Introduction to System Specification for IEC 61850 from a Standards Perspective

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Content

- Specifying a substation
- A word about product requirements in IEC 61850
- Specification aspects influenced by IEC 61850
- How to specify with IEC 61850?
- Advanced specification possibilities
- More features provided by IEC 61850-6-100
- Outlook – what has been discussed to be added?

New or retrofit substation?

- Retrofit of substation automation system
  - Stand alone specification for the SA system
  - Existing boundaries need to be considered (interfaces to switchgear, physical constraints like cable ducts, etc)
- New substation
  - Substation automation is part of the overall substation specification
  - More flexibility available
  - This flexibility can either be restricted by the specification or it can be kept as options for the design

Features of IEC 61850

- Interoperability between IEDs
- Standardized data access
- Object-oriented data model
- Free allocation of functions to IEDs
- Mainstream communication stack (MMS / TCP/IP / Ethernet)
- Standardized engineering through Substation Configuration description Language (SCL)

What is specified for a substation?

- The single line diagram
- Switchgear details and requirements
- Protection, control and automation requirements (Functional requirements)
- Requirements for protection, control and automation equipment
- SCADA communication and associated signal list
- Physical arrangements of switchyard and associated buildings to host the infrastructure
- Testing requirements
- Responsibilities for project realization
- Interaction of the substation with the rest of the power system

What is specified for a substation?

→ *Not everything is impacted by IEC 61850*

→ *The focus of this workshop will be on the elements affected by IEC 61850*

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Elements of a functional specification

Areas that need to be addressed

- Single line diagram and functional requirements
- Interfaces; e.g.
  - Process interface
  - Interface to SCADA system / control center
  - Service and maintenance access
- Constraints
  - Operator room and bay houses, cable channels and ducts
  - Power supply system
  - Re-use of existing non IEC 61850 compliant components and systems
- Reliability, Availability, Maintainability and Performance

Aspects with impact from IEC 61850

- Communication architecture
- Degree of function integration
- Object models
- Naming convention
- Communication services
- Engineering process
- Tool requirements

Roles in an IEC 61850 project

- End user
  - Creates the specification
  - Decides on acceptance of the delivered szstem
- Product vendor
  - Supplies the individual products
  - May be responsible for the configuration of the products
- System integrator
  - Is responsible to configure the system with the selected products to fulfill the requirements specified by the end user

System integrator

- Select IEDs (option)
- Reverse engineer the signal list (optional)
- Design the communication network
- Design the details of the schemes (option)
- Engineer the information flow between IEDs as well as to clients
- Verify communication architecture
- Define system test specification (Verify behavior and performance)

How much details shall the specification provide?

- Assuming the integration is not done by the end user, the specification can
  - be limited to specify only the functional requirements
  - include the specification of nonfunctional requirements like e.g. communication network architecture or function allocation to devices
- When the specification has only functional requirement, the system integrator may optimize the design
- Specifying nonfunctional requirements allows the end user to standardize across multiple projects

Project specification or supply contract?

- A specification may be made for a specific project only
- Alternately, the utility may produce a specification with
  - A generic part with the functional and nonfunctional requirements
  - A project specific part with the specific requirements
- A generic specification may be used for supply contracts
  - Supply contracts an be used for IEDs but as well for subsystems

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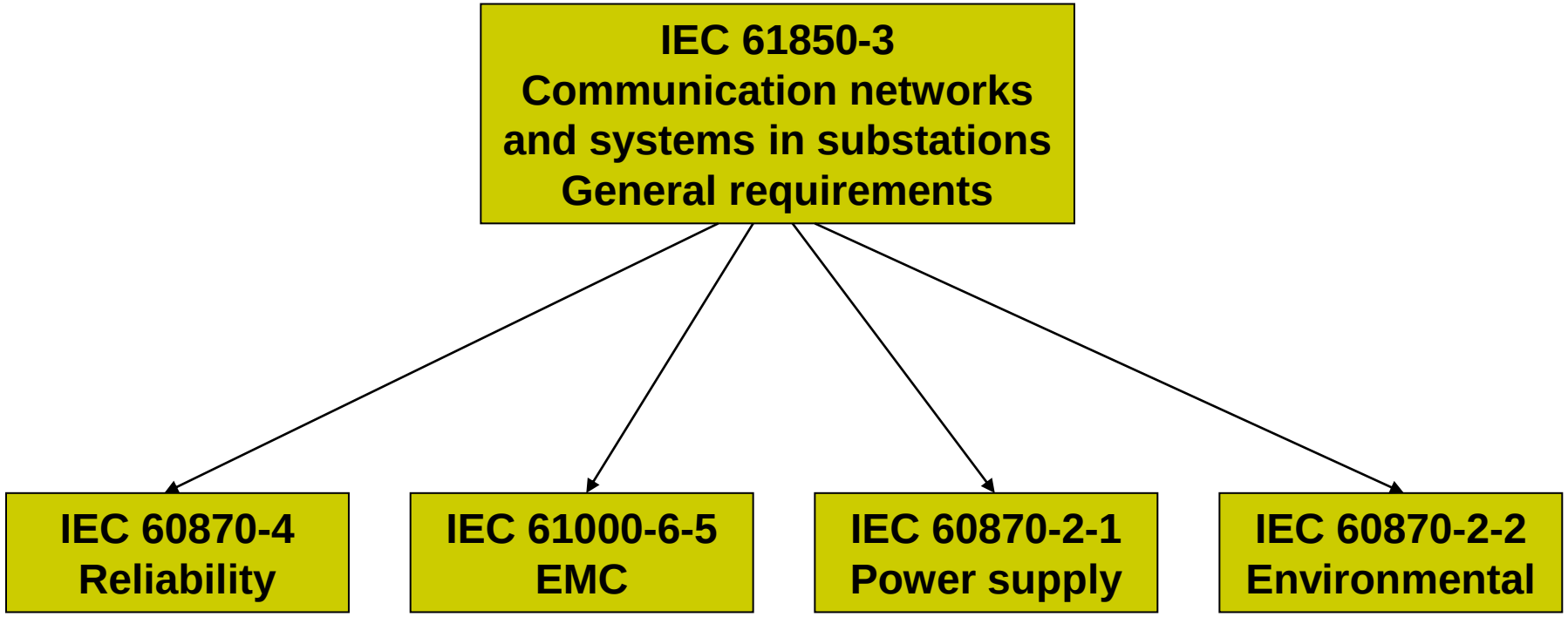
IEC 61850-3

