The inteGRIDy Reference Architecture: functional and technical specification

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ARTICLE INFORMATION	ABSTRACT
Published November 2018 Key words: inteGRIDy Reference Architecture, 4+1 View Mode, Logical View, inteGRIDy tools, Pilots.	This white paper is about the functional and technical specification of the inteGRIDy Reference Architecture. The methodology for designing the inteGRIDy architecture is based on the 4+1 View Model. Indeed, the inteGRIDy software architecture is designed using five concurrent views: Logical View, Implementation View, Process View, Deployment View and Use Cases View. This document focuses on the inteGRIDy Logical View, providing an overview of the macro functionalities offered by each architectural layer and the main interaction between them. An important piece of the inteGRIDy Reference architecture is the Cross-functional Modular Platform (CMP), an integrated framework of different tools, models and mechanism envisioned to support the smartening distribution services. The inteGRIDy Reference Architecture will be demonstrated in the ten Pilot sites, in which the innovative technologies and solution will be exploited to address the specific Project pillar: Demand Response, Smartening the Distribution Grid, Energy Storage, and Smart Integration of grid users from Transport. In the inteGRIDy project, ENG is mainly responsible for designing the inteGRIDy Reference architecture and for leading the development activities of the inteGRIDy framework.

Introduction

This paper aims at providing an overview of the inteGRIDy Reference Architecture. The inteGRIDy architecture represents the knowledge base for the implementation of the inteGRIDy Distribution Grid Optimization Framework, a set of innovative technologies and solutions addressing the four Project pillars: Demand-response, Smartening the distribution grid, Demonstration of energy storage technologies and Smart integration of grid users from transport.

This document addresses the following aspects:

- the applied methodology for the provision of the functional and technical specification of the inteGRIDy architecture;
- the architectural design model adopted to describe the inteGRIDy software architecture;
- the functionalities offered by each architectural layer and exploited in the inteGRIDy pilots.

Methodology for designing the inteGRIDy architecture

The design of the inteGRIDy Reference architecture has been performed following a specific methodology: the starting point is the represented by the information provided in the task titled Elicitation of Stakeholders, Market Needs & Implementation Priorities and the task called Pilot Sites Surveys, Use Case Requirements & Business Scenarios; then the Requirement Elicitation process is performed through the support of surveys and conference call involving both inteGRIDy technology providers and pilot leaders. The main outcome of this process is the definition of scenarios and use cases for each inteGRIDy pilot. Finally, a deep analysis determines the design of inteGRIDy architecture based the '4+1' view model of architecture[1]. The latter has been selected as architectural design model since this involves all necessary views to cover the functional and technical specification of the inteGRIDy reference architecture. Moreover, the 4+1 architectural model involves an iterative approach in the views specification helping to refine and better understand the requirements; this is compliant with the organization of the Project since expecting to deliver an updated version of the inteGRIDy Architecture at the end of this year. The architectural design represents the starting point for the development activities of WP4 inteGRIDy Distribution Grid Optimization Framework. This WP is organised in six tasks and each task is responsible for handling the implementation of Tools offering features related to the main research aspects addressed in the Project. This reflects the inteGRIDy approach of having macro-functionalities horizontally distributed into a layered architecture.

Figure 1 provides a graphical representation of the methodology for designing the inteGRIDy architecture.

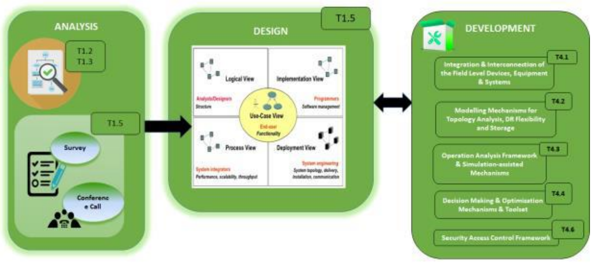

Figure 1. Methodology for designing the inteGRIDy Reference architecture

The inteGRIDy software architecture

As anticipated, the "The '4+1' view model of architecture" is adopted to describe the inteGRIDy software architecture. There are 5 concurrent views, each of which addresses a specific set of concerns allowing various stakeholders to find what they need in the software architecture:

- **Logical view**: involves a static approach of the system describing the architectural elements that deliver the system functionalities to end-users; this view is used to describe the macro-functionalities offered by each architectural layer and in particular by the inteGRIDy Cross-functional Modular Platform.
- **Process view**: deals with the dynamic aspects of the system; it is used to describe the main inteGRIDy process and the dynamic interaction of inteGRIDy tools.
- **Implementation view**: shows the system from the programmers' point of view; this view drives the development in relation to tools' features extension and development from scratch.
- **Deployment view**: depicts the mapping of the software onto the HW describing the physical environment, where the system is intended to run; this view is provided for all ten inteGRIDy pilots.
- **Scenario view**: describes the main functionalities of the system and works also as validation of the architecture after that the design is complete; it is useful since the information gathered in the elicitation phase are formalized in terms of use cases and functional requirements.

Moreover, the inteGRIDy Data View is explicitly added to the other five architectural views with the aim of describing the inteGRIDy Reference Knowledge Warehouse (RKW). The RKW refers to all information that is managed, stored, maintained or exchanged in the architecture. The Non-Functional Requirements that the inteGRIDy system should meet are described with the related implementation priority.

