Semantic Interoperability for Historical and Real Time Data Using CIM and OPC-UA for the Smart Grid in Mexico

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Abstract: - This paper describes the logic architecture implemented for exchanging data gathered in Real-Time as well as stored in Historical repositories, adopting a semantic interoperability architecture based on the Common Information Model (CIM) -which is defined in standards IEC 61968, IEC 61970 and IEC 62325-, and the OPen Connectivity Unified Architecture (OPC-UA) -defined in IEC 62541-. The main objective of this artifacts and architecture is to share the information gathered in real-time from the Electric Power System to many information systems that require it in order to supporting Management, Operational Analysis and other Advanced Functions in the Smart Grid context. The procedure to develop "CIM Wrappers" is showed, as well as results obtained and some conclusions about the works to integrate legacy systems of *Comision Federal de Electricidad* (CFE) in Mexico.

Keywords: Smart Grid, Common Information Model (CIM), IEC61968, IEC 61970, OPC-UA, Semantic Interoperability, Electric Power System, SCADA.

1 Introduction

One of the main technology trends in the electric power supply scope is the Smart Grid concept. In [1] the Smart Grid is described as "an advanced power grid for the 21st century hinge on adding and integrating many varieties of digital computing and communication technologies and services with the power-delivery infrastructure.", it also adds that "Bidirectional flows of energy and two-way communication and control capabilities will enable an array of new functionalities and applications that go well beyond «smart» meters for homes and businesses.". Also is defined as “The Smart Grid integrates electricity and communications in an electric network that supports the new generation of interactive energy and communication services and supplies digital quality electricity for the final customer. In this sense, the electric network must be always available, live, interactive, interconnected and tightly coupled with the communications in a complex energy and information real time network”, i.e. it is necessary defining and implementing an efficient and standard way to share and exchange real time information in all levels.

Thus, it can be shaped a technological strategic vision for the modernization of the electric power supply systems, including monitoring, protection and automatic optimization of operations from the bulk generation, distributed generation, transmission lines and distribution systems to the industrial users, energy storage, end users and consumer devices such as heating, electric vehicles and appliances.

“Interoperability refers to the capability of two or more networks, systems, devices, applications, or components to interwork, and to exchange and readily use information - securely, effectively, and with little or no inconvenience to the user.” [1].

The Smart Grid will be a system of interoperable systems; that is, different systems will be able to exchange meaningful, actionable information in support of the safe, secure, efficient, and reliable operations of electric systems. The systems will share a common meaning of the exchanged information, and this information will elicit agreed-upon types of response. The reliability, fidelity, and security of information exchanges between and among Smart Grid systems must achieve requisite performance levels. [1].

1.1 Literature review

In [5], authors describe an approach to publish SCADA data into Web Services to contribute to the Smart Grid vision in the area of interoperability among SCADA systems in electrical utilities. The SCADA data model is based on the Common Information Model (CIM) defined in IEC 61968, IEC 61970 and related standards. The SCADA data are exchanged using an Enterprise Service Bus (ESB) and the architecture implemented is aligned to the IEC-TC57 architecture for power system information exchange.

In the Smart Grid context, interoperability depends on a coordinated framework of protocols and standards, in order to reach this objective, in [2] three categories of interoperability for any system are identified. In the semantic category any information model can be used as long as it meets with the characteristics of being common to all the company or companies systems. The semantic interoperability compels to have a data model for the efficient exchange of information between domain systems. This model should include the ability to receive and send messages validated in the syntax (format) and semantics (meaning) defined for the exchange.

Currently in many utilities there are working numerous information systems that process and contain valuable information for the efficient operation of the electric power system, their integration has been achieved in a traditional way through specialized point-to-point interfaces as shown in [10], [11] and [13].

The complexity of maintaining these interfaces over time and adapting them to new requirements compels establishing new integration schemes applying standards with a low level coupling, for example Web Services, WCF Services, OPC Services, among others, so that a single data interface can be used in a generic way without relying on the technology or the specific data model for each source or target system. In [10] and [11] it is shown a Service-Oriented Architecture (SOA) using an Enterprise Service Bus (ESB) as a mean of transferring messages that meet with a common data model or scheme.

In [6], authors propose a generic strategy for CIM adoption based in 8 points:

1) Get to know CIM and related systems integration technologies.
2) Get familiar with CIM tools.
3) Make a test CIM model of a part of a distribution network.
4) Define a vision and strategy.
5) Define the implementation process.
6) Implement the integration platform.
7) Make the first CIM based integration project.
8) Continue with systems integration.

Additionally, apply the Smart Grid Architecture Model (SGAM) model is recommended (see Fig. 1).

