

Substation to control Centre Communication in IEC 61850

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Introduction

- > *Previous architecture for protection and control in transmission stations at Hydro-Quebec was mature and processes are well established to deploy and maintain the systems*
- > *However it relied on proprietary technologies and could not be modernized easily*
- > *A lot of installations were commissioned between the 70s and the 90s so their end of life is near or has been reached*
- > *Refurbishment of the Remote SCADA system is required partly due to obsolete technology and to stay ahead of future requirement with an innovative solution*

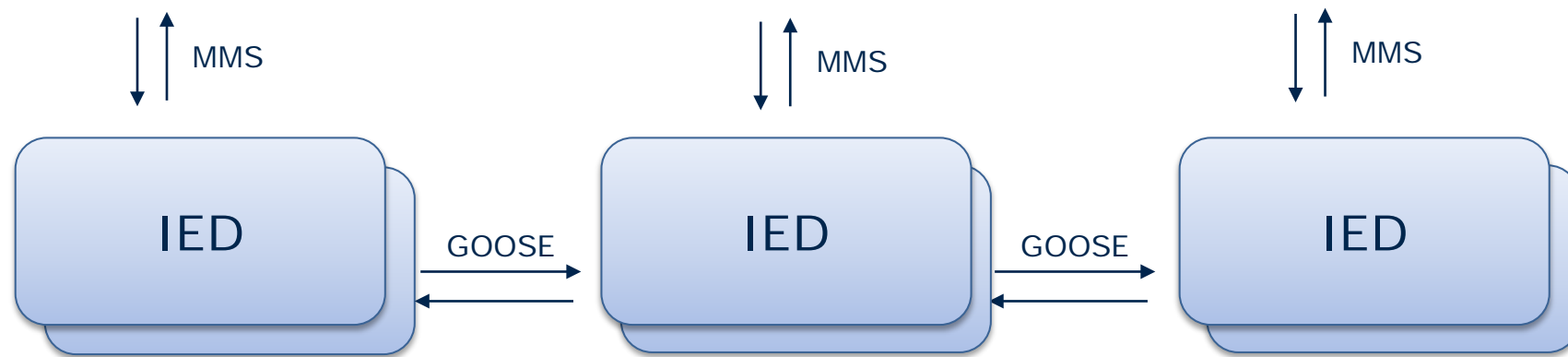
Architecture

A two-fold Plan

- > ***Refurbishment of the Remote SCADA system. Planned for 2024-2025***
 - > ***Complete remake of the system with compatibility with previous protocols for legacy stations and IEC61850 for future stations***
 - > ***Integration of Transmission and Distribution Management under the same scalable and flexible solution***
 - > ***New hardware and software solution based on IEC61850 for better interoperability***
- > ***Development for a new architecture for stations protection and control systems based on IEC61850. Pilot project delivered in 2019, standardized solution currently being deployed***
 - > ***This architecture to be designed to take the full potential of IEC61850***
 - > ***Improve on the accessibility of the station remotely in order to help with the maintenance of the station***
 - > ***Reduce costs of homologation of new products and solutions***

