Meeting requirements in an IEC 61850 station bus SAS

Answer to questions Q1-11 & Q1-12

RED ELÉCTRICA DE ESPAÑA

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INDEX

Paper D2-01_07

Main points

- The paper studies a real project commissioned in 2015 in Perú
- IEC 61850 station bus solution
- Relationship between SAS and network requirements
- How the engineering solution and the network architecture are related
- Use of VLAN and multicast address assignment to GOOSE policy for maintenance, testing and traffic control
- Technical limitations (no PRP in several IEDS, …)

Goal: find a network architecture that meets requirements

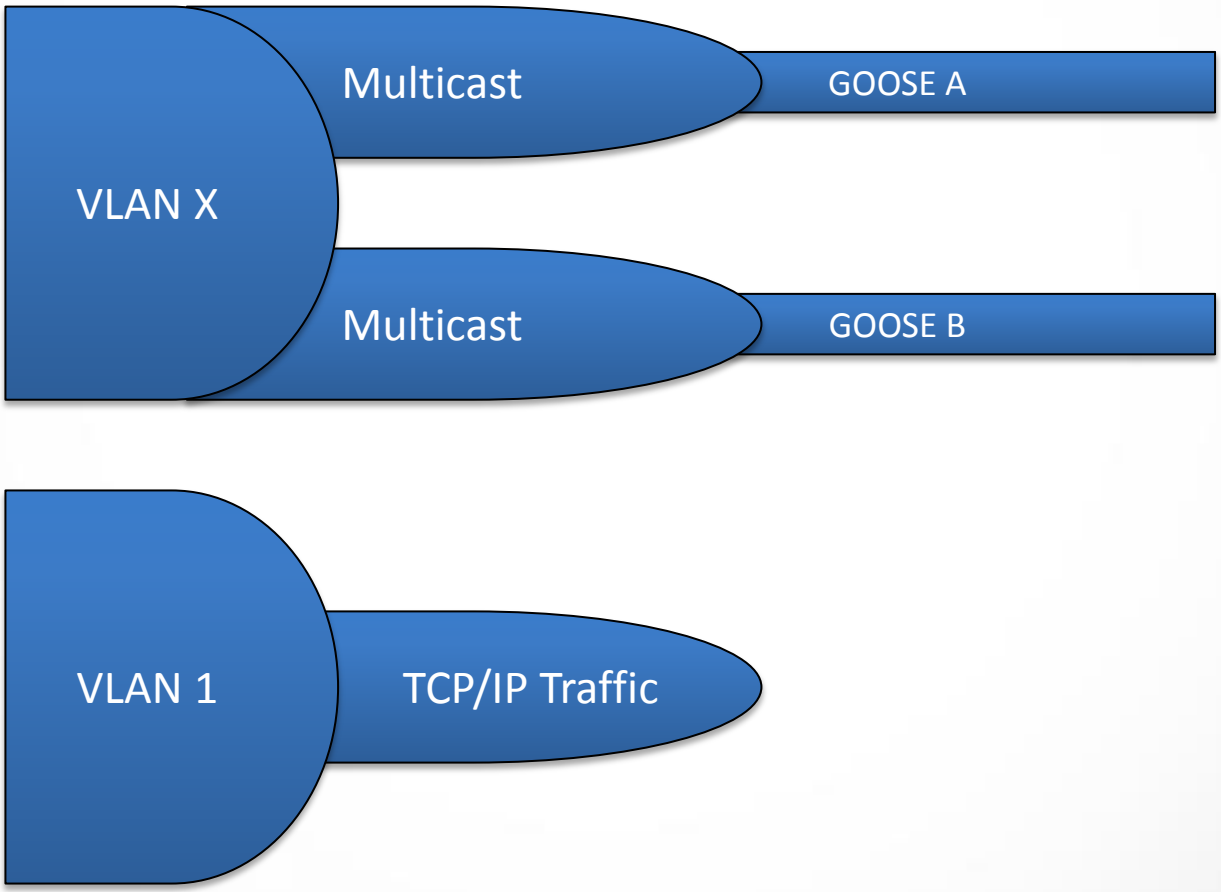
Starting point

- Nueva Tintaya and Socabaya 220 kV double bus bar substations
- Multivendor IEC 61850 station bus solution
  - Up to twelve (12) different IED models/manufacturers interconnected
- No PRP in protection IEDs. PRP in telecontrol IEDs.
- Two independent Protective System for each bay
- Two independent Differential Bus Bar Protection IEDs
- Use of Goose as much as possible and MMS for telecontrol

