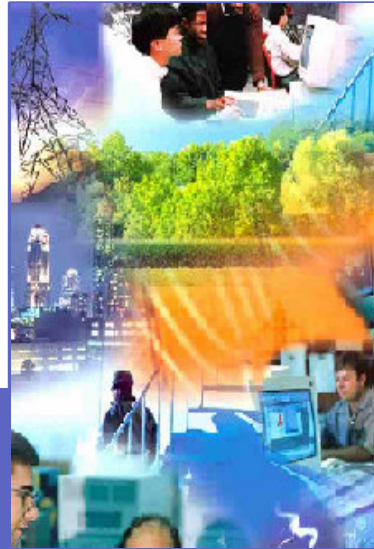




Klaus-Peter Brand

April 2006



Engineering according to IEC 61850



IEC 61850 Engineering Reference to IEC 61850-6

- ❑ **SCL**
- ❑ **Engineering process**
- ❑ **Tools**

To provide interoperability

- a **formal** description of the Substation Automation System with all *communication links* is needed
- all *IED capabilities* have to be described **formally** in an unambiguous way
- all *communication services* applicable have to be described **formally** in an unambiguous way
- the relationship between the switchgear (*single line*) and the functions of the substation automation system represented by objects (LD, LN, etc.) have to be described **formally** in an unambiguous way



The formal description is provided by the

Substation Configuration description Language (SCL)

- based on XML
- defined in part 6 of the standard (IEC 61850-6)
- usable for
 - IED Capability Description (ICD) files
 - System Configuration Description (SCD) file
 - System functional specification (SSD)

**The engineering information
is exchangeable between tools,
the tools get interoperable !!!bb**



```
<Substation Ref="">
  <VoltageLevel Ref="E1">
    <Bay Ref="Q1">
      <Bfunction Ref="">
        <Device Ref="QA1" Type="CBR">
          <Connection NodeRef="L1"/>
          <LNode Ref="1"
LNClass="CSWI"/>
        </Device>
        <Device Ref="QB1" Type="DIS">
          <Connection NodeRef="L1"/>
          <LNode Ref="2"
LNClass="CSWI"/>
        </Device>
      </Bfunction>
    </Bay>
  </VoltageLevel>
</Substation>
```

Described is a substation with the **bay E1Q1**, the **Circuit breaker QA1** and the **Isolator QB1**, both electrical connected in **Connection Node L1**. The Controller is represented by - **LN CSWI** controls both switches.



Hierarchical Data Structure

SCL description

The screenshot shows the SCL Editor interface with a hierarchical tree on the left and an XML view on the right. The tree structure includes:

- Substation Ref: "P2"
 - Voltage Level Ref="J1" Voltage=17"
 - Bay Ref: "Q4"
 - LN Ref: "1" LNClass="MMXU" LNTType="P2KA3/Measurement/MMXU1"
 - DO Ref: "Mod" Type: "INC"
 - Attribute Name: "stVal" Value: ""
 - Attribute Name: "q" Value: ""
 - Attribute Name: "" Value: ""
 - Attribute Name: "ctlModel" Value: ""
 - DO Ref: "Beh" Type: "INS"
 - DO Ref: "Health" Type: "INS"
 - DO Ref: "NamPlt" Type: "LPL"
 - DO Ref: "TotW" Type: "MV"
 - DO Ref: "TotVA" Type: "MV"
 - DO Ref: "TotVA" Type: "MV"
 - DO Ref: "TotPF" Type: "MV"
 - DO Ref: "Hz" Type: "MV"
 - DO Ref: "PPV" Type: "DEL"
 - DO Ref: "PhV" Type: "WYE"
 - DO Ref: "A" Type: "WYE"
 - Device Ref: "QE3" Type: "DIS"
 - Device Ref: "QA1" Type: "CBR"
 - Device Ref: "QB1" Type: "DIS"
 - Device Ref: "QE1" Type: "DIS"
 - Device Ref: "QC1" Type: "DIS"
 - Device Ref: "VT1" Type: "VTR"
 - Device Ref: "L1" Type: "IFL"
 - Device Ref: "CT11" Type: "CTR"
 - Device Ref: "QB2" Type: "DIS"

The XML view on the right shows the corresponding SCL code, with arrows pointing from the tree elements to the XML tags. For example, the "QE3" device is mapped to the following XML snippet:

```

<Device Name="QE3" Type="DIS">
  <Text>Isolator</Text>
  <Connection CNodeName="GROUNDED" />
  <Connection CNodeName="{5B8C15FD-436F-468E-A72C-99D0EC060CE1}" />
  <Private Type="Coord0">"v"</Private>
  <Private Type="CoordX">3</Private>
  <Private Type="CoordY">7</Private>
  <Private Type="IETCoord">X = 229; Y = 280; O = "v"</Private>
</Device>
    
```

For Engineers

For Tools



Reminder:

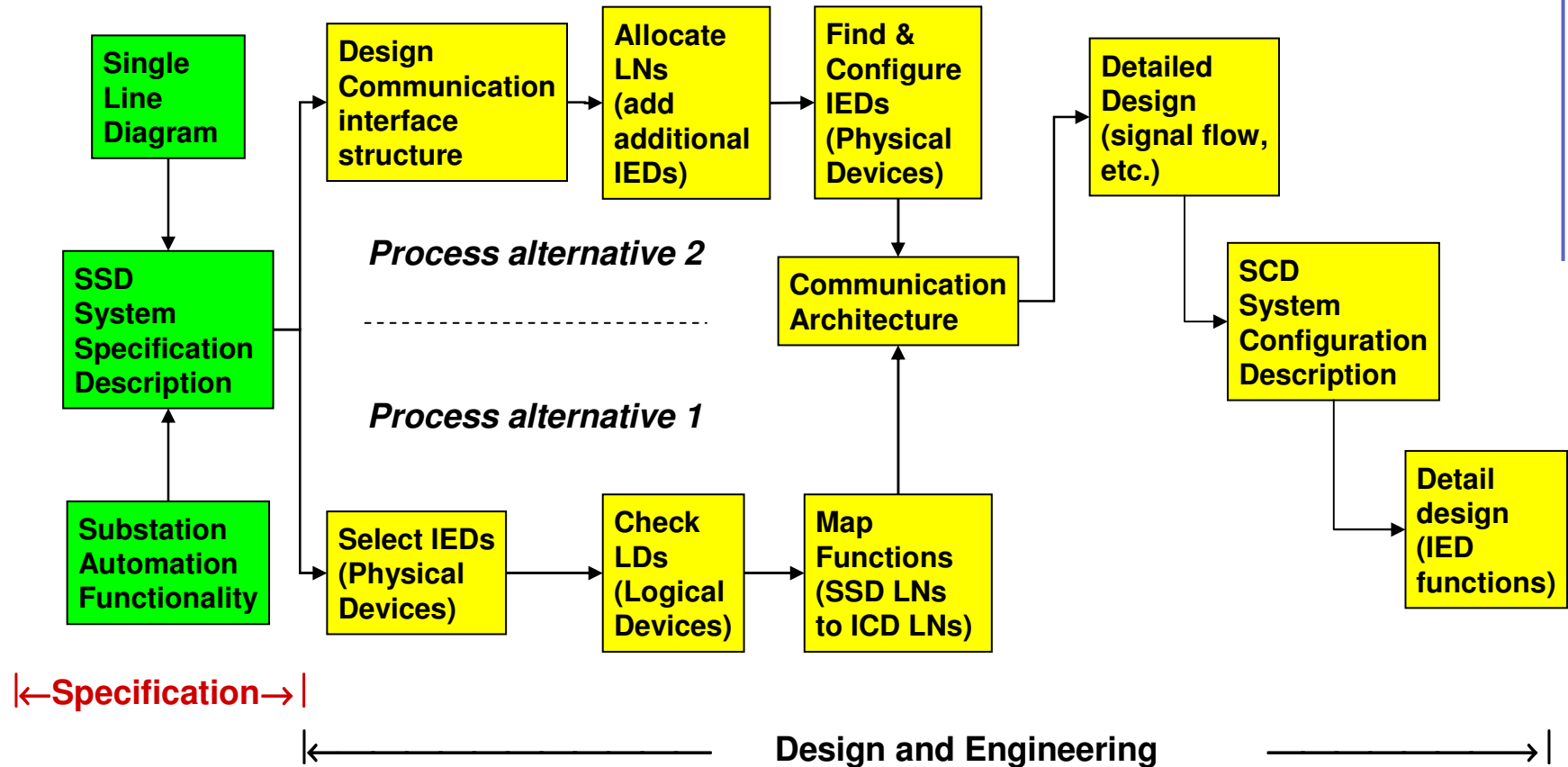
- The SA functions and devices are not standardized
- The SA architecture is not standardized
- Data and data exchange is standardized