- Environmental requirements are provided in IEC 61850-3
- They mainly refer to other standards



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Product lifecycle – from IEC 61850-4

- Version identification required for HW, SW and tools
- Products with same model number
  - HW is compatible
  - Functional changes are declared
  - Tools are backward compatible – new versions of the tool shall support the old version of the same model
- Discontinuation of the product needs to be announced well in advance (e.g. 2 years)
- Agreement for product support after discontinuation required
  - e.g. 5 years for compatible products for extension
  - e.g. 10 years for spare parts and repairs

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Communication architecture

- Performance and availability requirements will have an impact on the communication architecture
- Communication architecture may be specified in the requirements
  - May restrict optimization process
  - May help to standardize for the utility
- Specific requirements on communication equipment shall be specified

Degree of function integration

- IEC 61850 supports a free allocation of functions to devices
- Requirements concerning constraints of function integration need to be specified
  - Which functions are not allowed to be implemented in the same device?
  - Which functions shall be implemented in the same device?

Object models and naming conventions

- Standardized data model is implicitly specified by specifying the functional requirements → replacement of signal lists
  - If only signal list is supplied, reverse engineering needs to be done by system integrator
  - Optional data that is required needs to be specified
- Specification of logical devices not required
  - May be an option, to standardize on the data model
- Specification of the naming convention to be used (for primary equipment, LN instance names, etc.)

Communication services

- Detailed requirements on communication services may be specified
  - May be important for future extensions
- Data that need to be communicated towards local HMI, the station controller and the gateway is defined with datasets referred to in control blocks
  - All data sets and transmission conditions shall be specified

Engineering process and tools

- Responsibilities and roles shall be defined
  - Responsibility of the device vendor
  - Responsibility of the system integrator
  - Responsibility of the end user
- Integration of components fulfilling the specified behavior and performance is responsibility of the system integrator
- Requirements on tools shall be specified
  - What tools shall be supplied
  - What functionality is required for the tools?

Specification – example (1)

- System overview
  - Single line diagram
  - Secondary equipment
- Communication network
  - Topology
  - Management
- Interfaces
  - External - e.g. control center, event and disturbance recorder data, etc
  - Internal – between devices within the substation; legacy devices
- Functional requirements

Specification – example (2)

- Realization conform to IEC 61850
  - Architecture
  - Object model
  - Communication
  - Naming convention
  - Degree of function integration
  - IED qualification
  - Requirements on engineering process
  - Requirements on devices (PICS, MICS, etc)

Specification – example (3)

- Information security
- Implementation requirements
  - Reliability – Availability – Maintainability
  - Performance
  - Testing
- Capacity – Expandability – Upgrade
  - Capacity – e.g. bandwidth
  - Expandability – e.g. planned extensions
  - Upgrade – how to handle HW/ SW upgrade; how to implement new functionalities
- Migration
  - Migration plan
  - Migration constraints

