



February 29 2024



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Introduction to IEC 61850

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IEC 61850 Introduction

- Power systems' evolution:
 - Electro-mechanical to micro-processor
 - Internet/ethernet evolution
- UCA and IEC Technical Committee 57 (2002-2005)
- First edition in 2009
- Developed standard semantics, or modeling, mapped to different protocols

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IEC 61850 Introduction (cont.)

- General requirements in parts 1 to 5
- “Three pillars” in parts 6 to 9
 - Standard description of information exchange
 - Logical nodes, data objects, and attributes
 - Standard language
 - System Configuration Language (XML)
 - Set of communication services to exchange information
 - GOOSE, Sampled Values, PTP, MMS

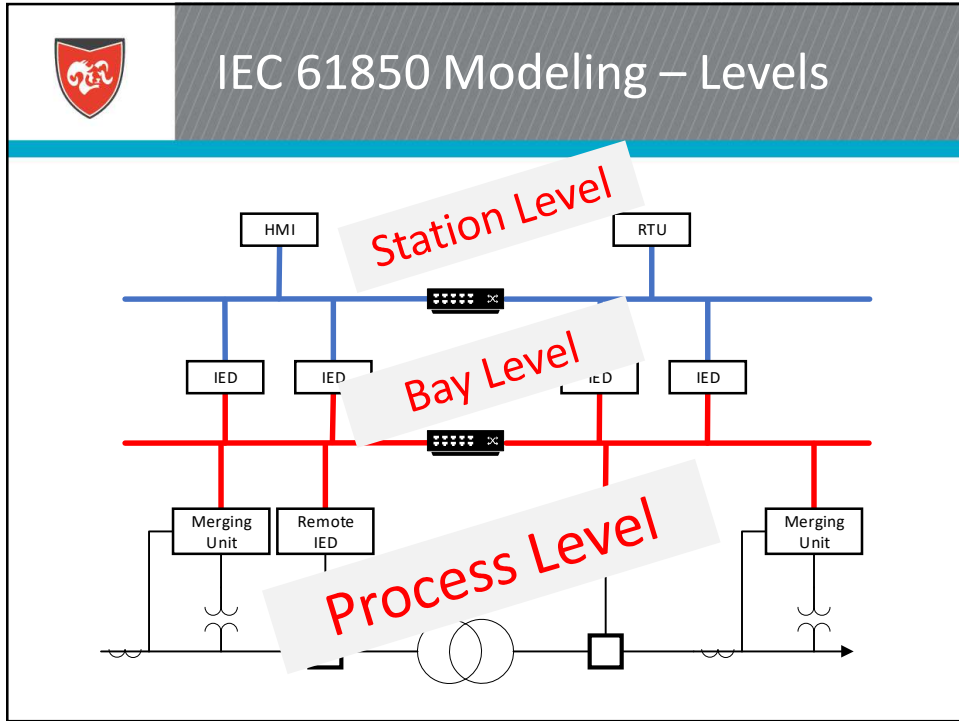
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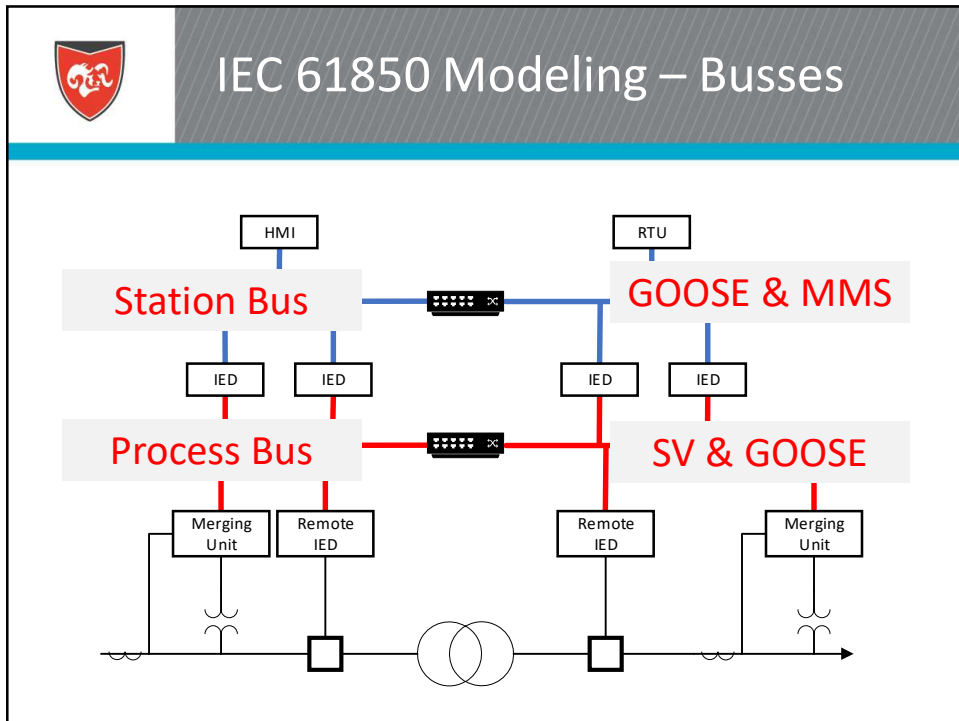
Terminology

