IEC 61970-401

Edition 1.0 2022-05

INTERNATIONAL STANDARD

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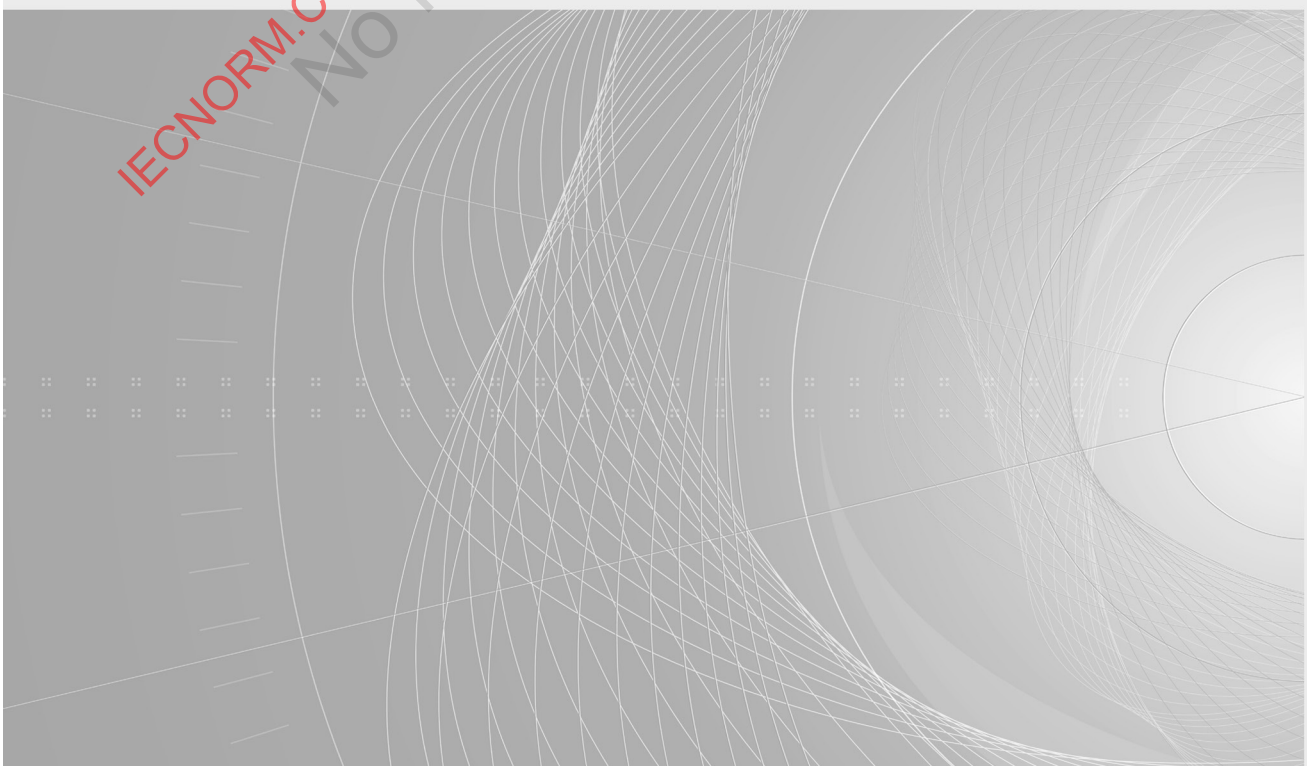
Energy management system application program interface (EMS-API) – Part 401: Profile framework

Interface de programmation d'application pour système de gestion d'énergie (EMS-API) –
Partie 401: Cadre de profils



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 401: Profile framework

FOREWORD

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IEC 61970-401 has been prepared by IEC technical committee 57: Power systems management and associated information exchange. It is an International Standard.

This first edition cancels and replaces IEC TS IEC 61970-401 published in 2005. This edition constitutes a technical revision.

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

a) The previous edition of IEC TS 61970-401:2005 provided an overview of the Component Interface Specifications (CIS) IEC 61970-402, IEC 61970-403, IEC 61970-404, IEC 61970-405, and IEC 61970-407. IEC 61970-402 to IEC 61970-407 are duplicates of existing OPC interfaces from OPC Foundation and the DAIS/HDA interfaces from OMG. Hence IEC 61970-402 to IEC 61970-407 have been withdrawn and IEC TS 61970-401:2005 no longer serves a purpose.

b) IEC 61970-401 (this document) does not contain an overview of Component Interface Specifications (CIS) but instead a description of how to create profile specifications that describes dataset contents (or message contents). Hence it has been renamed "Profile framework". The profile specifications IEC 61970-450 (all parts) and IEC 61970-600 (all parts) describe dataset contents. The purpose of this document is to define the rules to be followed in the process of creating profile specifications.

The text of this International Standard is based on the following documents:

Draft	Report on voting
57/2482/FDIS	57/2494/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 61970 series, published under the general title *Energy management system application program interface (EMS-API)*, can be found on the IEC website.

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

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

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INTRODUCTION

This document is one of the IEC 61970 series that defines message interfaces for network application data exchange.

The IEC 61970-300 series of documents specify a canonical Common Information Model (CIM) describing network application data. The CIM is an information model that represents all the major objects in an electric utility enterprise needed to describe data used by power network applications. The Canonical CIM provides the semantics for IEC 61970-450 (all parts) and IEC 61970-600 (all parts) profile specifications dedicated to specific data exchanges.

This document describes the framework in which profile specifications are created from the Canonical CIM. It describes the structure of profile documents and the rules for selection of information from the Canonical CIM to be included in profile specifications.

The reasons for creating this document are

1) The IEC 61970 profiles have for a long time been created using a profiling method not described by an IEC 61970 document.
2) The IEC 61970 profiling method has issues that need resolution. Issues and solutions are described in Annex A.

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

Part 401: Profile framework

1 Scope

This document describes how IEC 61970-450 (all parts), IEC 61970-600 (all parts) profile specifications are structured and created. Profile specifications describe a subset of the Canonical CIM dedicated to a specific data exchange. The Canonical CIM is described in IEC 61970-300 (all parts) as well as in IEC 61968-11.

Rules for creation or extension of Canonical CIM are outside the scope of this document.

This document specifies the structure of a profile specification and the rules for selecting subsets of information from the Canonical CIM. It standardizes the operations used to create the profile elements from the Canonical CIM. As Canonical CIM is described in UML the operations are described in terms of UML classes, attributes, and roles.

It is possible to map UML to RDFS or OWL, so any of the languages UML, RDFS or OWL can be used to describe the created profiles. Specification of languages (UML, RDFS or OWL) used to describe profiles as well as how profiles are presented and edited in user interfaces are outside the scope of this document. Languages used to describe profiles are specified in other specifications. Relevant specifications are referenced in Clause 2.

