Implementing Smart Grid with a CIM-oriented Integration and Data Acquisition Gateway

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***Abstract*—Electric power industries have expanded the automation of their networks in recent years to meet the growing demands for improvements in services. The introduction of the concept of Smart Grid, the increased availability of smart devices and improvements in telecommunications are key factors for that. Besides the benefits in control and management that this concept brings, there are some technical restrictions for the adoption due to legacy or multiple vendor equipments, each one with its own standard, as well as interoperability with supervisory and management softwares. This paper, then, proposes the use of a gateway to enable interoperability between devices using different communication protocols by translating them, centering data and control in a database defined by the Common Information Model(CIM) standard.**

I. Introduction

The electric power industries are undergoing a process of modernization on their structures to meet consumer demands for better quality and service availability. The concept of Smart Grid[1] has emerged as a solution to meet the diverse needs of electric power industries and their consumers. Bringing together concepts of data communication, smart electronic devices, microgeneration, energy storage and information technology, it has enabled the creation of a more secure, efficient, flexible and resilient power grid.

However, the benefits from the Smart Grid also creates challenges to be overcome. The major challenges are related to the acquisition, integration and handling the large volume of data made available by electronic devices that supports communication as well as extraction of useful information from this great mass of data created.

The acquisition problem occurs due to old legacy systems or the vendor strategies for "customer lock-in" through use of proprietary data models, methods and tools. This problem, on our solution, was solved by providing a extensible translation layer for communication protocols and data models, so that data can flow independent of its origin, allowing integration.

To handle the data, we use the Common Information Model (CIM) applied to a database structure.

The Common Information Model (CIM), a standard developed by the electric power industry that has been officially adopted by the International Electrotechnical Commission (IEC) for power transmission and distribution. The purpose is to allow application software to exchange information about an electrical network[2]. The CIM is object-oriented, can be extended, and consist of classes, attributes and the relationships among them, to describe the behavior of each and every electrical system resource, everything defined in Unified Modeling Language (UML) notation. The main purpose of the CIM is to provide a common language to semantically describe resources and data exchanged among systems[7]. It's usage is supported by the standards IEC 61968, information exchanges between electrical distribution systems[3], and IEC 61970, wich deals with the application program interfaces for energy management systems[4].

II. Theoretical Revision

The existing devices in the electrical distribution network have intrinsically heterogeneous characteristics. The various manufacturers and solutions result in a mix of proprietary interfaces and software tools that require diverse training and vendor dependency. In addition, the safety factor is decentralized, which causes the need for individual data model and passwords for each device.

All these factors prevent the optimization of the structured management of these equipments. Although the market has proposed solutions that enable the inclusion of certain devices to legacy protocols (Modbus, CAN, etc.), or even create simple translaters, there is a strong demand to have a single data model to store and work with the data. This is the reason of existence of Common Information Model (CIM).

Although the standards-based systems integration of utility software applications using the domain data standard common information model (CIM) exists, many utilities are facing difficulties in managing of data exchanges among software application systems due to lack of standard oriented database management systems. The standard oriented database can be built from the CIM object oriented model using object-relational mapping (ORM)[6] on a database.

With this topology, the integration of devices that are not compatible with the current standards related to Smart Grid structures is made with a lower cost and scalability. Additionally, manageable elements inherent to the devices are listed in a tree of objects allowing read access and/or writing through the operation center. This is of fundamental importance in the current structure of power supply, placing network operation with high levels of responsiveness and performance generating better satisfaction in service.

III. Functional Description of the Gateway

The gateway is designed to be highly transparent and modular to provide flexibility and high scalability. Allowing to adapt more easily to the data models, communication

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technologies and devices with non-standard interfaces. Monolithic structures tend to become closed, making the system integration more difficult in heterogeneous structures.

The gateway runs as a serie of services on a POSIX based operating systems (Linux, BSD), providing protocol libraries related to the Smart Grid (IEC61850, DNP3, Modbus) and a DBMS (Database Management System) that will implemente CIM model and be a central point of application. Other then direct SQL query to database, the whole gateway is defined in a client/server architecture of the TCP/IP stack as well as a WebServices to ease the extension of the architecture. An API is provided to easily add protocols and direct communication between new devices.

A. Internals

In the substation control center, all the control and supervision data are available and carried by a SCADA (Supervisory Control And Data Acquisition) software, which performs readings such as voltage, current, circuit status, and switch positions as writings, activating and deactivating elements of network.

The SCADA communicates with the gateway using a standard communication protocol, like DNP3, IEC 61850 or MODBUS, or via Webservice.

The communication between the SCADA and gateway is started by invoking one of the methods GWDNP3(), GWModbus(), GW61850(), GWws() to use, respectivelly, DNP3[5], MODBUS, [8]IEC61850 and Webservice for communication, all belonging to ”core” module on gateway.

When a request comes from SCADA, the gateway selects the appropriate protocol translator and, from this point on, all data and command are converted for a intermediate internal protocol, through the methods ”encode()” and ”decode()” standardized to, respectively, encode and decode a frame from any protocol. Then, if the SCADA request was a reading, a SQL select is issued on database and the result, after retranslated, sent back to SCADA. If, otherwise, an actuation is performed, an SQL insert is made into database. This change triggers a database object that calls a script that send an actuation command to the device.

Every time a new element connects to gateway via a microserver, its protocol is selected on the translating list and the communication starts. These elements can be any hardware, using any protocol that is already implemented, as TCP/IP or RS232 microservers. After that, it invokes a method ”anounce()” from ”core” module. So, all communication structure is created, including instantiation of internal protocol so that readings becomes possible. Then, a field of the database will be set, the device will be seen as ACTIVE from SCADA and will be already able to receive commands and to send readings.

Besides ”anounce()” and the communication methods, four other control methods are implemented on ”core” module of gateway. The first one is the ”sendResponseBack()”, whose purpose is to collect the answer for the query on the repository, regulate it, normalize it and send it back to the database. The second one is ”getMyQueries()”, used by microservers in fixed time cycles to get, from database, requests to the elements directly connected to them. The third method is the ”resposePush()”, also using by microservers, to send the answers to queries to be translated, processed and stored in database. The fourth and final method is the ”queryPush()”, invoked by the microserver to force a special send to database, in an emergency scenario or, in case of a parameter previously set to inform its modification (alarm), is triggered.

These methods from module ”core” are required to create and configure devices and allow a flow of communication and control between the SCADA and any type of device.

IV. Conclusion

This work has presented an integrator gateway that, in adition to create an easy extensible protocol translator and multilink communication solution, proposes a CIM-oriented database as a core of electric system integration. Part of this work has been the solution implemented on an electrical company in the state of Maranhão, Brazil to integrate with some network elements. The research that led to a previous version of this gateway and is part of a bigger solution to integrate and give inteligence to legacy devices on the operation center of the company.

The model is evolving. We are creating different triggers to the database and focusing on data analysis to foresee status of power grid and create a more general model.

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