NEW CDPSM (COMMON DISTRIBUTION POWER SYSTEM MODEL) PROFILE WITHIN CIM (COMMON INFORMATION MODEL)

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INTRODUCTION

The IEC 61968 series of standards is intended to facilitate inter-application integration as opposed to intra-application integration. Intra-application integration is aimed at programs in the same application system, usually communicating with each other using middleware that is embedded in their underlying runtime environment, and tends to be optimized for close, real-time, synchronous connections and interactive request/reply or conversation communication models. IEC 61968 is intended to support the inter-application integration of a utility enterprise that needs to connect disparate applications that are already built or new (legacy or purchased applications), each supported by dissimilar runtime environments. Therefore, these interface standards are relevant to loosely coupled applications with more heterogeneity in languages, operating systems, protocols and management tools. This series of standards, which are intended to be implemented with middleware services that exchange messages among applications, will complement, not replace utility data warehouses, database gateways, and operational stores.

As used in IEC 61968, a DMS consists of various distributed application components for the utility to manage electrical distribution networks. These capabilities include monitoring and control of equipment for power delivery, management processes to ensure system reliability, voltage management, demand-side management, outage management, work management, automated mapping and facilities management. Standards interfaces are defined for each class of applications identified in the Interface Reference Model (IRM), which is described in IEC 61968-1.

SCOPE OF CDPSM

The IEC 61968 standard, taken as a whole, defines interfaces for the major elements of interface architecture for Distribution Management Systems (DMS). This set of standards is limited to the definition of interfaces and is implementation independent. They provide for interoperability among different computer systems, platforms, and languages. Methods and technologies used to implement functionality conforming to these interfaces are considered outside of the scope of these standards; only the interface itself is specified in these standards.

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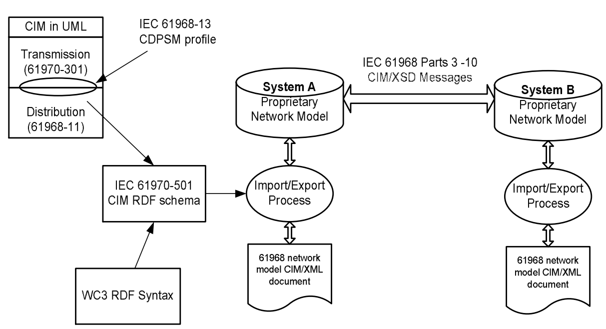
Electric utilities use power system models for a number of different purposes and an operational power system model can consist of thousands of classes of information. In addition to using these models in-house, utilities need to exchange system modeling information, both in planning, and for operational purposes. However, individual utilities use different software for these purposes, and as a result the system models are stored in different formats, making the exchange of these models difficult. CIM (Common Information Model) represents most of all objects inside an electric utility as classes and attributes, as well as their relationships. CIM uses these object classes and attributes to support the integration of independently developed applications among vendor specified DMS applications, or among a DMS system and other systems that are concerned with different aspects of power system operations, such as distribution management. In addition, to further support the ability to electronically exchange CIM models, the power industry has developed CIM/XML, a language for expressing CIM models in XML. CIM/XML is an RDF application, using RDF and RDF Schema to organize its XML structures.

New part of standard IEC 61968-13, based on the NERC profile for the transmission network, specifies the format and rules for exchanging modeling information based upon the CIM and concerning Distribution Network Data. The intention is that the imported network model data should be sufficient to allow performing:

- network connectivity analysis,
- distribution power load flow calculations,
- outage analysis.

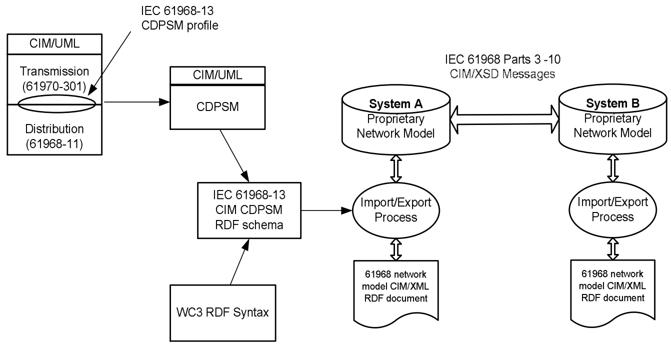
EPRI (Electric Power Research Institute) has conducted successful interoperability tests using CIM/XML to exchange real-life, large-scale between a variety of vendor products, and validating that these models would be correctly interpreted by typical utility applications. Although the CIM was originally intended for EMS systems, it is also being extended to support power distribution (DMS) and other applications as well.

