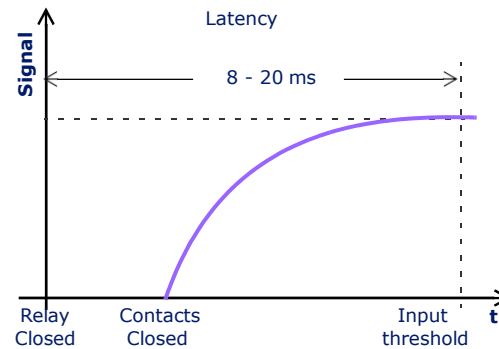
GOOSE Messages have the following data structure:

- **gocbRef**: address of the information
- **timeAllowedtoLive**: time to the next retransmission
- **datSet**: contents description
- **goID**: message identifier
- **t**: actual time
- **stNum**: state number is a message counter
- **sqNum**: sequence number of repetitions
- **test**: test message not a true value
- **confRev**: compatibility verification
- **ndsCom**: tells about the configuration
- **numDataSetEntries**: number of DataSet entries
- **allData**: data of the GOOSE message

1. if timeAllowedtoLive is greater subscribers can assume a communications failure
2. StNum + SqNum can be used to detect intrusion (cybersecurity without encryption)
3. if test = true indicates that the message is used only for test and simulations

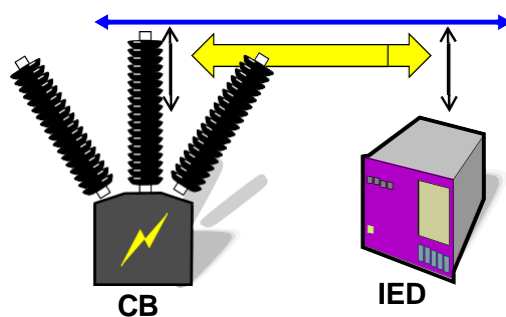


Hardwired Performance

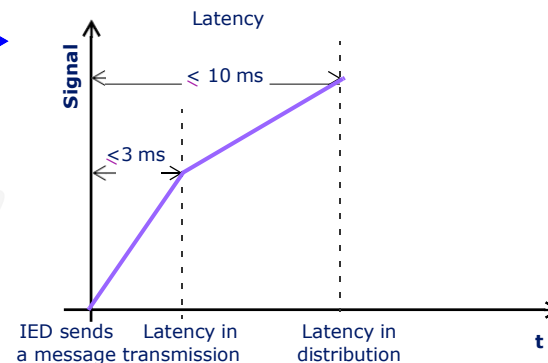


The performance of hardwired solutions is based on relays that, in the worst case, the IED transmission time can be 3/4 of the cycle (15ms), which is improved with the GOOSE alternative to less than 3ms.

When a GOOSE message is generated by the IED (IEC 61850 server), it uses a layer 2 multicast transmission to send the event on the network. Receiving devices, called subscribers, subscribe to the multicast address of the message to quickly filter the information and perform the required task(s).

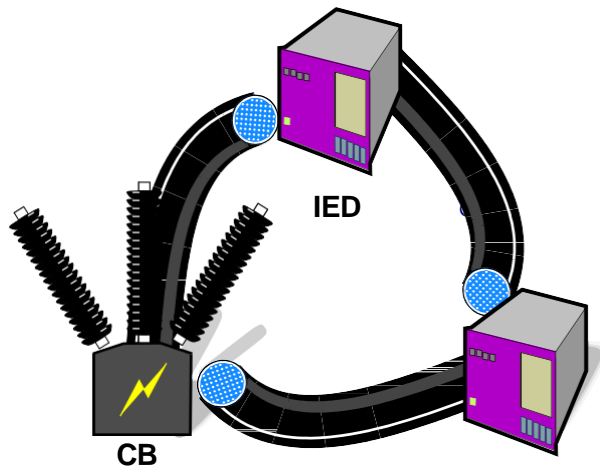


GOOSE Performance

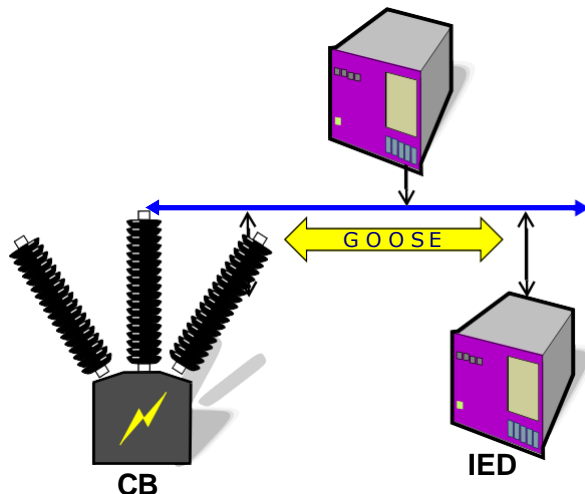


The requirements for a GOOSE message are stringent - no more than 4 ms should elapse between the time an event occurs and the time the message is received.