- | | |
|-------------------------------------|---|
| • LD - Logical Device | • ICD - IED Capability Description |
| • LN - Logical Node | |
| • FC - Functional Constraint | • CID - Configured IED Description |
| • CDC - Common Data Class | |
| • DA - Data Attribute | • SCD - Substation Configuration Description |
| • DO - Data Object | |

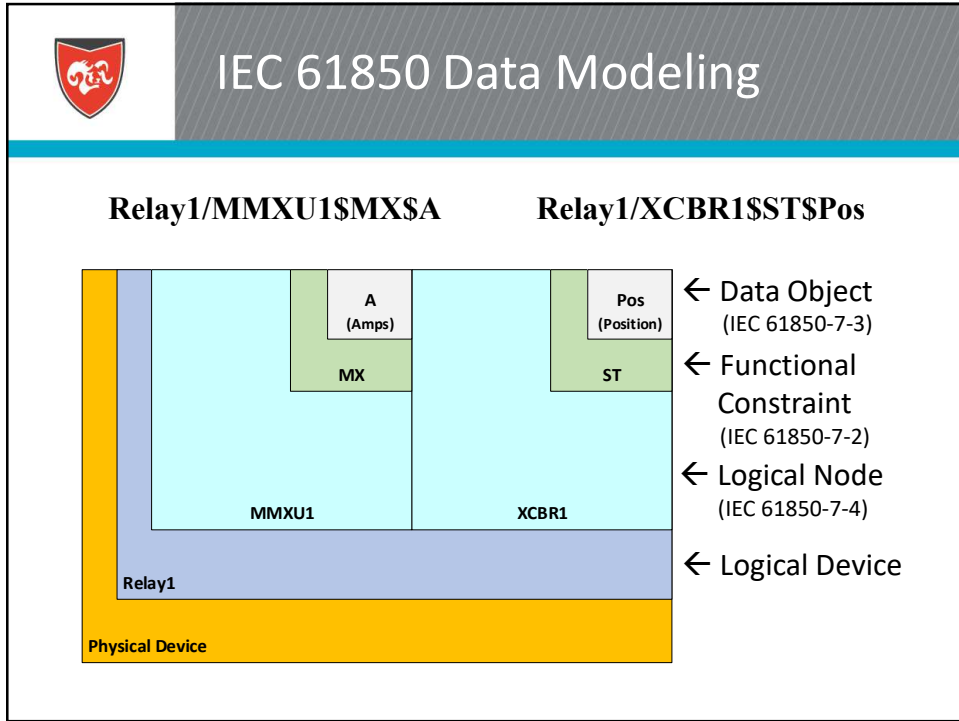
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Letter	Description	Letter	Description
A	Automatic Control	N	Reserved
B	Reserved	O	Reserved
C	Supervisory Control	P	Protection Functions
D	Distributed Energy Resources	Q	Power Quality Events
E	Reserved	R	Protection Related Functions
F	Functional Blocks	S	Supervision and Monitoring
G	Generic Function References	T	Instrument Transformer and Sensors
H	Hydro Power	U	Reserved
I	Interfacing and Archiving	V	Reserved
J	Reserved	W	Wind Power
K	Mechanical and Non-Electrical Primary Equipment	X	Switchgear
L	System Logical Nodes	Y	Power Transformer and related functions
M	Metering and Measurement	Z	Further (power system) equipment

