Model-based Requirements for Integrating Cloud Services

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Abstract. Cloud-based services provide an alternative to the in-house implementation of various types of functionality. Organizations rely on such services to minimize the need for long-term commitments and enhance scalability and ubiquitous access to the services. However, achieving complex tasks that require a combination of services is not well studied, despite the potential added value. This paper investigates the requirements encountered when integrating cloud-based services in the modern organization. The paper proposes a model-driven solution for capturing the requirements for integrating cloud-based services. The model is to be used within the larger context of the organizational design; modeling components used to describe requirements are related to other views of the organization. A prototype tool and an example business case are presented to illustrate how the requirements model can be elicited and designed. The models are capable of being transformed into an integration solution.

Keywords. Cloud Computing, Integration, Requirements, Enterprise Modeling, Model-Driven Development.

1 Introduction

Cloud services are becoming an increasingly appealing solution for organizations that want to outsource general functionality. Cloud computing relies on several technologies, and its definition is still being debated [6]. Most approaches that tackle cloud computing target its technical aspects and overlook the relationship/effect that cloud-based services can have to other parts of the organization. Research that covers requirements for cloud services generally addresses the design and development of individual services. Positioning cloud services within the organizational design and the integration of cloud-based services are two issues that are not well understood.

This paper proposes extending the unifying meta-model for enterprise modeling [17] to support describing cloud-based enterprise integration requirements. The proposed approach utilizes the principles of Model Driven Development (MDD) [3] to facilitate switching service providers at the enterprise-design level in response to changes in service provisioning needs. The concrete connections to the cloud services are delegated to the implementation level, described as a platform-specific integration

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solution. This is aligned with the vision for creating global cloud marketplaces, where cloud consumers are able to choose from a selection of comparable cloud-based commodities [5]. The proposed solution relies on incorporating the flexibility of switching between cloud providers into enterprise models.

The paper is structured as follows. Section 2 is an overview of cloud computing and services. Section 3 explores the requirements of cloud-based services in the literature. Section 4 presents the proposed requirements model for integrating cloud services and demonstrates its use with an example case study. Finally, section 5 includes concluding remarks and future work.

2 Cloud Computing

Cloud computing is gaining popularity as an emerging technology that resides at the intersection of concurrent advancements in diverse fields of technology [6,16]. It is driving a shift in the management attitude towards the use and utilization of existing technologies to capitalize on the combined added value [2,5]. Cloud computing relies on innovative and assets-free alternatives to traditional outsourcing approaches [9] to offer the necessary flexibility to meet changing usage patterns and support variable pricing [6], and to mitigating long-term commitments by cloud consumers and enable ubiquitous access by service end users [16].

The details of what constitutes "the cloud" are still debated among researchers and practitioners [6]. A widely adopted definition frames cloud computing as:

> "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." [10]

This definition highlights the technical perspective of cloud computing. Business aspects, especially the influence of adopting cloud services on value configurations, are often neglected [9]. Other financial, organizational, resource-related, and ecological characteristics influence what is viewed as cloud computing [12].

The flexibility in provisioning and pricing is facilitated through a service-oriented 3-layered architecture [16]: infrastructure layer (Infrastructure as a Service, IaaS), influenced by developments in grid and cluster computing; platform layer (Platform as a Service, PaaS): operating systems and software development frameworks; and software layer, or Software as a Service (SaaS): end-user services are offered through this layer over the Internet.

3 Requirements for Cloud-based Services

Despite the foreseen advantages, organizations hesitate to fully adopt cloud computing—a young domain with many unresolved challenges and associated risks and uncertainties [2,5]. Data storage and application platforms are still largely proprietary, which increases the risks of single failure points, raises the costs of switching cloud

providers, and impedes cloud adoption. Quality assurance and optimization requirements play a decisive role in choosing from amongst competing providers [8]. Furthermore, providing services in the cloud entails security and privacy implications that are unique to the cloud environment [13]. It also introduces additional integrity and confidentiality requirements for data that is moved between cloud providers [1].

Variations in legal jurisdiction and the continuously evolving privacy laws complicate the adoption of cloud services. Service Level Agreements (SLAs) are used as tools to govern the relationship between cloud provider and cloud consumer according to organizational policies and applicable rules and regulations [14].

