Study Committee B5

PROTECTION & AUTOMATION

10150

Analysis of Network Monitoring in the Context of IEC 61850

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CONPROVE

Objectives

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

Introduction

- Fully **digital substations** based on **IEC 61850**:
  - **Process Bus** highlights **Ethernet communication network performance**.
- **C/S**, **SV** and **GOOSE**:
  - **Network aspects** -> **reliability**, **speed**, **availability and security** of the information .
- 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.

- **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**.
- **IEC 62351-7**:
  - **Network and System Management (NSM)**;
  - **NSM Data Objects (NSM Dos)**;
  - **Management Information Base (MIBs)**.
- **IEC 62351-14**:
  - Implementation of **security logs** - **Syslog**;
  - Importance of security logs for the **cybersecurity operation centers**.
- **Detection mechanism** on the IEC 62351:
  - **SNMP** – defined on **part 7: operational monitoring**;
  - **Syslog** – defined on **part 14: security operation center**.

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**.

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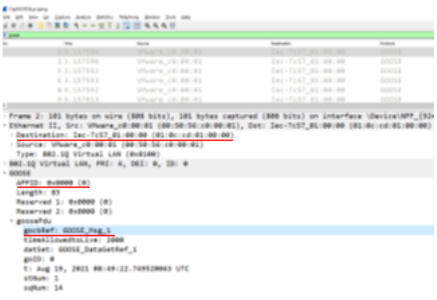
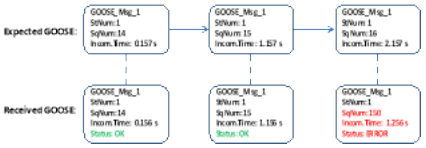
- **PACS network** must incorporate **mechanisms** that offer **cybersecurity** to ensure:
    - **Confidentiality**;
    - **Integrity**;
    - **Availability**;
    - **Authenticity**.
- Some **requirements may not be foreseen in the monitoring system** – **blind spot**;
- Monitoring deal with: **Test/Simulation 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



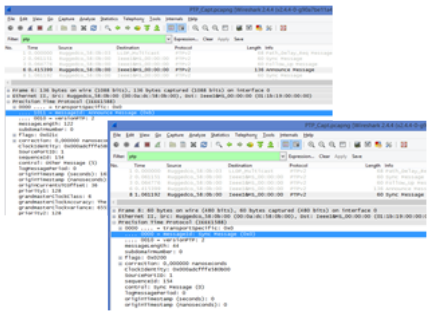
- An invader could publish **malicious GOOSE** frames:
    - To **open** or to **close** a **circuit breaker**;
    - Causing a **network overload**.

  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**.



- **Blind spot**: **invader** is able to publish **malicious GOOSE** frames in the **right retransmission time** and **sequence order**.
- **PTP** (Precision Time Protocol):
    - **BMCA**.

  Monitoring system:
    - To verify if **GM** messages;
    - Analyzing **Announce and Sync**.



- **Loss of time synchronism**, -> **threat** in the **Process Level**;

  Monitoring system:
    - Must be a **PTP slave**;
    - **To verify** 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"**.

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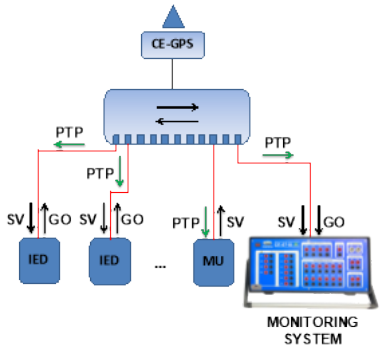
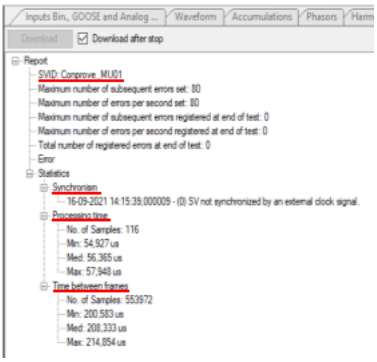
- **Monitoring system -> statistical analysis** of **SV** and **GOOSE** frames;



Sampled Values:

- **Propagation delay**;
- **Processing time**;
- **Time between frames**;
- **Errors in the network**;
- **Synchronism flag**.

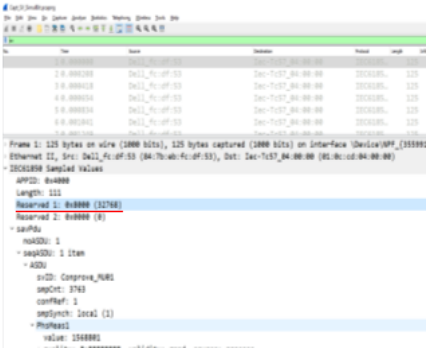


GOOSE:

- **Transfer time**.

- **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 with simulation bit set** x **MU/SAMU** -> to **publish real SV** frames;
  - If the **monitoring system** has **not** been **notified** that **substation** is **under maintenance**, it must **report data inconsistency** and save this information to a **log**.



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**.