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CE-B5 - Análise do monitoramento de rede no contexto da norma IEC 61850

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Objectives

- **Importance** of **monitoring** the **IEC 61850 network**;
- **Network requirements** necessary for **monitoring**;
- Implementation of **monitoring techniques**.

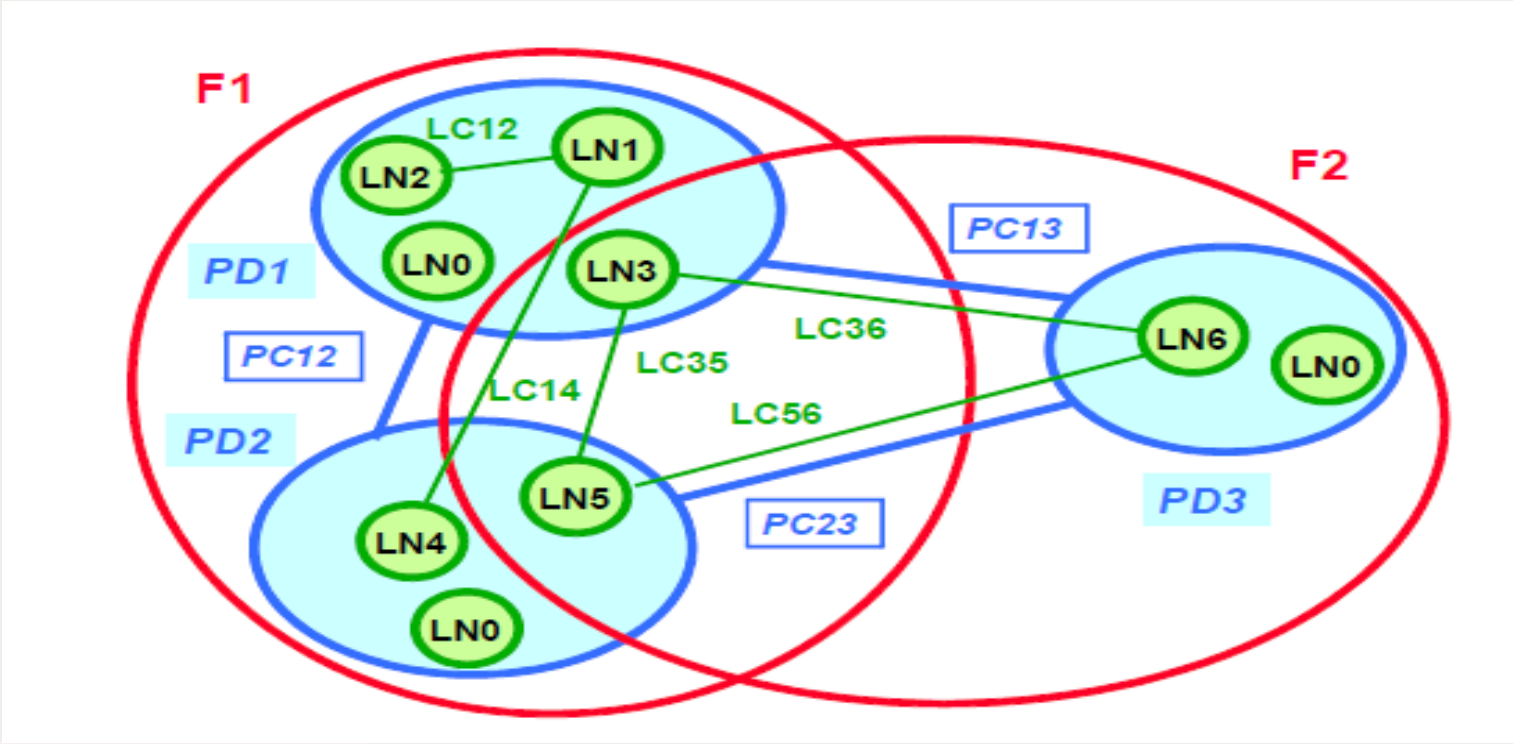
Introdution

- Fully **digital substations** based on **IEC 61850**:
  - **Process Bus** highlights **Ethernet communication network performance**.

- **C*/*S**, **SV** and **GOOSE**:
  - N**etwork aspects**: **reliability**, **speed**, **availability and security** of the information.

Introdution

- Item **8.4.2** of **IEC 61850-5 Ed.2**:
  - Different **application functions distributed** through allocations of LNs in different PDs: **exchange information** through a communication network.



