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MAPPING BETWEEN IEC 61850 AND IEEE 1815 (DNP3)

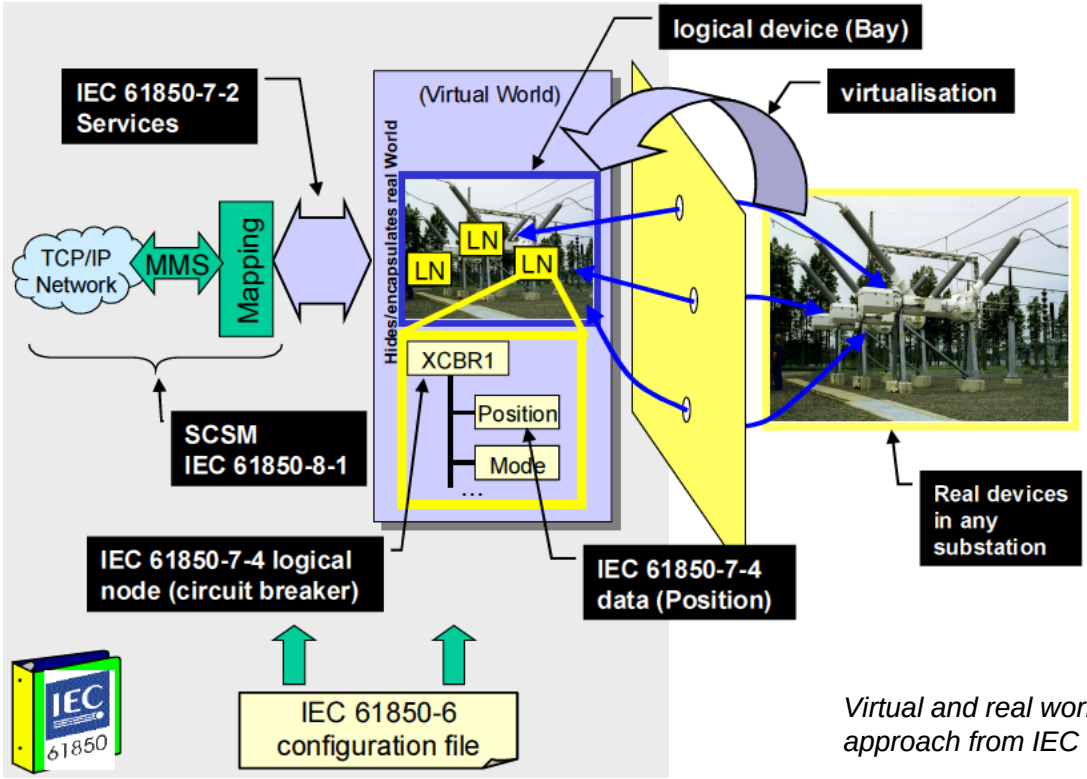
IEEE 1815.1 Genesis

- IEEE 1815 (DNP3) used by >75% of North American electricity utilities
- IEC 61850 initially focused on substation automation
  - Now targets all electric utility functions
- EPRI recognized need for mapping between DNP3 and IEC 61850
- IEEE 1815.1 Due December 2016
  - May be adopted as IEC 61850-80-2

IEC 61850 Data Models

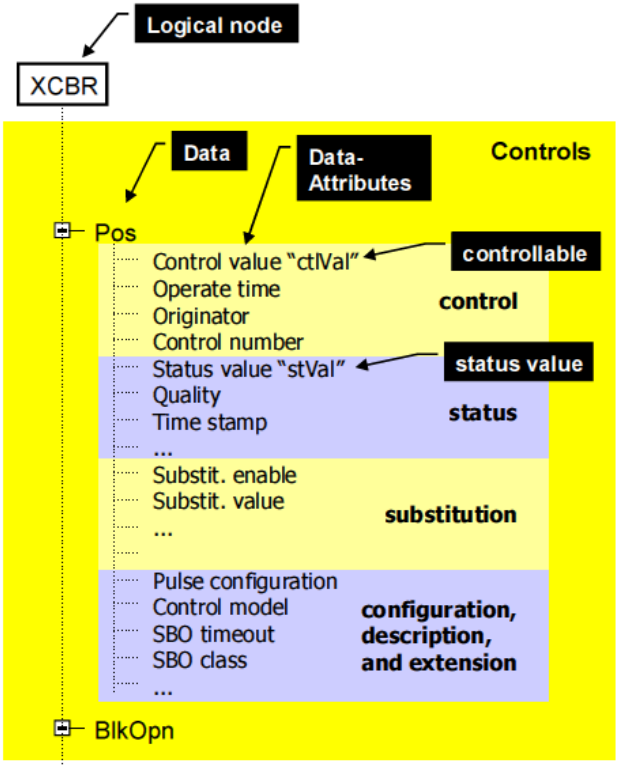
- Field equipment and substation protection and control functions are modelled as Logical Nodes (LN)
- Substation configuration in XML files based on SCL defined in IEC 61850-6