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IEC 61850 – Logical Node Groups

GGIO class			
Data object name	Common data class	Explanation	T M/O/C
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22.	
Data objects			
Descriptions			
EEName	DPL	External equipment name plate	O
Status information			
EEHealth	ENS	External equipment health	O
LocKey	SPS	Local or remote key	O
Loc	SPS	Local control behaviour	O
IntIn1	INS	Integer status input	O
Alm1	SPS	General single alarm	O
Wrn1	SPS	General single warning	O
Ind1	SPS	General indication (binary input)	O
Measured and metered values			
AnIn1	MV	Analogue input	O
AnOut1	APC	Controllable analogue output	O
CntRs1	BCR	Counter, resettable	O
Controls			
OpCntRs	INC	Resettable operation counter	O
LocSta	SPC	Switching authority at station level	O
SPCSO1	SPC	Single point controllable status output	O
DPCSO1	DPC	Double point controllable status output	O
ISCSO1	INC	Integer status controllable status output	O


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IEC 61850 – Logical Node Classes

XCBR class			
Data object name	Common data class	Explanation	T M/O/C
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22.	
Data objects			
Descriptions			
XCBR class			
Data object name	Common data class	Explanation	T M/O/C
CBOpCap	ENS	Circuit breaker operating capability	O
POWCap	ENS	Point on wave switching capability	O
MaxOpCap	INS	Circuit breaker operating capability when fully charged	O
Dsc	SPS	Discrepancy	O
Measured and metered values			
SumSwARs	BCR	Sum of switched amperes, resettable	O
Controls			
LocSta	SPC	Switching authority at station level	O
Pos	DPC	Switch position	M
BlkOpn	SPC	Block opening	M
BlkCls	SPC	Block closing	M
ChaMotEna	SPC	Charger motor enabled	O
Settings			
CBTmms	ING	Closing time of breaker	O


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IEC 61850 – Logical Node Classes

MMXU class				
Data object name	Common data class	Explanation	T	M/O/C
Data objects				
<i>Measured and metered values</i>				
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 ($VL1, VL2, \dots$)		O
PNV	WYE	Phase to neutral voltage		O
PhV	WYE	Phase to ground voltages ($VL1ER, \dots$)		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

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IEC 61850 – FC and CDC

- **Functional Constraint**
 - Defines data objects' function
 - Common examples:
 - ST – Status information
 - MX – Measurands
- **Common Data Class**
 - Defines common attributes of data
 - Common examples:
 - SPS – Single Point Status
 - (C)MV - (Complex) Measured Value

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SPS class					
Data attribute name	Type	FC	TrgOp	Value/Value range	M/O/C
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
<i>status</i>					
stVal	BOOLEAN	ST	dchg	TRUE FALSE	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
<i>substitution and blocked</i>					
subEna	BOOLEAN	SV			PICS_SUBST
subVal	BOOLEAN	SV		TRUE FALSE	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
blkEna	BOOLEAN	BL			O
<i>configuration, description and extension</i>					
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

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DPS class					
Data attribute name	Type	FC	TrgOp	Value/Value range	M/O/C
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
<i>status</i>					
stVal	CODED ENUM	ST	dchg	intermediate-state off on bad-state	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
<i>substitution and blocked</i>					
subEna	BOOLEAN	SV			PICS_SUBST
subVal	CODED ENUM	SV		intermediate-state off on bad-state	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
blkEna	BOOLEAN	BL			O
<i>configuration, description and extension</i>					
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

