DYNAMIC SCADA/DMS DATA MODEL - PLUG & PLAY SMART GRID SOLUTIONS

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ABSTRACT

This paper points the way to how the configuration at the upper SCADA/DMS levels is built automatically based on the lower level models, following the network architecture, providing a natural consistency between the models, reducing the overall configuration cost.

As the system complexity increases with a large volume of dispersed power production promoted by many different actors alongside with more flexible and controllable loads, traditional Supervisory Control And Data Acquisition (SCADA) is inadequate to manage and optimize all possible combinations of power production/consumption. The paper also proposes how SCADA/DMS systems should evolve to tackle new challenges, including new functionalities such as optimal network operation, voltage control and reconfiguration strategies, outage management, protection and fault detection, system stability and validation of maintenance schemes in order to minimize operational costs and increase reliability.

Based on the actual implementation of Smart Grids projects in countries such as Portugal, real examples are given on the impact of manual configuration of system data bases.

INTRODUCTION

The expected growth in Distributed Generation (DG) will significantly affect the operation and control of today's distribution system. In the near future, Smart Grids will pave the way towards a less passive and more active and efficient electrical network. To ensure a proper interface between DGs and the electric utility system, clever new controls will be essential if DG is to be used efficiently and safely.

More than a large technical challenge, it is also an excellent opportunity to progress towards the Smart Grid concept, integrating all new smart metering and commercial processes and at the same time, allowing operation flexibility at all distribution levels, efficiency improvement, network reinforcement cost deferment, and increase in quality of service while decreasing investment and operational costs 0.

With the explosion on the number of devices to be installed throughout the network, the configuration of data points increase exponentially. As the system complexity increases and many actors produce power, traditional Supervisory Control And Data Acquisition (SCADA) is inadequate to manage and optimize all possible combinations of power production/consumption. Loads will become more responsive to requests from system operators and their controllability should be properly represented.

DG units connected at the MV level, microgeneration in LV and responsive loads will greatly impact distribution automation through the expected explosion in numbers and sophistication of intelligent control devices and Remote Terminal Units (RTU).

SCADA/DMS and other utility systems should act as one and extend over the whole network, from generation to client. Control and automation functions are no longer limited to control centers and appear throughout the network.

SYSTEM ARCHITECTURE

The large scale deployment of communications and automation is changing the passive distribution network into an active Smart Grid where all maneuvers can be monitored and remotely operated. Distribution Transformer Controllers (DTC) and RTUs with "smart" onboard controls will be required to enable local network optimal operation based on constantly updated distribution system parameters 00.

The system should be seen as a whole with all parts inter-connected through a utility-wide and two-way data communications network, connecting customers, distributed resources and field devices with the enterprise systems.

On the consumer/producer level, smart meters enable accurate recording of load/generation profiles in real time, reducing billing costs, detecting fraud, providing energy balance opportunities and allowing the customer to actively manage his energy behavior and controlling microgeneration, allowing also for third-party related services implementation.

At the MV/LV Distribution Substation the DTC additionally clusters the attached meters, manage Public Lighting, monitors local components and automate their operation. It enables local network optimal operation based on constantly updated distribution system parameters optimizing energy flows, network topology and offer self-healing algorithms in collaboration with primary substation automation. Such controls will need to communicate with the utility to provide the information needed to operate the network in an optimal way resulting in new control capabilities accessible to the Distribution Network Operator (DNO) to improve reliability, quality of supply and in order to optimize network operation with distributed generation.

The primary substation will be complemented with Smart Substation Controller (SSC) able to optimize energy flows, network topology and self-healing algorithms coordinating with local automatisms 0.

Central system level aggregates capabilities of commercial and energy management, while accurately processes billing and load profiles. It also provides a global view over all these devices, operating over the active distribution network. The bridge between SCADA components, Energy Data Management (EDM) applications and other enterprise systems is made at all levels, from control centre through to lower levels. Effectively the SCADA will manage a collection of intelligent semi-autonomous sub-networks. The result is an optimal network management, enhanced reliability and quality of supply, opportunities for Demand Side Management,, energy balance for network losses characterization, optimal network operation and reconfiguration strategies, outage management, DG management and planning, protection and coordination, fault detection and analysis, system stability, optimal maintenance strategies (validation of day-ahead schedules).

