57/1881/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 61970-456 ED2**	
DATE OF CIRCULATION: **2017-06-23**	CLOSING DATE FOR VOTING: **2017-09-15**
SUPERSEDES DOCUMENTS: **57/1861/RR**	

IEC TC 57 : POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE	
SECRETARIAT: Germany	SECRETARY: Mr Heiko Englert
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT	☐ QUALITY ASSURANCE ☐ SAFETY
☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

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TITLE:

Energy management system application program interface (EMS-API) - Part 456: Solved power system state profiles

NOTE FROM TC/SC OFFICERS:

Further background information on this revision is provided in documents 57/1831/DC and 57/1858/INF; the list of main changes with respect to the previous edition is shown in the foreword of the document attached.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 456: Solved power system state profiles

FOREWORD

International Standard IEC 61970-456 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/1591/FDIS	57/1620/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,

- withdrawn,
- replaced by a revised edition, or
- amended.

The National Committees are requested to note that for this publication the stability date is 2017.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

Document history

Any person intervening in the present document is invited to complete the table below before sending the document elsewhere. The purpose is to allow all actors to see all changes introduced and the intervening persons.

Any important message to IEC editors should also be included in the table below.

Name of intervening person	Document received		Brief description of the changes introduced	Document sent	
	From	Date		To	Date
Lars-Ola Ö.			Updated after comments from ENTSO-E (Chavdar, Svein)	IEC Sec.	
Lars-Ola Ö.			Revised after continued discussions in WG13. Sent to IEC for circulation as CDV.	IEC sec.	2017-03-15

This table will be removed by IEC editors before FDIS circulation (in case of IS) or before final publication (in case of TS or TR).

This is a second edition, which replaces the first edition (dated 2013) and the amendment (2015). It is based on the 61970 UML CIM16 version 33.

This edition includes the following significant technical changes with respect to the previous edition:

a. The Steady State Hypothesis (SSH) profile has been added in new section 7.2.
b. Section 4 "Overview" has been extended to better describe the relation between different profiles and aligned with the current nomenclature used with profiles, e.g. "data set" and "network part".
c. The former section 6 "Architecture" has been shrunk and merged with section 5 "Use cases (informative)".
d. The former section 7 " Applying the standard to business problems" has been split and merged with section 5 "Use cases (informative)" and section 6 "Data model with CIMXML examples".
e. Section 5 "Use cases (informative)" description of the use cases has been extended.
f. The former section 8 " Data model with CIMXML examples" has become section 6 "Data model with CIMXML examples".
g. The CIMXML document examples in section 6 "Data model with CIMXML examples" has been updated to match with IEC 61970-552 Ed2.
h. Section 7 "Profiles" describe the actual profile data.
i. Section 7.1 "Comments and notes" gives additional information on the use some profile data.

INTRODUCTION

This standard is one of several parts of the IEC 61970 series that defines common information model (CIM) datasets exchanged between application programs in energy management systems (EMS).

The IEC 61970-300 series of documents specify the common information model (CIM). The CIM is an abstract model that represents the objects in an electric utility enterprise typically needed to model the operational aspects of a utility.

This standard is one of the IEC 61970-400 series of component interface standards that specify the semantic structure of data exchanged between components (or applications) and/or made publicly available data by a component. This standard describes the payload that would be carried if applications are communicating via a messaging system, but the standard does not include the method of exchange, and therefore is applicable to a variety of exchange implementations. This standard assumes and recommends that the exchanged data is formatted in XML based on the resource description framework (RDF) schema as specified in 61970-552 CIM XML model exchange standard.

IEC 61970-456 specifies two types of profiles

- Power flow application input variables such as voltage set points, switch statuses etc. This is the Steady State Hypothesis (SSH) profile.
- Steady-state solution and topology output from a power system case such as is produced by power flow or state estimation applications. This is the Topology (TP) and state variable (SV) profiles.

IEC 61970-456 describes the inputs and solutions with reference to a power system model that conforms to IEC 61970-452 in this series of related standards. The separation of information into profiles also enables separation of data into documents corresponding to the profiles. In this way the profiles defined in this standard generate small data documents compared with traditional bus-branch formats that include both the network, the initial conditions and the result.

ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 456: Solved power system state profiles

1 Scope

This part of IEC 61970 belongs to the IEC 61970-450 to IEC 61970-499 series that, taken as a whole, defines at an abstract level the content and exchange mechanisms used for data transmitted between control centers and/or control center components.

The purpose of this part of IEC 61970 is to rigorously define the subset of classes, class attributes, and roles from the CIM necessary to describe the result of state estimation, power flow and other similar applications that produce a steady-state solution of a power network, under a set of use cases which are included informatively in this standard.

This standard is intended for two distinct audiences, data producers and data recipients, and may be read from those two perspectives. From the standpoint of model export software used by a data producer, the standard describes how a producer may describe an instance of a network case in order to make it available to some other program. From the standpoint of a consumer, the standard describes what that importing software must be able to interpret in order to consume power flow cases.

There are many different use cases for which use of this standard is expected and they differ in the way that the standard will be applied in each case. Implementers should consider what use cases they wish to cover in order to know the extent of different options they must cover. As an example, this standard will be used in some cases to exchange starting conditions rather than solved conditions, so if this is an important use case, it means that a consumer application needs to be able to handle an unsolved state as well as one which has met some solution criteria.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61970-452 Ed3, *Energy Management System Application Program Interface (EMS-API) – Part 452: CIM Static Transmission Network Model Profiles*

IEC 61970-453 Ed1, *Energy Management System Application Program Interface (EMS-API) – Part 453: Diagram Layout Profile*

IEC 61970-552 Ed2, *Energy Management System Application Program Interface (EMS-API) – Part 552: CIM XML Model Exchange Format*

3 Profile information

The profiles defined in this document are based on the UML version CIM16v33 from 2016-03-09.

The profiles are listed in Table 1.

Table 1 – Profiles defined in this document

Name	Version	URI	Revision date
SteadyStateHypothesis (SSH)	1	http://iec.ch/TC57/2013/61970-456/SteadyStateHypothesis/1	2016-03-09
Topology (TP)	4	http://iec.ch/TC57/2013/61970-456/Topology/4	2016-03-09

StateVariables (SV)	4	http://iec.ch/TC57/2013/61970-456/StateVariables/4	2016-03-09

4 Overview

This document describes an interface standard in which XML payloads are used to transfer initial conditions and results created during typical steady-state network analysis processes (e.g. state estimation or power flow solutions). Major requirements/objectives driving the design of this standard include:

- Power flow solution algorithms and outputs are virtually the same whether run in operations or planning contexts. State estimator output shares a common core with power flow. A single standard is desired so as to minimize software development and enable use cases that cross between environments.
- While some users of this standard might only be interested in the output state, the more general situation is that users continue to perform follow-on analyses (e.g. security analysis, voltage stability) and require both the input on which the solution was based and the output result.
- Real life analytical processes often involve a series of solutions in which most of the input data remains the same from one solution to the next, and the standard must support these processes in a way that does not repeat data unnecessarily.
- Power flow solutions tend to drift if the result from a power flow run is used as input to a subsequent power flow run. By preserving the initial conditions between power flow runs the solution do not drift.

In order to meet these requirements, this standard depends on modularizing the potentially voluminous overall input and output data into subsets that would each be realized as smaller, XML payloads. An instance of one of these subsets is referred to herein as a ‘dataset’. Data set payloads are typically compressed to a zip archive.

Two types of partitioning into datasets are utilized. In the first, the data is modularized according to what kind of data is produced (which generally corresponds with what kind of application produces the data). CIM ‘profiles’ (subsets of the complete CIM) define the classes and attributes that make up of each kind of modularization. The second type of partitioning is by network parts, which divides data into sets of instances according to which utility or entity in an interconnection is responsible for the data. The party responsible for data is called the Model Authority of the data and the network parts are defined by Model Authority Sets (MAS). This partitioning occurs at the instance level and produces multiple datasets governed by a profile and network part. Datasets from different MAS combine to form the complete set of data for that profile, Figure 1 illustrates this.

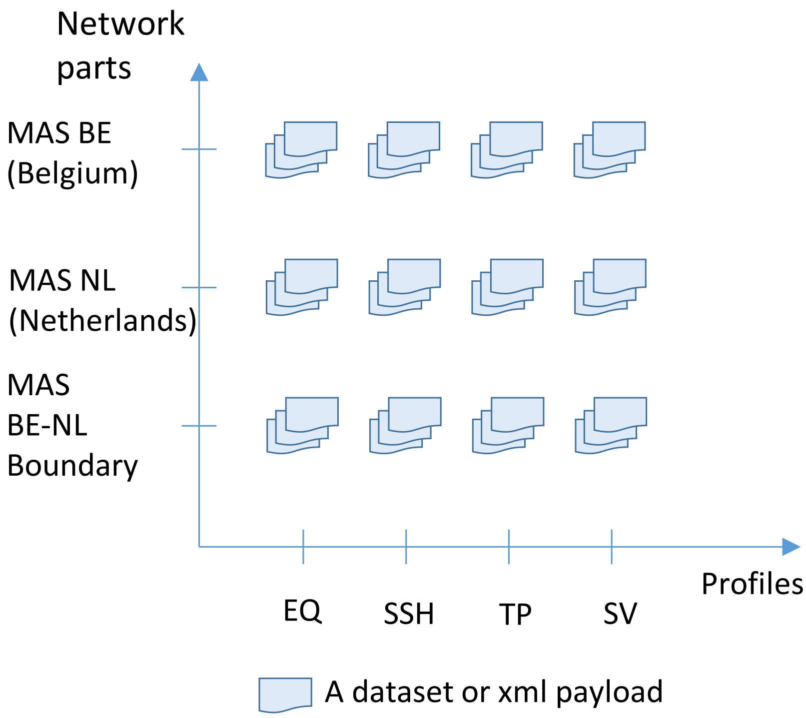

Figure 1 Relations between MAS, profile and dataset

Different IEC 61970 profiles are listed along the horizontal axis, they are

- EQ for equipment as described in IEC 61970-452
- SSH for power flow initial data as described in this document.
- TP for topology data as described in this document.
- SV for state variables data as described in this document.

A few example Model Authority Sets are listed along the vertical axis, they are

- MAS BE represent a regional Model Authority Set for Belgium that is a network part defined by a Model Authority BE, e.g. the Belgian TSO.
- MAS NL represent a regional Model Authority Set for Netherlands that is a network part defined by another Model Authority NL, e.g. the Netherlands TSO.
- MAS BE-NL Boundary represent a Model Authority Set that is a network part for the boundary between MAS BE and MAS NL. The boundary network part is typically agreed mutually between Model Authority BE and NL.

The document symbol in Figure 1 describe a dataset packaged as a payload, e.g. a CIMXML document as described in IEC 61970-552.

The Model Authority Sets along the vertical axis in Figure 1 define parts of a network. Datasets belong to a Model Authority Set and this is indicated in Figure 1 by the horizontally aligned datasets at each MAS.

The profiles along the horizontal axis in Figure 1 describe a subset of the CIM canonical data used for a particular purpose. A dataset Figure 1 contain data for a specific profile and this is indicated in Figure 1 by the vertically aligned datasets at each profile.

At each crossing point between a Model Authority Set and profile there is a stack of datasets meaning that for this particular Model Authority Set and profile there may be many datasets e.g. representing different points in time or different study cases. The ways datasets can be created and combined is dependent on the use case. The better support use cases on how to combine datasets an explicit CIM model for Model Authority Sets is being developed and will be released in the future as the CIM Frames model.

This standard is flexible and designed to satisfy a wide range of analytical scenarios in the planning and operating business environments. We expect that where parties are using it to collaborate in some business process, those parties will often want to create additional business agreements that describe any restrictions and customizations of the standard that are deemed necessary for their process. In most cases, these additional agreements will be local agreements and will not be IEC industry standards.

This specification do not specify a serialization format on its own but do so in companion with specification for CIMXML payloads is defined in IEC 61970-552. This method of serialization has the several useful characteristic

- The serialization format for a profile is defined by rules in IEC 61970-552 that describe the format based on the semantic model from the profile.
- Valid XML describing a complete model could be achieved simply by concatenating the CIMXML documents for each partial or profile document. Thus ‘merge’ and ‘extract’ of pieces of the modeling require no separate ‘stitching’ instructions and is conceptually a very simple process.
- IEC 61970-552 also describes how payload headers provide information as to how payloads fit together.

Figure 2 shows some of the profiles that are covered by the IEC 61970-450 to 61970-499 series specifications and depicts the relationships between them. The profiles are defined in different IEC 61970-450 specifications where each specification defines a group of profiles:

- Static network model profiles defined in IEC 61970-452
  - Equipment profile. The static modelling information describing power system physical elements and their electrical connections;
  - measurement profile that defines the existence of measurements and their relations to power system equipment.
- Schematic display layout exchange profiles defined in IEC 61970-453

  Schematic layout exchange profile. Describe the elements of schematic or geographic displays that typically shall be amended when new elements are added to a network model.
- Initial and solved power system state profiles defined in IEC 61970-456 (this document)
  - Steady State Hypothesis profile that provide the initial conditions to power flow. This profile have numerous sources, e.g. State Estimator or cases set up in a study;
  - Topology profile. The topology result as is produced by a network model builder;
  - State Variables profile. The result of a power flow calculation;

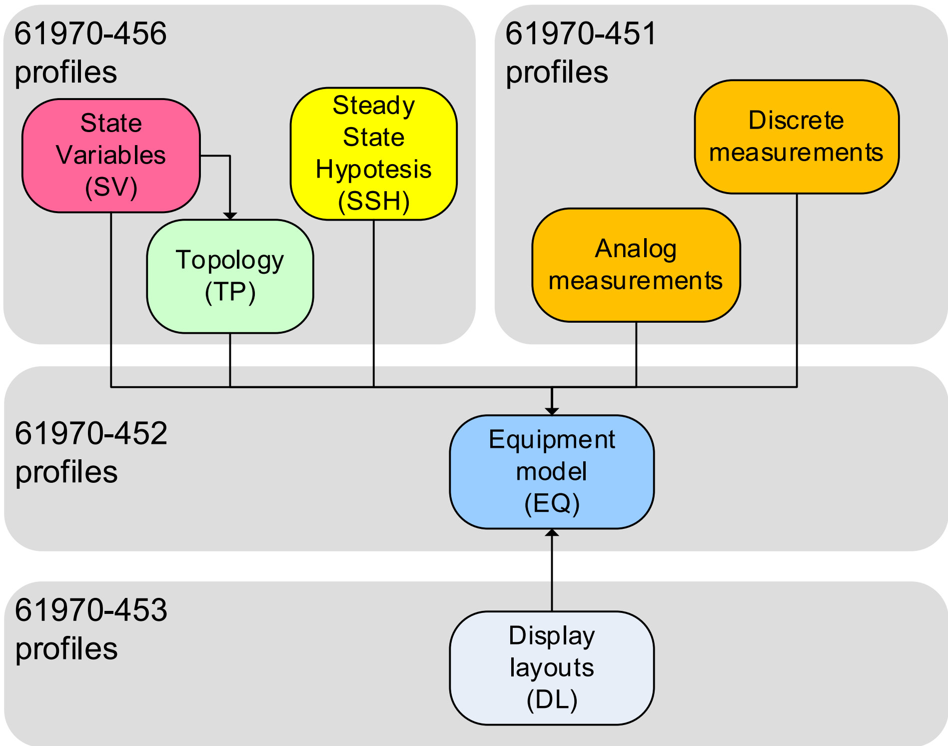

Figure 2 Profile relationships

These modules satisfy the needs of network analysis business processes used in operations, in planning studies, as well as for transfers between operations and planning. The IEC 61970-451 profiles that support transfer of SCADA measurements to EMS applications do not yet exist and is planned work.