It uses the CIM RDF Schema presented in IEC 61970-501 as the meta-model framework for constructing XML documents of power system modeling information. The style of these documents is called CIM XML format. Model exchange by file transfer serves many useful purposes, especially when some applications need to have the complete network model defined. Though the format can be used for general CIM-based information exchange, in this document specific profiles (or subsets) of the CIM are identified in order to address particular exchange requirements. Given the CIM RDF Schema described in IEC 61970-501, a DMS power system model can be converted for export as an XML document (see Figure 1). This document is referred to as a CIM XML document. All of the tags (resource descriptions) used in the CIM XML document are supplied by the CIM RDF schema. The resulting CIM XML model exchange document can be parsed and the information imported into a foreign system.



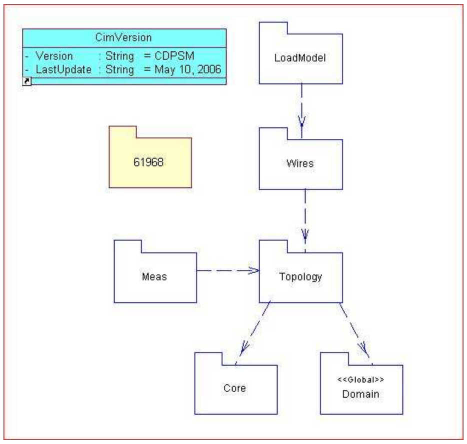
Picture 1 - XML-Based DMS Network Data Configuration Mechanism

Similar to using any programming language, implementers have many choices when creating a CIM XML document. The RDF syntax itself can be used in several ways to achieve the same basic result. The way one approaches the CIM RDF Schema can yield various forms when producing a CIM XML document. The following subsections discuss the style guidelines for producing a CIM XML document. Such guidelines rules are important to communicate and follow when producing these documents because they simplify and facilitate the software written to unambiguously interpret the model information.



Picture 2 – New approach of XML-Based DMS Network Data Configuration Mechanism

Initially, definition of CDPSM has been started within CIM version 10 revisions 4. The proposal of CDPSM is principally based on IEC 61970-301 part, without Asset notion that is described in IEC 61968-4. For the purpose of the defining CDPSM profile UML model has been done and it has only those classes, attributes and relations from original CIM model which are covered by subject profile. Picture 3 shows package of basic CIM/UML model which is covered by CIM/UML CDPSM.



Picture 3 – The packages of CIM CDPSM

RDF/OWL

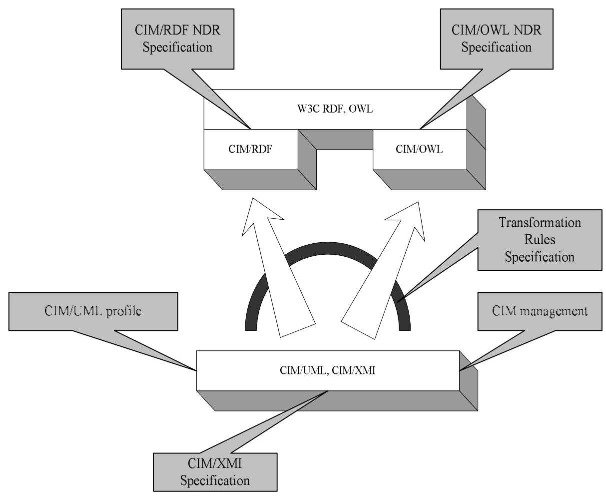
RDF (Resource Description Framework) is a language recommended by the W3C for expressing metadata that machines can process simply. RDF uses XML as its encoding syntax. RDF is a data model for objects ("resources") and relations between them provides a simple semantics for this data model and these data models can be represented in XML syntax.

RDF Schema is a schema specification language expressed using RDF to describe resources and their properties, including how resources are related to other resources, which is used to specify an application-specific schema. RDF Schema is a vocabulary for describing properties and classes of RDF resources, with a semantics for generalization-hierarchies of such properties and classes.

