CAIRNS 2023 INTERNATIONAL SYMPOSIUM

Study Committee: B5

Experiences and Learning on Monitoring Digital Substation Communication Networks

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Paper Number 1455

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Cairns Convention Centre
Queensland Australia
4-7 September 2023

Introduction

- Concept of **network monitoring**: **systematic verification** in search of **anomalies** that could compromise its **proper functioning**;
- **IEC 61850 network monitoring** throughout the **life cycle** of the **digital substation**: **commissioning, continuous monitoring** and **maintenance** tests;
- **Importance of monitoring**:
  - **Early error detection**;
  - **Network operating** conditions;
  - Reducing **network unavailability**;
  - **Logging** all network events;
  - **Security and stability** of the power system.

Monitoring for PACS / Brazilian TSO

- **Monitoring system** as an essential **tool for troubleshooting** the digital substation network;
- **Brazilian TSO – ONS**:
  - **IEC 61850 network monitoring** included in the **power system best practices**;
  - **PACS network** must incorporate **monitoring functions** able to:
    - Detect **anomalies** or **lacking of messages**;
    - Detect **lacking of synchronism** signal;
    - Verify **abnormal propagation time**;
    - **Independent system**;
    - Storing **event records**.
- **Specialized device:** for monitoring - "**communication network DFR** (Digital Fault Recorder)"
  - Implemented both in **hardware and software** to cover all the **time-critical** requirements – **GOOSE and SV**.

Network monitoring system: general aspects

- **Network aspects covered** by the **monitoring system**:
  - **Integrity** of the messages;
  - **Configuration and security** of the data;
  - **Frame´s structure**;
  - System's time **synchronism**;
  - Message timing **statistics**;
  - **Test / Simulation** configuration;
- Alert potential **communication failures** or **invasions**;
- **PCAP files** can be **recorded** for more detail;
- Monitoring through a **Trunk Port** or **Mirror Port**.

Network monitoring system: device and modes

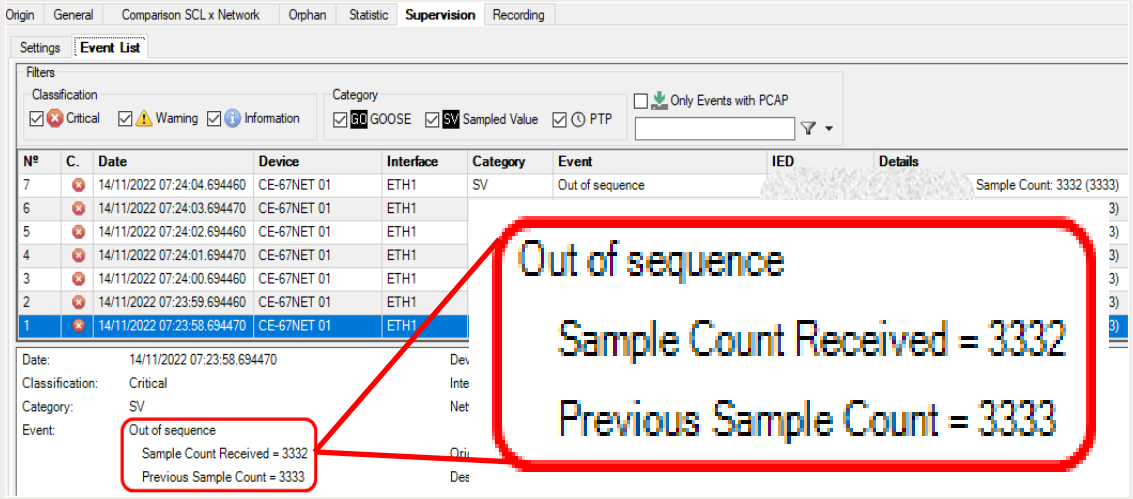
- **Monitoring system features**:
  - **SCL validation mode**:
    - **SCL imported** x **frame on network.**
  - **Sniffer mode**:
    - **Scan the network** in search of **traffic not foreseen** by the SCL files.
  - **Supervision mode**:
    - **Network errors**;
    - **Supervision events**: GOOSE, SV and PTP;
    - **PCAP recording**.
  - **Statistics mode**:
    - **Statistical analysis** of GOOSE and SV traffic.