Network models used in operations include detailed descriptions of measurements and their location in the network and switching devices, such models are called node-breaker models. Network models in used in planning may not have this level of detail and typically exclude measurements and switching devices. Instead of computing the power flow buses (TopologicalNodes) from switching device statuses the power flow buses are maintained manually.

It assumed that node-breaker and bus-branch models will be combined in the future to enable sharing of the same models between operations and planning.

In Figure 2, an arrow between profiles indicates that there are relationships defined between classes in the two profiles. The directionality indicates that classes in the “from” profile depend on classes in the “to” profile. For data this means that “from” class data refers to or depends on “to” class data. Example: a dataset of an equipment model may have many Topology, State Variable and Steady State Hypothesis datasets that refer to it.

In IT-systems, datasets corresponding to the profiles in Figure 2, are exchanged between functions and/or applications. Some examples of applications and their dataset exchange are described in the following sub clauses.

The equipment model has equipment connectivity described by the ConnectivityNode and Terminal classes, refer to Figure 3. The Terminal class is central in that it support Equipment, Topology, State Variables, Steady State Hypothesis and Diagram Layout profiles. Within the Equipment profile the Terminal associate ConnectivityNodes with ConductingEquipment and provide multi Terminal equipment (e.g. Switches, ACLinesegments etc.) with well-defined equipment “sides”.

The Equipment and Steady State Hypothesis profiles are the basis for network model building and power flow calculation. The Topology profile describe power flow busses, TopologicalNodes that are used as input by a power flow calculation. TopologicalNodes are created in a step preceding the actual power flow solution and can be the result of a network model builder using ConnectivityNodes as input or by manual editing in a bus-branch model editor. The state variables profile describes the result of a power flow application, refer to Figure 3.

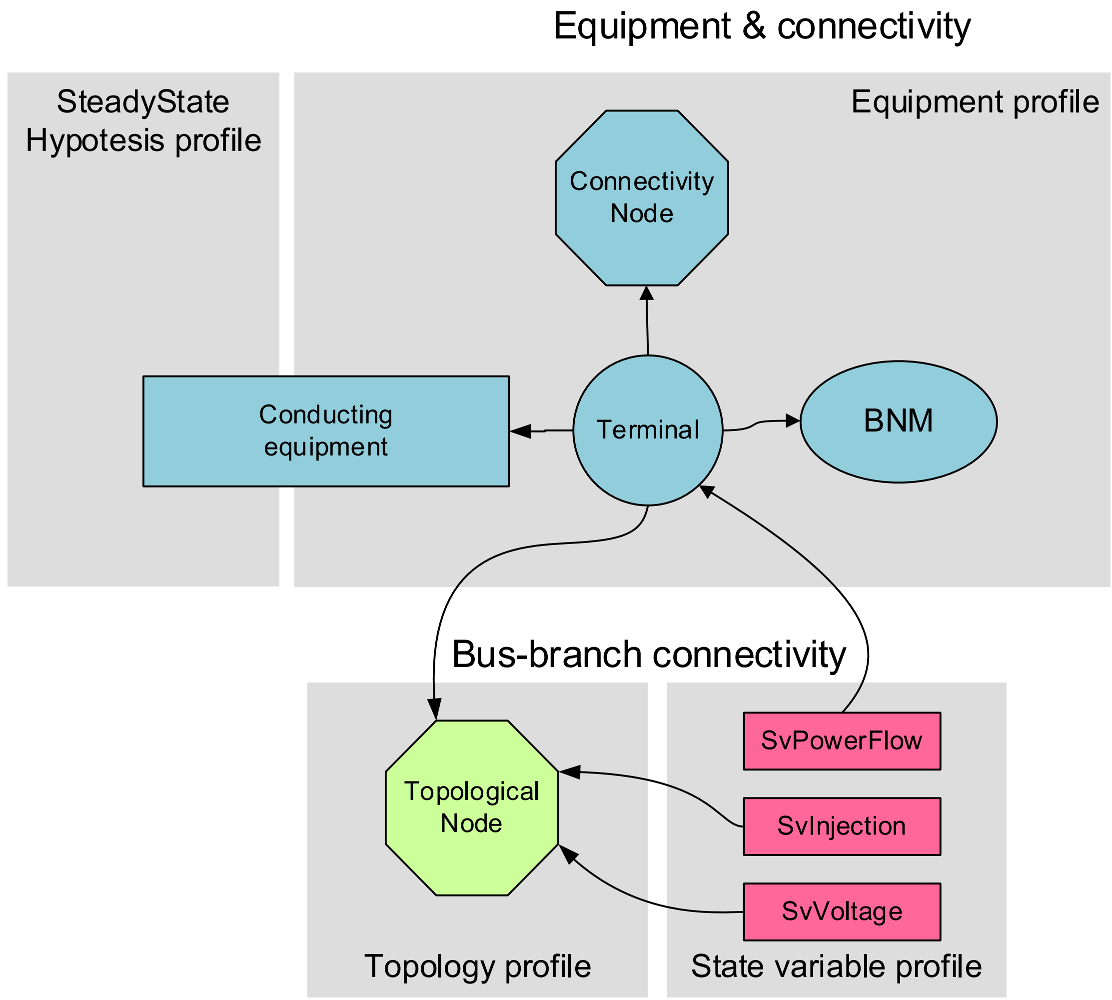

Figure 3 Connectivity model example

The arrows in Figure 3 describe references between the CIM objects. For a node-breaker model the TopologicalNodes are computed from switching devices connecting ConnectivityNodes and for a bus-branch model the TopologicalNodes are manually maintained.

A node-breaker model use ConnectivityNodes to describe how conducting equipment are connected. In topology processing all conducting equipment connected with each other through closed Switches are identified and conducting equipment Terminals are assigned to a TopologicalNode.

A bus-branch model use TopologicalNodes to describe how conducting equipment are connected. In this case the TopologicalNodes are manually maintained and the assignment of conducting equipment Terminals to TopologicalNodes is also manually maintained. The manually maintained TopologicalNodes have well know identifiers or “Bus numbers” that enables comparison of different studies on the same network.

In the case of a node-breaker models the TopologicalNodes are created by topology processing. BusNameMarkers (BNM) are used to avoid an arbitrary naming of TopologicalNodes resulting from topology processing, as described in section 6.1.1. The TopologicalNodes in a bus-branch model imply that the Switches in a corresponding node-breaker model have specified Switch statuses (Switch.open). By creating BusNameMarkers for one or more such sets of Switch statuses and use the BusNameMarker names to name the TopologicalNodes generated by topology processing it is possible to preserve the

TopologicalNode names. Variations in Switch statuses is managed by adding as many BusNameMarkers as needed to support the wanted variations.

This use of BusNameMarkers preserve TopologicalNode names but not the mRID (the rdf:ID/rdf:about in IEC 61970-552). Hence TopologicalNode mRIDs will vary between different topology processing runs. In version 17 of the canonical UML the information model has been modified to support preserving the TopologicalNode mRIDs (this version of the profile is based version 16 of the canonical UML).

An equipment model using ConnectivityNodes may not necessarily have any switches. A simplified equipment model can initially be created without switches similar to a bus-branch model. This enables mixing detailed node-breaker models having switches with simplified bus-branch style models without switches as both describe connectivity using ConnectivityNodes. This is useful when operational models are to be combined with planning models to verify that the planned extensions work with existing operational models.

5 Use cases (informative)

5.1 Overview

This section describes how the standard should be applied in business problems and gives examples of some scenarios.

Network applications use a bus-branch model in the basic power flow calculation where the branches are non-zero impedance elements. Real power systems have measurements and switching devices that are not described in bus-branch models but in node-breaker-models. So, to run network calculations on a node-breaker model a bus-branch model with all zero impedance elements removed is first created. In many study situations, it is impractical to deal with all the details in a node-barker model, hence studies often use a bus-branch model for building study cases. The Steady State Hypothesis profile describe the data, e.g. switch statuses, needed to transform a node-barker model into a bus-branch model.

A large interconnected power network is typically divided in regions with a system operator that is responsible for operating the power network within a region. With increased and stronger interconnections between the regions the mutual dependency between the regions increase. A consequence is that a power flow set up for a particular region must also include a substantial part of the neighboring regions including both EQ and SSH data. Figure 4 show an example from Europe.

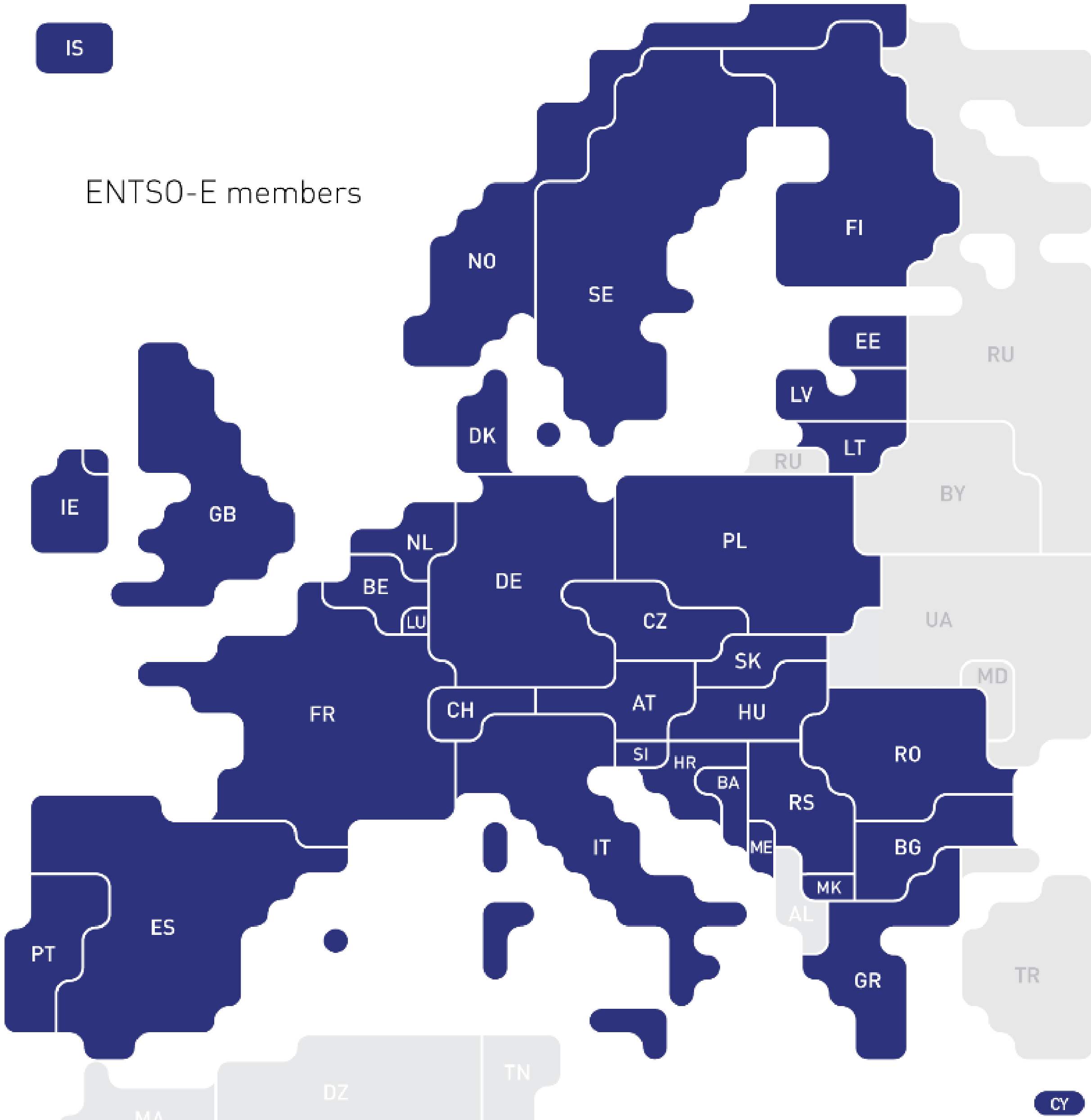

Figure 4 The European power system with regions

The Case building process includes many sources of SSH data, as follows.

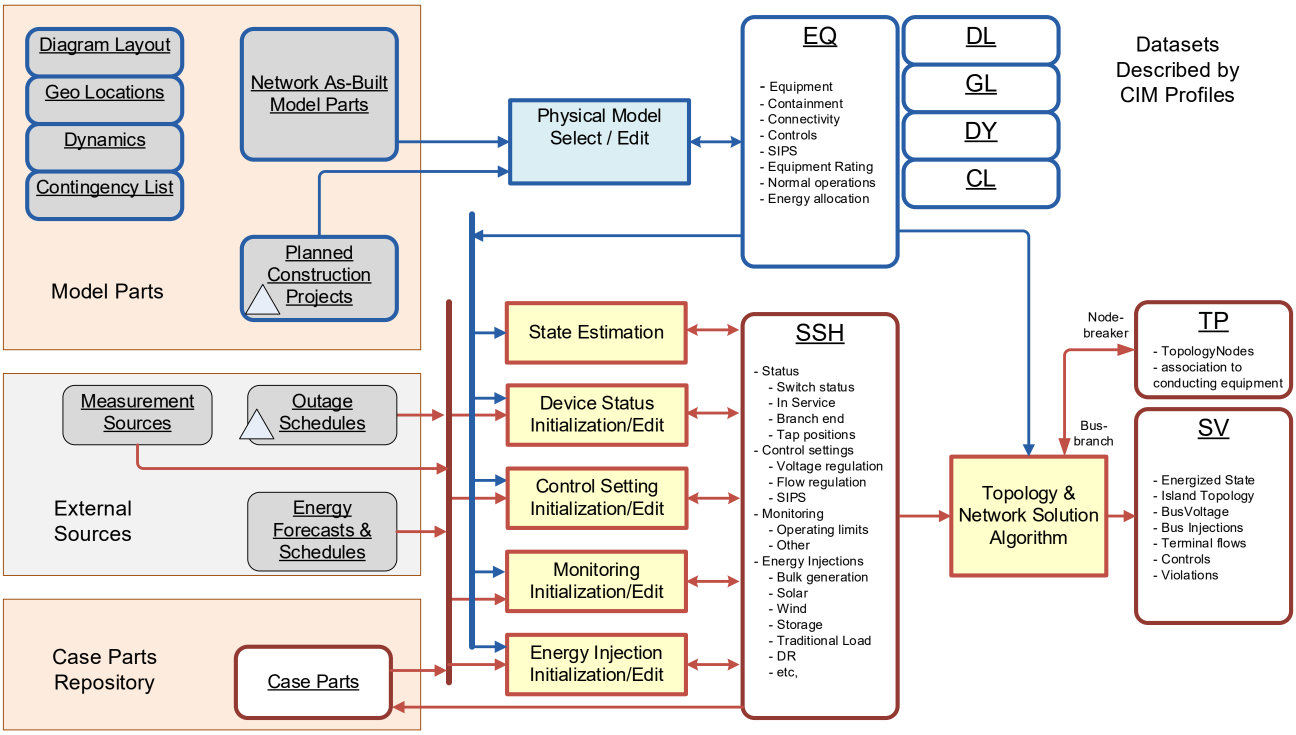

Figure 5 – Information exchange in power flow and sharing of results

Figure 5 describes how input to Power Flow calculation have many different possible sources. State Estimation and measurements create SSH data as input to Power Flow calculations. Case building includes selecting and combining data from different sources to form a complete input to a Power Flow study. The Study State Hypothesis (SSH), Topology (TP) and State Variables (SV) are in scope of this specification. Other interfaces indicated in are outside the scope of this specification.