Introdution

- **Performance of the function** to be executed **depends** on the **network communication performance**:
  - Communication network and its **availability** are part of this function: **monitoring** is **vital**.
- **Vulnerabilities of SAS** based on IEC 61850:
  - As the **complexity** of the system **increases**, more **vulnerable to cyber attacks** it becomes;
  - **External and Internal threats**.
- **COVID-19** pandemic scenario:
  - Power utility **staff** have been working from **home** and accessing the substation's internal network through **remote access**: one of the reasons for opening **security holes for threats**.

Considerations about IEC 62351

- Elaborated by **WG 15** of IEC **TC 57**;
- **Security aspects** related to series of standards covered by TC 57, including **IEC 61850 series**;
- **IEC 62351-6** “Security for IEC 61850”:
  - **Security** matters of **IEC 61850 communication protocols**;
  - Contributions to **GOOSE and SV security**: addition of **“Authentication Value”** and optional **encryption methods**;
  - **Performance** issues in case of **time-critical** requirements of **GOOSE and SV**;
  - **Encryption** methods are **recommended** whenever it **does not cause problems**.

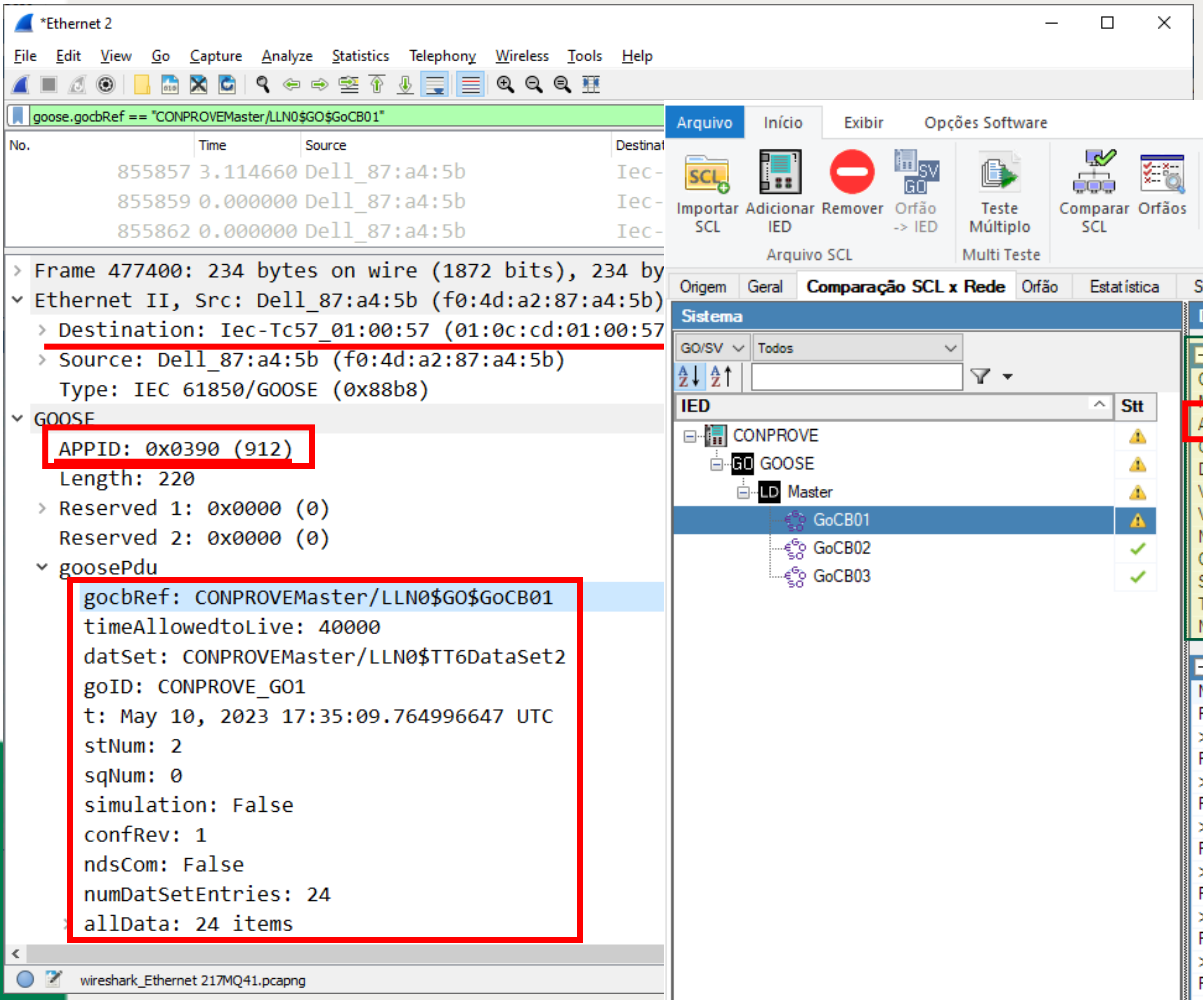
Network monitoring system and cybersecurity for PACS

