SGAM BUSINESS LAYER FOR A LOCAL FLEXIBILITY MARKET

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ABSTRACT

Developing the Smart Grid as complex System of Systems has proven to be a challenging task. To foster the cooperation of stakeholders across different domains it is necessary to provide a common language covering the needs of all involved parties. The European Smart Grid Architecture Model (SGAM) provides a suitable framework for development. By now it has proven itself as basis for the specification of holistic development methodologies. Also, it has turned out suitable as reference framework for representing the American NIST Logical Reference Model. However, both concepts lack an appropriate integration of business aspects. The presented approach provides a formal description of high-level business aspects and demonstrates its applicability on the basis of a particular Use Case.

INTRODUCTION

As a complex System of Systems (SoS) the Smart Grid involves numerous different stakeholders from different domains and disciplines such as business analysts, domain experts and engineers. In order to maintain the strict dependability requirements of such a critical infrastructure, a suitable engineering approach is deemed crucial. A very fundamental requirement for such an approach is the presence of a common context and language for development.

Under the umbrella of the European mandate M/490 the *Smart Grid Architecture Model* (SGAM) has been developed that provides a common reference for describing Smart Grid system architectures. Essentially, particular Smart Grid elements are located within a SGAM plane according to their position alongside the energy conversion chain (domains) and their role in context of automation (zones). The interrelation between particular elements is described over five interoperability layer (Business-, Function-, Information-, Communication and Component Layer).

Moreover, it has been taken as basis for the development of a Domain Specific Modeling Language (DSL). This DSL is aligned with the *Model Driven Architecture* (MDA) development approach as described by the *Object Management Group* (OMG). The mapping of the SGAM with the specific layer of the MDA is depicted in Figure 1. In essence, the MDA process aims at a separation of functionality and technology. Thus, it delivers development artifacts on basis of the four layers *Computational Independent Model (CIM), Platform Independent Model (PIM), Platform Specific Model (PSM)* and *Platform Specific Implementation (PSI).* The described DSL can be utilized for the first two layers with the CIM delivering a functional and the PIM an architectural description. Hence, in terms of the SGAM, the CIM is represented by the Business- and the Function-Layer, the PIM comprises the Information-, Communication- and Component-Layer.

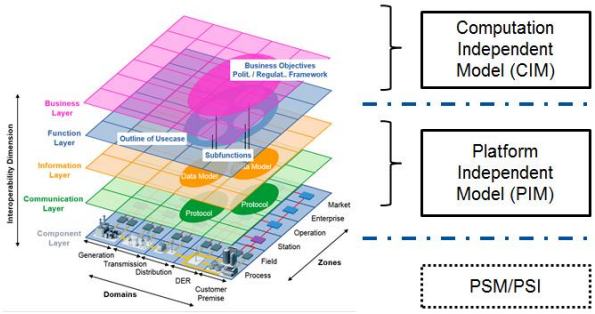

Figure 1 - The SGAM and its mapping with the upper two layers of the MDA

The implementation of this DSL is publicly available as *SGAM-Toolbox*[1] and has already proven its worth in numerous applications (e.g. [1]). It has also been used to place the American *NIST Logical Reference Model*, as described in the *NIST IR 7628 Guidelines for Smart Grid Cybersecurity*, into the context of the SGAM[2].

The description of the architecture oriented layers Information-, Communication- and Component-Layer is quite clear. Also, the description of the Function-Layer can build on existing use case templates (e.g. IEC PAS 62559). However, the Business-Layer lacks a formal specification on how to analyze and model particular aspects. The presented approach aims at delivering such a formal description on the basis of existing work such as the domain Specific *ENTSO-E Role Model.*

LOCAL FLEXIBILITY MARKET

In project Integra a local flexibility market has been developed [2]. This concept will be used for the case study. Aim of this market is to solve low voltage grid violations with regional flexibility. A so called Flexibility Operator predicts future grid problems based on sensor readings and load schedules provided by smart buildings. If a future problem is predicted the flexibility operator invites relevant grid entities to a flexibility auction. During this auction buildings can place a bid composed of an amount of flexibility and a price for a specific time slot.