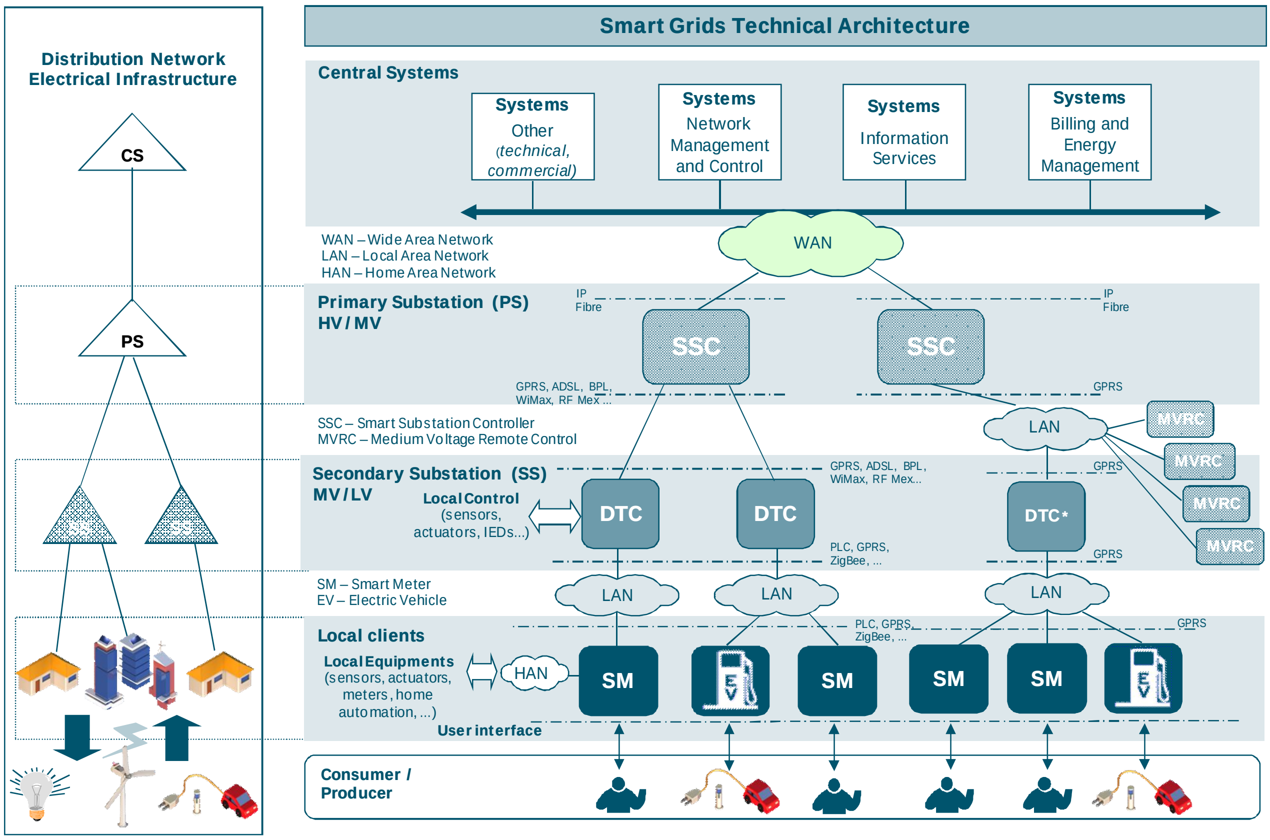

Figure 1. Technical architecture adopted for Smart Grids.

LOCAL CONTROL - DTC

This intelligent module is targeted to be used in MV/LV Distribution Substations and aims to supervise and control local equipment, as well as collecting remote metering data coming from smart metering devices, concerning downstream LV network branches belonging to that specific Distribution Substation.