Data modelling



Virtual and real world modelling approach from IEC 61850-7-1

Example components of a LN

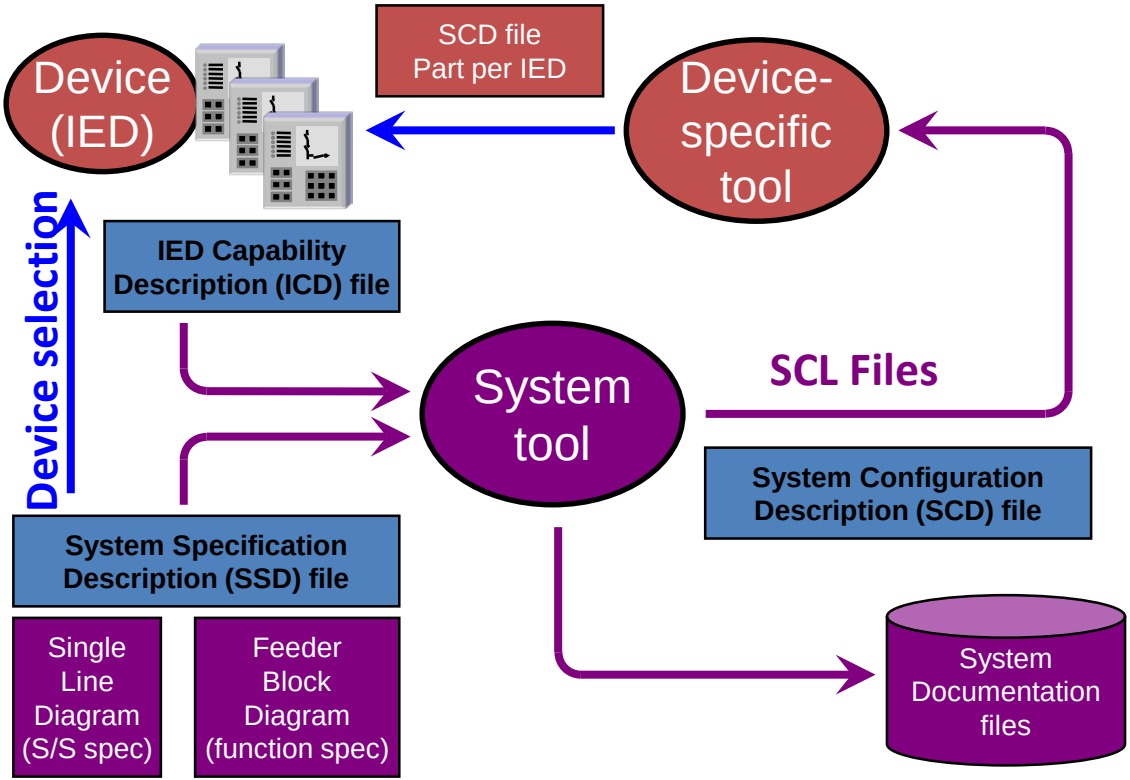


- Logical Nodes
  - Contain multiple data elements (typically about ~20 per LN)
- Data
  - Strongly typed & structured set of "data attributes" known as "Common Data Classes" or CDC
  - Strictly named
  - Typically ~20 data attributes per data element
  - CDCs defined in IEC 61850-7-3

CDC Example: Data attributes of the single point status (SPS) common data class

Attribute	Attribute Type	FC	TrgOp	Value / Value range	M / O / C
Status					
stVal	BOOLEAN	ST	Dchg	TRUE | FALSE	M
q	Quality	ST	Qchg		M
t	TimeStamp	ST			M
Substitution					
subEna	BOOLEAN	SV			PICS_SUBST
subVal	BOOLEAN	SV		TRUE| FALSE	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING 64	SV			PICS_SUBST
Configuration, description and extension					
d	VISIBLE STRING 255	DC		Text	O
cdcNs	VISIBLE STRING 255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING 255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING 255	EX			AC_DLN_M

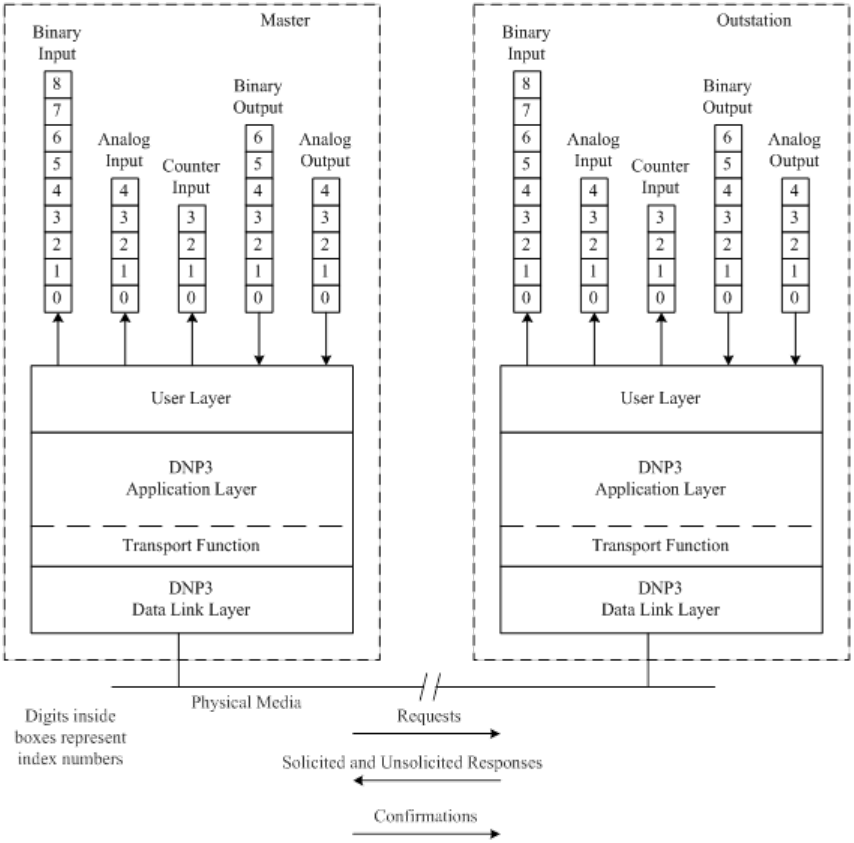
Configuration using SCL files



DNP3 Data Model

- DNP3 models data as one-dimensional arrays of simple data objects
  - Each data type has its own array
    - Binary input, double binary input, binary output, analog input & output, counters & frozen counters
    - Consists of {Value, Quality, Time}
  - Data objects are identified by the index in the array
    - This is the traditional SCADA “Anonymous Point” model
    - There is no semantic information about the purpose of the object

DNP3 Data Model



DNP3 Device Profile

- DNP3 optionally defines object semantics and device configuration data in the DNP-XML Device Profile
  - Specifies the device capabilities
  - Object parameters and naming information
  - Includes mapping between IEC 61850 data attributes and DNP3 objects