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IEC 61850 – CDC Examples

CMV class	Data attribute name	Type	FC	TrgOp	Value/Value range	M/O/C
	DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
	DataAttribute					
		<i>measured attributes</i>				
	meCVal	Vector				O
	cVal	Vector		dchg, dupd		M
	range	ENUMERATED		dchg	normal high low high-high low-low	O
	rangeAng	ENUMERATED		dchg	normal high low high-high low-low	O
	q	Quality		dchg		M
	t	TimeStamp				M
		<i>substitution and blocked</i>				
	subEna	BOOLEAN		SV		PICS_SUBST
	subCVal	Vector		SV		PICS_SUBST
	subQ	Quality		SV		PICS_SUBST
	subID	VISIBLE STRING64		SV		PICS_SUBST
	blkEna	BOOLEAN		BL		O
		<i>configuration, description and extension</i>				
	units	Unit		CF dchg	see Annex A	O
	db	INT32U		CF dchg	0 ... 100 000	O
	dbAng	INT32U		CF dchg	0 ... 100 000	O
	zeroDb	INT32U		CF dchg	0 ... 100 000	O
	rangeC	RangeConfig		CF dchg		GC_CON_range
	rangeAngC	RangeConfig		CF dchg		GC_CON_range Ang
	magSVC	ScaledValueConfig		CF dchg		AC_SCAV
	angSVC	ScaledValueConfig		CF dchg		AC_SCAV
	angRef	ENUMERATED		CF dchg	Va Vb Vc Aa Ab Ac Vab Vbc Vca Vother Aother Synchronphasor	O
	smprRate	INT32U		CF dchg		O
	d	VISIBLE STRING255		DC	Text	O
	dU	UNICODE STRING255		DC		O
	cdcNs	VISIBLE STRING255		EX		AC_DLND_A_M
	cdcName	VISIBLE STRING255		EX		AC_DLND_A_M
	dataNs	VISIBLE STRING255		EX		AC_DLND_M

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Protocol Aspects - SV

- VLAN for multicast MAC publication
- VLAN priorities (CoS)
- Publish → “Transmit”
- Subscribe → “Receive”
- 80 samples/cycle; unsolicited messages
- Protection, Automation, or SCADA
- Replaces hardwiring of CT/PT signals
- IEC 61850-9-1 & IEC 61850-9-2

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Protocol Aspects - GOOSE

- VLAN for multicast MAC publication
- VLAN priorities (CoS)
- Publish → “Transmit”
- Subscribe → “Receive”
- Unsolicited messages
- Protection/Automation applications
- IEC 61850-8-1

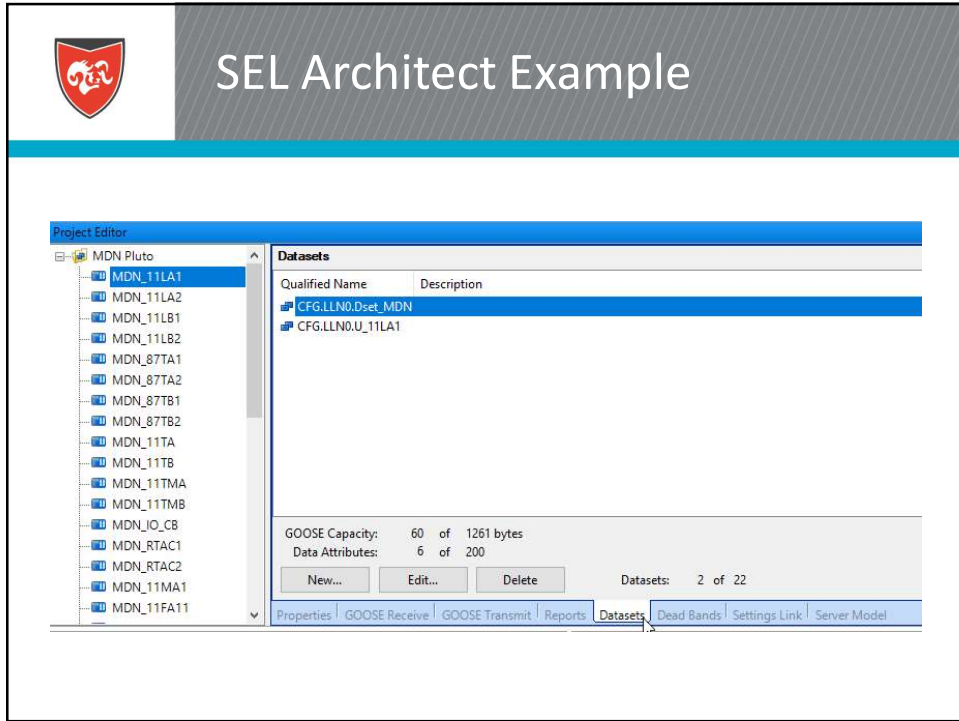
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Protocol Aspects - MMS

- Client/Server
- Unsolicited messages or polling
 - Report blocks, buffered or unbuffered
- SCADA application
- ISO-9506 (IEC 61850-8-1 details modeling)