5.2 EMS network analysis integration

An architecture for transfer of data from a SCADA/EMS to other applications is shown in Figure 6.

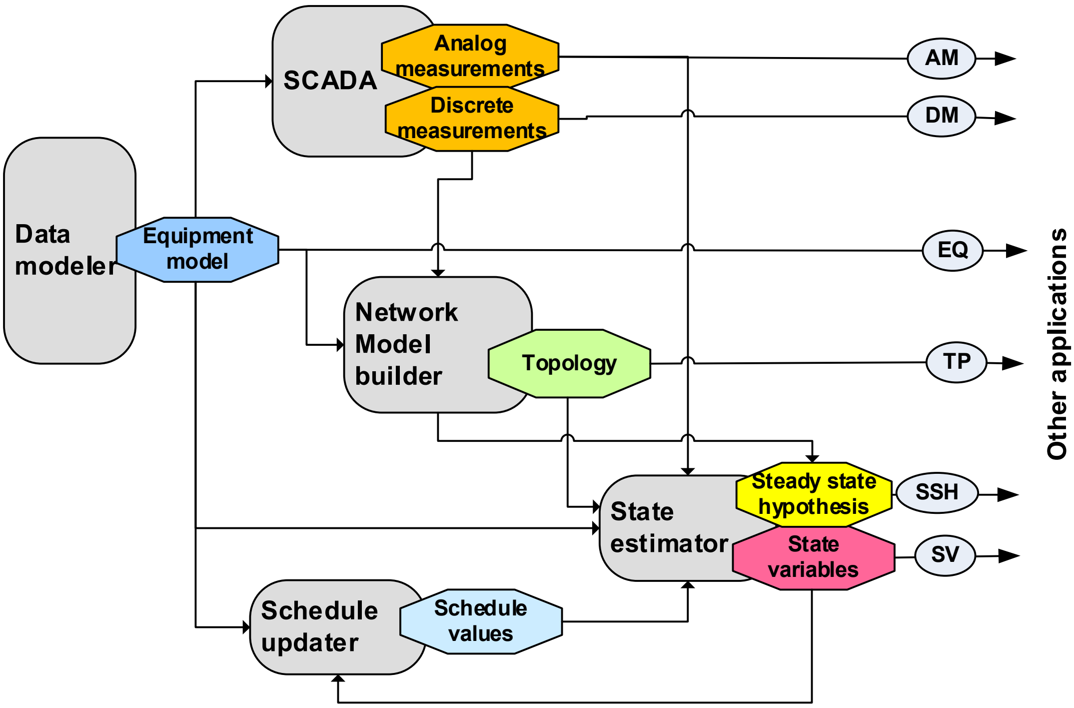

Figure 6– EMS datasets to an external client

The following interfaces are shown in Figure 6:

- EQ: Equipment model data as described in IEC 61970-452;
- DM: network discrete measurements dataset;
- AM: network analog measurements dataset;
- TP: Topology dataset from Network model builder;
- SV: State Variables dataset from state estimator.
- SSH: Steady State Hypothesis from the Network Model builder and State Estimator is an output that can be used as input to Power flow calculations as shown in Figure 7.

5.3 Power flow based network analysis

Architecture for Power Flow based applications on node-breaker models is presented in Figure 7.

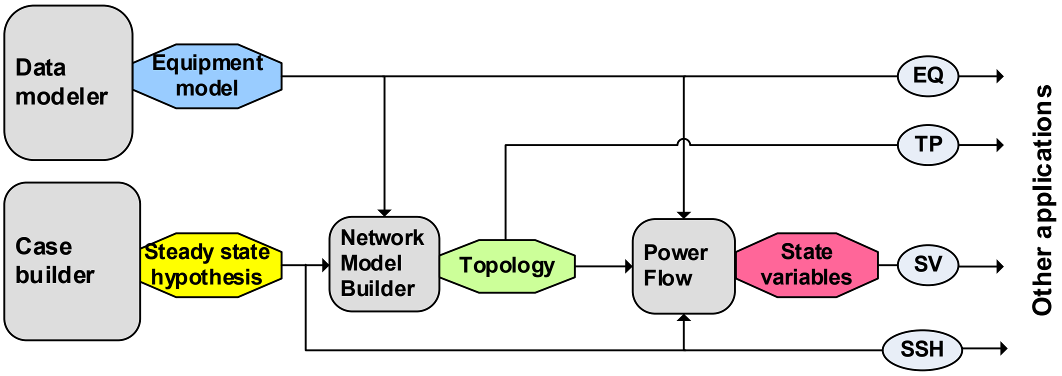

Figure 7– Node-breaker power flow Integration architecture

SSH and EQ data is results of the Case builder activity. The Case builder activity produces all inputs needed for the Power Flow in addition to the Equipment model. SSH data may also be provided by the State Estimator as in Figure 6.

Architecture for Power Flow based applications on bus-branch models is presented in Figure 7.

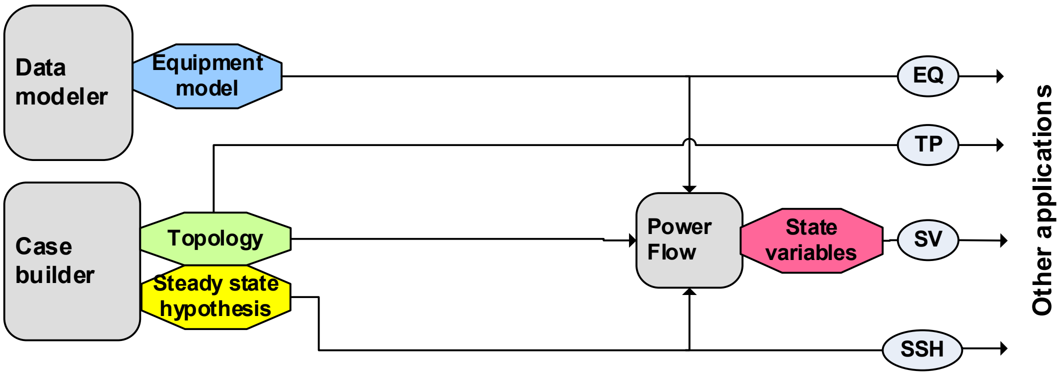

Figure 8– Bus-branch power flow Integration architecture

SSH, TP and EQ data is results of the Case builder activity. The Case builder activity produces all inputs needed for the Power Flow in addition to the Equipment model.

Figures Figure 7 and Figure 8 describe the case when all inputs to the power flow are known. For a large power network with many interconnected regions this may mean that data for many of the regions is collected and merged to form the study case. In many study situations, a large number of power flow calculations are run, e.g. congestion forecast, and the case set up is automated without requirement for human intervention. This implies that the regional network models are described such that they can be merged automatically. This is done with a method where the boundaries between the regions are described by separate boundary model authority sets that are used as an interface between the regions.

A way to solve the power flow for a regional network part without the neighbouring network parts is to represent the neighbours with equivalent injections connected to the boundary network part as shown in Figure 9.

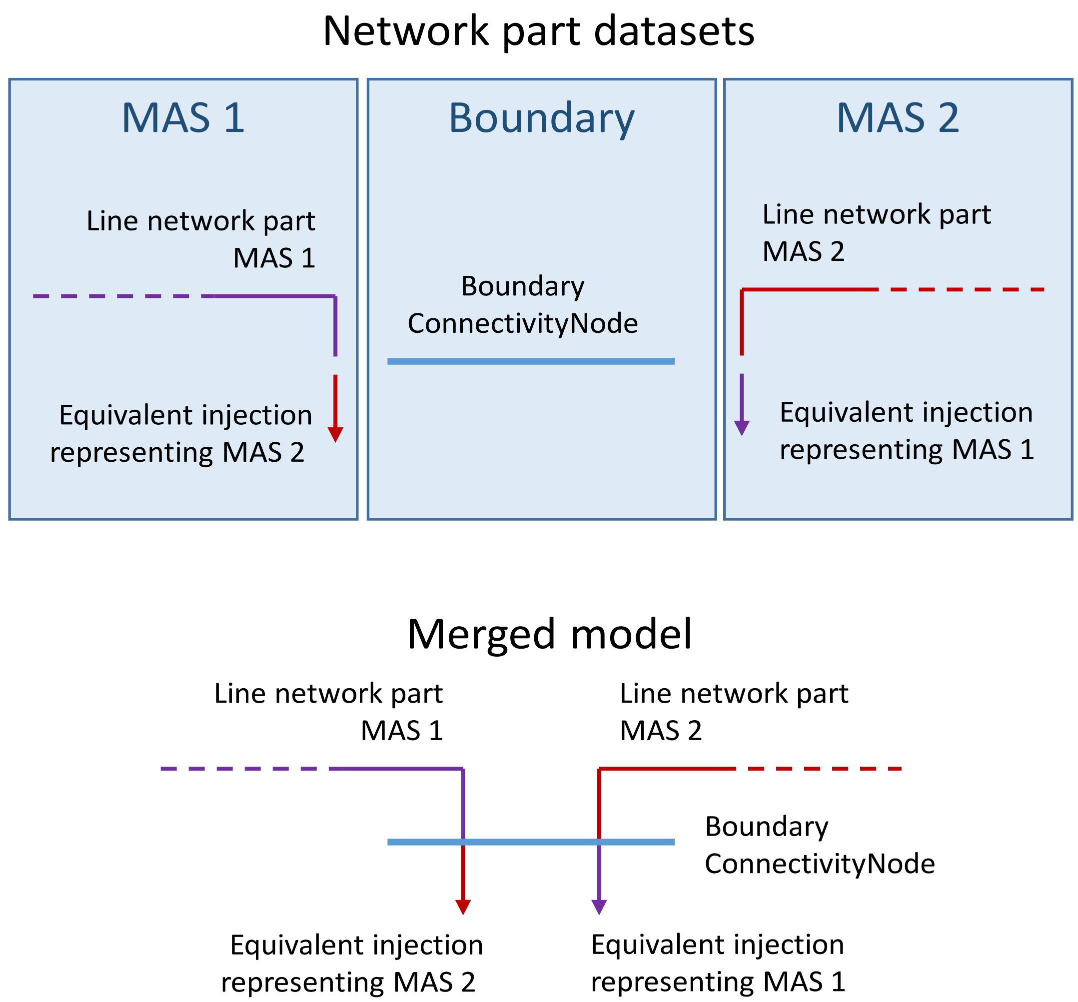

Figure 9 Boundary injection model

Note that the two equivalent injections in Figure 9 are always present and integral parts of the model authority sets describing the regional network parts. The upper part in Figure 9 show the regional network parts before merging and the lower part show the merged network model.

The equivalent injections in the boundary are used to verify that it is possible to solve the power flow for the regional network without the neighbouring network parts. In a merged network model the boundary injections are set to zero to avoid errors from differences in SSH injection values between the two equivalent injections. It is not described in data being exchanged (e.g. EQ or SSH data) if to set boundary injections to zero or not. Instead the context for the data being exchanged decide when to set the boundary injections to zero, e.g. data exchanges for congestion forecasting in Europe.

Another way to manage injections at boundaries is to treat the reduced representation of the network at the other side of the boundary as separate model authority sets as shown in Figure 10.

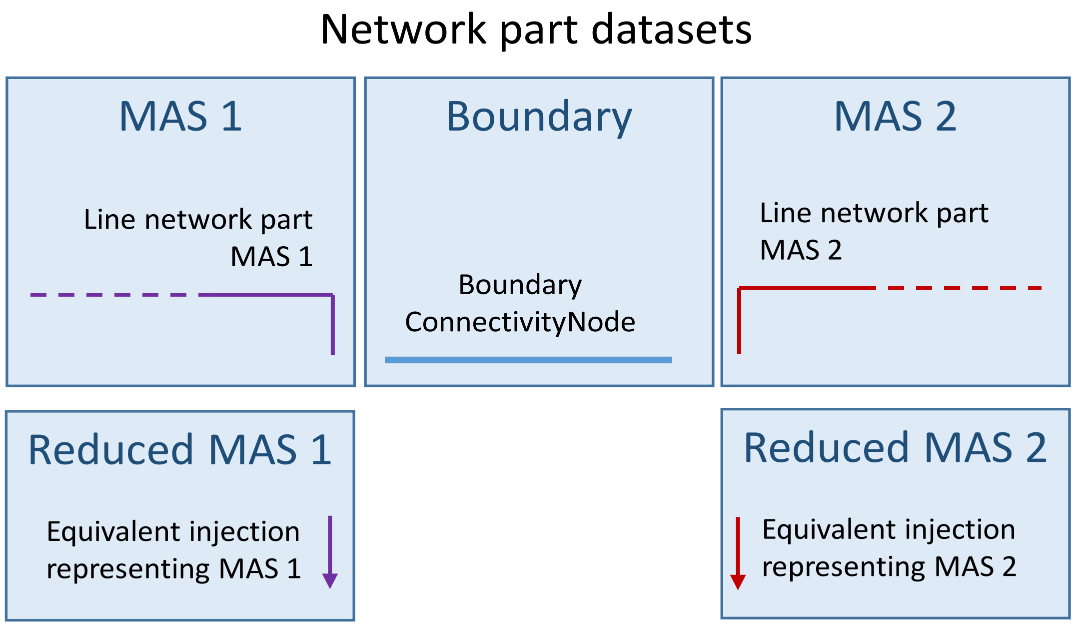

Figure 10 Alternate boundary modelling

In Figure 10 the two model authority sets “Reduced MAS 1” and “Reduced MAS 2” have simplified equivalents. More complex equivalents than this are of course possible. The model authority sets in Figure 10 can then be combined as shown in Figure 11.

