Lecture 5b

IEC 61850 standard introduction
Information modeling basics

Contents of the Lecture

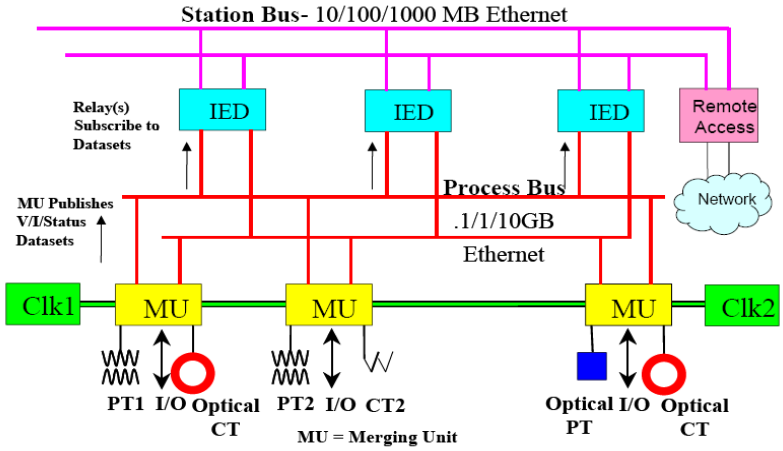
- Part – IEC 61850 Standard Introduction
  - Purpose & Scope of IEC 61850
  - The Information Model in 61850
  - Substation Communication (intro)
  - Device Configuration & Example

Part 2
The 61850 Standard

Purpose & Scope of 61850

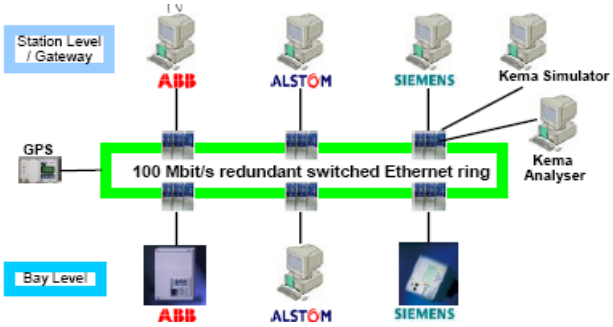
- The 61850 standard was developed to
  - Address the need for a more structured approach to design of Substation Automation Systems
  - Separate Data model from method of communication
  - Utilise new technologies (Ethernet, TCP/IP)
  - Enable vendor independence
  - Simplify system configuration
  - Enable sharing of measurement devices among

61850 Substation Architecture

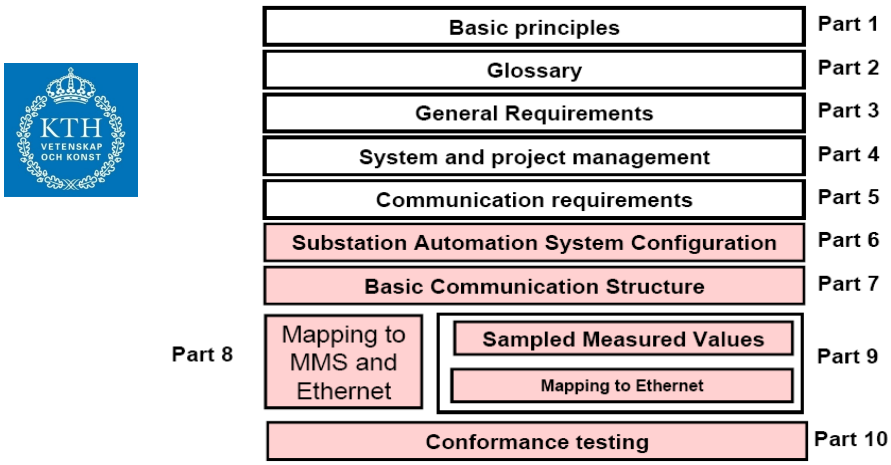


Vendor Independence

- The 61850 compliant Information model can be used to describe the structure of the Substation Automation System without using vendor tools