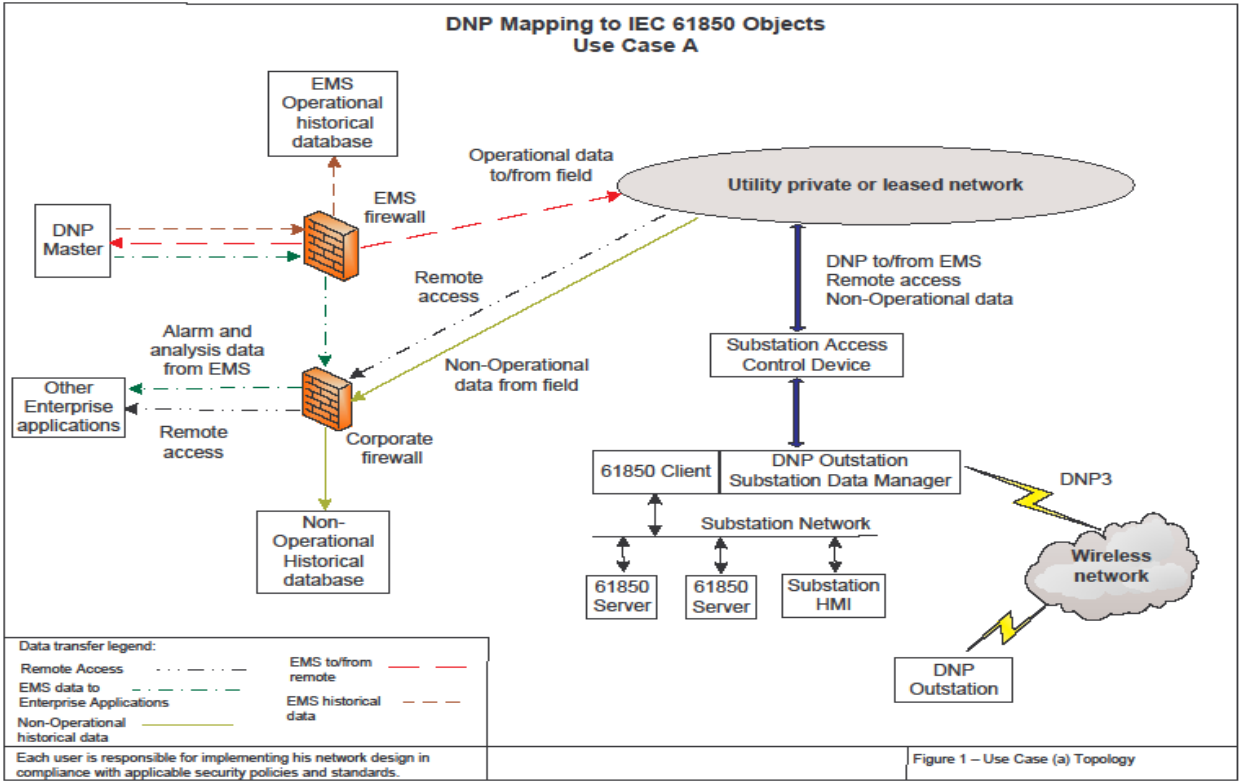
IEEE 1815.1:
Mapping Between DNP3 and IEC 61850

- To support the adoption of IEC 61850 substation automation into systems that use DNP3 for SCADA
- To allow integration of DNP3 IEDs into IEC 61850 Substation Automation
- The mapping is to be automatic as far as possible

