SMART GRID COMMUNICATIONS EMULATOR (100 000 SYNTHETIC USERS)

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ABSTRACT

The purpose of this paper is to inform to the Energy Sector of the first achievements of the Smart Grid Communications emulator developed under the GAD project in Spain (Active Demand Management).

Due to the current trend of enhancing the electrical network information and communication capabilities, the Smart Grid has raised an important issue about Demand Management in the last mile. A new communications architecture to cover the different aspects of the Smart Grid and Demand Management has been designed in the GAD project. This architecture supports the automatic business procedures from the TSO (Transport System Operator), DSO (Distribution System Operator) and Power Marketers, and considers protocols of recent introduction which still are under development, like PRIME.

INTRODUCTION

In this paper we are going to describe in detail the GAD consortium role to emulate a Spanish region, so that a first approach to a national deployment and its basic analysis and decisions could be taken into account, before jumping into a massive deployment to flatten the Demand Curve, shown in Figure 1.

In parallel, a technical prove of concept of the different devices and overall architecture is in place, so that any hardware, software and parameterization procedures can be run in parallel, to guarantee the latest status of the art of every piece of the project.

GAD consortium has established a very aggressive and advance concept of the Smart Grid architecture in the most complex arena, reaching not only Control Centres, Substations, and Transformation Centres, it reaches counters and even the domestic devices: a real last mile approach of the future Smart Grids with proactive users.

These new architecture designs, integrations and considerations need to be tested and stressed before being deployed. In order to get that, several models and tools have been developed by CEDETEL to eventually launch a new full set of simulations. These simulations have been carried out by CEDETEL and SIEMENS in collaboration with the different companies belonging to the GAD consortium, which are also the main actors of the actual smart grid: Red Eléctrica de España as the TSO, IBERDROLA as the DSO and GTD as a simulated Power Marketer.

The objective is to test the applications and even network behaviour with the different architecture options and physical constraints of the electrical and communications networks, before jumping into a massive national deployment. TSO, DSO and Power Marketer applications have been tested interfacing with a simulated environment which is already mapping a real smart grid communications network topology and behavior of a province of Spain. A synthetic population of 100,000 users has been created based on a Spanish citizens sample to simulate the users' reaction when a critical order is sent from the TSO, the DSO needs to carry out a technical order or a new pricing policy is sent from the Power Marketer.

The emulation process will lead to new procedures, technical analysis and new proposals, as well as new business models analysis to actually measure the benefit of different price policies or impact of a technical order. Deep analysis and learnt lessons will be shown soon, so that we expect to support the Electrical Community to understand the implications of new Smart Grid deployment at national levels, both in technical aspects (electrical and communications) and business impact. This will also allow us to understand the social impact of the Smart Grid and new regulation recommendations.

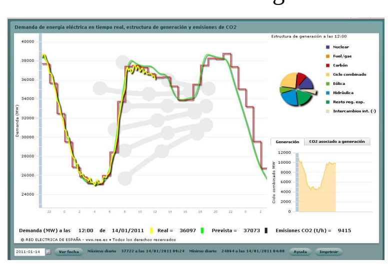

Figure 1. Spanish Demand Curve – source: www.ree.es.

POWER AND COMMUNICATION NETWORK SIMULATOR FOR SMART GRID

SIEMENS-CEDETEL has developed several emulation models for wide-area and access networks in order to reproduce key communication processes involved in active demand-side management (DSM) at national level. These models reproduce power demand models, narrowband PLC propagation models, physical devices and telemetry models development.

Development framework

Energy Sector new network models, which reproduces the dynamic behavior of complex communication systems, are built over an open source C++ infrastructure based on OMNeT++/OMNesT [1]. With them, discrete event simulations are generated, reproducing by means of messages exchange, the underlying processes involved in the communications of the system as a whole.

SIEMENS-CEDETEL has modeled all the necessary elements to introduce the communications of the DSM application. It includes physical media signal propagation models, communication protocols, messages and exchanged information, physical devices, interconnection networks and part of the application logic.

Its integration into a solution provides visibility and total control over system relevant phenomena, and enables oriented and representative studies on feasible communication solutions.

Physical communication media

Due to the current interest of the Energy Sector, and in addition to the traditional media based on cable and wireless propagation, SIEMENS-CEDETEL has implemented a propagation model for OFDM systems over PLC used in narrowband communications, where PRIME [2] standard is framed.

Medium characteristics such as propagation, attenuation, insertion loss, noise, collision phenomena, synchronization and Signal to Noise Ratio (SNR) degradation are reproduced.