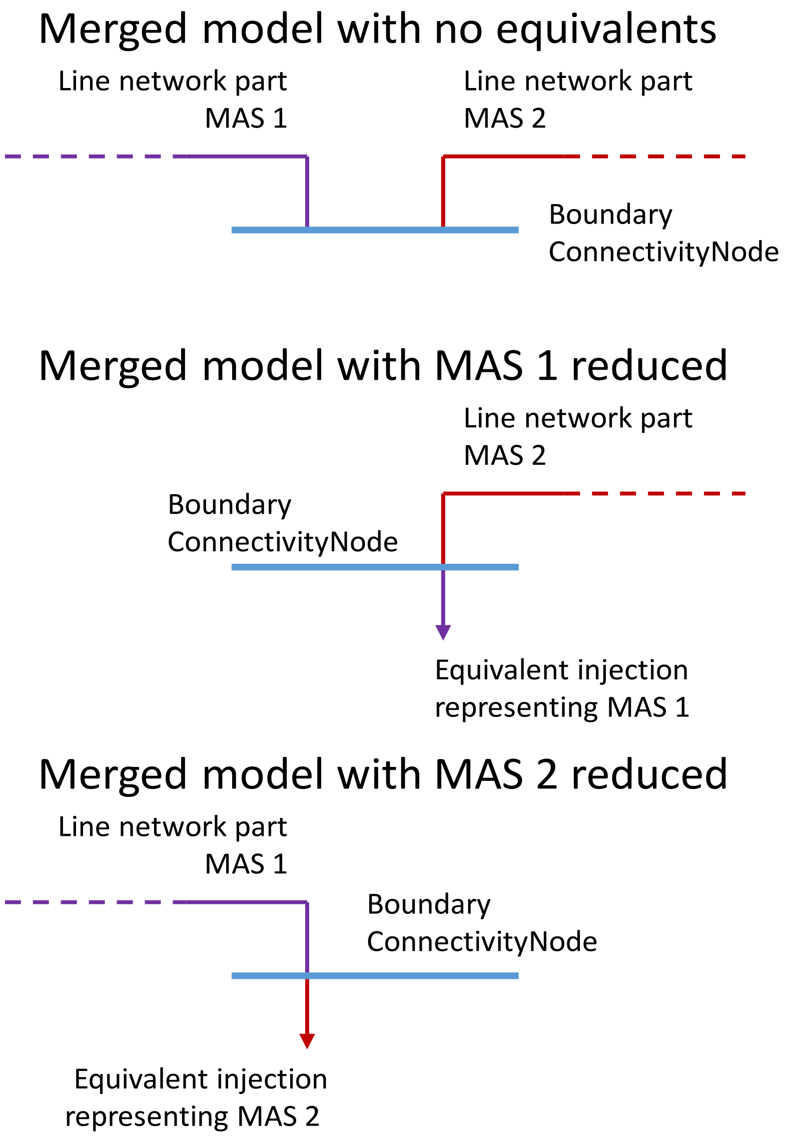

Figure 11 Merged model alternatives

When regional model authority sets MAS 1 and MAS 2 are merged, refer to upper part of Figure 11, no equivalents are included that need special treatment when solving a power flow. When power flow is run for a regional network without the neighbouring networks the equivalent injections are used instead as shown in the lower part of Figure 11.

The use of equivalent injections as shown in Figure 9 violates the original and intended use of equivalent injections. In this case a power flow need to recognize a merged case and then ignore the equivalent injections. Hence it is recommended not to use this modelling practice.

The use of equivalent injections as shown Figure 10 comply with the original and intended use of equivalent injections and is the recommended usage.

The use cases described in this section overlaps with IEC 61970-452 and the EQ profile. As this specification, IEC 61970-456, is intended for TP, SV and SSH profiles next edition (Edition 3) will be better coordinated with IEC 61970-452.

6 Data model with CIMXML examples

6.1 Use of the interfaces

6.1.1 Overview

Input to Network model building is the Equipment model data and Steady State Hypothesis data. The output is Topology data that is addressed in this section. Its purpose is to provide a bus-branch model described by TopologicalNodes needed by state estimation or any other power flow based application as input. ConnectivityNode in the Equipment model is the input to the Network model building for creation of the TopologicalNodes.

A Topology dataset always depend on an Equipment dataset. Hence a Topology dataset refer to the Equipment dataset on which it is based, and in most use cases, this is the Equipment dataset that the consumer will want to use. This does not prevent its attempted use with other Equipment datasets, which may make sense in some use cases. Basically, the only software requirement is that all the external references from the Topology dataset resolve to objects in the Equipment dataset that it is used with. If a Topology dataset was created by a network model builder using switch statuses from a Steady State Hypothesis dataset the Topology dataset may have a reference to the Steady State Hypothesis dataset.

A network model builder will generate the TopologicalNodes at each run and with potentially different switch statuses from the Steady State Hypothesis dataset. To enable comparing network topologies the identity associated with the main buses of each substation to be the same and stable. CIM modeling allows the modeler to provide input data to identify the main buses and provide direction as to how bus identity is to be created in the topology processing algorithm by the use of BusNameMarkers. If modelers provide BusNameMarkers, and establish multiple main buses separated by retained Switches wherever bus splits are common, then the TopologicalNodes can have consistent names from one Topology dataset to another.The CIM BusNameMarker class provides a way to give a persistent name to TopologicalNodes. A Network model builder can copy the name from a BusNameMarker to the TopologicalNode given that a BusNameMarker is present at a Terminal linked to the TopologicalNode. In cases where multiple BusNameMarkers are present at the same TopologicalNode a priority is used to select the BusNameMarker. Note that:

- A BusNameMarker is related to Terminal which means that a ConductingEquipment must be present to allow placement of a BusNameMarker.
- BusNameMarkers that may appear at the same TopologicalNode must have strict priority ordering to provide over time consistent naming of TopologicalNodes.
- The BusNameMarker mRID cannot be copied to the TopologicalNode as this will break the uniqueness requirement for mRIDs. Hence TopologicalNodes are not persistent in this version of the specification..

6.1.2 Network model boundaries

ConnectivityNodes also forms the interface point in boundary datasets between network parts as shown in Figure 12 and Figure 13.

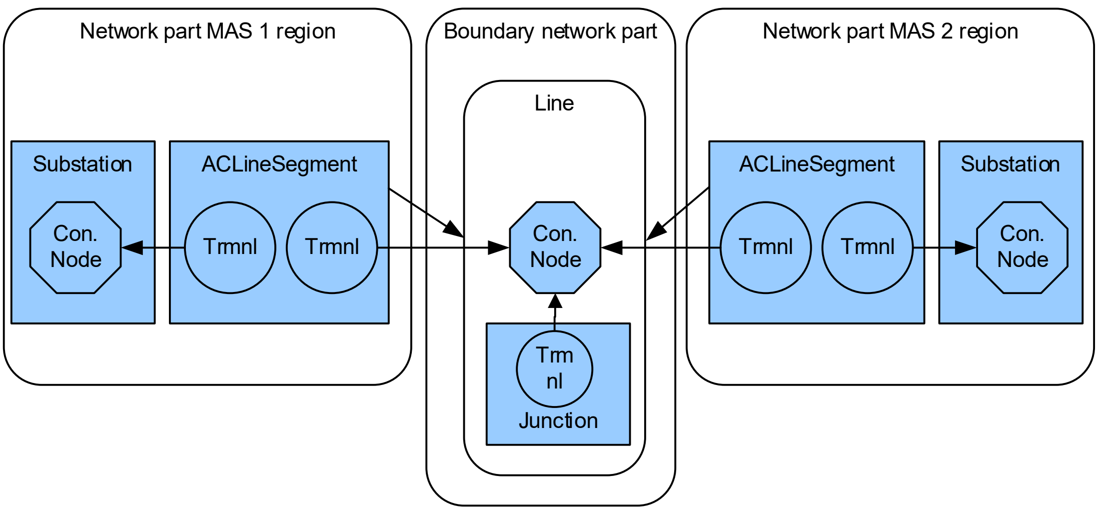

Figure 12 – Line boundary dataset example

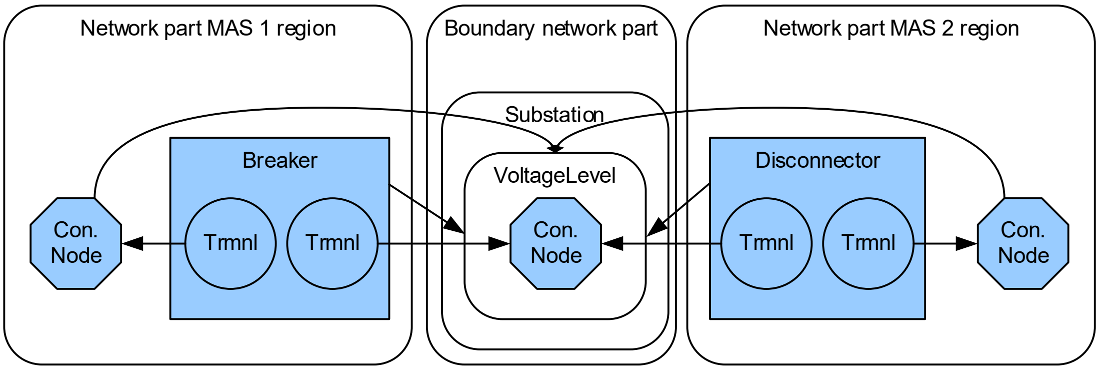

Figure 13 Substation boundary dataset example

The following abbreviated CIM class names are used in Figure 12 and Figure 13:

- Con.Node = CIM ConnectivityNode;
- Top.Node = CIM TopologicalNode;
- Trmnl = CIM Terminal.

The arrow reflect the directions of references as defined in the profile documents and instantiated in datasets. All references are going from the regional network parts into the boundary network part and the boundary network part has no references outside itself. Hence the boundary network parts are self-contained and not dependent on any other network parts.

Figure 12 shows a Line between two Substations in different regional network parts named “Network part MAS 1” and “Network part MAS 2”. The boundary network part is described with a Line and a ConnectivityNode. To describe the physical location of the ConnectivityNode a Junction may be added to the ConnectivityNode. The ACLineSegments are described in the regional network parts but are contained by the Line in the boundary as well as being connected to the ConnectivityNode in the boundary. A boundary network part may also have a Substation instead of a Line as shown in Figure 13. In this case the Substation, a VoltageLevel and a ConnectivityNode is in the boundary network part while the rest of the Substation equipment is defined within the regional network parts.

Figure 14 show how a merged Power Flow cases isare partitioned in two ways

- Regions separated by boundaries
- Data sets according to CIM profiles

By splitting CIMXML documents corresponding the cross section between regions and profile data sets a large network can be described by many smaller XML documents as shown in

Figure 14.

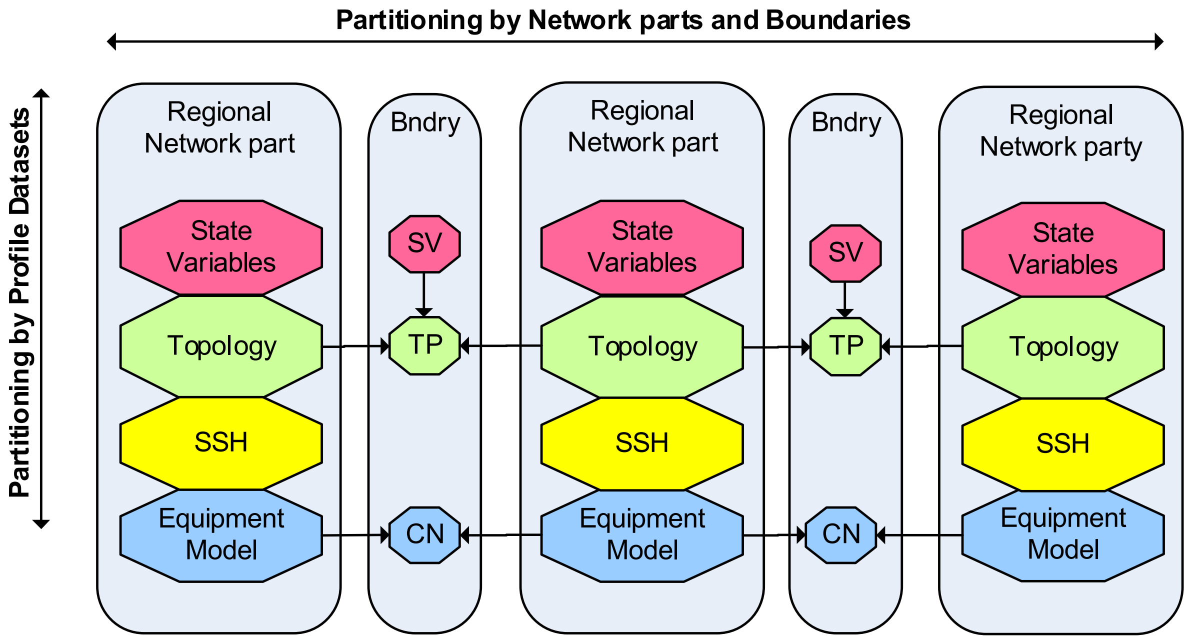

Figure 14 Power Flow on a merged model

Figure 15 show the same partitioning as shown in but for a single regional network part. Steady State Hypothesis injections in the boundary representing the regional network parts are indicated with “BI” for boundary injection. As described in the boundary injections are only used when power flow is solved for a single regional network part. When solving power flow for multiple regional network parts the boundary injections between them are ignored.

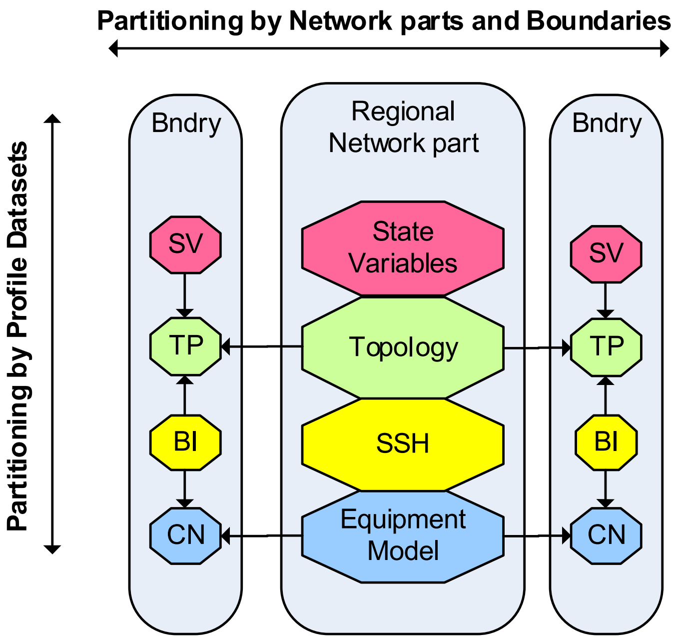

Figure 15 Power Flow on a regional network part

6.1.3 Bus-branch and node-breaker models

A network model can be described in two different levels of detail

- Bus-branch model without any substation details.
- Node-breaker model with switches and measurement details.

A bus-branch models use TopologicalNodes for connectivity ConnectivityNodes while a node-breaker models have use ConnectivityNodes separated by Switches (Breakers, Disconnectors). Network model building involves reducing away Switches based on the inputs Switch.open, Equipment.normallyInService, ACDCTerminal.connected and create corresponding TopologicalNodes. By using BusNameMarkers the names of the TopologicalNodes resulting from Network model building can be made persistent with TopologicalNodes in a bus-branch model. Persistency of the TopologicalNode itself and its mRID is not supported however.

One of the inventions in CIM is the support of mixed bus-branch and node-breaker models. This is made possible by the linkage between ConnectivityNode and TopologicalNode as shown in Figure 16.