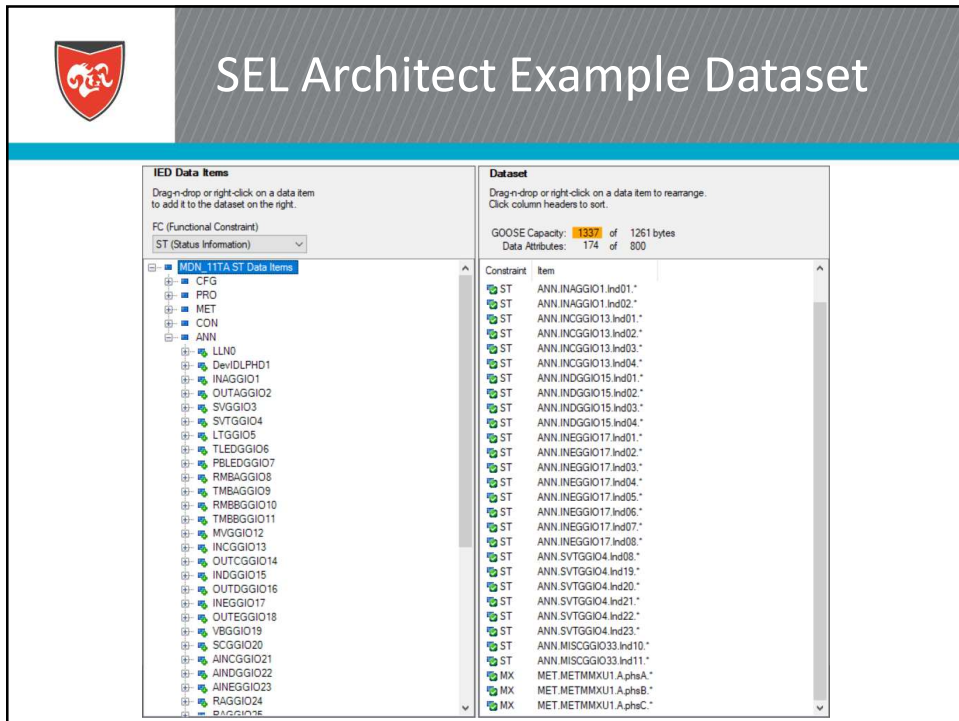
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SEL Architect Example

The screenshot shows the SEL Architect software interface. On the left, a tree view under 'MDN Pluto' lists various data items including MDN_11LA1 through MDN_11FA11. The main window displays the 'Datasets' section, which contains a table with columns for 'Qualified Name' and 'Description'. Two datasets are listed: 'CFG.LLN0.Dset_MDN' and 'CFG.LLN0.U_11LA1'. Below the table, summary statistics are shown: 'GOOSE Capacity: 60 of 1261 bytes' and 'Data Attributes: 6 of 200'. There are 'New...', 'Edit...', and 'Delete' buttons, and a status 'Datasets: 2 of 22'. A navigation bar at the bottom includes 'Properties', 'GOOSE Receive', 'GOOSE Transmit', 'Reports', 'Datasets', 'Dead Bands', 'Settings Link', and 'Server Model'.

