Writing PACS specification towards a future-proof Digital Substation

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AGENDA

1. *Specification writing*
2. *Specification in IEC 61850 Engineering Process*
3. *Producing IEC 61850 Specifications*
4. *Substation PACS Specification*
5. *Conclusions and future developments*

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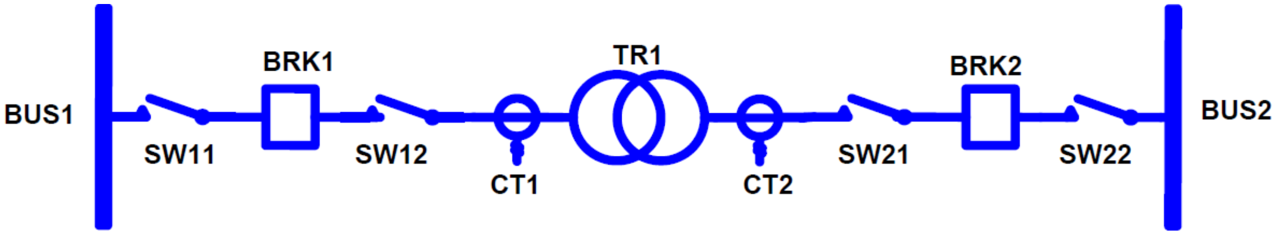
- How to describe functional requirements?
  - Natural Language:
    - Example[1]:



      - "Transformer TR1 should be tripped during any overload greater than 120% of any of its coil nominal current that stays for at least 50ms in no more than 100ms"
    - Has been significantly used so far
    - Many easy-to-use tools are available: text and spreadsheet processors

[1] – Taken from CIGRE Task Force B5.02 Survey issued early 2017

- How to describe functional requirements?
  - IEC 61850 Substation Configuration Language (SCL):
    - Example[1]:
      - XCBR – Circuit Breaker; TCTR – Current Transformer; PTOC – Time Overcurrent; PTRC – Protection trip conditioning

Data objects & attributers	Type	Value	Description
TCTR.AmpSV.instMag.i	INT32	-	Current (sampled value), Output
TCTR.AmpSV.sVC.scaleFactor	FLOAT32	0.001	According to IEC61850-9-2LE
TCTR.AmpSV.units.SIUnit	ENUM	5	Represents the SI unit ampere
PTOC.InRef1.setSrcRef	ObjectRef	TCTR.AmpSV	Input to PTOC logical node
PTOC.StrVal.setMag.i	INT32	"1.2 x I_nom"	Pick up value for 1. stage of PTOC
PTOC.StrVal.units.SIUnit	ENUM	5	Represents the unit ampere
PTOC.OpDlTmms.setVal	INT32	50	Intentional time delay for 1. stage
PTOC.OpDlTmms.units.SIUnit	ENUM	4	Represent the SI unit second
PTOC.OpDlTmms.units.multiplier	ENUM	-3	Multiplier to obtain milliseconds
PTOC.Str.general	BOOL	[TRUE,FALSE]	Start of PTOC
PTOC.Op.general	BOOL	[TRUE,FALSE]	Operate of PTOC
PTRC.InRef1.setSrcRef	ObjectRef	PTOC.Op	Input to PTRC logical node
PTRC.Tr.general	BOOL	[TRUE,FALSE]	Trip signal for the XCBR
XCBR.InRef1.setSrcRef	ObjectRef	PTRC.Tr	Input for the trip signal from PTRC

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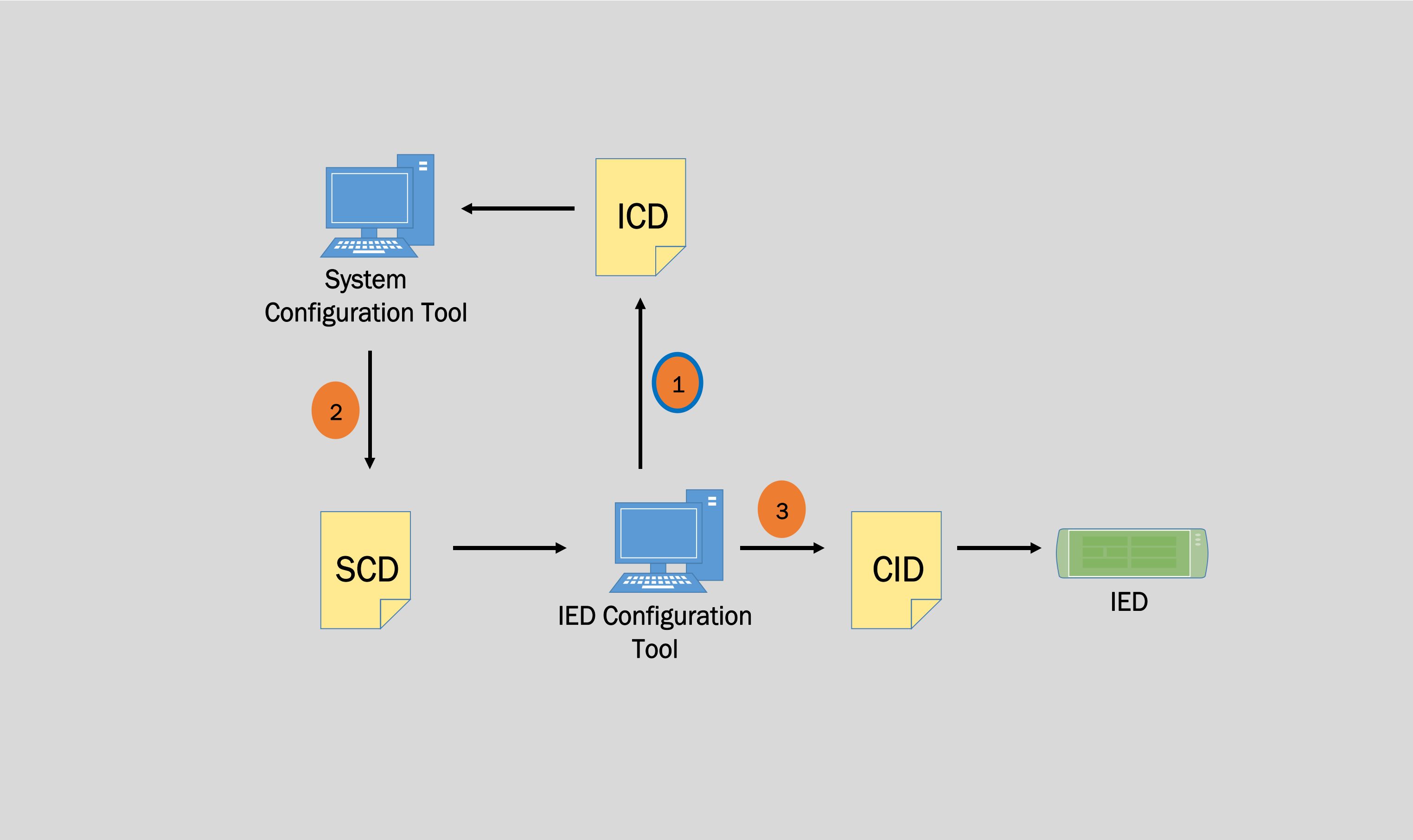
- **Bottom-up approach:**



