EVALUATION OF REQUIREMENTS FOR AN INTEROPERABLE FLEXIBILITY PLATFORM FOR BALANCING, REDISPATCH AND INTRADAY MARKETS

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Abstract

Flexibility in a power system encompasses a broad range of heterogeneous products and their applications. Managing them well is essential for enabling a successful energy transition. This is a challenging task because of the complexity of having multiple stakeholders, products, systems, scenarios, etc., in addition to different flexibility applications with varying needs and technical ecosystems. The work presented in this paper focuses on three interoperable use cases of flexibility for balancing, congestion management, and intraday markets. It refines their requirements to model key functions in a flexibility platform, with a focus on balancing energy considering network restrictions for practical implementation. The developed model is complemented with business, high-level, and primary use cases that describe various processes at the appropriate level of abstraction. It identifies major classes of stakeholders along with their needs, expectations, relationships, and technical interfaces. Its usage of a shared visual language and framework for depicting system requirements, design, and architecture proved useful in improving communication across multidisciplinary teams and stakeholders. Improved communication reduces misconceptions and misinterpretations, allowing for greater collaboration.

1 Introduction

An optimized approach to managing flexibilities within the power system stands as a crucial element in facilitating a smooth transition toward sustainable energy practices. However, the presence of various stakeholders, products, systems, and boundary conditions introduces a significant degree of technical and organizational intricacy.
Different applications of flexibility possess different requirements and operate within their individual technical environment, encompassing various systems, interfaces, communication protocols, and platforms. Initiatives like pan-European balancing platforms have been established to promote the integration of flexibility resources across different countries [1]. Despite their undoubted value, they increase the complexity of the whole technical ecosystem.

This paper provides a high-level architecture that is founded on universal requirements rather than relying on existing systems. It can serve as the basis for implementing specific use cases or components thereof. As a first step, a stakeholder structure is developed, followed by the definition of common business requirements and corresponding use cases. The goal is to articulate and model the fundamental interactions or scenarios representing the core functions anticipated in the envisioned flexibility platform. These are further supplemented with business, high-level, and primary use cases, elucidating the various processes at the appropriate level of abstraction.

To enhance the analysis and facilitate practical implementations, particular emphasis will be placed on a special use case, which proposes the utilization of balancing energy while considering network constraints in the distribution grid [2]. This use case advocates for an integrated approach to tasks previously treated separately, namely balancing and capacity management. While potentially advantageous, this integration necessitates partial interoperability between the previously distinct processes and the flexibility platforms employed.

The model takes a holistic view of the flexibility platform by considering not just individual components but also their interactions, interfaces, and the system's context within its environment. It can further help in evaluating the trade-offs between conflicting objectives to make informed decisions. Furthermore, the model is defined in a way that shows the various classes of stakeholders along with their relationships, interactions, and, in some cases, interdependencies. The levels of interactions are organized as a hierarchy of the Business Processes that are executed to fulfill the stakeholder's needs and goals resulting in various interactions and events.

Modeling the requirements for an interoperable flexibility platform using MBSE methodologies has numerous advantages, including the model serving as the single source of truth, providing better traceability, improving communication across interdisciplinary teams and stakeholders, assisting in the elimination of misunderstandings and misinterpretations, and so on. Furthermore, such a model may be used to create digital twins. A digital twin is a constantly updated representation of a physical system that uses a physical counterpart to function. A digital thread is a communication infrastructure that keeps a system digitally connected throughout its life cycle, ensuring that feedback from all phases is given back into system ideation, conceptualization, and development. These concepts supplement MBSE in system development by offering cost-effective methods for increasing system verification and testing, particularly for checking performance envelopes and failure response protocols [3].

The rest of this paper is organized as follows: Section 2 provides an introduction and background on the analytical methodology, followed by a presentation and discussion of the findings in Section 3. Section 4 summarizes the findings, draws conclusions, and discusses future directions.

2 Methodology

Systems engineering (SE) is an interdisciplinary field that assists with designing and analysing complex engineering systems. It governs the overall technical and management effort necessary to translate a combination of stakeholder needs, expectations, and limitations into a solution and sustain that solution during its life cycle [4]. Different industries have adopted the SE as a standard way for designing and assessing complex engineering systems. Using SE, they can ensure that the finished system meets stakeholder expectations and achieves its intended objectives while successfully addressing quality characteristics and cross-cutting concerns.