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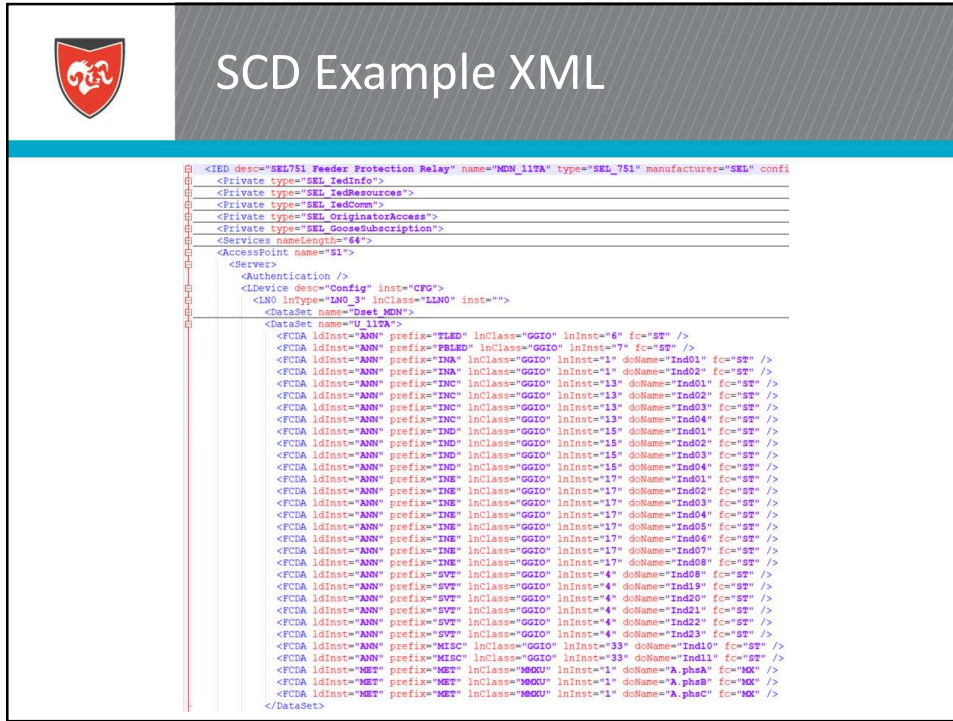


SEL Architect Example Dataset

The screenshot shows the 'Dataset' configuration window in SEL Architect. The left pane, titled 'IED Data Items', shows a tree view for 'MDN_11TA ST Data Items' with a list of items from CFG to RAGGIO25. The right pane, titled 'Dataset', shows a table of constraints and items. The 'GOOSE Capacity' is 1337 of 1261 bytes, and 'Data Attributes' are 174 of 800. The table lists constraints (all 'ST') and items (e.g., ANN.INAGGIO1.Incl01, ANN.INAGGIO1.Incl02, etc.).

Constraint	Item
ST	ANN.INAGGIO1.Incl01.*
ST	ANN.INAGGIO1.Incl02.*
ST	ANN.INCGGIO13.Incl01.*
ST	ANN.INCGGIO13.Incl02.*
ST	ANN.INCGGIO13.Incl03.*
ST	ANN.INCGGIO13.Incl04.*
ST	ANN.INDGGIO15.Incl01.*
ST	ANN.INDGGIO15.Incl02.*
ST	ANN.INDGGIO15.Incl03.*
ST	ANN.INDGGIO15.Incl04.*
ST	ANN.INEGGIO17.Incl01.*
ST	ANN.INEGGIO17.Incl02.*
ST	ANN.INEGGIO17.Incl03.*
ST	ANN.INEGGIO17.Incl04.*
ST	ANN.INEGGIO17.Incl05.*
ST	ANN.INEGGIO17.Incl06.*
ST	ANN.INEGGIO17.Incl07.*
ST	ANN.INEGGIO17.Incl08.*
ST	ANN.SVTGGIO4.Incl08.*
ST	ANN.SVTGGIO4.Incl19.*
ST	ANN.SVTGGIO4.Incl20.*
ST	ANN.SVTGGIO4.Incl21.*
ST	ANN.SVTGGIO4.Incl22.*
ST	ANN.SVTGGIO4.Incl23.*
ST	ANN.MISCGGIO33.Incl10.*
ST	ANN.MISCGGIO33.Incl11.*
MIX	MET.METMMXU1.A.phaA.*
MIX	MET.METMMXU1.A.phaB.*
MIX	MET.METMMXU1.A.phaC.*