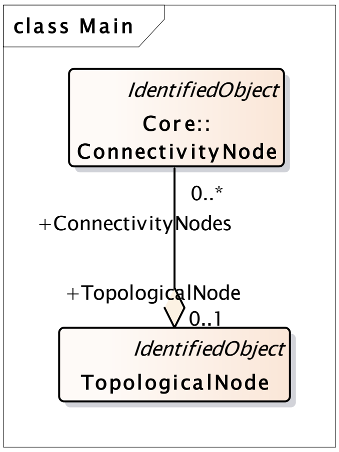

Figure 16 CIM relation between ConnectivityNode and TopologicalNode

When a Network model builder create a bus-branch model from a node-breaker model the TopologicalNodes and the link ConnectivityNode to TopologicalNode are created. There are several methods to do this

- Use the BusNameMarker names from node-breaker model to match the bus-branch model TopologicalNodes and merge the Topology models at the time of Network model building. Note that using names is an insecure way of merging TopologicalNodes. Preferably persistent TopologicalNodes should be used instead. This will be possible once TopologicalNodes are made persistent.
- Convert bus-branch equipment and topology models to node-breaker equipment models and merge the equipment models. This is done by creating ConnectivityNodes and BusNameMarkers from the TopologicalNodes in the bus-branch models.

The rules for the Network model building are

- Calculate TopologicalNodes from ConnectivityNodes by processing Switch.open and ACDCTerminal.connected. An open ended branch result in a TopologicalNode at the open end to keep the voltage and angle.
- Exclude all equipment where Equipment.normallyInService=false from power flow.

In a bus-branch model a bus split and transfer of a line between split buses, is illustrated in Figure 17. This can be modeled as follows

- A voltage level should be represented with two busses (ConnectivityNodes) with a retained switch (Switch.retained=true) between them with the bus tie closed. The switch will be treated as a zero impedance logical branch within the power flow.
- The bus may then be split by opening the bus coupler switch, as shown in Figure 17.
- Transfer of a branch or other equipment between bus bars cannot be made with switching. Instead, the equipment model is updated so that branch/equipment terminal link to the ConnectivityNode is updated.

- Opening of an ACLineSegment end can be made by using the ACDCTerminal.connected flag. In this case a TopologicalNode that represent the voltage at the open ACLineSegment end is needed.

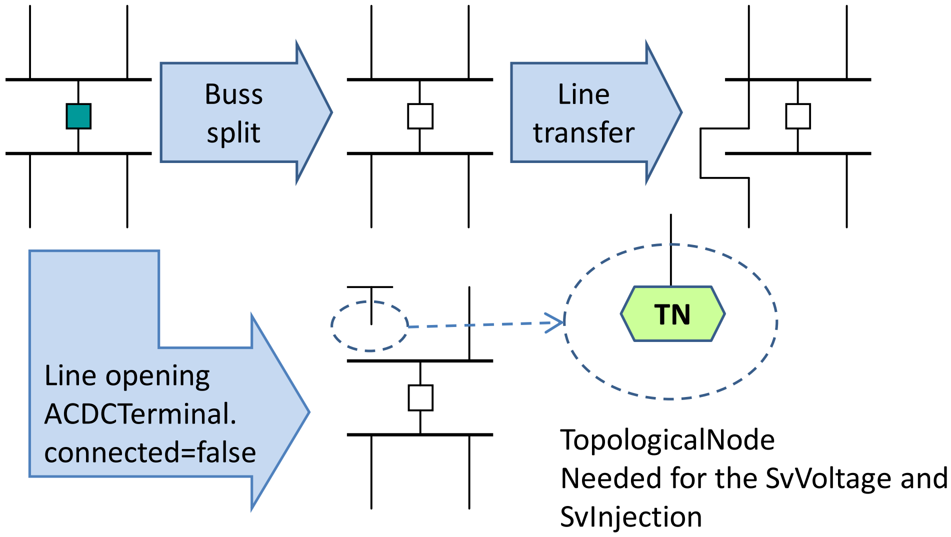

Figure 17 – Bus-branch modeling of bus coupler and line transfer

6.2 Topology (TP) interface

The CIM for topology is shown in Figure 18. For the TP profile refer to section 7.

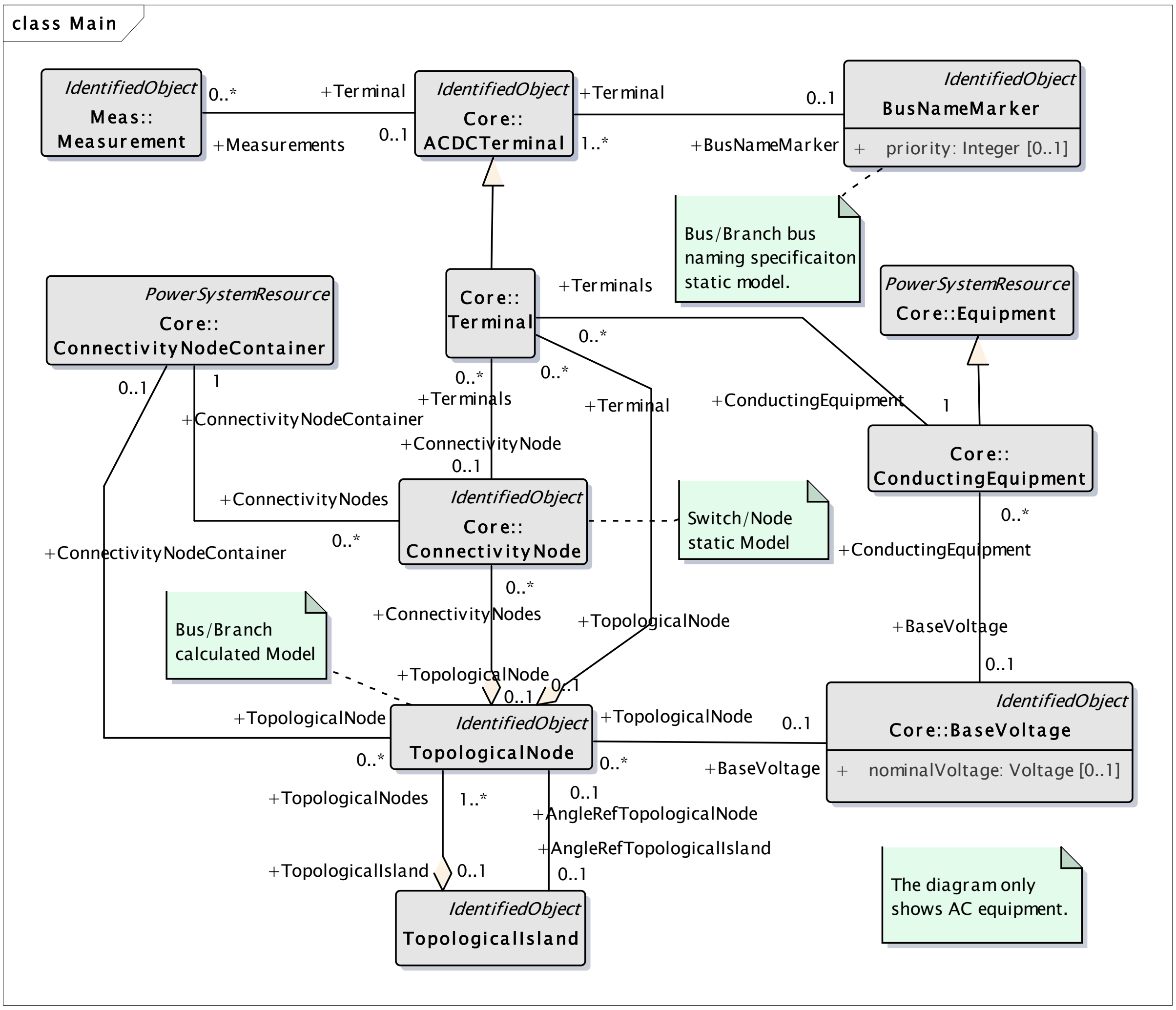

Figure 18 – CIM topology model

Figure 18 shows the CIM UML for the Topology interface.

A dataset example based on the model in Figure 18 and the corresponding Topology profile is shown in Figure 19.

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns:cim="
http://iec.ch/TC57/2013/CIM-schema-cim16#">
        <cim:TopologicalNode rdf:ID="_fe3b0741-0393-4f3f-9863-7658d6e61a60">
                <cim:IdentifiedObject.name>BLO0400SUBNET_7048</cim:IdentifiedObject.name>
                <cim:TopologicalNode.BaseVoltage rdf:resource="#_f9872320-6d88-43d1…"/>
                <cim:TopologicalNode.ConnectivityNodeContainer rdf:resource="#_8837228a…"/>
        </cim:TopologicalNode>
        <cim:TopologicalNode rdf:ID="_a1ed01d2-700c-4360-92cd-c4961eacd1eb">
                <cim:IdentifiedObject.name>BLO0220SUBNET_7067</cim:IdentifiedObject.name>
                <cim:TopologicalNode.BaseVoltage rdf:resource="#_f9872320-6d88-43d1…"/>
    <cim:TopologicalNode.ConnectivityNodeContainer rdf:resource="#_8837228a…"/>
        </cim:TopologicalNode>
        <cim:TopologicalNode rdf:ID="_325a0d99-4e2c-4456-8ed5-3af7cad51df6">
                <cim:IdentifiedObject.name>BLO0220SUBNET_7082</cim:IdentifiedObject.name>
                <cim:TopologicalNode.BaseVoltage rdf:resource="#_8b09c1fa-447a-4a0b-baca…"/>
    <cim:TopologicalNode.ConnectivityNodeContainer rdf:resource="#_f06f9c19-3123…"/>
        </cim:TopologicalNode>
```

```
        ...

        <cim:Terminal rdf:about="#_caec8e6b-6936-4926-89d5-76910fdae26b">
                <cim:Terminal.TopologicalNode rdf:resource="#_fe3b0741-0393-4f3f-98…"/>
        </cim:Terminal>
        <cim:Terminal rdf:about="#_da219c6a-d43b-4ac1-ab52-4212e9283c08">
                <cim:Terminal.TopologicalNode rdf:resource="#_fe3b0741-0393-4f3f-98……"/>
        </cim:Terminal>
        <cim:Terminal rdf:about="#_fe6773e3-14dc-4539-8899-2ceaed0ff46a">
                <cim:Terminal.TopologicalNode rdf:resource="#_fe3b0741-0393-4f3f-………"/>
        </cim:Terminal>
        <cim:Terminal rdf:about="#_b8bd4d23-c102-4d8e-8acc-1cd5b138119a">
                <cim:Terminal.TopologicalNode rdf:resource="#_a1ed01d2-700c-4360-………"/>
        </cim:Terminal>
        ...
        <cim:ConnectivityNode rdf:about="#_e6250f56-230d-4be8-a0e7-b8a0d91679b1">
                <cim:ConnectivityNode.TopologicalNode rdf:resource="#_a1ed01d2-70………"/>
        </cim:ConnectivityNode>
        ...
</rdf:RDF>
```

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Figure 19 – Topology solution interface

6.3 State Variables (SV) interface

The state variables CIM UML is shown in Figure 20. For the SV profile refer to section 7.

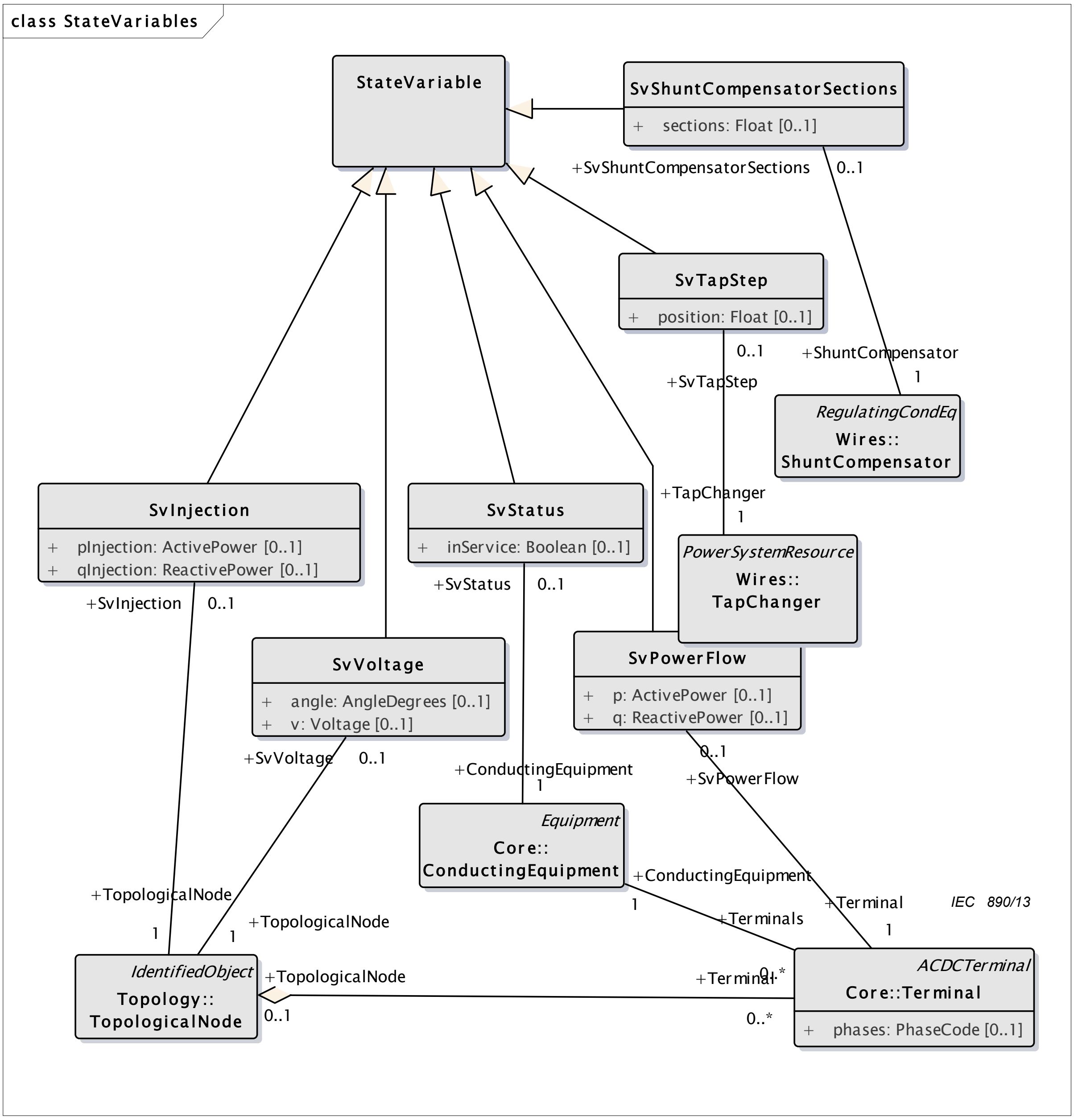

Figure 20 – CIM state variable solution model

The state variables are identified by the objects they belong to and their life time depends on that object, i.e. the objects TopologicalNode, ConductingEquipment, Terminal, TapChanger, etc. State variable mRIDs are required to be unique within a message only and their mRIDs cannot be correlated between messages.

The steady state solution is based on the class StateVariable that is specialized into a set of state variables as shown in Figure 20. Note that StateVariable does not inherit from IdentifiedObject as it is fully identified by the object it is attached to.

A CIM XML example based on the model in Figure 20 is shown in Figure 21.

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:cim="http://iec.ch/TC57/2013/CIM-schema-cim16#">
        <cim:TopologicalIsland rdf:ID="_20e3b9de-5d6e-4f36-9435-6fd02e234e67">
                <cim:IdentifiedObject.localName>_1001</cim:IdentifiedObject.localName>
                <cim:TopologicalIsland.TopologicalNode rdf:resource="#_fe3b0741-0393-4f3f-98…>
                <cim:TopologicalIsland.TopologicalNode rdf:resource="#_325a0d99-4e2c-4456-8e…>
                …
                <cim:TopologicalIsland.AngleRefTopologicalNode rdf:resource=#_20e3b9de-5d6e…>
        </cim:TopologicalIsland>
        ...

        <cim:SvInjection rdf:ID="_e7a35941-f376-47c4-950e-41cf06e3b838">
                <cim:SvInjection.TopologicalNode rdf:resource="#_fe3b0741-0393-4f3f-98…>
                <cim:SvInjection.pInjection>123</cim:SvInjection.pInjection>
                <cim:SvInjection.qInjection>456</cim:SvInjection.qInjection>
        </cim:SvInjection>
        <cim:SvInjection rdf:ID="_85f1c150-7308-41b0-bb7e-25ed518cc67d">
                <cim:SvInjection.TopologicalNode rdf:resource="#_325a0d99-4e2c-4456-8e…>
                <cim:SvInjection.pInjection>123</cim:SvInjection.pInjection>
                <cim:SvInjection.qInjection>456</cim:SvInjection.qInjection>
        </cim:SvInjection>
        ...
        <cim:SvVoltage rdf:ID="_e3a9aac0-2b0c-404b-929a-f30299fb2dc5">
                <cim:SvVoltage.TopologicalNode rdf:resource="#_325a0d99-4e2c-4456-8e…>
                <cim:SvVoltage.v>400</cim:SvVoltage.v>
                <cim:SvVoltage.angle>11.2</cim:SvVoltage.angle>
        </cim:SvVoltage>
        <cim:SvVoltage rdf:ID="_85f1c150-7308-41b0-bb7e-25ed518cc67d">
                <cim:SvVoltage.TopologicalNode rdf:resource="#_fe3b0741-0393-4f3f-98…>
                <cim:SvVoltage.v>400</cim:SvVoltage.v>
                <cim:SvVoltage.angle>10.3</cim:SvVoltage.angle>
        </cim:SvVoltage>
        ...
        <cim:SvPowerFlow rdf:ID="_85464e5f-2011-4d8c-89b1-0355de6eac53">
                <cim:SvPowerFlow.Terminal rdf:resource="#_caec8e6b-6936-4926-89d5_…>
                <cim:SvPowerFlow.p>123</cim:SvPowerFlow.p>
                <cim:SvPowerFlow.q>456</cim:SvPowerFlow.q>
        </cim:SvPowerFlow>
        ...
</rdf:RDF>
```

