THE DISCERN TOOL SUPPORT FOR KNOWLEDGE SHARING IN LARGE SMART GRID PROJECTS

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ABSTRACT

The development of future Smart Grids requires experts from different fields (such as, electrical engineering, ICT, or automation) and organisations to share knowledge with each other. This work addresses such a complex task by means of a structured approach and tool support that facilitate exchange of Smart Grid requirements and architectures. The tools presented in this study are freely accessible, rely on international standards (IEC 62559 Use Case Methodology) and frameworks (SGAM), and were successfully adopted in a large European Smart Grid project called DISCERN.

INTRODUCTION

Facilitating knowledge sharing among partners from different organisations and areas of expertise is one key enabler of Smart Grids. The lack of a common framework for representing Smart Grid solutions, however, hinders this task. Consequently, it is currently very difficult for domain experts to learn from experiences gained in previous Smart Grid projects, or to discuss technical options with ICT or automation specialists.

In order to address these issues and improve Smart Grid design and communication, this paper proposes a structured approach and tool support for expressing Smart Grid requirements and architectures. Both the proposed approach and tools were developed and evaluated in the context of a large European project called DISCERN. It is worth noting that the work presented here relies on international standards and, therefore, can be adopted in other projects, standardisation groups, as well as internally within utilities, vendors, or research institutions.

DISCERN PROJECT

The aim of DISCERN is to provide DSOs with tools that enable them to assess the optimal level of intelligence in their distribution networks. DISCERN is built on five demonstration projects operated by major European DSOs allowing to gain required insight and evaluate the results. These projects unite a variety of solutions for enhanced monitoring and control of distribution networks [1].

One objective of DISCERN is to agree on a common framework to share experiences among the demonstration projects. The concept of leading, learning and listening DSO was introduced in DISCERN for that purpose. Leaders were the DSOs with good knowledge on one particular functionality (e.g., “calculation of non-technical losses”), because they had implemented it at their demonstration sites previously. Learners were the DSOs that learned from the information provided by leaders in order to implement this functionality in their own networks during DISCERN. Listeners were the DSOs that studied the information provided by leaders and learners with the aim of performing a feasibility analysis to decide whether it is interesting for them to implement the functionality in the future or not. In addition to the exchange of experiences among demonstration projects, Learner DSOs and vendors or technology providers discussed possible alternatives to implement the functionalities at the demonstration sites. Moreover, both Leaders and Learners shared their solutions with other DISCERN partners that performed simulations and assessed the solutions.

USE CASE & SGAM APPROACH

The approach proposed by DISCERN to facilitate knowledge sharing within and among Smart Grids projects is based on the IEC 62559 Use Case Methodology and the Smart Grid Architecture Model (SGAM).

Use cases, originating from the Software-Engineering discipline, describe requirements of a system of interest. The use case methodology was first adopted in energy systems by the Intelligrid project [2] and later standardised in the IEC 62559 “Use Case Methodology” series [3], which include: Part 1 describing how the methodology will be used within the IEC for standardisation activities; Part 2 presenting the use case template; and Part 3 including the UML data model and XML schemas to exchange use cases across software applications.

When designing Smart Grid systems, in addition to the use cases, it is necessary to represent the physical distribution of the components meeting the requirements, identify the communication protocols and data models necessary to achieve interoperability, and show how the components, protocols and data models relate with the technical functions and business goals of the solution.

The SGAM provides a framework for defining high-level Smart Grid architectures covering all these aspects [4] (Figure 1).

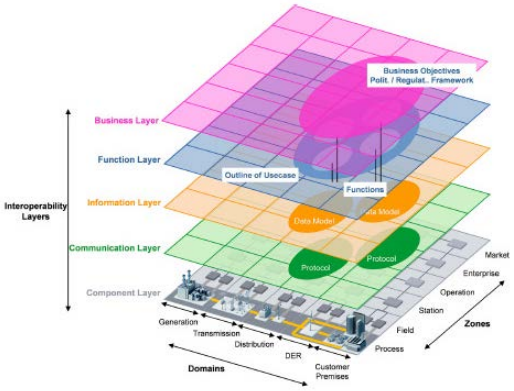

Figure 1. SGAM framework

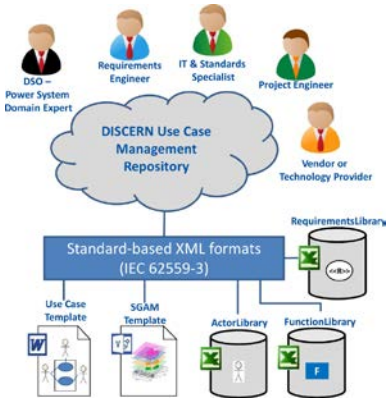

Figure 2. DISCERN Use Case & SGAM tool support

By creating the use cases and mapping them into the SGAM framework, domain experts can express the requirements and architectures of the Smart Grid systems under design in a structured and intuitive manner. This makes it easier to discuss technical solutions with experts in ICT, standards, automation, or regulation. Furthermore, once the use cases and SGAM models are created, these can be shared, both internally across different departments of the company and externally with other partners within a large project consortium, in order to analyse the solution by carrying out simulations, or to facilitate communication with technology providers during the procurement process.