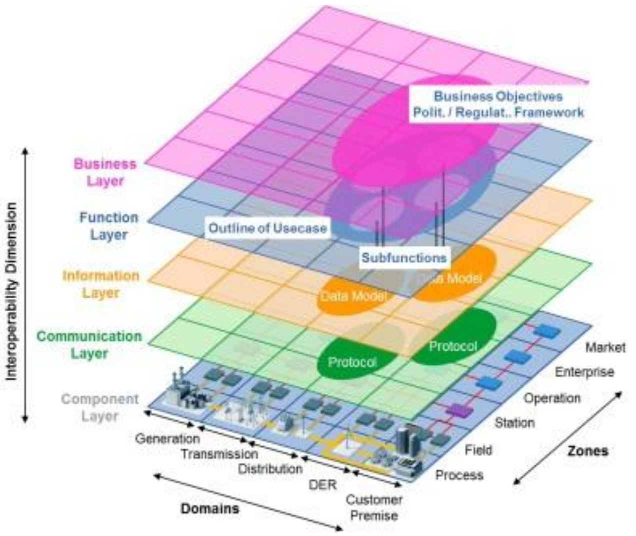

Fig. 1. Smart Grid Architecture Model (SGAM) framework. [4]

In [7] a mobile application is presented as result of information systems integration. The application provides useful information regarding assets and state of network in the field and is part of the EPRI IntelliGrid program. Application includes some abilities to show: Asset information, Map View for network data with geographical positioning (see Fig. 3) and an augmented reality interface for the electrical network model. Many data transformations where implemented in order to reach objectives, Fig. 2 shows the logical architecture implemented.

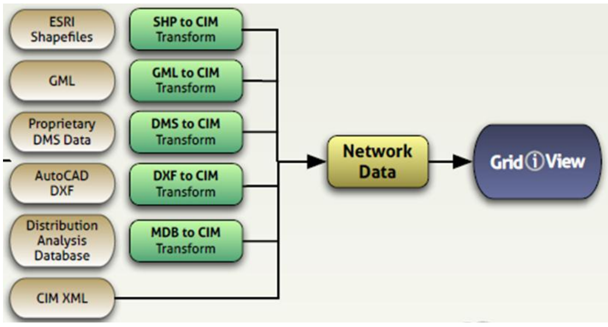

Fig. 2. Data transformation architecture for Grid(i)View application. [7]

Fig. 3. Grid(i)View application GUI example - network data with geographical positioning. [7]

2 CIM Wrappers

For the development of data interfaces that meet with the Semantic Model of the utility, it is required to establish a specific architecture that allows the translation of the source data into a common format (syntax) and meaning (semantics), which can be understood by all actors in the domain of the desired integration.

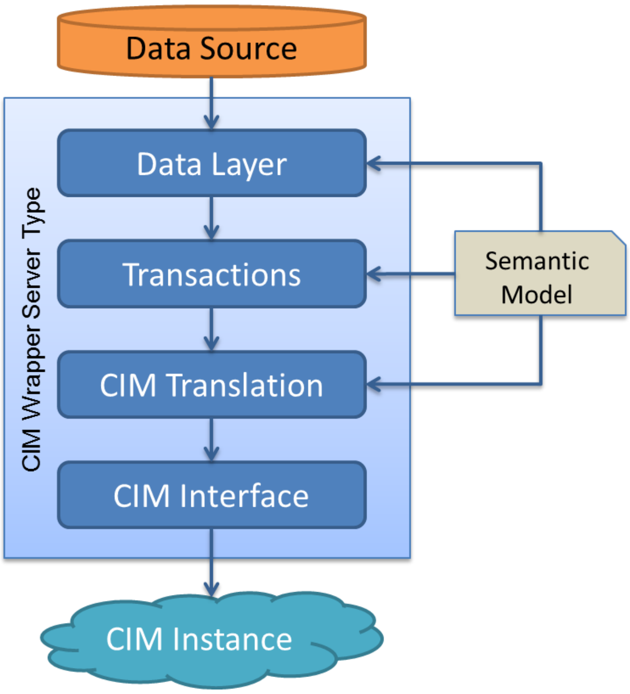

Fig. 4. Architecture for a generic "CIM Wrapper - Server Type".

Thus, a "CIM Wrapper - Server Type" (Fig. 4) is a type of data interface specialized in extracting data from the source systems (data layer), making transactions, calculations and conversions defined in the Semantic Model of the utility and deliver the response in a specific and standard format, under the rules and structure commonly defined by all involved. [8]

For its part, a "CIM Wrapper – Client Type" is the application that can consume the services and understands the information shared by a "CIM Wrapper - Server Type"; it uses the same Semantic Model to understand in a common way the format and meaning of the message (CIM Instance) received as response.

3 Methodology

The process for developing a "CIM Wrapper" is not only a programming task, it is a whole process that involves Mapping activities between the concepts of legacy systems and the concepts defined in CIM in order to agree the meaning of the information to be exchanged, the message format or CIM Instances, as well as the structure of the requests and responses of the data interfaces or services that exposes the information of the data source.

The Common Information Model (CIM Base) defined in standard IEC 61970 - Part 301 [14], is used to build the Semantic Model, as well as the extensions for the Distribution Domain defined in standard IEC 61968 – Part 11 [15].

In addition, CIM also establishes rules for specialized extension to allows to any company to take the base model (CIM Base) and customize it to a specific context to meet specific needs; in [3] extension rules are described, as well as some examples. It is recommended to do the minimum amount of extensions since being specific to the utility or the application context; these extensions will not be compatible with products that comply with the standard CIM Base.

On [8] and [9] it is detailed the adoption process of CIM in an electric utility, the described methodology and sequence are applied to the present development of "CIM Wrappers".

4 Architecture

The architecture used for the semantic interoperability of the systems with historical and real-time information is described below and goes according to Fig. 4. Additionally, two layers for standard data access were included, one based on OPC UA and other based on WCF Services (Windows Communication Foundation) as showed in Fig. 5.