UML supports adding free text that describes further restrictions on UML constructs, e.g. classes, attribute values, association roles and cardinalities. Languages such as OCL and SHACL are dedicated to describing constraints. OCL is used to describe constraints for object data described in UML while SHACL is used to describe constraints on graph data described by RDFS or OWL. OCL is within the scope of this document, but SHACL is not.

This document supports profiles describing data exchanged as CIMXML datasets or messages. The exchange format within the scope is in accordance with IEC 61970-552 but other formats are possible.

Tool interoperability and serialisation formats are outside the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes the requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61968-11, *Application integration at electric utilities – System interfaces for distribution management – Part 11: Common information model (CIM) extensions for distribution*

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

IEC 61970-300 (all parts), *Energy management system application program interface (EMS-API)*

IEC 61970-501:2006, *Energy management system application program interface (EMS-API) – Part 501: Common Information Model Resource Description Framework (CIM RDF) schema*[1]

IEC 61970-552, *Energy management system application program interface (EMS-API) – Part 552: CIMXML Model exchange format*

OMG Unified Modeling Language®, OMG document number: formal/2015-03-01, available at http://www.omg.org/spec/UML/2.5

World Wide Web Consortium (W3C), RDF 1.1 Primer from 24 June 2014, available at https://www.w3.org/TR/rdf11-primer/

World Wide Web Consortium (W3C), RDF 1.1 Concepts and Abstract Syntax from 25 February 2014, available at https://www.w3.org/TR/rdf11-concepts/

World Wide Web Consortium (W3C), RDF 1.1 XML Syntax from 25 February 2014, available at https://www.w3.org/TR/rdf-syntax-grammar/

World Wide Web Consortium (W3C), RDF Schema 1.1 from 25 February 2014, available at https://www.w3.org/TR/rdf-schema/

World Wide Web Consortium (W3C), OWL 2 Web Ontology Language Primer (Second Edition), W3C Recommendation 11 December 2012, available at https://www.w3.org/TR/owl2-primer/

World Wide Web Consortium (W3C), OWL 2 Web Ontology Language Structural Specification and Functional-Style Syntax (Second Edition), W3C Recommendation 11 December 2012, available at https://www.w3.org/TR/owl2-syntax/

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC TS 61970-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
Canonical CIM
agreed semantic information model describing the power system domain; the information model aims at describing the power system domain in a normalized way without overlap

Note 1 to entry: The Canonical CIM is described in UML. UML can be serialized (saved as a document) in the standardized data format XMI for exchange between UML tools. Ecore is another serialization format with capability to describe UML.

[1] This specification is based on the W3C specification RDF Schema 1.0 from early 2000 which has since been revised multiple times.

3.1.2
profile
subset derived from Canonical CIM supporting the exchange of a specific set of data in a specific context

Note 1 to entry: A semantic information model in the same way as Canonical CIM, can be serialized in several different formats:

- XMI that is the serialisation format of UML as described by OMG, see clause 2;
- RDF/XML used to serialize RDFS or OWL;
- RDF/XML as described by IEC 61970-501. IEC 61970-501 contains several custom extensions to the RDFS specification from 1999;
- Ecore for exchange with Eclipse Modelling Framework (EMF).

Note 2 to entry: The serialisation of IEC 61970 profiles is standardised by IEC 61970-501. A collection of profiles supports a specific use case.

3.1.3
profiling
process of creating profiles

3.1.4
dataset
set of data described by a profile which means that the data in a dataset align with the information described by the profile

Note 1 to entry: A profile does not say anything about the data format.

3.1.5
data format
datasets carrying data described by profiles as defined in this document using CIMXML described in IEC 61970-552 and RDF/XML based on RDFS as described in IEC 61970-501

3.2 Abbreviated terms

The abbreviated terms are given in Table 1.

Table 1 – Abbreviated terms

Abbreviated term	Description
CIMXML	CIMXML is an RDF/XML data format and is described in the specification IEC 61970-552.
RDF/XML	A serialization format for RDF and graph data. For more details refer to the W3C specification RDF 1.1 XML Syntax.
RDF	RDF stands for Resource Description Framework and is an information model for graph data consisting of a: – Resource, in CIMXML this is an object identifier. – Predicate, in CIMXML this is an attribute or role name. – data item, in CIMXML this is a value or a resource reference. For an introduction to RDF refer to the W3C specification RDF 1.1 Primer.
RDFS	RDFS stands for RDF Schema and is an extension of RDF with capability to describe a vocabulary for data-modelling. Hence it is an information modelling language but with less capability than UML. For more details refer to the W3C specification RDF Schema 1.1.
OWL	OWL is an ontology language supporting the semantic web, it is a further development and extension of RDFS. For an introduction to OWL refer to the W3C recommendation OWL 2 Web Ontology Language Primer (Second Edition).
UML	UML stands for Unified Modelling Language. For more details refer to the OMG specification formal/2015-03-01.

4 Overview

4.1 Profiles and profiling

Profiling is the process of selecting information from the Canonical CIM and including it in profiles.

The Canonical CIM is described in IEC 61970-300 (all parts) and IEC 61968-11.

The guiding principle for the profiling method is that the information described by a profile is a true subset of the Canonical CIM and retains class, role names, attribute names and datatypes from the Canonical CIM. The datatypes in CIM are described by classes stereotyped Primitive, CIMDatatype, and Compound. CIMDatatype is a composition of three attributes: value, unit, and multiplier while Compound consists of an arbitrary set of attributes.

The main objective is that different datasets (see Clause 3) exchanged using different profiles based on Canonical CIM solely rely on the definitions and basic principles of the Canonical CIM. This is key to make interoperability feasible. This also enables different profiles to relate data between them by using the Canonical CIM as a hub and supports a reader of a dataset or a message to easily find descriptions of elements in both the profiles and the Canonical CIM. The support for relating data in different datasets or messages described by different profiles is needed when data is divided across different datasets governed by different profiles. Such use cases are defined for network models where the network description is separated from the operational conditions of the network (seen as an input) and the results.

There are several languages that can describe profiles, e.g. UML (serialized as XMI), RDFS, Ecore or OWL. UML includes a graphical language that is implemented by UML editors. OWL does not have a graphical language, but several editors exist that support the display and editing of OWL data.