Note:

- The engineering tools are not standardized
- The engineering process is not standardized
- The configuration description is standardized (SCL)



Process from Specification to Solution



Engineering Process

Engineering according to IEC 61850

*) The IED object models i.e. defined objects with defined data

Control* CB
Q0/CSWI
Control* ES
Q8/CSWI
Control* IS
Q9/CSWI
Bay-HMI* (HMI)

Earthing switch*
Q8_L1/XSWI
Gas density mon.*
Q8_L1/XGMU

Isolator*
Q9_L1/XSWI
Gas density mon.*
Q9_L1/XGMU

Circuit Breaker*
Q0_L1/XCBR
Gas dens. monitoring*
Q0_L1/XGMU

Distance protection* PDIS

Primary technology **Secondary technology**

Data modeling: GIS substation

Device capability

Device data

Device selection

ICD

Device capability

SSD

System Topology & Functionality

System specification

Device (IED)

CID

Device specific tool

System Configuration tool

System Configuration Description

SCD

Device Configuration

Device data

System Documentation

System documentation

Functionality

Substation Topology

Communication Architecture

```

<SCL xmlns:si="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://www.iec61850.org/2003/9/IEC61850-4" Header id="1" Substation name="AA1" desc="Substation" VoltageLevel name="D1" desc="Voltage Level" DeviceInst="C1" InClass="LLNO" InType="LLNO_REC316-4_IEC61850" InClass="GGIO" InType="FG_LineGeneral_REC316-4_IEC61850" InClass="CSWI" InType="DC3_Switch Controller_REC316-4_IEC61850" InClass="Pos" desc="Position Indication" InType="Set" Command enabled="true"/>
  </SCL>
  The system SCD file may be reused for any maintenance action and for any extension projects after years and with state-of-the-art tools compliant with IEC 61850.
  </SCL>
  <DAI name="d" valKind="Set">
  </DAI>
  </SCL>
  