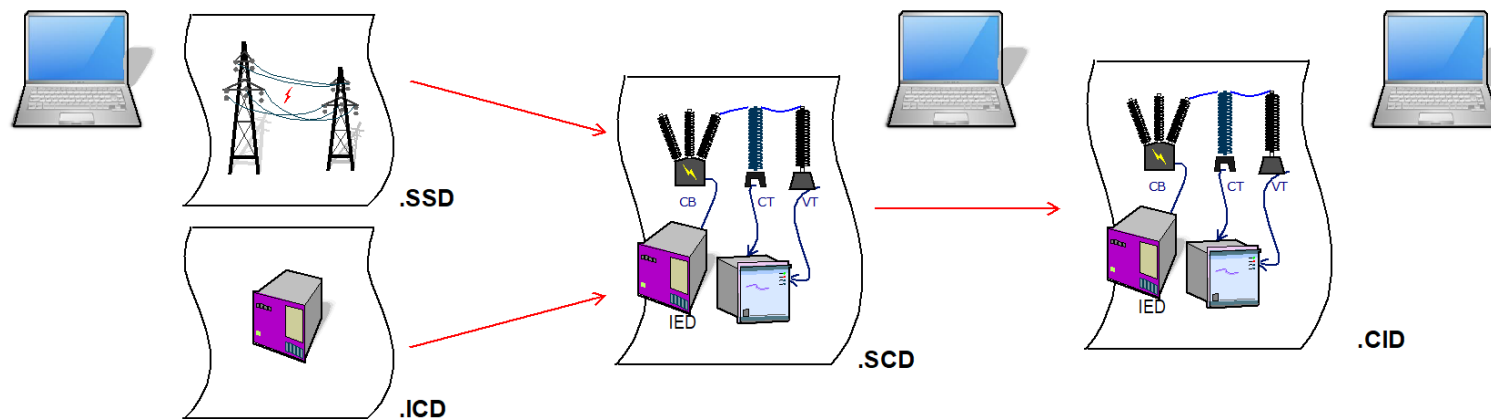
Hardwired Signals



Communicating via GOOSE



- **Installation costs:** by replacing thousands of individual copper control cables with a limited number of fibre optic cables from the terminal blocks to the relay terminals with a single pair of fibres.
- **Test costs:** by simplifying the testing of all hardwired interfaces against Ethernet GOOSE messages.
- **Flexibility:** GOOSE messages and SCL virtual signals can be used without the need to be physically present in the substation.
- **Multipoint:** a single message can reach multiple subscribers, simplifying interconnection, especially when multiple IEDs are involved, for example in a protection operation.
- **Interoperability:** the use of a standard improves the reliability of both IEDs on each side of a multi-manufacturer subscription.
- **Reduced maintenance:** If hard-wired connections cannot be monitored, then verification of all interfaces between individual components of the protection and control system is expensive.
- **Remote testing:** of protection systems in a digital substation allows testing to be performed remotely using GOOSE and SV messages.