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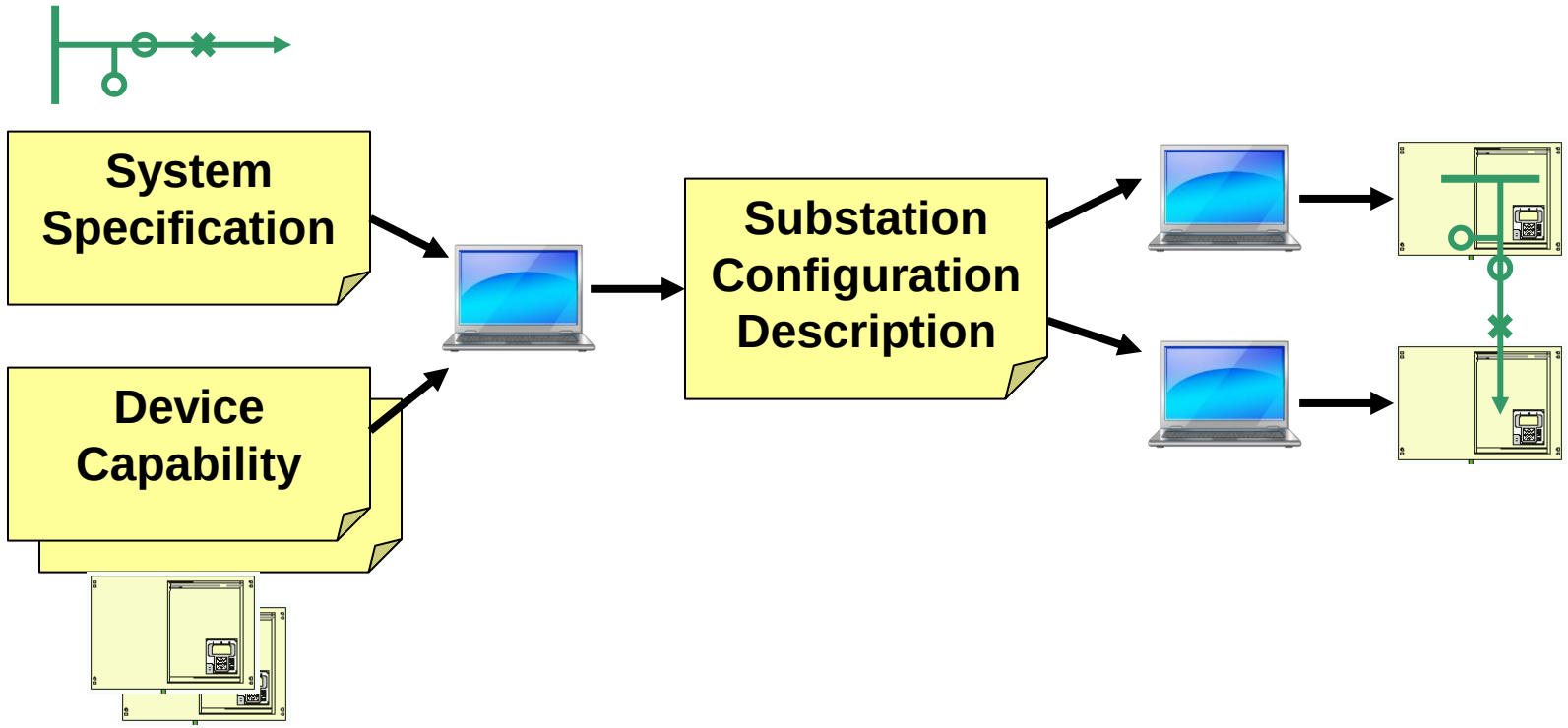
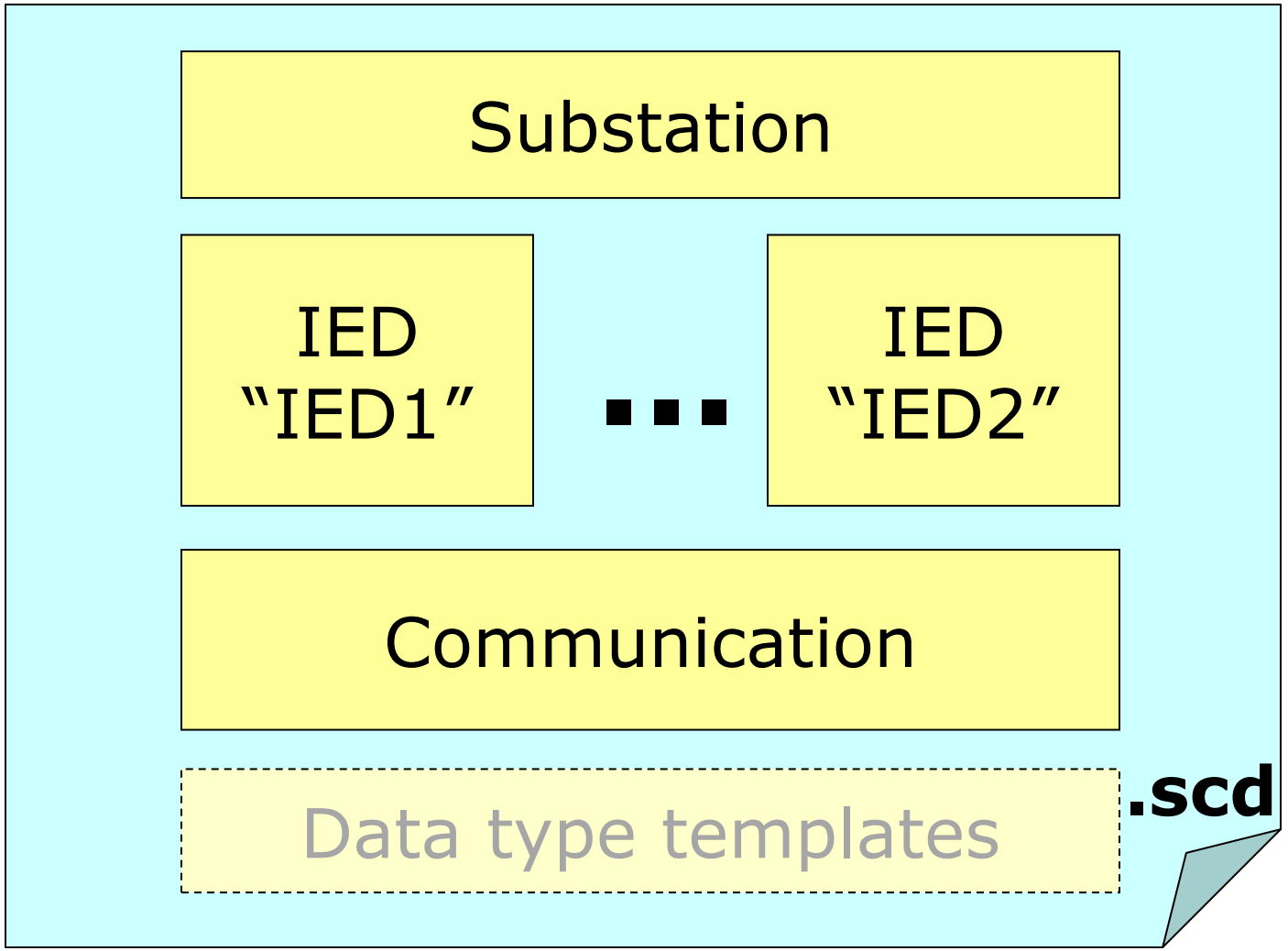
A reminder of the IEC 61850 engineering process



What is described in SCL?

- Functionality of the system
  - Single line
  - Process hierarchy
  - Function / sub-function hierarchy
- Communication
  - Communication network configuration
  - Information exchange
- Devices
  - IED configuration
  - IED data model
  - IED capability description
  - Link between the function realized in the IED and the primary process it controls