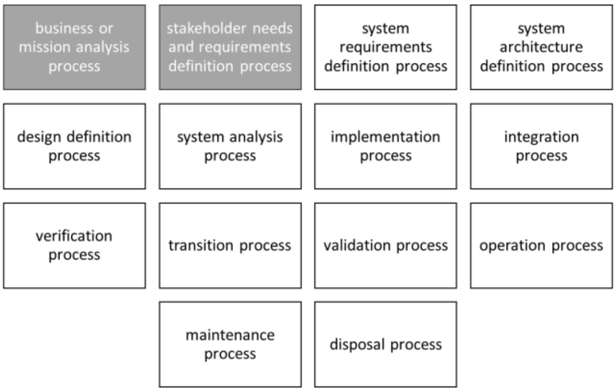

Figure 1: The fourteen-process defined under technical process category in ISO/IEC/IEEE 15288:2023 [4]. The first two, with grey background, are the focus of this work.

To address the complexity of modern system engineering, the SE community has been engaged in developing worldwide standards, guidelines, and best practices to facilitate adoption. ISO/IEC/IEEE 15288 [4] and ISO/IEC 29110 [5] are two well-known, closely related standards. Both contain the concept of a *lifecycle*, which specifies the stages that the system might go through based on the processes and methods used by its stakeholders. The former explains a full system's lifetime (including the processes inside it), whereas the latter focuses on Very Small Entities (VSEs) and specifies a subset that may be used to architect these systems. The ISO/IEC/IEEE/15288 defines thirty processes grouped into four categories (agreement, organizational project-enabling, technical management, and technical), that are to be performed during the lifespan of a system. The Vee Model rendering of ISO/IEC/IEEE/15288 by System Engineering Body of Knowledge (SEBoK) [6] provides a convenient way of visualizing the lifecycle phases and the decision gates for transitioning to next phase.

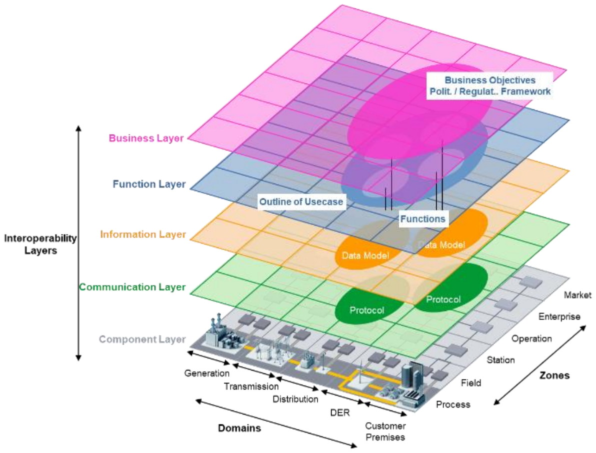

Figure 2: The Smart Grid Architecture Model (SGAM) [5].

Model-Based Systems Engineering (MBSE) is an SE technique that produces and uses system models in various system modeling languages as the basis for designing and developing systems. This contrasts sharply with Documents Centric Systems Engineering (DCSE), which focuses on traditional, natural language-based documents and textual representations that may not always have precise interpretations. The MBSE, therefore, is useful in improving communication across interdisciplinary teams and stakeholders because it uses a common visual language and framework for portraying system requirements, design, and architecture. Improved communication helps to eliminate misunderstandings and misinterpretations, resulting in greater collaboration.

Based on its suitability for large systems (such as an integrated energy trading platform) the ISO/IEC/IEEE 15288 together with MBSE is used for defining the methodology for eliciting and analysing the requirement in this work. The proposed methodology follows the first two technical processes (1. *business or mission analysis process* and 2. *stakeholder need and requirements definition process*) from the technical processes (see Figure 1) to define the business and