- **Bottom-up approach:**
  - Starts in IED Configuration Tool

    specification is done before IEC61850
  - Specification

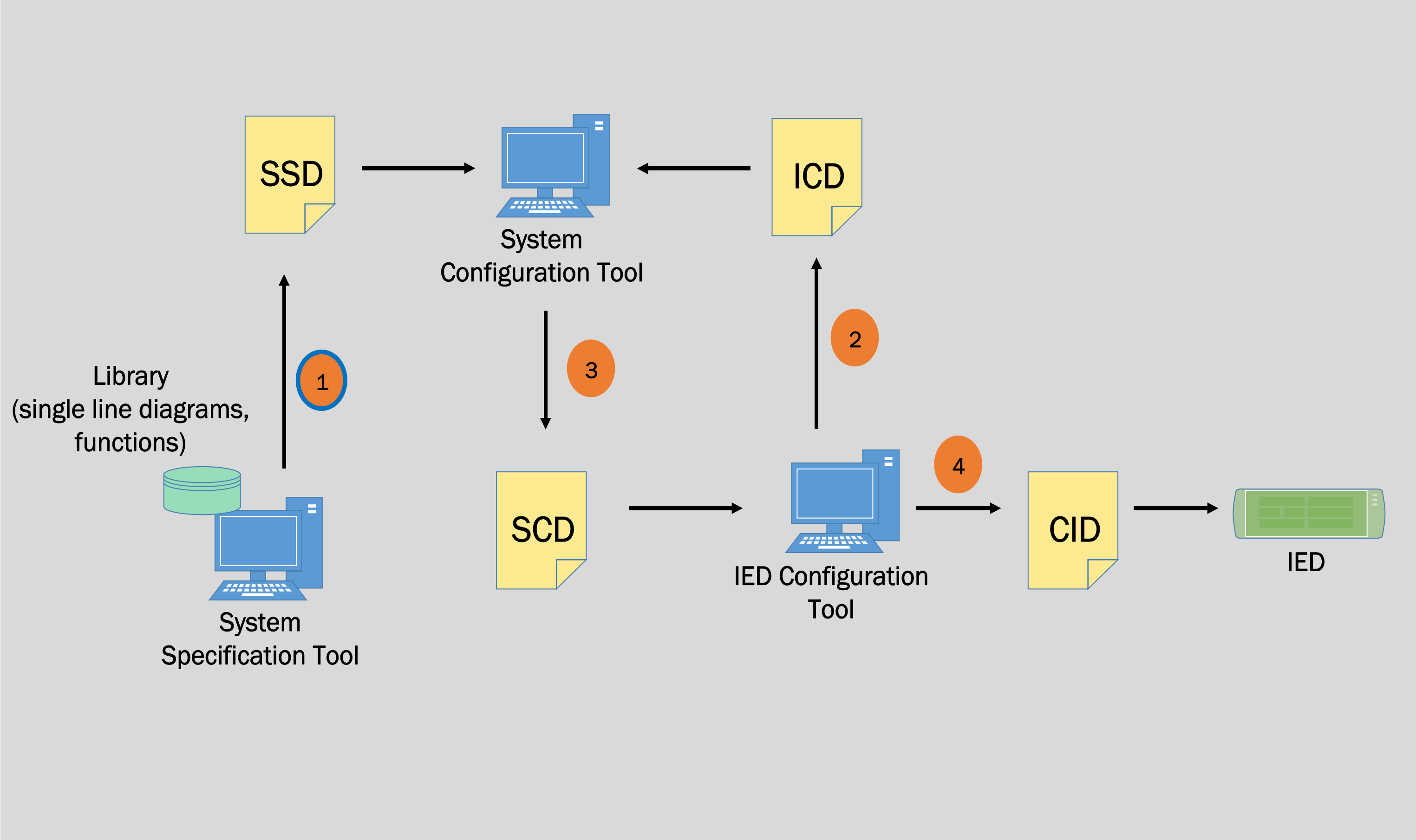
    mainly done in Natural Language
  - Engineering Process

    is based on manufacturer's data model
  - Utilities have

    less control on IED data model
  - Easier to kick-off IEC 61850 implementation

    but is **NOT FUTURE-PROOFED!**

- **Top-down approach:**



- **Top-down approach**

  - Engineering Process **starts by utility SPECIFICATION!**
  - Specification of PACS functions **through SCL files**
  - Manufactures shall **implement specified data model**
  - Utilities have **more control in their assets!**