Elements of an SCL file

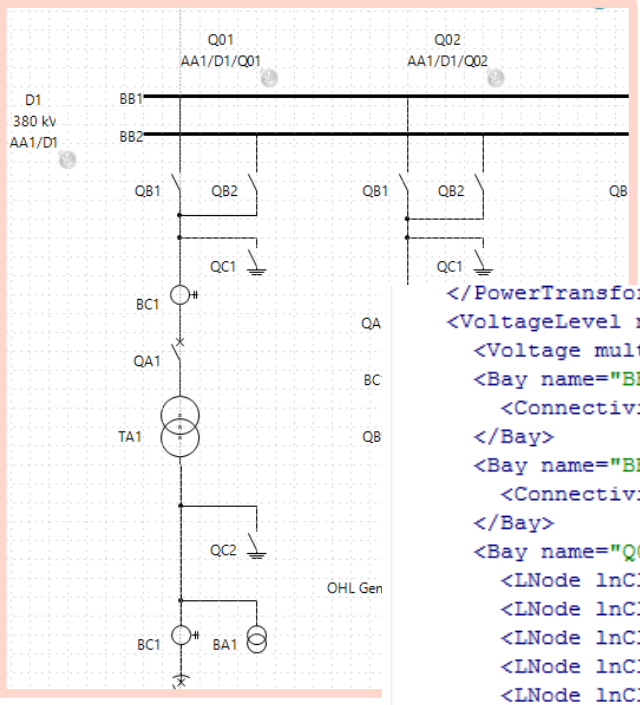


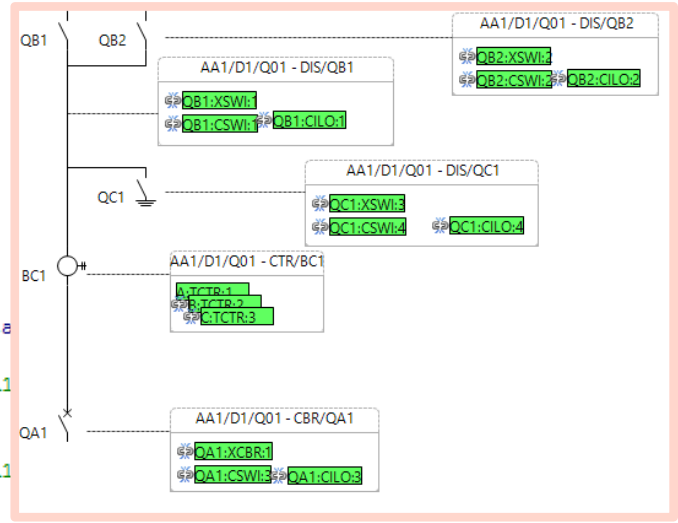
Specification in SCL

According to IEC 61850, a "System Specification Description file" (SSD) can be created, using a System Specification Tool (SST)

- Single line diagram
  - Structured in voltage level and bays
  - Showing connections between substation equipment like switches or sensors
- Functional requirements
  - By associating logical nodes to the elements of the single line diagram
- Signal list
  - By specifying the data model requirements for the logical nodes

The description of the functionality






```
    </PowerTransformer>
    <VoltageLevel name="D1">
      <Voltage multiplier="k" unit="V">380</Volta
      <Bay name="BB1">
        <ConnectivityNode name="L1" pathName="AA1
      </Bay>
      <Bay name="BB2" sxy:y="1">
        <ConnectivityNode name="L1" pathName="AA1
      </Bay>
      <Bay name="Q01" sxy:y="2">
        <LNode lnClass="RBRF" lnInst="1" prefix="" ldInst="BF" iedName="None" ln
        <LNode lnClass="MMXU" lnInst="1" prefix="" ldInst="MEAS" iedName="None"
        <LNode lnClass="PDIF" lnInst="1" prefix="" ldInst="PROT" iedName="None"
        <LNode lnClass="PTOC" lnInst="1" prefix="" ldInst="PROT" iedName="None"
        <LNode lnClass="PTRC" lnInst="1" prefix="" ldInst="PROT" iedName="None"
        <LNode lnClass="ATCC" lnInst="1" prefix="" ldInst="TFC" iedName="None" ln
        <LNode lnClass="YPTR" lnInst="1" prefix="" ldInst="TFC" iedName="None" ln
        <LNode lnClass="YLTC" lnInst="1" prefix="" ldInst="TFC" iedName="None" ln
        <ConductingEquipment name="QB1" type="DIS">
          <LNode lnClass="XSWI" lnInst="1" prefix="QB1" ldInst="DIS/QB1" iedName=
          <LNode lnClass="CSWI" lnInst="1" prefix="QB1" ldInst="DIS/QB1" iedName=
          <LNode lnClass="CILO" lnInst="1" prefix="QB1" ldInst="DIS/QB1" iedName=
          <Terminal bayName="Q01" cNodeName="L1" name="T1" substationName="AA1"
          <Terminal bayName="BB1" cNodeName="L1" name="T2" substationName="AA1"
        </ConductingEquipment>
        <ConductingEquipment name="QB2" sxy:x="2" type="DIS">
          <LNode lnClass="XSWI" lnInst="2" prefix="QB2" ldInst="DIS/QB2" iedName=
          <LNode lnClass="CSWI" lnInst="2" prefix="QB2" ldInst="DIS/QB2" iedName=
```

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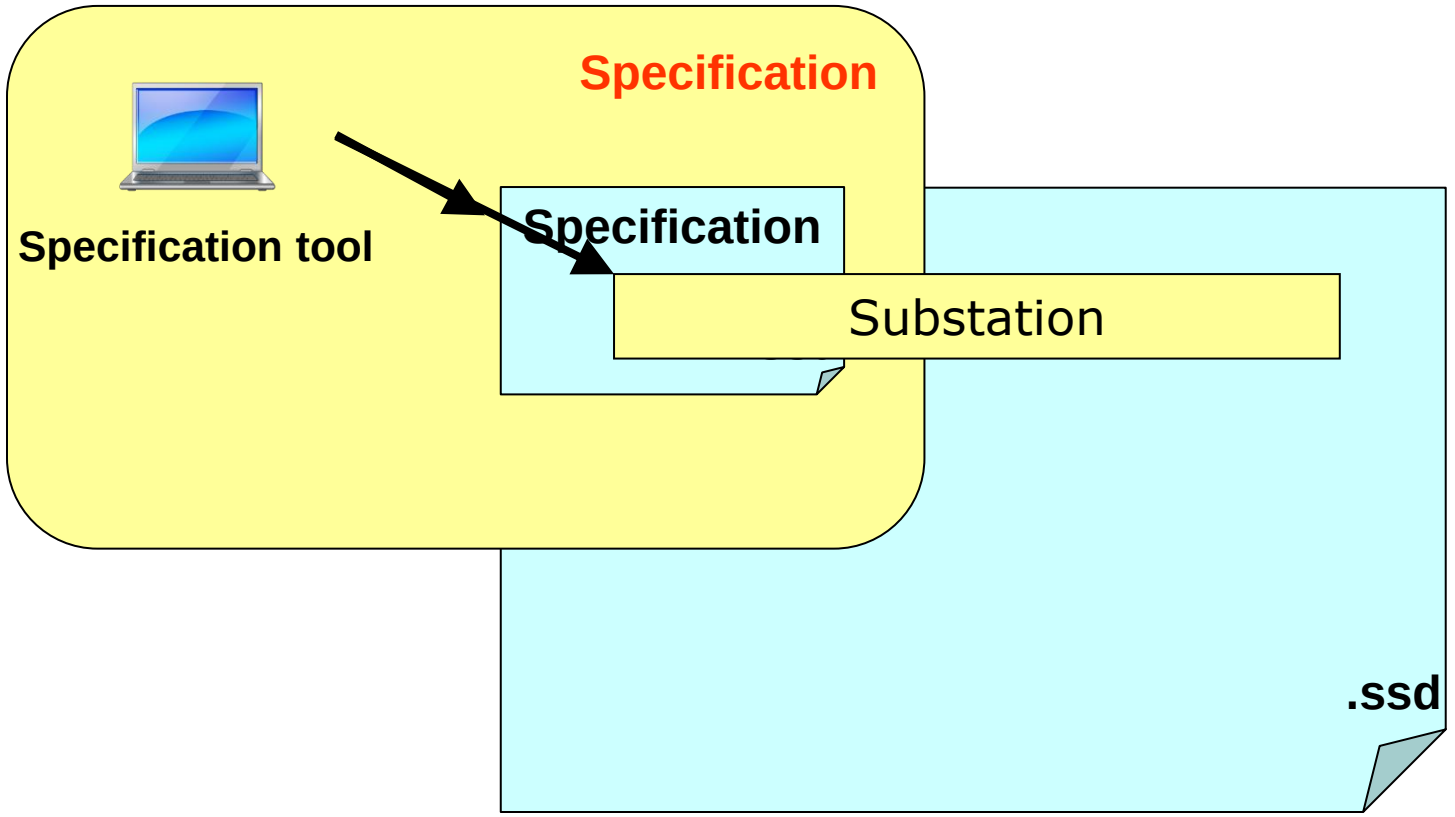
Specification