While an invitation to an auction is based on technical criteria; selection and acceptance of bids is based on the offered price only. Thus a transparent acceptance

1 www.en-trust.at/SGAM-Toolbox
2 www.en-trust.at/NISTIR

criterion is used and other entities can adapt their strategies. In case enough flexibility is offered and bought the problem can be avoided. Otherwise the distribution grid operator (DSO) must use other means, e.g. change the grids load by priority signals to solve the problem. This event is undesirable due to unplanned inference with comfort requirements and self consumption optimization schedules.
The three main actors are the building operator (BEMS), the distribution grid operator, and the energy retailer (VPP). During normal operation VPP and BEMS are trading undisturbed. An auction has to bring more revenue to a BEMS than what the VPP usually offers while waiting for a priority signal has to be disadvantageous. On the long term priority signals have to be more expensive than auctions to the DSO, for the Flexibility Operator concept to work.

APPROACH

The SGAM business layer intends to host all necessary business aspects for managerial tasks that are relevant to smart grid systems. It should, therefore, be able to map business objectives pertaining to a as well as economic and regulatory constraints for a given business use case. In order to enable the mapping of economic and regulatory structures the business layer should also host harmonized roles and responsibilities [3]. It should furthermore be able to host elements such as policies, business models and use cases that are of relevance to different stakeholders. Market parties involved will also need to model their business portfolio, which includes products and services. In order to attain the objectives of a particular portfolio business capabilities and processes that are needed for these will have to be visualized onto the SGAM as well [3]. Essentially, the business layer should host elements that help with managerial and strategic decisions in the context of smart grid systems.
The SGAM methodology provides a general guidance on how to approach the modeling of these elements by starting with the mapping of elements with a higher level of abstraction and finishing with more detailed perspectives. In the context of the business layer this means that elements such as the business actors, roles and responsibilities are the first ones to be derived from a case and mapped onto the corresponding domains and zones. In the next level of granularity parties involved should analyze elements such as policies, regulation and business models, followed by more detailed elements such as the business services and processes. Finally the most detailed view should enable stakeholders to visualize and analyze specific business cases and their portfolios, with their particular returns on investment or cost-benefit analysis [3]. However this methodology does not provide a formal specification for approaching and modeling the elements onto the business layer. This paper, aims to provide an approach for high level elements using different tools and frameworks.

As roles and responsibilities are on the spectrum of high-level abstraction, these elements are the first to be mapped onto the Business Layer. There are currently two models that can be used as a common foundation for the mapping of roles and responsibilities onto the Business Layer: The Harmonized Electricity Market Role Model (HEM-RM) and the EU conceptual model, which originated from the NIST model. The HEM-RM was specifically developed for all European electricity markets by ENTSO-E, EFET, and ebiX. It defines all the business roles currently in existence that are engaged in the information exchange process within the European electricity market [4]. In order to provide a consistent and solid approach to the SGAM toolbox it should, therefore, be used for identifying and defining one's own case actors' and domains.
During the modeling of the exemplary case from a local flexibility market, the approach to mapping one's actors' roles merely using the HEM-RM has proven to be an inefficient method for the identification and positioning of roles and domains. In combination with the second model, however, this process can be simplified. The EU conceptual model provides an overview of smart grid specific domains and specifies communication and energy flows between these domains [5]. The domains which contain business actors were identified and the HEM-RM was incorporated into the EU conceptual model to show the relationship between the domains of the two individual models [5]. The only roles not incorporated into a specific domain are the Billing Agent and the Data Provider, as both of these are able to carry out the tasks of several actors within the HEM-RM [4]. The domains Transmission and Distribution were found to contain no business actors and are thus excluded from the combined model, while Generation and DER were implemented as sub-domains of Grid Users or respectively Flexibility Providers [5]. Utilizing these models and visualizations one should map each actor's roles and corresponding HEM-RM domain applying the following approach: The first step should be a thorough analysis of one's stakeholders; this is the required basis for identifying the corresponding HEM-RM roles with the help of the EU conceptual model. The second step should focus on finding the HEM-RM roles corresponding to ones actor's responsibilities. The third step utilizes the EU Conceptual model that combines the roles of the HEM-RM and shows within which domains the different roles operate. Once a role has been identified and roughly mapped to its domain the last step should then focus on the SGAM zone and domain definitions, so as to find the right position for the roles and their relevant HEM-RM domains.
Once roles and responsibilities have been established and mapped onto the SGAM Business layer the mapping can be extended to more detailed elements. Even though the case under analysis is of a relatively