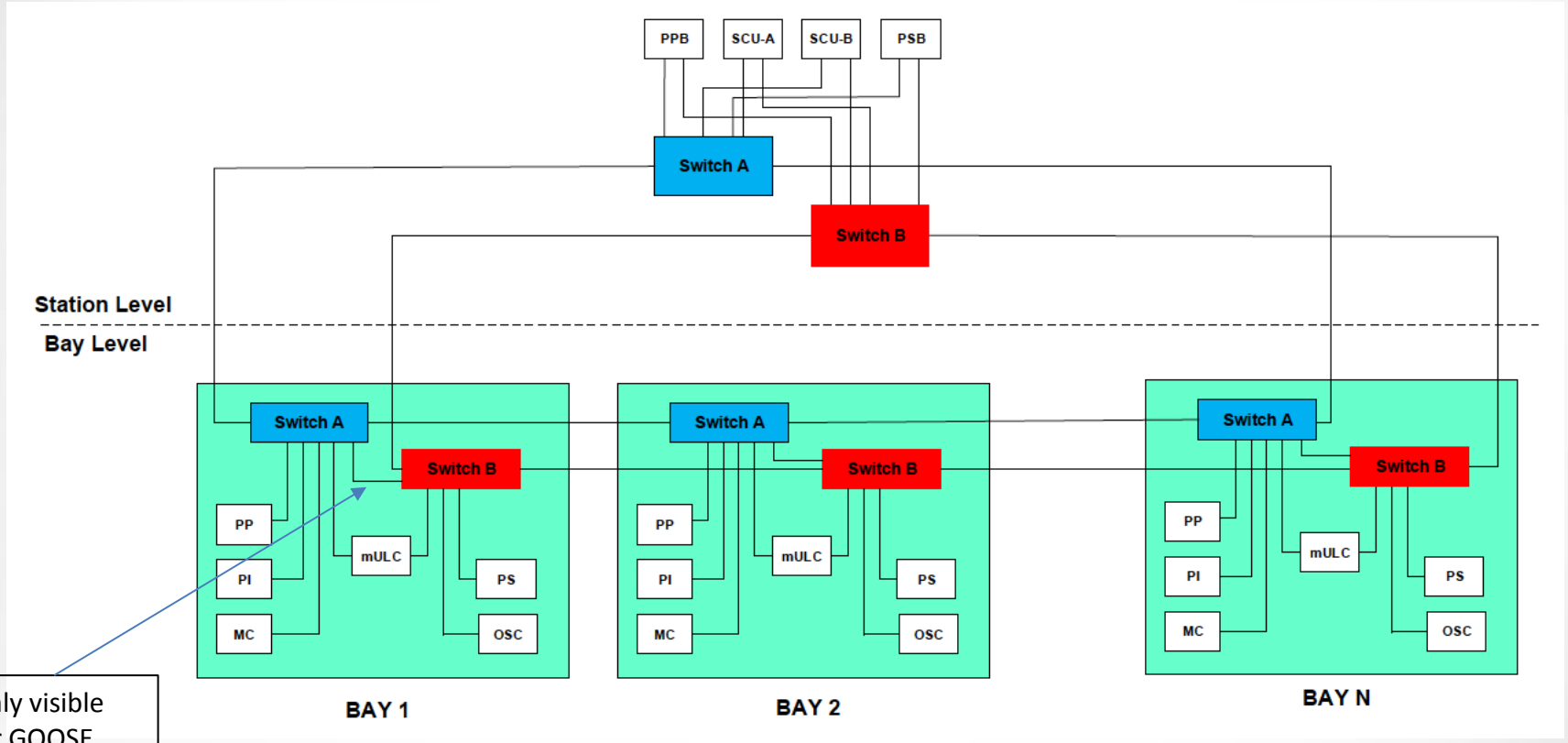
Structure

1. Context
2. Requirements
3. Protection & Control subsystem architecture
4. Telecontrol subsystem architecture
5. IEC 61850 interchanges and interfaces
6. Network architecture study
7. Adopted architecture
8. Lessons learned

