INTRODUCTION TO IEC 62361-102 CIM - 61850 HARMONIZATION

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ABSTRACT

TR IEC 62361-102 [1] is a Technical Specification that describes a mapping for information exchange between power system installations based on the modelling approach of IEC 61850; and business systems based on IEC CIM standard data exchanges. The document includes proposals to 'harmonize' the two standards by adapting or extending existing information models and/or defining new models, where such changes will enable more effective communication. This paper explains the key mapping principles and some of the recommendations for future editions of the standards.

WHAT IS THE PROBLEM?

The smart grid initiatives in the USA, Europe and Asia have all recognized the necessity to establish solid standards for communicating between all the "smart" devices. For interoperability purposes, it has been recognized, at an early stage, that widely shared semantics to describe power systems would be necessary. Power systems are complex and several technical groups have worked on different aspects of communication. There are different needs for information exchange within different contexts e.g. within a substation or within control centres. This has led to some gaps between the models within different standards, even though they reflect aspects of the same power system entities.

IEC TC57 WG19 is responsible for a series of standards on the topic of Power systems management and associated information exchange – Interoperability in the long term.

One of the key documents is the Reference Architecture [2]. This describes a Smart Grid Architecture Methodology based on three different information models:

- IEC 61850 for substation automation and other device level applications
- Common Information Model CIM (IEC 61970, IEC 61968, IEC 62325) for control centre applications
- Companion Specification for Energy Metering (COSEM) for metering (IEC 62056).

APPROACH

A task force within IEC TC57 WG19 was formed to address the harmonization of IEC 61850 and CIM data models.

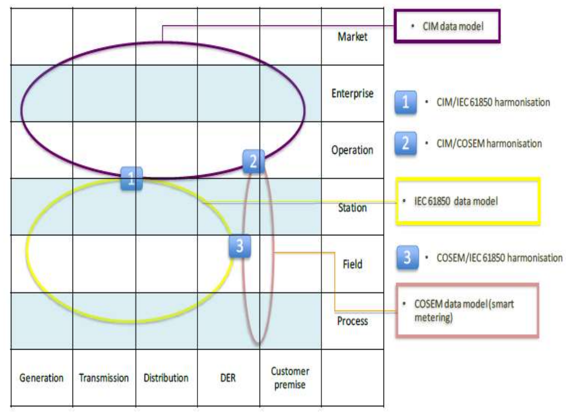

Figure 1: *Data models for Smart Grids Architectural Methodology*

Several studies [3] and reports [4,5] have already been produced on the subject of harmonization, but failed to get sufficient support for publication as IEC standards or technical specifications. The approach taken by the task force was to concentrate on a fundamental use case related to configuration of real time communication between substations and control centres. This use case extends the top-down engineering process described in IEC 61850-4 by adding steps related to extending the network models within SCADA/EMS/DMS systems in the control centre.

The task force recognised that utilities have already made significant investments in systems and products based on the existing standards. They therefore defined a mapping between the two models that could be used by transformation tools. Based on this mapping, several recommendations were made so that future editions of the standards would make transformations easier, for example by reducing ambiguities.

DATA MODELLING PRINCIPLES

IEC 61850

One of the original design aims behind the IEC 61850 standards was to provide inter-operability for communication between intelligent devices providing functions such as protection and switch control.

The principle features of the standard are:

- Hierarchal data model

- System Configuration Language (SCL)
- Abstract Communication Services
- Specific communication mappings
  - Client-server services
  - High speed events
  - Sampled values

In addition to the main set of documents, a series of technical reports describe mappings of subsets of the communication services to other protocols in common use for control centre communications such as to IEC 60870-5-104 or IEEE1815 (DNP3).

The data model defines a rich set of data objects for real-time data exchange, settings and descriptions. These data objects are grouped into logical nodes with defined classes. For some simpler logical node classes, the internal functions are described or implied, but for most the internal function is a "black-box".

Manufacturers can choose how the logical nodes are grouped into logical devices within physical devices.

