INTEREST OF A COMMON INFORMATION LANGUAGE FOR EXCHANGING DATA: CASE STUDY OF THE IMPACT OF DER ON DISTRIBUTION NETWORK

Henri BACK
EDF R&D – France
henri.back@edf.fr

Eric LAMBERT
EDF R&D – France
eric.lambert@edf.fr

ABSTRACT

This article presents a common language for the exchange of data from power systems based on CIM. The interest of the product is underlined in a case study on the stability of a distribution power system in the presence of distributed energy resources.

INTRODUCTION

IEC 61968 standards develop standard interfaces for Distribution Management Systems. Among these parts, part 13 defines a profile for exchanging Network Data based on CIM classes, attributes and relationships. This profile is called Common Distribution Power System Model (CDPSM) and is based on the CPSM profile which is used at the transmission level.

After a simplified presentation of the CDPSM profile in terms of CIM classes, attributes and associations, we will detail the methodology for the consistent derivation of a profile based on CIM, the UN/CEFACT Core Component Specification and XML.
We shall then see the interest of a common language for the exchange of data on power systems in the context of the increase in distributed energy resources on distribution networks.
Finally, we shall consider the interoperability with a range of commercial tools.

PROFILES

The CIM (Common Information Model) is a conceptual data model of power systems which was developed in UML by TC 57 (Power System Management and information exchange) of the IEC (International Electrotechnical Commission). From a technical point of view, it is described using UML notation (Unified Modelling Language).

This model is very extensive, as it includes all the aspects of the management of power systems (technical characteristics of installations, asset management, outage management, transactions between companies, market data etc.). In addition, it allows a certain freedom of interpretation or possible alternatives for describing certain properties of the objects in the system.

If we are interested only in technical calculations, it is necessary, on the one hand, to restrict the field of application of the model and, on the other hand, to define a certain number of modelling rules.

This was done by NERC (North American Electric Reliability Council); it indeed defined data exchange requirements that should be fulfilled by the participants in the security of the North-American power system. This gave rise to the CPSM (Common Power System Model) exchange profile, which is a sub-set of the CIM. The objective was to make data exchange possible between North-American companies operating neighbouring networks.
The CDPSM profile, more suitable for distribution networks, was then defined, ensuring that it was compatible with the CPSM.

Cpsm

The CPSM profile is a restriction of the CIM to the specific data for load flow calculations in transmission networks. It defines:
- the objects (entities and relationships) of the CIM that can be used,
- those that are obligatory, those that are optional and those that are present subject to certain conditions,
- the attributes that are possible, obligatory, optional or present subject to certain conditions,
- choices regarding the modelling of loads, voltage regulations, reactive power capabilities of units,
- the structuring of the network (grouping of the objects in substations, voltage levels etc.),
- the way in which certain objects are modelled (three winding transformers),
- the scope of the descriptions (no zero component data),
- the format of the data file (XML RDF: eXtensible Markup Language Resource Description Framework).

This profile includes:
- objects relating to the Production function: SynchronousMachine and GeneratingUnit,
- objects relating to the Consumption function: EnergyConsumer and its various sub-types,
- objects relating to the Transmission function: Substation, Line, Transformer, TapChanger, Compensator, StaticVarCompensator, Switch, BusbarSection,
- grouping objects such as GeographicalRegion, SubGeographicalRegion, BaseVoltage, LoadArea,
- technical objects, such as Measurement, RegulationSchedule (for modelling voltage regulation) ,

MVArCapabilityCurve (for modelling the reactive generation capability of generators).
The line breaks down into ACLineSegments with homogeneous characteristics. The transformer consists of windings that are described separately.