- Walk through a specification project in Helinks

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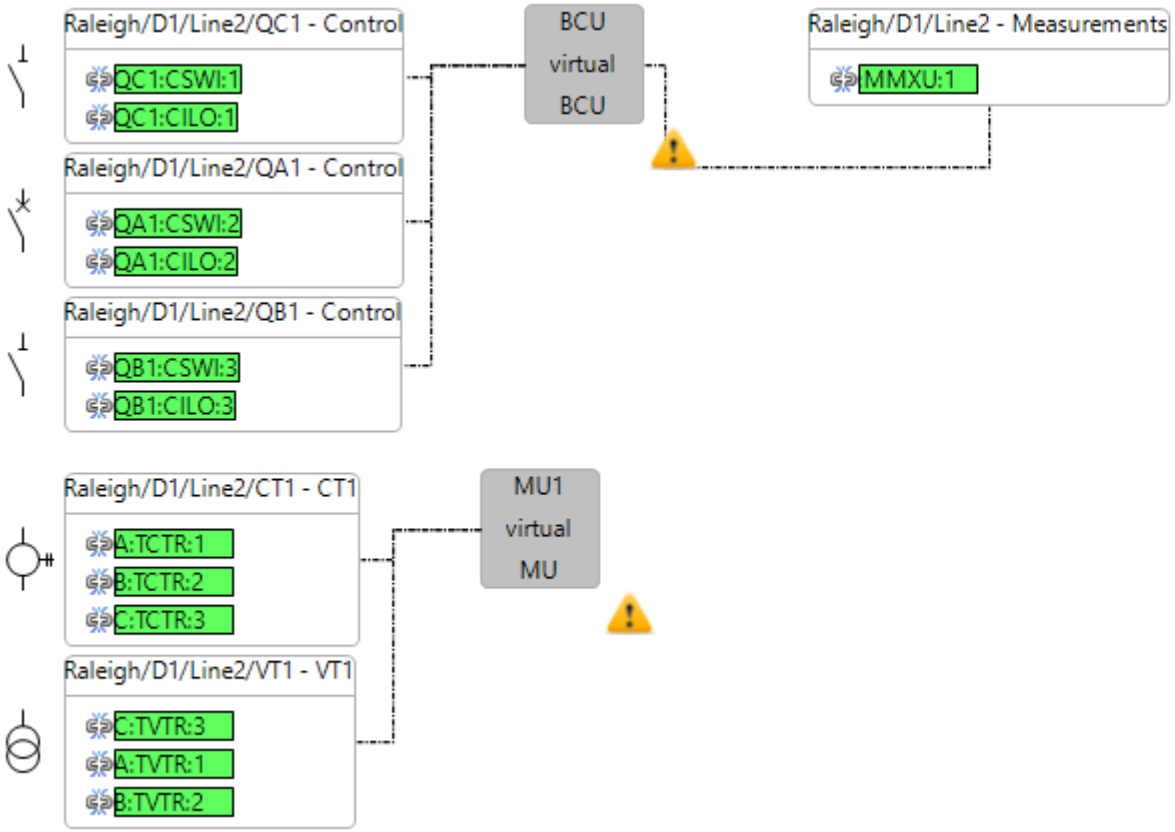
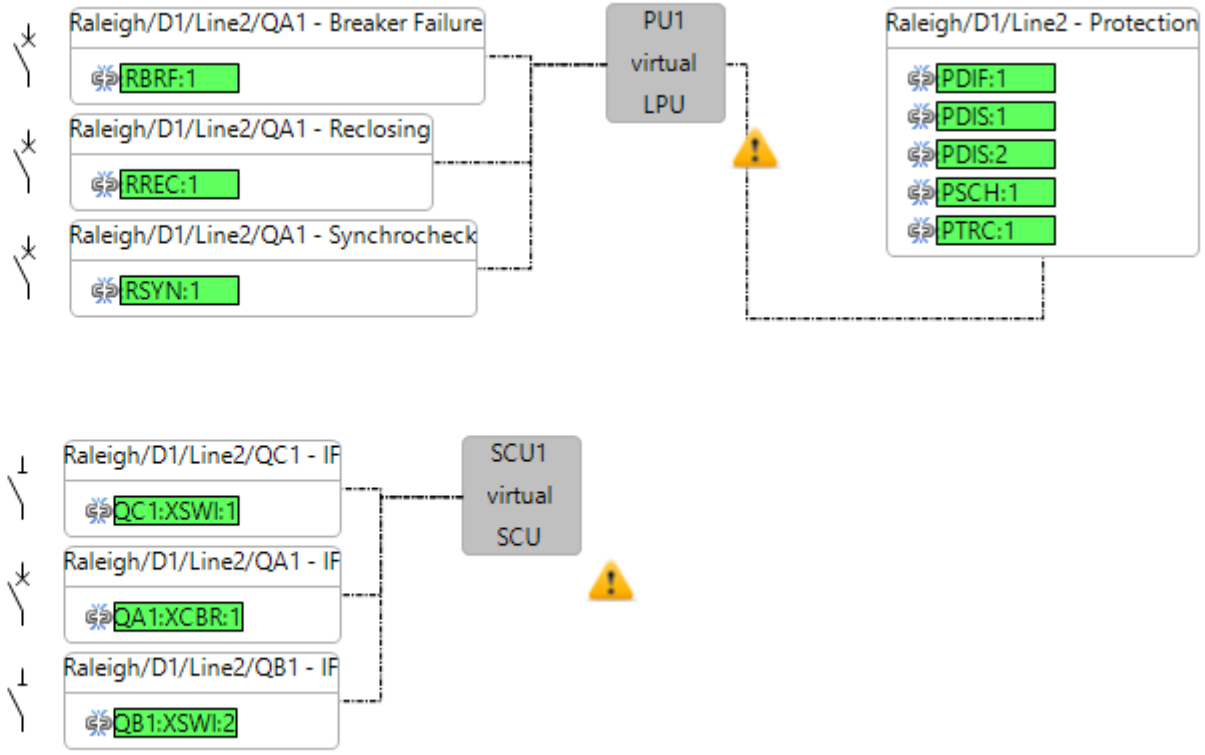
Advanced specification