OWL (Ontology Web Language) is intended to be used when the information contained in documents needs to be processed by applications, as opposed to situations where the content only needs to be presented to humans. OWL can be used to explicitly represent the meaning of terms in vocabularies and the relationships between those terms. This representation of terms and their interrelationships is called ontology. OWL has more facilities for expressing meaning and semantics than XML, RDF and RDFS, and thus OWL goes beyond these languages in its ability to represent machine interpretable content on the Web. OWL adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjoint ness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry) and enumerated classes.

CIM/XML's need to extend RDF Schema to support cardinality constraints and inverse relationships also illustrates the kinds of requirements that have led to the development of more powerful RDF-based schema/ontology languages such as OWL. Such languages may be appropriate in supporting many similar modeling applications in the future.

RDF was designed primarily for semantic representation, not data exchange, but industry standards have continued to evolve beyond RDF. OWL provides a more robust structure for representing complex and object-oriented data. OWL builds upon RDF specification and will be the language of choice for representing semantics. OWL was only recently enacted as a standard and there are not many implementations as of yet.



Picture 4 – Transformation of CIM based on related standards

EXAMPLE OF RDFS/RDF/OWL

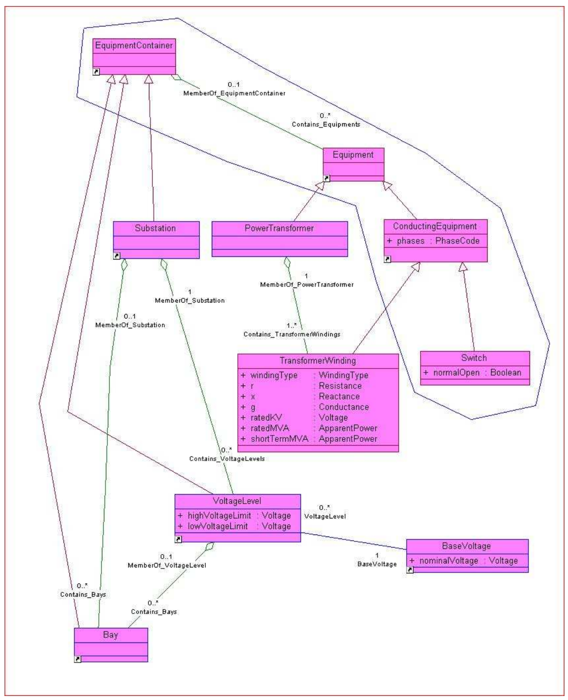
The base class of the CIM is the PowerSystemResource class, with other more specialized classes such as Substation, Switch, and Breaker being defined as subclasses. CIM/XML represents the CIM as an RDF Schema vocabulary, and uses RDF/XML as the language for exchanging specific system models. The examples 1 – 3 show RDF/XML (RDFS) and OWL parts of CIM model based on CDPSM profile, as well as RDF with the corresponding test network data.

```
<?xml version="1.0" encoding="UTF-8"?>

<rdf:RDF xmlns:cims=http://iec.ch/TC57/1999/rdf-schema-extensions-19990926#
         xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-ns#
         xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
<rdfs:Class rdf:ID="PowerSystemResource">
        <rdfs:label xml:lang="en">PowerSystemResource</rdfs:label>
        <cims:profile>CDPSM</cims:profile>
        <cims:belongsToCategory rdf:resource="#Core"/>
        <rdfs:subClassOf rdf:resource="#Naming"/>
</rdfs:Class>
<rdfs:Class rdf:ID="ConductingEquipment">
        <rdfs:label xml:lang="en">ConductingEquipment</rdfs:label>
        <cims:profile>CDPSM</cims:profile>
        <cims:belongsToCategory rdf:resource="#Core"/>
        <rdfs:subClassOf rdf:resource="#Equipment"/>
</rdfs:Class>
```

```
<rdf:Property rdf:ID="ConductingEquipment.phases">
        <rdfs:label xml:lang="en">phases</rdfs:label>
        <rdfs:comment>Describes the phases carried by a conducting equipment. Possible values
        {ABCN, ABC, ABN, ACN, BCN, AB, AC, BC, AN, BN, CN, A, B, C, N}.</rdfs:comment>
        <cims:profile>CDPSM</cims:profile>
        <rdfs:domain rdf:resource="#ConductingEquipment"/>
        <cims:dataType rdf:resource="#PhaseCode"/>
</rdf:Property>
<rdf:Property rdf:ID="EquipmentContainer.Contains_Equipments">
        <rdfs:label xml:lang="en">Contains_Equipments</rdfs:label>
        <rdfs:domain rdf:resource="#EquipmentContainer"/>
        <rdfs:range rdf:resource="#Equipment"/>
        <cims:multiplicity
  rdf:resource="http://iec.ch/TC57/1999/rdf-schema-extensions-19990926#M:0..n"/>
  <cims:inverseRoleName rdf:resource="#Equipment.MemberOf_EquipmentContainer"/>
</rdf:Property>
</rdf:RDF>
```