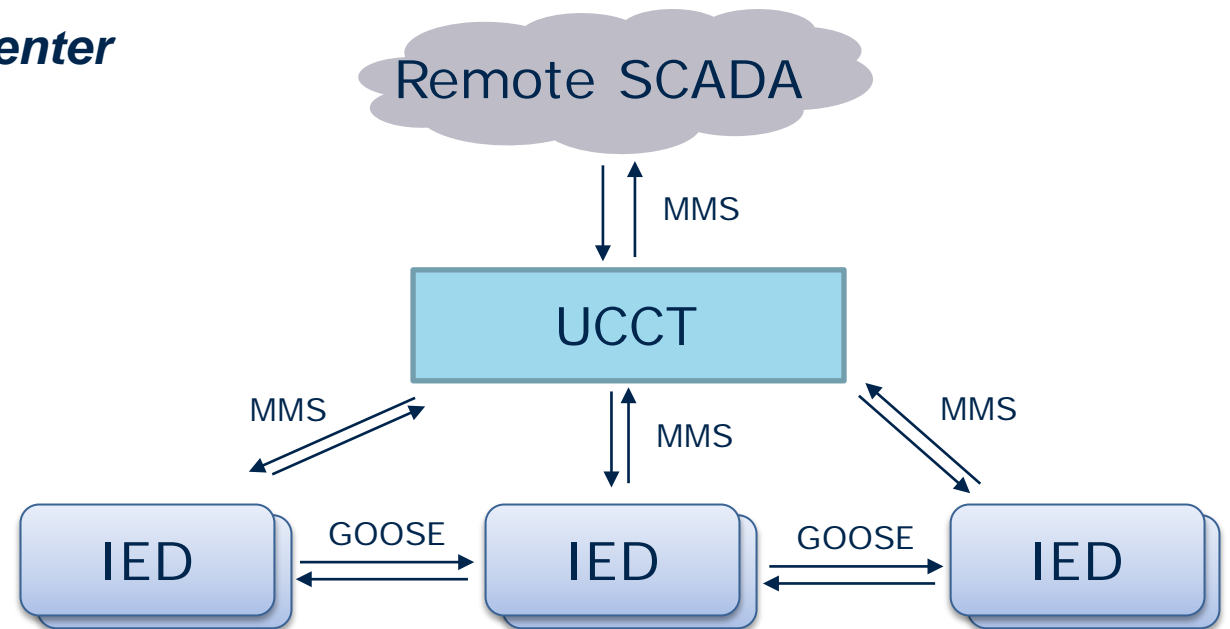
New Station Architecture

- > **For optimisation of the solution, commands and protections functions are fit within the same IED**
- > **All IED are IEC 61850 relays. Communication will be by IEC61850: GOOSE between relays for protections functions and real-time automation functions. MMS reports are used for communication for bay level to station level & Station level to Remote level.**
- > **IEDs are application based for the protection of the different major components in the station : Transformer, Line, Busbar, Feeders**
- > **All protection IEDs are redundant for better availability and reliability**



New Station Architecture

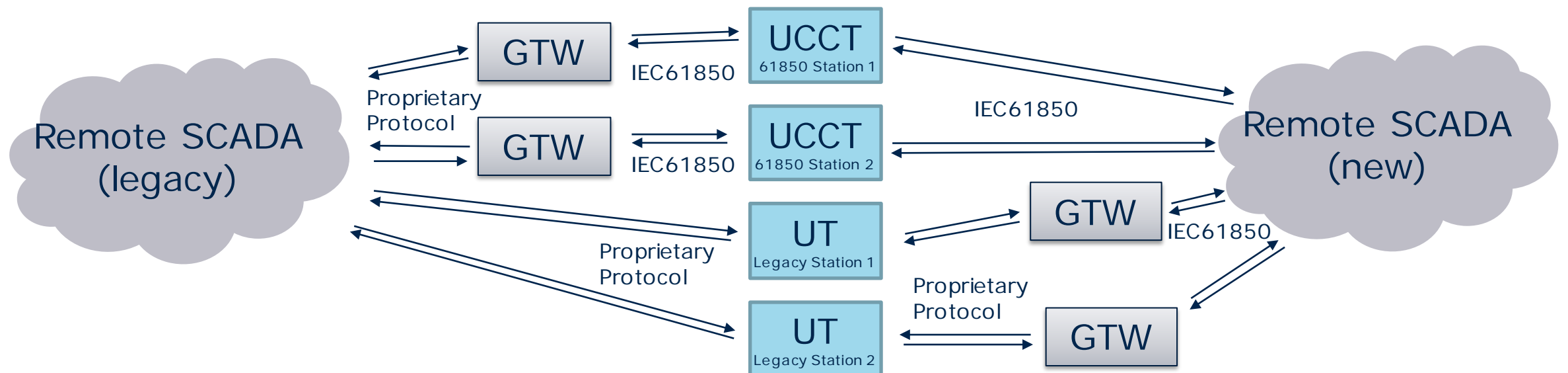
- > **Station level communication (UCCT) is handled by a windows based software that handle local HMI and remote level communication.**
 - > **Data concentrator for signals coming from all IEDs**
 - > **Redundancy management**
 - > **Communication with Remote SCADA center for operation information and to the maintenance servers**
 - > **Local HMI with event & alarms**
 - > **Software installed on a virtual Machine for easier deployment and easier integration with other services**