- If a utility wants to standardize on the IEC 61850 implementations, more details need to be specified
  - Communication architecture
  - Allocation of functions to IEDs
  - Detailed implementation of protection, control and automation schemes including dataflow
    - Includes specification of input requirements for IED functions
  - Specification of signals to be transmitted to SCADA and to local HMI
    - Including mapping on e.g., 60870-5-101 data points
  - IED requirements according to IEC 61850 (services supported, engineering flexibility)
- This can be done by creating an SCD file using virtual IEDs

Creating a virtual IED

- Allocate Functions / LNodes to virtual IEDs
- Create an IED template (ICD file)





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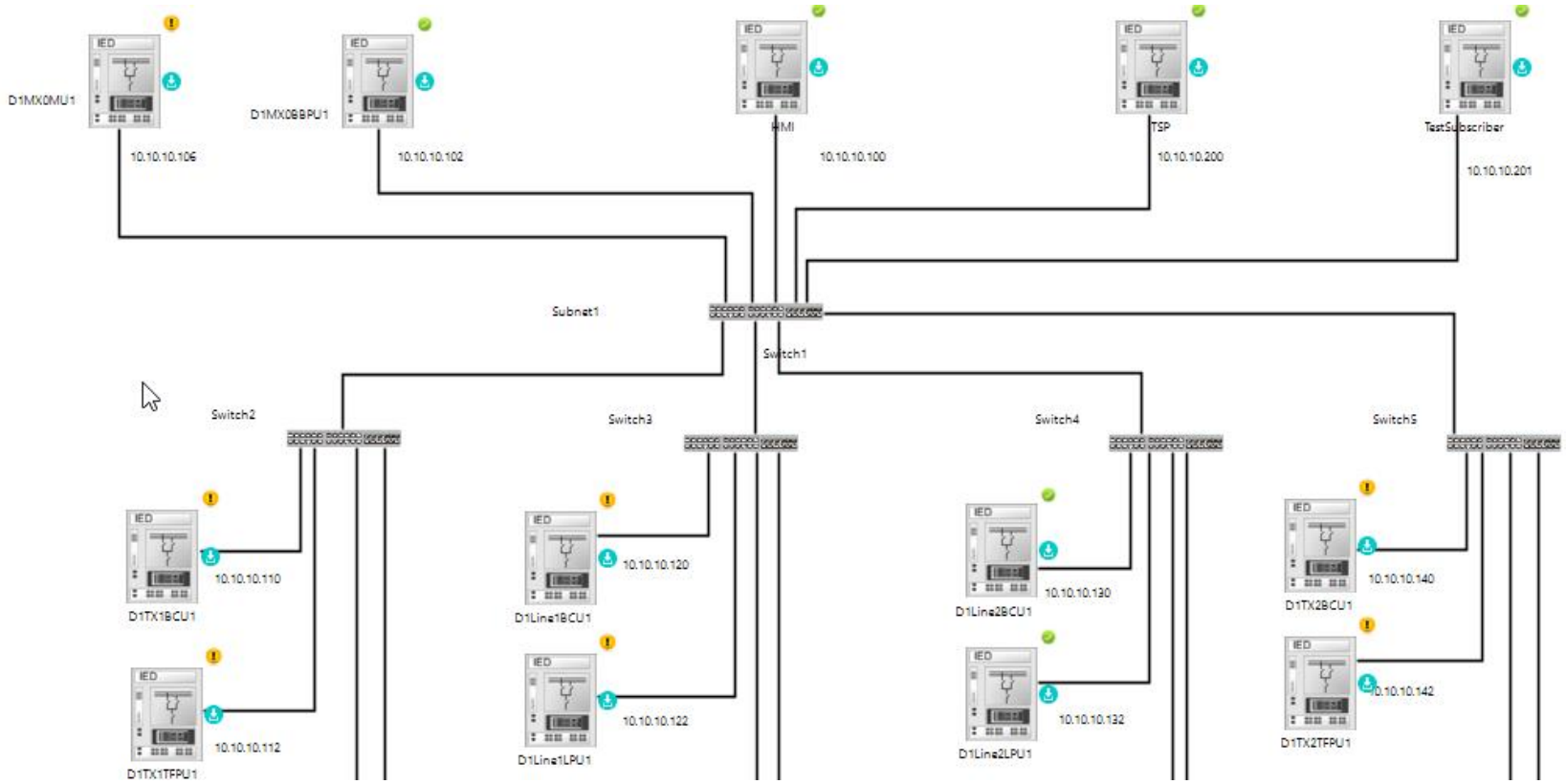
Communication architecture

- Virtual IEDs can be allocated to subnets to reflect communication requirements



Scheme implementation

- Some tools allow already today to specify signal flow independent of IEDs
  - Using IEC 61850-6 only, signal flow can only be described using virtual IEDs and ExtRef
  - Optionally configuring GOOSE messages
- Signal flow to SCADA (Gateway) and local HMI can be specified by creating ExtRef on the IED with LN IHMI / ITCI and optionally configuring report control blocks