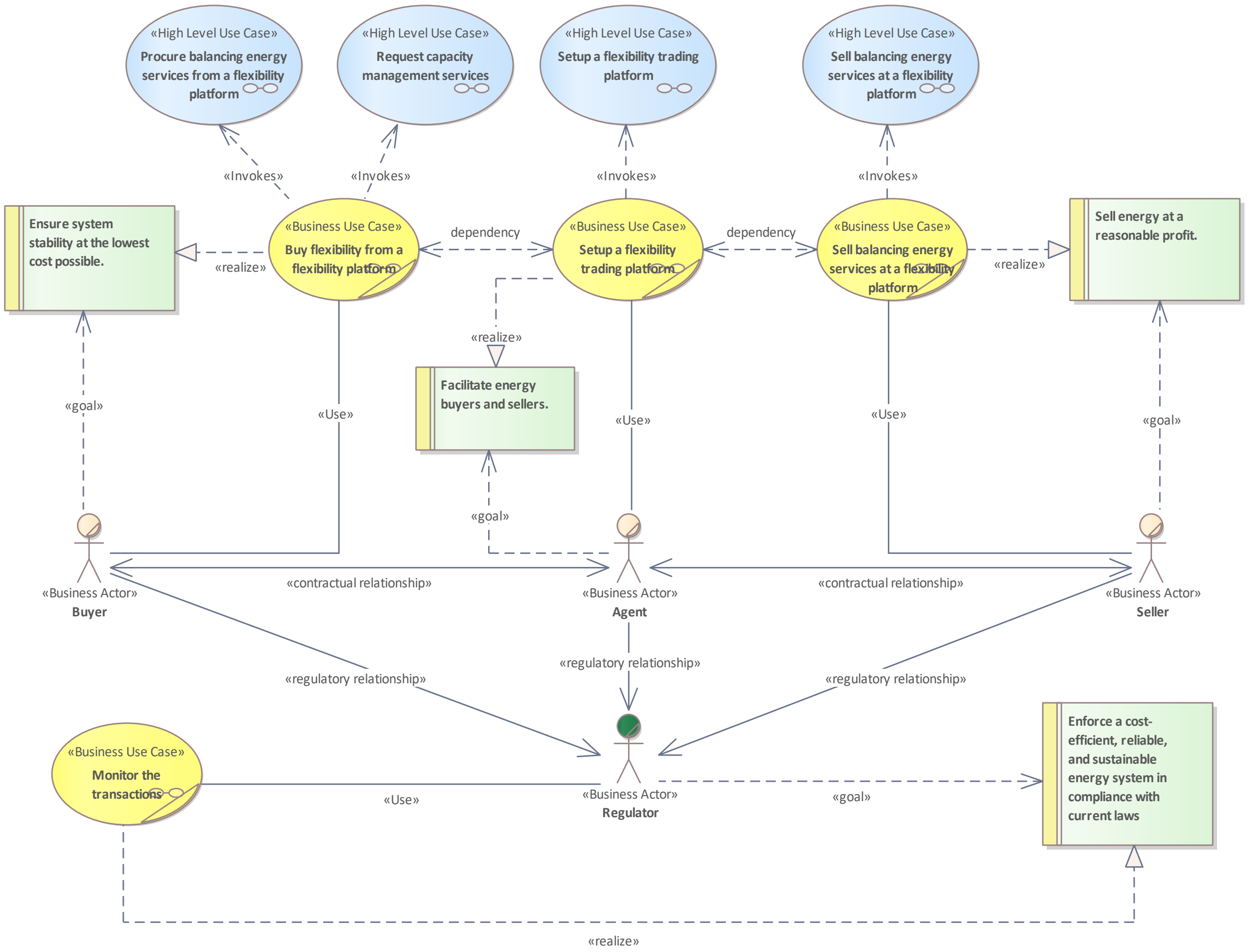

Figure 3: Business and high-level use cases [19]

stakeholder needs and document them in a model. This is consistent with the standard's guidelines, which say that the processes should be implemented using an MBSE-based approach. For performing these two processes the primary modeling methodology is based on the IEC 63200 [7], also known as the Smart Grid Architecture Model (SGAM). It is a conceptual framework that offers a systematic way to understand and construct smart grids. SGAM was coined by the CEN-CENELEC-ETSI Smart Grid Coordination Group (now known as SEG-CG or Smart Energy Grid Coordination Group) under the European mandate M/490.

It is a three-dimensional cubical architectural framework (

Figure 2) consisting of five layers of SGAM *plane*. It is used as a visual representation of the architecture into domains and zones to help organize and categorize the various components and functions within a smart grid system [8].

The modelling is based on the use case approach for SGAM where the outer view of the system-to-be is defined from the perspective of its stakeholders. For this, a holistic representation for an interoperable flexibility platform, enabling actors to gather, activate, and settle flexibility bids despite potential grid restrictions is considered at first. The SGAM Business Interoperability Layer is dedicated to representing the classes of stakeholders, their goals, and *Business Cases (BUC)*. A further level of detail then shows the *High-Level Use Cases* (HL-UC) that are triggered by the stakeholders to fulfil their goals. Going further, the High-Level Use Cases are decomposed into *Primary Use Cases* (PUC) that represent the SGAM Function Interoperability Layer. For modeling, a combination of formal notation and semantics of UML and SysML are used.