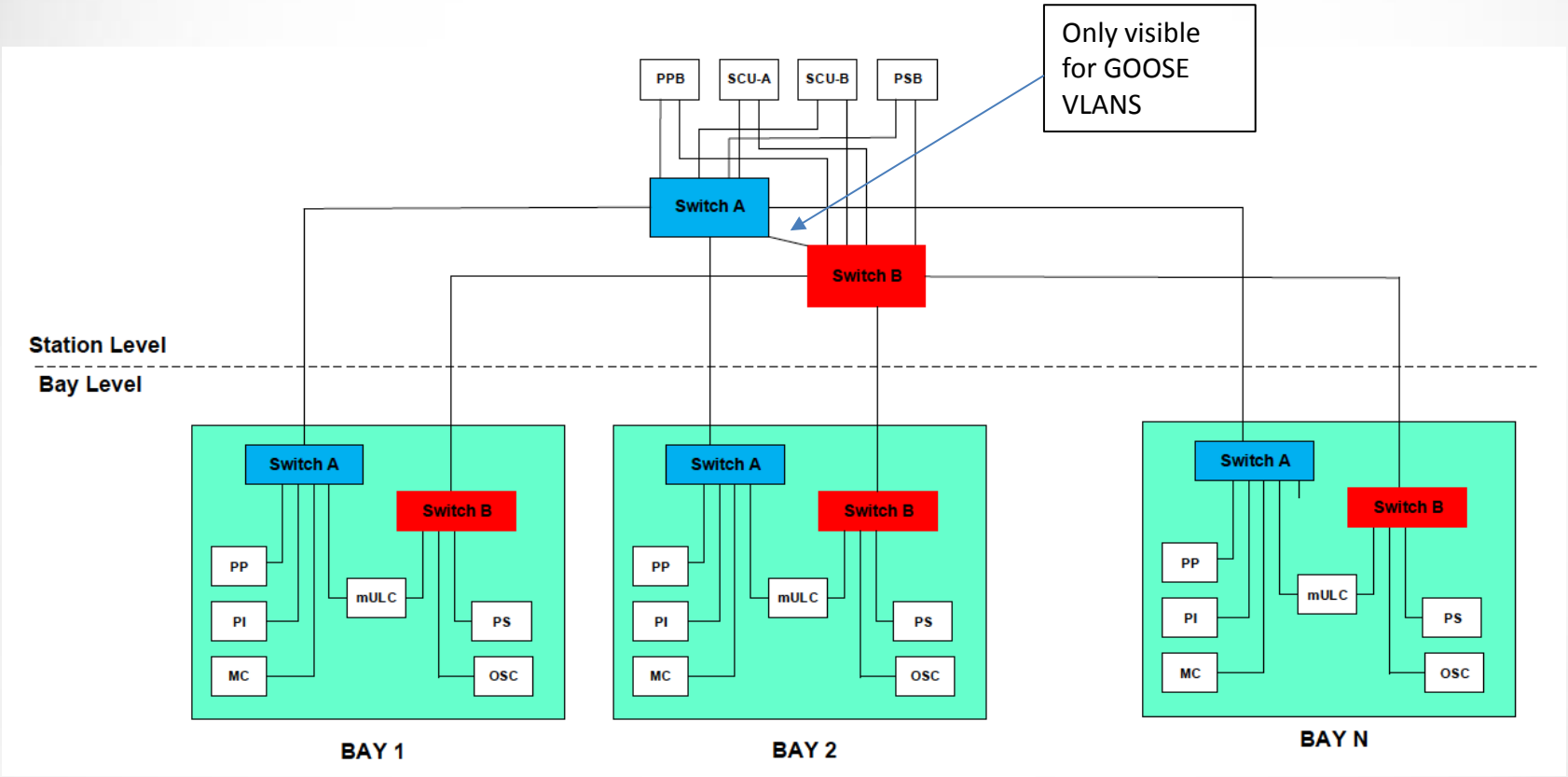
VLAN and multicast address policy



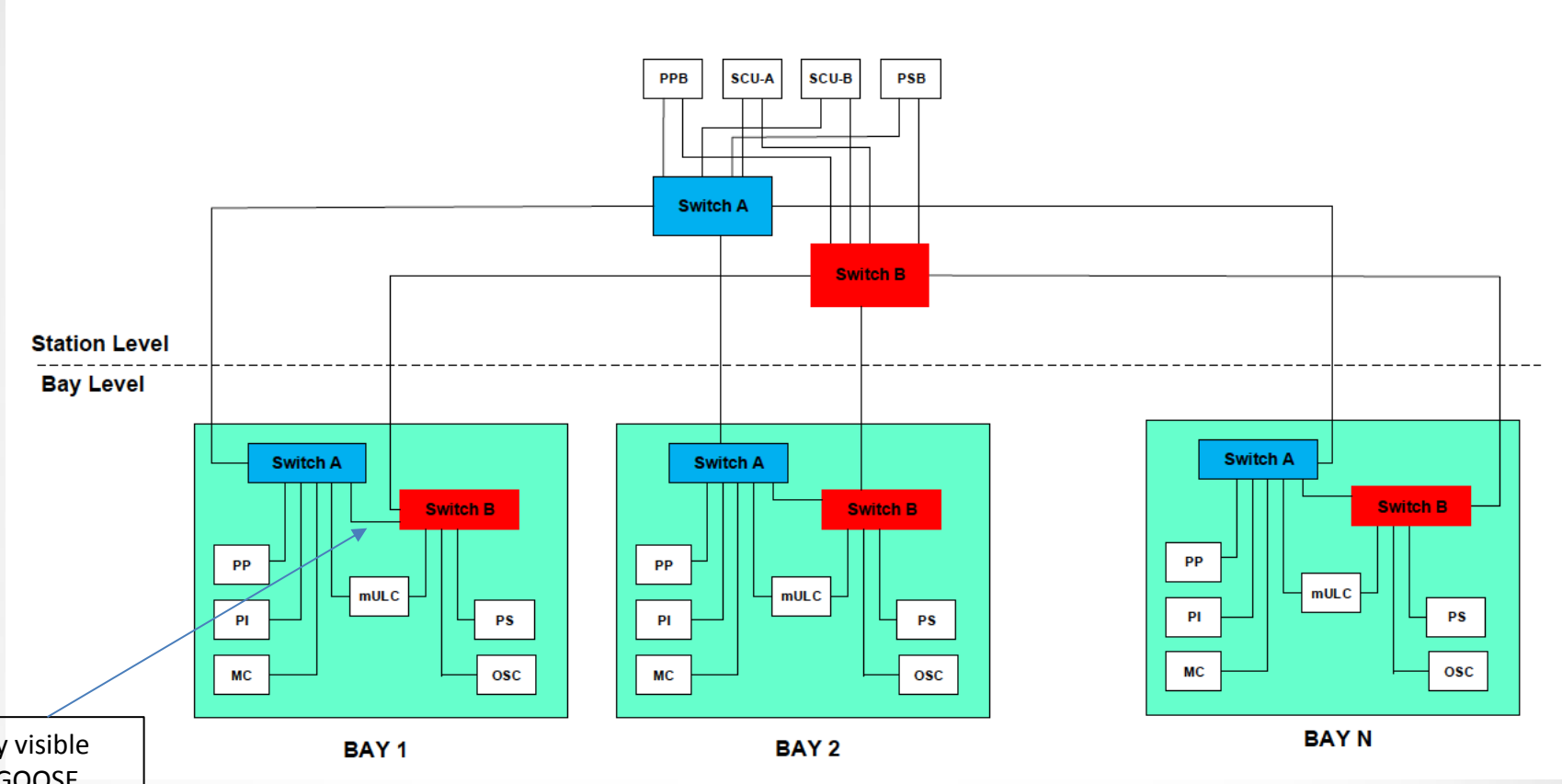
Double ring with connection at bay level



Double star with core switches connected



Double star with connection at bay level



Selection

- Double star with connection at bay level
- Star is more deterministic than the ring
- Using VLAN the traffic can be controlled
- Maintenance actions in one bay does not affect the whole system
- Connection at bay level is better than at station level
- The cost of the studied solutions is quite similar
- The best option is having PRP in all IEDs

INDEX

1. Overview of the paper
2. **Question Q1-11**
3. Question Q1-12

Q1-11: Based on your experience, is it possible to give us a general overview of advantages and disadvantages of the different topologies and also when to deploy them?