IEC 61850-80-1

Specifying the communication towards the network control center

- Information exchange between a substation using IEC 61850 data model and control centers using IEC 60870-5-101 / -104
- Mapping architecture
  - Conceptual architecture of the gateway
  - Mapping of information model
  - Mapping of services

Address configuration in SCL

```
<DOI name="SPS01">
    <DAI name="stVal">
      <Private type="IEC_60870_5_104">
          <IEC_60870_5_104:Address
              casdu="1"
              ioa="1010"
              ti="30"/>
      </Private>
    </DAI>
</DOI>
```

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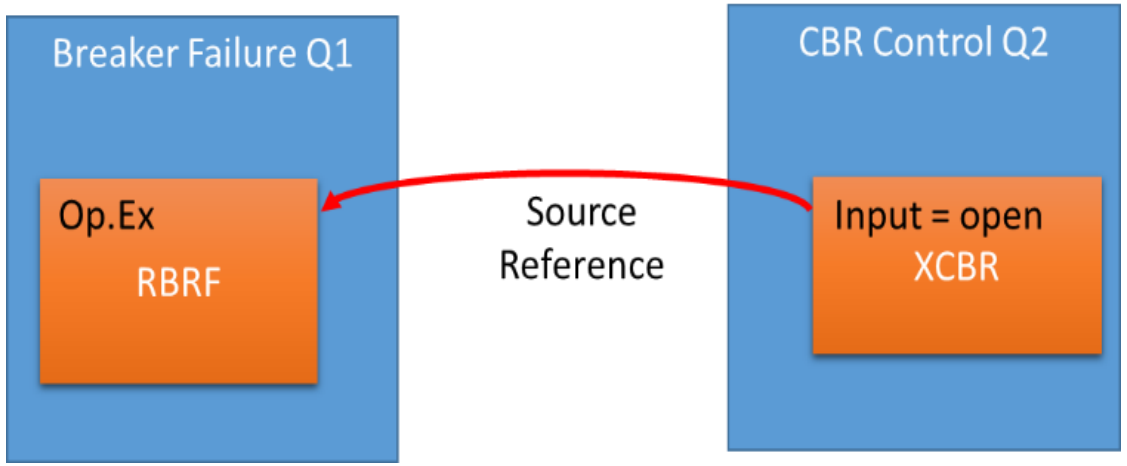
Improving Specification

Describe data exchange in specification

- Adding new elements "SourceRef" and "ControlRef" as inputs to LNodes in Process section
  - Comparable to ExtRef as input to LN in IED section
- Supports specification of control and protection schemes independent of IED implementation



Improving Specification

Specify function allocation to IEDs

- Introducing virtual IEDs
- Support allocation of functions to devices without referencing a particular IED brand
- New SCL file type "ISD"; IED name is "SPECIFICATION"

Improving semantics

Function / Subfunction hierarchy

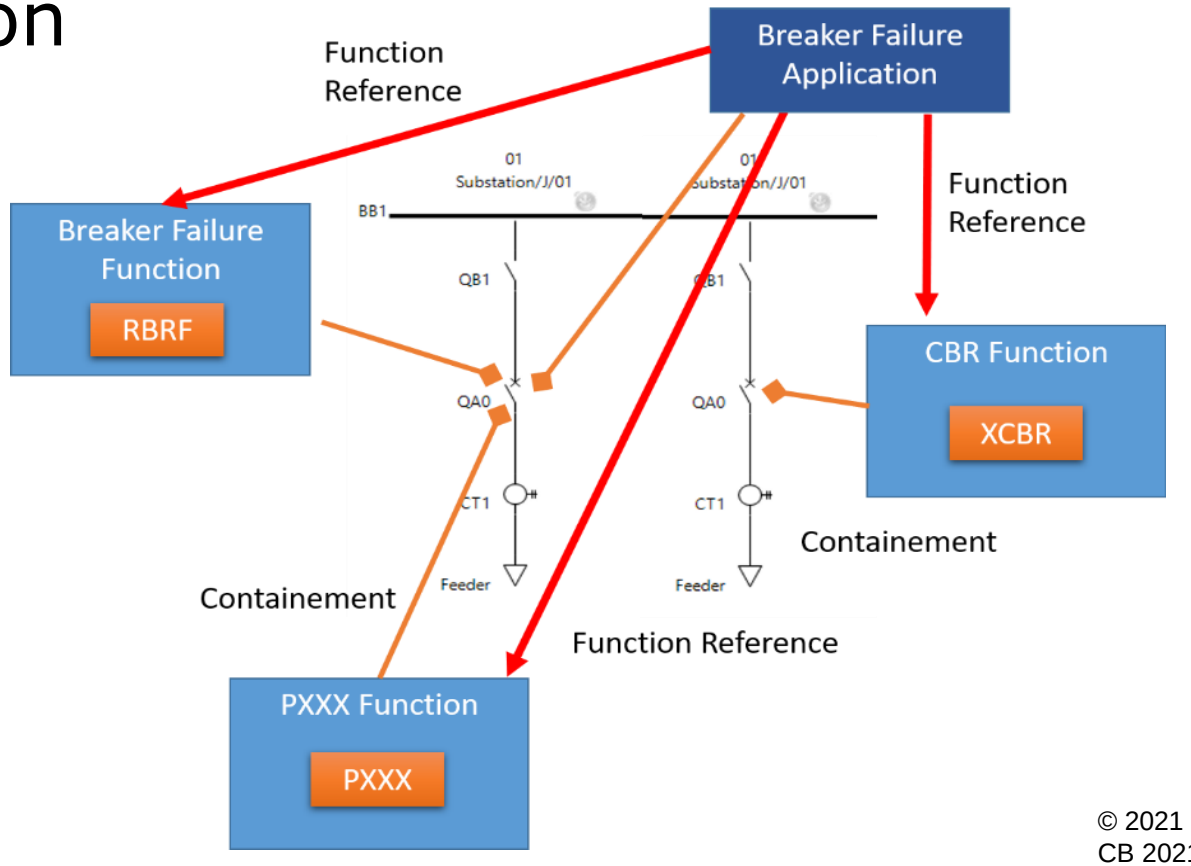
- LNodes in the process section can be embedded in a function hierarchy
- Function / subfunction names and types can provide additional semantic
  - Possibility to standardize on function / subfunction types

```
<Function name="DistanceProtection" type="DistanceProtection">
    <Text>Distance Protection</Text>
    <SubFunction name="DisZSOTFBW" type="DisZSOTFBW">
        <Text>Distance Z SOTF Backward </Text>
        <LNode lnClass="PSOF" lnType="PSOF_DisZSOTFBW">
    </SubFunction>
    <SubFunction name="DisZSOTFFW" type="DisZSOTFFW">
        <Text>Distance Z SOTF Forward</Text>
        <LNode lnClass="PSOF" lnType="PSOF_DisZSOTFFW">
    </SubFunction>
    <SubFunction name="DistZTPR1ph" type="DistZTPR1ph">
        <Text>Distance Z TPR 1 phase</Text>
        <LNode lnClass="PDIS" lnType="PDIS_DistZTPR1ph">
    </SubFunction>
    <SubFunction name="DisZTPR23ph" type="DisZTPR23ph">
        <Text>Distance Z TPR 2-3 phase</Text>
        <LNode lnClass="PDIS" lnType="PDIS_DisZTPR23ph">
    </SubFunction>
    <SubFunction name="DistZ1T11ph" type="DistZ1T11ph">
        <Text>Distance Z1T1 1 phase</Text>
        <LNode lnClass="PDIS" lnType="PDIS_DistZ1T11ph">
```