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Figure 21 – State solution interface example

6.4 Steady State Hypothesis (SSH) interface

The SSH profile is a subset of control variables located at the equipment CIM classes. As SSH just have attributes and no relations a UML diagram will show classes with a few attributes in them. Hence no UML diagram showing the profile is included, instead refer to section 7.

7 Profiles

7.1 Comments and notes

The CIMXML data format described in IEC 61970-552 use the XML attributes rdf:ID and rdf:about for object identification. Generally for IEC 61970 profiles the IdentifiedObject.mRID UML attribute is mapped to the rdf:ID and rdf:about XML attributes, hence the IdentifiedObject.mRID is not needed in CIMXML based exchanges. But IdentifiedObject.mRID is optionally included for the purpose of better compatibility with XML Schema based datasets that rely on the mRID attribute for object identification.

Note that the IdentifiedObject.mRID is only included in profiles for classes where objects are created with a full description, e.g. TopologicalIslands that are created when connectivity for TopologicalNodes are analysed in a power flow.

Notes on the profiles

a) SSH EquivalentInjection
   1) EquivalentInjection.regulationStatus and EquivalentInjection.regulationTarget are required attributes if the EquivalentInjection is connected to a non-Boundary node.
b) SSH Generating unit
   1) The active power slack is specified by using the multiple generator slack participation factor in CIM. In case GeneratingUnit.normalPF is set to one and all other generating units have a zero participation factor the GeneratingUnit which has normalPF equal to one will be the active power slack for the ControlArea to which it belongs. In case multiple generators all these GeneratingUnit(s) have non-zero normalPF, but there must be one GeneratingUnit per control area that have maximum participation factor (GeneratingUnit.normalPF).
   2) In case of exchange of steady state hypothesis (non-solved model) or solved model normalPF can be non-zero only for generators which are in operation (participate in the load flow).
   3) In case of exchange of steady state hypothesis (non-solved model, i.e. SV profile is not exchanged) the tools should assign the slack node.
c) SSH RegulatingControl
   1) Note that RegulatingControl.targetDeadband is primarily used if the RegulatingControl.discrete is set to "true". Tools should handle cases in which RegulatingControl.targetDeadband has a value if RegulatingControl.discrete is set to "false" or cases in which RegulatingControl.targetDeadband equals zero.
   2) Note that for instance, if the targetValue is 100 kV and the targetDeadband is 2 kV the range is from 99 to 101 kV.”
d) SSH VsConverter
   1) Note that for ACDCConverter.targetPpcc load sign convention is used, i.e. positive sign means flow out from a node.
   2) Note that for VsConverter.targetQpcc load sign convention is used, i.e. positive sign means flow out from a node.
e) SSH ACDCConverter
   1) Note that for ACDCConverter.targetPpcc load sign convention is used, i.e. positive sign means flow out from a node
f) Simple_Float, all profiles
   1) Value type is IEEE 754 simple precision floating point.
g) TP TopologicalNode
   1) ConnectivityodeContainer is an abstract class. It is used in the TopologicalNode to generate the TopologicalNode.ConnectivityNodeContainer association that is a pointer to ConnectivityNodeContainer concrete subclasses in the Equipment Profile.

   2) BaseVoltage is an abstract class. It is used in the TopologicalNode to generate the TopologicalNode.BaseVoltage association that is a pointer to BaseVoltage concrete class in the Equipment Profile.

h) IdentifiedObject, all profiles

   1) IdentifiedObject.name is 32 characters maximum. It shall be consistent with the name of the object used in companies, in daily operation (e. g. in SCADA systems), in planning processes or in asset related systems and should allow inter-communicating of TSO, using general names.

   2) IdentifiedObject.name is inherited by many classes and is not required to be unique. Software developers should not count on this to link the power system mode

   3) IdentifiedObject.description is 256 characters maximum.

i) SV SvPowerFlow

   1) The active power flow into the ConductingEquipment. If the associated Terminal.connected status is "false", the flow specified in the SvPowerFlow.p should be zero.

   2) The reactive power flow into the ConductingEquipment. If the associated Terminal.connected status is "false", the flow specified in the SvPowerFlow.q should be zero.

   3) SvPowerFlow class is required to be instantiated for the following classes: subclasses of the RotatingMachine, subclasses of the EnergyConsumer, EquivalentInjection, ShuntCompensator, StaticVarCompensator and EnergySource

j) Conflicts between Equipment and SteadyStateHypothesis

   1) Some revisions of some equipment profiles (e.g. IEC 61970-452 Ed3) may include attributes that are also included in the SteadyStateHypothesis profile. When using an equipment profile that contains this duplication, the duplicate attributes in the SteadyStateHypothesis profile shall be considered optional. If the duplicated attributes are included in a SteadyStateHypothesis instance, then the values in the SteadyStateHypothesys shall override the corresponding values in the Equipment profile.

7.2 SteadyStateHypothesis profile

7.2.1 General

A Steady State Hypothesis dataset contains all objects required to exchange input parameters to be able to perform load flow simulations. Due to the nature of the SSH profile, all objects in a Steady State Hypothesis instance file should have persistent mRIDs.

Profile URI: http://iec.ch/TC57/2013/61970-456/SteadyStateHypothesis/1#

7.2.2 Concrete Classes

7.2.2.1 ACDCConverterDCTerminal

Package: DC

A DC electrical connection point at the AC/DC converter. The AC/DC converter is electrically connected also to the AC side. The AC connection is inherited from the AC conducting equipment in the same way as any other AC equipment. The AC/DC converter DC terminal is separate from generic DC terminal to restrict the connection with the AC side to AC/DC converter and so that no other DC conducting equipment can be connected to the AC side.

Inherited Members

connected	1..1	boolean	see ACDCTerminal

7.2.2.2 ActivePowerLimit

Package: OperationalLimits

Limit on active power flow.

Native members

value	1..1	ActivePower	Value of active power limit.

7.2.2.3 ApparentPowerLimit

Package: OperationalLimits

Apparent power limit

Native members

value	1..1	ApparentPower	The apparent power limit.

7.2.2.4 AsynchronousMachine

Package: Wires

A rotating machine whose shaft rotates asynchronously with the electrical field. Also known as an induction machine with no external connection to the rotor windings, e.g squirrel-cage induction machine.

Native members

asynchronousMachineType	1..1	AsynchronousMachineKind	Indicates the type of Asynchronous Machine

Inherited Members

p	1..1	ActivePower	see RotatingMachine
q	1..1	ReactivePower	see RotatingMachine
controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.2.5 Breaker

Package: Wires

A mechanical switching device capable of making, carrying, and breaking currents under normal circuit conditions and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions e.g. those of short circuit.

Inherited Members

open	1..1	boolean	see Switch

7.2.2.6 ConformLoad

Package: LoadModel

ConformLoad represent loads that follow a daily load change pattern where the pattern can be used to scale the load with a system load.

Inherited Members

p	1..1	ActivePower	see EnergyConsumer
q	1..1	ReactivePower	see EnergyConsumer

7.2.2.7 ControlArea

Package: ControlArea

A control area is a grouping of generating units and/or loads and a cutset of tie lines (as terminals) which may be used for a variety of purposes including automatic generation control, powerflow solution area interchange control specification, and input to load forecasting. Note that any number of overlapping control area specifications can be superimposed on the physical model.

Native Members

netInterchange	1..1	ActivePower	The specified positive net interchange into the control area, i.e. positive sign means flow in to the area.
pTolerance	0..1	ActivePower	Active power net interchange tolerance

7.2.2.8 CsConverter

Package: DC

DC side of the current source converter (CSC).

Native Members

operatingMode	1..1	CsOperatingModeKind	Indicates whether the DC pole is operating as an inverter or as a rectifier. CSC control variable used
pPccControl	1..1	CsPpccControlKind	Kind of active power control.
targetAlpha	1..1	AngleDegrees	Target firing angle. CSC control variable used in power flow.
targetGamma	1..1	AngleDegrees	Target extinction angle. CSC control variable used in power flow.
targetIdc	1..1	CurrentFlow	DC current target value. CSC control variable used in power flow.

Inherited Members

p	1..1	ActivePower	see ACDCConverter
q	1..1	ReactivePower	see ACDCConverter
targetPpcc	1..1	ActivePower	see ACDCConverter
targetUdc	1..1	Voltage	see ACDCConverter

7.2.2.9 CurrentLimit

Package: OperationalLimits

Operational limit on current.

Native members

value	1..1	CurrentFlow	Limit on current flow.

7.2.2.10 DCTerminal

Package: DC

An electrical connection point to generic DC conducting equipment.

Inherited Members

connected	1..1	boolean	see ACDCTerminal

7.2.2.11 Disconnector

Package: Wires

A manually operated or motor operated mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a source of power. It is required to open or close circuits when negligible current is broken or made.

Inherited Members

open	1..1	boolean	see Switch

7.2.2.12 EnergyConsumer

Package: Wires

Generic user of energy - a point of consumption on the power system model.

Native Members

p	1..1	ActivePower	Active power of the load. Load sign convention is used, i.e. positive sign means flow out from a node. For voltage dependent loads the value is at rated voltage. Starting value for a steady state solution.
q	1..1	ReactivePower	Reactive power of the load. Load sign convention is used, i.e. positive sign means flow out from a node. For voltage dependent loads the value is at rated voltage. Starting value for a steady state solution.

7.2.2.13 EnergySource

Package: Production

A generic equivalent for an energy supplier on a transmission or distribution voltage level.

Native Members

activePower	1..1	ActivePower	High voltage source active injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
reactivePower	1..1	ReactivePower	High voltage source reactive injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.

7.2.2.14 EquivalentInjection

Package: Equivalents

This class represents equivalent injections (generation or load). Voltage regulation is allowed only at the point of connection.

Native Members

p	1..1	ActivePower	Equivalent active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
q	1..1	ReactivePower	Equivalent reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
regulationStatus	0..1	boolean	Specifies the default regulation status of the EquivalentInjection. True is regulating. False is not regulating.
regulationTarget	0..1	Voltage	The target voltage for voltage regulation.

7.2.2.15 ExternalNetworkInjection

Package: Wires

This class represents external network and it is used for IEC 60909 calculations.

Native Members

p	1..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.

q	1..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for steady state solutions.
referencePriority	1..1	integer	Priority of unit for use as powerflow voltage phase angle reference bus selection. 0 = don t care (default) 1 = highest priority. 2 is less than 1 and so on.

Inherited Members

controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.2.16 GeneratingUnit

Package: Generation

A single or set of synchronous machines for converting mechanical power into alternating-current power. For example, individual machines within a set may be defined for scheduling purposes while a single control signal is derived for the set. In this case there would be a GeneratingUnit for each member of the set and an additional GeneratingUnit corresponding to the set.

Native Members

normalPF	1..1	Simple_Float	Generating unit economic participation factor.

7.2.2.17 GroundDisconnector

Package: Wires

A manually operated or motor operated mechanical switching device used for isolating a circuit or equipment from ground.

Inherited Members

open	1..1	boolean	see Switch

7.2.2.18 HydroGeneratingUnit

Package: Generation

A generating unit whose prime mover is a hydraulic turbine (e.g., Francis, Pelton, Kaplan).

Inherited Members

normalPF	1..1	Simple_Float	see GeneratingUnit

7.2.2.19 LinearShuntCompensator

Package: Wires

A linear shunt compensator has banks or sections with equal admittance values.

Inherited Members

sections	1..1	Simple_Float	see ShuntCompensator
controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.2.20 LoadBreakSwitch

Package: Wires

A mechanical switching device capable of making, carrying, and breaking currents under normal operating conditions.

Inherited Members

open	1..1	boolean	see Switch

7.2.2.21 NonConformLoad

Package: LoadModel

NonConformLoad represent loads that do not follow a daily load change pattern and changes are not correlated with the daily load change pattern.

Inherited Members

p	1..1	ActivePower	see EnergyConsumer
q	1..1	ActivePower	see EnergyConsumer

7.2.2.22 NonlinearShuntCompensator

Package: Wires

A non-linear shunt compensator has bank or section admittance values that differs.

Inherited Members

sections	1..1	Simple_Float	see ShuntCompensator
controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.2.23 NuclearGeneratingUnit

Package: Generation

A nuclear generating unit.

Inherited Members

normalPF	1..1	Simple_Float	see GeneratingUnit

7.2.2.24 PhaseTapChangerAsymmetrical

Package: Wires

Describes the tap model for an asymmetrical phase shifting transformer in which the difference voltage vector adds to the primary side voltage. The angle between the primary side voltage and the difference voltage is named the winding connection angle. The phase shift depends on both the difference voltage magnitude and the winding connection angle.