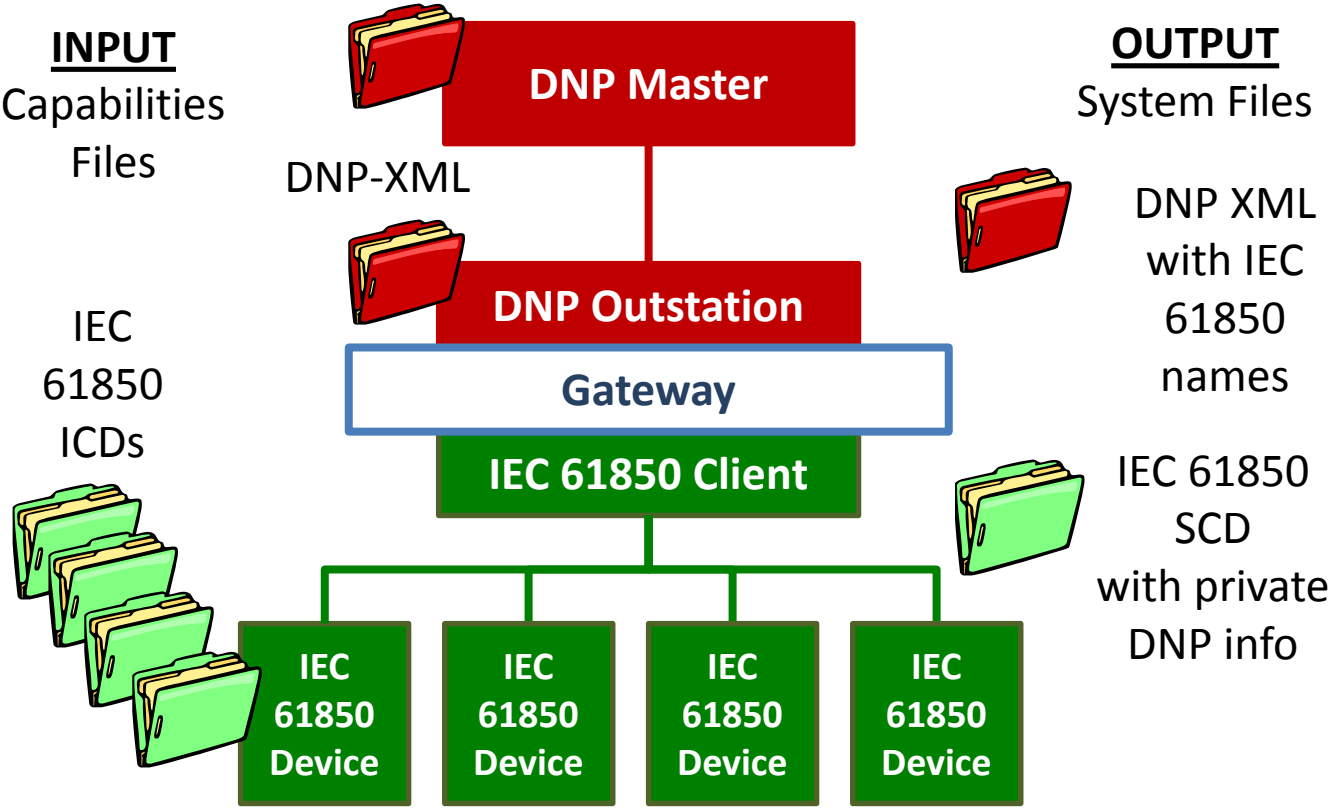
IEEE 1815.1 Use Cases

- Two basic use cases:
  - (a) Mapping from IEC 61850 to DNP3
  - (b) Mapping from DNP3 to IEC 61850
- Use case (a) sub-cases
  - (a1) Greenfield:
    - Free data selection
  - (a2) Retrofit:
    - The DNP3 point list is already defined

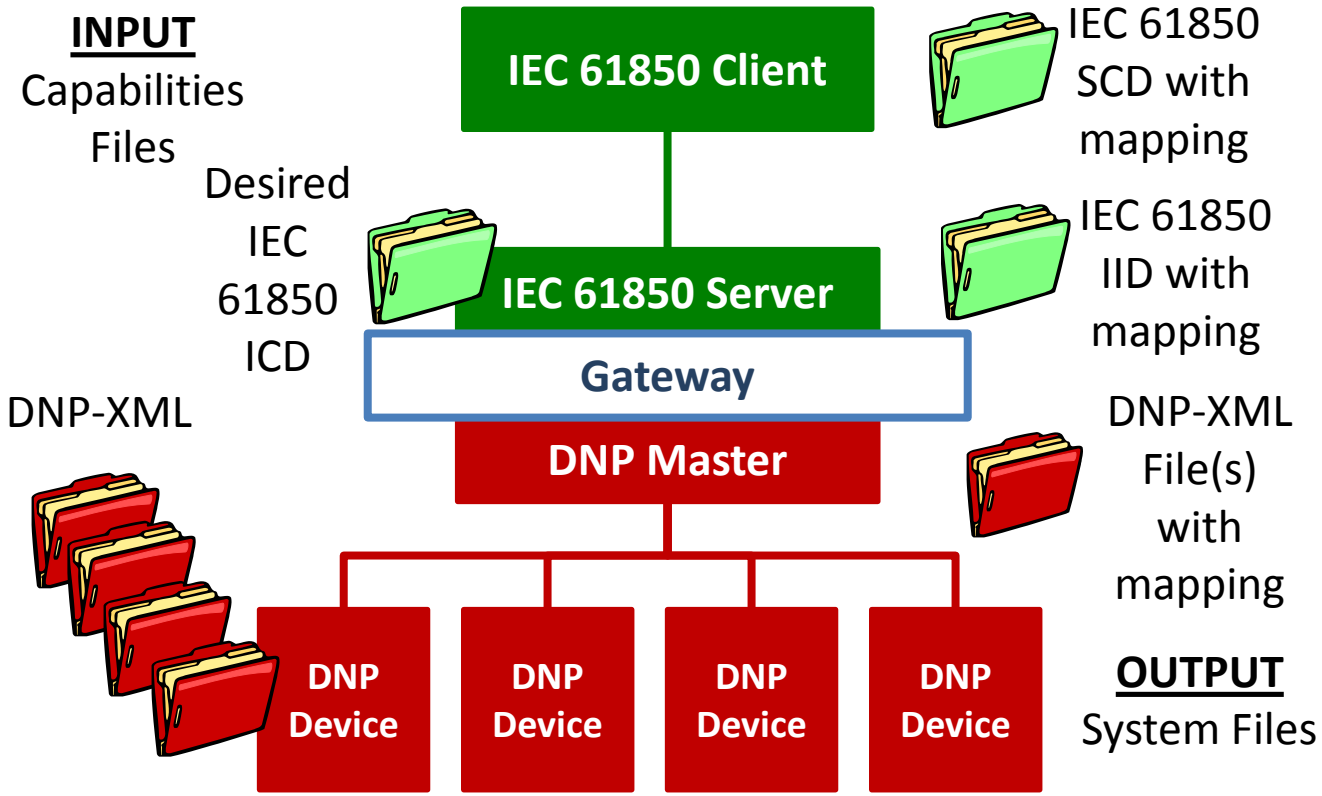
Topology Diagram – Use Case (a)