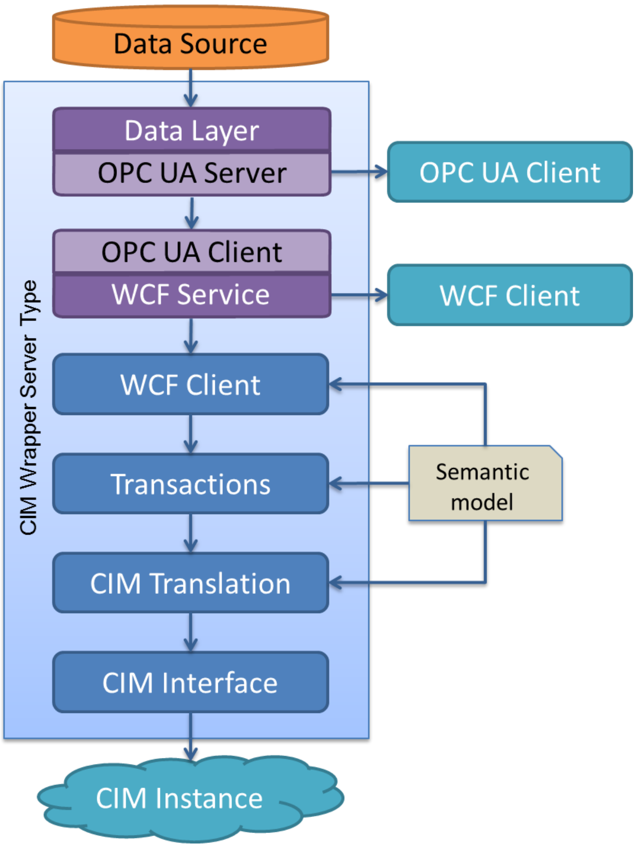

Fig. 5. Modified architecture for a “CIM Wrapper - Server Type” for historical and real-time information.

4.1 Data layer

Access to data from the source systems was performed using the specific technology of each system; in this case MySQL ODBC was used for historical data and SQL Server ODBC for real-time data. Once extracted, the data are presented through an OPC UA Service to allow the access reuse through an international standard [17], likewise, it enables decouple the data layer and increase the interface security on its whole.

Subsequently, the data are consumed by an OPC UA Client in charge of expose data using a native WCF Service (Windows Communication Foundation) to allow access through better technology for mobile devices and thus have the advantages and benefits equivalent to the architecture and technology described for "Process monitoring in your hand" [12].

4.2 Transactions

Because of the large amount of information that is requested and transmitted, the access to historical data of an information system can cause conflicts and a poor performance of the computer equipment that support them; in the historical data CIM Wrapper a transactions layer has been added which, apart from mapping the information to the CIM concepts that model it, allows to perform a data smart extraction through a series of calculations to optimize the desired results, so that is very simple to perform advanced queries that present calculated values such as the average, maximum, minimum, summation, among others, embedded in specific periods, i.e. annual, monthly, weekly, daily and hourly.

Additionally, this layer is in charge of ensuring the stability or operational security by limiting the time and amount of information to be transmitted, so if a "suspect" request is detected, e.g. "request all data from all metering equipment installed" this layer limits the request and response data, providing, for example, only a sample of the first 100 data from the first 10 meters, so for a very long request the Consumer application is obliged to carry out the requests explicitly, filtering settings using several consecutive requests, ensuring that the data source server, network and applications are not saturated and all simultaneous Customers receive adequate response in the shortest possible time.

The transactions layer for historical data has enabled the optimization of response times by over 90% compared to a simple raw data extraction.

Transactions for real-time data are limited to doing the mapping of concepts to the company Semantic Model.

4.3 CIM Translation

This layer performs the format conversions of the received data to the format, schema and rules defined in CIM and in the Semantic Model, so that the information to be presented will be encoded according to CIM on a message or CIM Instance.

Any CIM Instance received from the CIM Wrappers shall comply with the format and structure of the Semantic Model to be accepted as valid, so it can be verified by any specialized tool in order to meet the established Semantic Interoperability scheme.

4.4 CIM Interface
Finally, once the data has been extracted, formatted and translated, the CIM interface is responsible for presenting the information through the rules defined in the standards [16], as well as in respecting the company's agreements.

This CIM Interface is responsible for answering the requests from the Client applications, so it must contain a set of validation rules for messages according to CIM, as well as implement the established agreements, namely it must integrate the company's specific communication rules plus the standard rules, such as error handling, access security, or schemes for complex processing.

The CIM Interface for the Wrappers developed for historical and real-time data presents the information through WCF Services (Windows Communication Foundation), which is one of the accepted technologies in the standard IEC 61968-100 [16] and encodes the information according to the company's CIM Profile [8] and [9].

5 OPC UA
OPC UA (OPen Connectivity Unified Architecture) is a set of industrial standards for the interconnectivity of systems, provides a common interface for communications between different products from different suppliers. In [9] it is described in detail some of the advantages of having a single connectivity standard for equipment and industrial information systems with measurements acquired and stored in historical records.

The OPC UA interoperability standards were developed by the OPC Foundation and are the successors to the OLE for Process Control (OPC). Although it was developed by the same organization, OPC UA differs significantly from its predecessor; the objective was to remove the reliance on the Component Object Models (COM and DCOM) to a Service Oriented Architecture (SOA) for the control of industrial processes.