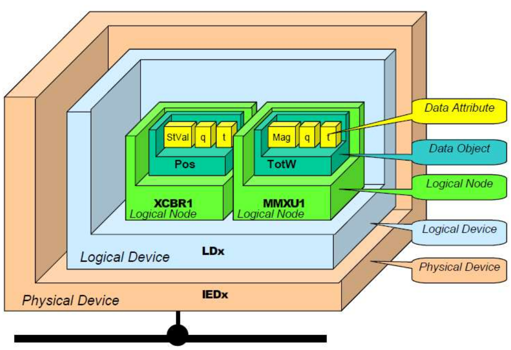

Figure 2: *IEC 61850 Hierarchal data model*

The System Configuration Language provides a standard way to describe the data models and communication services of devices or systems. For devices, SCL is used to describe the capability or configuration of individual physical devices. SCL is also used for system descriptions including details of the IEDs, the communication between them and optionally a description of the primary power system.

Common Information Model : CIM

The design aim behind the CIM is to facilitate the integration of EMS, DMS and other control centre applications. It is "*an abstract model that represents all the major objects in an electric utility enterprise typically needed to model the operational aspects of a utility … as well as the relationships between them*". [8]

From the beginning the CIM was designed to describe real-time information exchange via SCADA but also the attributes required for analytic applications such as state estimation or power flow studies. IEC 61970-301 describes how these are used in mathematical models for simulation or other studies.

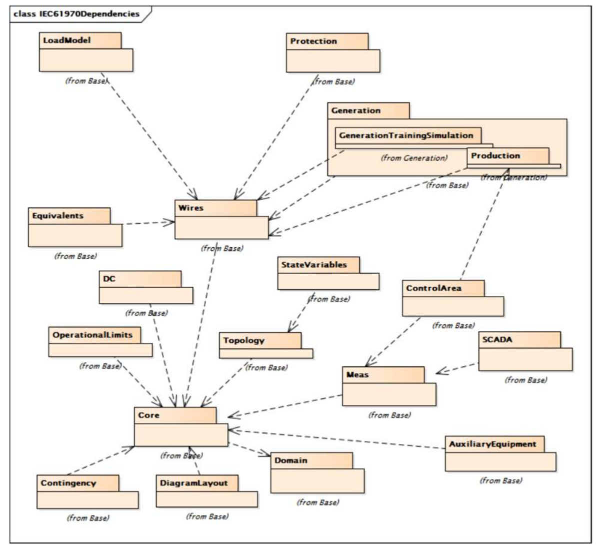

Figure 3: *IEC 61970 Model packages*

USE CASE: CONFIGURATION OF REAL TIME COMMUNICATION BETWEEN SUBSTATIONS AND CONTROL CENTRES.

Both the IEC 61850 and CIM data models are large and complex. The task force first defined a short list of use cases that link control centre applications and substation automation, but it was clear that there was a fundamental use case for configuration of the real-time communications that applied to any sort of data.

The use case was written using the example of a transmission substation automation system, but the general steps are applicable to any power system related local automation system.

The use case starts with requirements specification determined by a planning department e.g. following a request for a new connection or a review of assets or load growth. The next few steps of the use case use the top-down engineering process described in more detail in IEC 61850-4 and IEC 61850-6.

1. The System Configuration Tool (SCT) is used by a System Engineer to model any SCL defined installation, for example an electrical substation. The process starts by creating a formal specification of the system requirements. The engineer inputs information on primary equipment

types, names and connectivity, typically based on the station's single line diagram. The required monitoring, protection, local automation and other functions may be described as template Logical Nodes that are allocated to the equipment or container instances.

2. This formal model can be exported from the System Configuration Tool as a System Specification Description (SSD) file.

3. This SSD file can then be transformed and/or imported into a CIM based modelling tool for review. If necessary, comments may be provided on paper or verbally for the System Engineer to update the model in the SCT. The review cycle may be repeated several times.

4. In the next phase of the design process, the System Configuration Tool is used to import descriptions of the capabilities of specific Intelligent Electronic Devices (IEDs). The System Engineer extends the automation system model by redefining the required Logical Nodes with specific instances of Logical Nodes with specific types of IEDs. The final phase of the automation system design is to define the communication configuration.

5. At any stage during this process, the automation system model can be exported as a System Configuration Description (SCD) file.

6. IEC 61850-6 describes how this SCD file is used as an input to IED tools in order to provide the IED specific configuration including the configuration of the communication between IEDs.

For control centre configuration the use case describes additional steps:

7. The same SCD file is also used as an input for a CIM based modelling tool. If necessary, the model may be updated in the SCT and the review cycle repeated.

8. CIM information which is required for EMS or DMS applications, but which is not present or derived from information in the SCD file, is added within a CIM based modelling tool.