```



IED Capability Description file

*Device on the shelf - **mandatory***



System Specification Description file

Single line and function allocation



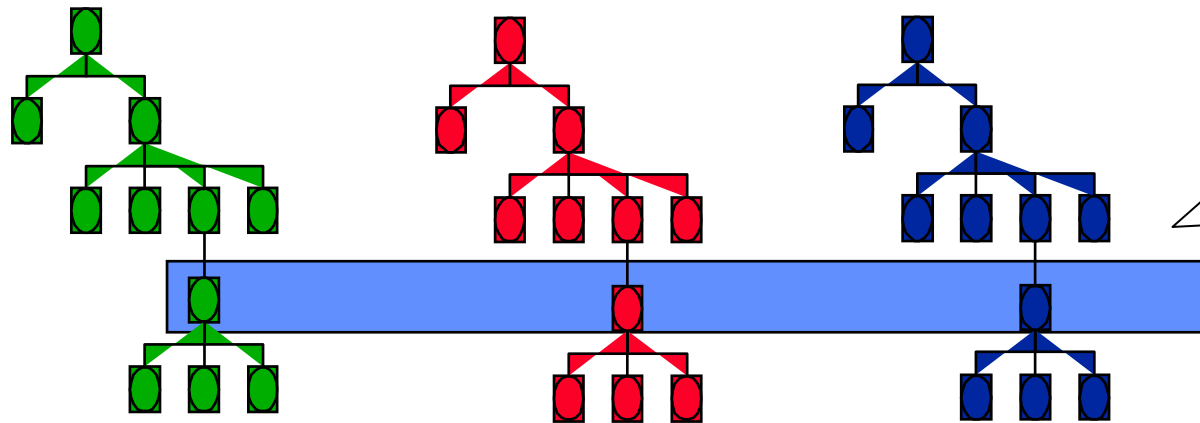
System Configuration Description file

Configured system description



Configuration IED Description file

*Configured IED description incl.
device specific data beyond IEC 61850*



Geographic,
Location,
Placement
structure

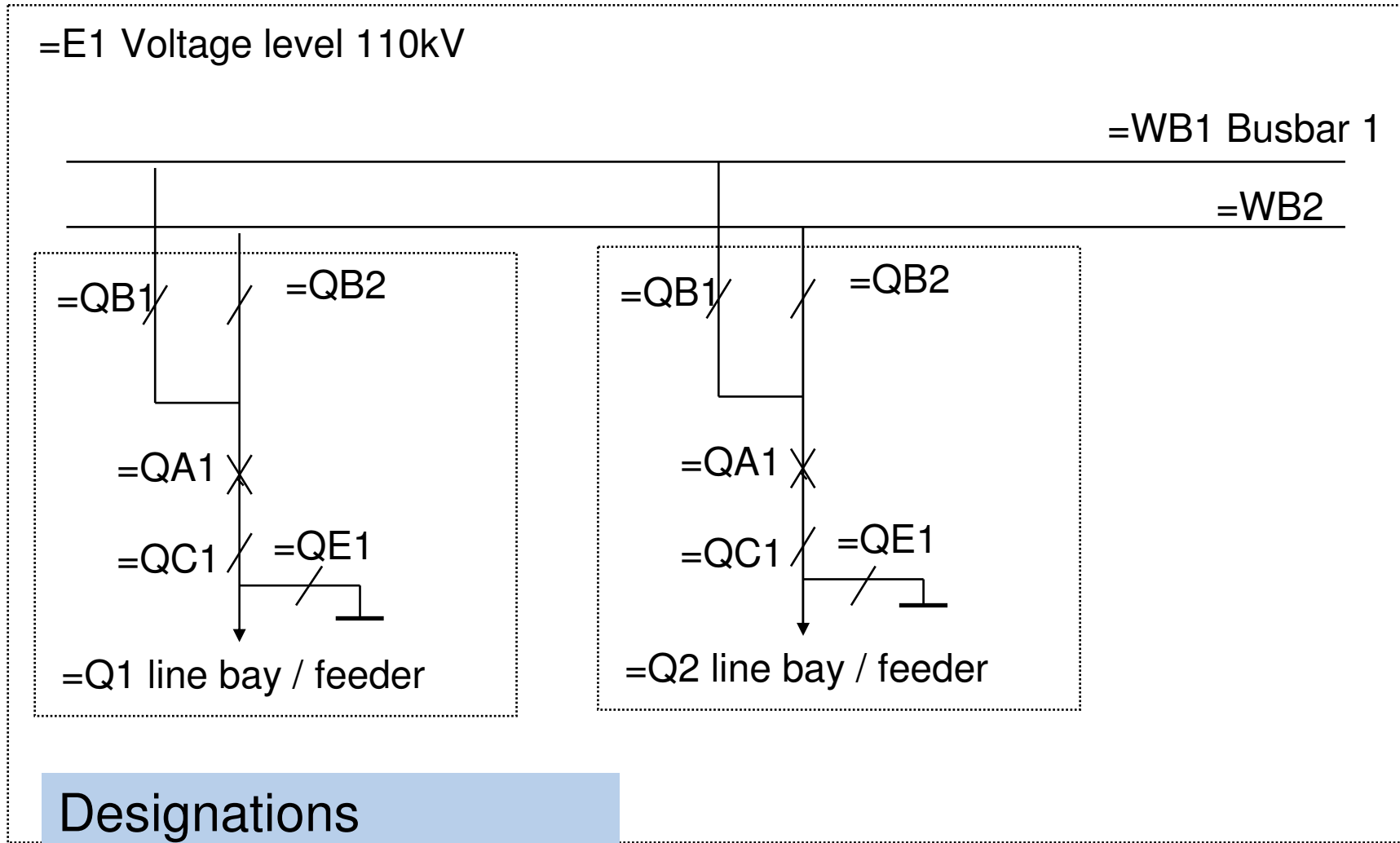
Function,
Software,
Data (Product)
structure

Devices / Physics,
Hardware (Product)
structure

Interface to environment or external world



SCL Contents – Single Line Diagram



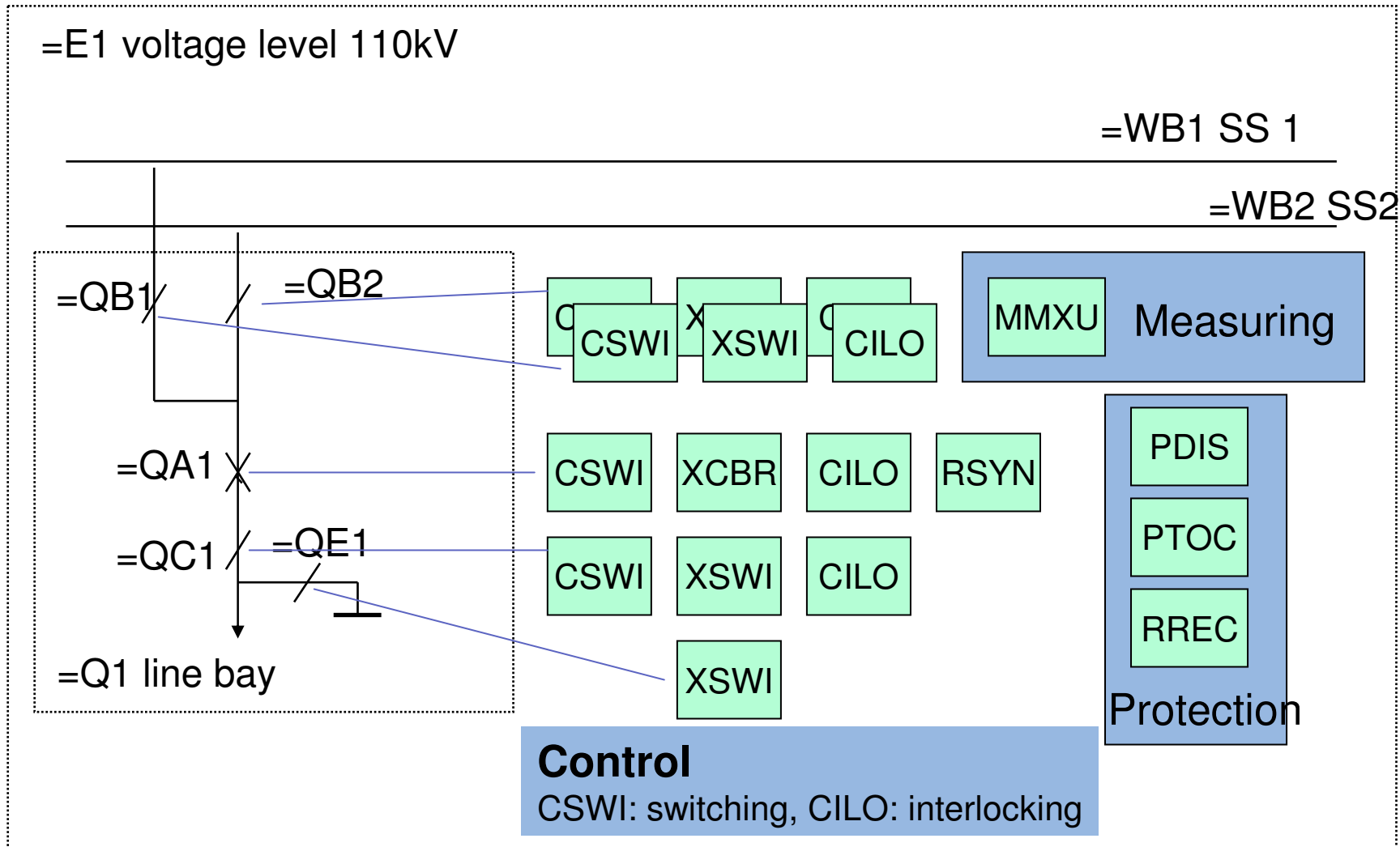
Designations according to IEC 61346



- Hierarchy **Station / Voltage level / Bay / Apparatus / apparatus part (Phase)** acc. IEC 61346-1
 - Electrical connections between apparatuses
 - Several stations model a power network
 - Focus: Naming hierarchy of substation functions
- **Model is compatible with IEC 61970**
 - Different data exchange formats (although XML based)
 - Data integration needs identical naming
 - *WG19: global Identifier, Identification server*