DISCERN TOOL SUPPORT

Until recently, uses cases and SGAM models were represented as plain documents or drawings, which can be easily interpreted by humans, but make it difficult to: 1) ensure consistency of the descriptions, that is to make sure that all partners use the same names to refer to the same elements (e.g. a component); 2) enable multi-editing, that is, to assign access rights and a centralised platform for allowing different partners editing the same descriptions; 3) reuse use cases and SGAM models in external repositories or applications that can extract useful information from these descriptions. The tool support developed in this work aims at addressing the three issues mentioned above. In addition, with the aim of making it easier for domain experts to create their use cases and SGAM models, the tools presented here provide intuitive interfaces leveraging applications that can be easily integrated into the software portfolio of the involved parties, such as Microsoft (MS) Word, Visio, or Excel.

As shown in Figure 2, the tool support comprises: 1) MS Word template based on IEC 62559-2 to create use cases; 2) MS Visio template to create SGAM models; 3) MS Excel libraries of actors, requirements, and functions to agree on a common terminology; 4) Web Use Case Management Repository to store and manage use cases, SGAM models, and libraries.

Standard-based XML formats

Expressing use cases and SGAM models in standard formats based on machine-processable languages (such as XML) improves their reusability, and, therefore, promotes their adoption in Smart Grids. The IEC 62559-3 includes a UML data model formally defining use case concepts. The objective of the standard is to derive XML schemas from the data model defining the formats for exchanging use-case-related data between software applications.

Given that the IEC 62559-3 standard does not cover SGAM-related concepts, in DISCERN it was necessary to extend the IEC 62599-3 data model. The extended model served as the basis for developing the XML schemas that were used within the project. Each of the XML schemas developed in DISCERN defines one particular interface: UseCaseRepository.xsd is the format for exchanging complete use case repositories; UseCase.xsd enables the exchange of a single use case; Sgam.xsd defines the exchange of SGAM models; and ActorLibrary.xsd, FunctionLibrary.xsd and RequirementLibrary.xsd are the formats for exchanging libraries of actors, technical functions, and types of requirements, respectively.

DISCERN Use Case Template

The MS Word use case template developed in DISCERN enables to create use cases following the standard IEC 62559-2. The template was enhanced with a macro written in Visual Basic for Applications (VBA) that automatically exports the use cases as valid XML files against the UseCase.xsd, and guides users by means of warning messages against inconsistencies.

DISCERN SGAM Template

The MS Visio SGAM template is an easy-to-use tool to visually create SGAM models by dragging and dropping symbols from a set of stencils into the SGAM planes. It includes a VBA macro that synchronises the SGAM layers, optimises the layout of the models, and automatically infers meta-data from the SGAM elements.

These meta-data includes information such as the name, type, identifier, and position (domains and zones) of an SGAM element (Figure 3), but also about relationships between elements placed at different layers by comparing the coordinates of the elements in the planes – for instance, it identifies which components at the component layer are the information producers and receivers of the information objects shown at the information layer. The meta-data inferred by the template can be exported as an XML file valid against the schema Sgam.xsd.

DISCERN LIBRARIES

The MS Excel libraries contain the lists of actors, functions, and requirements that were used to agree on a common understanding within DISCERN. The actor and function libraries were based on the Entso-e Role Model [5], IEC 61968 Interface Reference Model [6], whereas the requirements library refined the requirements list developed by the Intelligrid project [2]. The libraries not only include the names and description of the elements, but also the parent-child relationships that determine the hierarchy of the terms.

DISCERN UCMR

The DISCERN Use Case Management Repository (UCMR) is a web-based software application for managing use cases and libraries of terms (actors, functions, requirements) as well as for visualising SGAM models. It consists of three main functional modules. The Import & Export module enables users to import and export use cases, SGAM models, and libraries in XML files valid against the standard-based XML schemas presented previously, and to export use cases in DISCERN Use Case Template.

The Web Front-end makes it possible for users to freely access and manage the use cases, SGAM models, and libraries without installing any program. It provides an intuitive graphic user interface that facilitates editing of the descriptions. The database formally organises and relates the data stored in the UCMR. It is structured according to the extended IEC 62559-3 data model. What follows summarises the main features of the UCMR:

Account management and access rights. The UCMR is organised in areas, which might refer to projects. Each user have their own personal area. Area managers can assign four types of access rights to users: read, which enables to view the data; submit, which enables users to submit data from their personal space to the target area; write, which enables to create and edit data within the area; and management, which in addition to the write services, enables to give user rights, create sub-areas, and accept or decline submitted data.