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*Going towards a **solid adoption** of IEC 61850 specification…*

- Guarantee the future replacement, expansion, efficient maintenance and good operation of PACS
- Future-proofed substations must provide the same **availability, dependability and maintainability** as conventional ones, or **better!**
- IEC61850 **triggers** the need for **adaptation** of the specification for Protection, Automation and Control Systems (PACS)
  - Previous specifications can have **technical constraints** which do not exist anymore
- Utilities are the responsible entity

so they play a crucial role!

*Going towards a **solid adoption** of IEC 61850 specification…*

1. **Standardization** is essential:
   – Identification of all **different topologies** existing in utility's substations
   – For **each topology**, identification of:
     • **Functions**
     • **Equipment** (IED) aggregating functions
     • **Signals** for communication between equipment
     • Set of **parameters** to be specified for each function

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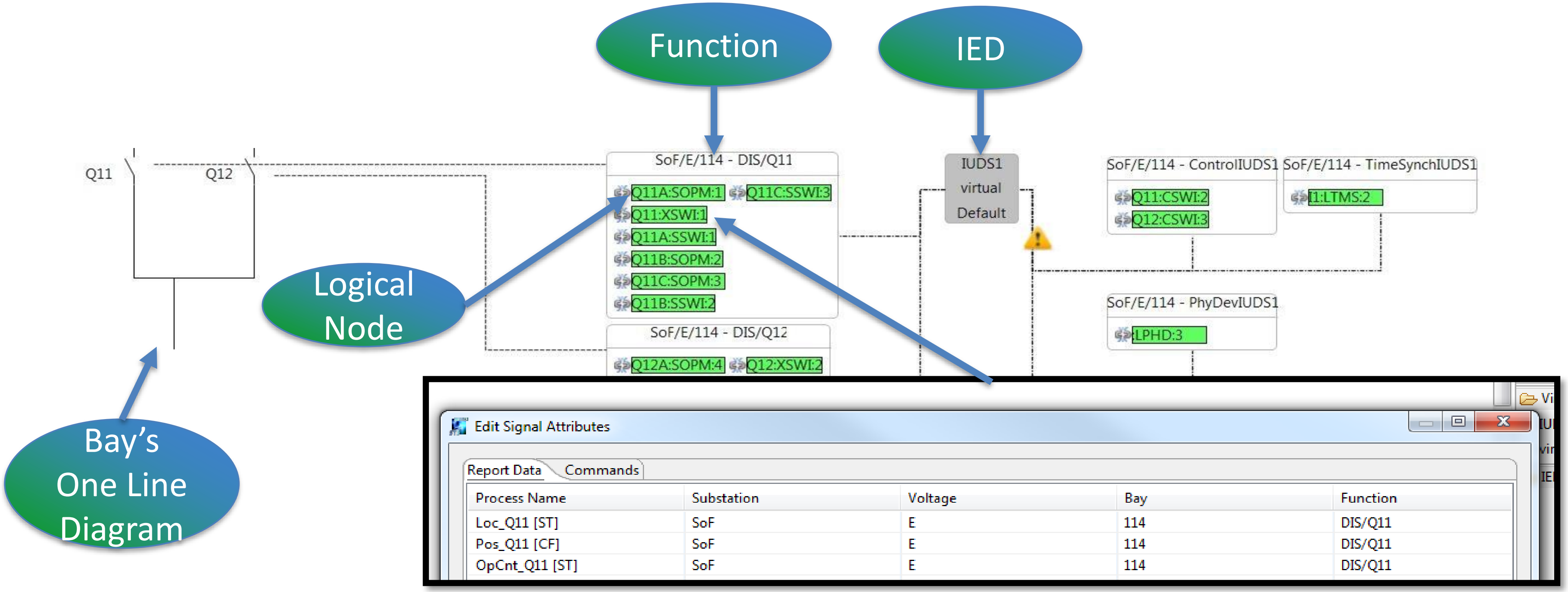
2. Model each bay template functions and signals:



Process Name	Substation	Voltage	Bay	Function
Loc_Q11 [ST]	SoF	E	114	DIS/Q11
Pos_Q11 [CF]	SoF	E	114	DIS/Q11
OpCnt_Q11 [ST]	SoF	E	114	DIS/Q11