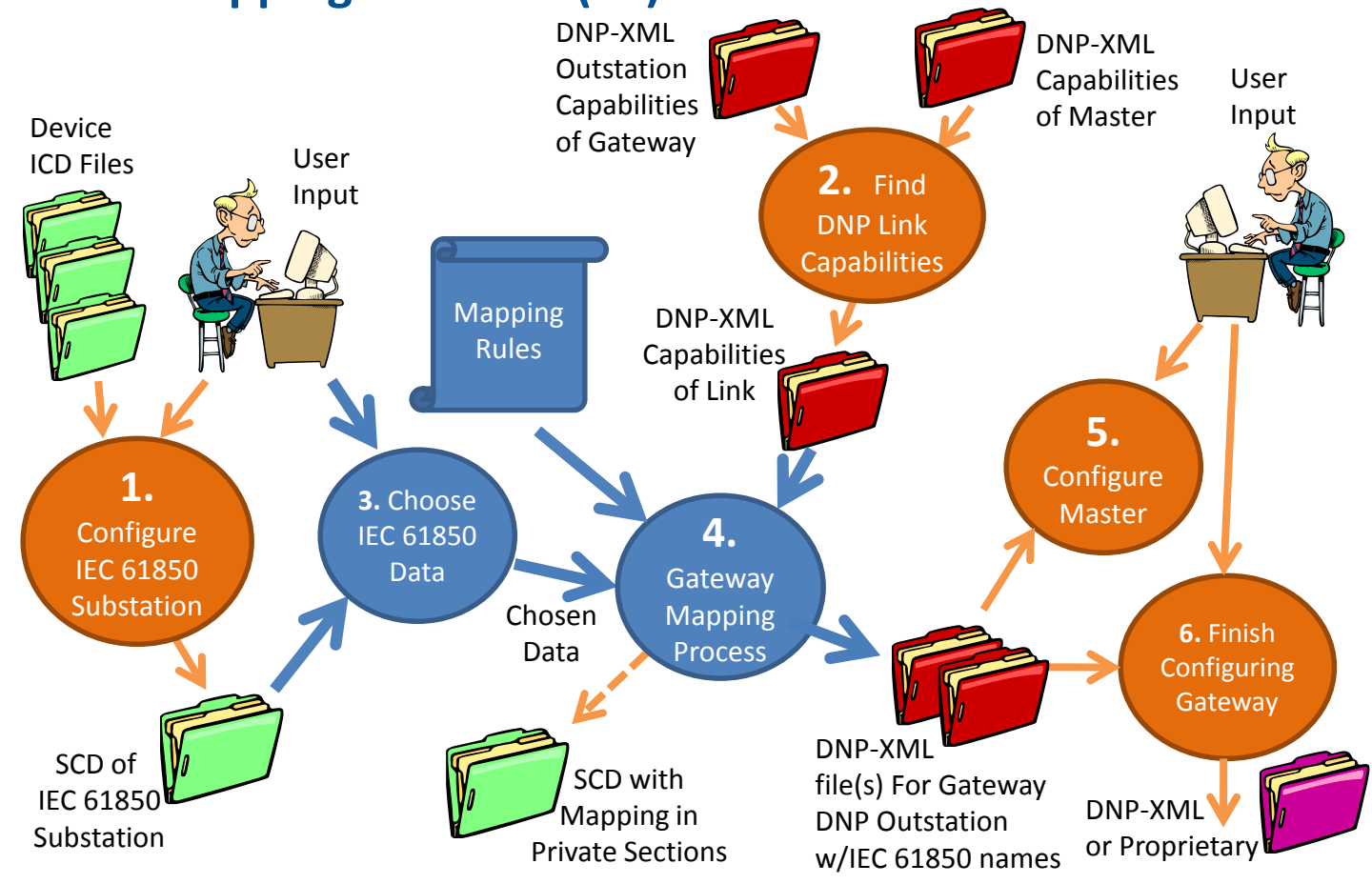
Mapping Use Case (a)



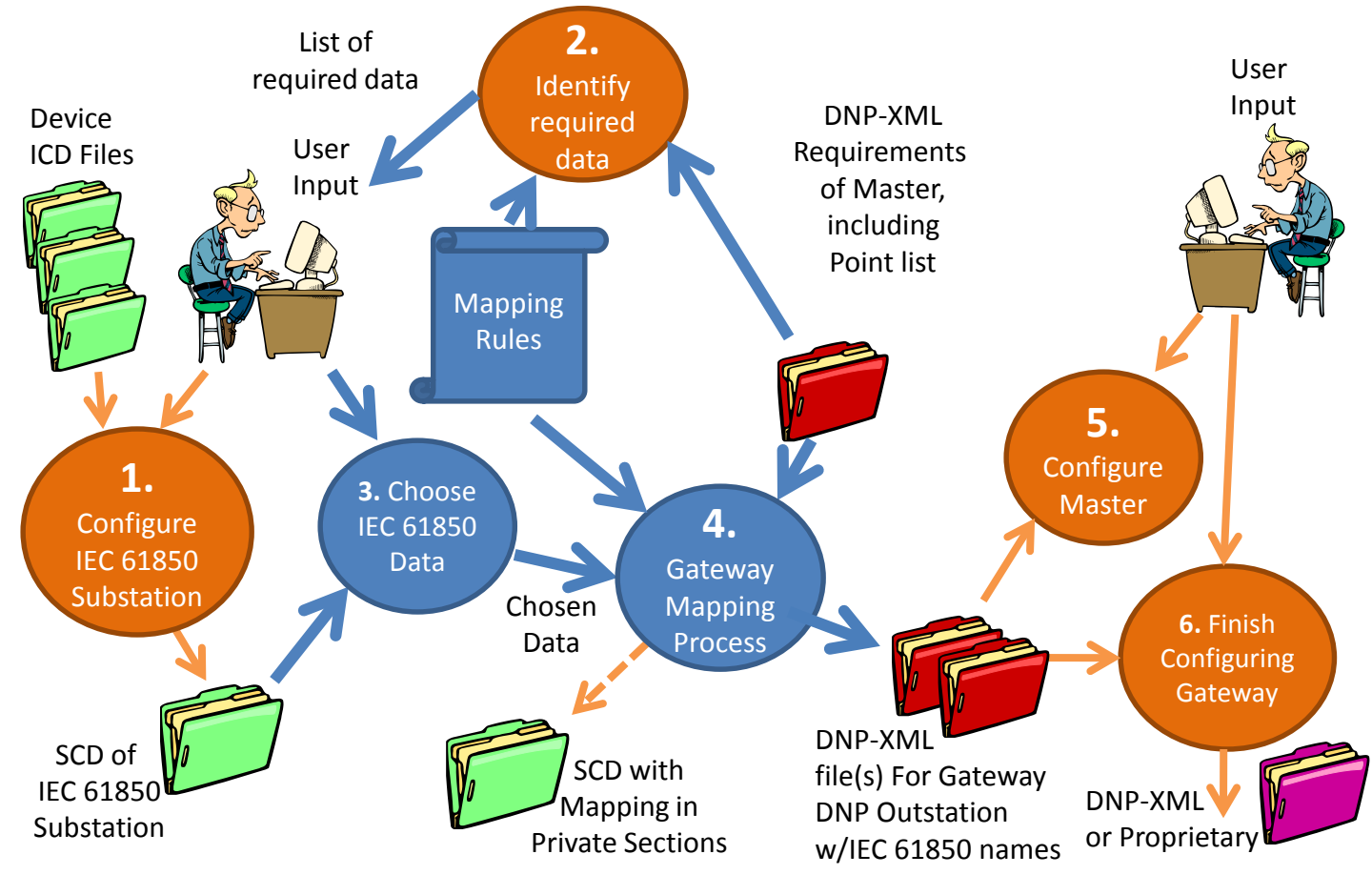
Mapping Use Case (b)