Conductive objects have Terminals. The connectivity of the network is provided by Connectivity Nodes to which the Terminals of the system objects are connected (Figure 1).
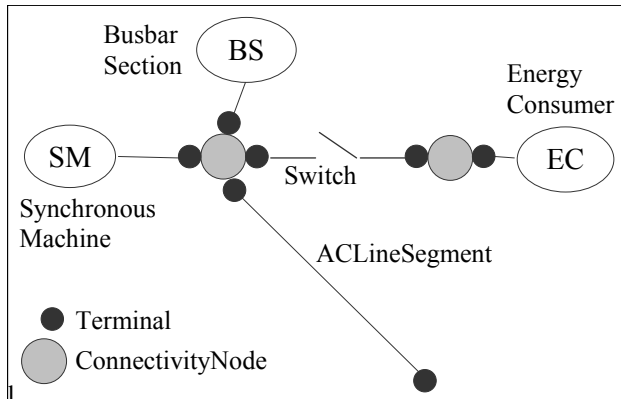

Figure 1 - Example of connectivity

Each object is described by attributes and associations with other objects in the model. For example, for an ACLineSegment, the main attributes are: name, reactance, resistance and susceptance. Associations can be made with an operating voltage, a geographic region, terminals, measurements etc.

Cdpsm

The CDPSM (Common Distribution Power System Model) profile is specific to distribution networks but shows great similarities with the CPSM. Most objects and relationships are common to both profiles.

There are, however, some differences: the CDPSM does not compulsorily retain TapChangers, the voltage regulation of machines or reactive generation curves; on the other hand, it includes the description of source substations (points in the distribution network where power is injected from the transmission network) and the possibility of associating localisation information with the objects in the system. For a point feature (for example, a substation), this information takes the form of the geographic coordinates of a point. For a linear object, such as a line, it consists of the geographic coordinates of all the points of inflection of the line.

The distributed production facilities that are becoming more and more widespread on distribution networks are described in the CDPSM profile in the same way as generators in the CPSM profile, i.e. by means of the SynchronousMachine and GeneratingUnit objects.

Methodology for using the CIM

The CIM is an information model that, starting from an analysis of the business processes, makes it possible to define exchange profiles or messages that favour integration between applications. The methodological approach developed by EDF R&D combines the CIM with the UN-CEFACT CCTS (Core Component Technical Specification) methodology (Figure 2).
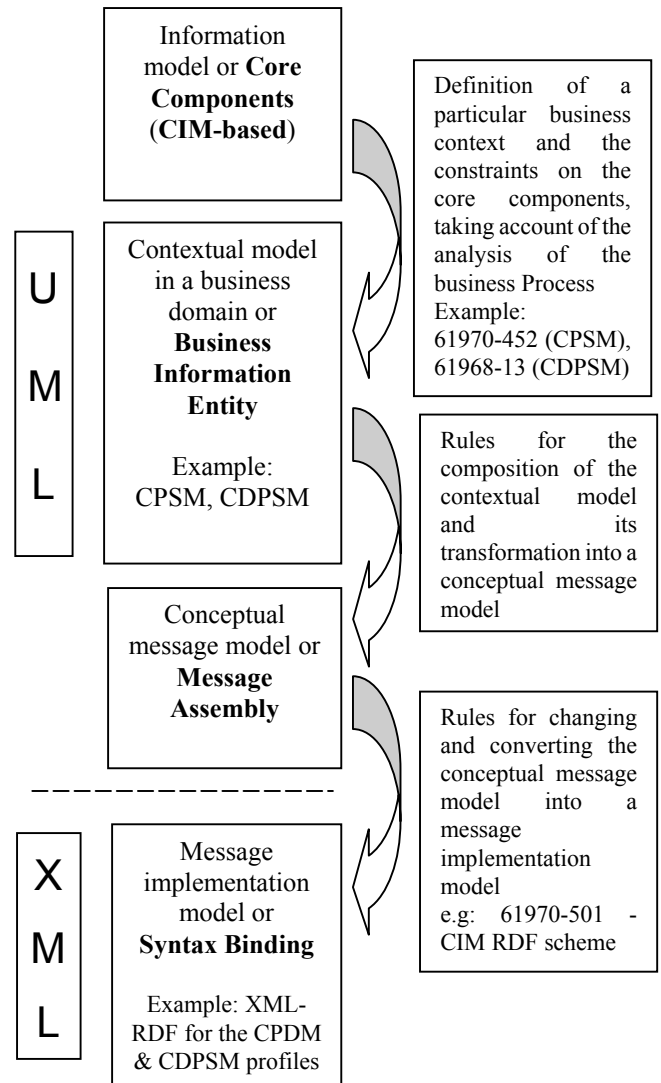