SCL Contents – Function specification



LN classes acc. IEC 61850

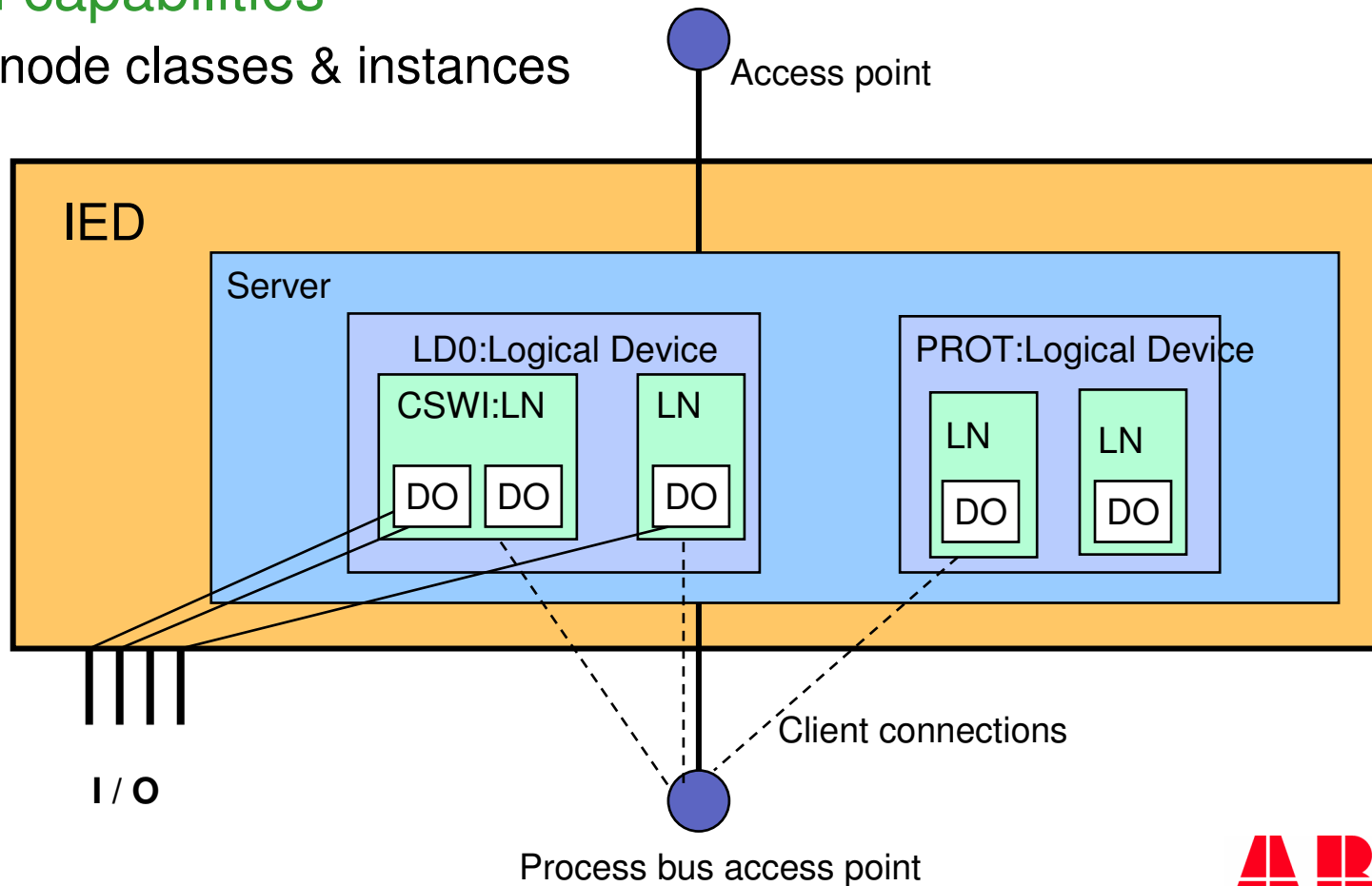


Communication capabilities

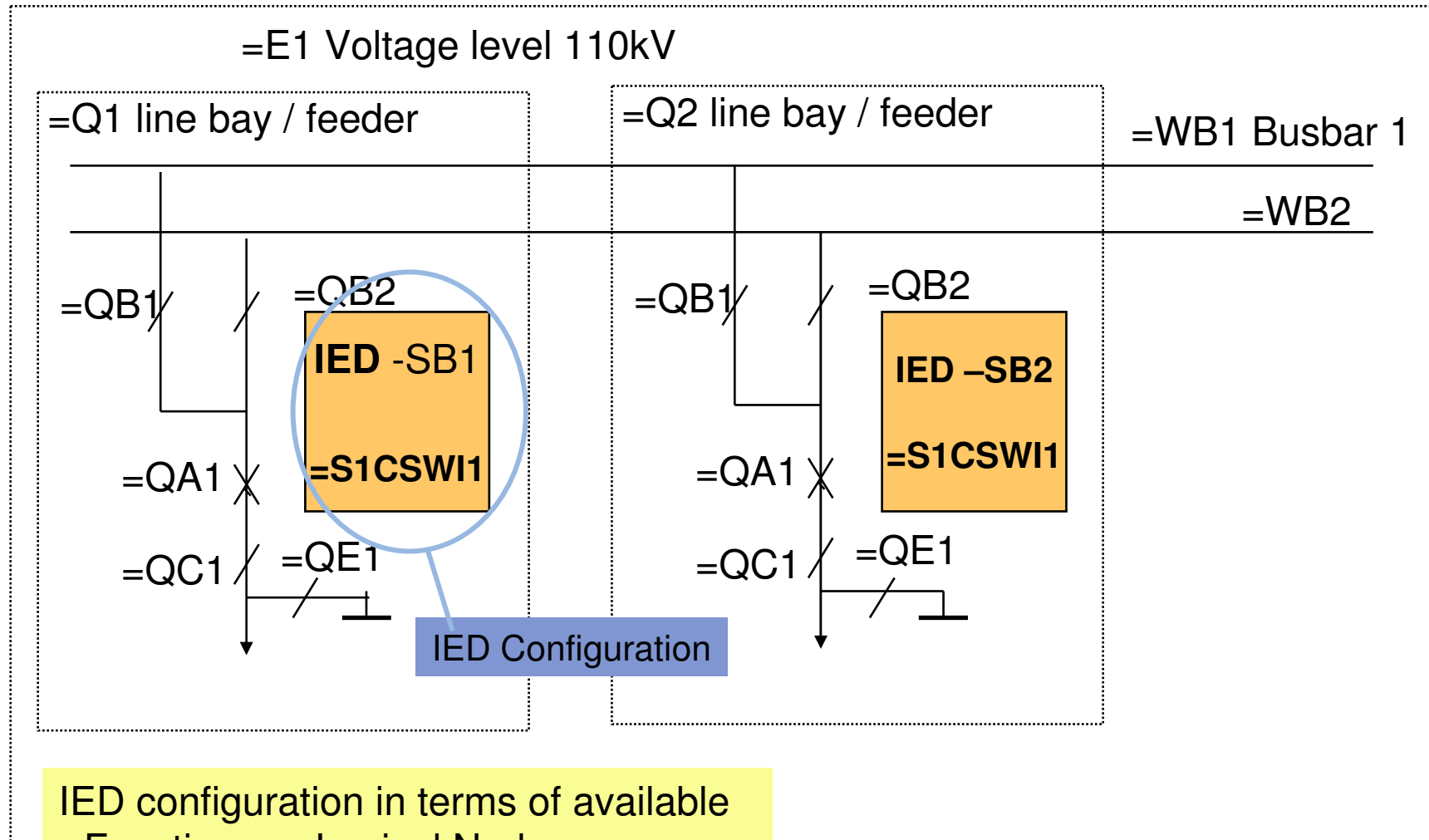
Services, limits

Function capabilities

Logical node classes & instances