Clustering and managing bi-directional communications with the smart meters, the DTC will be responsible for collecting information from the Prosumer devices, process some of that data and send it upward, splitted in operational and commercial categories. It enables optimal local network operation based on constantly updated distribution system parameters optimizing energy flows. The local network topology is thus controlled locally, including the adoption of self-healing algorithms. These autonomous functions will need to communicate with the centre to provide the information needed to operate the network in an optimal way, offering in new control capabilities to the DNO that improve reliability, quality of supply and optimize network operation while supporting distributed generation.

Being a flexible solution, capable of managing multiple input data, for multiple applications, the DTC allows the system to identify, at the distribution transformer substation level, the demand shifts, the independent production, and the power resources present in the network. Additionally, the DTC sends that data to the upstream systems, either to the respective distribution network control centre, or to the utility's corporative information system. Besides this standpoint, the DTC also offers electrical interface mechanisms, providing not only alarm or metering, but also voltage, current, power and power factor values. Moreover, it executes remote controls, sent by the control centre operator or the Information System, as well as local controls, when applicable, over the MV or LV circuit breakers.

The processing power permits the implementation of algorithms for MicroGrids management. Corresponding to the MicroGrid Central Controller, to be housed in MV/LV distribution substations, the DTC will be responsible for managing the MicroGrid, including the control of the microsources and responsive loads as well as managing storage systems 0.

Besides these functions, the DTC allows detecting upstream MV network faults, as well as managing a set of alarms concerning the internal operating environment, namely those related to the state of the equipment, ambient temperature, MV/LV transformer oil temperature, intrusion, among others.

PLUG&PLAY DATA MODELS

The sheer size of the distribution system implies that the manual creation and maintenance of a traditional SCADA model will become impossible in this new environment. The obvious answer is to automate this process by using a restricted number of patterns for the monitoring equipment, progressively describing in this way the distribution substations and switching stations in the network. With the advent of models for distributed control we can see a situation where the DTC will use a complete local model of the equipment covering electrical characteristics, circuit naming and SCADA model. The in-factory installation of an equipment is unlikely to cover all of this, but the on-site installation should result in a complete working model, the field telemetry linked to the correct SCADA and energy model elements. The interchange of models as standard XML documents will permit flexibility here, will allow the central systems to acquire this model and load it into the central models specific to each system and will allow model updates to be downloaded from the central systems. These models, including the necessary contractual aspects, will be required and used at every level.

Currently an automatic loading process can expect to pre-define a distribution substation by its code or number, latitude and longitude or installed IP address, the latter derived from the registered GPRS card. The profile or pattern indicated for the substation indicates the services to be offered by the DTC, including monitoring switching equipment adjacent to the transformer, public lighting services or additional meter or IED information to be handled (Figure 2). Any other additional information concerning the installation, not readily retrievable from the other enterprise systems, could be added to this registration process. When the DTC is powered on its registration state can be checked and any downloads and database management completed ready for telemetry point checking. The point checking itself can become more automated, the registration agent in the SCADA/DMS can offer a web service allowing personnel local to the new DTC to open a web browser and initiate point checking (Figure 3), the web page guiding the user through the telemetry point by point and monitoring the changes in value at the control centre. The more the pattern approach is adopted, the fewer characteristics to register, the higher the confidence in the installation, the less point checking required.