Current profile specifications, IEC 61970-450 (all parts) and IEC 61970-600 (all parts) use UML to describe the information and OCL to further restrict the information. A profile in UML is described by classes, attributes, associations, roles and datatypes, the common way to describe information in UML. The UML language includes the concept of stereotypes and tagged values that enables custom extensions of the UML language. Hence profiling with UML means copying and updating classes, attributes, associations, stereotypes and tagged values from the Canonical CIM. A profile in RDFS or OWL is described by classes and properties but UML stereotypes and tagged values do not have a direct mapping to RDFS/OWL. Profiling using OWL mean creating OWL classes and properties by selecting UML classes, attributes, and roles from Canonical CIM the same way as for profiling with UML. UML stereotypes and tagged values need a specific mapping depending on the meaning of the stereotypes or tagged values. Clause A.1 presents a mapping of the Canonical CIM UML to OWL.

Figure 1 gives an overview of the IEC 61970 specifications in the context of profiling.

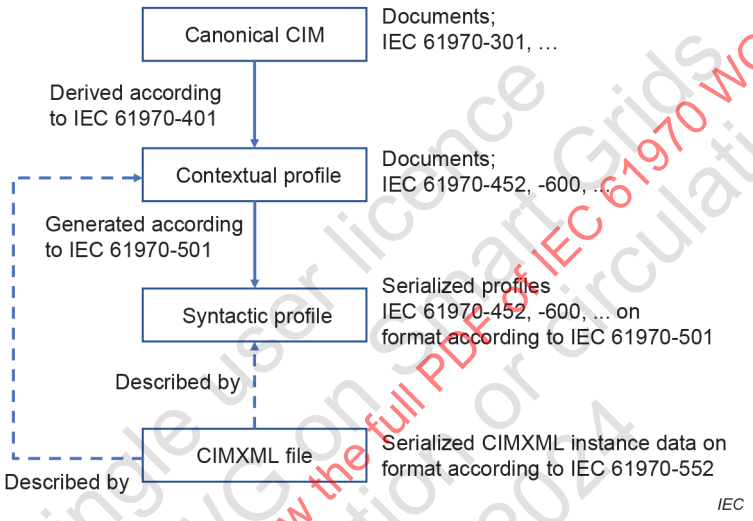

Figure 1 – Relations between standards and profiling

The Canonical CIM is shown at the top in Figure 1. Based on the Canonical CIM and a context for the usage, a contextual profile is created. A serialisation of the contextual profile is a syntactic profile. The serialisation format for contextual profiles is described by IEC 61970-501. IEC 61970-501 is the only graph based syntactic profile. Other syntactic profile exists, e.g. a UML based tool can serialize the profile in the XMI format, a tool based on Eclipse Modelling Framework (EMF) can serialize a profile in Ecore and an OWL based tool can use RDF/XML. All these syntactic profiles describe the same contextual profile but, in a format, specific for the chosen serialisation (UML/XMI, Ecore, RDFS, OWL, etc.). Each possible syntactic profile has its own specification, e.g. like IEC 61970-501.

Datasets on CIMXML format are serialized according to IEC 61970-552 and the data in a CIMXML dataset is described by a profile. The contextual and syntactic profile describe the same information, the only difference being that the syntactic profile is machine readable and can be used in processing or validation of CIMXML datasets.

Tools that process data described by profiles, created according to this document, need a machine-readable serialization of the profiles, the syntactic profile. IEC 61970-501 is an RDFS based serialization intended for this. Profiling tools shall support the generation of profiles in the IEC 61970-501 serialisation format. Any tool, regardless of whether it is based on UML or OWL, will have to serialize profiles into a syntactic profile that is used for exchange with other tools or saved for persistency. IEC 61970-501 does not contain all information needed by profiling tools, e.g. it is possible to generate a IEC 61970-501 syntactic profile from a UML representation but not possible to recreate UML from a profile on IEC 61970-501 format. Hence IEC 61970-501 cannot be used as an exchange format between UML based profiling tools.

Standardized vocabularies, that may be used in addition to Canonical CIM, are available from many sources, e.g.:

- The Dublin Core™ from the Dublin Core Metadata initiative dated 18 December 2006,
- The Profiles Vocabulary (DX-PROF) from W3C, a note dated 18 December 2019,
- Profile Guidance from W3C, a draft dated 24 November 2021.

How such vocabularies may be used together with Canonical CIM is not described and requires further development.

4.2 Relations between Canonical CIM, profiles and datasets

The CIM specifications can be divided in two groups:

- Canonical CIM,
- Profile derived from Canonical CIM.

The Canonical CIM is an information model for the power system domain standardized by IEC and it is intended to be normalized (information is described only once) without duplicate definitions of the same concept. Canonical CIM is intended to be an information model for the concepts in a domain and not a description of data exchanged by messages.

A profile is a subset of the Canonical CIM intended for a specific data exchange in a specific context, hence a profile is an information model for exchanged data. Information from Canonical CIM is divided into profiles that describe data exchange in different contexts; examples are equipment data that is relatively stable with a low change frequency and power system state that change in times from milliseconds up to hours depending on the use case. The context for equipment data is typically a data modeller tool where the equipment data is maintained while the context for power system state could be real time systems (WAMS, SCADA) or operational planning systems.

IEC 61970 (all parts) support analytical functions used in studies of power systems. A case used in a study is assembled by several datasets described by different profiles, e.g. to run a power flow both equipment data and power system state are needed. Hence the IEC 61970 profiles are dependent on each other and use cases typically involve multiple datasets described by different profiles.

This Subclause (4.2) explains the relationship between the information discussed above and in 4.1. Figure 2 shows the dependencies.

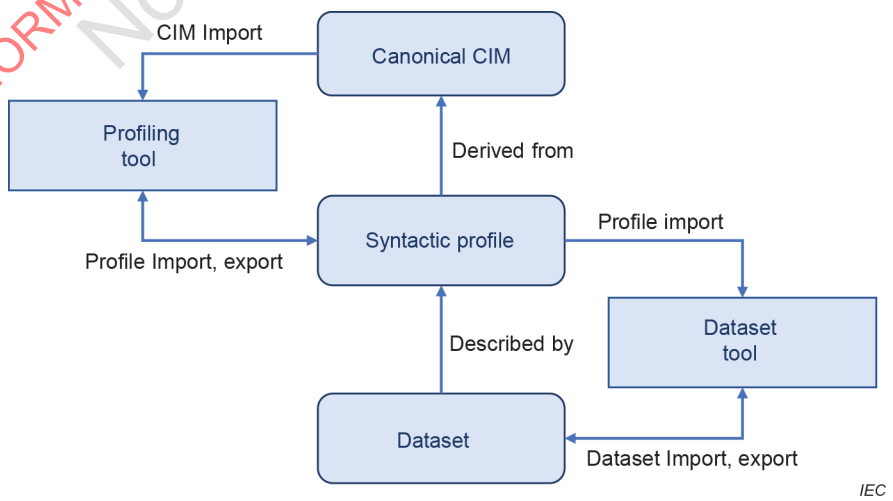

Figure 2 – Relation between Canonical CIM, profiles and datasets

Figure 2 describes the relations between the Canonical CIM, profiles and datasets. The Canonical CIM at the top of Figure 2 is described in IEC 61970-300 (all parts) and in IEC 61968-11. The profiling process described in this document is represented by the arrow "Derived from" and the "Profiling tool" that is used to create the "Syntactic profiles". Examples of profiles created using the profiling process are IEC 61970-450 (all parts) and IEC 61970-600 (all parts).