The IEC 61850 Standard

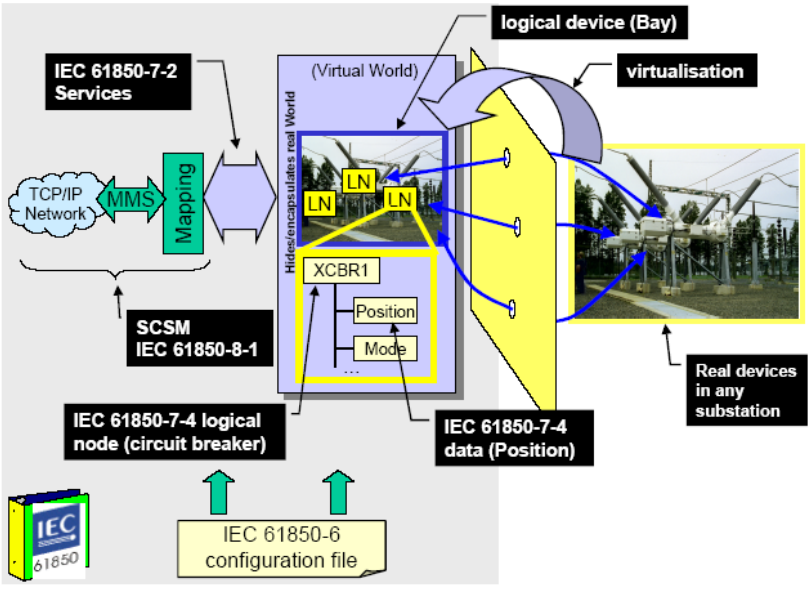


Core contents

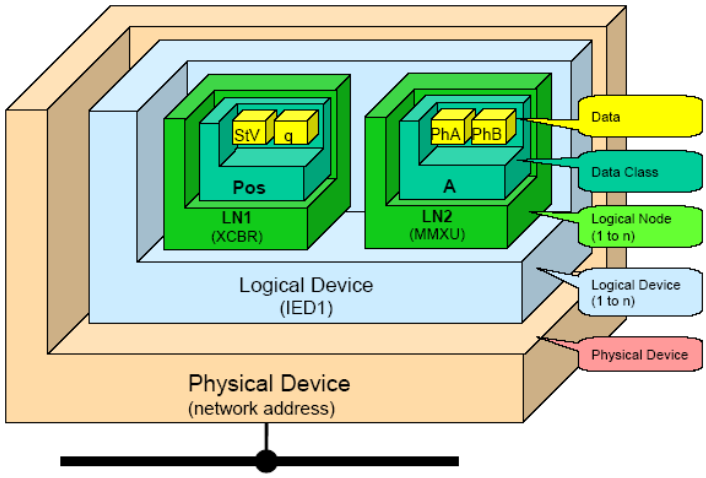
- Part 6-1: Substation Configuration Language (**SCL**)
- Part 7-2: Abstract Communications Service Interface (**ACSI**) and base types
- Part 7-3: Common Data Classes (**CDC**)
- Part 7-4: Logical Nodes
- Part 8-1: Specific Communications Service Mappings(**SCSM**) - MMS & Ethernet
- Part 9-2: SCSM - Sampled Values over Ethernet
- Part 10-1: Conformance Testing

Substation Information Modeling

Modeling a substation



Putting it all together



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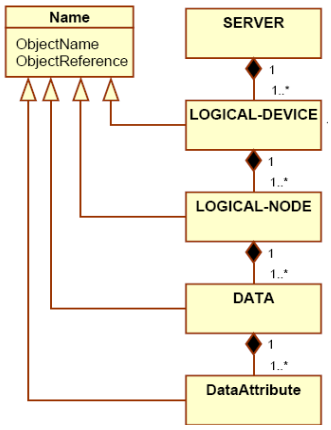
Component hierarchy in 61850



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Groups of logical nodes

Name	Description
Axxx	Automatic Control (4). ATCC (tap changer), AVCO (volt. ctrl.), etc.
Cxxx	Supervisory Control (5). CILO (Interlocking), CSWI (switch ctrl), etc.
Gxxx	Generic Functions (3). GGIO (generic I/O), etc.
Ixxx	Interfacing/Archiving (4). IARC (archive), IHMI (HMI), etc.
Lxxx	System Logical Nodes (2). LLN0 (common), LPHD (Physical Device)
Mxxx	Metering & Measurement (8). MMXU (meas.), MMTR (meter.), etc.
Pxxx	Protection (28). PDIF, PIOC, PDIS, PTOV, PTOH, PTOC, etc.
Rxxx	Protection Related (10). RREC (auto reclosing), RDRE (disturbance)..
Sxxx	Sensors, Monitoring (4). SARC (archs), SPDC (partial discharge), etc.
Txxx	Instrument Transformer (2). TCTR (current), TVTR (voltage)
Xxxx	Switchgear (2). XCBR (breaker), XCSW (switch)
Yxxx	Power Transformer (4). YPTR (transformer), YPSH (shunt), etc.
Zxxx	Other Equipment (15). ZCAP (cap ctrl), ZMOT (motor), etc.
Wxxx	Wind (Set aside for other standards)
Oxxx	Solar (Set aside for other standards)
Hxxx	Hydropower (Set aside for other standards)
Nxxx	Power Plant (Set aside for other standards)
Bxxx	Battery (Set aside for other standards)
Fxxx	Fuel Cells (Set aside for other standards)