Focusing on the inteGRIDy Logical View, Figure 2 provides an overview of the macro functionalities offered by each layer and the main interaction between them. Starting from the button, the **Field Middleware** relying on physical equipment like sensors and meters collecting energy data to be processed by the upper levels. This layer is also composed of actuators connected to controllers handling the set points provided by the upper levels of the inteGRIDy architecture. Indeed, the communication interfaces and protocols are taken in account. One important piece of this architecture is the **inteGRIDy Cross-functional Modular Platform (CMP)**, an integrated framework of different tools, models and mechanism envisioned to support the smartening distribution services. The CMP is organises in three layers:

- the **Modelling and Profiling of Grid, DR/DSM & Storage systems Layer** deals with the most suitable mathematical representation and modelling of both energy devices and energy actors behavioural profiling;
- the **Operation Analysis Framework/Simulation Layer** focuses on the implementation of analysis, simulation and forecasting techniques that are crucial for the analysis of the behavioural of all energy systems involved in moderns power system;
- the **Decision Making & Optimization Mechanisms/Toolset Layer** provides a set of tools able to perform optimisation and decision-making processes in smart energy scenarios.

The top level of the inteGRIDy architecture represents the **Integrated Visualization Platform (IVP) Layer** that is related to the inteGRIDy tools providing interfaces, dashboard and service in order to exploit data processed inside the CMP. These data can be additionally analysed and interpreted; the main goal of this analysis is to enable all of the stakeholders like DSOs and final users to access to this data and to exploit and manage the functionalities provided by the CMP.

The interconnection between the CMP and both the upper layer and the top layer is covered by the **Cross-functional Standardized Interface API Layer**; the latter plays an important role in this architecture since allowing and formalising this bidirectional data flow.

The **Security Access Control Framework** deals with all security aspects of the inteGRIDy Reference Architecture. It is applied both in the communication between the top and bottom layer with the CMP components, as well as in the handling of sensitive data stored in the Reference Knowledge Warehouse. The inteGRIDy tools will be developed with security-by-design.

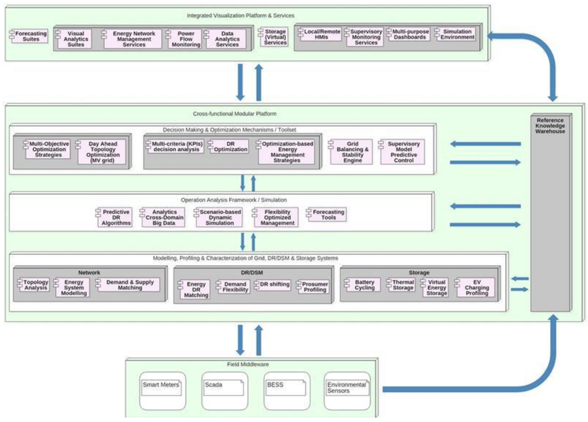

Figure 2. inteGRIDy Reference Architecture – Logical View

The inteGRIDy Reference Architecture will be instantiated in the ten inteGRIDy Pilots. Indeed, during the development phase, the inteGRIDy tools will be enhances and extended in order to be compliant with the inteGRIDy Reference Architecture and the particular needs and objectives of the pilot(s) where they will be integrated. And in addition, each Pilot site will make the required adjustments to their already deployed infrastructures, so that the inteGRIDy technologies could be properly integrated and deployed.

The functionalities that each inteGRIDy tool provides over the inteGRIDy architectural layers are therefore exploited in the specific pilot site for addressing the four pillars on which the inteGRIDy project is based.

Conclusions

This document provides to the Reader an overview of the overall architecture of the inteGRIDy Framework focusing on the Logical architectural view. In the Project, this view is designed in order to capture the functionalities offered by the inteGRIDy Reference Architecture and in particular by the CMP. The Logical View is useful for Analysts and Software Designer but can be also exploited by Project's stakeholders.

The functional and technical specification of the inteGRIDy architecture, drives the development of inteGRIDy tools that will be exploited in the ten Project pilots.

The design of the inteGRIDy software architecture summaries the fruitful collaboration that has been established between ENG and all partners involved in the project with the role of technology providers and pilot leaders.

References

[1]. Philippe Kruchten (1995). Architectural Blueprints—The “4+1” View Model of Software Architecture. Paper published in IEEE Software 12 (6) November 1995, pp. 42-50

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In the inteGRIDy project, ENG works on the definition of the functional and technical specification of the inteGRIDy software architecture and it is also in charge of leading the design and development activities of the inteGRIDy framework. Moreover, a strong participation is foreseen in tasks related to the optimization of energy flows, and, as large enterprise and IT company, also contributes to the definition of business models for the InteGRIDy future sustainability. ENG is the technology provider offering the inteGRIDy solution for the pilot demonstration of Terni (Italy).

Information about the authors

Since 2007, Marilena Lazzaro works as a researcher in Engineering’s Research and Development Laboratory. She got his University Degree in Computer Science in 2004 from Palermo University. She got Master of Science in Computer Engineering in 2010 from Torino Politecnico.

In the inteGRIDy project, she leads the task responsible for the functional and technical specification of the inteGRIDy Architecture. Moreover, she leads the WP titled inteGRIDy Distribution Grid Optimization Framework by coordinating all the tasks assigned.

Acknowledgment

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 731268.