The datasets (bottom of Figure 2) are typically exchanged as CIMXML files but other data formats are possible if they comply with profiles generated according to this document. A dataset is described by a profile ("Described by" in Figure 2) and is serialized as CIMXML files as described in IEC 61970-552.

The "Dataset tool" processes "Datasets", e.g. export, import, validation, etc. A "Dataset tool" could be hardcoded against a set of profiles but could also import profiles and use them upon processing as indicated in Figure 2 with the arrow "Profile import". For this to work, a machine-readable version of a profile is needed such as a syntactic profile on RDFS format as described in IEC 61970-501. Serializations for other information modelling languages are also possible, e.g. XMI, OWL or Ecore, but IEC 61970 uses RDF based technologies as defined by IEC 61970-501. The ability for a "Dataset tool" to import and use a machine-readable version of a profile ("Profile import" in Figure 2) is sometimes referred to as a model-driven architecture as the tool adapts to the profiles. To support a model-driven usage the "Dataset tool" the "Profiling tool" shall import and export syntactic profiles on IEC 61970-501 format. Example use cases for syntactic profiles are:

- Profiling tools that read, update, and save profiles.
- Validation tools that read CIMXML files and check that they comply with syntactic profiles.
- Data management tools that import and export CIMXML files.
- Analytical functions importing input data and exporting result data.

The syntactic profile language in IEC 61970-501:2006 has custom extensions to RDFS as the RDFS standard had not yet been finalized when IEC 61970-501 was published. RDFS has evolved and has been extended so that IEC 61970-501:2006 custom extensions can be replaced. Also note that IEC 61970-501:2006 does not provide sufficient information to enable tool interoperability: other formats need to be considered for this, e.g. XMI that is standardised by OMG and OWL standardized by W3C.

4.3 Profiles and business processes

Datasets are exchanged in the context of a business process which typically means multiple datasets defined by different profiles. The Canonical CIM is typically split over the different profiles. Consequently, the datasets need to be assembled into a complete model whereby each dataset contributes data according to its defining profile.

IEC 61970-450 (all parts) and IEC 61970-600 (all parts) describe data that are used in analytical calculations (e.g. power flow calculations, security analysis, short circuit calculations). Input to such calculations are models including a complete set of data needed to solve the analytical calculation. It is common to divide data in groups. Profiling support grouping by dividing information in multiple profiles where each profile describes one group. Reasons for creating data groups could be different origins and change rates. Power system equipment is stable over time and is only changed when new equipment is added, or old equipment removed. Hence data describing the power system equipment has a low change rate and typically originate from dedicated data management tools. Power system state may change monthly for long term planning, hourly for operational planning, secondly for real time operation and down to millisecond for studies of the dynamic behaviour. Hence power system state data benefit from being exchanged separately from equipment data. A result of this is that data in a model used by analytical functions can be divided in profiles that support exchange of parts of the model as CIMXML files. A consequence is that running an analytical calculation with CIMXML files as input requires an assembly process where the CIMXML files are assembled into a complete

model. The profiling process shall then ensure that the profiles describe the relations not only within a CIMXML file but also between data in different CIMXML files.

Whether an assembled model is complete and valid is determined in a validation process where all the profiles defined for the business process are used. A per profile validation is in many cases not meaningful as information distributed over different profiles cannot be checked until the complete model has been assembled.

5 Profile document structure

The IEC 61970-450 and IEC 61970-600 profile documents shall strictly follow a common structure including the following clauses:

1) “Scope” that describes the document application.
2) “Normative references” that contains a list of publications that are referred to in the text in such a way that some or all of their content constitutes the requirements of this document.
3) “Terms, definitions and abbreviated terms” used in the profile.
4) “Application profile specification” that specifies the following
   a) A reference to the canonical information model as an XMI file name from which the profile is derived.
   b) A list of the profiles defined in the document. Each profile definition consists of:
      i) Name, e.g. StateVariables (SV),
      ii) Version, e.g. 4.,
      iii) Date of the version,
      iv) URI that uniquely identifies the profile including its version, e.g. http://iec.ch/TC57/2013/61970-456/StateVariables/4.
   c) Requirements
   d) Constraints
5) “Overview” that describes the context in which this profile is intended to be used and the relation to other profiles. Use cases for which the profile is applicable are also described.
6) Use cases that describe where the profile is applicable.
7) Profile sections describing the information in the profiles.

6 Profiling Use cases

6.1 Overview

This Subclause 6.1 describes the use cases for how profiles are created from the Canonical CIM. This subclause provides a descriptive overview. The normative use is described in Clause 7.

Profiling is the process where UML classes, attributes, roles and datatypes are selected to be included in a profile. This process follows the rules described in Clause 7.

In the profiling process, a subset of the attributes and roles from a class in Canonical CIM are included in a profile. It is then possible to change attribute and role cardinalities. If new information is needed that is not in Canonical CIM, existing classes can be extended with more attributes or roles as well as new classes added to the Canonical CIM. When adding new attributes new datatypes may also be needed, they are then first added in the Canonical CIM.

Profiling use cases that have been identified can be done as follows.

a) Include different sets of attributes and roles from the same class in different profiles, see 6.2.

b) Include overlapping sets of attributes and roles from the same class in different profiles, see 6.3.

c) Include a base class with different sets of attributes or roles, see 6.4.

d) Extend an existing class, see 6.5.

e) Extend an existing class used differently in different profiles, see 6.6.

f) Different cardinalities, see 6.7.

g) Add a new datatype, see 6.8.

The above profiling cases are limited to the use cases related to the IEC 61970-450 profiles and modelling capability of UML. When profiling is made additional constraints that goes beyond the capability of UML are often needed. Such constraints could be

- Constraining the value space of an attribute. This could be numeric value constraints, enumeration lists, string length constraints, string content constraints, complex comparisons including attributes from related classes, etc.
- Constraining role cardinalities for subclasses inheriting associations from a more generic class.
- Constraining the occurrence of class instances depending on context.