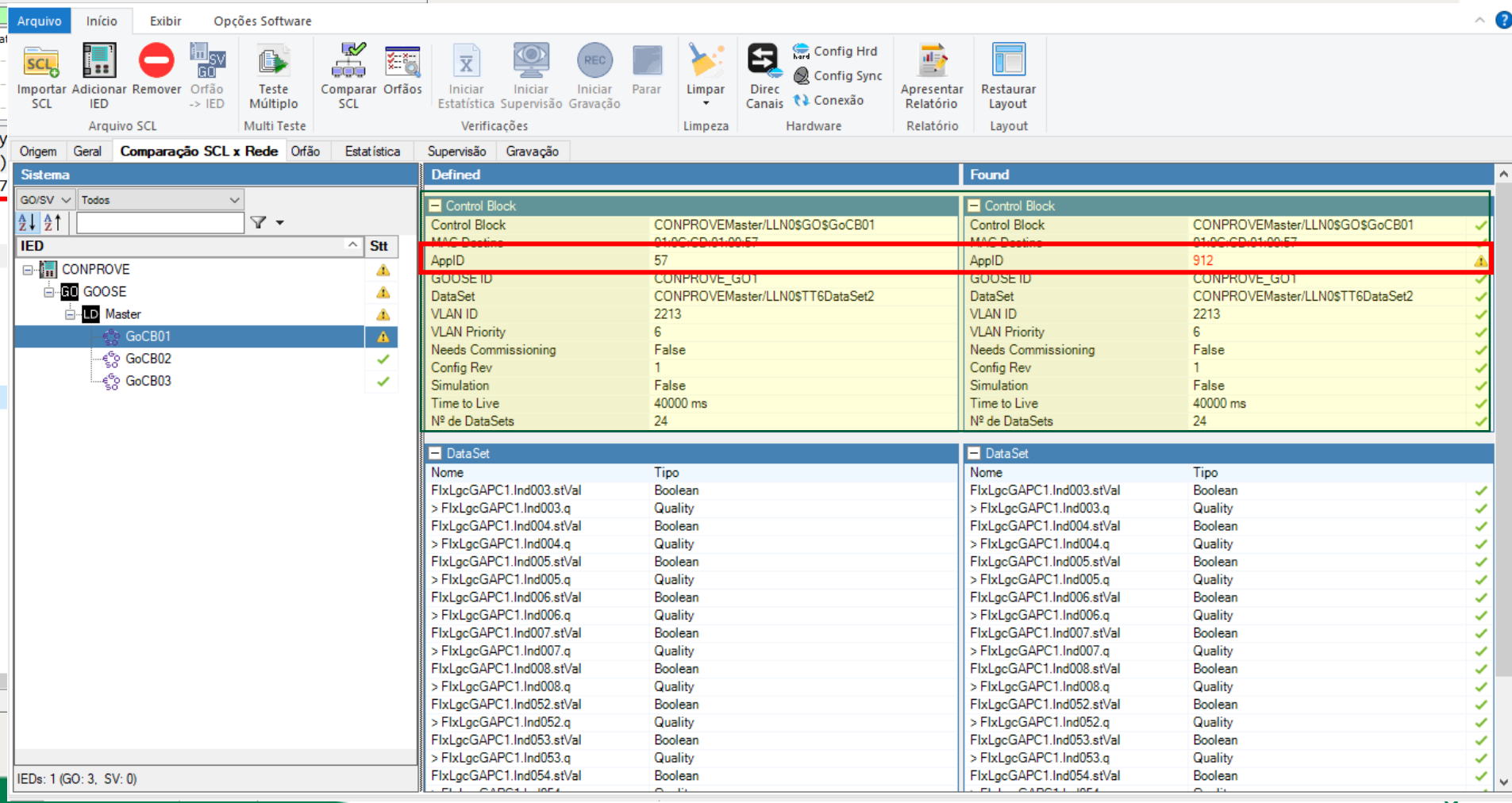
- **PACS network** must incorporate **monitoring functions** able to:
  - Detect and point out **anomalies** or **lacking** of messages;
  - Detect **lacking of synchronism** signal;
  - Verify and point out **abnormal propagation time**;
  - **Independent system**;
  - **Storing event records**.
- **PACS network** must incorporate **mechanisms** that offer **cybersecurity** to ensure:
  - **Confidentiality**;
  - **Integrity**;
  - **Availability**;
  - **Authenticity**.