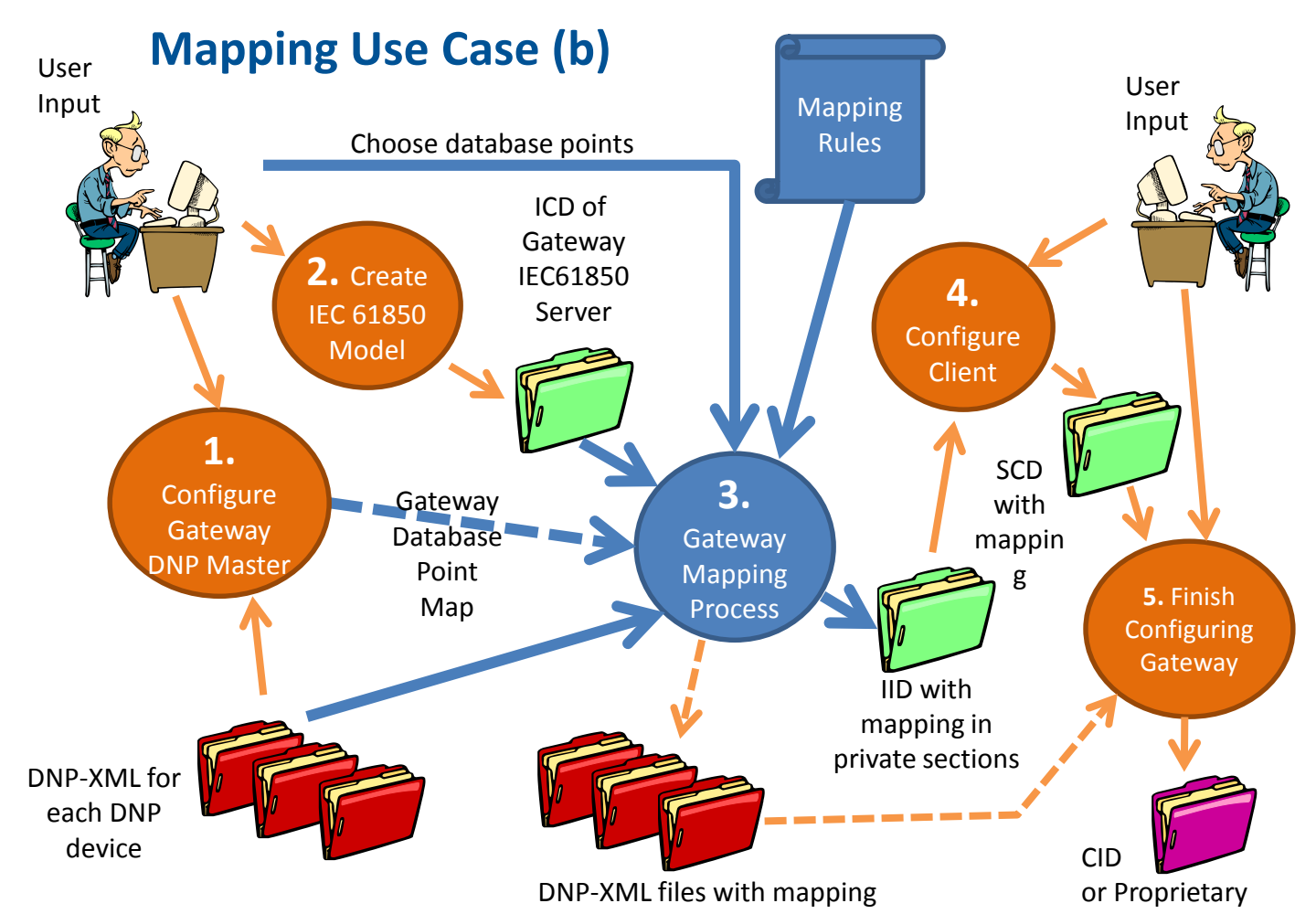
Mapping Use Case (a1)