Constraints like this can be described by the formal languages OCL or SHACL. As OCL or SHACL constraints are not included in the Canonical CIM they are not part of the profiling process but added to the profiles after profiling has been made.

Subclauses 6.2 to 6.8 contain examples from existing profiles, e.g.:

- Steady State Hypothesis (SSH) from IEC 61970-456 and IEC 61970-600;
- Equipment (EQ) IEC 61970-452 and IEC 61970-600.

6.2 Class in different profiles with no overlap

This is the most common use case. A non-overlapping subset of the attributes and roles from a class is included in one or more profiles, see Figure 3.

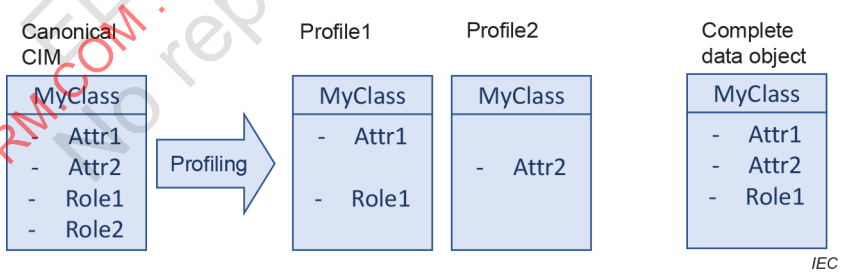

Figure 3 – Class in different profiles with no overlap

An example of MyClass in Figure 3 could be any CIM class with power flow injection data in the SSH profile and static data in the EQ profile, e.g. cim:EnergyConsumer.

A power flow application will then have to collect data from both the EQ and SSH profile datasets to set up the power flow case. A complete object with both EQ and SSH data may then be constructed and described by the “Complete data object” as in Figure 3. Note that inheritance should also be considered but for simplicity it is not shown in Figure 3.

6.3 Include overlapping sets of attributes and roles from the same class in different profiles

This is an uncommon use case that appears in a few cases. Having the same attribute or role in two different profiles can result in ambiguity as to which data to use in datasets for the different profiles. Attributes in the profiles may be given slightly different meanings, e.g. a default value in one profile and current value in another. This way of profiling shall be avoided as it is likely to create confusion. The meaning defined in Canonical CIM shall not be changed.

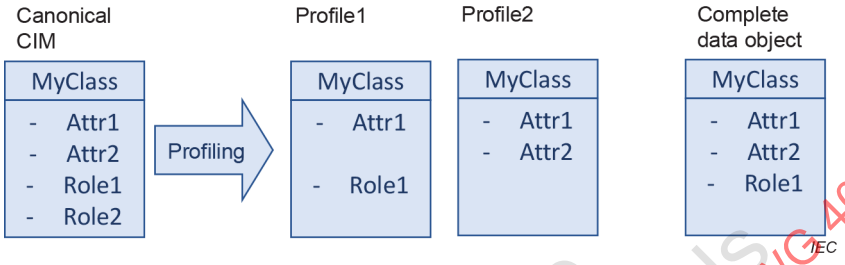

Figure 4 – Class in different profiles with overlap

Figure 4 describes the same case as in Figure 3 with the difference that the same attribute "Attr1" is included in more than one profile. An example is cim:OperationalLimits where the limit values appear both in the equipment profile (IEC 61970-452:2021) and the Solved power system state profiles (IEC 61970-456:2018).

6.4 Include a base class with different sets of attributes or roles

This is a case where the same class is included differently in different profiles.

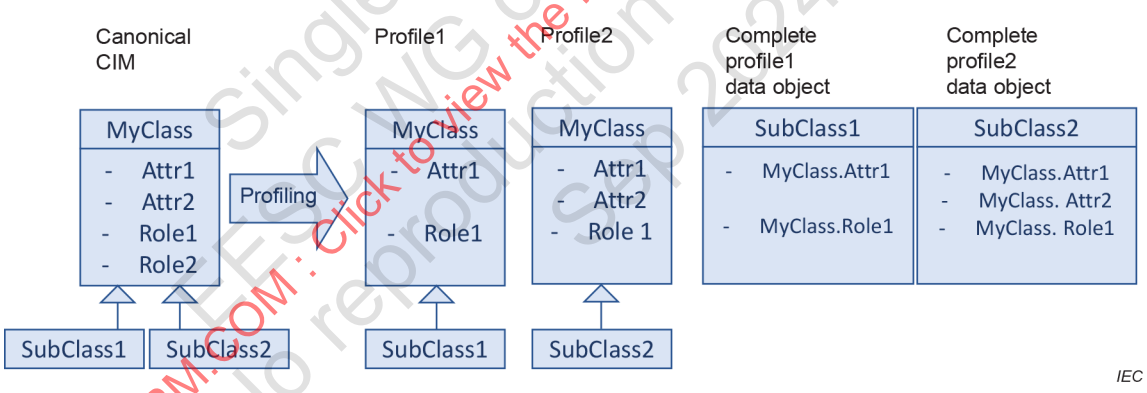

Figure 5 – Same base class with different sets of attributes or roles

Figure 5 shows a case where the "MyClass" is the base class to two other classes "SubClass1" and "SubClass2". In the profiling, "SubClass1" is put in "Profile1" and "SubClass2" is put in "Profile2". The attributes and roles from "MyClass" included in the profiles are not exactly the same. An example would be if "MyClass" is cim:IdentifiedObject, where cim:IdentifiedObject.name and cim:IdentifiedObject.description is included in "Profile2" but only cim:IdentifiedObject.name in "Profile1". "SubClass2" could be any class in the EQ profile and "SubClass1" could be cim:TopologicalNode in the TP profile.

6.5 Extending an existing class

A class is extended with the requirement that the extension be the same for all profiles. The rules for extending the Canonical CIM are outside the scope of this document.

In the profiling step the extension attributes and roles are moved into a profile version of the class as shown in Figure 6.