3 Results

Following the proposed decomposition, the methodology is applied to provide a generic representation of the envisioned framework. Based on available project results [9, 10], existing modeling efforts [11], supplementary references [12, 13, 14] , and various workshops with domain experts, the architectural model was created [15]. Following the high-level black box approach, the details of the implemented systems will be intentionally left open to encourage reuse.
At present, balancing energy is solely procured based on the merit order list of submitted bids without considering

network restrictions [10]. Avoiding network congestions is conducted by separate redispatch measures. Following the concepts of [2], the herein described flexibility platform leverages synergies between redispatch and balancing energy procurement by considering network restrictions in balancing energy activation. Therefore, the platform needs to provide coordination between the previously separate processes of balancing energy activation and grid congestion management. In the use case, a balancing energy bid combination is only accepted if no congestion within the distribution grid is detected and no additional need for redispatch measures is induced.

From the vision of including grid states in balancing energy procurement, it can be directly seen that additional business actors that provide the network information become relevant. Following the engineering methodology, the main stakeholders are modeled. Figure 4 shows a simplified view of these business actors and their relations. The generalized buyer-agent-seller ontology [16, 17, 18, 19] is used to categorize the main stakeholders. Buyers who obtain energy-related services from the platform can be further subdivided into the ENTSO-E roles [11] Load Frequency Operator (LFCO) that requests balancing energy and System Operators (SO) that requests grid capacity management services. While Transmission System Operators (TSOs) can fulfill both LFCO and SO roles, Distribution System Operators (DSOs) commonly only adhere to the SO role of managing their power grids.

The flexibility services themselves are provided by the two seller actors, the traditional Balancing Service Providers (BSPs) and the more general Flexibility Service Providers (FSPs) who are market participants that offer services using flexible resources. Both, sellers, and buyers are linked by agent actors that operate the platform (operating agent) and interact with secondary information flows (reporting agent). Since the flexibility platform operates in a highly regulated environment, another actor, the regulator grouping all relevant regulation bodies, is introduced.

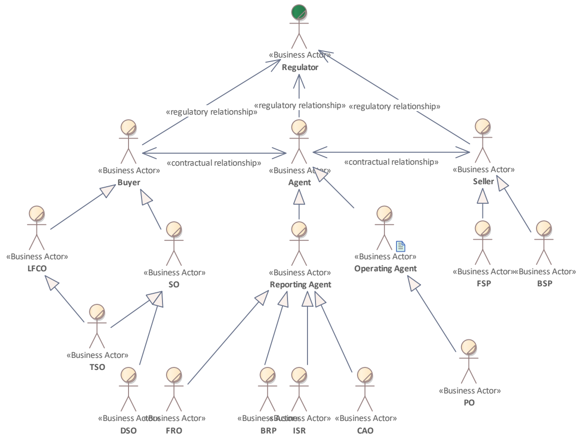

Figure 4: Simplified interactions of the main business actors

The business use cases in Figure 3 directly follow from the top-level actors and their business goals. Due to the largely diverging provisioning services for the procurement of balancing energy and the request for capacity management services by the LFCO and SO, respectively, the business use case was further subdivided into two high-level use cases. For setting up the flexibility platform and for selling balancing energy, a direct one-to-one mapping was introduced to the high-level use cases.

The high-level use cases are further refined into various primary use cases that describe the platform interactions in detail. For instance, Figure 5 partitions the request for capacity management services that are commonly not related to traditional balancing energy procurement.

To consider grid capacity restrictions, each participating SO submits a simplified representation of their grid model [2]. In contrast to the sensitive detailed grid models, the simplified version reduces the business-critical insights into the power grid and focuses on the indication of potential problems only. To support having different update intervals for the actual simplified power system representation and any fast-changing boundary conditions such as external schedules, two dedicated primary use cases are added. In combination, the information submitted by both primary use cases is then used to determine feasible bid combinations in the LFCO-specific use cases.