Network monitoring system and cybersecurity for PACS

- Some **requirements may not be foreseen in the monitoring system – blind spot**;
- Monitoring deal with: **Test/Simulation configuration -> two SV streams: simulated and the real one**;
- Monitoring system -> **event logs** to be **stored and consulted**;
- **Trunk Port** on the network Switch or through **Port Mirroring**;
- **GOOSE** frames carrying as data a **Trip** command:
  - **Not delivered** to the **SCU** -> the **protection system is compromised**,
- **Monitoring system** must **detect** this anomaly:
  - **Is the GOOSE there?**
  - **Analyzing** all IEDs instances through **SCL file (SCD or ICD)**;
  - **Filters** like **Destination MAC Address**, **GOOSE Control Block Reference** and **Application ID**.

Network monitoring system and cybersecurity for PACS

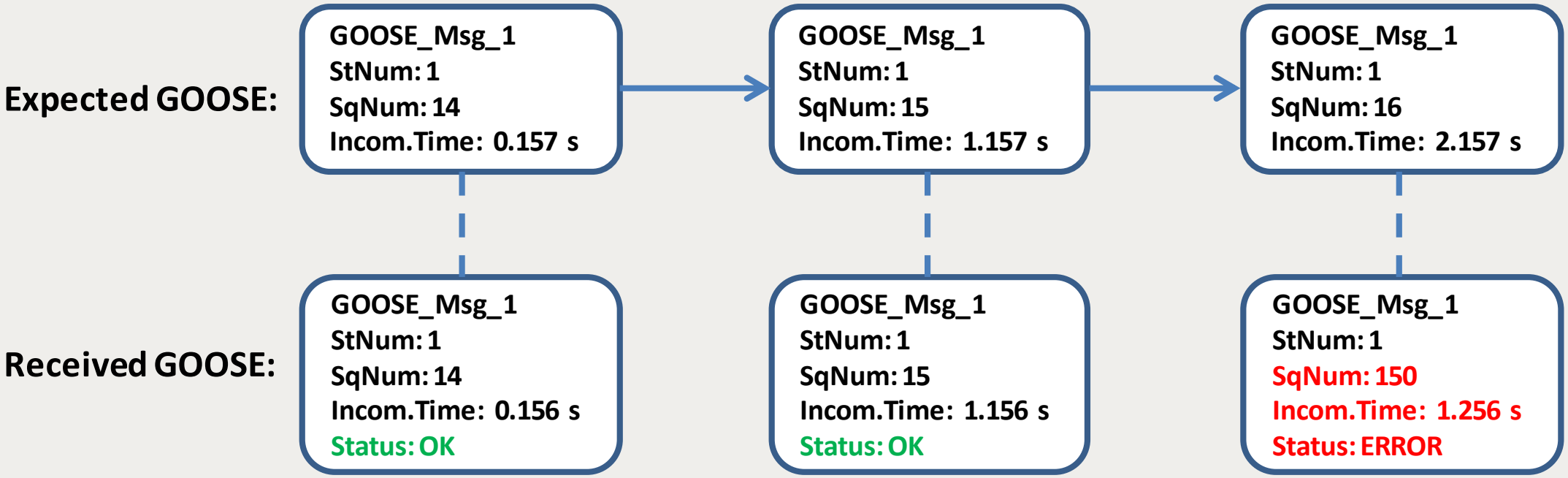




Network monitoring system and cybersecurity for PACS

- An invader could publish **malicious GOOSE** frames:
  - To **open** or to **close** a **circuit breaker**;
  - Causing a **network overload**.
- **Monitoring system** must detect this anomaly:
  - **Retransmission times** too different from what is configured or with **wrong SqNum (out of order)**;
  - **Analyzing reception times** of the frames and verifying the **time difference**, also **SqNum**.