Improving semantics

Application schemes

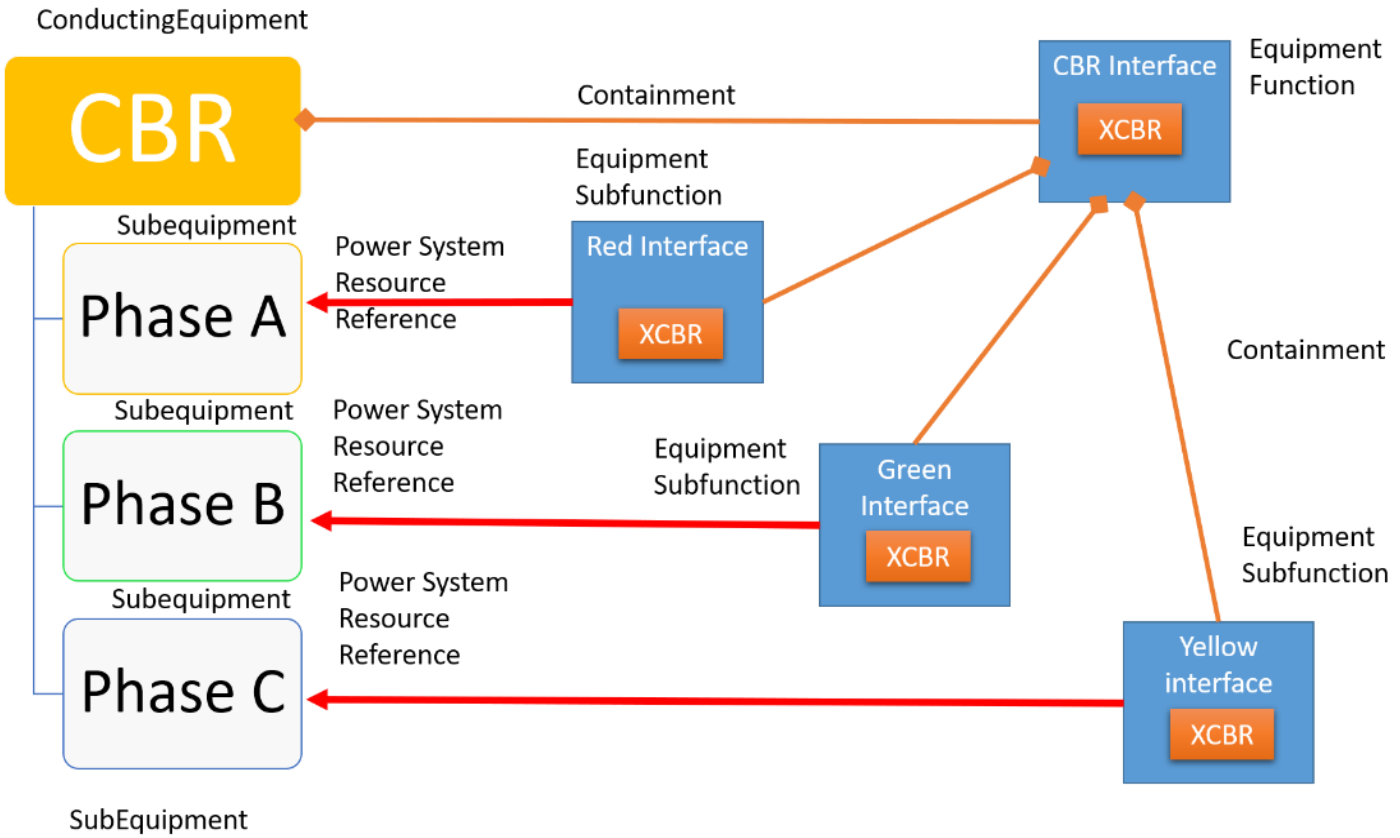
- Introducing a new element "Application" allows to group functions together that form an application
- A function or subfunction can participate in multiple applications



Improving semantics

Power system resource reference

- Supports association of a subfunction to a conducting equipment



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Further enhancements of the engineering process

- Describe logic in a standardized way based on IEC 61850-90-11 (TR)
  - Embed custom logic in a LN GAPC
- Standardized way to configure an HMI based on IEC 61850-6-2 (under development)
  - Introducing a graphical configuration languages and an HMI configuration language
- Extension to IEC 61850-7-6 to describe basic application profiles in SCL
  - Based on SCL extensions proposed in IEC 61850-6-100

Additional elements to be added to ISD

To further enhance the formal specification of IED requirements, it was suggested to add to an ISD file

- Specification of I/O requirements
- Formal specification of e.g. environmental requirements
- Logic capabilities
- … and more

Due to limited resources, that standardization work is currently on hold

To summarize…

- What is needed to specify a substation (or any other system) is independent of IEC 61850
- Specific requirements related to aspects of IEC 61850 need to be formulated – like for any technology

IEC 61850 provides support to describe some aspects of a specification for a substation (or any other system) as a standardized, machine processable specification

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