OPC UA is formally documented in the IEC 62541 standards group and enables, among other things, to define the Semantic Model of the information to be transmitted [17].

6 Semantic Model
The segment of the Semantic Model used in the CIM Wrappers for the historical and real-time information basically uses two segments or CIM hierarchies: "Organizational Structure" and "Measurements".

6.1 Organizational Structure
Allows to identify in a unified manner any area or administrative unit and includes some extensions to the Base CIM in order to suit actual conditions, see Fig. 6.

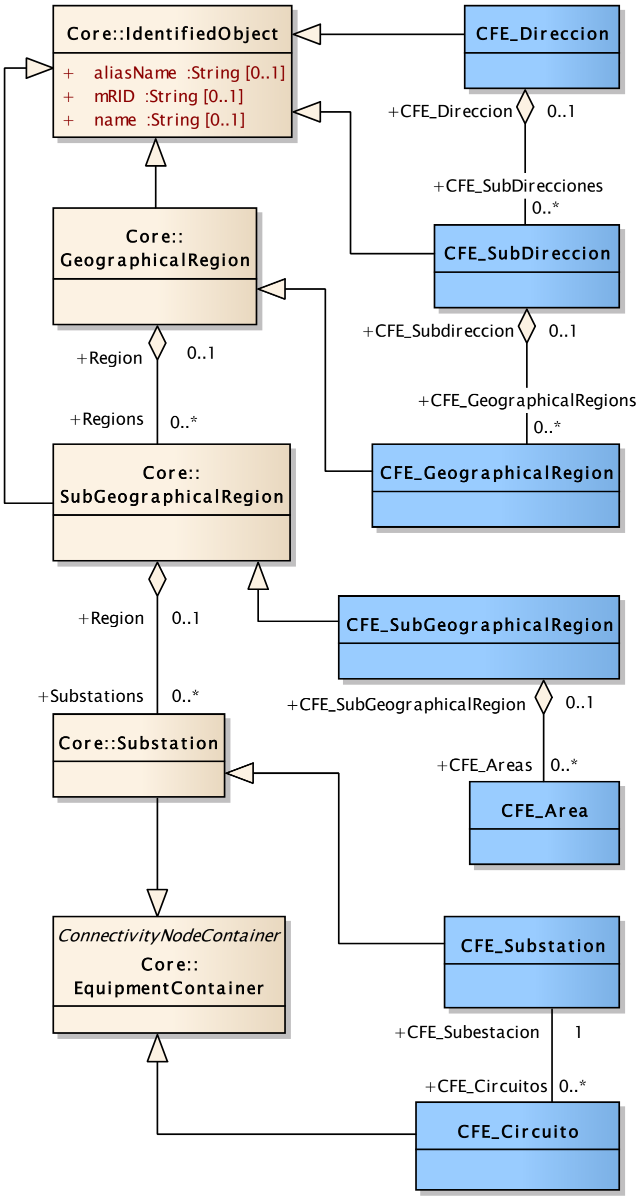

Fig. 6. CIM Class Diagram for the Organizational Structure hierarchy.

- *CFE_Dirección*: Allows modeling administrative Directorates (Directorate General, Operation, Administration, etc.).
- *CFE_SubDirección*: Allows modeling administrative sub-Directorates (Generation, Transmission, Distribution, etc.).

- *CFE_GeographicalRegion*. Represents an administrative unit with influence over a defined territorial region (Distribution Division, Control Area, etc.).
- *CFE_SubGeographicalRegion*. Represents an administrative unit with influence over a defined territorial region within a *CFE_GeographicalRegion* (Distribution Zone, Control Sub-area, etc.).
- *CFE_Área*: The administrative units that make up a *CFE_SubGeographicalRegion* (Commercial Area, Commercial Agency, etc.).
- *CFE_Subestacion*: It represents a CFE's Substation, it could be of Transmission or Distribution.
- *CFE_Circuito*: It depicts a Circuit or a Feeder of a CFE's Distribution Substation; it has the functionality of an equipment container.

6.2 Measurements

It allows identifying in a unified way any analog or digital measurement obtained from measuring equipment in the Electric Power System. In this segment of the CIM Profile the power quality measurements are integrated (see Fig. 7).

All classes of the hierarchy were implemented in .NET classes for the development of the CIM Wrappers that allow getting the messages of CIM Instances in accordance to the defined Semantic Model.

This Measurements CIM Profile in conjunction with the definitions and technology of OPC UA enabled to implement the extraction capacity of historical and real-time data from source systems and present them in two different formats:

OPC UA Server: Considering only the semantic information Model for analog, digital and power quality events measurements. But available for any direct connection to a standard *OPC UA Client* application requiring to consume the information.

CIM Interface: It considers the full Semantic Model of analog, digital and power quality events measurements, but includes the association to the company's Organizational Structure, so that it is possible to "browse" significantly over the presented data to reach the desired information.