Network monitoring system and cybersecurity for PACS



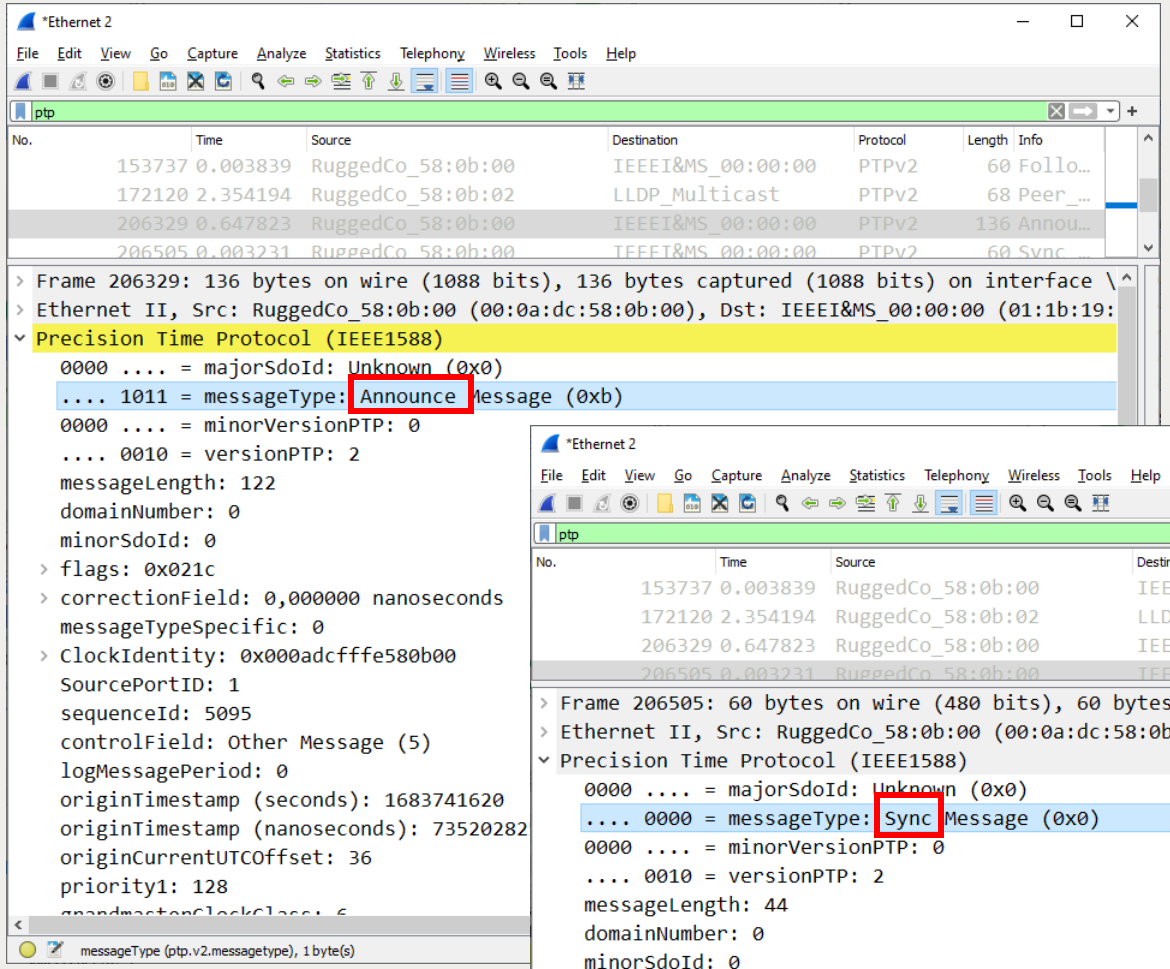
- **Blind spot**: **invader** is able to publish **malicious GOOSE** frames in the **right retransmission time** and **sequence order**.

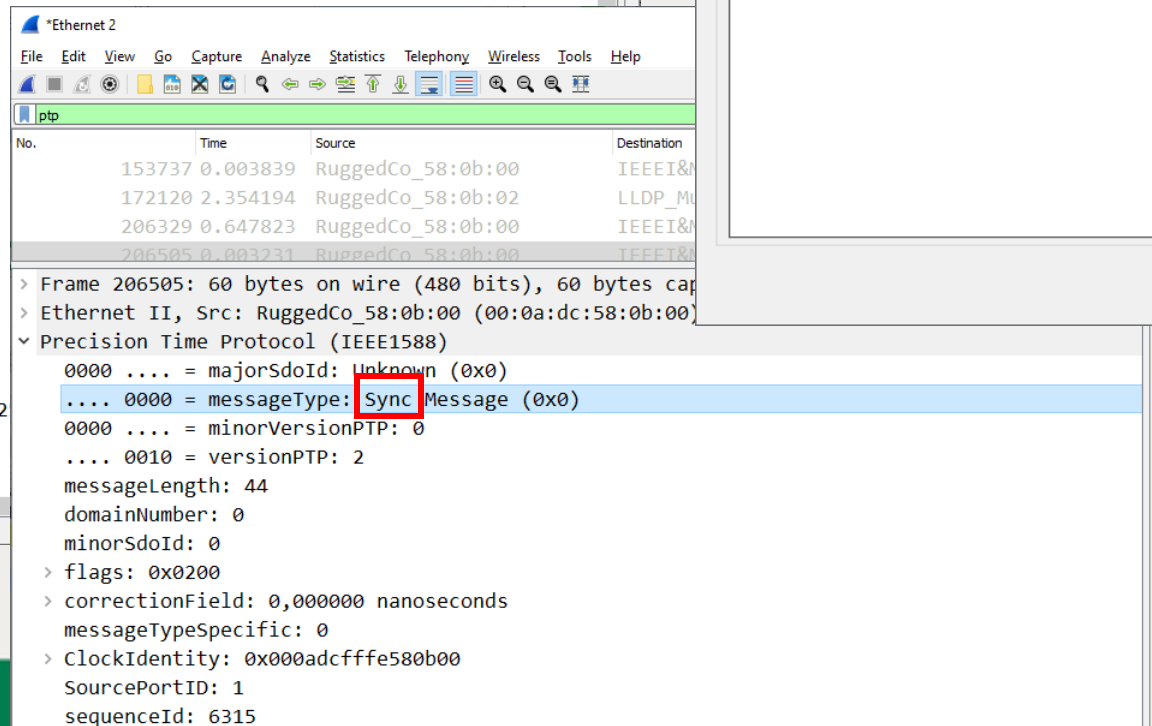
Network monitoring system and cybersecurity for PACS