9. The output of the CIM model tool is an incremental update that can be applied to SCADA/EMS/DMS control centre systems.

MAPPING BETWEEN THE TWO MODELS

As described in the use case, the SCD file is to be used as an input for a CIM based modelling tool. The task force reviewed each section and element of the SCD file to identify where the models overlap i.e. refer to the same real-world concept.

The information in the SCD file is not always sufficient to define a one-to-one mapping to CIM objects or attributes. In some cases, the report makes recommendations for future revisions to reduce ambiguities and make transformations easier. In other cases, it will unavoidable that a CIM data modeller will have to make an appropriate choice.

MAPPING

SCL files have several different sections.

1. The Substation / Line / Process section describes the primary system equipment and therefore has considerable overlap with the CIM. This section may also describe the one-line connectivity. Whilst both models have classes for Terminals and Connectivity Nodes, the treatment of phase information in the SCL and CIM models is different.

2. The IED instances section is a list of Logical Nodes that refers to data type templates that define the Data Objects and their Data Attributes. Some of these data objects/attributes map to instances of CIM measurements (analogs, discretes, accumulators) & controls (commands, setpoints).

3. Optionally the IED instances section may include information about the values for specific instances of data objects/attributes e.g. configuration settings. Some of these setting objects can be mapped to CIM object attributes or associations.

Containers & Equipment identifiers

Substation equipment identification and one-line connectivity description has a similar business requirement within IEC 61850 based system engineering tools and within CIM based network engineering tools.

The inheritance hierarchy of the SCL is similar but not the same as that of the CIM. Within SCL, the type of conducting or non-conducting equipment is defined by a type code, whilst in the CIM the equipment type is defined by a concrete class.

The SCL is intended to describe the power system such that the primary equipment type does not depend on the associated logical nodes. If logical node information is available it may allow the CIM model to be refined. This additional information could simply be the logical node class type, or it could be the configured value for a data object within the logical node. For example, the XSWI logical node has a data object that defines the sub-type of the associated switch equipment.

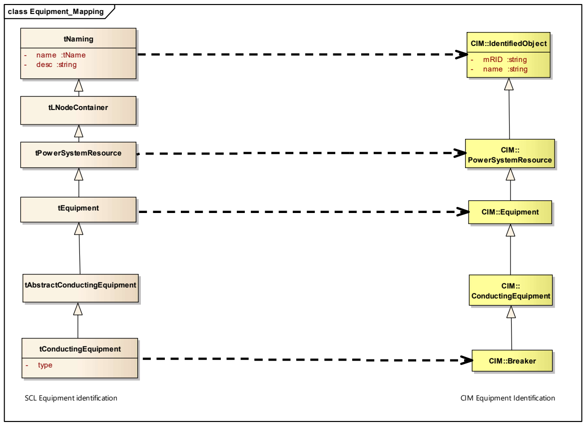

Figure 4: *Equipment mapping*

The mapping of IEC 61850 type codes to CIM classes is not one-to-one. The report recommends that the list of device type codes in IEC 61850-6 should be extended to correspond better with the IEC 61970 / IEC 61968 Common Information Model, particularly to support applications related to distribution networks. This would allow the Substation section to be used to more fully describe the power system equipment and its connectivity without needing any details of Logical Nodes. The aim is that the type code indicates the fundamental nature of the physical equipment, not necessarily its usage within a particular software application.

Status, Measurements and Controls

A full System Configuration Description file will define the instances of Logical Nodes that are attached to containers such as substation, voltage level, bay, equipment, sub-equipment, function, or sub-function. Within IEC 61850, Logical Node instances are contained by IEDs. These IEDs may be located in close proximity to the primary or auxiliary equipment that the IED is controlling or monitoring, or they may be located in a centralised control cubicle connected by the communication network. In all cases, it is the equipment/power system resource to which the Logical Node is associated that determines the measurements that are produced. The physical location of the IED has no bearing on these measurements. In some instances, the IED may act as a Bay Controller or a Substation Controller and in these cases usually provides aggregated measurements.

Some of the IEC 61850 data attributes correspond to traditional SCADA digital, analogue and counter objects. Controls are modelled as services that can be applied to relevant Data Objects.

Compared to the data point lists of traditional SCADA protocols, IEC 61850 allows systems to be designed and configured using fewer but more complex objects.