Objective

- To compare network topologies
- Select the key indicators
- Take into account Substation Automation System requirements
- Take into account fault tolerance situations N-1, N-2, …
- There is no perfect solution
- Need a compromise
- Study each topology

Key indicators

- Cost
- Complexity (configuration, wiring)
- Reparations and substitutions
- Adding/Removing new bays
- Testing
- Availability under faulty situations N-1, N-2, …
  - Protection functions
  - Telecontrol functions

Availability Key indicators

- Protection functions
  - PDIF (87B, 87L, 87T)
  - PDIS (21)
  - RBRF (50S/62)
  - PTUV (27)
  - PTOV (59)
  - RREC (79)
  - RSYN (25)
- Telecontrol functions
  - Remote control of primary elements
  - Data acquisition

Other issues

- IEC61850 implementation
  - Station bus: The network does not affect tripping and main protection functions
  - Process bus: The network affects tripping and is key for the system
- Maintainability
  - Star topologies are better than rings: repairing a switch in a star only affects locally, with the ring all the system is affected (and out of service while the ring is being reconfigured)
- Traffic control: better with a star
- The more redundant the system is, the more difficult to isolate IEC 61850 edition 1 IEDs is

Comparison (I)

Issue	Single ring	Double star	Double ring
Deterministic	Poor	Good	Poor
Traffic control	Poor	Good	HSR- Not possible
Maintenance only affects locally	No	Yes	No
Fault recovery time	Yes	DAN – No SAN – No recovery	HSR – No
Basic Configuration	Easy	Easy	Easy
Adding/Removing bays	Carefully	Easy and simple	Carefully
Link fault tolerance	Yes	DAN – Yes, SAN - No	Yes

Comparison (II)

Issue	Single ring	Double star	Double ring
Switch fault	Yes, partial	DAN – Yes SAN – No	HSR – Yes (IED fault)
Station bus	Suitable	Suitable	Suitable
Sampled Values	Not suitable	Suitable	Not recommended
Digital process bus	Not suitable	Suitable	Suitable
IEC 61850 ed. 1 IED isolation[1]	Possible[2]	Possible[3]	Not possible[4]
IEC 61850 ed.2 IED isolation[1]	Yes	Yes	Yes

[1] Connected to the network

[2] Using a special VLAN for isolating the IED

[3] Multicast filtering for some IEDs; special VLAN for others; [4] Possible if the HSR ring is done with switches

Comparison (III)

Issue	Single ring	Double star	Double ring
Wiring	Depend on the layout	Easy	Depend on the layout
Cost	Cheaper[1]	Expensive	Cheaper[2]
Switch CPU load	High	Medium	High (if used)
IED CPU load	Low	DAN – Medium SAN – Low	High
Network bandwidth available	100%	100%	50%
Connecting testing equipment	Easy	Easy	HSR – Difficult and affects the system

[1] Except if two switches are used at bay level (one for protection system A, one for protection system B)

[2] There are no switches, although IEDs are more expensive due to CPU load; If switches are used, is as expensive as Double star

Conclusions

- Rings look good but be careful
  - Difficult for maintenance works at bay level
  - No easy traffic control
  - Recovery time and network bandwidth
- Stars look easy but be careful
  - Without redundancy there is no fault tolerance
  - PRP is the appropriate protocol
- For sampled values process bus we recommend not using rings
- For digital process bus we recommend to use a star
  - Two independent stars, for protection systems A and B, no PRP
  - Two independent stars with PRP , for protection systems A and B

But there is not a perfect solution

INDEX

Q1-12: What is your advice to deal with the complexity of the network to minimize its possible impact on the continuity of the services?

Options

- Physical isolation of sampled values network
- Traffic segmentation
  - Use of VLAN
  - Use of multicast filtering (if needed)
- Traffic pattern analysis (especially for ring topologies)
- Traffic control policy
  - Do not send information to IEDs that does not need them
  - Route Goose messages
- PRP networks: connect the minimum SAN IEDs as possible

Thank you very much for your attention!!

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