Physical devices

Devices' models incorporate a whole protocol stack, from physical to application layer, where they perform their main functions.

The tool supports devices' models such as smart metering and intelligent load control devices, Figure 2, as well as access nodes and intermediate communication elements. Smart metering and load control devices are located at customer premises and are incorporated among other user level devices.

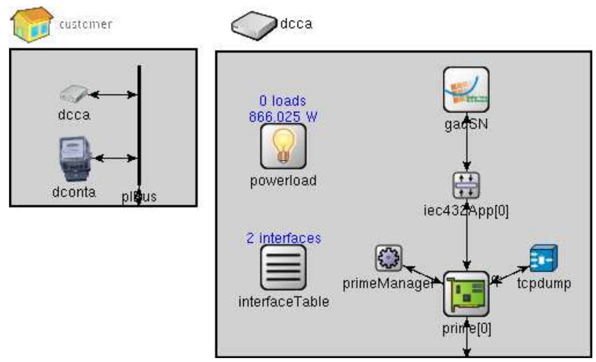

Figure 2. Devices for customer model and intelligent load control devices.

The GAD load control device is a representation of its functionality, which manages the domestic appliances' power demand and has been specified for PRIME networks and incorporates information related to its interaction with smart meter (DCONTA device).

Topologies and networks

The emulation tool allows representing a comprehensive set of network topologies according to transmission and distribution schemes, Figure 3. These topologies can be generated deterministically (e.g. to reproduce a specific case of interest) or randomly from statistical data of networks whose topology characterization is incomplete.

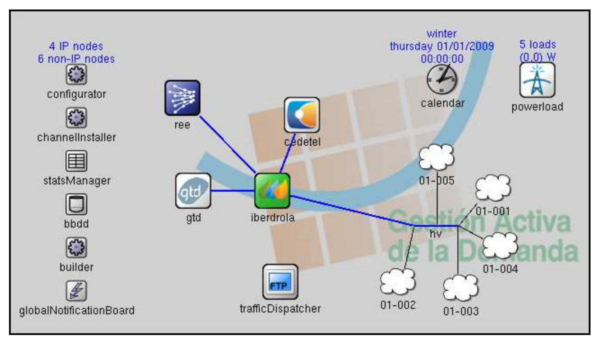

Figure 3. Topology according to transmission and distribution network.

The network topology generation system is also connected to database engines (DDBB), facilitating the study of large areas (e.g.: regional or national grids) from actual data which may be provided by the Utilities.

Individual and Aggregated Demand Support

Client's individual demand, Figure 4, has been modeled considering time-varying properties (hourly demand) with the aim of incorporate power demand measures from each simulated customer. These properties can be modified *ad hoc* according to assumptions established in the simulated clients' contracts.

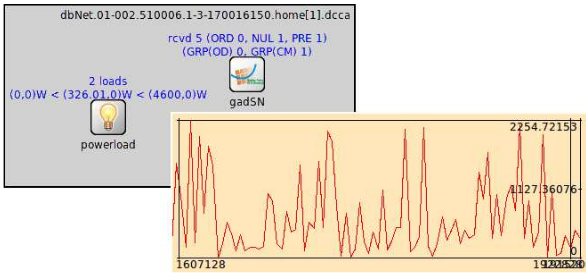

Figure 4. Customer's individual demand.

Thus, into each customer implementation, a power demand varying according to parametric statistical models and other system variables, i.e.: location, weather, contract, performance history, etc.

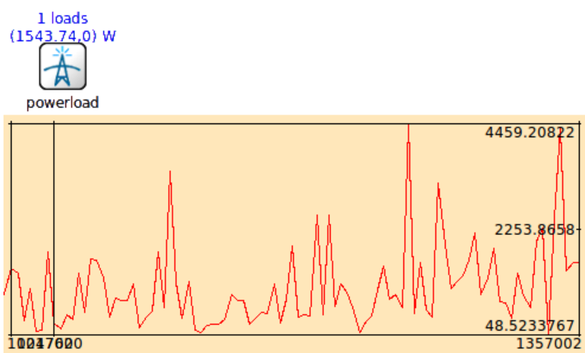

Figure 5. Customer's total demand.

A selective demand aggregation system allows automatic calculations of clients' aggregated demand according to interest criteria, Figure 5. This will facilitate the implementation and testing of algorithms for demand-side management or other focused studies.