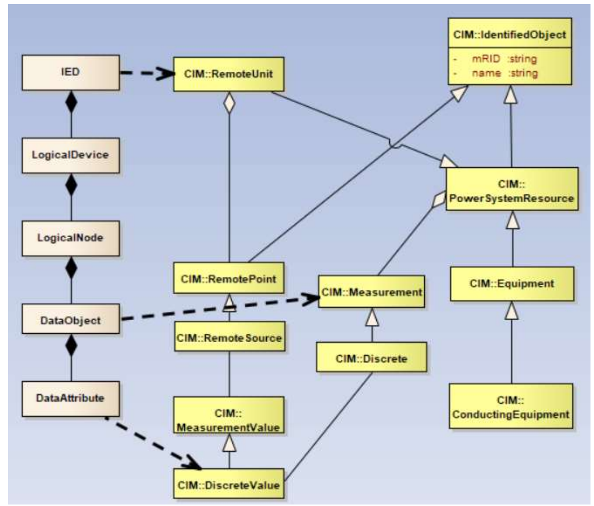

Figure 5: *Measurement mapping*

The technical report has many tables that list details of the mappings.

Logical Node mapping

Table 1 shows some examples of logical nodes classes from IEC 61850-7-4 that have information relevant to specific CIM entities.

Logical Node	Description	Associated CIM Classes
MMXU	currents, voltages, powers in a three-phase system.	Several instances of Analog
PIOC, PTOC	Instantaneous over-current, time over-current	CurrentRelay (a subtype of ProtectionEquipment)
XCBR, CSWI, SCBR	circuit breakers, i.e. switches able to interrupt short circuits	Breaker
XSWI, CSWI, SSWI	switching devices not able to switch short circuits	Switch Disconnector Jumper LoadBreakSwitch GroundDisconnector
YLTC, ATCC, SLTC, AVCO	Transformer tap changer, automatic tap change controller, tap changer supervision, automatic voltage controller	TapChanger RatioTapChanger PhaseTapChanger others

Table 1 *Example of Logical Node mapping*

Data Object mapping

Table 2 shows some example of mapping IEC 61850 Data Objects to CIM measurement types defined in IEC 61970-301 or IEC 61970-452. IEC 61850 defines considerably more data objects than the list of measurement type names defined in those parts of IEC 61970. The harmonization report recommends that CIM based standards should allow any IEC 61850 data object names to be used as a CIM MeasurementType names.

Data Object	MeasurementType	Subclass of CIM Measurement
TotW	ThreePhaseActivePower	Analog
TotVAr	ThreePhaseReactivePower	Analog
A	LineCurrent	3 or more instances of Analog
PhV	PhaseVoltage	3 or more instances of Analog
Pos	SwitchPosition	Discrete
Auto	Automatic	Discrete

Table 2 *Example of Data Object to Measurement Type mapping*

Mapping Data Objects for Settings

SCL files may contain the values of instantiated settings. A few of the settings can be mapped to CIM classes and attributes, but many have no direct equivalent. For example, the settings for protection logical nodes do not correspond well with the CIM protection model attributes. Settings that cannot be mapped to existing CIM attributes may be copied to instances of AnalogValue or DiscreteValue.

CONCLUSION

IEC 62361-102 has been published as a Technical Specification. It outlines a technical approach for achieving effective information exchange between power system installations governed by IEC 61850 and business systems integrated with IEC CIM standard data exchanges, based on a selected specific set of use cases, but also with the goal of creating a framework that will extend successfully to other use cases in the future. The document includes proposals to 'harmonize' the two standards by adapting or extending existing information models and/or defining new models, where such changes will enable more effective communication.

The specification defines a transformation of the data governed by IEC 61850 SCL XSD to data governed by CIM UML. The transformations in the document are based on the configuration for real time communication use case and only consider SCL data relevant to that use case.
The aim is to allow the development of tools that perform automatic transformation from an SCL instance file into a CIM based instance model that can then be exported using existing standards such as IEC 61970-552: CIMXML Model exchange format.

The first edition of IEC 62361-102 considers the logical nodes in the IEC 61850-7-4 and the base part of the CIM described in IEC 61970-301. Future editions will consider logical nodes for other application areas such as Distributed Energy Resources.

GLOSSARY

CIM Common Information Model
IED Intelligent Electronic Device
SCD System Configuration Description
SCL System Configuration description Language
SCT System Configuration Tool
SSD System Specification Description
XSD XML Schema

REFERENCES

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