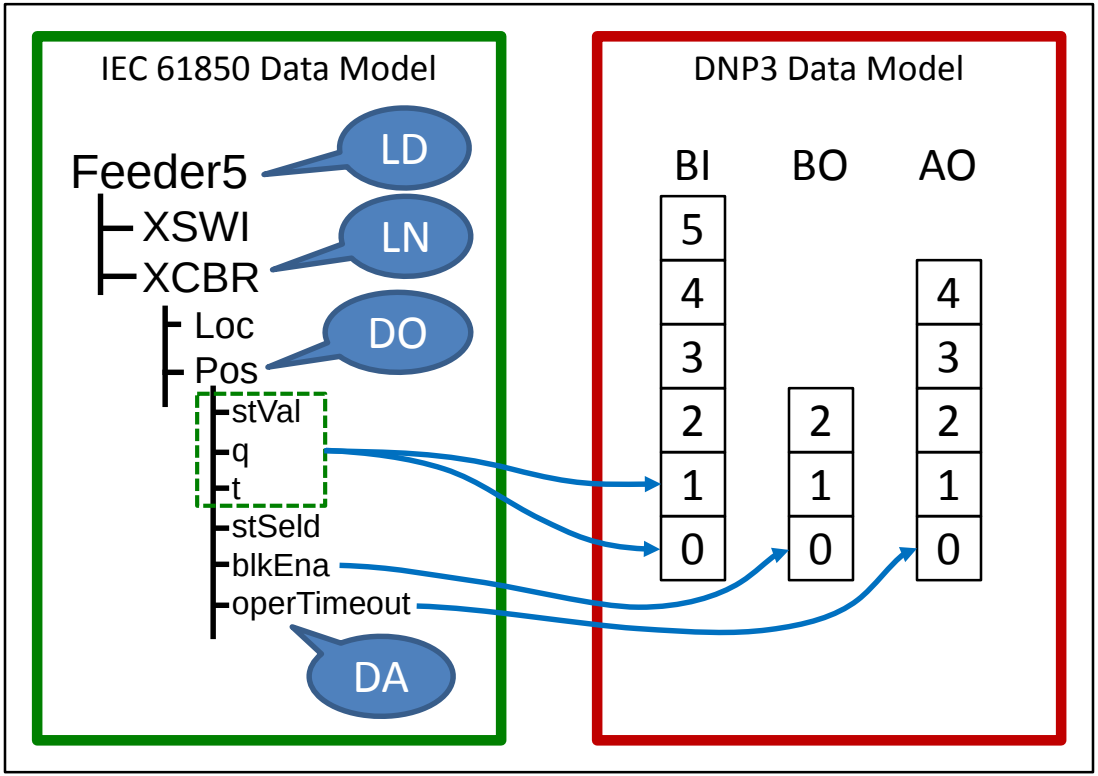
Mapping Use Case (a2)



Mapping Use Case (b)



Attribute to data point mapping



Enumerations

- The DPS or DPC StVal can map to either:
  - two DNP3 binary inputs
  - a single DNP3 double-bit binary
- Other enumerated input attribute types are mapped to analog inputs
- Enumerated output types with two states map to binary outputs, those with more than two states map to analog outputs

Mapping of CDCs

- The majority of the significant mapping information in IEEE 1815.1 describes mapping of CDC attributes
- Mapping of individual attributes is controlled by a “Recommended Level” of the mapping:
  - Basic mappings are mandatory
  - Intermediate mappings are for common functions
  - Advanced mappings are for rarely used functions

Typical CDC mapping

- Double Point Status (DPS)

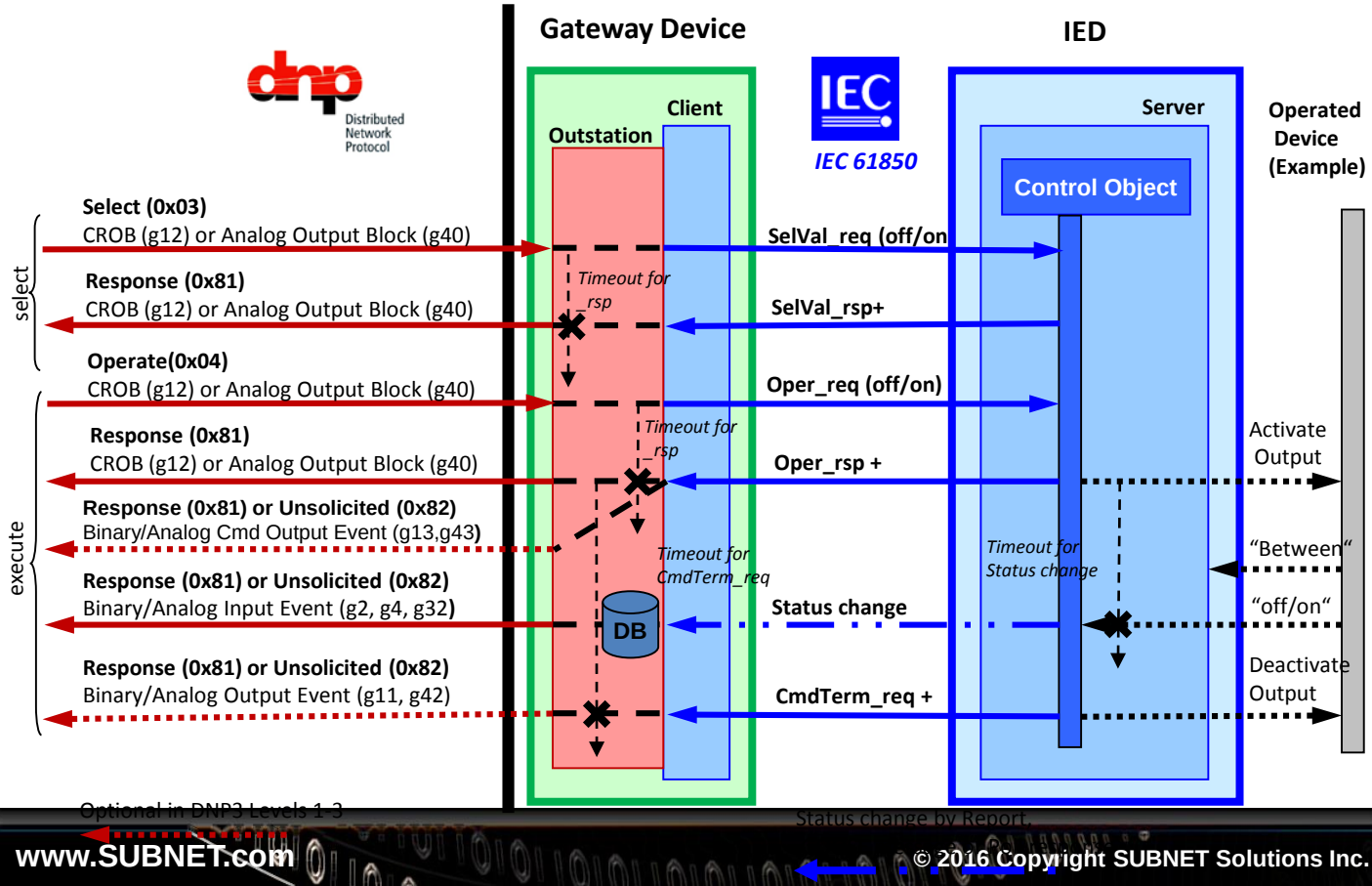
	Preferred DNP3 Implementation						
	First Choice		Second Choice			Notes	
Data Attribute Name	Point Type	Point Count or Note	Point Type	Point Count or Note	Mapping Rule (Annex A)	Use Case (a) Mapping IEC 61850 Substation to DNP3 Master	Use Case (b) Mapping DNP3 Substation to IEC 61850 Client
stVal	DBBI	1	BI	2	DPS_TO_DBBI DPS_TO_2_BI	See 7.1.2.1 for mapping of two DNP binary inputs	See 7.1.2.1 for mapping of two DNP binary inputs
q	DBBI	quality – stVal	BI	quality – stVal	QUALITY_TO_FLAG	If two single Bis are used, the quality of both DNP points are the same as the IEC 61850 quality	If two single Bis are used, the IEC 61850 quality is the worst of the two DNP qualities
t	DBBI	time - stVal	BI	time - stVal	TIME_TO_TIME	If two single Bis are used, the timestamp of both DNP points are the same as the IEC 61850 timestamp	If two single Bis are used, the IEC 61850 timestamp is the most recent received in DNP3
subEna	BO	1			BOOLEAN_TO_BO		
subVal	BO	1			DPS_TO_BO	Cannot force to intermediate or bad state using DNP3	
subQ	OCT	1			QUALITY_TO_OCT	Order of bits as defined in IEC 61850	Order of bits as defined in IEC 61850
subID	OCT	1			STRING_TO_OCT		
blkEna	BO	1			BOOLEAN_TO_BO		
Etc…							

