DER AND OPENNODE: INTEGRATION OF DG IN AN OPEN ARCHITECTURE FOR SECONDARY NODES IN THE SMART GRID

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ABSTRACT

The operation of power distribution networks becomes more and more challenging in the presence of DER, as well as new DSM requirements. Utilities need new tools to monitor and control the power distribution network, maintaining the reliability and the QoS facing these new conditions. Today's power distribution grids have to be transformed into "smart distribution grids" that feature on-line monitoring data and enable efficient, fast and secure grid operation. This issue is tackled in the OpenNode project, funded by European Commission in the 7th framework program (www.opennode.eu).

OpenNode focuses on the research and development of: (1) An open Secondary Substation Node (SSN), which is an essential control component of the future smart distribution grid; (2) A middleware to couple the SSN operation with the utility systems for grid and utility operation; (3) A modular communication architecture based on standardised communication protocols to grant the flexibility required by the stakeholder diversification and to cope with massively distributed embedded systems in the distribution grid.

To address the problem, a consortium of nine organizations from six European countries is cooperating in the OpenNode project. The project started on January 2010 with duration of 33 months.

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INTRODUCTION

OpenNode brings together the two main aspects of future smart distribution grids:

- On the one hand, there is the communication with customer meters regardless of the meter manufacturer supported by the use of standardized protocols such as DLMS/COSEM.
- On the other hand, the metering infrastructure goes hand in hand with automation of the distribution network, applying legacy (IEC 60870-5-104) as well as future-oriented protocols (IEC 61850).

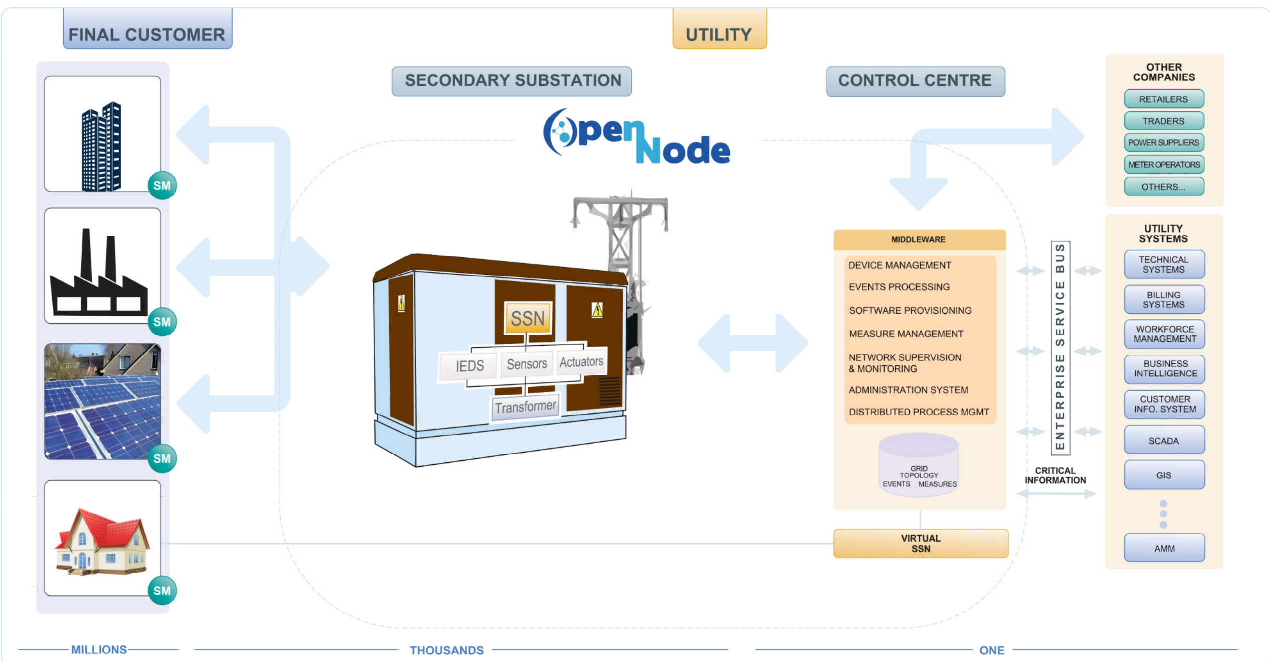

Figure 1: OpenNode's overall architecture

The overall architecture is presented in figure1. A modular and extensible software architecture inside the SSN allows for customer-specific implementation of advanced grid control algorithms – as required for true distribution network operation – as well as their dynamic installation during live operation. This essentially allows a gradual, controlled shift of grid intelligence from centralized systems in the control centre towards the lower echelons of the grid hierarchy, and provides means to balance and optimize control intelligence across future distributed grid devices [1].

The OpenNode project details a proposal and support for the integration of DERs and prosumers in the Distribution Network, as well as the automation capabilities and the development and deployment of complex algorithms for DG management automation. These functionalities have been described in the project through grid operating requirements and developed into Use Cases.