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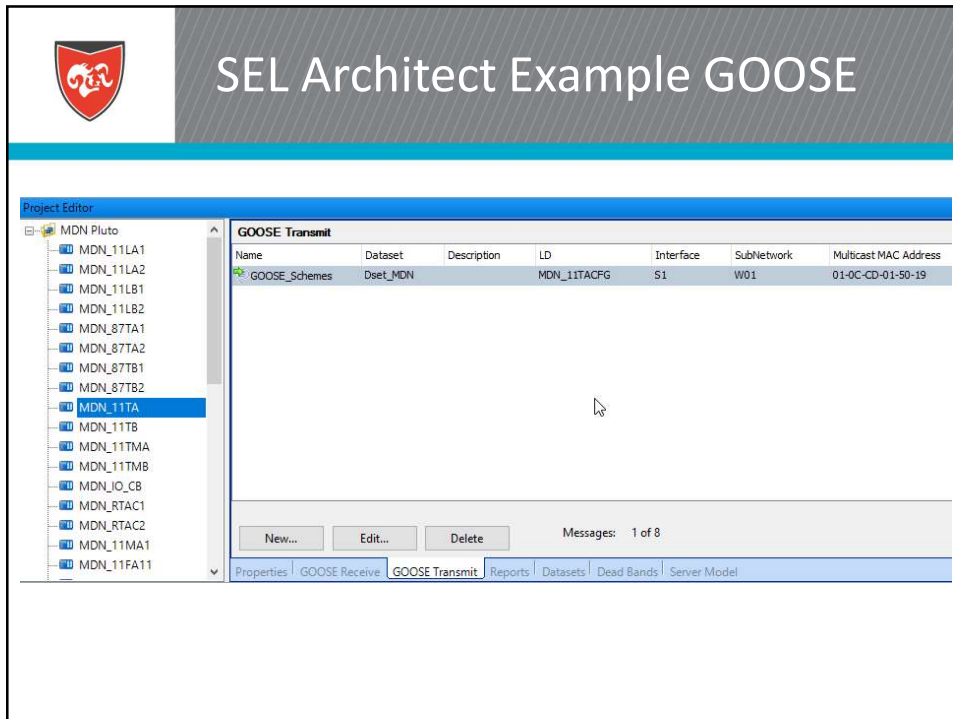


SCD Example XML

```

<IED desc="SEL751 Feeder Protection Relay" name="MDN_11TA" type="SEL_751" manufacturer="SEL" confi
<Private type="SEL_IedInfo">
<Private type="SEL_IedResources">
<Private type="SEL_IedComm">
<Private type="SEL_OriginatorAccess">
<Private type="SEL_GooseSubscription">
<Services nameLength="64">
<AccessPoint name="S1">
  <Server>
    <Authentication />
    <LDevice desc="Config" inst="CFG">
      <LNO lnType="LNO_3" lnClass="LNO" inst="">
        <DataSet name="Dset_MDN">
          <DataSet name="U_11TA">
            <FCDA ldInst="ANN" prefix="TLED" lnClass="GGIO" lnInst="6" fc="ST" />
            <FCDA ldInst="ANN" prefix="FRLD" lnClass="GGIO" lnInst="7" fc="ST" />
            <FCDA ldInst="ANN" prefix="INA" lnClass="GGIO" lnInst="1" doName="Ind01" fc="ST" />
            <FCDA ldInst="ANN" prefix="INA" lnClass="GGIO" lnInst="1" doName="Ind02" fc="ST" />
            <FCDA ldInst="ANN" prefix="INC" lnClass="GGIO" lnInst="13" doName="Ind01" fc="ST" />
            <FCDA ldInst="ANN" prefix="INC" lnClass="GGIO" lnInst="13" doName="Ind02" fc="ST" />
            <FCDA ldInst="ANN" prefix="INC" lnClass="GGIO" lnInst="13" doName="Ind03" fc="ST" />
            <FCDA ldInst="ANN" prefix="INC" lnClass="GGIO" lnInst="13" doName="Ind04" fc="ST" />
            <FCDA ldInst="ANN" prefix="IND" lnClass="GGIO" lnInst="15" doName="Ind01" fc="ST" />
            <FCDA ldInst="ANN" prefix="IND" lnClass="GGIO" lnInst="15" doName="Ind02" fc="ST" />
            <FCDA ldInst="ANN" prefix="IND" lnClass="GGIO" lnInst="15" doName="Ind03" fc="ST" />
            <FCDA ldInst="ANN" prefix="IND" lnClass="GGIO" lnInst="15" doName="Ind04" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind01" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind02" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind03" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind04" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind05" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind06" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind07" fc="ST" />
            <FCDA ldInst="ANN" prefix="INE" lnClass="GGIO" lnInst="17" doName="Ind08" fc="ST" />
            <FCDA ldInst="ANN" prefix="SVT" lnClass="GGIO" lnInst="4" doName="Ind08" fc="ST" />
            <FCDA ldInst="ANN" prefix="SVT" lnClass="GGIO" lnInst="4" doName="Ind19" fc="ST" />
            <FCDA ldInst="ANN" prefix="SVT" lnClass="GGIO" lnInst="4" doName="Ind20" fc="ST" />
            <FCDA ldInst="ANN" prefix="SVT" lnClass="GGIO" lnInst="4" doName="Ind21" fc="ST" />
            <FCDA ldInst="ANN" prefix="SVT" lnClass="GGIO" lnInst="4" doName="Ind22" fc="ST" />
            <FCDA ldInst="ANN" prefix="SVT" lnClass="GGIO" lnInst="4" doName="Ind23" fc="ST" />
            <FCDA ldInst="ANN" prefix="MISC" lnClass="GGIO" lnInst="33" doName="Ind10" fc="ST" />
            <FCDA ldInst="ANN" prefix="MISC" lnClass="GGIO" lnInst="33" doName="Ind11" fc="ST" />
            <FCDA ldInst="MET" prefix="MET" lnClass="MGOU" lnInst="1" doName="A.phaA" fc="MX" />
            <FCDA ldInst="MET" prefix="MET" lnClass="MGOU" lnInst="1" doName="A.phaB" fc="MX" />
            <FCDA ldInst="MET" prefix="MET" lnClass="MGOU" lnInst="1" doName="A.phaC" fc="MX" />
          </DataSet>
        </LNO>
      </LDevice>
    </Server>
  </AccessPoint>
</Services>
</Private>
</IED>
  