LNs

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XCBR – Circuit Breaker

XCBR class				
Attribute Name	**Attr. Type**	**Explanation**	**T**	**M/O**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
Loc	SPS	Local operation (local means without substation automation communication, hardwired direct control)		M
EEHealth	INS	External equipment health		O
EEName	DPL	External equipment name plate		O
OpCnt	INS	Operation counter		M
Controls				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M
ChaMotEna	SPC	Charger motor enabled		O
Metered Values				
SumSwARs	BCR	Sum of Switched Amperes, resetable		O
Status Information				
CBOpCap	INS	Circuit breaker operating capability		M
POWCap	INS	Point On Wave switching capability		O
MaxOpCap	INS	Circuit breaker operating capability when fully charged		O

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Examples of Logical Nodes

- TVTR – Voltage transformer
- TCTR – Current transformer
- MMXU – Voltage Measurement
- XCBR – Circuit Breaker
- PDIF – Differential Protection
- PDIS – Distance Protection

MMXU - Measurement

MMXU class				
Attribute Name	Attr. Type	Explanation	T	M/O
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
EEHealth	INS	External equipment health (external sensor)		O
Measured values				
TotW	MV	Total Active Power (Total P)		O
TotVAr	MV	Total Reactive Power (Total Q)		O
TotVA	MV	Total Apparent Power (Total S)		O
TotPF	MV	Average Power factor (Total PF)		O
Hz	MV	Frequency		O
PPV	DEL	Phase to phase voltages (VL1VL2, ...)		O
PhV	WYE	Phase to ground voltages (VL1ER, ...)		O
A	WYE	Phase currents (IL1, IL2, IL3)		O
W	WYE	Phase active power (P)		O
VAr	WYE	Phase reactive power (Q)		O
VA	WYE	Phase apparent power (S)		O
PF	WYE	Phase power factor		O
Z	WYE	Phase Impedance		O

TVTR – Voltage Transformer

TVTR class				
Attribute Name	**Attr. Type**	**Explanation**	**T**	**M/O**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
EEHealth	INS	External equipment health		O
EEName	DPL	External equipment name plate		O
OpTmh	INS	Operation time		O
Measured values				
Vol	SAV	Voltage (sampled value)		M
Status Information				
FuFail	SPS	TVTR fuse failure		O
Settings				
VRtg	ASG	Rated Voltage		O
HzRtg	ASG	Rated frequency		O
Rat	ASG	Winding ratio of external voltage transformer (transducer) if applicable		O
Cor	ASG	Voltage phasor magnitude correction of external voltage transformer		O
AngCor	ASG	Voltage phasor angle correction of external voltage transformer		O

TCTR – Current Transformer

TCTR class				
Attribute Name	**Attr. Type**	**Explanation**	**T**	**M/O**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
EEHealth	INS	External equipment health		O
EEName	DPL	External equipment name plate		O
OpTmh	INS	Operation time		O
Measured values				
Amp	SAV	Current (Sampled value)		M
Settings				
ARtg	ASG	Rated Current		O
HzRtg	ASG	Rated Frequency		O
Rat	ASG	Winding ratio of an external current transformer (transducer) if applicable		O
Cor	ASG	Current phasor magnitude correction of an external current transformer		O
AngCor	ASG	Current phasor angle correction of an external current transformer		O