In the project, 3 SSN prototypes (2 physical, 1 virtual) and 1 Middleware system have been developed and will now be evaluated in a laboratory trial in France and a field test in Spain. These will assess the scalability and the actual deployment of such architecture but also demonstrate how it improves operations from the utilities' point of view.

The outstanding technical aspects of the OpenNode system are:

- a flexible and dynamic extension possibility of the SSN software by using Java and OSGi as basis for "bundling" of required functions,
- the development of 2 different kind of prototypes, a first one for the fast integration of the OpenNode system in the usual control centre systems of today based on IEC 60870-5-104 (telecontrol systems), and a second one for a future-oriented solution based on the upcoming standard IEC 61850 for electrical Smart Grids on on the flexible concept of Web Services,
- an integration of metering use cases and grid automation use cases that may be combined later to functions like Volt-VAR control and LV state estimation.

In the conclusions section, the project main outcomes will be summarized focusing on how the proposed architecture is capable to support the requirements needed to manage DER integration.

INTEGRATION OF DG IN OPENNODE

How DG & DER are managed in OpenNode

Overview

With the number of DER bound to rise quickly, it is important to be able to monitor these new power inputs into the grid.

The main problems with this kind of disperse and small generation are its availability and location. A demand curve specifies how much energy is necessary at any time, which has no relation with when this generation is available. Therefore, the problem to coordinate all this generation becomes more important as more generators are connected to the distribution grid. Furthermore, the general power network nowadays is centralized, with the power going downstream. The massive integration of DER would therefore require proper monitoring in regard to the new strains to the grid.

Thanks to Secondary Substation Node (SSN) being placed in Secondary Substations (SS), the management of DER is

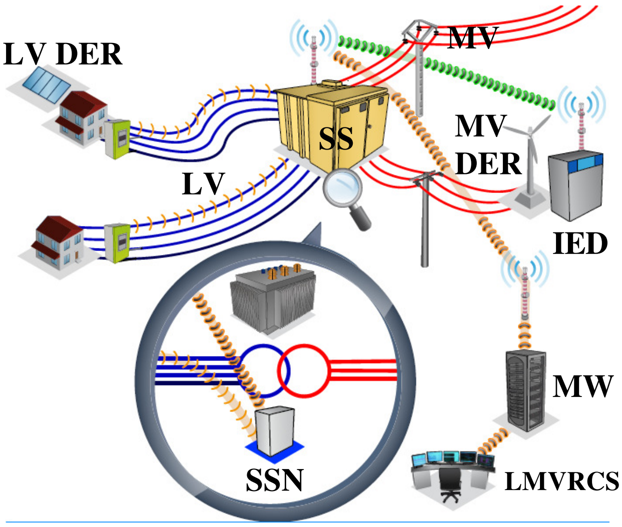

Figure 2: Integration of DER in the OpenNode system

totally included in the scope of the OpenNode project.

Use Cases

Eleven grid Use cases have been studied to be performed by the OpenNode system. The first ones deal with general automation issues, such as remote actions on actuators, IED management, data processing, etc. These are minimum requirements to allow the system to perform more complex functions. The latter, dealing with long-term approaches, have been studied in the project but could not be implemented in the prototypes.

Among these more advanced grid Use Cases established at the beginning of the project, several are linked, directly or indirectly, with DER-monitoring issues [2].

Self-healing issues are addressed, for which the SSNs communicate together and can isolate or restore a SS on the MV line. This microgrid approach is made possible thanks to local DG management that may provide power supply to isolated portions of the grid.

Other functions, though not directly connected with DER management, have similar issues. This is typically the case for the management of Electric Vehicles (EV), in which Use Case the OpenNode system is in charge to evaluate the power supply capabilities of the grid and act upon the recharge requests coming from the EV.

Management of DER

OpenNode has studied scenarios that deal directly with DER management: they describe the different operations needed by the network operator to be able to control DG in the LV and MV grid [2]. Two major aspects have been considered:

- **Monitoring of the DER connected to SSs**. In a MV/LV SS, the SSN can communicate with the Smart Meters (SMs) connected to LV DER via PLC (Power Line Communication). In case of a SS connecting MV DER to the grid, the SSN can monitor the installation through an IED. This scenario consists in retrieving the power supply information of the DER and process the data in order to compute the aggregated power supply value and deduce the flexibility brought by the DER with remote control access.
- **Managing the power supply provided by the DER**. In order to satisfy the demanded power, a command may be sent by the utility's LMVRCS (Low/Middle Voltage Related Companies System) to regulate the active or reactive power supply. Thanks to the information gained in the preceding scenario, the OpenNode system, aware of the controllability of the DER connected to it, may then interact with the most suitable, by sending for example a disconnection order or remotely setting the power setpoint. It could also be imagined, as the OpenNode architecture allows it, to distribute some of the intelligence of the power regulation directly to the SSN in the SS, which can then perform the power analysis and take the necessary actions on the LV DER, the MV DER needing a broader point of view of the grid.