Most literature describing the requirements for cloud services focuses on the design of individual services. However, efforts are made to facilitate dynamic provider switching, such as the proposals in [5] and [7].

4 Model-based Integration of Cloud Services

To describe requirements for integrated, complex cloud services, we propose a model-based approach that captures the design of the integrated services on a higher level of abstraction, i.e. the enterprise level. Doing so: a) addresses the business aspects of cloud services and exposes the value added by the integrated services to the overall organizational design, b) improves the alignment between the business goals and the eventual implementation of the integrated services, and c) facilitates the automated switching between candidate service providers, hence taking a step closer towards realizing the vision of global cloud marketplaces.

Information systems requirements must describe the underlying motivation for developing a system in addition to the desired functionality of the system [11]. Approaches that support modeling goals in addition to requirements can serve as suitable means to describe requirements for cloud adoption [15].

4.1 The Unifying Meta-Model for Enterprise Modeling

Enterprise Modeling (EM) provides means for describing the elements of business, information, and technology components [4]. The unifying meta-model for enterprise modeling offers a platform for capturing enterprise models and eliciting supporting system design models following MDD principles [17]. The meta-model, illustrated in **Fig. 1**, is divided into (1) enterprise-level views that represent enterprise knowledge, and (2) system-level views that describe design details of the supporting information systems. Composite views are used to offer more elaborate representations of the organization. The coarse-grained relationships between the views are interpreted as *inter-model relationships (IMRs)* that relate model components across different views, thus enabling the definition of composite views. Traceability across the unifying meta-model is thereby supported.

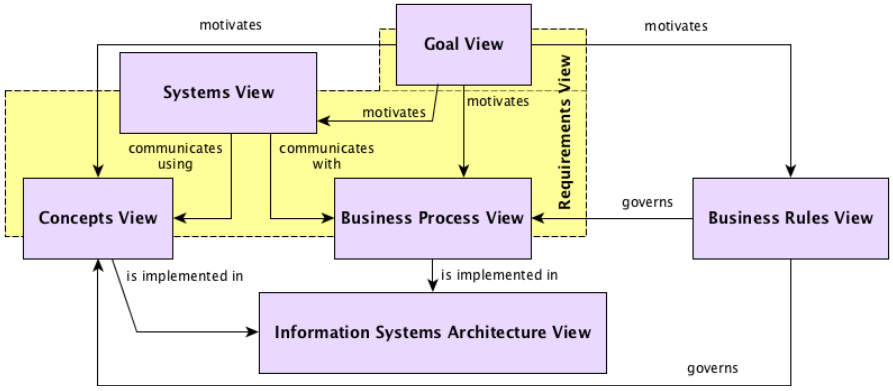

Fig. 1. Overview of the Unifying Meta-Model, highlighting the Requirements View (RV).

4.2 The Requirements View

The Requirements View (RV) is proposed as a composite view cutting through the Goal View (GV), Concepts View (CV), Business Process View (BPV), and Systems View (SV). The components of the RV (**Fig. 2**) belong to these four views.

The *RequirementsTable* modeling component is a list of stakeholder-friendly requirements. A *Requirement* in the table contains the textual statement of the requirement (in the traditional sense). It is annotated by a *priority* value to create an order in which requirements should be implemented. Each requirement is associated with a *RequirementView*, a representational modeling component that groups together the components comprising a single requirement.

Concept from the CV represents the entities affected by the requirement. *Process* and *Role* from the BPV represent the functionality expressed by and the organizational structures affecting the requirement, respectively. The *consume* and *produce* IMRs capture how the concepts are processed. The attributes *frequencyOfExecution* and *concurrentInstances* describe non-functional performance aspects of a requirement.

BusinessGoal from the GV and the *motivate* IMR account for the motivation of a requirement. The *motivate* relationships enables motivating the requirement directly (a requirement being a model component itself) or indirectly through the requirement's parts (e.g. concepts, processes, etc.). *Problem* (either internal, i.e. *Weakness*, or external, i.e. *Threat*) and *Constraint* capture the limitations affecting a requirement via the underlying goal of the requirement. Describing the *Cause* of a problem helps in designing suitable solutions to mitigate it. *Opportunity* describes growth potential in the organization and is used to model future desired requirements. Finally, *Key Performance Indicators (KPIs)*, which are part of the GV, provide means for evaluating the fulfilment of a requirement in the implemented solution.

