Ontology-based Integration of IEC TC 57 standards

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Abstract. This contribution provides a short summary on the work conducted within several projects dealing with the integration of heterogeneous standards developed by the International Electrotechnical Commission IEC. Unlike other models, the standards have already been made international standards and can therefore not be harmonized directly and need a mediator layer to cope within semantic problems. Our approach is to use ontologies to deal with this kind of heterogeneity.

Keywords: IEC, CIM, Ontology Alignment, mediators, TC57, OWL

1 Introduction

In the electric utility domain, several changes impose new requirements to the IT infrastructure of the companies. First, the generating structure used to be very closely aligned to the communication infrastructure. Electric energy was delivered top-down from the high voltage grid having large scale generation attached to the lower voltage grid and the households. The corresponding communication infrastructure worked the same way; steering information was mainly passed down the supply chain while data points from the field level were submitted to the SCADA (Supervisory Control and Data Acquisition System).

With the upcoming distributed generation, the legal requirements imposed by federal regulation and the resulting unbundling, things have changed a lot. Due to the new generation facilities like wind power plants or fuel cells, energy is fed into the grid at different voltage levels und by different producers – former customers having their own generation can now both act as consumers and producers which feed into the utilities' grid. Therefore, the communication infrastructure has to change. On the other hand, the legal unbundling leads to separation of systems which have to be open to more market participants. Hence, this results in more systems which have to be integrated and more data formats for compliance with the market participants. The overall needs for standards increase. This problem must be addressed by an adequate IT-infrastructure within the utility, supported by architectures like SOA (Service-oriented Architectures). Within this scope, the IEC has developed data models, interfaces and architectures [4] for both running the grid and automating the substations.

2 The IEC TC57 standards reference framework

The International Electrotechnical Commission IEC has the vision of enabling seamless integration of data for the electric utility domain using the standards reference framework. Within this standards framework, several standards have been developed by different working groups (WG). Unfortunately, those groups have different ideas about what to standardize what is the overall focus.
Two main standards families exist within the TC 57 framework, the so called IEC 61970 family, the Common Information model CIM and the IEC 61850 family for substation communication coping with the data exchanged between SCADA system and the field devices. Those two families have been developed with a different technical background.

2.1 The IEC 61970 family – The Common Information Model CIM

The Common Information Model CIM [3] can be seen as the basic domain ontology for the electric utility domain at SCADA level. It is standardized in two different sub-families, namely the IEC 61970 family for the data model and OPC-based data models dealing directly with the day-to-day business of running the electric power grid and the IEC 61968 family which has to cover the needed objects to integrate the CIM into the overall utility having to exchange data with systems like GIS (Geographical Information Systems), CSS (Customer Support System), or ERP (Enterprise-Resource Planning). Overall, the CIM data model covers 53 UML Packages, having roundabout 820 Classes with more than 8500 Attributes overall. A lot of effort and work has been put into the model to cover the most important objects for the electric utility domain. Furthermore, different serializations exist. First of all, XML and XML schema exist for building your own EAI messages [2] based on the CIM and to use pre-defined messages built by the IEC. Furthermore, RDF serializations and RDF schemas used for modeling the graphs of power grids for electrical distribution exist, and, based on this work, an overall CIM OWL Serialization has been developed. Therefore, and due to the maturity of the use of CIM, CIM can be regarded as one of the biggest standardized domain ontologies. Unfortunately, this work was done by the IEC Working groups WG 13 and 16 which do not standardize the other big family, the IEC 61850 one.

2.2 The IEC 61850 family - Communication for substations

The IEC TC 57 working group 10 has developed the IEC 61850 family dealing with substation automation systems and the corresponding communications. The standard itself is very large, comprising sub-standards of different kinds like communication protocols, data models, security standards etc. The overall control system domain for IEC 61850 system automation [1] while the CIM focuses on energy management systems, the IT domains are substation intra-application communication and, for the CIM, control-center intra-application communication. Both standards have a basic data model, the CIM itself is a data model, but the serializations differ. While only a small subset for engineering of substations needs a XML-serialization in IEC 61850, all CIM objects can either be serialized using XML, RDF or OWL. Also, the IEC 61850 family lacks a significant support of APIs. Those differences lead to problems when coping in real-world projects with the IEC TC 57 reference framework.