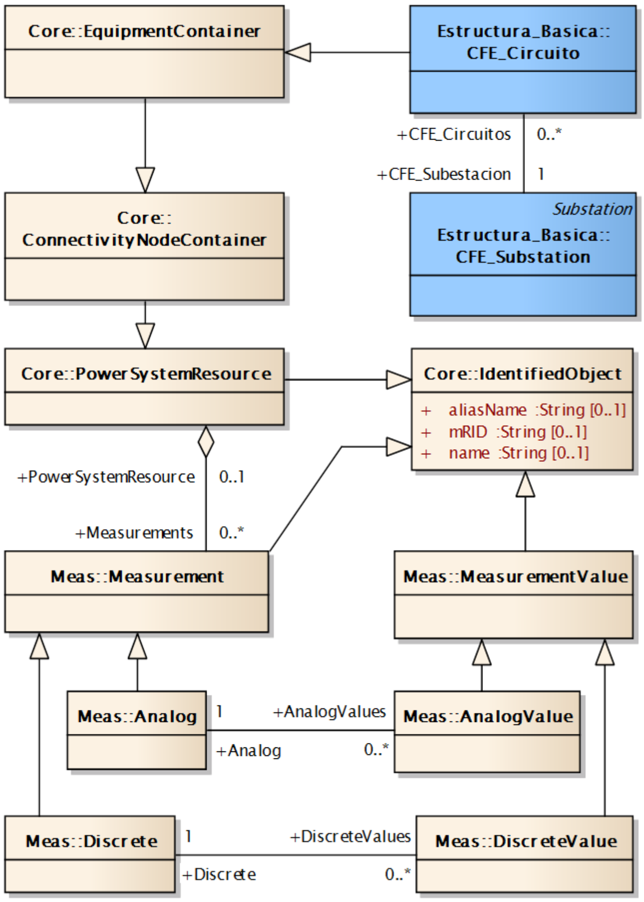

Fig. 7. CIM Class Diagram for the Measurements hierarchy.

Fig. 8 shows the traditional scheme for accessing data from a measurement system or device using standards or data protocols with a high-level coupling, such as MODBUS, DNP, Profibus, classic OPC, etc. On these systems it is necessary to know in advance the TAG, memory address or identifier of the variable required to consult.

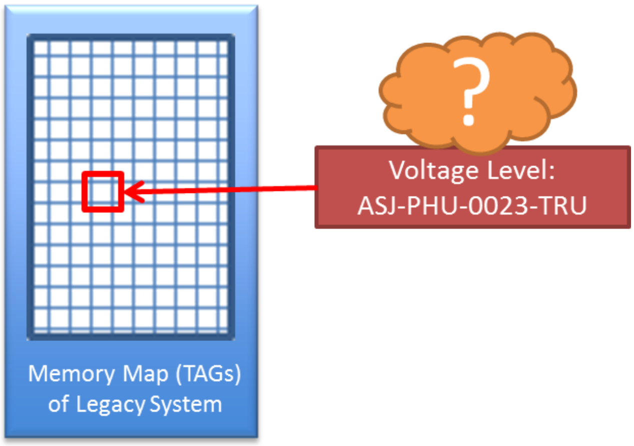

Fig. 8. Traditional data access for measurement devices using TAG or memory maps.

If the information model and its explicit and unified meaning are available, it is possible to browse the presented data by one or multiple systems together to reach the desired information; Fig. 9 shows a hierarchical tree that can be followed to consult the voltage of a circuit in a specific substation.

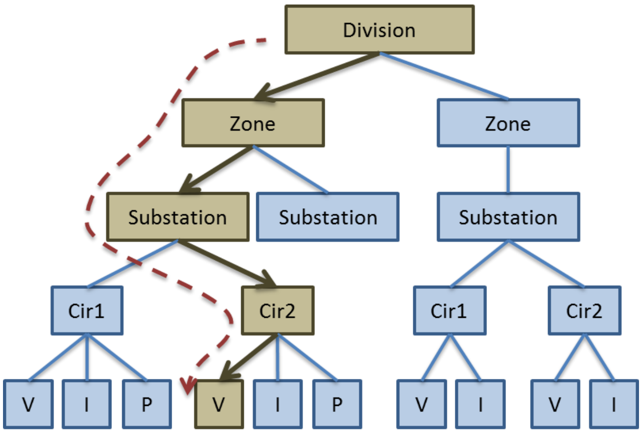

Fig. 9. Contextual data access for measurement devices using a semantic model.

7 CIM Instances

Each one of the developed CIM Wrappers includes the CIM interface which allows displaying the measurement data through an Enterprise Service Bus, where messages with the CIM Instances are transmitted in XML format.


```
...
<s:Body>
    <GetCFE_SIMOCE xmlns="http://iec.ch/TC57/2011/GetCFE_SIMOCE">
    <request xmlns:d4p1="http://schemas ... /XMLSchema-instance">
    <a:GetCFE_SIMOCE>
    <a:Header>
    ...
        <a:Noun>analog</a:Noun>
        <a:Property>
            <a:MessageProperty>
                <a:Name>asociation</a:Name>
                <a:Value i:nil="true" />
            </a:MessageProperty>
        </a:Property>
        ...
        <a:Verb>get</a:Verb>
    </a:Header>
    <a:Payload i:nil="true" />
    <a:Request>
        <a:name>analog.analogvalues</a:name>
        <a:value>HTC53035@ia#9000</a:value>
        <a:StartTime>2014-09-25</a:StartTime>
        <a:EndTime>2014-09-25</a:EndTime>
        ...
        </a:OptionType></a:Option>
    </a:Request>
    </a:GetCFE_SIMOCE>
    </request>
    </GetCFE_SIMOCE>
</s:Body>
...
```