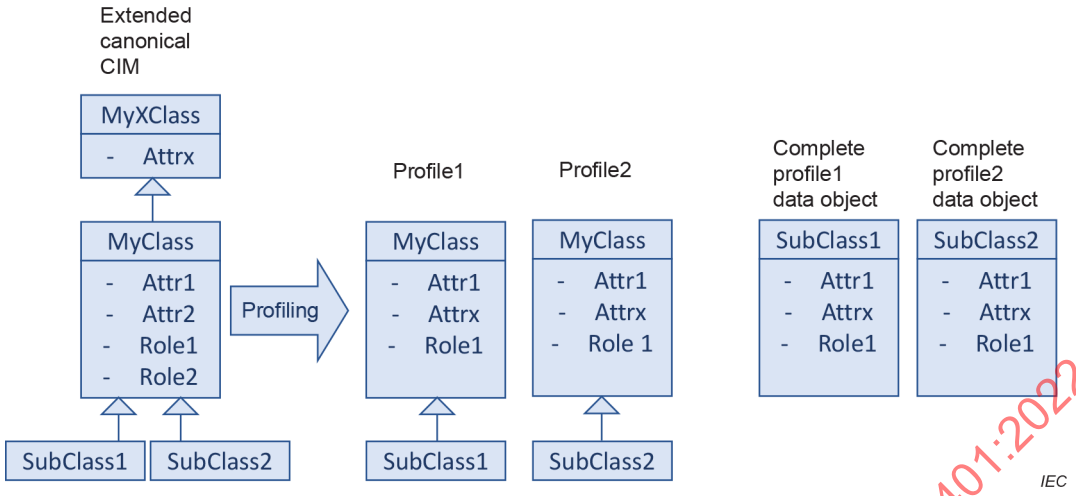

Figure 6 – Extending a class the same way in all applicable profiles

Figure 6 shows how “MyClass” is extended with an attribute “Attrx” inherited from “MyXClass”. “Attrx” is included in “MyClass” for the profiles where “MyClass” is included. An example of this case is when cim:IdentifiedObject is extended with a new attribute (e.g. shortName) used in all profiles where cim:IdentifiedObject is included, e.g. most classes in the EQ profile and cim:TopologicalNode in the TP profile.

6.6 Extending an existing class used differently in different profiles

A class is extended with the requirement that the extension be the same for all profiles where it is used. This is the same case as in 6.5 but the extension is included differently in different profiles.

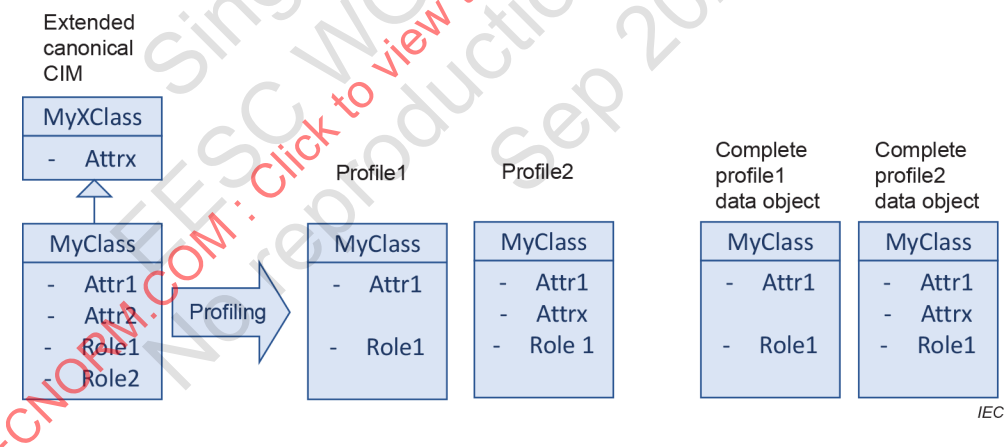

Figure 7 – Extending an existing class used differently in different profiles

In Figure 7 “MyClass” has the extension “Attrx” in “Profile2” but not in “Profile1”. This is the same use case as in 6.4 but for extensions.

An example is cim:ConnectivityNode and cim:TopologicalNode extended with additional data used in boundary profiles leaving the non-boundary versions of cim:ConnectivityNode and cim:TopologicalNode unchanged.

6.7 Different cardinalities

In the case where a class is included in different profiles as in 6.4 and 6.6, it is possible to use different cardinalities for the same attribute in the different profiles which means that the profiled classes have the same class name but different attribute or role cardinalities.

This is a violation of object-oriented design as a class with the same name is defined differently in different profiles. An example is if cim:IdentifiedObject.name is required in the equipment profile but not in the topology profile as is the case in IEC TS 61970-600. Object-oriented designs require that different classes have different names.

As discussed in 6.1, the IEC 61970-450 series profiles describe CIMXML documents that are assembled into models used by analytical calculations. If then instances with the same class name but with different attribute or role cardinalities appear in the model this would require different class names to distinguish the cardinality differences. As this is not the case implementers need to spend extra effort to work around this, e.g. use different class names within the implementation or use some decoration technique.

6.8 Add a new datatype

When attributes are added it may be that the existing datatypes do not cover the needs. Hence a new datatype needs to be added.

7 Profiling rules

7.1 Overview

This Clause 7 includes rules that shall be followed when creating IEC 61970 profiles. The preceding clauses give the background to the rules.

7.2 R0101 Information model class, attribute, role and datatype names

When profiling, it is not permitted to change the class, attribute, role or datatype names. The reason is to enable direct tracing of the profiled entities back to the Canonical CIM which enables interoperability between the created profiles. This is also a prerequisite for efficient model assembly (see 6.1) as it does not require any mapping between the information in the different profiles.

7.3 Class rules for classes without stereotype

7.3.1 R0201 Including a class

Only classes from the Canonical CIM or extensions based on Canonical CIM can be included in a profile.

7.3.2 R0202 Adding a new class

If a new class is needed the Canonical CIM shall be extended with the class as described in Clause 8. After this extension, the new class is included as described in 6.5.

7.3.3 R0203 The description of a class

The description of the class in the Canonical CIM or extensions based on Canonical CIM shall be included unchanged, and no additions are allowed.

7.3.4 R0204 Name of a class

Changing the name of a class included in a profile is not allowed.

7.3.5 R0205 Cardinality of a class

It shall be possible to specify the cardinality of a class, i.e. the number of instances that can appear for a class.

Examples where it would be useful to specify class cardinality are as follows.

- At least one cim:ConnectivityNode for models built with cim:ConnectivityNodes.
- Exactly one cim:ControlArea is required for a TSO network model.
- At least one cimTopologicalIsland is required for a solved power flow case.

7.3.6 R0206 Concrete class

For a class it is possible to specify if it is allowed to have any instances, i.e. the class is concrete. A class that is not allowed to have any instances shall be declared abstract (a UML meta data attribute).

7.4 Attribute rules

7.4.1 R0301 Including an attribute

For UML an attribute from a class in the Canonical CIM or extensions based on Canonical CIM can be included if the class having the attribute is already included in the profile.

7.4.2 R0302 Adding a new attribute

If a new attribute is needed for an already existing class in the Canonical CIM, the class shall be extended with the new attribute before including it in the profile as described in Clause 8.

7.4.3 R0303 The description of an attribute

The description of an attribute in the Canonical CIM or extensions with additional attributes based on Canonical CIM shall be included unchanged.