XCBR – Cricuit Breaker

XCBR class				
Attribute Name	**Attr. Type**	**Explanation**	**T**	**M/O**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
Loc	SPS	Local operation (local means without substation automation communication, hardwired direct control)		M
EEHealth	INS	External equipment health		O
EEName	DPL	External equipment name plate		O
OpCnt	INS	Operation counter		M
Controls				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M
ChaMotEna	SPC	Charger motor enabled		O
Metered Values				
SumSwARs	BCR	Sum of Switched Amperes, resetable		O
Status Information				
CBOpCap	INS	Circuit breaker operating capability		M
POWCap	INS	Point On Wave switching capability		O
MaxOpCap	INS	Circuit breaker operating capability when fully charged		O

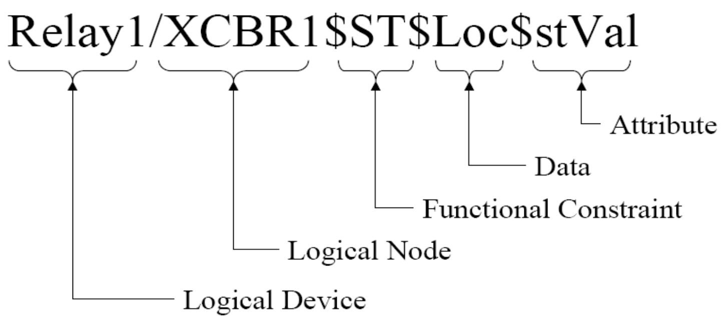
PTOC – Overcurrent protection

PTOC class				
Attribute Name	**Attr. Type**	**Explanation**	**T**	**M/O**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
OpCntRs	INC	Resetable operation counter		O
Status Information				
Str	ACD	Start		M
Op	ACT	Operate	T	M
TmASt	CSD	Active curve characteristic		O
Settings				
TmACrv	CURVE	Operating Curve Type		O
StrVal	ASG	Start Value		O
TmMult	ASG	Time Dial Multiplier		O
MinOpTmms	ING	Minimum Operate Time		O
MaxOpTmms	ING	Maximum Operate Time		O
OpDlTmms	ING	Operate Delay Time		O
TypRsCrv	ING	Type of Reset Curve		O
RsDlTmms	ING	Reset Delay Time		O
DirMod	ING	Directional Mode		O

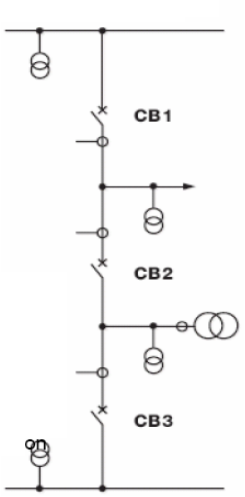
PDIS - Distance Protection

PDIS class				
Attribute Name	**Attr. Type**	**Explanation**	**T**	**M/O**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
OpCntRs	INC	Resetable operation counter		O
Status Information				
Str	ACD	Start		M
Op	ACT	Operate	T	M
Settings				
PoRch	ASG	Polar Reach is the diameter of the Mho diagram		O
PhStr	ASG	Phase Start Value		O
GndStr	ASG	Ground Start Value		O
DirMod	ING	Directional Mode		O
PctRch	ASG	Percent Reach		O
Ofs	ASG	Offset		O
PctOfs	ASG	Percent Offset		O
RisLod	ASG	Resistive reach for load area		O
AngLod	ASG	Angle for load area		O
TmDlMod	SPG	Operate Time Delay Mode		O
OpDlTmms	ING	Operate Time Delay		O
PhDlMod	SPG	Operate Time Delay Multiphase Mode		O
PhDlTmms	ING	Operate Time Delay for Multiphase Faults		O
GndDlMod	SPG	Operate Time Delay for Single Phase Ground Mode		O
GndDlTmms	ING	Operate Time Delay for single phase ground faults		O