SCL Contents – IED Configuration

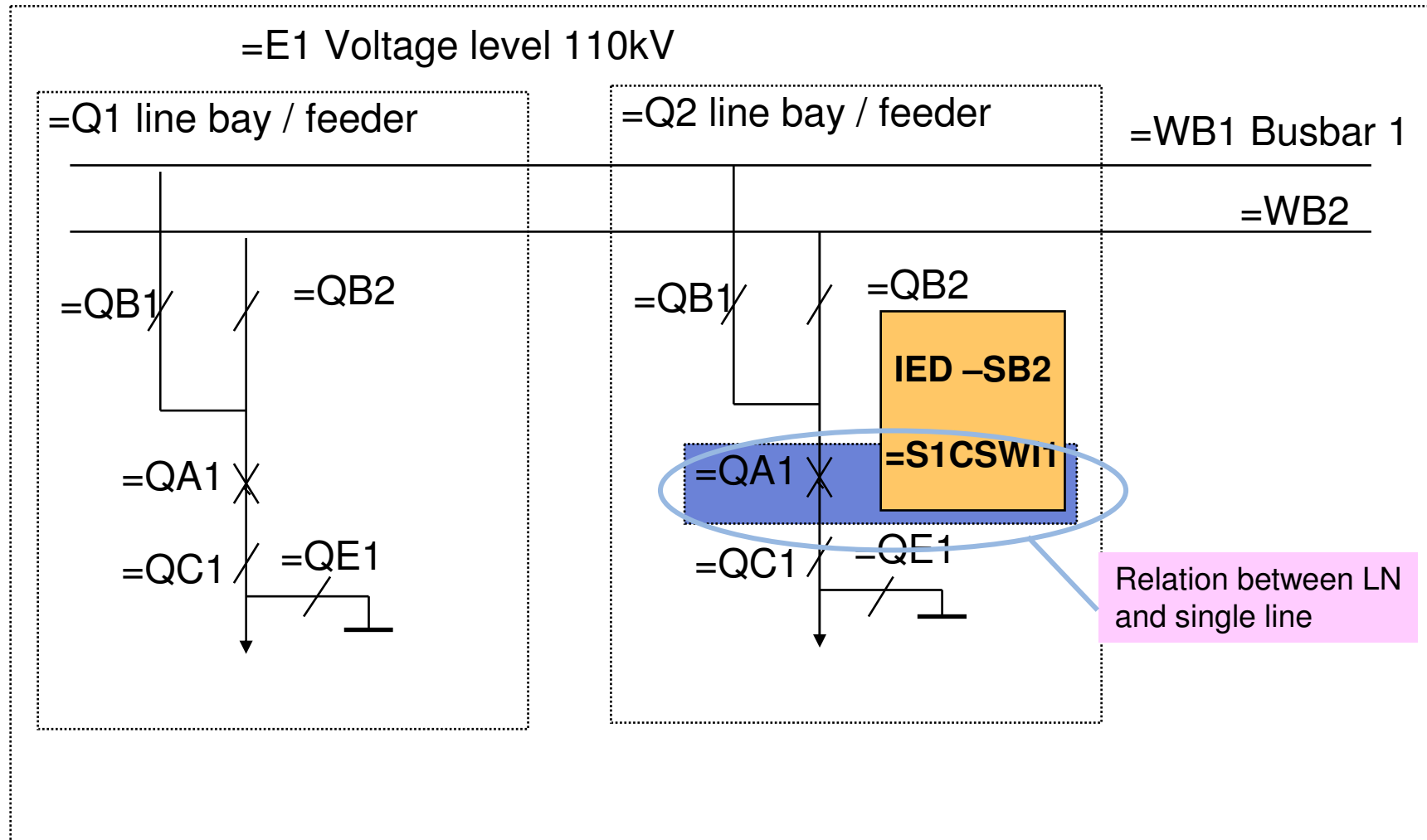


IED configuration in terms of available

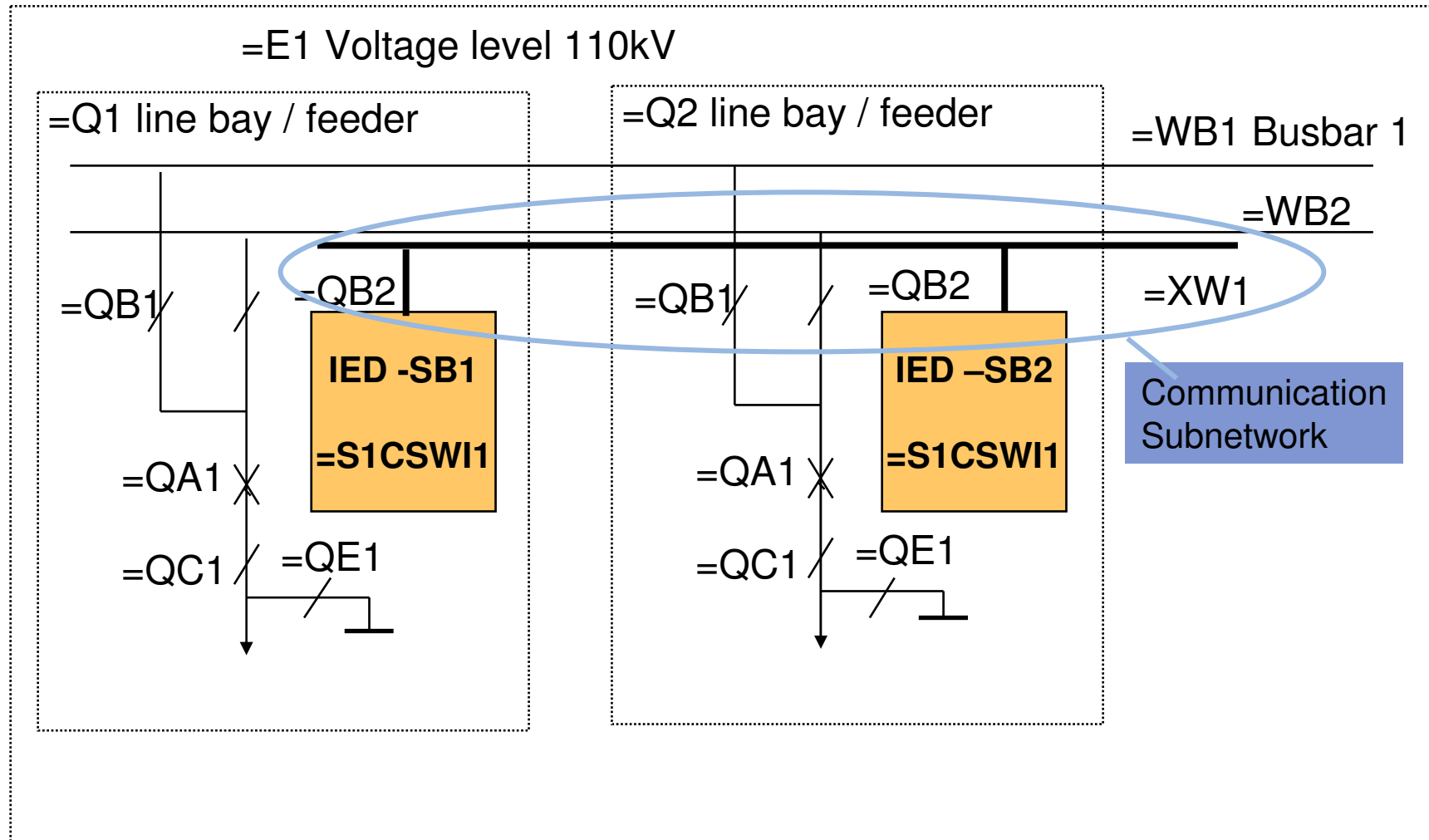
- Functions -> Logical Nodes
- Sent data -> Data sets, Control blocks