Figure 2 - Methodology for deriving a profile or an exchange message based on the CIM-UN/CEFACT methodology

On the basis of the information model, a contextual view of this model is possible in order to get a view of the profile or the message to be exchanged. These three levels are managed under UML; the message level is then projected in an exchange syntax (XML RDF for the exchange profiles of network models, or XML XSD (XML Schema Definition) for exchange messages).

This methodology guarantees overall consistency of the exchanges, which are all derived from this shared, exchange-dedicated information model. It thus favours the reusability and interoperability between application components sharing common semantics.

EXCHANGING DATA

Historically, each software supplier has used proprietary data formats. Under these conditions, it is difficult to study a given network with different tools or to test and select new software packages for use.

One solution, where the problem arises, is to implement converters between the various formats. This, however, can lead to a large number of converters and a heavy maintenance load.

The other solution is to use a single core format and implement a converter between each proprietary format and this core format. This is what we have done with a certain number of software packages. The number of converters required is considerably reduced (Figure 3) and, if the core format is stable, the maintenance load is also reduced.
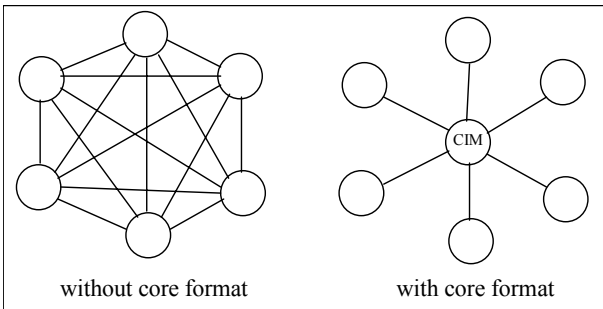

Figure 3 - Less converters with a core format

The generalised implementation of converters to the CIM format allows communication between packages that were not originally designed to work together.

Converters

A converter works in three steps (Figure 4). In the proprietary-format-to-CIM-format direction, we have: reading proprietary file and building proprietary objects (1), converting proprietary objects into CIM objects (2), writing CIM file (3). In the other direction, we have: reading CIM file and building CIM objects (4), converting CIM objects into proprietary objects (5), writing the proprietary file (6). In the proprietary formats, the network is generally described as a nodal topology, whereas CIM-compliant profiles use the detailed topology.

In the detailed topology, all objects in the real network are described, especially all switching devices.

In nodal topology,
- the line-end switching devices are built in the lines and the open/closed information is retained only at line level,
- the real nodes connected by closed switching devices are then regrouped into a single node,

- going further, loads and generators connected to these nodes can also be grouped together.

Converters must therefore be able to convert one topology into the other and to indicate to the user which regroupings have been carried out.
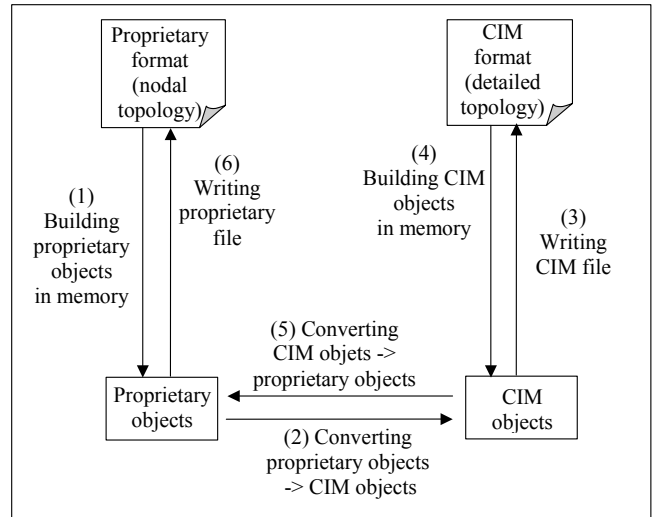

Figure 4 - Operation of a converter

Practical case

The increase in distributed energy resources on distribution networks gives rise to a new analysis requirement for these networks: stability analysis.