UCCT : Unit for centralized command and tele-control (French)

Two projects, one goal

- > *Remote level communications is part of a major project to upgrade the technology used in the system used for transmission network management and distribution network management*
- > *Planned to take into account new station built in 61850 and legacy stations in proprietary protocol*
 - > *Intermediate gateways to do the IEC61850-proprietary protocol conversion*



Hydro-Québec Model based on IEC61850

A Common Datamodel

- > *At the root of the new Hydro-Quebec architecture is a common datamodel based on IEC61850*
- > *Standard applications were already present at Hydro-Quebec.*
 - > *Standard application for protection relays*
 - > *Standard applications for devices (CB, SW, TR, etc.)*
- > *In order to have a unique identifier for all signals, the LD is defined according to a predefined structure :*

Station->Voltage Level-> Bay-> Device -> Function
- > *This allows all data to be unique across all ~500 installation using the function-related naming. (IEC61850-6 section 8.5.3)*
- > *Internal tools allows the creation of SSD per station with reference with the common generic model*

A Common Datamodel

Typical Circuit breakers

- > **Command module (Location code)(Voltage Level)(Bay)(Device)CM**
L12345NT35L123D25_23CM/CSWI1.Pos.StVal
 - > **Position: XCBR1.Pos & CSWI1.Pos**
 - > **Command: CSWI1.Pos**
 - > **Local indications: XCBR1.LocKey, CSWI1.Loc, CSWI1.LocSta**
- > **Supervision module (Location code)(Voltage Level)(Bay) (Device)SP**
L12345NT35L123D25_23SP/CC_PTUV1.Op.StVal
 - > **Voltage indication: CC_PTUV1.Op**
 - > **Coil alarm: SCBR1.CoIAIm**

Product-Related Naming vs Function-Related naming

- > *Limitations in IEDs and tools does not allow us to easily implement function-related naming in the IEDs. Most tools have been created with product-related naming in mind.*
- > *Configuration time for each IED can greatly vary between technologies. Templates can help reduce configuration time. However, across multiple vendor solution, a homogeneous solution is preferred*
- > *Current Station level software allows to implement function related naming independent from acquisition from IED (product-based naming or function-related naming)*
- > *The solution adopted was to implement product-related naming in the IEDs and function related naming in the UCCT going to remote SCADA.*

Acceptable workaround

This creates an increase in UCCT configuration in order to do the translation between product-related naming and function related naming. However, the translation can be predicted quite easily with simple tools.