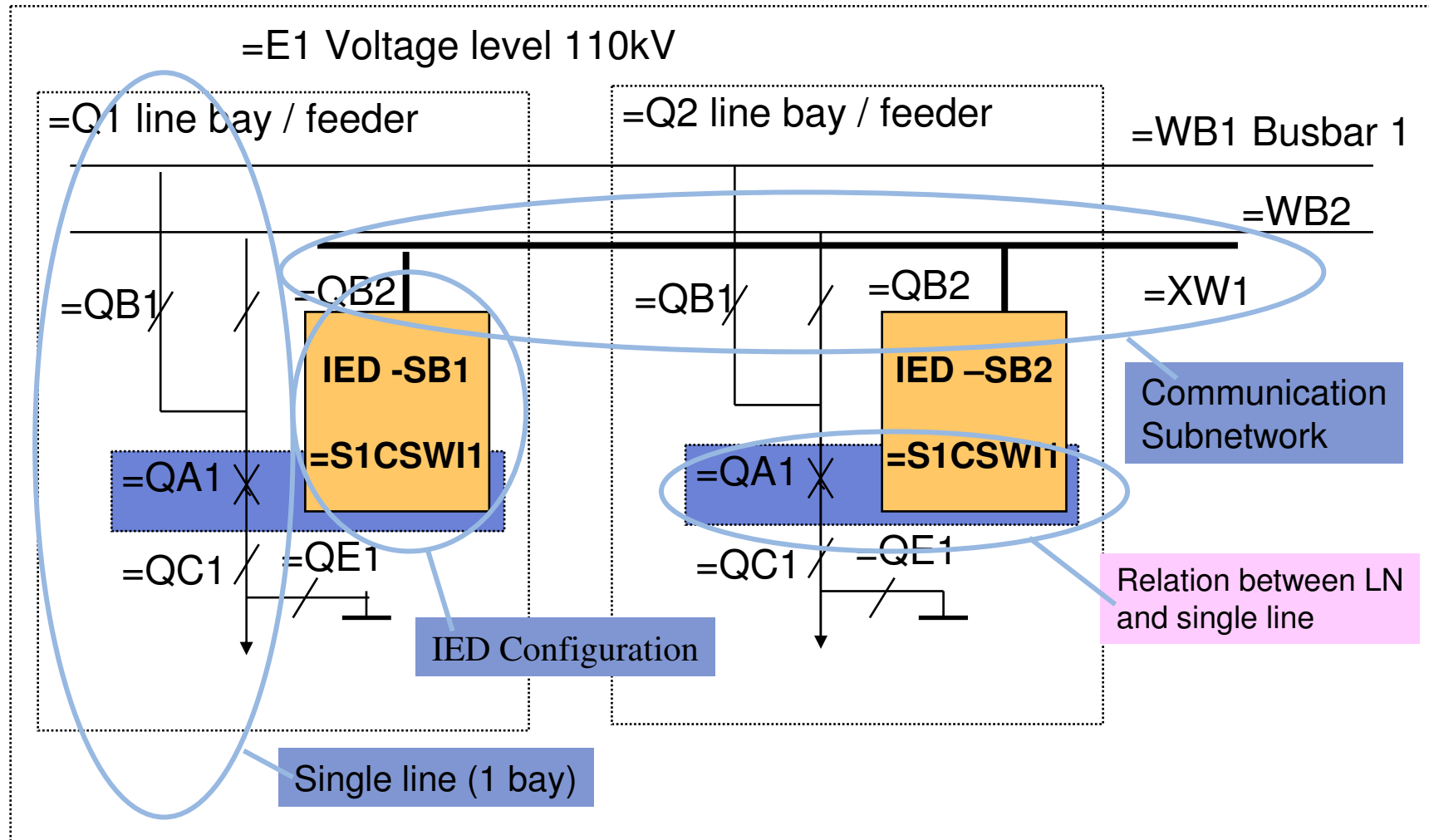
SCL Contents – Function relation



SCL Contents – Communication relation



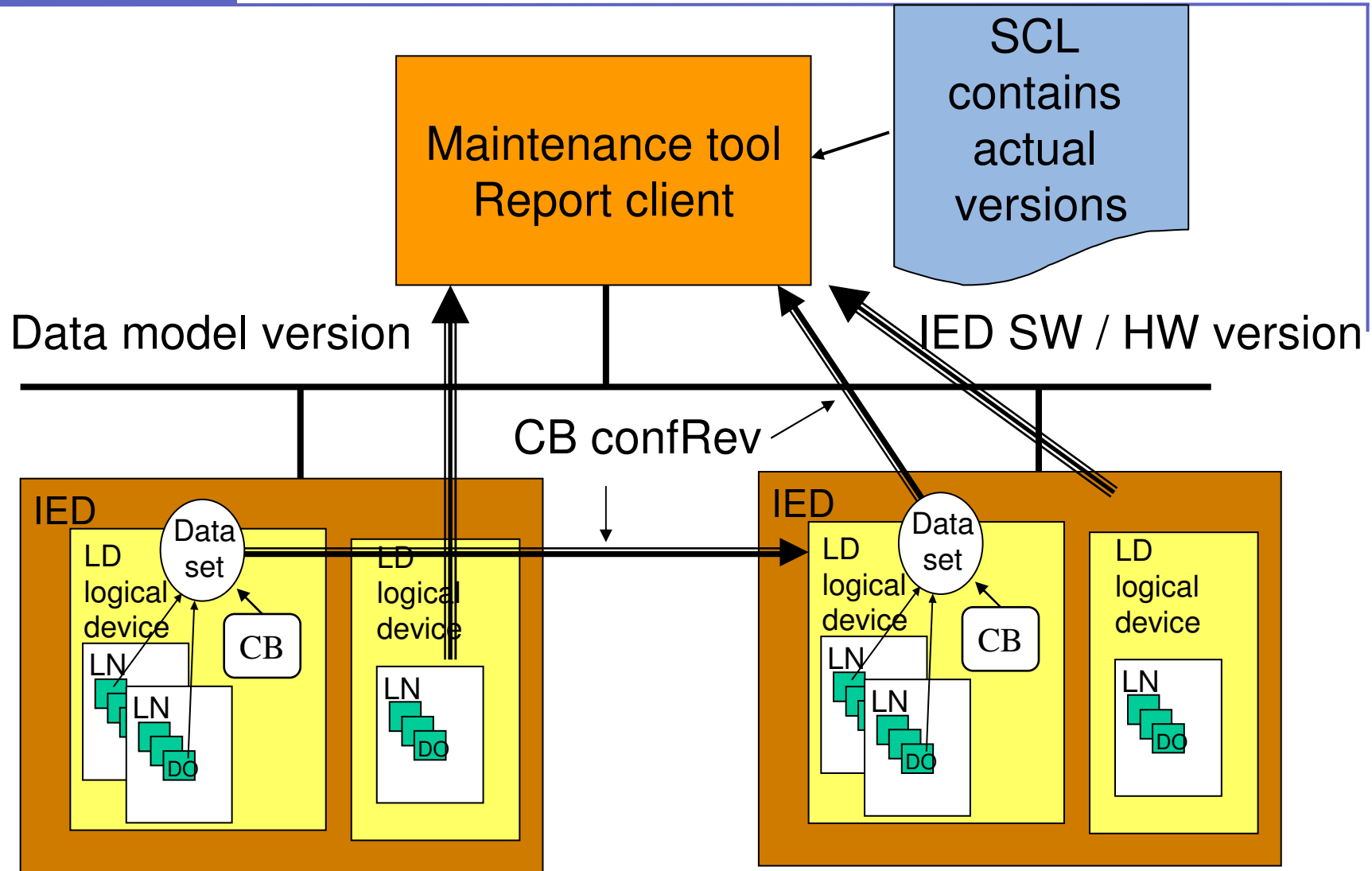
SCL Contents illustrated



- The IEC 61850 IED data model and SCL language provides....
 - A standardized description of
 - Substation Automation System functionality
 - Communication system logical structure
 - Binding of IEDs and their functions to the switch yard
- .. And thus enables
 - Automated configuration of **communication** and **function**
 - System **performance checking** (performance)



- Import of SCD into IED (-Tool)
- Detail engineering of IED, as necessary
 - Marshalling of inputs / outputs to terminals
 - Eventual additional logics, HMI, texts,
 - Marshalling of external (communication-)signals to application inputs
- Loading of configuration onto the IED
- Integration into system communicationwise and functionwise



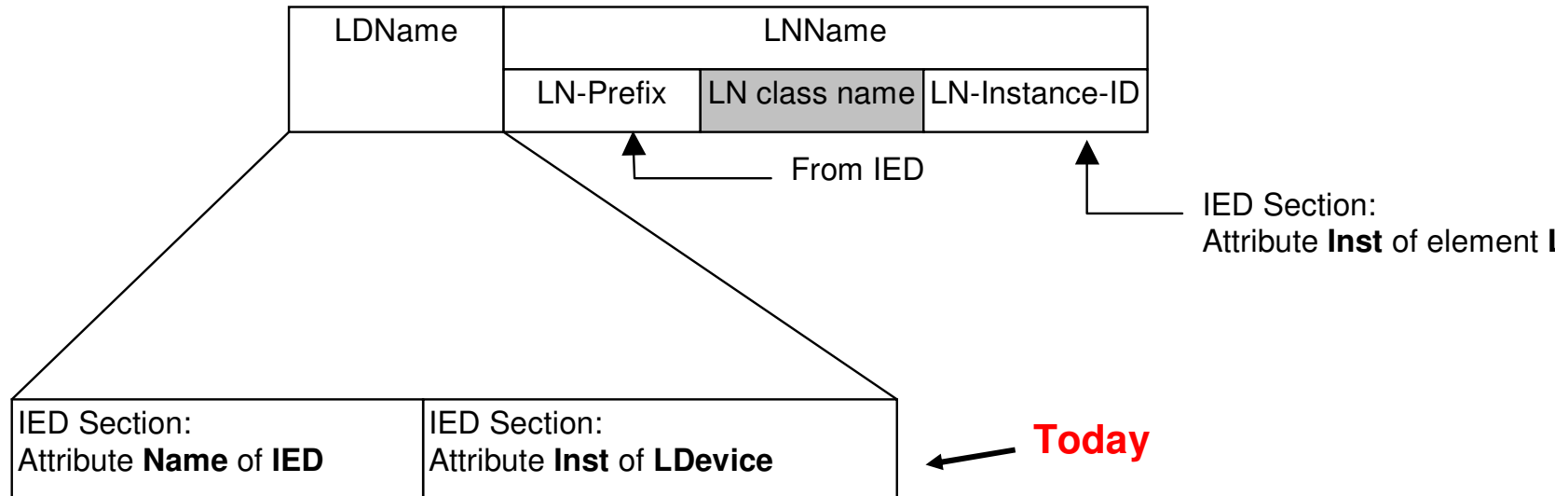
Real time confRev is always sent with data



- Configuration revision information (project specific)
 - Data model revision
 - Communication related configuration: data set / control block revision
- Information is available online and in SCL file
 - **Real time services** always have **revision** of data sets **in the sent message**. The receiver checks this always to assure configuration compatibility.
 - **Reporting version** information can be read **on demand**
 - **Data model version** and IED HW / SW version can be read **on demand**
 - Comparison with released SCL configuration file can be automated



SCL name definition: IED based names



Next version:

- LDName= Domain name, freely customer definable
- Default: as today
- IED name stays always as SCL reference

Engineering Process

Engineering according to IEC 61850

*) The IED object models
i.e. defined objects with defined data

Control* CB
Q0/CSWI
Control* ES
Q8/CSWI
Control* IS
Q9/CSWI
Bay-HMI* (HMI)

Earthing switch*
Q8_L1/XSWI
Gas density mon.*
Q8_L1/XGMU

Isolator*
Q9_L1/XSWI
Gas density mon.*
Q9_L1/XGMU

Circuit Breaker*
Q0_L1/XCBER
Gas dens. monitoring*
Q0_L1/XGMU

Distance protection* PDIS

Primary technology **Secondary technology**

Data modeling: GIS substation

Device capability

Device data

Device (IED)