System from the SV represents the systems affected by the requirement. The *type* attribute captures the specific type of the modelled system. System maybe specialized to reflect possible implementation platforms, including cloud-based services. The type

and specialization of a system affect the selection of the appropriate transformation rules that are applied to generate the integration solution.

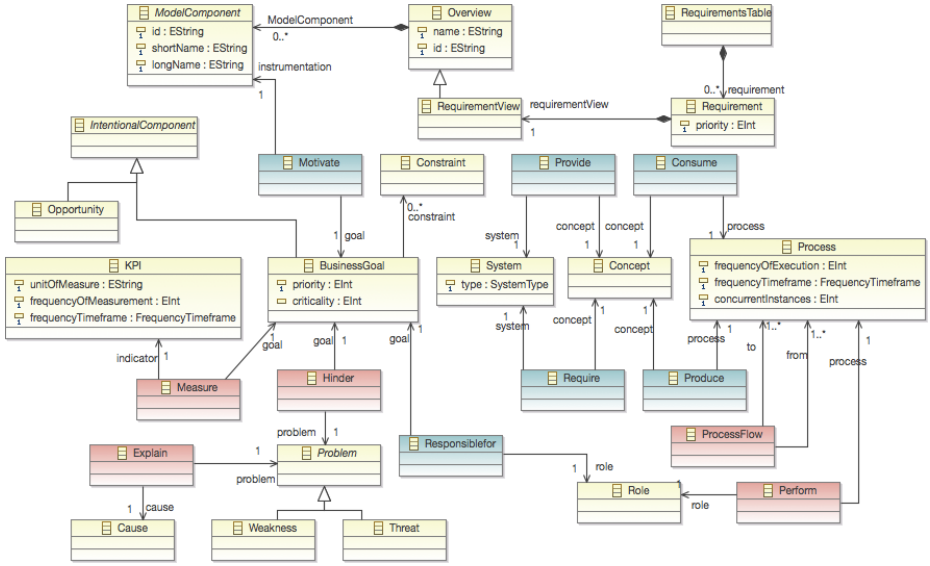

Fig. 2. The Requirements View (RV): modeling components involved in capturing information about the requirements.

4.3 Modeling Requirements for Integrating Cloud-based Services

The use of the proposed RV for modeling cloud integration requirements is illustrated in this section using the example business case of the imaginary organization Aid&More. The requirements model is developed using a prototype tool that implements the unifying-meta model for enterprise modeling. The tool supports modeling enterprise- and system-level models as well as transforming the designed models to a platform-specific implementation.

Overview of the Example Business Case. Aid&More is a Non-Governmental Organization (NGO) active in the humanitarian aid domain. It offers support to people in distress situations as a result of natural disasters. Each aid project includes several types of aid and targets a specific distress situation described by: the type of natural disaster, number of affected people, target geographical location, etc. Types of aid in a project prescribe the necessary resources to deliver the aid—personnel, vehicles, warehouses, offices, and aid items. Creating a recognizable and popular brand is essential for the growth of Aid&More's work; the organization relies mainly on public donations to fund its operations. Using information collected from social media, the NGO aims to understand and analyse its reputation and identify improvement potential, both in terms of project execution and public relations.

Aid&More is looking for a solution that automatically retrieves mentions of the NGO in social media. The solution should then, with the help of online analyses services, generate summary reports of how Aid&More is perceived. The desired archi-

tecture is illustrated in **Fig. 3**. The solution has access to project details, managed using a central Project Management System (called internally as PROM). The system has a public interface on the Web (i.e. website) to advertise statistics and results from projects. Google Analytics is employed to monitor and provide feedback on the impact of the Website. AnalyzeThis is an online service used for analysing data collected from social networks.