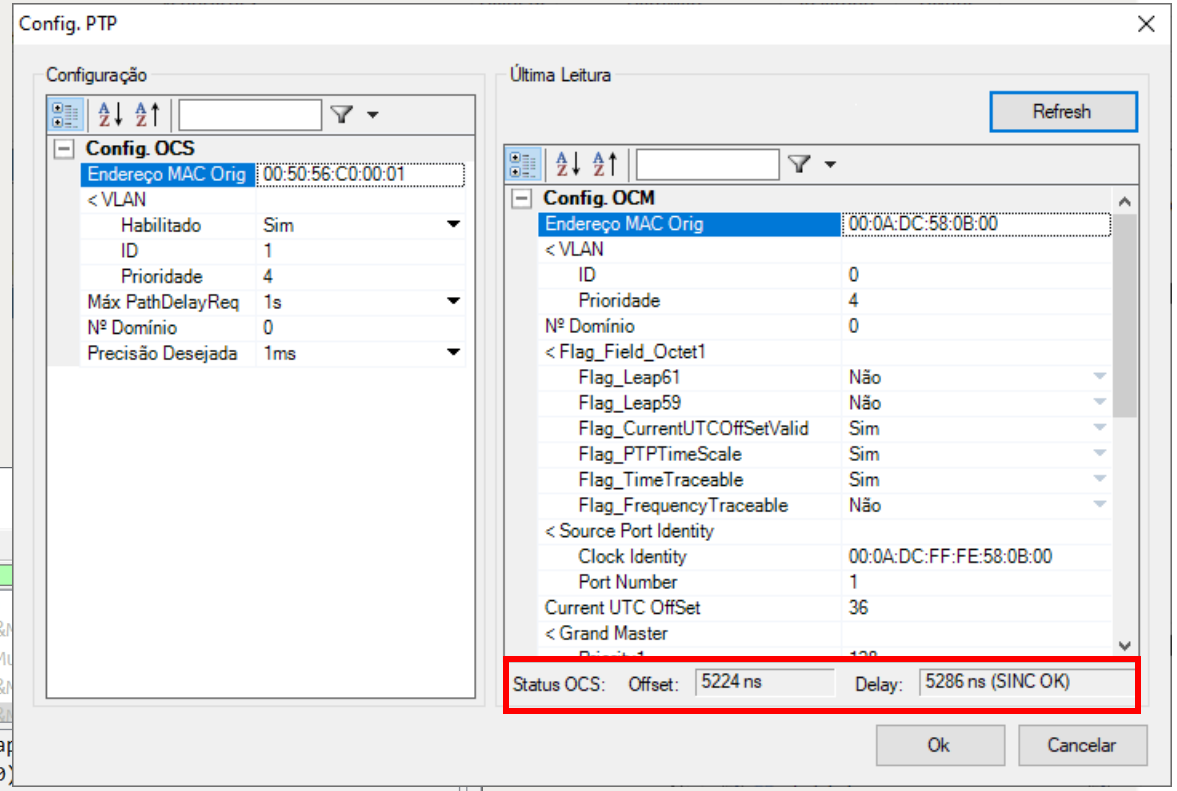
- **PTP** (Precision Time Protocol)**:**
  - **BMCA**: used to choose the **best node** in the network in order to become the **GM**;

- **Monitoring system:**
  - To verify if **GM** messages are **running** on the Ethernet network;
  - Must analyze **Announce and Sync.**