3 The need for integration of the IEC standards

Of course, the data from both standards must be used in the same context, therefore, a seamless integration of i.e. the functional description structure of a substation must be known to the SCADA and a mapping between structure from IEC 61850 and IEC 61970 is needed. Furthermore, all data points and measurements from the field devices must be mapped from IEC 61850 semantics to IEC 61970 semantics. Without any doubt, those two scenarios are the most striking ones, but further scenarios exist.

Unfortunately, problems occur when trying to use the standards. The different WGs have used different naming schemes, object-oriented modeling vs. hierarchical modeling, different semantics, different tools and serializations and, the IEC 61850 model does not exist as an electronic model, just within tables in a Word document. Finally, all the standards have been made final international standards; therefore they are being implemented by big vendors like ABB, Areva, Siemens who rely on the stability of the standards and their products. Their existing implementations cannot be harmonized at the meta-model level breaking several aspects for a new, overall harmonized standard family comprising IEC 61850 and IEC 61970. We have to deal with harmonization on a conceptual mediator layer.

To cope with all those problems and to facilitate integration, we have worked out a methodology for integrating the standards which will be discussed in the next chapter.

4 Our proposed methodology – COLIN

Our Cim Ontology aLigNment methodology (abbrev.: COLIN) tries to overcome all the fallacies described in the previous sections by establishing a methodology for integrating utility standards taking the domain requirements and current research trends into account.

First of all, there are some perquisites for the approach. We take the CIM as the basic domain ontology due to its overall size and the objects, attributes and relations already modeled and agreed upon by domain experts. Therefore, the other standards must be transformed into electronic models, preferably OWL ontologies to be harmonized. In order to simplify the mapping process, quantity-based analysis of the standards in conducted and an overall classification and typology of standards in the utility domain has been created. This data is taken into consideration trying to find overlapping parts of the standards which have to be integrated and cannot be found easily like the ones mentioned above. Afterwards, the specific parts are modeled using Protége and serialized in RDF/XML. Now, all the standards have an OWL representation. We than use our developed mapping to load the OWL models and try to find matches based on standard algorithms (structural similarity and phonetic

similarity) into account. This leads to a number of trivial mappings which are afterwards verified by domain experts. In order to find more sophisticated mappings, we have developed special domain ontologies and glossaries very close to approaches like WordNet – but purely electricity domain based. This process step is the most difficult one and is supported by domain experts. Finally, the mapping or mediator ontologies are validated by prototyping and use in production environment, using the ontologies as rule base for EAI based message conversion and pipelining.
Currently, we have created an overview on the standards for the utility domain based on several taxonomies. This lead to 6 standards which have to be taken into account when dealing with the IEC TC 57 framework, namely including the IEC 61850, the IEC 61970 family, the UN/CEFACT CCTS, ebXML, IEC 62361 Quality Codes for Harmonization and the German national grid standard codes. We have developed ontologies for each standard and therefore all electronic models exist. Currently, the IEC 61850 family and the CIM are being having, we have already mappings for UN/CEFACT CCTS and XML naming and IEC 62361 quality codes which are now given to the standards committee to be published as technical reports supporting the standards family.

5 Conclusion

Within this contribution, we have given a short overview on the IEC TC 57 standards framework and its two main standard families. We discussed the focus of those families and provided a short view on where fallacies for integration lay, mainly based on organisatorial and technical problems. Afterwards, we introduced a description of our COLIN methodology for overcoming those problems using mediator ontologies and ontologizing standards taking the CIM OWL ontology as our basic domain and upper ontology.

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