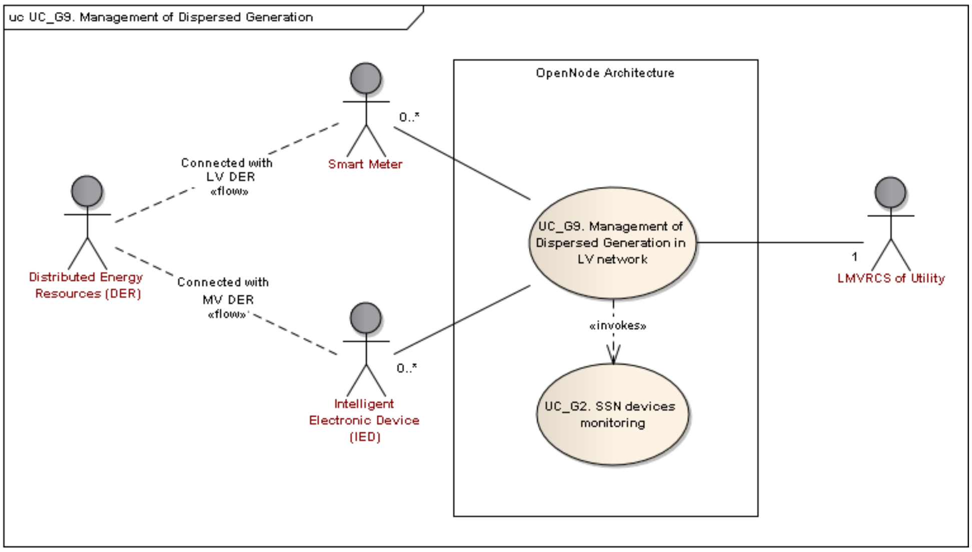

Figure 3: Use case diagram for DER integration [2]

OpenNode architecture

To carry these scenarios through, the OpenNode architecture relies on SSNs and a MW, managed by the LMVRCS. The SSN's role is to communicate with the devices to which it is connected, which are kept in the local database. The processing of the data happens in the Middleware (MW), interface between the Information System and the SSNs. Some of the intelligence in the MW may however be distributed to the SSNs. The MW sends reports to the LMVRCS of the utility with feedback on what has been calculated and the outcome of the operations launched.

Distributed Intelligence for DG

Considering the immense number of secondary substation nodes in operation in a large city, the shift from centralized, monolithic systems governing grid intelligence to a more distributed approach is a natural demand for the future Smart Grid.

The OpenNode architecture features the possibility to extend SSN functions during hot operation by distributing algorithms from the middleware/-/SCADA tiers via a special configuration webservice.

The distributed algorithms can be installed and setup for later activation to allow for synchronized updates.

The algorithm partition runs as a secure layer on top of basic automation and metering functions, which expose a specific, controlled interface to the "extended application modules" (EAM) [3][4]). This defensive approach hardens the architecture against misconfiguration and attacks.

Overall, the hot intelligence distribution architecture allows for dynamic reactions to increased DER distribution in the electrical grid: If the voltage (or current) problem situation aggravates due to DER installation, operators can easily download new EAMs to provide balancing and control algorithms, or reconfigure existing EAMs to deal with the new situation. EAM configuration is possible via a secure webservice interface.

The result is a more autonomous substation, which improves on communication network load, computation load in the middleware and breaks down complexity into a hierarchical structure [3][4]. The OpenNode specification contains a number of grid automation use cases meant to illustrate the processes of configuration, software download, monitoring of external sensors and autonomous reaction to impending problems.

CONCLUSIONS

All the research activities in the Smart Grid have defined a whole set of new services and technologies. OpenNode has the ability to successfully integrate and give support to all these technologies. OpenNode is not just an AMM/AMI, DSM, DER or PEV integration project, OpenNode technology is a facilitator that can make true these advanced Smart Grid features and give support to the ones to come.
OpenNode's goal is the research and development of a whole base platform in which the Smart grid can be properly built based on existing open standards as well as new ones.
Modularity and extensibility are at the core of the project allowing the distribution of intelligence along the grid where it is needed.
The evolutionary approach of the projects allows the integration of current and ancillary infrastructures into the smart grid and the progressive addition of future oriented equipment and services (Demand Side Management, Electric Vehicle integration Distributed Generation aggregation and management, etc.)
In this paper it has been presented and analysed the use case for dealing with DER integration in the OpenNode platform.
Finally, it has been also introduced the concept of distributed intelligence as a solution for dealing with DER integration issues.

REFERENCES

[1] R. Soriano, M. Alberto et al., "OpenNode. Open Architecture for Secondary Nodes of the Electricity Smartgrid", *Proceedings CIRED 2011 21st International Conference on Electricity Distribution,* CD1.
[2] OpenNode, 2010, *D1.3 Functional Use cases,* OpenNode, 86-89, www.opennode.eu, accessed on 01/02/2012.
[3] OpenNode, 2010, *D2.1 Hardware and Software Reference Architecture,* OpenNode, 51-61, www.opennode.eu, accessed on 01/02/2012.
[4] OpenNode, 2010, *D2.2 In Depth Software and Hardware Specification,* OpenNode, 40-54, www.opennode.eu, accessed on 01/02/2012.