Study Cases: Experiences and Learning (1st)

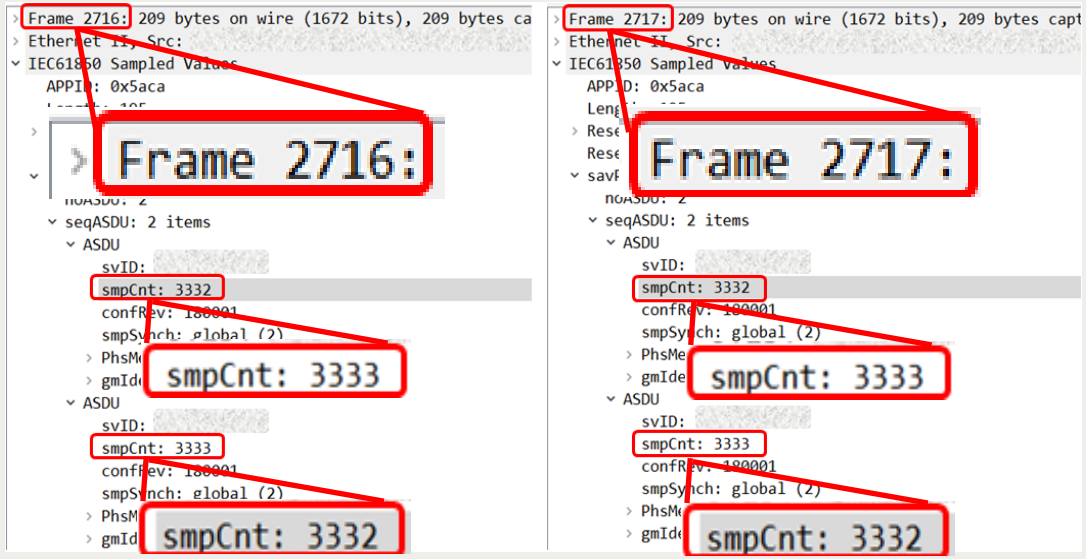
- **Network issues** in **Brazilian digital substations**:
  - **Monitoring system**: **detect and identify** these problems to help find a solution.

- **First study case**: **duplicated SV frames errors** due to a **RedBox** problem:
  - **Digital substation** with **13 Merging Units** and about **168 GOOSE messages** inserted into the network architecture;
  - **SV frames** published at **IEC 61869-9 preferred sampling rate** – 4800 samples/second and 2 ASDUs;
  - The **duplication issue**: **every second** on the **same sample count**, in **RedBox output**;
  - Detection by the monitoring system: **out of sequence event** in **supervision mode**, as also in **statistical mode**.

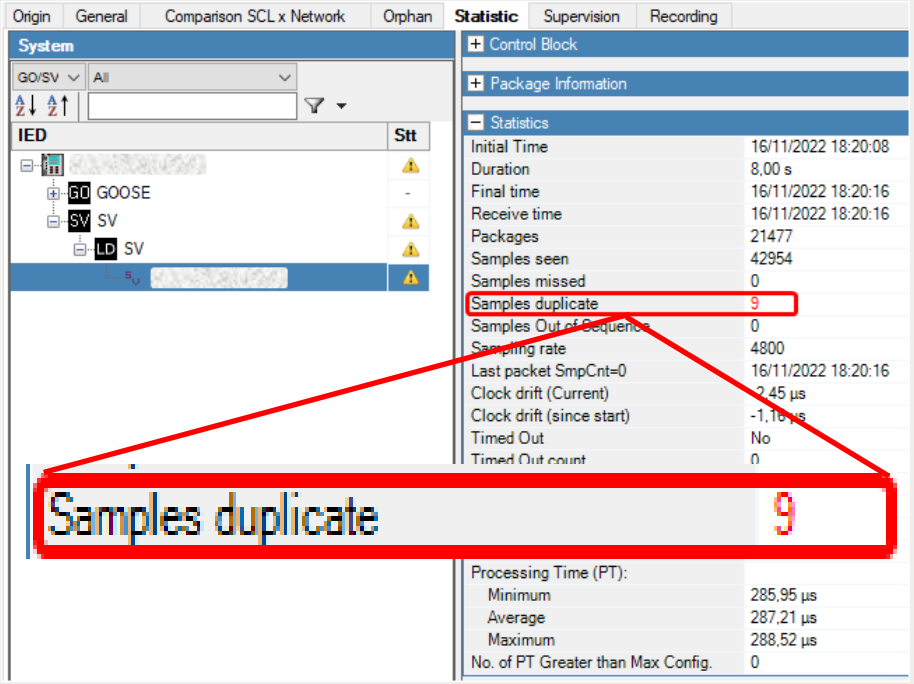
- **Out of Sequence Event – Supervision Mode:**