Inherited Members

controlEnabled	1..1	boolean	see TapChanger
step	1..1	float	see TapChanger

7.2.2.25 PhaseTapChangerLinear

Package: Wires

Describes a tap changer with a linear relation between the tap step and the phase angle difference across the transformer. This is a mathematical model that is an approximation of a real phase tap changer.

The phase angle is computed as stepPhaseShitfIncrement times the tap position.

The secondary side voltage magnitude is the same as at the primary side.

Inherited Members

controlEnabled	1..1	boolean	see TapChanger
step	1..1	float	see TapChanger

7.2.2.26 PhaseTapChangerSymmetrical

Package: Wires

Describes a symmetrical phase shifting transformer tap model in which the secondary side voltage magnitude is the same as at the primary side. The difference voltage magnitude is the base in an equal-sided triangle where the sides corresponds to the primary and secondary voltages. The phase angle difference corresponds to the top angle and can be expressed as twice the arctangent of half the total difference voltage.

Inherited Members

controlEnabled	1..1	boolean	see TapChanger
step	1..1	float	see TapChanger

7.2.2.27 PhaseTapChangerTabular

Package: Wires

A tabular Phase Tap Change.

Inherited Members

controlEnabled	1..1	boolean	see TapChanger
step	1..1	float	see TapChanger

7.2.2.28 RatioTapChanger

Package: Wires

A tap changer that changes the voltage ratio impacting the voltage magnitude but not the phase angle across the transformer.

Inherited Members

controlEnabled	1..1	boolean	see TapChanger

Step	1..1	float	see TapChanger

7.2.2.29 RegulatingControl

Package: Wires

Specifies a set of equipment that works together to control a power system quantity such as voltage or flow. Remote bus voltage control is possible by specifying the controlled terminal located at some place remote from the controlling equipment. In case multiple equipment, possibly of different types, control same terminal there must be only one RegulatingControl at that terminal. The most specific subtype of RegulatingControl shall be used in case such equipment participates in the control, e.g. TapChangerControl for tap changers. For flow control load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.

Native Members

discrete	1..1	boolean	The regulation is performed in a discrete mode. This applies to equipment with discrete controls, e.g. tap changers and shunt compensators.
enabled	1..1	boolean	The flag tells if regulation is enabled.
targetDeadband	0..1	Simple_Float	This is a deadband used with discrete control to avoid excessive update of controls like tap changers and shunt compensator banks while regulating. The units of those appropriate for the mode.
targetValue	1..1	Simple_Float	The target value specified for case input. This value can be used for the target value without the use of schedules. The value has the units appropriate to the mode attribute.
targetValueUnitMultiplier	1..1	UnitMultiplier	Specify the multiplier used for the targetValue.

7.2.2.30 SolarGeneratingUnit

Package: Production

A solar thermal generating unit.

Inherited Members

normalPF	1..1	Simple_Float	see GeneratingUnit

7.2.2.31 StaticVarCompensator

Package: Wires

A facility for providing variable and controllable shunt reactive power. The SVC typically consists of a stepdown transformer, filter, thyristor-controlled reactor, and thyristor-switched capacitor arms.

The SVC may operate in fixed MVar output mode or in voltage control mode. When in voltage control mode, the output of the SVC will be proportional to the deviation of voltage at the controlled bus from the voltage setpoint. The SVC characteristic slope defines the proportion. If the voltage at the controlled bus is equal to the voltage setpoint, the SVC MVar output is zero.

Native Members

q	1..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.

Inherited Members

controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.2.32 StationSupply

Package: LoadModel

Station supply with load derived from the station output.

Inherited Members

p	1..1	ActivePower	see EnergyConsumer
q	1..1	ActivePower	see EnergyConsumer

7.2.2.33 Switch

Package: Wires

A generic device designed to close, or open, or both, one or more electric circuits. All switches are two terminal devices including grounding switches.

Native Members

open	1..1	boolean	The attribute tells if the switch is considered open when used as input to topology processing.

7.2.2.34 SynchronousMachine

Package: Wires

An electromechanical device that operates with shaft rotating synchronously with the network. It is a single machine operating either as a generator or synchronous condenser or pump.

Native Members

operatingMode	1..1	SynchronousMachineOperatingMode	Current mode of operation.
referencePriority	1..1	Integer	Priority of unit for use as powerflow voltage phase angle reference bus selection. 0 = don t care (default) 1 = highest priority. 2 is less than 1 and so on.

Inherited Members

p	1..1	ActivePower	see RotatingMachine
q	1..1	ReactivePower	see RotatingMachine
controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.2.35 TapChangerControl

Package: Wires

Describes behaviour specific to tap changers, e.g. how the voltage at the end of a line varies with the load level and compensation of the voltage drop by tap adjustment.

Inherited Members

discrete	1..1	boolean	see RegulationControl
enabled	1..1	boolean	see RegulationControl
targetDeadband	0..1	Simple_Float	see RegulationControl
targetValue	1..1	Simple_Float	see RegulationControl
targetValueUnitMultiplier	1..1	Unit_Multiplier	see RegulationControl

7.2.2.36 Terminal

Package: Core

An AC electrical connection point to a piece of conducting equipment. Terminals are connected at physical connection points called connectivity nodes.

Inherited Members

connected	1..1	boolean	see ACDCTerminal

7.2.2.37 ThermalGeneratingUnit

Package: Generation

A generating unit whose prime mover could be a steam turbine, combustion turbine, or diesel engine.

Inherited Members

normalPF	1..1	Simple_Float	see GeneratingUnit

7.2.2.38 VoltageLimit

Package: OperationalLimits

Operational limit applied to voltage.

Native members

value	1..1	Voltage	Limit on voltage. High or low limit nature of the limit depends upon the properties of the operational limit type.

7.2.2.39 VsConverter

Package: DC

DC side of the voltage source converter (VSC).

Native Members

droop	1..1	pu	Droop constant; pu value is obtained as D [kV/MW] x Sb / Ubdc.
droopCompensation	1..1	Resistance	Compensation constant. Used to compensate for voltage drop when controlling voltage at a distant bus.
pPccControl	1..1	VsPpccControlKind	Kind of control of real power and/or DC voltage.
qPccControl	1..1	VsQpccControlKind	Kind of reactive power control.
qShare	1..1	PerCent	Reactive power sharing factor among parallel converters on Uac control.
targetQpcc	1..1	ReactivePower	Reactive power injection target in AC grid, at point of common coupling.
targetUpcc	1..1	Voltage	Voltage target in AC grid, at point of common coupling.

Inherited Members

p	1..1	ActivePower	see ACDCConverter
q	1..1	ReactivePower	see ACDCConverter
targetPpcc	1..1	ActivePower	see ACDCConverter
targetUdc	1..1	Voltage	see ACDCConverter

7.2.2.40 WindGeneratingUnit

Package: Generation

A wind driven generating unit. May be used to represent a single turbine or an aggregation.

Inherited Members

normalPF	1..1	Simple_Float	see GeneratingUnit

7.2.3 Abstract Classes

7.2.3.1 ACDCConverter

Package: DC

A unit with valves for three phases, together with unit control equipment, essential protective and switching devices, DC storage capacitors, phase reactors and auxiliaries, if any, used for conversion.

Native Members

p	1..1	ActivePower	Active power at the point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node.

			Starting value for a steady state solution in the case a simplified power flow model is used.
q	1..1	ReactivePower	Reactive power at the point of common coupling. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution in the case a simplified power flow model is used.
targetPpcc	1..1	ActivePower	Real power injection target in AC grid, at point of common coupling.
targetUdc	1..1	Voltage	Target value for DC voltage magnitude.

7.2.3.2 ACDCTerminal

Package: Core

An electrical connection point (AC or DC) to a piece of conducting equipment. Terminals are connected at physical connection points called connectivity nodes.

Native Members

connected	1..1	boolean	The connected status is related to a bus-branch model and the topological node to terminal relation. True implies the terminal is connected to the related topological node and false implies it is not. In a bus-branch model, the connected status is used to tell if equipment is disconnected without having to change the connectivity described by the topological node to terminal relation. A valid case is that conducting equipment can be connected in one end and open in the other. In particular for an AC line segment, where the reactive line charging can be significant, this is a relevant case.

7.2.3.3 DCBaseTerminal

Package: DC

An electrical connection point at a piece of DC conducting equipment. DC terminals are connected at one physical DC node that may have multiple DC terminals connected. A DC node is similar to an AC connectivity node. The model enforces that DC connections are distinct from AC connections.

Inherited Members

connected	1..1	boolean	see ACDCTerminal

7.2.3.4 PhaseTapChanger

Package: Wires

A transformer phase shifting tap model that controls the phase angle difference across the power transformer and potentially the active power flow through the power transformer. This phase tap model may also impact the voltage magnitude.

Inherited Members

controlEnabled	1..1	boolean	see TapChanger
step	1..1	float	see TapChanger

7.2.3.5 PhaseTapChangerNonLinear

Package: Wires

The non-linear phase tap changer describes the non-linear behavior of a phase tap changer. This is a base class for the symmetrical and asymmetrical phase tap changer models. The details of these models can be found in the IEC 61970-301 document.

Inherited Members

controlEnabled	1..1	boolean	see TapChanger
step	1..1	float	see TapChanger

7.2.3.6 ProtectedSwitch

Package: Wires

A ProtectedSwitch is a switching device that can be operated by ProtectionEquipment.

Inherited Members

open	1..1	boolean	see Switch

7.2.3.7 RegulatingCondEq

Wires

A type of conducting equipment that can regulate a quantity (i.e. voltage or flow) at a specific point in the network.

Native Members

controlEnabled	1..1	boolean	Specifies the regulation status of the equipment. True is regulating, false is not regulating.

7.2.3.8 RotatingMachine

Package: Wires

A rotating machine which may be used as a generator or motor.

Native Members

p	1..1	ActivePower	Active power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.
q	1..1	ReactivePower	Reactive power injection. Load sign convention is used, i.e. positive sign means flow out from a node. Starting value for a steady state solution.

Inherited Members

controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.3.9 ShuntCompensator

Package: Wires

A shunt capacitor or reactor or switchable bank of shunt capacitors or reactors. A section of a shunt compensator is an individual capacitor or reactor. A negative value for reactivePerSection indicates that the compensator is a reactor. ShuntCompensator is a single terminal device. Ground is implied.

Native Members

sections	1..1	float	Shunt compensator sections in use. Starting value for steady state solution. Non integer values are allowed to support continuous variables. The reasons for continuous value are to support study cases where no discrete shunt compensators has yet been designed, a solutions where a narrow voltage band force the sections to oscillate or accommodate for a continuous solution as input.

Inherited Members

controlEnabled	1..1	boolean	see RegulatingCondEq

7.2.3.10 TapChanger

Package: Wires

Mechanism for changing transformer winding tap positions.

Native Members

controlEnabled	1..1	boolean	Specifies the regulation status of the equipment. True is regulating, false is not regulating.

step	1..1	float	Tap changer position. Starting step for a steady state solution. Non integer values are allowed to support continuous tap variables. The reasons for continuous value are to support study cases where no discrete tap changers has yet been designed, a solutions where a narrow voltage band force the tap step to oscillate or accommodate for a continuous solution as input. The attribute shall be equal or greater than lowStep and equal or less than highStep.

7.2.3.11 AsynchronousMachineKind

Package: Wires

Kind of Asynchronous Machine.

Native Members

generator	The Asynchronous Machine is a generator.
motor	The Asynchronous Machine is a motor.

7.2.3.12 CsOperatingModeKind

Package: DC

Operating mode for HVDC line operating as Current Source Converter.

Native Members

inverter	Operating as inverter
rectifier.	Operating as rectifier

7.2.3.13 CsPpccControlKind

Package: DC

Operating mode for HVDC line operating as Current Source Converter.

Native Members

activePower	Active power control at AC side.
dcCurrent	DC current control.
dcVoltage	DC voltage control.

7.2.3.14 SynchronousMachineOperatingMode

Package: Wires

Synchronous machine operating mode.

Native Members

condenser	
generator	
motor	

7.2.3.15 UnitMultiplier

Package: Domain

The unit multipliers defined for the CIM.

Native Members

G	Giga 10**9.
M	Mega 10**6.
T	Tera 10**12.
c	Centi 10**-2.
d	Deci 10**-1.
k	Kilo 10**3.
m	Milli 10**-3.
micro	Micro 10**-6.
n	Nano 10**-9.
none	No multiplier or equivalently multiply by 1.
p	Pico 10**-12.

7.2.3.16 UnitSymbol

Package: Domain

The units defined for usage in the CIM.

Native Members

A	Current in ampere.
F	Capacitance in farad.
H	Inductance in henry.
Hz	Frequency in hertz.
J	Energy in joule.
N	Force in newton.
Pa	Pressure in pascal (n/m2).
S	Conductance in siemens.
V	Voltage in volt.
VA	Apparent power in volt ampere.

VAh	Apparent energy in volt ampere hours.
VAr	Reactive power in volt ampere reactive.
VArh	Reactive energy in volt ampere reactive hours.
W	Active power in watt.
Wh	Real energy in what hours.
deg	Plane angle in degrees.
degC	Relative temperature in degrees Celsius. In the SI unit system the symbol is Âº C. Electric charge is measured in coulomb that has the unit symbol C. To distinguish degree Celsius form coulomb the symbol used in the UML is degC. Reason for not using Âº C is the special character Âº is difficult to manage in software.
g	Mass in gram.
h	Time in hours.
m	Length in meter.
m2	Area in square meters.
m3	Volume in cubic meters.
min	Time in minutes.
none	Dimension less quantity, e.g. count, per unit, etc.
ohm	Resistance in ohm.
rad	Plane angle in radians.
s	Time in seconds.

7.2.3.17 VsPpccControlKind

Package: DC

Types applicable to the control of real power and/or DC voltage by voltage source converter.

Native Members

pPcc	Control variable (target) is real power at PCC bus.
pPccAndUdcDroop	Control variables (targets) are both active power at point of common coupling and local DC voltage, with the droop.
pPccAndUdcDroopPilot	Control variables (targets) are both active power at point of common coupling and the pilot DC voltage, with the droop.
pPccAndUdcDroopWithCompensation	Control variables (targets) are both active power at point of common coupling and compensated DC voltage, with the droop; compensation factor is the resistance, as an approximation of the DC voltage of a common (real or virtual) node in the DC network.
udc	Control variable (target) is DC voltage and real power at PCC bus is derived.

7.2.3.18 VsQpccControlKind

Package: DC

Types applicable to the control of real power and/or DC voltage by voltage source converter.

Native Members

powerFactorPcc	
reactivePcc	
voltagePcc	

7.2.4 Data Types

7.2.4.1 ActivePower

Product of RMS value of the voltage and the RMS value of the in-phase component of the current.

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = W)
multiplier (UnitMultiplier = M)

7.2.4.2 AngleDegrees

Measurement of angle in degrees.

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = deg)
multiplier (UnitMultiplier = none)

7.2.4.3 CurrentFlow

Electrical current with sign convention: positive flow is out of the conducting equipment into the connectivity node. Can be both AC and DC.