high level of abstraction further elements can still be derived from it and exemplarily mapped onto the Business Layer. Thus the next elements with a lower level of abstraction that are deduced from this case are services and objectives. Since different approaches to integrating the new flows of flexibility usually have varying business models, not all services are conducted by the same actors or executed uniformly. Hence there is no common reference dictionary available for services and their objectives. They have to be extrapolated individually for each business case. In order to model a service onto the business layer one should encircle the roles, in conjunction with the HEM-RM domains, which are related to the particular service and map the corresponding business use case onto the SGAM plane. The business use case thereby defines and visualizes the scope of the particular service within the SGAM domains and zones. A service is provided or used so as to achieve a certain goal. Since business use cases contain a description of their goal, the mapping of a certain service or process implicitly also covers the domain reach of the goal.

To provide a general overview of the scope of a certain process it can be mapped similarly to services. The business use case is mapped over the roles involved in the particular process, thereby visualizing the approximate range of a particular process. For an in-depth modeling of a business process a detailed business use case with the description of the activity sequences is required. Various notations for mapping business processes could be implemented into the SGAM toolbox. In [7] an energy billing process was modeled within the NIST conceptual model using the Business Process Modeling Notation (BPMN) language. Due to the common application of BPMN and its application in the exemplary energy billing process BPMN could be used within the toolbox for the mapping of business processes. However, as the case under analysis is of a higher level of abstraction, a detailed business process has not been elaborated thus far and an exemplary mapping cannot be done within the scope of this study.

EVALUATION

Following the steps outlined above we analyzed the stakeholders from a case that focuses on a few selected roles with regard to flexibility provision. Since the main interaction in this local flexibility market case occurs between the Energy Responsible, the DSO and the Building Owner we focus on extracting their roles from the HEM-RM and then on mapping these onto the SGAM Business Layer. Given the stakeholder specification we identified six relevant roles that the DSO embodies, within this case. This actor can take up the role of a system operator, a grid operator, a grid access provider, a reserve allocator and a reconciliation responsible. The Building Owner takes up the roles of a balance supplier, a party connected to the grid, more specifically a consumer and a producer. With a total of ten roles the Energy Responsible takes up the roles of a balance responsible party, a production responsible, a consumption responsible, a trade responsible, a block energy trader, an imbalance settlement responsible, a schedule coordinator, and a reconciliation accountable. For the purpose of preparing the mapping of the roles onto the SGAM Business Layer we visualized the relationships between the roles and their domains by taking out an excerpt from the HEM-RM with all the relevant business roles (see Figure 2).

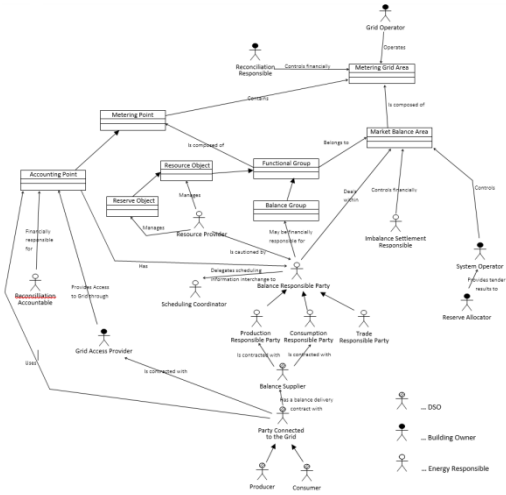

Figure 1 Case roles extracted from HEM-RM

After establishing the roles and domains for this case we identified each role's conceptual domain with the EU conceptual model where the relationship of HEM-RM is combined and transferred it onto the SGAM Plane considering the zones and domains for an exact location. For a clear illustration of the case we decided to omit the visualization of sub-roles and sub-domains. This process was repeated for each actor. Figure 3 shows the case modeled onto the Business Layer, mapping the roles, domains and business service relationships.