Device specific tool

Device Configuration

Device selection

ICD

Device capability

System Configuration tool

System Configuration Description

Device data

SSD

System Topology & Functionality

System specification

System Documentation

System documentation

Communication Architecture

Functionality

Substation Topology

```

<SCL xmlns:base="http://www.iec61850.org/IEC61850-4/2007" xmlns="http://www.iec61850.org/IEC61850-4/2007" Header id="1" Substation name="AA1" desc="Substation" VoltageLevel name="D1" desc="Voltage Level" VoltageLevel name="AA1" desc="Voltage Level" ...
= "AA1A1" desc="Bay Control Unit" type="REC316-4" manufacturer="ABB" configVersion="1.0" point name="S1" ...
device Inst="C1" ...
<LN Inst="1" InClass="LLNO" InType="LLNO_REC316-4_IEC61850" ...
+ <LN Inst="2" InClass="GGIO" InType="FG_LineGeneral_REC316-4_IEC61850" prefix="FO" ...
prefix="DC3_3" ...
- <LN Inst="4" InClass="CSWI" InType="DC3_Switch Controller_REC316-4_IEC61850" prefix="DC3_3" ...
- <DOI name="Pos" desc="Position Indication" ...
- <DAI name="d" valKind="Set" ...
</LN>
</DI>
The system SCD file may be reused for any maintenance action and for any extension projects after years and with state-of-the-art tools compliant with IEC 61850.
- <DC ...
- <DAI name="d" valKind="Set">
    
```



IED Capability Description file

*Device on the shelf - **mandatory***



System Specification Description file

Single line and function allocation



System Configuration Description file

Configured system description



Configuration IED Description file

*Configured IED description incl.
device specific data beyond IEC 61850*

Two group of tools

Protection

Control

etc.

Station Computer

Gateway

Device
Specific
Tools

Typical features of Device Specific Tools

- are strong in configuring dedicated device features also beyond IEC 61850
- work with application libraries
- do normally not handle the single line diagram since it is beyond one device
- working on-line with the devices

System

System
Configuration
Tools

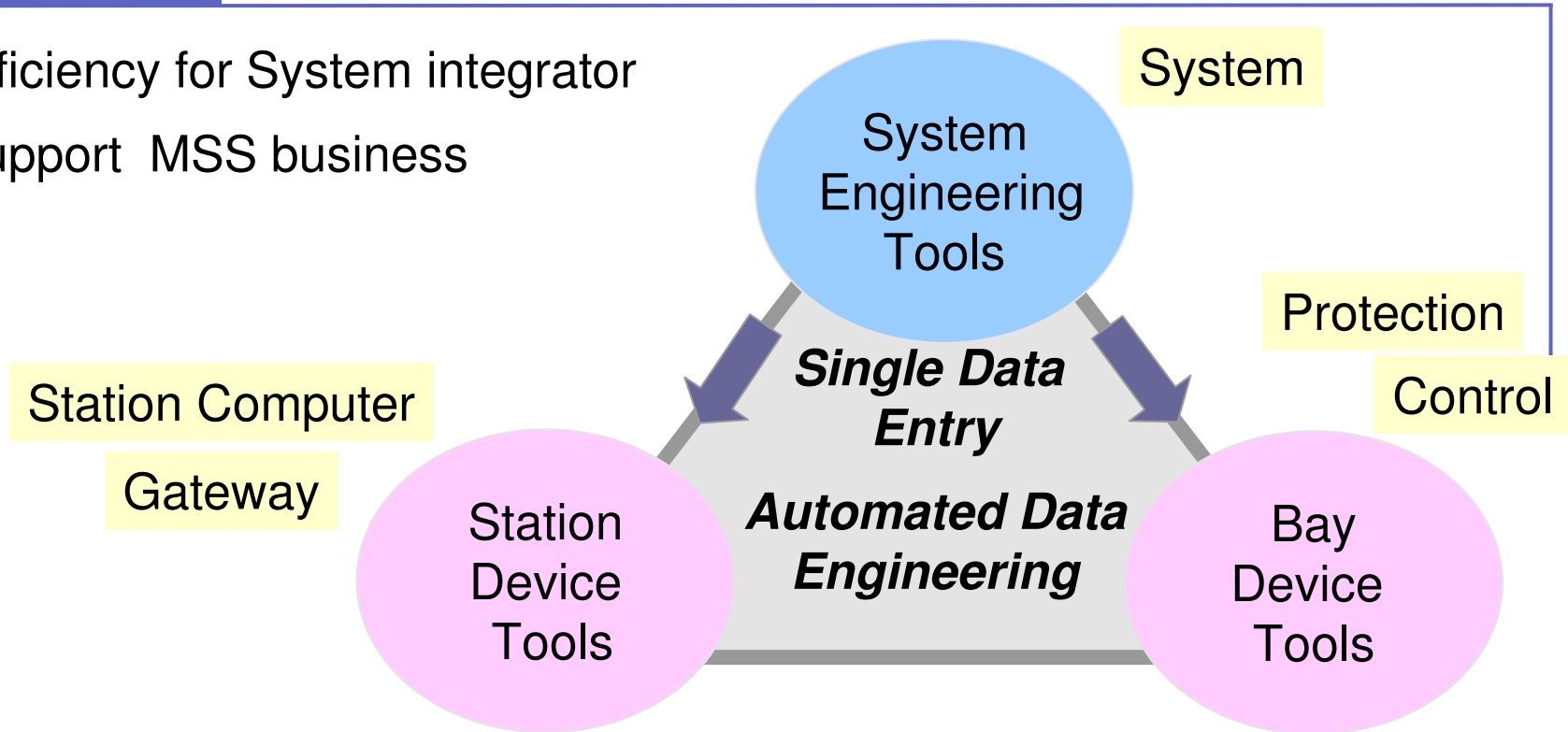
Typical features of System Configuration Tools

- allow top-down Engineering
- support the engineering of systems off-line from the specification
- are strong in reusing solutions and combining solution parts
- provide the administration of other project data like cubicle layouts
- support the creation of comprehensive project documentation



Main dependencies between tools

- Efficiency for System integrator
- Support MSS business



- State of the art tool support
- Automated configuration
- Open interfaces

- State of the art device tool support
- Eng./Test/Com. Efficiency
- Common look and feel



- Etz-Report 34, VDE Verlag 2004 (allgemein + Engineering, German)
- Praxis profiline, IEC 61850, Juli 2005 (general + Engineering)
- Design of IEC61850 based Substation Automation Systems according to Customer Requirements, CIGRE B5 PS1 2004, Brand, Brunner, Wimmer
- IEC 61850 SCL – more than interoperable data exchange, PSCC 2005 Liege, Wimmer
- Safety related distributed functions in Substations and the standard IEC 61850, IEEE BPT 2003 Milano, Brand, Ostertag, Wimmer
- Reliability investigations in SA architectures based on IEC 61850, IEEE PT 2005 Petersburg, Andersson, Brand, Brunner, Wimmer