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = A)
multiplier (UnitMultiplier = none)

7.2.4.4 PerCent

Percentage on a defined base. For example, specify as 100 to indicate at the defined base.

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = none)
multiplier (UnitMultiplier = none)

7.2.4.5 PU

Per Unit - a positive or negative value referred to a defined base. Values typically range from -10 to +10.

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = none)
multiplier (UnitMultiplier = none)

7.2.4.6 ReactivePower

Product of RMS value of the voltage and the RMS value of the quadrature component of the current.

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = VAr)
multiplier (UnitMultiplier = M)

7.2.4.7 Resistance

Resistance (real part of impedance).

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = ohm)
multiplier (UnitMultiplier = none)

7.2.4.8 Voltage

Electrical voltage, can be both AC and DC.

XSD type: float

Native Attributes

value (Float)
units (UnitSymbol = V)
multiplier (UnitMultiplier = k)

7.3 Topology profile

7.3.1 General

A Topology dataset contains all objects defined in topology profile and includes data for topology information relating to a given exchange.

Profile URI: http://iec.ch/TC57/2013/61970-456/Topology/4

7.3.2 Concrete Classes

7.3.2.1 ACDCConverterDCTerminal

Package: DC

A DC electrical connection point at the AC/DC converter. The AC/DC converter is electrically connected also to the AC side. The AC connection is inherited from the AC conducting equipment in the same way as any other AC equipment. The AC/DC converter DC terminal is separate from generic DC terminal to restrict the connection with the AC side to AC/DC converter and so that no other DC conducting equipment can be connected to the AC side.

Inherited Members

DCTopologicalNode	1..1	DCTopologicalNode	see DCBaseTerminal

7.3.2.2 ConnectivityNode

Package: Core

Connectivity nodes are points where terminals of AC conducting equipment are connected together with zero impedance.

Native Members

TopologicalNode	1..1	TopologicalNode	The connectivity nodes combine together to form this topological node. May depend on the current state of switches in the network.

7.3.2.3 DCNode

Package: DC

DC nodes are points where terminals of DC conducting equipment are connected together with zero Impedance.

Native Members

DCTopologicalNode	1..1	DCTopologicalNode	see association end TopologicalNode.ConnectivityNodes

7.3.2.4 DCTerminal

Package: DC

An electrical connection point to generic DC conducting equipment.

Inherited Members

DCTopologicalNode	1..1	DCTopologicalNode	see DCBaseTerminal

7.3.2.5 DCTopologicalNode

Package: Topology

A class to describe the DC bus.

Native Members

DCEquipmentContainer	1..1	DCEquipmentContainer	The connectivity node container to which the toplogical node belongs.

Inherited Members

mRID	0..1	string	see IdentifiedObject
description	0..1	string	see IdentifiedObject
name	1..1	string	see IdentifiedObject

7.3.2.6 Terminal

Package: Core

An AC electrical connection point to a piece of conducting equipment. Terminals are connected at physical connection points called connectivity nodes.

Native Members

TopologicalNode	1..1	TopologicalNode	The terminals associated with the topological node. This can be used as an alternative to the connectivity node path to terminal, thus making it unneccesary to model connectivity nodes in some cases. Note that if connectivity nodes are in the model, this association would probably not be used as an input specification.

7.3.2.7 TopologicalNode

Package: Topology

For a detailed substation model a topological node is a set of connectivity nodes that, in the current network state, are connected together through any type of closed switches, including jumpers. Topological nodes change as the current network state changes (i.e., switches, breakers, etc. change state). For a planning model, switch statuses are not used to form topological nodes. Instead they are manually created or deleted in a model builder tool. Topological nodes maintained this way are also called "busses".

Native Members

BaseVoltage	1..1	BaseVoltage	The base voltage of the topologocial node
ConnectivityNodeContainer	1..1	ConnectivityNodeContainer	The connectivity node container to which the toplogical node belongs.
ReportingGroup	0..1	ReportingGroup	The topological nodes that belong to the reporting group.

Inherited Members

mRID	0..1	string	see IdentifiedObject
description	0..1	string	see IdentifiedObject
name	1..1	string	see IdentifiedObject

7.3.3 Abstract Classes

7.3.3.1 DCBaseTerminal

Package: Core

An electrical connection point at a piece of DC conducting equipment. DC terminals are connected at one physical DC node that may have multiple DC terminals connected. A DC node is similar to an AC connectivity node. The model enforces that DC connections are distinct from AC connections.

Native Members

DCTopologicalNode	1..1	DCTopologicalNode	see association end Terminal.TopologicalNode.

7.3.3.2 IdentifiedObject

Package: Core

This is a root class to provide common identification for all classes needing identification and naming attributes.

Native Members

mRID	0..1	string	Master resource identifier issued by a model authority. The mRID is globally unique within an exchange context. Global uniqueness is easily achieved by using a UUID, as specified in RFC 4122, for the mRID. The use of UUID is strongly recommended. For CIMXML data files in RDF syntax conforming to IEC 61970-552 Edition 1, the mRID is mapped to mRID or rdf:about attributes that identify CIM object elements.
description	0..1	string	The description is a free human readable text describing or naming the object. It may be non- unique and may not correlate to a naming hierarchy.
name	1..1	string	The name is any free human readable and possibly non unique text naming the object.

7.4 StateVariables profile

7.4.1 General

A State Variable dataset contains all objects required to complete the specification of a steady-state solution. A State Variables dataset is always exchanged in full. A State Variables dataset of an assembled model contains state variables related objects for all model authority sets being part of the assembled model.

Profile URI: http://iec.ch/TC57/2013/61970-456/StateVariables/4#

7.4.2 Concrete Classes

7.4.2.1 CsConverter

Package: DC

DC side of the current source converter (CSC).

Native Members

alpha	1..1	AngleDegrees	Firing angle, typical value between 10 and 18 degrees for a rectifier. CSC state variable, result from power flow.
gamma	1..1	AngleDegrees	Extinction angle. CSC control variable used in power flow.

Inherited Members

idc	1..1	CurrentFlow	see ACDCConverter
poleLossP	1..1	ActivePower	see ACDCConverter

uc	1..1	Voltage	see ACDCConverter
udc	1..1	Voltage	see ACDCConverter

7.4.2.2 DCTopologicalIsland

Package: DC

An electrically connected subset of the network. DC topological islands can change as the current network state changes: e.g. due to

- disconnect switches or breakers change state in a SCADA/EMS

- manual creation, change or deletion of topological nodes in a planning tool.

Native Members

DCTopologicalNodes	1..unbounded	DCTopologicalNodes	The DC topological nodes in a DC topological island.

Inherited Members

mRID	0..1	string	see IdentifiedObject
description	0..1	string	see IdentifiedObject
name	1..1	string	see IdentifiedObject

7.4.2.3 SvInjection

Package: StateVariables

The SvInjection is reporting the calculated bus injection minus the sum of the terminal flows. The terminal flow is positive out from the bus (load sign convention) and bus injection has positive flow into the bus. SvInjection may have the remainder after state estimation or slack after power flow calculation.

Native members

pInjection	1..1	ActivePower	The active power mismatch between calculated injection and initial injection. Positive sign means injection into the TopologicalNode (bus).
qInjection	0..1	ReactivePower	The reactive power mismatch between calculated injection and initial injection. Positive sign means injection into the TopologicalNode (bus).
TopologicalNode	1..1	TopologicalNode	The topological node associated with the voltage state.

7.4.2.4 SvPowerFlow

Package: StateVariables

State variable for power flow. Load convention is used for flow direction. This means flow out from the TopologicalNode into the equipment is positive.

Native members

p	1..1	ActivePower	The active power flow.

			Load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.
q	1..1	ReactivePower	The reactive power flow. Load sign convention is used, i.e. positive sign means flow out from a TopologicalNode (bus) into the conducting equipment.
Terminal	1..1	Terminal	The terminal associated with the power flow state variable.

7.4.2.5 SvShuntCompensatorSections

Package: StateVariables

State variable for the number of sections in service for a shunt compensator

Native members

sections	1..1	Simple_Float	The number of sections in service as a continous variable. To get integer value scale with ShuntCompensator perSection.
ShuntCompensator	1..1	ShuntCompensator	The shunt compensator for which the state applies.

7.4.2.6 SvStatus

Package: StateVariables

State variable for status.

Native members

inService	1..1	boolean	The in service status as a result of topology processing.
ConductingEquipment	1..1	ConductingEquipment	The conducting equipment associated with the status state variable.

7.4.2.7 SvTapStep

Package: StateVariables

State variable for transformer tap step. This class is to be used for taps of LTC (load tap changing) transformers, not fixed tap transformers.

Native members

position	1..1	float	The floating point tap position. This is not the tap ratio, but rather the tap step position as defined by the related tap changer model and normally is constrained to be within the range of minimum and maximum tap positions.

TapChanger	1..1	TapChanger	The tap changer associated with the tap step state.

7.4.2.8 SvVoltage

Package: StateVariables

State variable for voltage

Native members

angle	1..1	AngleRadians	The voltage angle in radians of the topological node.
v	1..1	Voltage	The voltage magnitude of the topological node.
TopologicalNode	1..1	TopologicalNode	The topological node associated with the voltage state.

7.4.2.9 TopologicalIsland

Package: Topology

An electrically connected subset of the network. Topological islands can change as the current network state changes: e.g. due to

- disconnect switches or breakers change state in a SCADA/EMS
- manual creation, change or deletion of topological nodes in a planning tool.

Native members

AngleRef_TopologicalNode	1..1	TopologicalNode	The angle reference for the island. Normally there is one TopologicalNode that is selected as the angle reference for each island. Other reference schemes exist, so the association is optional.
TopologicalNodes	1..unbounded	TopologicalNodes	A topological node belongs to a topological island.

Inherited members

mRID	0..1	string	see IdentifiedObject
description	0..1	string	see IdentifiedObject
name	1..1	string	see IdentifiedObject

7.4.2.10 UnitMultiplier

Package: Domain

The unit multipliers defined for the CIM.

Native members

G	Giga 10**9.
M	Mega 10**6.

T	Tera 10**12.
c	Centi 10**-2.
d	Deci 10**-1.
k	Kilo 10**3.
m	Milli 10**-3.
micro	Micro 10**-6.
n	Nano 10**-9.
none	No multiplier or equivalently multiply by 1.
p	Pico 10**-12.

7.4.2.11 UnitSymbol

Package: Domain

The units defined for usage in the CIM.

Native members

A	Current in ampere.
F	Capacitance in farad.
H	Inductance in henry.
Hz	Frequency in hertz.
J	Energy in joule.
N	Force in newton.
Pa	Pressure in pascal (n/m2).
S	Conductance in siemens.
V	Voltage in volt.
VA	Apparent power in volt ampere.
VAh	Apparent energy in volt ampere hours.
VAr	Reactive power in volt ampere reactive.
VArh	Reactive energy in volt ampere reactive hours.
W	Active power in watt.
Wh	Real energy in what hours.
deg	Plane angle in degrees.
degC	Relative temperature in degrees Celsius. In the SI unit system the symbol is Â°C. Electric charge is measured in coulomb that has the unit symbol C. To distinguish degree Celsius form coulomb the symbol used in the UML is degC. Reason for not using Â°C is the special character Â° is difficult to manage in software.
g	Mass in gram.

h	Time in hours.
m	Length in meter.
m2	Area in square meters.
m3	Volume in cubic meters.
min	Time in minutes.
none	Dimension less quantity, e.g. count, per unit, etc.
ohm	Resistance in ohm.
rad	Plane angle in radians.
s	Time in seconds.

7.4.2.12 VsConverter

Package: DC

DC side of the voltage source converter (VSC).

Native Members

delta	1..1	AngleDegrees	Angle between uf and uc. Converter state variable used in power flow.
uf	1..1	Voltage	Line-to-line voltage on the valve side of the converter transformer. Converter state variable, result from power flow.

Inherited Members

idc	1..1	CurrentFlow	see ACDCConverter
poleLossP	1..1	ActivePower	see ACDCConverter
uc	1..1	Voltage	see ACDCConverter
udc	1..1	Voltage	see ACDCConverter

7.4.3 Abstract Classes

7.4.3.1 ACDCConverter

Package: DC

A unit with valves for three phases, together with unit control equipment, essential protective and switching devices, DC storage capacitors, phase reactors and auxiliaries, if any, used for conversion.

Native Members

idc	1..1	CurrentFlow	Converter DC current, also called Id. Converter state variable, result from power flow.

poleLossP	1..1	ActivePower	The active power loss at a DC Pole = idleLoss + switchingLoss*|Idc| + resitiveLoss*Idc^2 For lossless operation Pdc=Pac For rectifier operation with losses Pdc=Pac-lossP For inverter operation with losses Pdc=Pac+lossP Converter state variable used in power flow.
uc	1..1	Voltage	Converter voltage, the voltage at the AC side of the bridge. Converter state variable, result from power flow.
udc	1..1	Voltage	Converter voltage at the DC side, also called Ud. Converter state variable, result from power flow.

7.4.3.2 IdentifiedObject

Package: Core

This is a root class to provide common identification for all classes needing identification and naming attributes.

Native Members

mRID	0..1	string	Master resource identifier issued by a model authority. The mRID must semantically be a UUID as specified in RFC 4122. The mRID is globally unique. For CIMXML data files in RDF syntax, the mRID is mapped to mRID or rdf:about attributes that identify CIM object elements.
description	0..1	string	The description is a free human readable text describing or naming the object. It may be non-unique and may not correlate to a naming hierarchy.
name	1..1	string	The name is any free human readable and possibly non unique text naming the object.

7.4.4 Data Types

7.4.4.1 ActivePower

Product of RMS value of the voltage and the RMS value of the in-phase component of the current.

XSD type: float

Native Attributes

value	(Float)
units	(UnitSymbol = W)
multiplier	(UnitMultiplier = M)

7.4.4.2 AngleDegrees

Measurement of angle in degrees.

XSD type: float

Native Attributes

value	(Float)
units	(UnitSymbol = deg)
multiplier	(UnitMultiplier = none)

7.4.4.3 CurrentFlow

Electrical current with sign convention: positive flow is out of the conducting equipment into the connectivity node. Can be both AC and DC.

XSD type: float

Native Attributes

value	(Float)
units	(UnitSymbol = A)
multiplier	(UnitMultiplier = none)

7.4.4.4 ReactivePower

Product of RMS value of the voltage and the RMS value of the quadrature component of the current.

XSD type: float

Native Attributes

value	(Float)
units	(UnitSymbol = VAr)
multiplier	(UnitMultiplier = M)

7.4.4.5 Simple_Float

A floating point number. The range is unspecified and not limited.

XSD type: float

7.4.4.6 Voltage

Electrical voltage, can be both AC and DC.

XSD type: float

Native Attributes

value	(Float)
units	(UnitSymbol = V)
multiplier	(UnitMultiplier = k)

Bibliography

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org/)

IEC 61970-1, *Energy management system application program interface (EMS-API) – Part 1: Guidelines and general requirements*

IEC/TS 61970-2, *Energy management system application program interface (EMS-API) – Part 2: Glossary*

IEC 61970-301, *Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base*

IEC 61970-501, *Energy management system application program interface (EMS-API) – Part 501: Common Information Model Resource Description Framework (CIM RDF) schema*

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