```

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SEL Architect Example GOOSE

Project Editor

- MDN Pluto
 - MDN_11LA1
 - MDN_11LA2
 - MDN_11LB1
 - MDN_11LB2
 - MDN_87TA1
 - MDN_87TA2
 - MDN_87TB1
 - MDN_87TB2
 - MDN_11TA**
 - MDN_11TB
 - MDN_11TMA
 - MDN_11TMB
 - MDN_IO_CB
 - MDN_RTAC1
 - MDN_RTAC2
 - MDN_11MA1
 - MDN_11FA11

GOOSE Transmit

Name	Dataset	Description	LD	Interface	SubNetwork	Multicast MAC Address
GOOSE_Schemes	Dset_MDN		MDN_11TACFG	S1	W01	01-0C-CD-01-50-19

Messages: 1 of 8

Properties | GOOSE Receive | **GOOSE Transmit** | Reports | Datasets | Dead Bands | Server Model

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SEL Architect Example GOOSE

GOOSE Transmit (Edit)

Message Name:

Description:

Goose ID:

Configuration Revision:

Min Time: (ms) Max Time: (ms)

Dataset:

Address:

MAC Address:

APP ID:

VLAN ID:

VLAN PRIORITY:

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SEL Architect Example MMS

Project Editor

MDN Pluto

- MDN_11LA1
- MDN_11LA2
- MDN_11LB1
- MDN_11LB2
- MDN_87TA1
- MDN_87TA2
- MDN_87TB1
- MDN_87TB2
- MDN_11TA
- MDN_11TB
- MDN_11TMA
- MDN_11TMB
- MDN_JO_CB
- MDN_RTAC1
- MDN_RTAC2
- MDN_11MA1
- MDN_11FA11


Reports

Type	Name	ID	Dataset
Unbuffered	UR_11LA1_RTAC1	MDN_11LA1	U_11LA1
Unbuffered	UR_11LA1_RTAC2	MDN_11LA1	U_11LA1
Unbuffered	UR_11LA1_HMI	MDN_11LA1	U_11LA1

Buffered: 0 of 7
 Unbuffered: 3 of 7

[Properties](#) | [GOOSE Receive](#) | [GOOSE Transmit](#) | **Reports** | [Datasets](#) | [Dead Bands](#) | [Settings Link](#) | [Server Model](#)

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SEL Architect Example MMS

Report (Edit)

Report Type
 Buffered
 Unbuffered

Buffer Time (bufTime)
250 ms

Name (name)
UR_11TA_RTAC1

Description (desc)
[Empty text area]

Report ID (rptID)
MDN_11TA

Configuration Revision (confRev)
1

Dataset (datSet)
CFG.LLN0.U_11TA

Trigger Options
 Data Change (dchg)
 Quality Change (qchg)
 Period (period)
Integrity Period (intgPd)
3600000 ms

[Optional Fields](#)

OK Cancel

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QUESTIONS?

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