Naming of objects in 61850



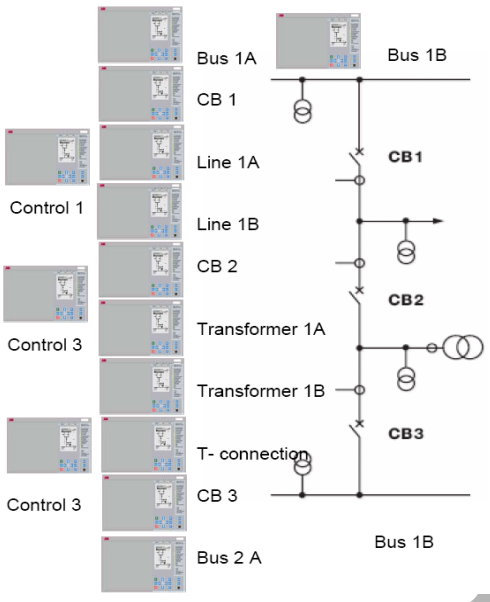
Substation Example



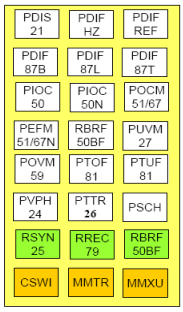
Possible LNs

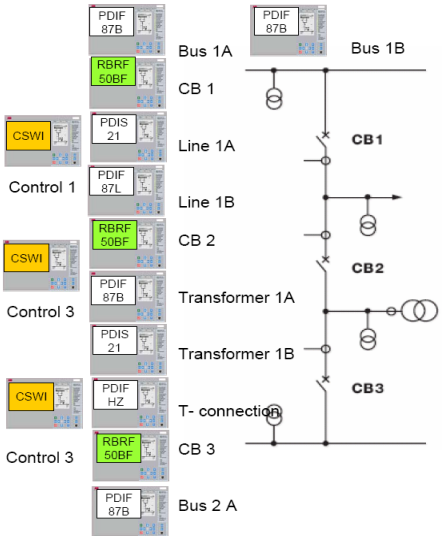
PDIS 21	PDIF HZ	PDIF REF
PDIF 87B	PDIF 87L	PDIF 87T
PIOC 50	PIOC 50N	POCM 51/67
PEFM 51/67N	RBRF 50BF	PUVM 27
POVM 59	PTOF 81	PTUF 81
PVPH 24	PTTR 26	PSCH
RSYN 25	RREC 79	RBRF 50BF
CSWI	MMTR	MMXU

Add IEDs



Allocate LNs to IEDs





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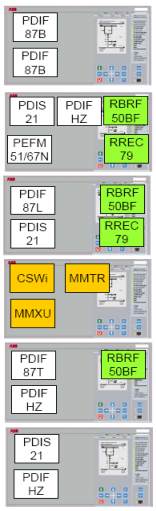
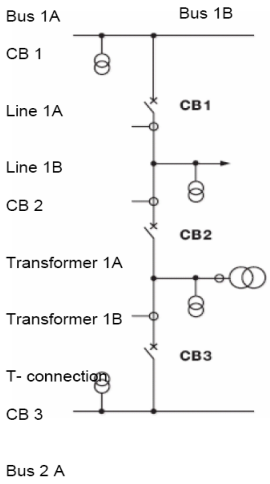
Or allocate like this…





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Communication Service Mapping

Communication of the data

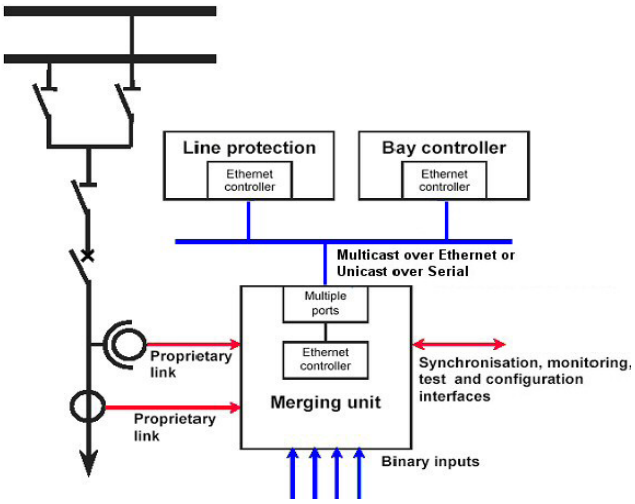
- The information descried in the Logical Nodes must be communicated to the outside world
  - E.g to other IEDs or to a SCADA system
- Most likely this will be done using some already available protocol, like TCP/IP, Ethernet, MMS, or other.
- To ensure that the translation from Information model to communication protocol is coherent and similar for all logical nodes and vendor independent the ACSI has been introduced

Sharing Measurement Devices

Sampled Values

- A method for transmitting sampled measurements from transducers such as CTs, VTs, and digital I/O.
- Enables sharing of I/O signals among IEDs
- Supports 2 transmission methods:
  - Multicast service (MSVC) over Ethernet
  - Unicast (point-to-point) service (USVC) over serial links.
- Communication defined in IEC 61850-9-2