Signal List for Logical Node Q11XSWI1

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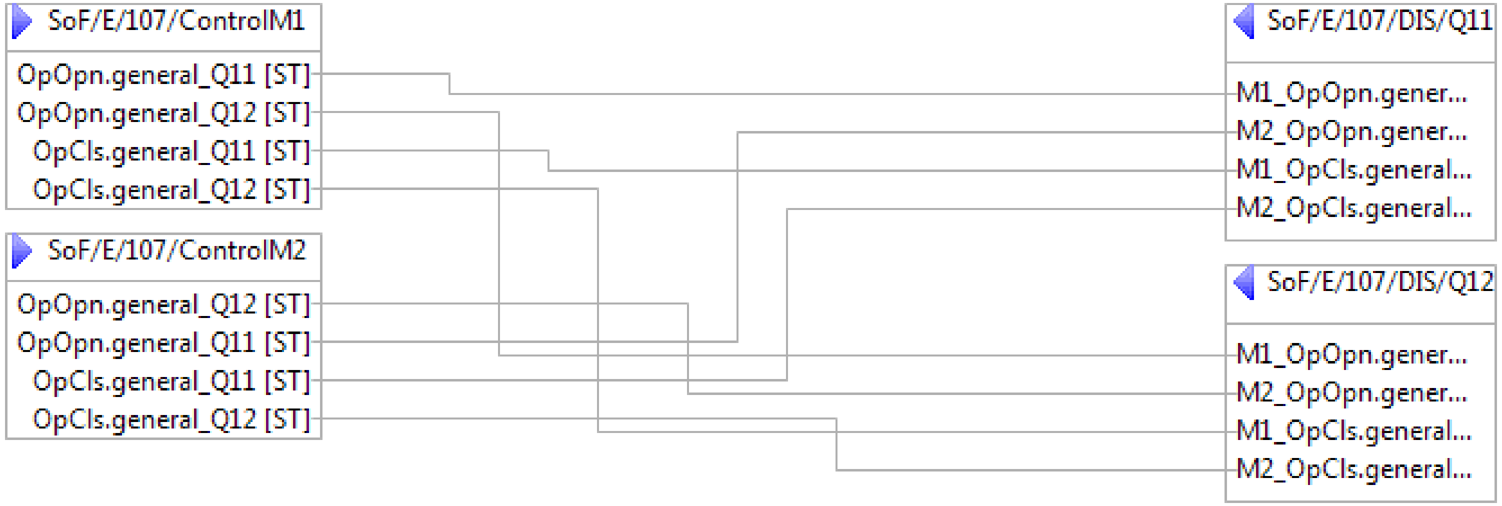
3. Model each bay template Report, GOOSE and SV application:



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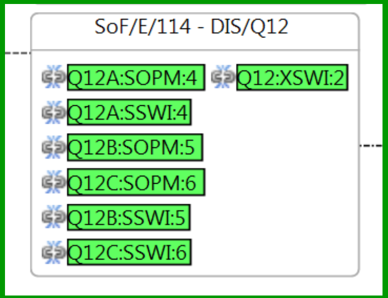
4. Creation of libraries:

Specification Library – ***Basic Application Profiles*** (IEC TR 61850-7-6 is WIP)

Functions Library



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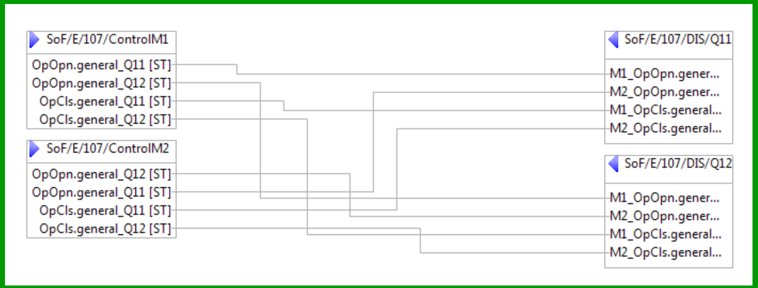
Applications Library



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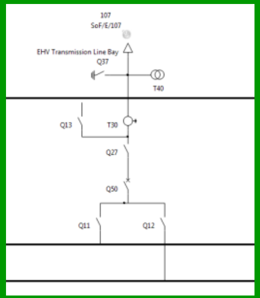
Bay Library