Starting from a stable state of the power system, events are simulated, such as a short-circuit at the terminals of a generator, a line opening, an abrupt load increase or the shut-down of a generator, and the behaviour of the power system is observed. The objective is to act in such a way that the stable state is quickly restored.

This type of analysis is traditionally carried out on transmission networks, for which there are many software packages. We therefore wished to use the EUROSTAG package, which falls within this category. The distribution networks in France are analysed with another package, PRAO, which is planning-oriented. We thus have all the necessary network data but not in the right format.

Each of these packages includes a converter to convert its data to CIM format (CPSM profile for EUROSTAG and CDPSM profile for PRAO) and back again. It was therefore easy to convert the PRAO data into EUROSTAG data via the CIM core format.

To convert via the CIM format, the nodal topology of PRAO is converted to the CIM detailed topology, which is then converted to the EUROSTAG nodal topology.

The conversion can be validated by comparing the results of load flow calculations carried out before conversion with PRAO with those carried out after conversion with EUROSTAG.

Without the existence of these CIM format conversion tools, it would have been necessary to develop a customised PRAO - EUROSTAG conversion module.

Generalisation

It may be noted that the intermediate CIM files can be read by any CPSM or CDPSM-compatible software package. For example, this realisation between EUROSTAG and PRAO was demonstrated during the EPRI No 9 interoperability tests in October 2006, in which a number of suppliers of CIM-compatible solutions participated.

For our part, in addition to the two packages, EUROSTAG and PRAO, already mentioned, we have bi-directional converters with the UCTE exchange format, and with the JPELEC package (simulation of electricity networks in steady state) of the SUPELEC engineering school. We also have a Matlab converter but only in the CIM-to-Matlab direction.

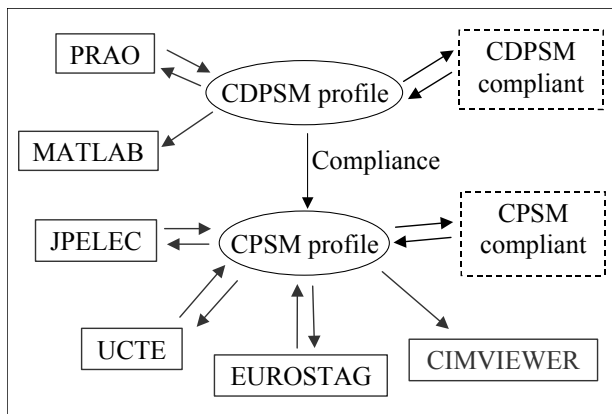Finally, a network visual display package, CimViewer, is available (Figure 5).

Figure 5 - Possible data exchanges

The generalisation of software compatibility with the CIM-based CPSM and CDPSM profiles should, in the future, enable more detailed and extensive analyses to be carried out on a given set of data, while reducing the burden of data acquisition.

ACKNOWLEDGMENTS

REFERENCES

[1] IEC 61970-301 Cim Model

[2] CIM XML Model under Rational Rose: available on the web site of the Cim User Group (http://www.cimuser.org/) by following CIM UG SharePoint, then CIM Releases, then CIM10_v004_2006-10-12

[3] CDPSM Profile:
Draft IEC 61968-13 Ed 1: System interfaces for distribution management - CIM RDF Model Exchange Format for Distribution - 2006-07-28

[4] CPSM Profile:
Draft IEC 61970: Energy Management System - Application Program Interface (EMS-API) Part 452,: CIM Network Applications Model Exchange Specification - Revision 3 - 2006-08-29

[5] IEC 61970-501 CIM RDF Schema.