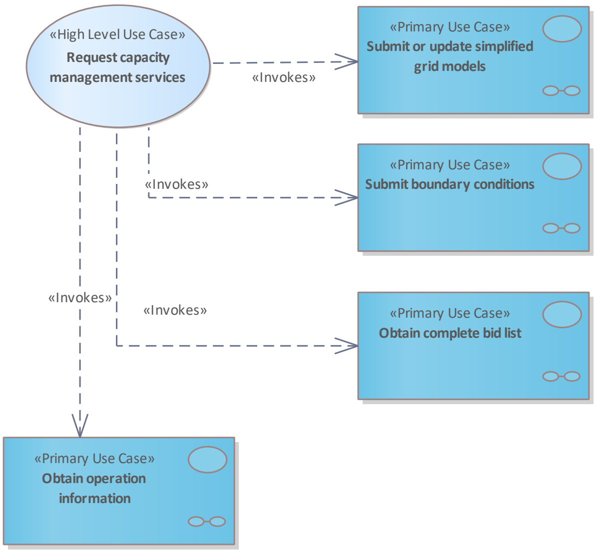

Figure 5: Capacity management service requests

To provide further services for connected SOs, the platform may expose information that can be used to secure and control the grid operation. The list of optimized bids (without any sensitive market information) that are connected to the grid area may be used to prepare the network for possible upcoming activations. Similarly, other non-sensitive data on the operational status of flexibilities may be safely exposed to the system operators to assist the network operation. In addition, the transferred data shall enable an evaluation of the submitted power system models and their benefits in reducing redispatch needs. However, the platform itself will not process sensitive information from the SO as only simplified representations are exchanged.

4 Conclusion

In conclusion, the developed architectural model for the flexibility platform has achieved a significant refinement of the proposed use case, involving structuring the original use case into multiple sub-use cases. The analysis provides a broader perspective within the energy trading landscape, encompassing business cases, overarching goals, and requirements, as well as stakeholder categories. Additionally, various secondary stakeholders requiring information exchange have been identified. Functional requirements for business processes have been delineated, incorporating regulatory aspects to ensure compliance. Furthermore, efforts have been made to promote interoperability and traceability in solution development, such as highlighting interoperability dependencies. Moreover, several gaps have been identified throughout the analysis, including the sequence of actions, and involved stakeholders. Another identified obstacle is the information flow between different actors, particularly with participating balance groups. These aspects are crucial for a comprehensive understanding and effective implementation of the considered use case within the broader context of energy trading operations.

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6 References

[1] 'Balancing Energy Platforms – European Union Agency for the Cooperation of Energy Regulators', https://www.acer.europa.eu/electricity/market-rules/electricity-balancing/balancing-energy-platforms, (accessed: 10.03.2024).
[2] DigIPlat EU Project, 'D3.3 Definition of multifunctional flexibility use cases', 2023.
[3] A. Madni and N. Augustine, "Introduction to the Handbook," in Handbook of Model-Based Systems Engineering, Springer, 2023.
[4] ISO/IEC/IEEE 15288: 'Systems and Software Engineering -- Life Cycle Management', 2023.
[5] "ISO/IEC 29110-2-1: 'Lifecycle profiles for Very Small Entities (VSEs)'," 2015.
[6] "Guide to the Systems Engineering Body of Knowledge (SEBoK) v. 2.9", https://sebokwiki.org. (accessed: 10.03.2024).
[7] IEC SRD 63200: 'Definition of extended SGAM smart energy grid reference architecture model', 2021.
[8] CEN-CENELEC-ETSI Smart Grid Coordination Group, 'SGAM User Manual V3.0', 2014.
[9] DigIPlat EU Project, 'D3.1 Current framework and best practices from existing flexibility platforms', 2023.
[10] DigIPlat EU Project, 'D3.2 Standardized Flexibility products and attributes', 2023.
[11] ENTSO-E Role Models, https://www.entsoe.eu/data/cim/role-models/, (accessed: 10.03.2024).
[12] ENTSO-E, "ENTSO-E Automatic Frequency Restoration Reserve Process Implementation Guide," ENTSO-E, Brussels, 2021.
[13] V. Charbonnier, C. Dikaiakos, M. Foresti, N. Appleman, M. Cooper, A. Hussein, D. Roberts and A. Siriyatorn, "Review of Flexibility Platforms," ENTSO-E and Frontier Economics Ltd, Brussels, 2021.
[14] P. D. K. Frauendorfer, "Neue Wertschöpfung durch Handel mit flexiblen Kapazitäten," Universität St. Gallen, Institut für Operations Research und Computational Finance, St. Gallen, 2022.
[15] DigIPlat EU Project, 'D3.4 Standardized framework for interoperable flexibility', 2023.
[16] "GoodRelations Language Reference', https://www.heppnetz.de/ontologies/goodrelations/v1.html. (accessed: 10.03.2024).
[17] "Schema.org BusinessFunction, https://schema.org/BusinessFunction, (accessed: 10.03.2024).
[18] "The Financial Industry Business Ontology, https://spec.edmcouncil.org/fibo/, (accessed: 10.03.2024).
[19] "FIBO Markets Ontology, https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/Markets/, (accessed: 10.03.2024).