Interactive Simulation

With this simulation-based Smart Grid analysis tools, we will be able to model communications from Control Centers of the Agents (Transport, Distribution, Commercials) till final users, going through Substation and Transformation Centers special communication devices [3], as stated in Figure 5.

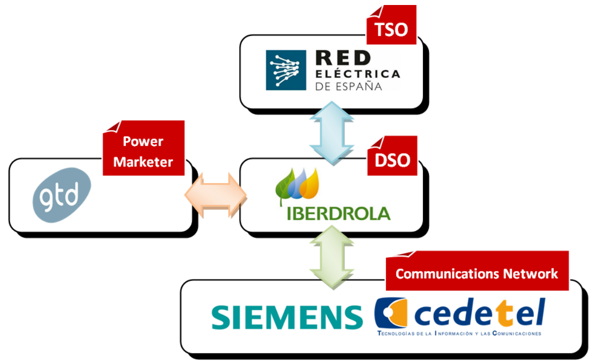

Figure 6. Interactive simulation structure.

The tool can be used in wall clock time or accelerated time It also includes web integration which, through XML files, allow to act and control the simulator.

CONCLUSIONS

Thanks to the CENIT GAD project, the Consortium has proven the technical concept of the Active Demand Management, both in devices and simulation of a regional grid, with ability to jump into a National scale.

We have established a new Smart Grid architecture of communications, to inform and manage the network from the control centers till the last mile users (home devices). This architecture is open, flexible, scalable, interoperable, and able to support different status of the art protocols and technologies and migrate them independent of the network layer or OSI level.

We think a new massive role out in a region, previous to a national scope deployment, needs to be set up, in order to prove in a real environment that the overall benefits to the Energy grid compensates the initial investments, thanks to a better citizen information and proactive collaboration to the 2020 Strategy, helping the National Demand Curve to be flattened, moving consumptions from peak to valley in a transparent and automatic way to the final users.

The simulation tool could be now be industrialized, and used for several applications like network status analysis, decision support system, or emergency training tool.

BACKGROUND

For some other references and evolution of the GAD consortium decisions on Smart Grid architecture, please refer to publications mentioned in references [4] to [12].

REFERENCES

[1] OMNeT++ Community, 2009, “OMNeT++ Network Simulator Framework”, http://www.omnetpp.org/, last access Dec. 10.

[2] PRIME Project, 2008, “PRIME. PHY, MAC and Convergence Layers”, *Technology Whitepaper*. http://www.iberdrola.es/webibd/gc/prod/es/doc/MAC_Spec_white_paper_1_0_080721.pdf, last access Dec. 2010.

[3] R. Mora, A. López, et al., 2010 "Early-Stage Smart Grid Deployment: leveraging DNO’s Legacy Assets", *CIRED Workshop*, paper 0122, Lyon, France.

[4] GAD Project, “Active Demand Side Management.GAD Project”, http://www.gadproject.com/

[5] R. Mora, A. López et al., “Smart Communications in Demand Management”, CIRED SmartGrids, paper 15, Frankfurt, Germany, 2008.

[6] R. Mora, A. López et al., “Demand Management Communications Architecture”, CIRED SmartGrids, paper 368, Praha, Czech Republic, 2009.

[7] F. Lobo et al., “Distribution Network as Communication System, CIRED SmartGrids, paper 22, Frankfurt, Germany, 2008.

[8] F. Lobo, A. López et al., “How to Design a Communication Network over Distribution Networks”, CIRED SmartGrids, paper 641, Praha, Czech Republic, 2009.

[9] REE, “Power demand tracking in real time.”, http://www.ree.es/ingles/home.asp

[10] Iberdrola, “Smart Metering”, http://www.iberdrola.es/webibd/corporativa/iberdrola?cambioIdioma=ESWEBPROVEEBASDOCCONT

[11] Iberdrola et al., “PRIME. PHY, MAC and Convergence Layers”, Technology Whitepaper 2008. http://www.iberdrola.es/webibd/gc/prod/es/doc/MAC_Spec_white_paper_1_0_080721.pdf, last access Aug. 2009.

[12] R. Mora, A. López, et al., "Communications architecture of smart grids to manage the electrical demand", WSPLC, paper 4169, Udine, Italy, 2009.

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For more info, please refer to the project home page http://www.proyectogad.es/.

CEDETEL is the research organization chosen by SIEMENS to design the architecture of the WAN network of the GAD Project. Iberdrola leads the Integration Phase. Siemens has defined Smart Grids as a strategic topic in Energy Sector. All of them are part of the communications WP (Work Package) of the GAD Project.