Network monitoring system and cybersecurity for PACS





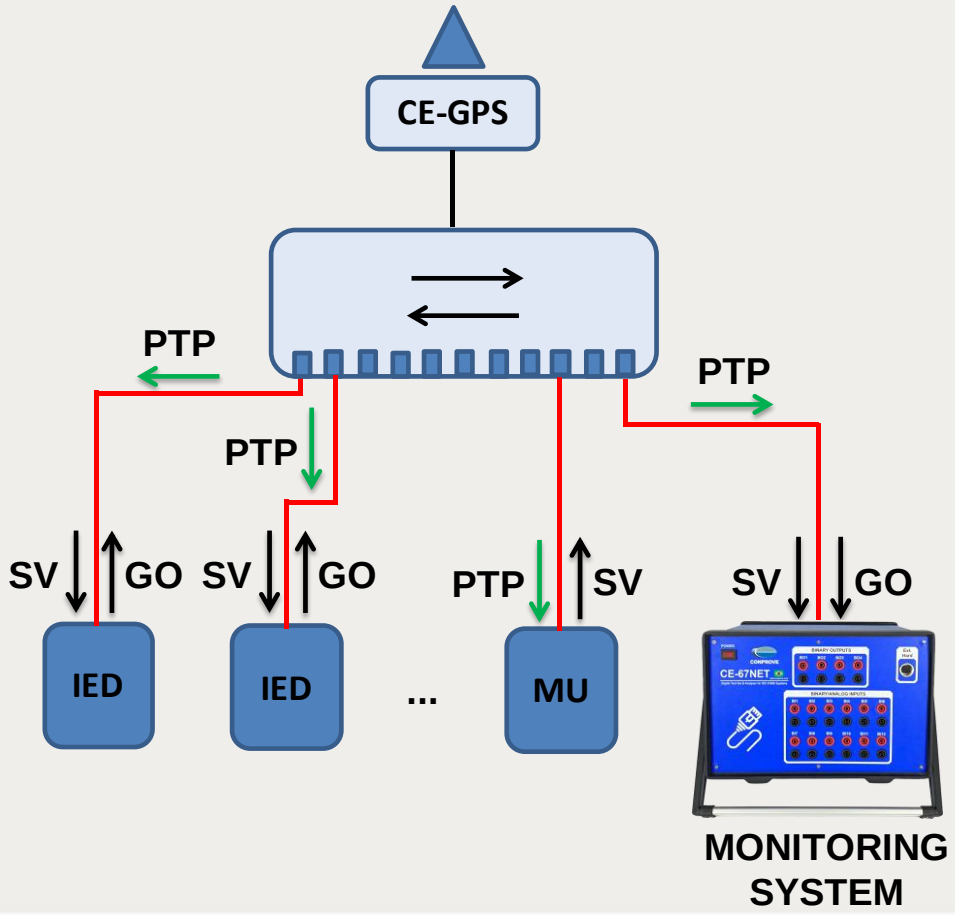


Network monitoring system and cybersecurity for PACS

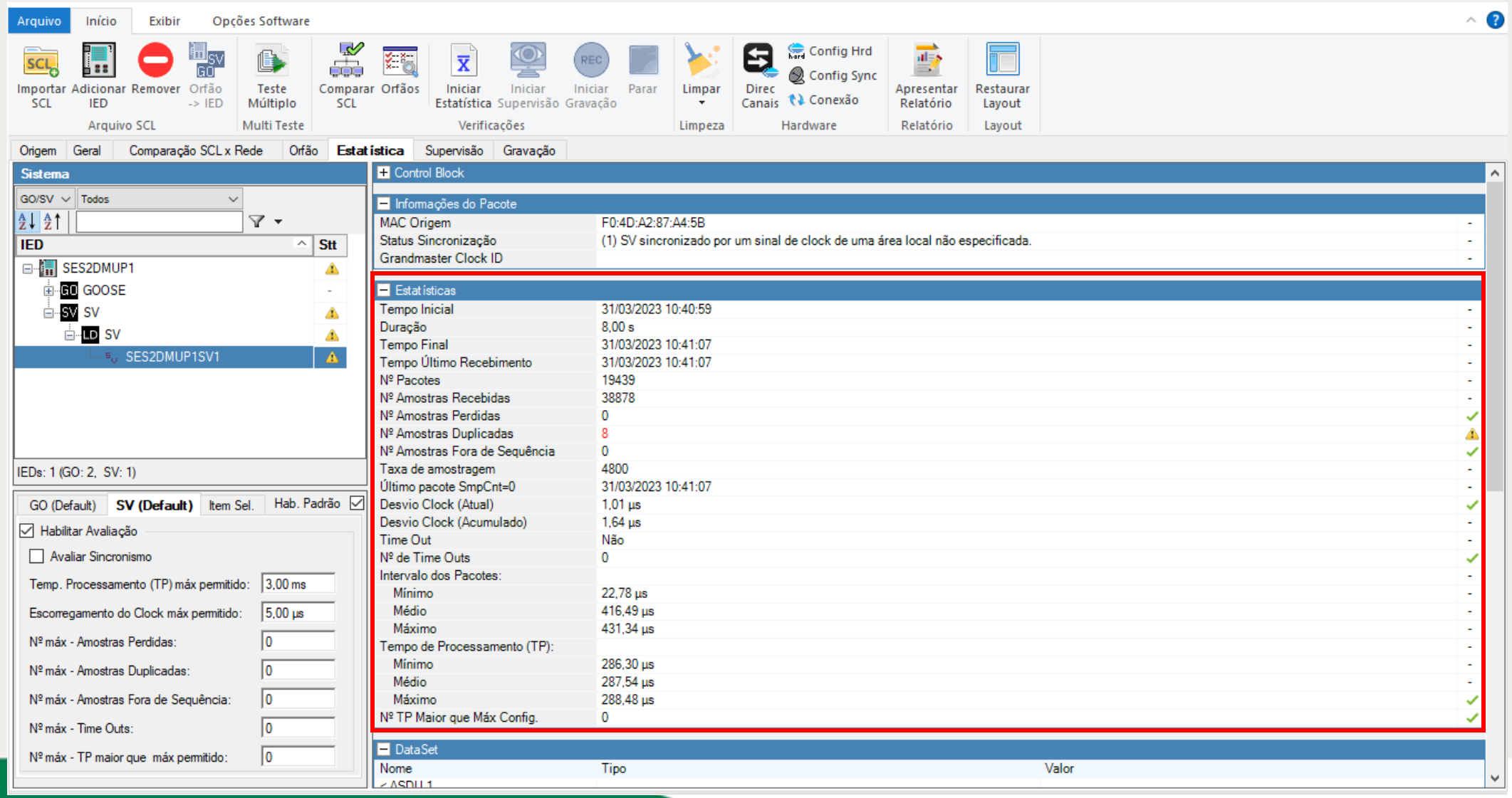
- **Loss of time synchronism** -> **threat** in the **Process Level**;
- **Monitoring system**:
  - Must be a **PTP slave**;
  - **To** v**erify** if the slave **clock jitter** is increasing in relation to **master clock**.
- If **time synch** is **lost** -> two possibilities
  - **Some interference**;
  - **Hardware problem** with **Transparent Clock** or **calibration** of **GM clock**.
- **Invader** pretends to be the **GM** and **break down** the **time synchronism**:
  - With the **same Clock Identity** of the current GM - **blind spot** for **monitoring systems**;
  - With **different Clock Identity** - can be verified by the monitoring system through a **“White List”**.

Network monitoring system and cybersecurity for PACS

- **Monitoring system -> statistical analysis** of **SV** and **GOOSE** frames;
- **Sampled Values**:
  - **Propagation delay**;
  - **Processing time**;
  - **Time between frames**;
  - **Errors in the network**;
  - **Synchronism flag**.



Network monitoring system and cybersecurity for PACS



Network monitoring system and cybersecurity for PACS

- **GOOSE**:
  - **Transfer time**, **out of order, quality not good**
- **LN for monitoring** - **IEC 61850-7-4 Ed.2.1**:
  - **LGOS**;
  - **LSVS.**
- **Monitoring system** -> **two SV** frames running: one **simulated** and other **real**:
  - **Test set** -> to **publish SV (simulation bit set)** x **MU/SAMU** -> to **publish real SV** frames;

Network monitoring system and cybersecurity for PACS

Control Block	
Control Block	CONPROVEMaster/LLN0GOGoCB01
MAC Destino	01:0C:CD:01:00:57
AppID	57
GOOSE ID	CONPROVE_GO1
DataSet	CONPROVEMaster/LLN0$TT6DataSet2
VLAN ID	2213
VLAN Priority	6
Needs Commissioning	False
Config Rev	1
Simulation	False
Time to Live	40000 ms
Nº de DataSets	24

Control Block	
Control Block	CONPROVEMaster/LLN0GOGoCB01
MAC Destino	01:0C:CD:01:00:57
AppID	912
GOOSE ID	CONPROVE_GO1
DataSet	CONPROVEMaster/LLN0$TT6DataSet2
VLAN ID	2213
VLAN Priority	6
Needs Commissioning	False
Config Rev	1
Simulation	True
Time to Live	40000 ms
Nº de DataSets	24

Conclusions

- It was possible to evaluate the **requirements** for the **monitoring** of the network and the **failure identification methodologies**;
- Aspects not foreseen by network monitoring were also addressed (**blind spots**);
- The deployment of a **digital substation** can be more **reliable** with the implementation of the **monitoring system**:
  - Any failure event will be **alarmed** and **logged** so that will be possible to **trace its causes**.
- It is expected that this work contributes to enable **proper operation of communication networks**, as this is the only way to ensure safe and **reliable traffic of information**.

MUITO OBRIGADO!!!

Paulo Sergio Pereira Junior

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