- **PCAP file register:**



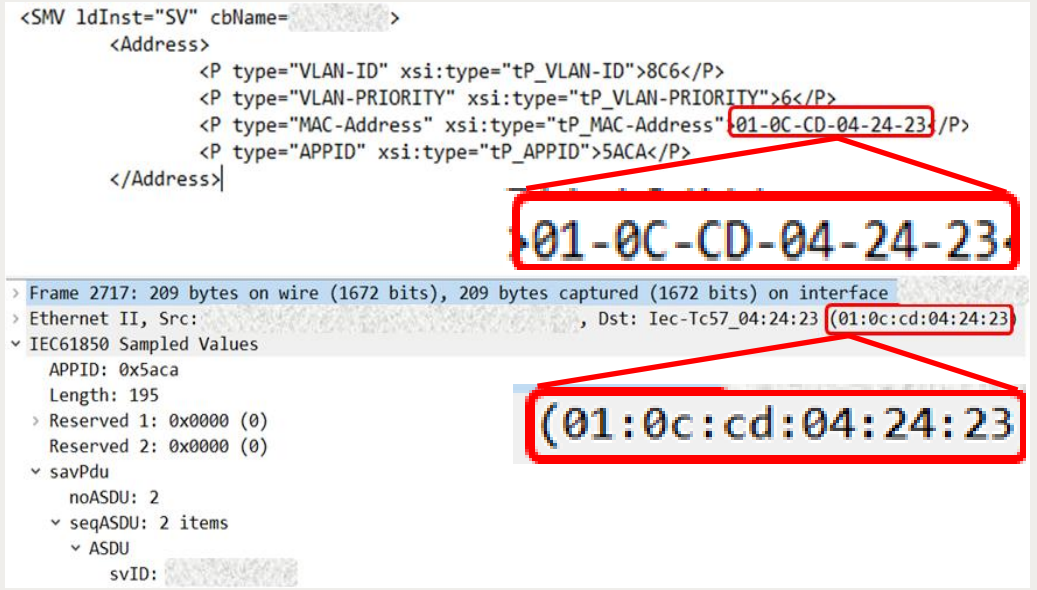
- **Statistical mode:**



Study Cases: Experiences and Learning (1st)

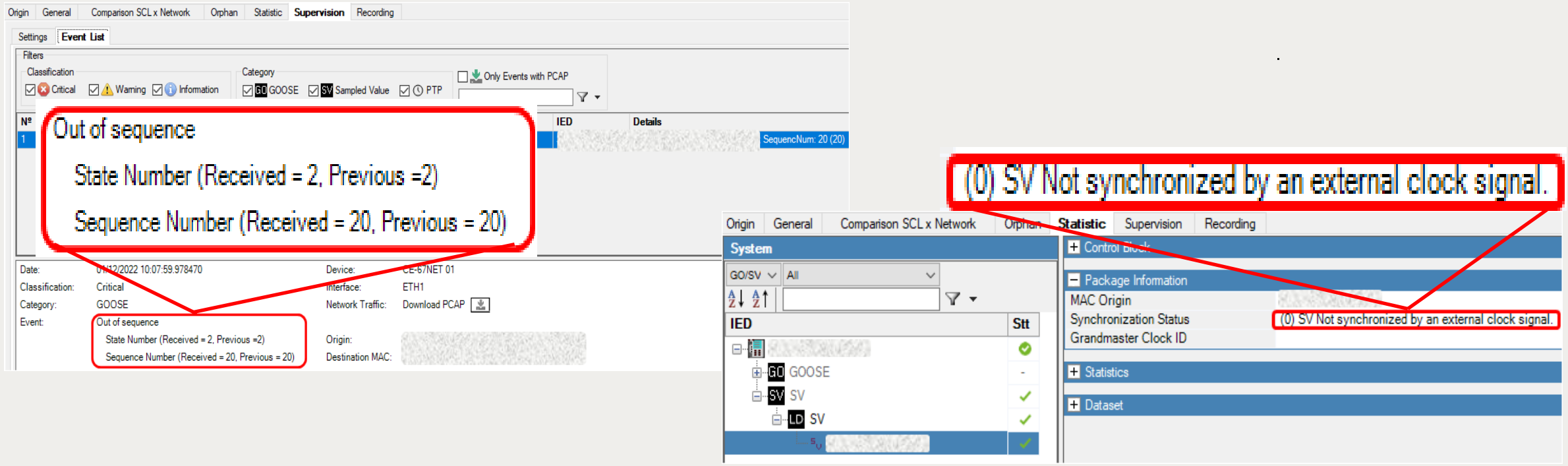
- **First study case** - **SCL file non-compliance** with the **recommendation** of IEC 61850-9-2 Ed. 2, Annex B. Detected through **SCL validation mode**:

Service	Recommended address range assignments	
	Starting address (hexadecimal)	Ending address (hexadecimal)
GOOSE	01-0C-CD-01-00-00	01-0C-CD-01-01-FF
GSSE	01-0C-CD-02-00-00	01-0C-CD-02-01-FF
Multicast sampled values	01-0C-CD-04-00-00	01-0C-CD-04-01-FF



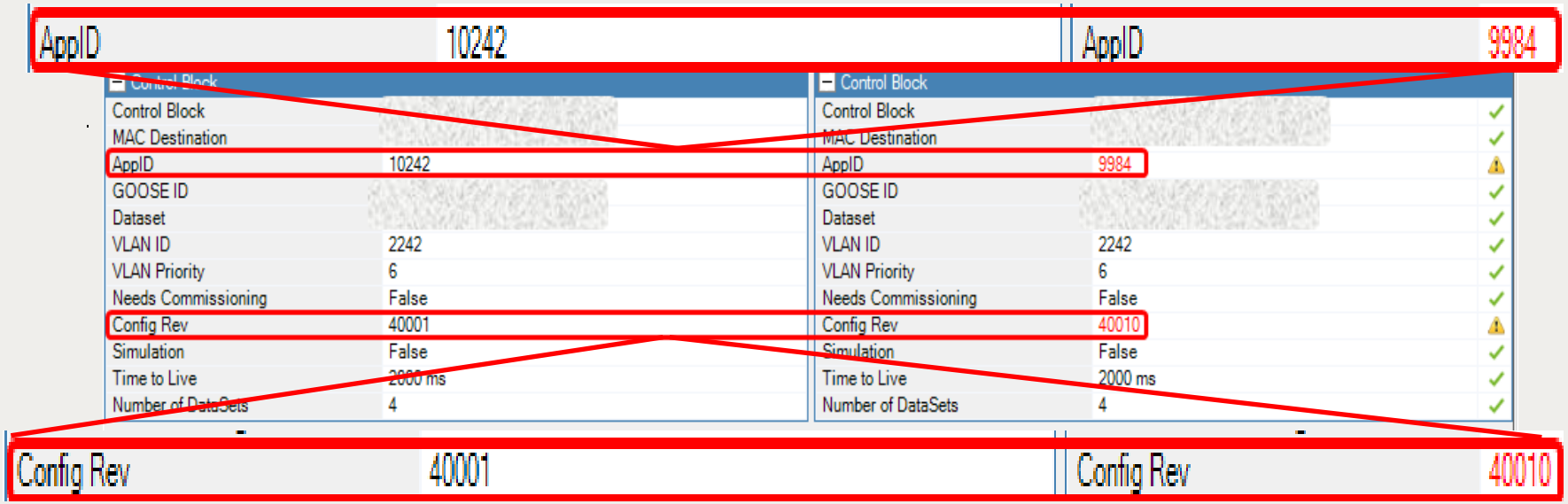
Study Cases: Experiences and Learning (2nd)

- **Second study case** – digital substation **with four different IEDs vendors**; **GOOSE** and **SV** streams being published:
  - **Network issues**: **duplicated GOOSE** frames and **loss of MUs' synchronism**;
  - Detection by the monitoring system: **supervision mode** and **statistical mode**.



Study Cases: Experiences and Learning (3rd)

- **Third study case** – digital substation with **26 MUs** and about **148 GOOSE messages**:
  - **SCL files incompatibility**;
  - Detection by the monitoring system**: SCL validation mode.**



Conclusions

- Detailed **network monitoring** study in a **digital substation context**:
  - Discussion of the **requirements** for **implementation** of a **complete monitoring system**.

- **Experiences and learning** with **network problems** occurred in **Brazilian digital substations**, and **the role of monitoring system**;

- The **importance** of **network monitoring system**:
  - **Specialized device** for **network troubleshooting**.

- 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 power system**.

THANK YOU!

Paulo Sergio Pereira Junior