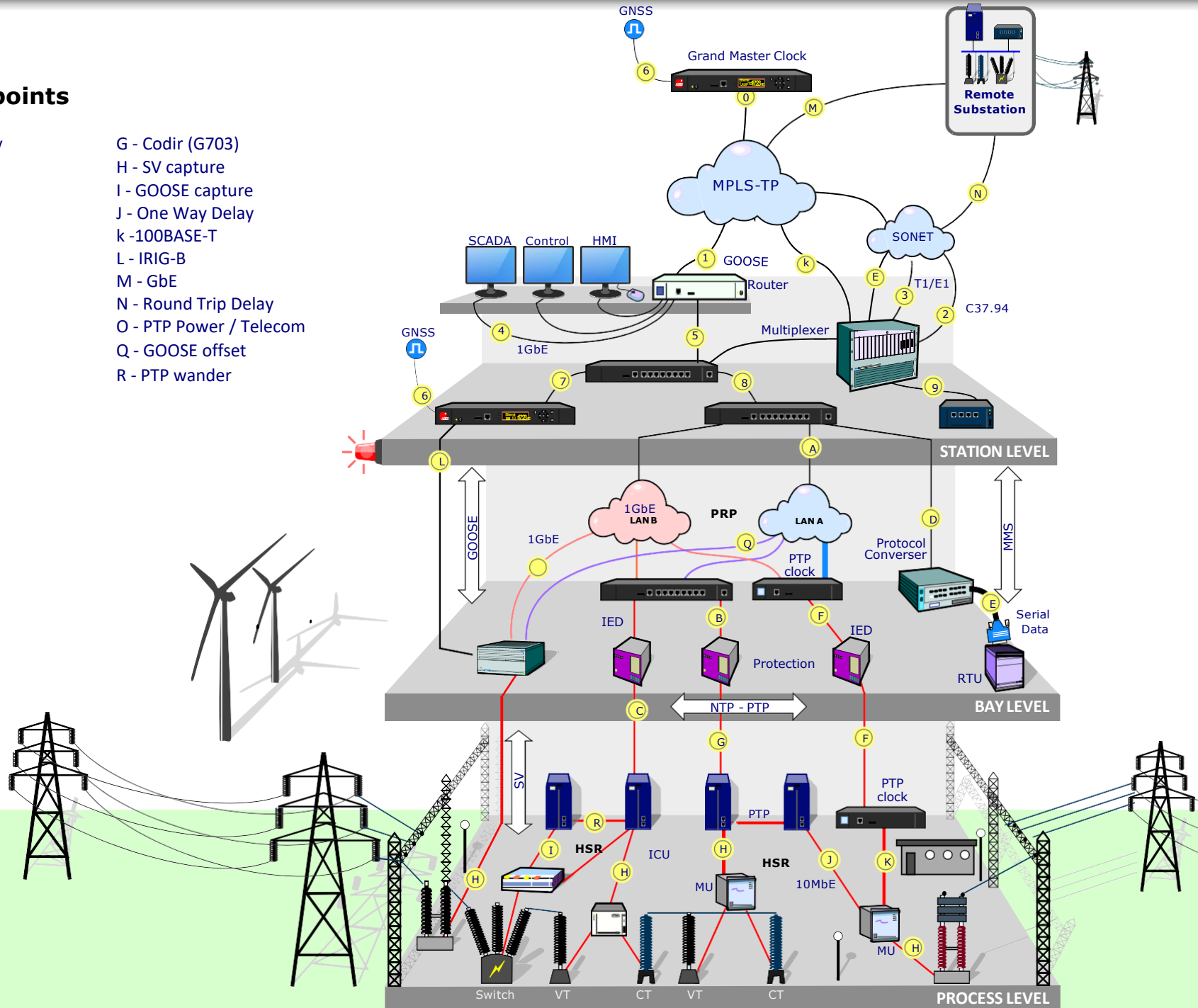


The Substation Configuration Language (SCL) allows the configuration of substations to be described in terms of data structures and protocols that are used to exchange information between IEDs. SCL includes import/export files to simulate and facilitate vendor interoperability. SCL terms:

- **Logical node:** the smallest part of a function that can exchange data. For example, an XCBR has a data structure called POS that indicates its position (closed, open, intermediate).
- **Logical device:** a group of logical nodes. For example, we can group PIOC (instantaneous current) with PIOTC (time current) and a logical IED groups several logical devices.
- **ECL language:** the description of the SSD substation.
- **ICD capabilities:** description of the substation as an addition of all IEDs.
- **SCD:** Substation Configuration Description is the combination of SSD
- **IEDs.CID:** Individual configuration of each IED that can be transferred to individual IED.

Key points

- 1 - GOOSE delay
- 2 - C37.94
- 3 - E1/T1
- 4 - GbE
- 5 - MMS
- 6 - GNSS
- 7 - 1PPS
- 8 - Eth/IP
- 9 - MPLS
- A - PTP
- B - NTP
- C - GOOSE
- D - PTP wander
- E - RS-232
- F - SyncE
- G - Codir (G703)
- H - SV capture
- I - GOOSE capture
- J - One Way Delay
- k - 100BASE-T
- L - IRIG-B
- M - GbE
- N - Round Trip Delay
- O - PTP Power / Telecom
- Q - GOOSE offset
- R - PTP wander



That's all



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