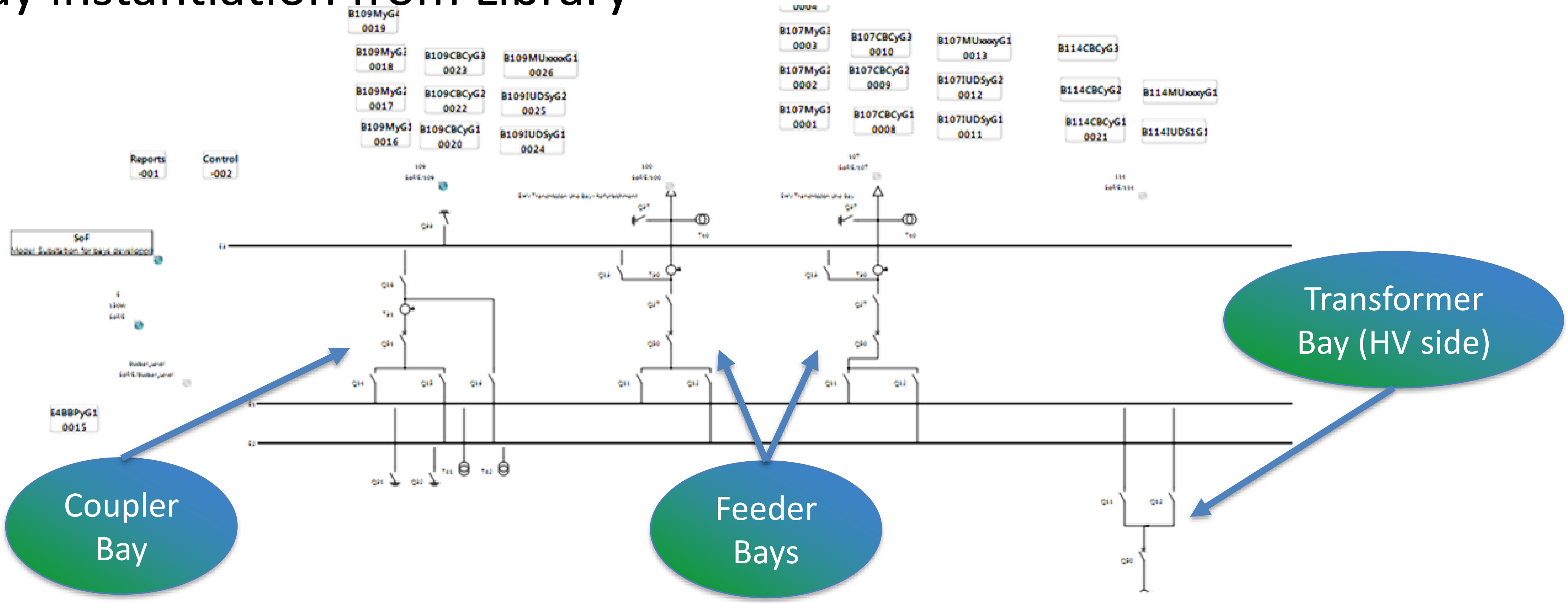


Now we can create substation specifications…

*Going towards a **solid adoption** of IEC 61850 specification…*

Now we can create substation specifications…

1. Bay instantiation from Library



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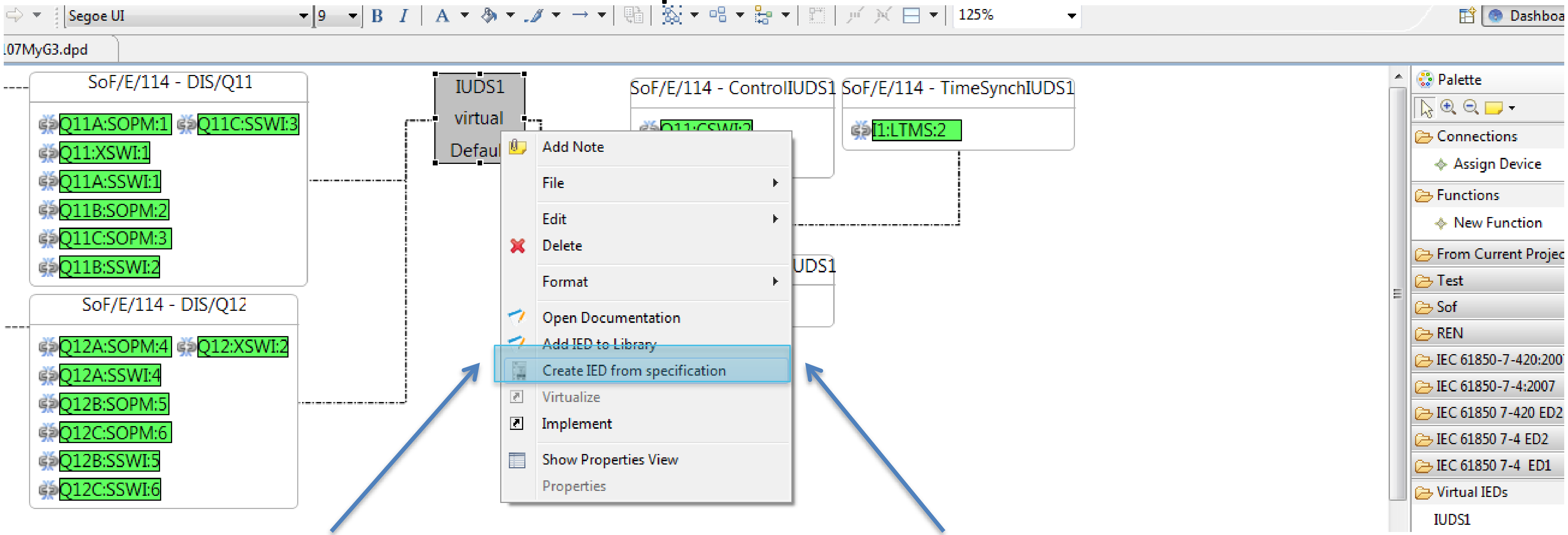
Now we can create substation specifications…

2. Create IED SCL file from specification



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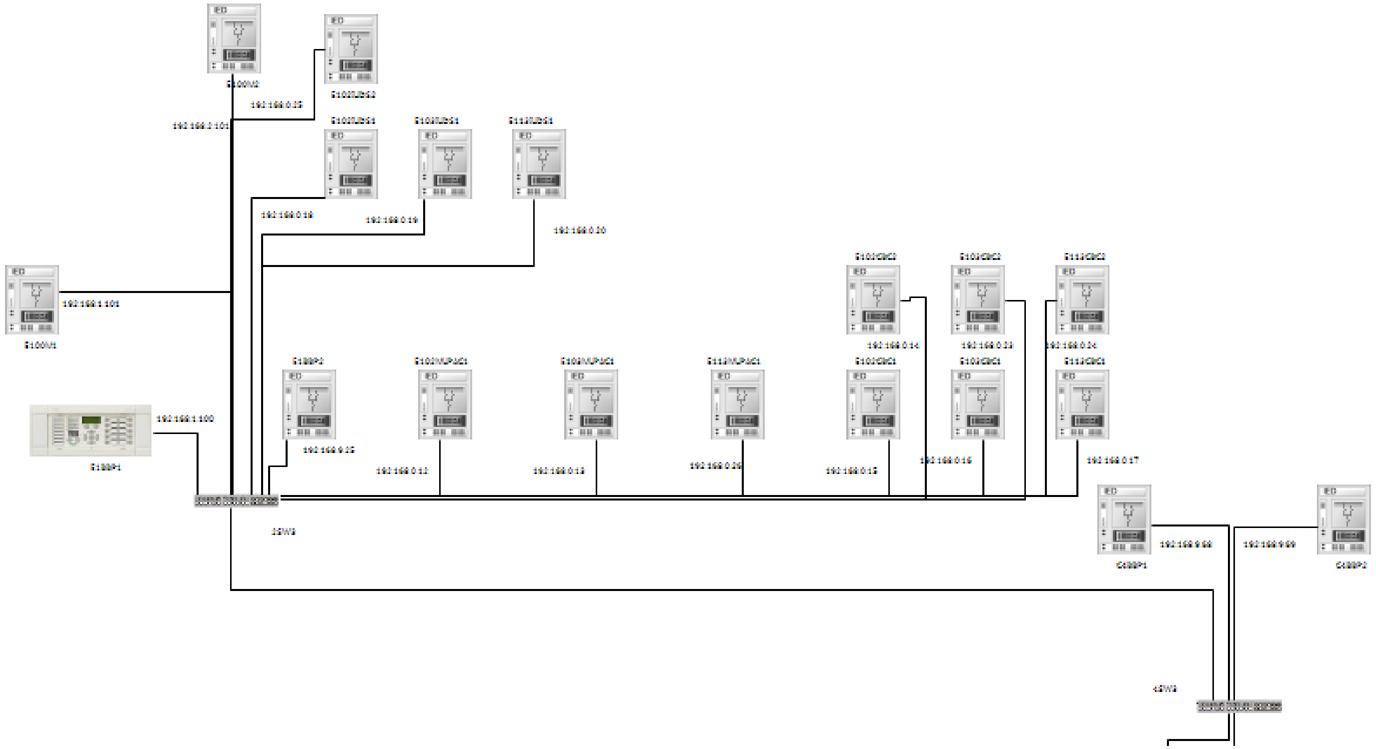
Now we can create substation specifications…