Example 1 - CIM/XML classes, property definitions and extensions



Picture 5 – Overview of Equipment Containment in Wires package

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>

<rdf:RDF xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-ns#
          xmlns:cim="http://iec.ch/TC57/2003/CIM-schema-cim10#">
<cim:Breaker rdf:ID="50">
   <cim:Naming.name>SW</cim:Naming.name>
   <cim:Equipment.MemberOf_EquipmentContainer rdf:resource="#6"/>
   <cim:ConductingEquipment.Terminals rdf:resource="#51"/>
   <cim:ConductingEquipment.Terminals rdf:resource="#52"/>
   <cim:Switch.normalOpen>false</cim:Switch.normalOpen>
  </cim:Breaker>
<cim:Bay rdf:ID="6">
   <cim:Naming.name>BF 1</cim:Naming.name>
   <cim:Naming.description>BAY FEEDER </cim:Naming.description>
   <cim:PowerSystemResource.Location rdf:resource="#7"/>
```

```
  <cim:EquipmentContainer.ConnectivityNodes rdf:resource="#8"/>
  <cim:EquipmentContainer.ConnectivityNodes rdf:resource="#9"/>
  <cim:EquipmentContainer.Contains_Equipments rdf:resource="#50"/>
 </cim:Bay>
 <cim:Terminal rdf:ID="51">
  <cim:Terminal.ConductingEquipment rdf:resource="#50"/>
  <cim:Terminal.ConnectivityNode rdf:resource="#8"/>
 </cim:Terminal>
 <cim:Terminal rdf:ID="52">
  <cim:Terminal.ConductingEquipment rdf:resource="#50"/>
  <cim:Terminal.ConnectivityNode rdf:resource="#9"/>
 </cim:Terminal>
</rdf:RDF>
```


Example 2 - Part of test network data in RDF

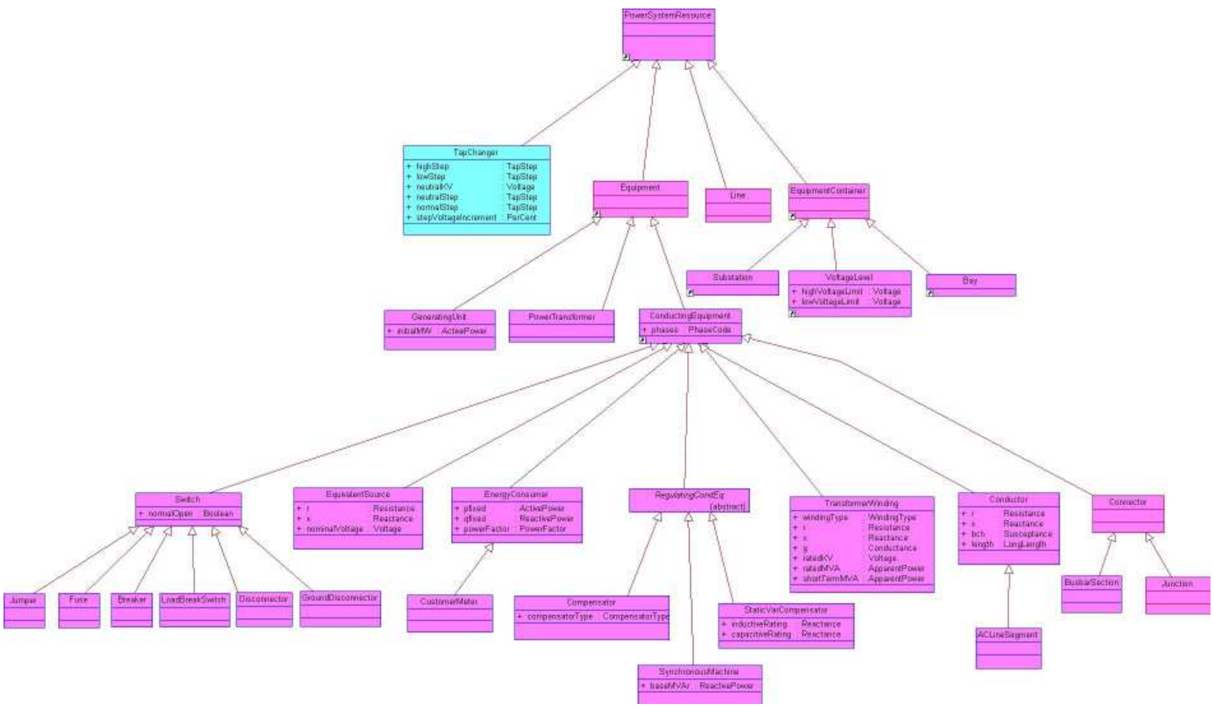