Mapping functions & services

- IEEE 1815.1 defines mappings for functions and services
  - all supported combinations of control command operations are defined
  - information flows shown for success and failure cases

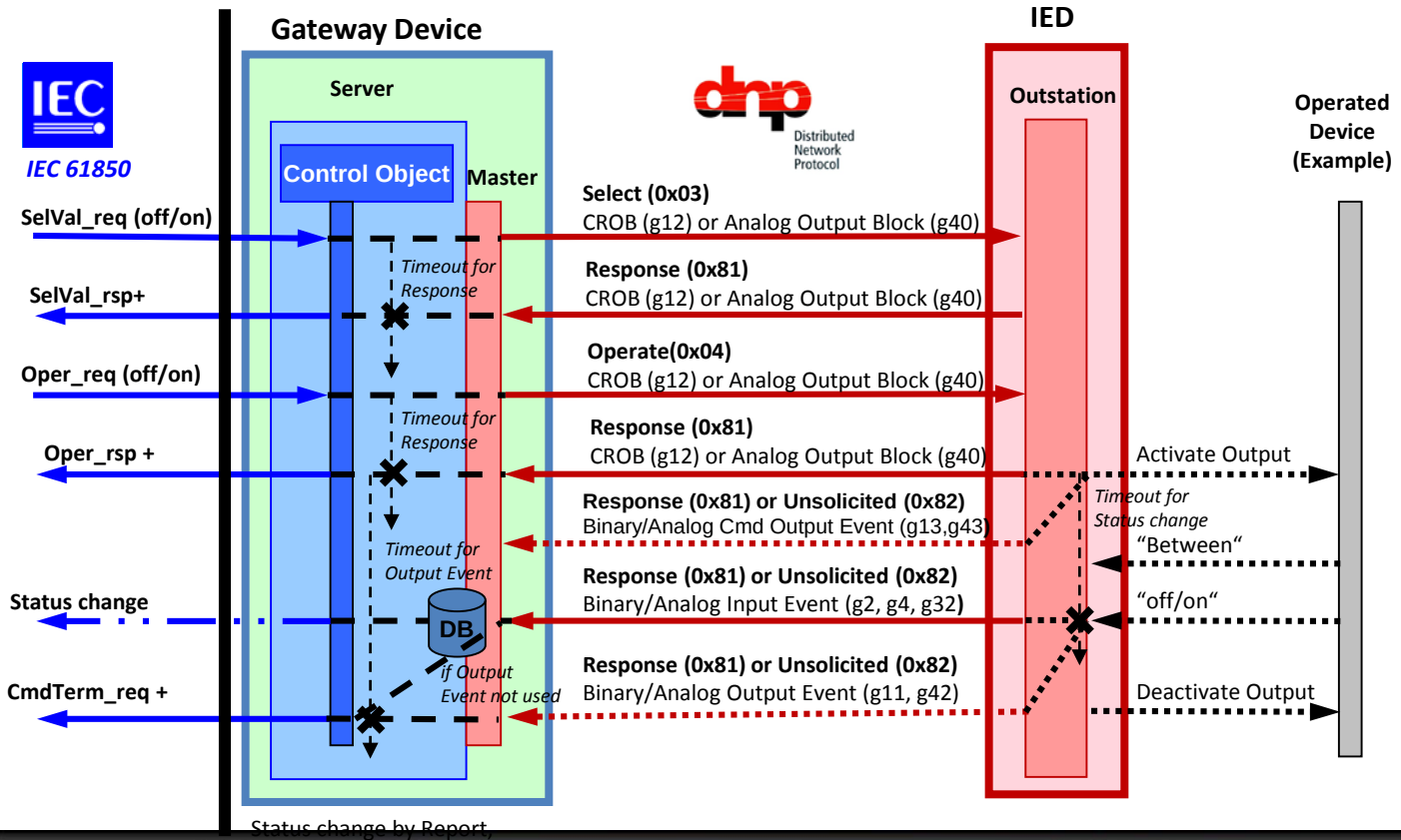
SBO Control with Enhanced Security

Use Case (a)



SBO Control with Enhanced Security

Use Case (b)



Summary

- IEEE 1815.1 defines a set of mapping rules to help automate the mapping between IEC 61850 and DNP3 in a consistent manner with minimized engineering effort
- The use cases show that considerable manual selection of options can be required