L12345NT35L123CEPA_A_D25_23CM/CSWI 1.Pos.StVal

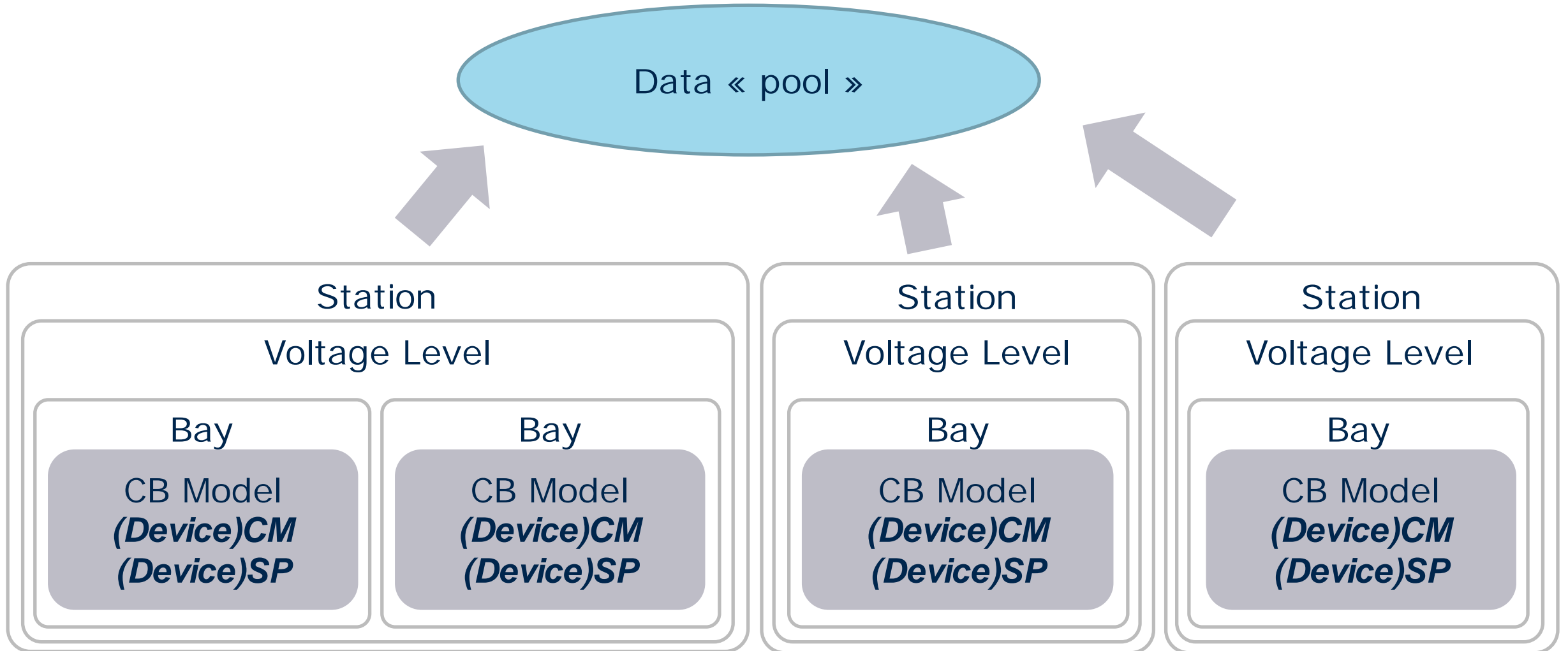
[IED Name(Location code)(Voltage Level)(Bay)(A/B)] (Device) (Function) / (prefix) + LN . DO . DA



L12345NT35L123D25_23CM_A/CSWI 1.Pos.StVal

(location code)(Voltage Level)(Bay)(Device)(function)(A/B) / (prefix) + LN . DO . DA

A Common Datamodel across all installations

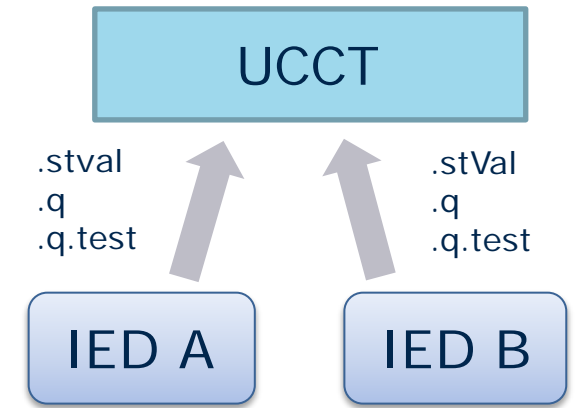


Custom Best-of Function

As data now comes from redundant IEDs, The station level equipment need to take into account a common data acquired by redundant sources.