3. Drawing substations communications network



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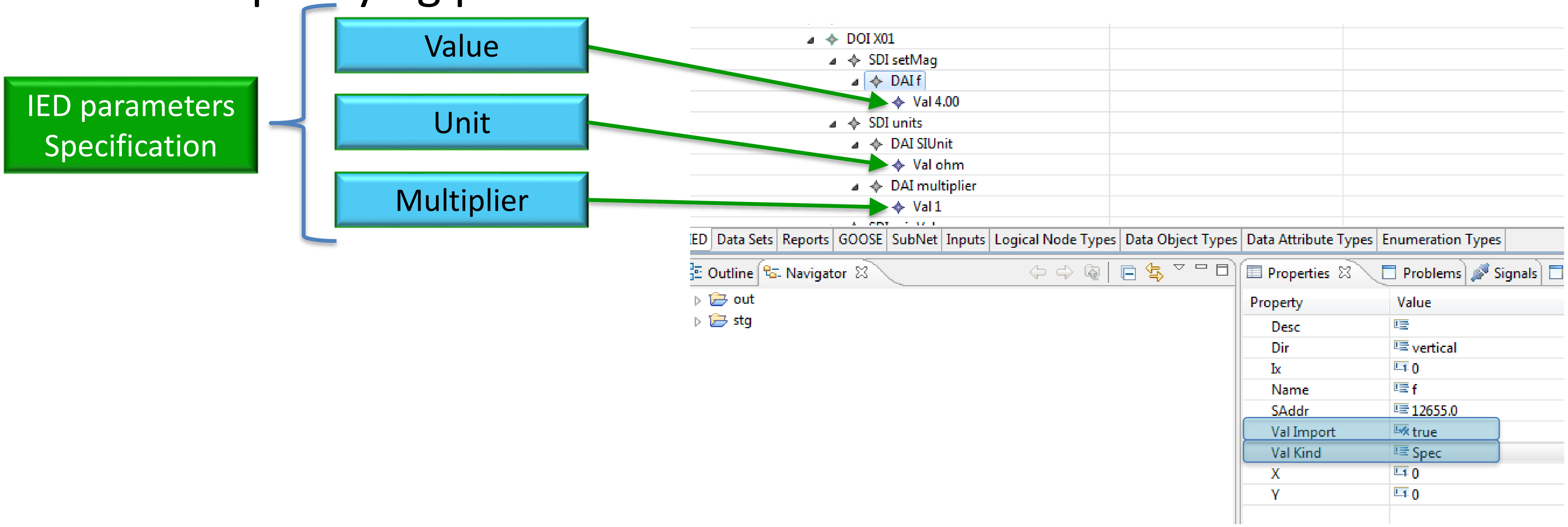
Now we can create substation specifications…

4. Specifying parameter values in IED data model



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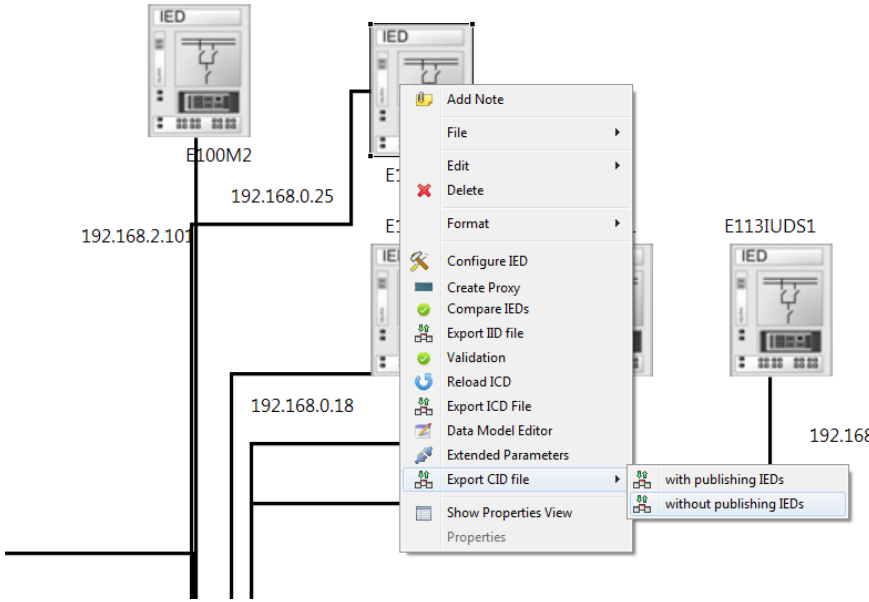
Now we can create substation specifications…

5. Create IED CID file (what about ISD file?) and deliver it to vendors!



CID File:

- **Specified IED services**
- **Specified data model**
- **Specified parameters**
- **Specified internal connections**

Producing IEC 61850 specifications

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And then?