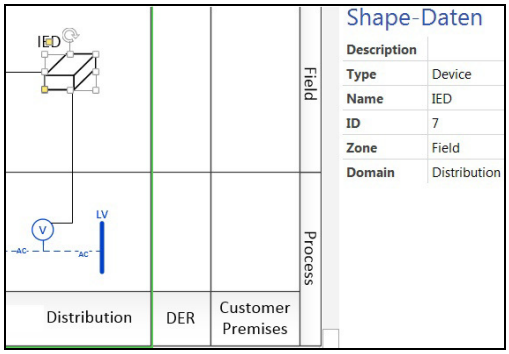

Figure 3. DISCERN SGAM template

Managing use cases and libraries. Users with write or management rights can create, edit, import and export use cases and libraries within an area. In order to ensure consistency of the descriptions, during the creation of the use cases, users can drag and drop terms from the libraries into the use cases. In addition to this, when a use case is imported into an area, the UCMR automatically maps the use case actors to the existing actors in the library of that area.

Multi-editing. The UCMR avoids conflicts when more than one user wants to edit the same data object simultaneously. If one data object (e.g. use case, or actor) is being edited by a user, other users are restricted to read this data object until the first user selects the option "release write access" or logs out.

SGAM 3-D visualisation. The UCMR imports SGAM models represented in XML files that are valid against the Sgam.xsd schema. Once the file is imported, the UCMR provides direct access to the SGAM 3-D Visualisation Tool, which also runs as a standalone application and creates 3-D visualisations of SGAM models (Figure 4).

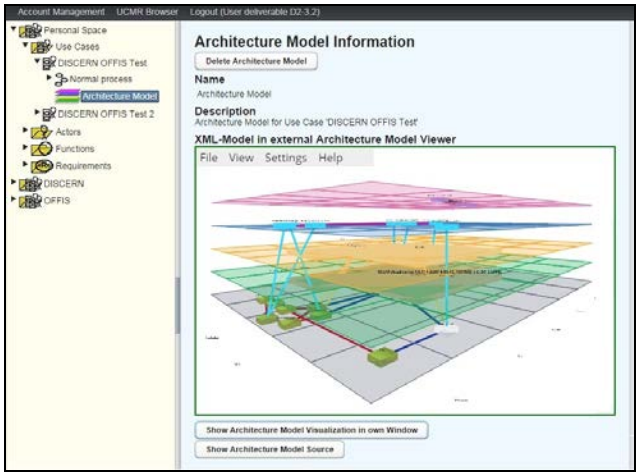

Figure 4. DISCERN UCMR

With the 3-D visualisation a holistic view on the complete SGAM model becomes available. This facilitates the visual analysis and inspection of the model, helps users identify missing relationships, and serves as an entry point for discussions on future architecture developments.

CASE STUDIES

The approach and tool support presented in this paper were successfully tested within DISCERN in three case studies:

Case study 1: Leading and Learning

Leader DSOs utilised the DISCERN templates and libraries to develop their use cases and SGAM models, which represent the solutions they had implemented in previous research projects. By using the standard-based formats created in DISCERN, Leaders' descriptions were imported and stored in the DISCERN UCMR, which enabled to identify and resolve inconsistencies. The consistent set of Leader use cases and SGAM models formed the basis for the discussions between Leader and Learner DSOs that were carried out in two workshops. The adoption of a structured and intuitive framework for representing the solutions made it easier for Learners to compare technical options and learn from previous experiences of Leader DSOs. As a result, Learner DSOs developed their own use cases and SGAM models designing the solutions that were be implemented on their demonstration sites during the project. For instance, as a Learner DSO in functionality "Real time monitoring of LV grid", Iberdrola learned from previous solutions developed by Unión Fenosa Distribución, SSEPD and RWE. Further details on the leading-learning process carried out in DISCERN can be found in [7].

Case study 2: DSO-vendor communication

The Use Case & SGAM approach was also adopted to facilitate communication between DSOs and vendors when procuring systems for implementation. The approach enabled DSOs to design multi-vendor solutions in a structured way, since requirements were grouped per use case actor or component highlighting the communication standards to achieve interoperability. The approach was beneficial for vendors as well, as they received requirements and architectures from different DSOs in the same "language". With the aim of investigating if the approach and tool support presented in this study add value in the communication between DSO and vendors beyond the project, an additional workshop was organised with vendors that do not belong to DISCERN consortium. All participants expressed the view that the use cases and SGAM models provide a structured approach to support communication between parties, and that the tools created through DISCERN strongly facilitate the adoption and application of this approach [8].

Case study 3: Simulation and Assessment

The sequence of events described in the use cases and SGAM models served as the basis for the generation of simulation scenarios. Moreover, both leading and learning use cases and SGAM models are currently being analysed by listening DSOs and other DISCERN partners with the aim of performing both qualitative and quantitative assessments of the solutions.

CONCLUSION AND FUTURE WORK

This paper presented an approach and tool support to address one of the key issues in Smart Grids: facilitating knowledge sharing among partners coming from different areas of expertise. Both the approach and tools were developed and evaluated in three case studies within the context of a large European Smart Grid project called DISCERN. Given that the work presented here relies on international standards (IEC 62559) and frameworks (SGAM), it can be adopted in other projects or internally within companies as a structured methodology to express and share requirements and architectures of complex Smart Grid systems. In future work, new interoperability tests will be carried out between the DISCERN tools and external applications developed outside the project, such as the SGAM Toolbox [9] and EDF's Modsarus [10]

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