```
<rdf:RDF   xmlns:j.0="http://iec.ch/TC57/2001/CIM-schema-cim10#"
           xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
           xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
           xmlns:owl="http://www.w3.org/2002/07/owl#"
           xmlns:j.1="http://langdale.com.au/2005/UML#" >

<rdf:Description rdf:about="http://iec.ch/TC57/2001/CIM-schema-cim10#PowerSystemResource">
  <rdfs:subClassOf rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#Naming"/>
  <rdf:type rdf:resource="http://langdale.com.au/2005/UML#Component"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Class"/>
  <rdfs:isDefinedBy rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#Package_Core"/>
  <rdfs:label xml:lang="en">PowerSystemResource</rdfs:label>
 </rdf:Description>
<rdf:Description rdf:about="http://iec.ch/TC57/2001/CIM-schema-cim10#ConductingEquipment">
  <rdfs:isDefinedBy rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#Package_Core"/>
  <rdf:type rdf:resource="http://langdale.com.au/2005/UML#Component"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Class"/>
  <rdfs:subClassOf rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#Equipment"/>
  <rdfs:label xml:lang="en">ConductingEquipment</rdfs:label>
 </rdf:Description>
<rdf:Description
   rdf:about="http://iec.ch/TC57/2001/CIM-schema-cim10#ConductingEquipment.phases">
  <rdf:type rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#Property"/>
  <rdfs:label xml:lang="en">phases</rdfs:label>
  <rdfs:comment>Describes the phases carried by a conducting equipment. Possible values {ABCN ,
ABC, ABN, ACN,    BCN, AB, AC, BC, AN, BN, CN, A, B, C, N }.</rdfs:comment>
  <rdfs:domain rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#ConductingEquipment"/>
  <rdfs:isDefinedBy rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#Package_Core"/>
  <rdf:type rdf:resource="http://langdale.com.au/2005/UML#Attribute"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DatatypeProperty"/>
  <rdfs:range rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#PhaseCode"/>
 </rdf:Description>
<rdf:Description
rdf:about="http://iec.ch/TC57/2001/CIM-schema-cim10#EquipmentContainer.Contains_Equipments">
  <rdfs:domain rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#EquipmentContainer"/>
  <rdfs:label xml:lang="en">Contains_Equipments</rdfs:label>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#InverseFunctionalProperty"/>
  <rdfs:range rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#Equipment"/>
  <rdfs:isDefinedBy rdf:resource="http://iec.ch/TC57/2001/CIM-schema-cim10#Package_Wires"/>
  <owl:inverseOf
rdf:resource="http://iec.ch/TC57/2001/CIM-schema-
cim10#Equipment.MemberOf_EquipmentContainer"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#ObjectProperty"/>
 </rdf:Description>
</rdf:RDF>
```


Example 3 - OWL classes, property definitions and extensions

CDPSM TEST NETWORK

For the needs of CDPSM profile creation we are using two different test networks, one for the European and the second for North American electric distribution network. The both test networks according their dimension and characteristics to not give real picture of the distribution network that we want to describe. Because of that we have created completely new test network that will be able to cover all characteristic elements present in it, but at the same time by its dimension to be come closer to real configuration of the distribution networks. So we have created following: test network with four base voltages, real portion of overhead and underground distribution network, characteristic topologies (rings and interconnecting lines), typified characteristics of distribution network elements, applied equipment for the network automation, as well as typical load profiles. Currently, this test network has been made with the four main stations and over 90 substations of MV/LV. This test network will be used for the next IOP test planned for this autumn. The currently published CDPSM profile has been enlarged to include some of the classes missed in CPSM (Common Power System Model) (TapChanger, CompositeSwitch, etc.) or they have not been created in CIM model (VT – Voltage Transformer, CT – Current Transformer, etc.). The Picture 6 shows UML diagram of Inheritance Hierarchy, where one of enlargement (TapChanger) is marked.