The local flexibility market case does not provide a specified and detailed description of a business service. However, [6] identified possible generic services from the prosumer's perspective for the deployment of flexibility. It states that prosumers can provide services such as peak shifting, demand adjustments, generation adjustments and voltage control [6]. As the services of peak shifting is set in the context of the local flexibility market it is adopted and used to provide an exemplary mapping approach. The exemplary business service is modeled onto the SGAM plane by mapping it over all the roles involved in the service. It would cover the rows Market to Field and the columns Distribution to Costumer Premise in Figure 3. Since peak shifting is of a higher level of abstraction and involves all actors' roles and domains previously mapped onto the SGAM, the mapping spans across a large part of the SGAM business layer. Since the models and frameworks used

for this mapping are still open to change and new business roles might be created and defined, the SGAM toolbox should be regularly updated accordingly so as to assure it is up to date with the latest harmonization changes within the electricity market.

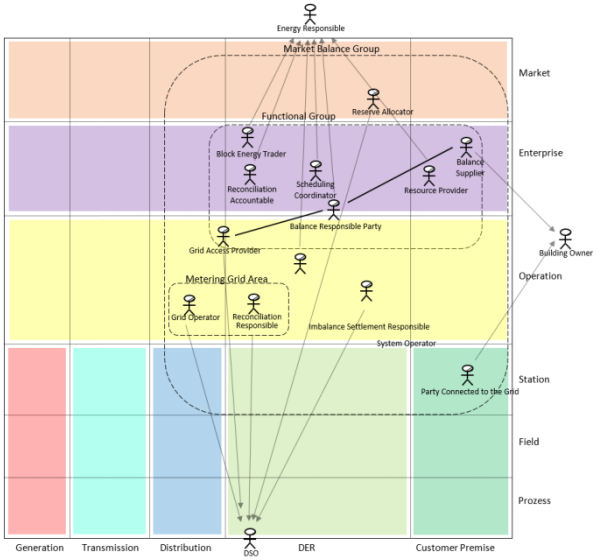

Figure 32 ***Roles and Domains mapped onto the SGAM Business Layer***

DISCUSSION

The chosen use case of a local flexibility market contains novel technical aspects of the interaction between smart buildings and low voltage grids. To develop a business case from this technical focus a best practice approach is chosen to compose a generic case in the local flexibility market. This case is then studied and mapped onto the SGAM plane. Due to the case's high level of abstraction we primarily focus on modeling of business actors, roles and their responsibilities. The case itself is to some extent limited for the deduction of additional elements. However, more detailed elements such as services, objectives or processes are developed for this case with the help of further literature and common standards for smart grid practices. Since the case under analysis focuses on a small area of application, further research should be conducted to achieve a comprehensive approach to the SGAM business layer. Not all elements addressed in the formal business specification could be analyzed in this paper. These elements still need to be addressed and methods for mapping these onto the SGAM plane have to be devised and are subject to further research.

The elements and adoptions to the SGAM toolbox proposed in this paper will need to be implemented and tested thoroughly in practice afterwards. One restriction regarding the elements derived for the depiction of the business layer is its deduction for this specific case. Practical field tests of these elements should be conducted using specified business related use cases to map the business elements. Therefore future research should not only develop further elements but also focus on the elaborated solutions within a proof-of-concept.

A further important aspect not reviewed in this study is the examination of all possible relationships between the individual elements and its relation to other layers. Thus, the development of a comprehensive meta-model is subject to further research.

In essence, the development of a comprehensive business layer for the SGAM toolbox is an iterative process still open to further research. This article provides a foundation by analyzing and extending the business layer regarding a specific use case. It therefore provides a common base for practitioners to utilize the SGAM toolbox within their smart grid projects. It supports the objective of the EU mandate M/490 by further developing the common basis for information exchange. Thus, leading to a more efficient communication between practitioners involved in smart grid systems.

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