7.4.4 R0304 The name of an attribute

It is not allowed to change the name of an attribute included in a profile.

7.4.5 R0305 The cardinality of an attribute

The cardinality of an attribute can be made more restrictive, i.e. cardinality changed from 0..1 to 1..1. The profile shall not make cardinality less restrictive as defined in Canonical CIM or extended Canonical CIM.

7.4.6 R0306 The datatype of an attribute

The datatypes are defined in the Canonical CIM or an extended Canonical CIM. Datatypes are classified into different types by using a stereotyped class, such as one of Primitive, CIMDatatype, Compound or enumeration.

The datatype of an attribute in the Canonical CIM or extensions based on Canonical CIM shall not be changed in a profile.

7.4.7 R0307 Initial value of an attribute

If an attribute has an initial value in the Canonical CIM or in extensions based on Canonical CIM it shall not be overridden in the profile.

If an attribute is without an initial value in the Canonical CIM or extensions based on Canonical CIM it can be specified in the profile.

7.5 Datatypes

7.5.1 R0401 Including a datatype

A datatype used by an attribute in a profile shall be included in the profile.

7.5.2 R0402 Adding a new datatype

If a new datatype is needed, the Canonical CIM shall be extended with the new datatype before including the new datatype in the profile.

7.5.3 R0403 Primitive datatype

A Primitive datatype used in a profile shall be included unchanged.

The value space of an existing Primitive datatype can be further restricted by use of additional constraints described in OCL or SHACL, e.g. string values can be restricted by regular expressions or lists of values.

7.5.4 R0405 CIMDatatype

A CIMDatatype stereotyped class has three attributes: value, unit, and multiplier. A profile may decide that the unit and multiplier are determined for the profile or the context for the exchange, so they are the same for all instances of a particular CIMDatatype stereotyped class. If so the attributes value, unit, and multiplier are removed and the CIMDatatype stereotyped class is assigned the datatype from the value attribute in the CIMDatatype stereotyped class.

Hence a CIMDatatype stereotyped class can be included in a profile in two ways.

a) The CIMDatatype stereotyped class is flattened by excluding the attributes value, unit, and multiplier and given the datatype from the value attribute value in the CIMDatatype stereotyped class.

b) The CIMDatatype stereotyped class attributes value, unit and multiplier are included as is.

Which of the profiling methods in a) and b) is used is determined per profile or context for the data exchange.

The value space of an existing CIMDatatype may be further restricted by use of additional constraints described in OCL or SHACL.

7.5.5 R0405 Compound datatype

A compound datatype follows the same rules as a class.

7.5.6 R0406 Enumeration

An enumeration datatype used in a profile shall be included unchanged to avoid interoperability issues between profiles using different subsets of the enumeration in Canonical CIM.

7.5.7 R0407 The description of a datatype

The description of a datatype in the Canonical CIM or extensions based on Canonical CIM shall be included unchanged.

7.5.8 R0408 The name of a datatype

It is not allowed to change the name of a datatype included in a profile.

7.6 Association rules

7.6.1 R0501 Including an association

An association in the Canonical CIM or extensions based on Canonical CIM can be included if both of the classes referenced by the association roles are present in:

a) the profile.

b) two different profiles and both profiles are included in the data exchange.

A check (tool dependent) shall be carried out to verify that the set of profiles covers a complete information model including a full description of the two classes in an association across profiles.

7.6.2 R0502 Adding a new association

If a new association is needed, the Canonical CIM shall be extended with the new association before adding the association in the profile.

7.6.3 R0503 The names of the two roles in an association

The names for both roles in an association shall be present in Canonical CIM. If this is not the case, this is an error that shall be corrected before profiling is done.

The names of roles in an association shall not be changed in a profile.

7.6.4 R0504 The cardinality of an association role

The cardinality of an association role can be made more restrictive in a profile e.g. cardinality changed from 0..1 to 1..1. The profile shall not make cardinality less restrictive as defined in Canonical CIM or extended Canonical CIM.

7.6.5 R0505 Association navigability

An association in Canonical CIM does not specify the navigability for the roles but a profile shall add this information to specify which of the two roles shall be exchanged. This avoids exchanging redundant information.

The navigability shall always be specified for an association.

Note that IEC 61970-501 does not include the navigability information. IEC 61970-501 needs to be updated with a description on how navigability is described. Some other formats describe the navigability by excluding the role in the non-navigable direction resulting in lost cardinality information.

7.6.6 R0506 The description of an association

The description of an association in the Canonical CIM or extensions based on Canonical CIM shall be included unchanged.

7.7 Attribute and association restrictions

7.7.1 R0601 Overlap between profiles

Overlapping profiles include the same attribute or role. This means that the same information can be exchanged using different profiles. This is described by the use case in 6.3.

Profiles with overlapping attributes or associations are not allowed.

7.7.2 R0602 Same base class with different sets of attributes and associations in different profiles

As described by use cases in 6.4 and 6.6 the same base class can be included in different profiles with different sets of attributes and associations.

If the intent of the base class is to provide the same kind of information to a profile it shall be profiled the same way in all profiles where it is included, i.e. exactly the same set of attributes and associations shall be included in all profiles. If this is not the case the class, despite having the same name, will be different, e.g. have different:

- sets of attributes,
- sets of associations,
- cardinalities for the same attribute or association role.

Differences as described in the bulleted list above are not allowed in different profiles.

7.8 R0701 Inheritance structure

The inheritance structure from the Canonical CIM or extensions based on Canonical CIM shall be kept unchanged in a profile.

7.9 R0801 Constraints

The UML language lacks the capability to describe constraints other than what is described by cardinalities. The Object Constraint Language (OCL) is currently used to describe constraints on profiles. The rules may use attributes or roles in statements that describe the constraint.

Common cases where additional constraints are desired are as follows.

- Numerical values where only values in a range are meaningful, e.g. a resistance that is negative means generation of active power which is not meaningful.
- A class high up in an inheritance hierarchy has an association that is meaningful only for a subset of the derived classes. The containment structure defined by the association cim:Equipment-cim:EquipmentContainer can be restricted for the subtypes, e.g. cim:Line can be restricted to only contain cim:ACLineSegments.

OCL can be used to implement restrictions described in the bulleted list above. OCL is similar to a programming language where an OCL statement is linked to a class in a profile. This means that when a restriction is implemented in OCL a decision on what class to place it on is needed. In the above example with the containment many design choices are possible.