Fig. 10. Extract of a CIM/XML message based on IEC 61968-100 for request historical data to a CIM Wrapper - Server Type.


```
...
<s:Body>
    <GetCFE_SIMOCEResponse xmlns="http://iec.ch/TC57/2011/GetCFE_SIMOCE">
    <GetCFE_SIMOCEResult xmlns:a="http://schemas ... XMLSchema-instance">
    <a:CFE_SIMOCEResponseMessage>
    <a:Header>
        ...
        <a:Noun>analog</a:Noun>
        ...
    </a:Header>
    <a:Payload>
    <a:Profile>
    <a:Analog i:nil="true" xmlns:b="http://schemas ... IEC61970.Meas" />
    <a:AnalogValue xmlns:b="http://schemas ... IEC61970.Meas">
    <b:AnalogValue>
        ...
        <name xmlns="http://schemas ... IEC61970.Core">HTC53035@ia</name>
        <b:timeStamp>2014-09-25T00:00:00Z</b:timeStamp>
        <b:Analog i:nil="true" /> <b:value>40.8</b:value>
    </b:AnalogValue>
    <b:AnalogValue>
        ...
        <name xmlns="http://schemas ... IEC61970.Core">HTC53035@ia</name>
        <b:timeStamp>2014-09-25T00:10:00Z</b:timeStamp>
        <b:Analog i:nil="true" /> <b:value>40.7</b:value>
    </b:AnalogValue>
    ...
    <b:AnalogValue>
        ...
        <name xmlns="http://schemas ... IEC61970.Core">HTC53035@ia</name>
        <b:timeStamp>2014-09-25T23:50:00Z</b:timeStamp>
        <b:Analog i:nil="true" /> <b:value>44.8</b:value>
    </b:AnalogValue>
    <a:Meter i:nil="true" xmlns:b="http://schemas ... IEC61968.Metering" />
    </a:Profile>
    </a:Payload>
    ...
</s:Body>
...
```


Fig. 11. Extract of a CIM/XML message based on IEC 61968-100 for response historical data from a CIM Wrapper - Server Type.

Fig. 12 shows a graphical representation of the information included in the CIM/XML message committed by CIM Wrapper - Server Type developed. The historical information (timestamp and values) are the same data shown in Fig. 11 but in different format.

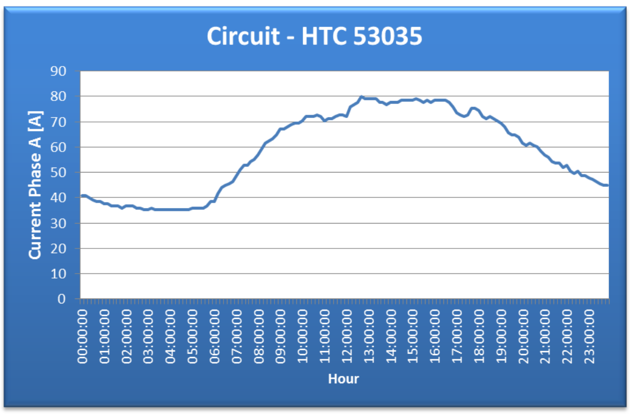

Fig. 12. Graphical representation of the CIM/XML message committed by CIM Wrapper - Server Type.

```xml
...
<a:Profile>
    <a:Analog i:nil="true" xmlns:b="http://schemas ... CIM.IEC61970.Meas" />
    <a:AnalogValue xmlns:b="http://schemas ... CIM.IEC61970.Meas">
    <b:AnalogValue>
        <aliasName i:nil="true" xmlns="http://schemas ... CIM.IEC61970.Core" />
        <idRDF i:nil="true" xmlns="http://schemas ... CIM.IEC61970.Core" />
        <mRID i:nil="true" xmlns="http://schemas ... CIM.TC57CIM.IEC61970.Core" />
        <name xmlns="http://schemas ... CIM.IEC61970.Core">
            HTC-53085-MED@Mess_IL1</name>
        <b:timeStamp>0001-01-01T00:00:00</b:timeStamp>
        <b:Analog i:nil="true" />
            <b:value>198</b:value>
        </b:AnalogValue>
    </a:AnalogValue>
    <a:Discrete i:nil="true" xmlns:b="http://schemas ... CIM.IEC61970.Meas" />
    <a:DiscreteValue i:nil="true" xmlns:b="http://schemas ... CIM.IEC61970.Meas" />
    <a:Meter i:nil="true" xmlns:b="http://schemas ... CIM.IEC61968.Metering" />
</a:Profile>
...
```


Fig. 13. Extract of a CIM/XML message based on IEC 61968-100 for response real-time data from a CIM Wrapper - Server Type.

8 Results

Currently, the developed CIM Wrappers for historical and real-time data are integrating high level applications that suit the company's business processes to achieve strategic objectives, such as "Power Loss Reduction".

Particularly, a client application was integrated which consumes data from the two CIM Wrappers to calculate and display the level of phase unbalance of the Distribution circuits, so that Analysts and Operators in the Control Center may have the information for the operational decision making.