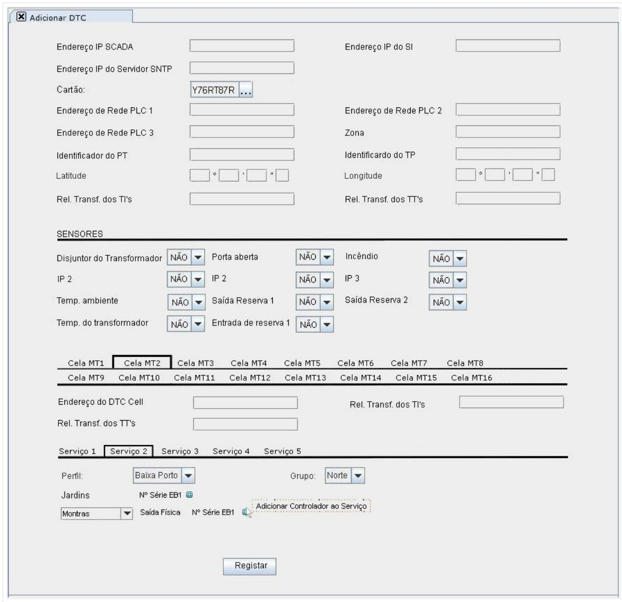

Figure 2. DTC addition and registration process.

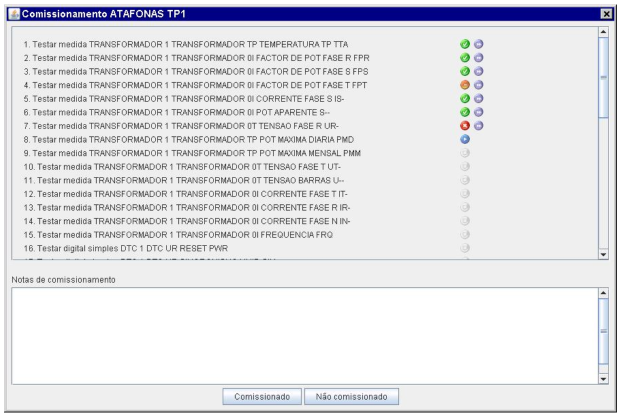

Figure 3. Commissioning process and check list.

It should not escape our attention that the size of the SCADA model will, now or at some date in the near future, become enormous but full of repeated 'patterns'. The next obvious step is not automatic loading of the DTC model into the SCADA model, but a simple registration of the DTC within the model, the pattern becoming a run-time implementation of the services and telemetry desired.

THE DSO EXPERIENCE

For a Smart Grid implementation, the Distribution System Operator (DSO) should to extensively deploy the architecture detailed previously, installing several new equipments and sensors on their network. Each of these new sources of data must be configured at the central systems level. It would be unthinkable to manually configure telemetry, controls, and function parameters of hundreds of thousands of entities. This is where Plug & Play is of invaluable help to the operator. Typified databases match automatically and the commissioning and entities confirmation can be quickly executed. This way, DTCs installed at the MV/LV substation levels will not require to build and map SCADA/DMS models manually and will only need to perform a verification process.

FINAL REMARKS

Future distribution networks require new planning for novel, decentralized network architectures able to incorporate all these new grid elements, including the need for new design and planning tools that rely on heuristics, probabilistic approaches, multi-scenario analyses, a more loosely defined normal switching state, amongst other features.

Complementarily, it is necessary to develop new active network technologies that enable a massive deployment and control of industrial and residential generation in combination with demand side participation. Tools here to link to the energy market as well manage and optimize the grid operation while maintaining network stability.

Systems interoperability, information management and data integration are among the key requirements for achieving the benefits of active networks. Automation and intelligent operations will require timely and accurate data, and the need for operational efficiencies demand coordination, orchestration and synchronization of information used by various elements of the utility operation.

The Smart Grid strategy calls for enterprise-level integration of these islands of information to improve information flow and work throughout the organization. Only in this way can the DNO predict and control the Smart Grid. With the addition of self-contained, self described, equipment (IED's, DTC's) with their several aspects described independently and coherently through an editor designed for that equipment, the central system should now be acquiring the new equipment data for connection into the central SCADA/DMS database, absorbing the telemetry configuration, electrical characteristics and default limits from 'below'.

None of this changes the basic requirement for a distribution system, to give to the clients the energy they want, at the times they want it, at the lowest cost, maintaining system conditions such that the unpredictable accidents will not unnecessarily disrupt the energy supply. The change is in the way it will be done and the emphasis on reducing the environmental impacts, since large scale of renewable power sources integration is a main goal to achieve.

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