- IED is **delivered**
- IED’s **ICD file is imported** in System Configuration Tool
- **Mapping** between specified and implemented Logical Nodes
- Applying **application configuration** → GOOSE, SV, report
- **IED configuration with CID file**: parameters, GOOSE, SV, and report configuration

Main ***advantages*** *foreseen:*

- **Less ambiguity** on understanding the requirements

- Great kick-off effort to create the libraries

But easier and faster future substation specifications

- Suppliers can still **improve their devices** – they just enable Logical Nodes **<u>specified by utilities</u>**

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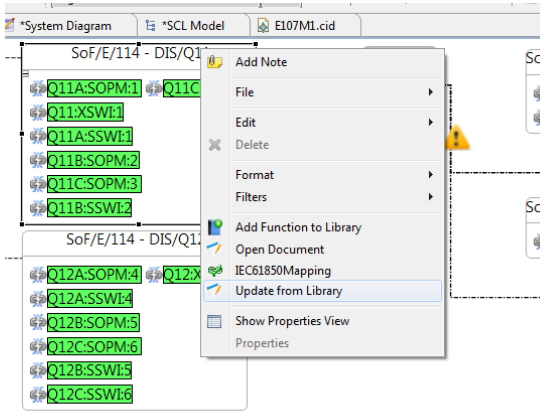
*Main **advantages** foreseen:*

- Modification in specifications means library modifications

  Done in template project

- Simple to update previous projects with updated specifications:
  - Easy **upgrade to future IEC 61850 editions**
  - Easier to specify and configure **multi-edition systems**



- Increase interoperability and data model similarity among vendors – towards **interchangeability**
- **SCL has good applicability to power systems, implementability by tools and equipment, testability, modularity and modeling!**

Producing IEC 61850 specifications

*What is **blocking** effective specification writing?*

- SCL files not suitable to be readable/writable **directly by humans**
  - Need for **specific tools**:
    - Tools are not mature – **need constant fixes**
- Frequent bugs due to the **highly IED firmware change rhythm**
- **Incompatibilities** among different IED, specification and configuration tools
- Some manufactures are **not willing to deliver** IED with client-defined data model
  - Many IED with **fixed** or **poorly flexible** data models

*What is **blocking** effective specification writing?*

- **Qualified personnel** dominating IEC 61850 standard is needed to specify, design and commission
  - **Not easy** for a new user **to quickly learn** the concepts and techniques
- **Great initial effort** from utility
- Not easy to **prove** that the specification **attends the requirements**

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- What needs to be specified?

What?	How? SPECS
Protection and automation devices	IEC 61850 SCL files
Interlocking	.doc
HMI: data acquisition, data storage, log management, access control	.doc, .xls
Oscillography recording	IEC 61850 SCL files
Time synchronization system	.doc
Communication infrastructure (links, switches, routers)	.doc, .xls
Metering devices	IEC 61850 SCL files
Gateways	IEC 61850 SCL files
Monitoring devices	IEC 61850 SCL files
Wiring and cubicle works	.dwg, .doc, .xls
Substation Redundancy schemes	.doc