On one side, from the historical information are extracted the per phase monthly average of electrical current, real power, reactive power and voltage, the percentage of imbalance is also calculated and displayed in an organized manner for every circuit in a substation or Distribution Zone, then the same procedure is performed to the average of the last 48 hours and is plotted together with the value of the previous month, finally the same algorithm is applied to the real time data and these are plotted together with the two previous values.

These graphs allow a very quick way of identifying the circuits that require more attention and enable to quickly validate the actions taken on the field, the same day, the day before and on a monthly basis to verify the correction permanency.

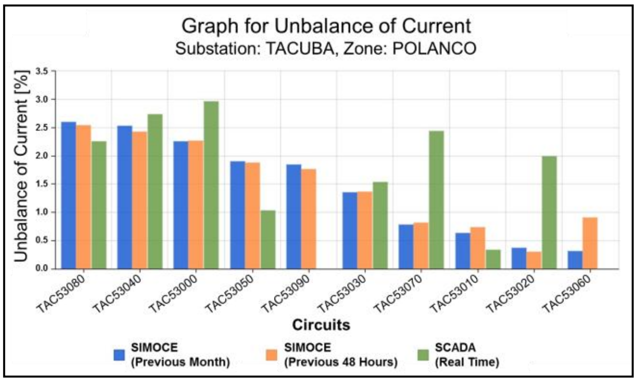

Fig. 14. On-Line graph bar, it is built using historical and real-time data from CIM Wrappers Server Type. The graph shows the historical and real-time phase unbalance for distribution Substation circuits.

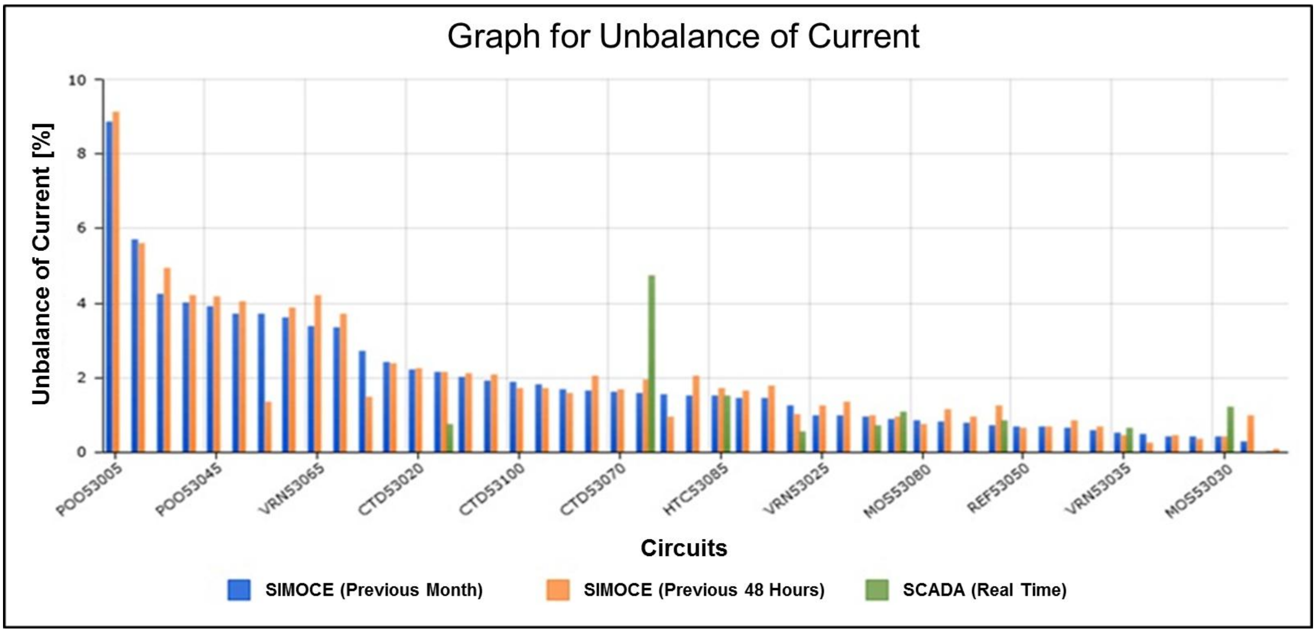

Fig. 15. On-Line graph bar, it is built using historical and real-time data from CIM Wrappers Server Type. The graph shows the historical and real-time phase unbalance for all distribution circuits in a Zone.

Manually, the graph of Fig. 14 is normally made by an expert analyst in electric power system in 4 hours for a Substation (a Zone includes 10 or more Substations); using CIM Wrappers developed, the same graph is made in 20 seconds for a Substation and 40 seconds for a Zone (Fig. 15).

The graph of Fig. 16 is normally made manually in 2 hours; using CIM Wrappers, the same graph is made in 20 seconds.

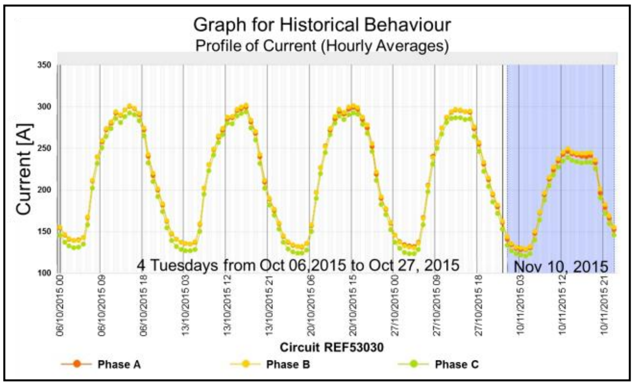

Fig. 16. Graph for compare the feeder's daily profile; it is built using the CIM Wrapper Server Type. The graph shows the historical behaviour (months) against historical profile (days) for the same weekday.