The requirements :

- > **choose the best data (for device positions)**
- > **execute an OR function of the data (alarms or trips)**
- > **Calculate the average of two measurements (analog values)**
- > **Take into account quality (valid, invalid, questionable) and the test flag**
- > **Detects discrepancy between A&B value when quality and test are a match. Detects greater than normal difference between two analog values. Changes the quality to the result value to questionable and raises an alarm**



A (valid, not test) -> A OR B
B (valid, not test)

A (valid, not test) -> A
B (valid, test)

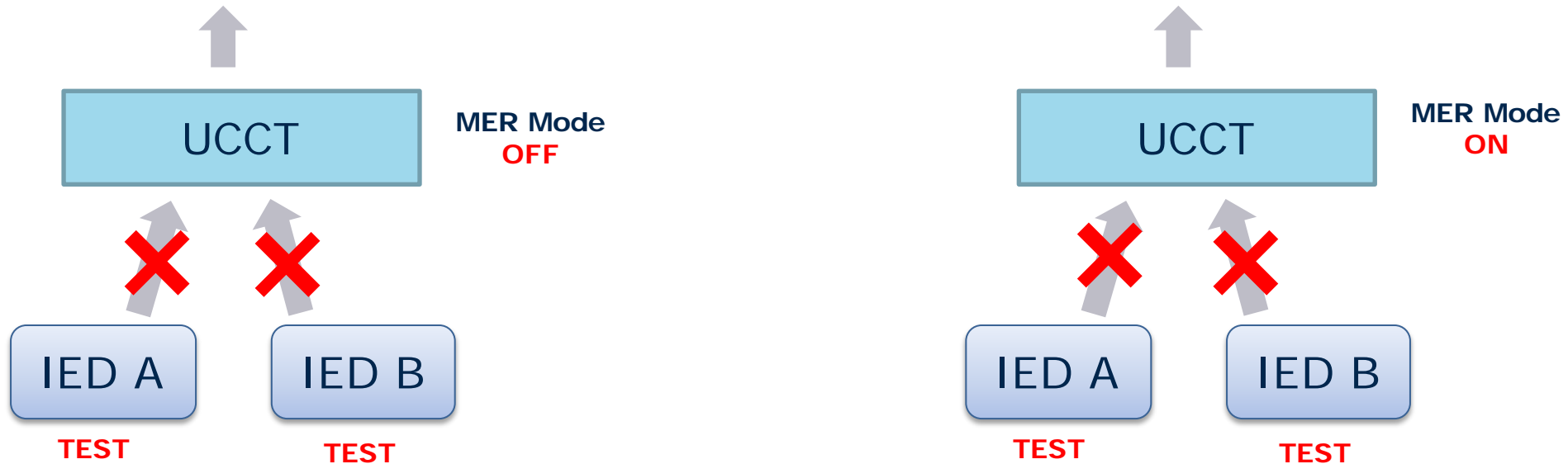
A (invalid, not test) -> B
B (valid, not test)

A (valid, test) -> A OR B, test
B (valid, test)

A ≠ B -> Alarm

Custom Best-of Function

- > Has a “Test mode” for station level in order to prioritize the value in test during commissioning



- > Sends the command to only of the IEDs based on the most available IED
 - > Availability of an IED based on health, mode & communication
 - > Other signals preventing operation can be used as well. For example, Trip Coil Supervision can also be added for a trip signal availability