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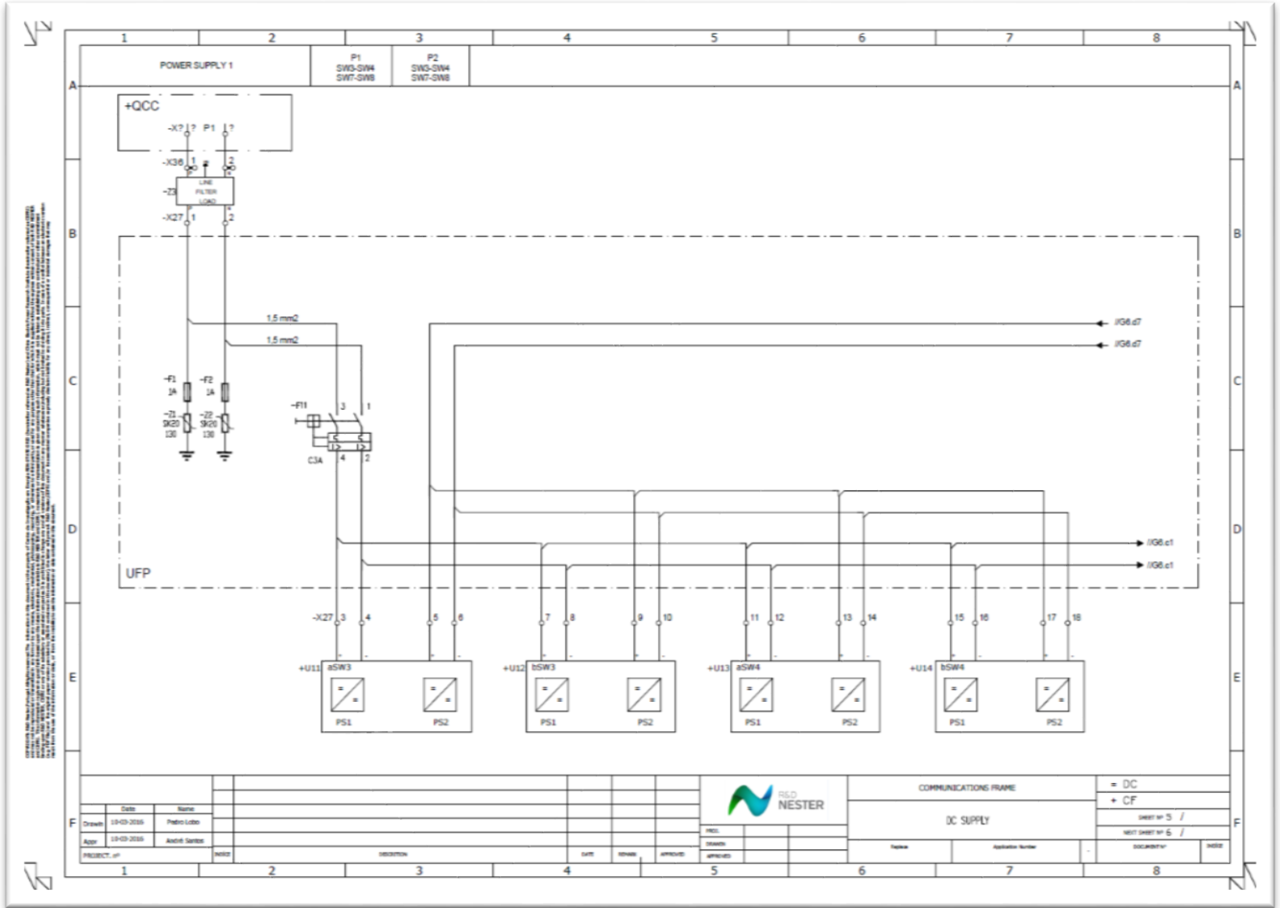
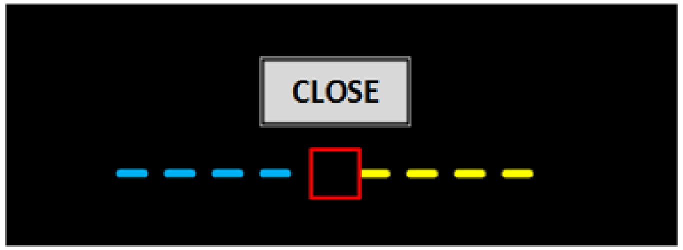
- What needs to be specified?
  - Examples of non-IEC 61850 SCL specifications:
    - Wiring and cubicle works

SPECS



- What needs to be specified?
  - Examples of non-IEC 61850 SCL specifications:
    - Interlocking

Category	Safety, avoid damage of equipment and hazard for people
Name	Rule 11
Device	Circuit breaker, isolator, earthing switch
Operation	Close
Topology change	Connection of active and earthed sections
Reason for interlocking	Earth fault yields damage
Graphic representation	 (same rule for isolators and earthing switches)

Substation PACS Specification

- What needs to be specified?
  - Examples of non-IEC 61850 SCL specifications:
    - Substation Redundancy schemes

The clients are the local SCADA units and the gateway and the servers are all IEDs that send information to the station level. In this case, there is not a preferred server (in a pair of redundant IEDs), that is, there is not an 'active' and a 'stand-by' server. This principle is depicted in **Figure 9**.

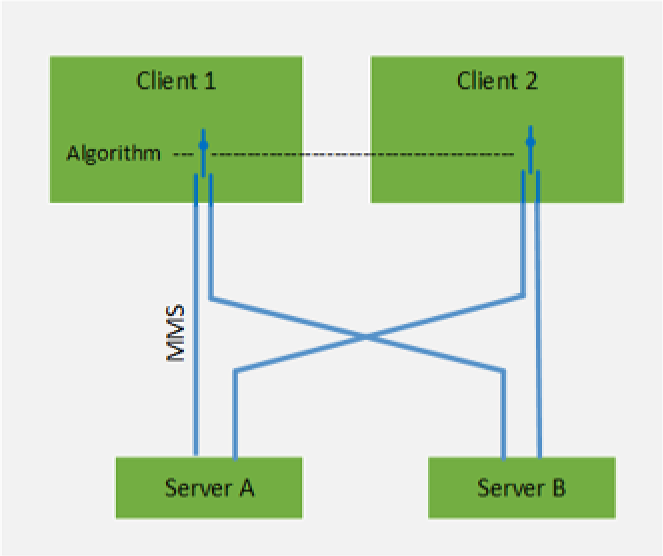


Figure 9 – Principle for MMS redundancy

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Conclusions and future developments

To conclude…

- Specification shall **consider** replacements, future expansions and refurbishments

<u>Live together with legacy systems!</u>

- **<u>Recommendations:</u>**
  - **Avoid GGIOs** – an important IEC61850 feature is the **standardized data model**
  - **Standardization** of system engineering
  - Adoption of **future-proofed procedures** for specification, FAT, SAT and maintenance tests using IEC61850
  - **Cyber-security**: need to plan the system, access rules, configuration procedures, maintenance procedures
  - How to **start**? Pilot projects…

For the future…

- **Manufacturers** could be more willing to **cooperate** on having a efficient specification process…
- Tools have to reach a **steady development state**
- Future work:
  - **Fully implement and improve specification** while IEC 61850 experience growths
  - **Interchangeability**
  - **Semi-automatic methods** to speed-up repetitive tasks

WORK TOGETHER towards future-proofed DIGITAL SUBSTATIONS!

?

Thanks for your attention!

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