1) Place the OCL code on the leaf classes to cim:Equipment.
2) Place the OCL code on the leaf classes to cim:EquipmentContainer.
3) Mixing 1 and 2 is possible but is a poor design choice.
4) Place the OCL code on cim:Equipment.
5) Place the OCL code on cim:EquipmentContainer.
6) Mixing 4 and 5 is possible but is a poor design choice.
7) Mixing 1 and 4 or 2 and 5 is possible and can make sense in some cases.

The numbered list above implies that OCL allows for many design choices, hence a restriction shall always be described in (English) language before the corresponding OCL rules are created as OCL rule creation is similar to programming.

Hence the following applies:

- Restrictions shall be described in (English) text on the restricted UML artefact (Class, Attribute or Role) either in Canonical CIM or in a profile.
- A restriction described in (English) text shall have a translation to OCL that can be implemented on one or more UML classes.

It is also possible to restrict data by use of XML Schema (xsd) or XSLT scripts with regular expressions. These technologies are well suited for syntax checks and are an alternative to OCL in the case of syntax checks.

8 Extending Canonical CIM

Canonical CIM can be extended in two ways:

1) By adding a new class where associations and attributes are mixed into an existing class with multiple inheritance. This will leave the existing class unchanged in the sense that its attributes and associations in Canonical CIM are unchanged. Figure 6 in 6.5 shows an example of this.
2) By subtyping an existing class. This method has not been used to extend Canonical CIM yet.

Extension classes in the above list shall be included in a separate package and not be included in the Canonical CIM packages. This makes it easy to distinguish them from the Canonical CIM classes.

If a base class is extended according to case 1), the rules in 7.7.2 shall be observed meaning that the base class shall be profiled the same way in all profiles where it is included. When the extended class is included in a profile, the rdx in inheritance is removed. The attributes and association roles are instead included directly in the extended class as shown in Figure 6.

If the extension is intended to describe different types of objects, then extension according to case 2) above is recommended. However, making extensions this way creates the risk of conflicting with later extensions of Canonical CIM. The following example illustrates this

- The class cim:GeneratingUnit in Canonical CIM is extended according to case 2) with new attributes supporting market applications and the new class is called cim:GeneratingUnitMkt.
- The cim:GeneratingUnit has been subtyped into the classes cim:ThermalGeneratingUnit and cim:HydroGeneratingUnit. The extension of cim:GeneratingUnitMkt in the above bullet is not available to these subtypes as they are in different inheritance paths. But if the application data is instead added to cim:GeneratingUnit according to case 1) it will be available to cim:ThermalGeneratingUnit and cim:HydroGeneratingUnit. The cim:GeneratingUnit is subtyped into other classes and it is now realized that the attributes in cim:GeneratingUnitMkt are also needed for these subclasses.

This is one example of how the extension of Canonical CIM shall not be done. The topic of how to carry out information modelling is wide, and outside the scope of this document.

9 Requirements for a profiling tool

9.1 Minimum requirements

A profiling tool shall comply with the following minimum requirements. A tool shall:

- R1001 have a user interface that support the functions listed below in this bulleted list.
- R1002 be able to include classes, attributes, associations and datatypes from Canonical CIM or an extended Canonical CIM;

- R1003 be able to read and write a profile according to the existing format specifications , e.g. RDF/XML according to IEC 61970-501:2006;
- R1004 in the case of a profile in UML, be able to export and import UML XMI for exchange with commercial UML tools.
- R1005 be able to restrict cardinalities and initial values of a class, an attribute, an association, a datatype;
- R1006 be able to flatten a CIMDatatype stereotyped class by removing the attributes value, unit and multiplier as described in 7.5.4;
- R1007 be able to visualise profiles graphically in UML or other technology;
- R1008 support synchronisation of a profile with an updated Canonical CIM to support evolution on the profile in parallel with Canonical CIM. The CIM namespace is the same in this case;
- R1009 support migration of profiles from one version of Canonical CIM to another. The CIM namespaces are different in this case;
- R1010 be able to specify the direction of associations;
- R1011 retain the meaning of stereotypes and tagged values.

9.2 Extended requirements for OCL rules

The extended requirements describe additions to the minimum requirements in 9.1. The extended requirements are optional and cover requirements on tools managing OCL rules.

Based on experiences from EMF tools that support maintaining OCL rules and validating data with OCL rules the following extended requirements shall be supported:

- R1101 a tool shall have a user interface that shows the information model with OCL rules and supports the functions listed below in this bulleted list.
- R1102 serialize profiles to the Ecore XMI to support import and validation with EMF.
- R1104 editing of the OCL rules is linked to the classes in the information model.
- R1105 context sensitive editing of OCL rules such that errors are reported while typing.
- R1106 export of OCL rules from an information model as a separate file on Ecore XMI format.
- R1107 import of OCL rules to an information model from any number of separate files containing OCL rules on Ecore XMI format.
- R1108 import CIMXML instance files in a model and validate them with the information model extended with OCL rules.

R1109 creation of XML Schemas for syntax checks.

Annex A
(informative)

A.1 Mapping of UML to OWL

A profile can be defined in UML or OWL. Hence the two languages have constructs that are capable of describing the same semantics. It is then important to know how these constructs map to each other, see Table A.1.

Table A.1 – UML and ontology languages

CIM UML elements	OWL elements
Package	Ontology
Class	Class
Class stereotyped as “Compound”	Class
Simple valued attribute	Data property
Class attribute or role	Object property
Association	Object properties with inverse relation
Class stereotyped as Primitive	Equivalenced with XML Schema types
Class stereotyped as CIMDatatype	The CIMDataType value attribute are mapped to XML Schema types and the internal CIMdatatype attributes value, unit and multiplier are removed (flattened)
Role cardinality	Restriction on Object property (minQualifiedCardinality and maxQualifiedCardinality)
Inheritance between classes	Subtypes
Enumeration literal	An instance
Enumeration class	A class describing the enumeration member instances

Most of the mappings in Table A.1 are straightforward except for the stereotypes where additional assumptions need to be made.

Table A.1 includes constraints as UML does not have a formal constraint language.

OCL is a constraint language that is defined for object data and SHACL is a constraint language defined for graph data. This annex does not describe a mapping between OCL and SHACL.

Mapping of stereotypes and tagged values are made case by case. The stereotypes Primitive and CIMDatatype are described in Table A.1, other stereotypes will need their own rows in Table A.1.

Clause A.2 discusses the units and multiplier issue. Table A.1 does not include rows for this issue as it is not related to the mapping of UML to OWL. The units and multiplier issue is rather an incompatibility between two different profiles.

A.2 Units and multipliers issue

A.2.1 Description of issue

The issues described in this Subclause A.2.1 are exemplified with syntactic profile examples showed by figures based on IEC 61970-501:2006.