Picture 6 – Overview of Inheritance Hierarchy

CDPSM PROTOTYPE

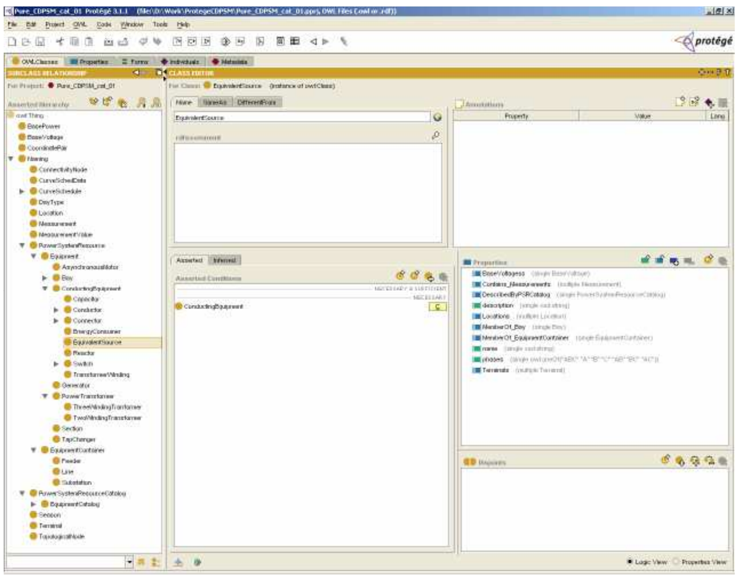
For the creation of CDPSM prototype platform Protégé has been used, which has been an expansion in the last period. Protégé is a free, open-source platform that provides a growing user community with a suite of tools to construct domain models and knowledge-based applications with ontologies. At its core, Protégé implements a rich set of knowledge-modeling structures and actions that support the creation, visualization, and manipulation of ontologies in various representation formats. Also, Protégé can be customized to provide domain-friendly support for creating knowledge models and entering data.

The Protégé platform supports two main ways of modeling ontologies:

- The Protégé-OWL editor enables users to build ontologies for the Semantic Web.
- The Protégé-Frames editor enables users to build and populate ontologies that are frame-based.

By choosing this platform and implementation of CDPSM profile in the form of OWL we tried to make CIM model closer to large number of users, the people being familiar with the latest IT technologies as well as the integration strategies. In this way we set a route for its further improvements and implementation, as the users in a very simple way could modify profile, input data and adapt visualization for their own needs. The present results clearly shows that realization of the subject prototype enables very fast implementation of the solutions based on CIM model, as the target users will though the realization of the similar prototypes solved the all doubts they would have during the standard procedure of implementation of their solutions.

As the platform is being in the development phase, the several problems appeared regarding import procedure already generated RDF schema from CIM/UML model based on the available tools. Also, there has been problem of the direct import of CIM/OWL file, cause by the impossibility of creating planned enumerations. OWL Validator tool has been used and it detected numerous problems during the import. We have been trying very hard to solve this problem and we expect to solve it very soon. So we started creating OWL CDPSM prototype trough the direct input trough OWL editor. In this way, we made target set of classes, their properties and relationships, as well as the corresponding set of instances of those classes (see Picture 7).



Picture 7 – Overview of the Protégé-OWL editor

CONCLUSION

The change of CIM model as an integral frame for dynamic integration of the existing applications, as well as the development of the new ones within electric utility doesn't have its alternative at present. On the other hand, specifics of the electric utilities deserve the clear distance from the present CIM model. So defining of this CDPSM profile is imposed as one of the solutions. By creating CDPSM profile we will solve only initial basic problems, but by its further development all issues present at electric utilities will be covered. By its final realization we will shorten route to its implementation solutions based on CIM model within electric utilities.

Keywords**: CIM, CDPSM, UML, RDF, OWL**

LIST OF REFERENCES

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- 4 WEB site of Protégé (http://protege.stanford.edu).