Currently, this software tools and CIM Wrappers are running normally in a Division of CFE in Mexico, the data access is direct to productive servers of legacy enterprise systems.

9 Performance

Implementing “semantic” interfaces for a Semantic Interoperability strategy in any utility, implies including an information overload in messages from/to systems, this because all information exchanged must comply the structure or Scheme defined by the strategy selected and the interface must be based in a canonical definition that allows unify the methodology to develop CIM Wrappers in Server or Client mode.

9.1 Performance test (Historical)

A performance measure is very important in order to verify if the strategy will be successful in the long time. For CIM Wrappers developed to request historical data from real legacy systems, here some performance results:

Historical Data – Test 1:

- Feeder: CDS53000 – Current Phase A
- Period: from Oct 01, 2014 to Feb 01, 2015
- Request values: 8,999 row data
- Request time: 1 ms

Historical Data – Test 2:

- Feeder: CDS53000 – Current Phase A
- Period: from Oct 01, 2014 to Feb 01, 2015
- Request values: 8,999 row data, Hourly Average and Daily Average
- Total samples: 12,073
- Request time: 2 ms

Historical Data – Test 3:

- Feeder: CDS53000 (12 parameters)
- Period: from Jan 01, 2014 to Dec 31, 2014
- Request values: Hourly Average
- Total samples: 104,808
- Request time: 27 ms

Historical Data – Test 4:

- Feeder: CDS53065 (12 parameters)
- Period: from Jan 01, 2014 to Dec 31, 2014
- Request values: Hourly Average
- Total samples: 108,000
- Request time: 34 ms

Historical Data – Test 5:

- Feeder: CDS53065 (12 parameters)
- Period: from Jan 01, 2014 to Dec 31, 2014
- Request values: Daily Average
- Total samples: 4,236
- Request time: 10 ms

For historical data the average performance is $4.5x10^6$ samples/s.

9.2 Performance test (Real Time)

For CIM Wrappers developed to request real time data from real legacy systems, here some performance results:

Real Time Data – Test 1:

- Meter: CMC-53115 (Current Phase A)
- Period: Now
- Request values: Real Time - Analog Values
- Total samples: 1
- Request time: 77 ms

Real Time Data – Test 2:

- Meter: CMC-53115 (Current Phase A, B, C)
- Period: Now
- Request values: Real Time - Analog Values
- Total samples: 3
- Request time: 40 ms

Real Time Data – Test 3:

- Meter: CMC-53115, HTC-53055, CMC-53115 and HTC-53055 (Current Phase A, B, C)
- Period: Now
- Request values: Real Time - Analog Values
- Total samples: 12
- Request time: 234 ms

Real Time Data – Test 4:

- Meter: CMC-53115, HTC-53055, CMC-53115, HTC-53055 and VRN-55035 (Current Phase A, B, C)
- Period: Now
- Request values: Real Time - Analog Values
- Total samples: 15
- Request time: 154 ms

Real Time Data – Test 5:

- Meter: All of MOS substation (Current Phase A, B, C)
- Period: Now
- Request values: Real Time - Analog Values
- Total samples: 234
- Request time: 546 ms

For real time data the average performance is 133 samples/s.

The main difference against historical data is the scheme of messages and the strategy to recover many samples; historical information is included in a single structure (Fig. 11), real time data requires an individual structure for each value (Fig. 13).

9.3 Adaptation test

An additional performing test was conducted in order to estimate the time for a change adaptation. In this test, the real SCADA was changed. That means, the data source for the SCADA CIM Wrapper was replaced, from the original SCADA in the Distribution Control Center to a new SCADA in the Energetics Fuel Supply. The replace implies changes only in the Data Layer (see Fig. 4 and Fig. 5) and the time required for this test was only 4 hour of an expert CIM developer for CIM Wrapper modification and 1 hour of an expert in the new SCADA technology.

Finally many validation tests were applied and results shown exactly the same value in the SCADA GUI, SCADA Historical database and in the Client application developed to test CIM Wrappers.

For this adaptation test, the CIM Profile and the Concept Mapping of the Semantic Model were the same in order to maintain consistency. If a new adaptation function is required to use a new Concept Mapping, the Transactions Layer or the CIM Translation Layer could be affected (see Fig. 4 and Fig. 5).

10 Conclusions

Developing CIM Wrappers is an arduous task, there is an initial effort and cost for their implementation, but the effort and cost are not replicated in subsequent CIM Wrappers since a lot of the previous products are reused.

Similarly, once developed a complete CIM Wrapper, its adaptation to changes, new requirements and even complete replacement of the source system involves a minor change in the CIM Wrapper, as only the data layer must be modified because is the only technology that is totally dependent on the specific product from the source system, the other layers and components are unchanged, which means that they Client information systems should not be modified in any way since the functionality, strategy, architecture and services will remain unchanged; this feature is one of the main advantages of using CIM and associated standards for development of the Semantic Model for a utility and to implement the architecture of Semantic Interoperability for the Smart Grid.

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