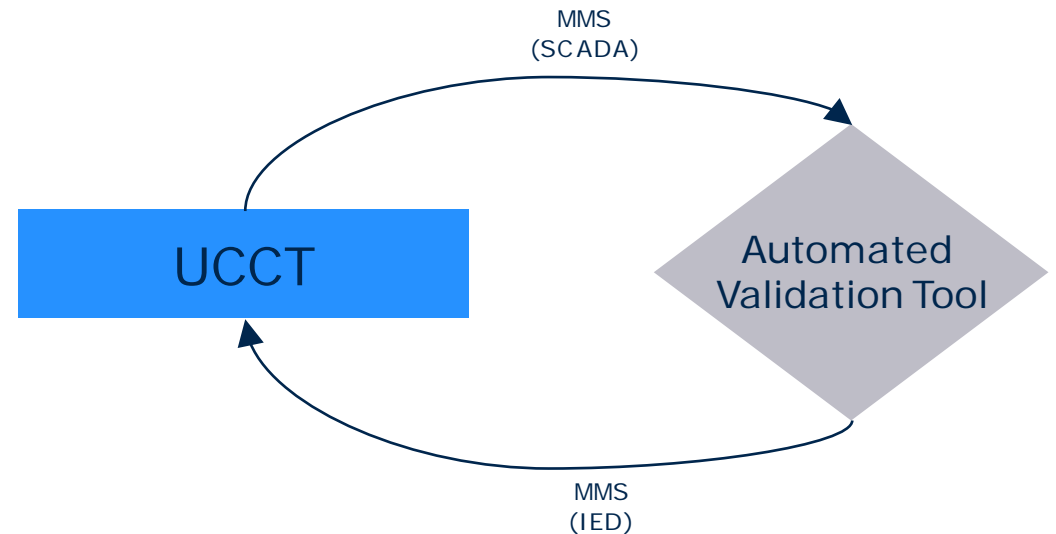
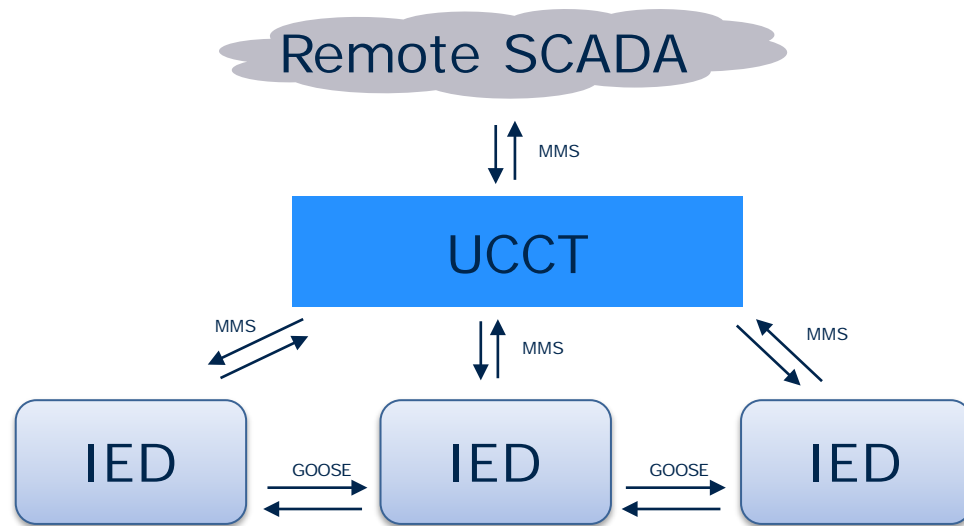
Automated validation

Automated validation

- > *With the change of protocol and architecture, the amount of points that can be provided to remote SCADA has increased.*
- > *However, with the advantages of IEC61850, it is much more convenient to associate a signal at the IED level and the same signal at Station level.*
- > *Using a IEC61850 simulation software that allows to define MMS servers and MMS Clients, it is possible to simulate all IEDs feeding information on the bay level of the UCCT and receive the information on the remote side of the UCCT.*
- > *Simulating Servers and clients is not enough! The ability to implement custom script within the software allows to tailor the validation to specific needs.*
- > *In our case, validation of all signals and validation of specific functions*

Automated validation

- > *For this purpose, we replace the IEDs and the remote SCADA with the validation software.*
- > *Using java scripts, we can simulate changes on the IEDs simulated by the validation software and log them in a CSV file. Using other script we “listen” to any transitions we see on the remote side and log them in a CSV file.*



Automated validation

Current validation

- > The first validation is to produce one transition for all signals. This allows us to validate the data concentrator part of the station level equipment (UCCT). All signals are supposed to be transferred as is from the bay level to the remote level.***
- > The second validation is to verify that for all signal that are concerned by the best-of function is behaving correctly. For each signal, the script provoke a change in both data sequentially in order to validate the function***
- > The third validation validates all inputs of grouped functions to verify that all members are triggering grouped alarms correctly***

Future Validation

- > Subset of signals triggered in a specific sequence to reproduce an alarm list or inputs conditions of specific functions***
- > Commands and dynamic feedbacks including blocking conditions***