Sampled Values & Merging Units



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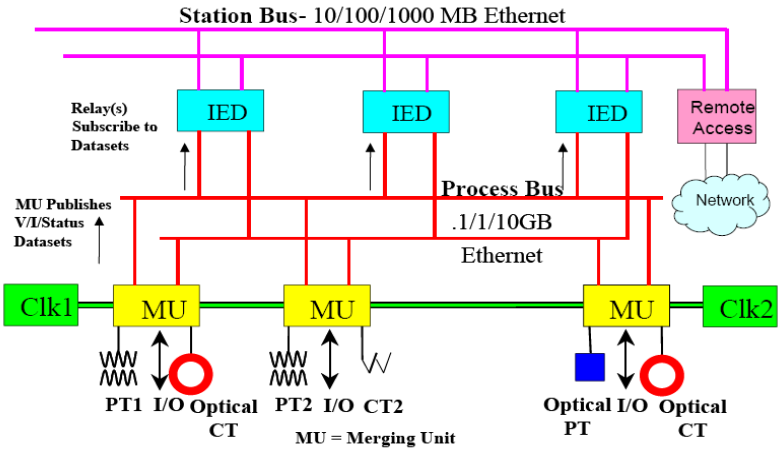
61850 Substation Architecture



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System Configuration

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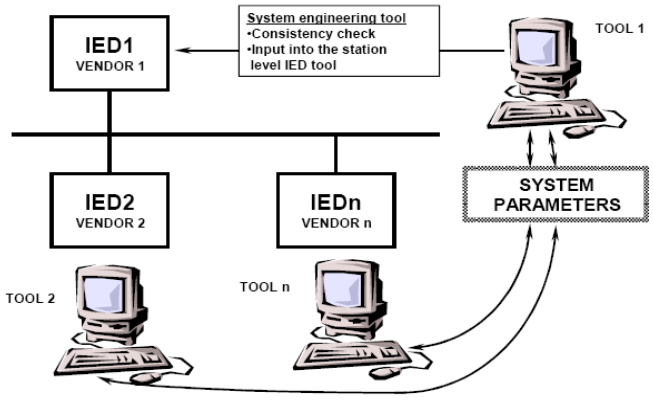
Ease of configuration



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SCL
Substation Configuration Language

- SCL is Part 6 of the 61850 standard
- XML based language that allows a formal description of
  - Substation automation system and the switchyard and the relation between them
  - IED configuration

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Types of SCL files

- **SSD**: System Specification Description.
  - XML description of the entire system.
- **SCD**: Substation Configuration Description.
  - XML description of a single substation.
- **ICD**: IED Capability Description.
  - XML description of items supported by an IED.
- **CID**: Configured IED Description.
  - XML configuration for a specific IED.

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SCL Example


```
<?xml version="1.0" encoding="UTF-8" ?>
- <SCL xmlns="http://www.iec.ch/61850/2003/SCL" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.iec.ch/61850/2003/SCL SCL.xsd">
  <Header id="SISCO_IED1_Complete" version="1" revision="2" toolID="xml spy" nameStructure="IEDName" />
- <Communication>
  - <SubNetwork name="Subnetz1" type="8-MMS/TCP">
      <Text />
      <BitRate unit="b/s" multiplier="M">100</BitRate>
    - <ConnectedAP iedName="SISCO_IED1" apName="AXS4MMS_CIGRE">
      - <Address>
          <P type="IP" xsi:type="tP_IP">192.168.2.11</P>
          <P type="IP-SUBNET" xsi:type="tP_IP-SUBNET">255.255.255.0</P>
        </Address>
      - <GSE ldInst="CTRL" cbName="Control_DataSet1">
        - <Address>
            <P type="VLAN-ID" xsi:type="tP_VLAN-ID">001</P>
            <P type="VLAN-PRIORITY" xsi:type="tP_VLAN-PRIORITY">4</P>
            <P type="MAC-Address" xsi:type="tP_MAC-Address">01-0C-CD-01-F1-04</P>
            <P type="APPID" xsi:type="tP_APPID">0000</P>
          </Address>
          <MinTime unit="s" multiplier="m">10</MinTime>
          <MaxTime unit="s" multiplier="m">2000</MaxTime>
        </GSE>
      </ConnectedAP>
    </SubNetwork>
  </Communication>
```