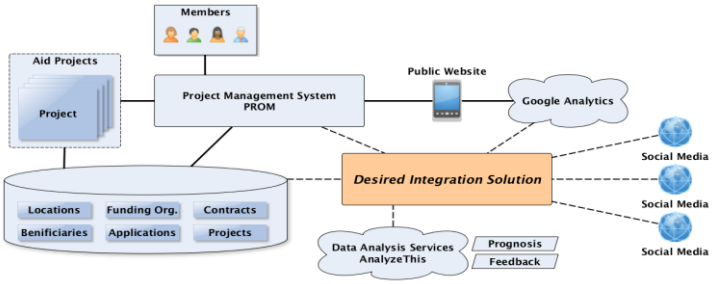

Fig. 3. The desired integration architecture of Aid&More.k

Modeling the Integration Requirements. The business goals of Aid&More are described using a goal model (i.e. instance of the GV), a part of which is shown in **Fig. 4**. Only the goals that motivate the cloud integration requirements are shown.

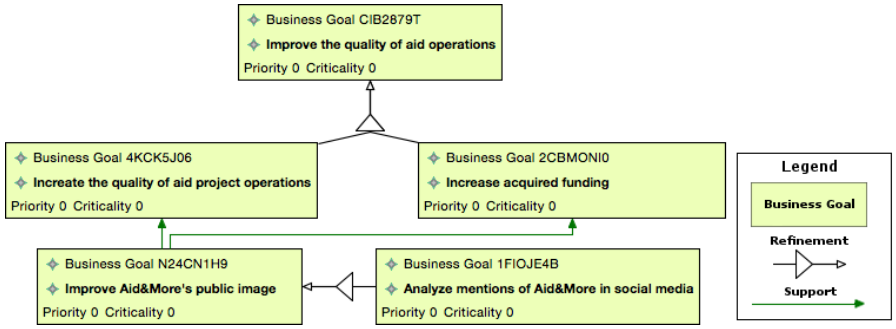

Fig. 4. Part of the goal model for Aid&More.

A section of the requirements table describing the desired integration solution is shown in **Fig. 5**. Each of the requirements has an associated requirement view (i.e. instance of the RV) that includes the design details of the requirement.

Requirement A3774OOJ **The system must retreive mentions about Aid&More from social media**
Requirement 6375C4IP **The system must retreive usage data of Aid&More's public website**
Requirement J84O2AM2 **The system must merge mentions from different social media sources into a single representation form**
Requirement UN8LINNR **The system must generate reputation reports using collected mentions data**

Fig. 5. Requirements for the desired integration solution by Aid&More.

The requirement view for Requirement A3774OOJ is illustrated in **Fig. 6**. To fulfill the requirement (i.e. retrieve Aid&More mentions), the integration solution performs

two activities: “send search query” and “retrieve search results.” The search query is affected by two factors: the aid project and the specific social media outlet being queried. The details of the aid project are used to formulate the content of the query. The interface details of the social media outlet describe the parameters used to establish a connection for sending the query and retrieving the results.

The concept “SocialMediaMention” represents occurrences in social networks, including tags, referrals, shares, likes, re-tweets, etc. The model enables switching the RESTful services that require (i.e. receive) the search query. The switching is then reflected in the implementation of the integration solution by applying a different transformation rule that is suitable for the new service. A new transformation rule needs to be developed for every new service to be added, but this is done only once and the transformation rule can be reused in this or other projects.

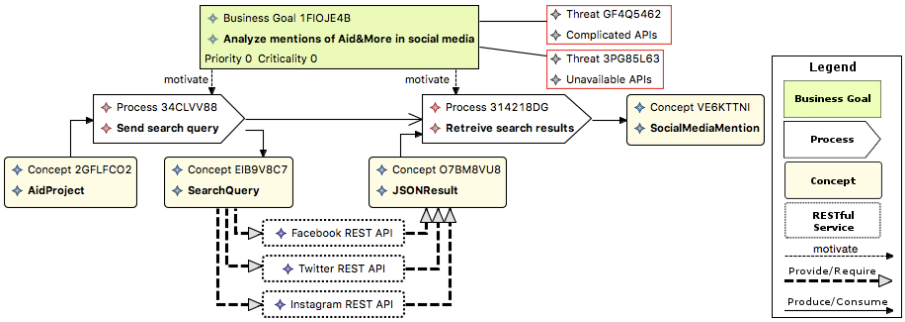

Fig. 6. Requirement view for Requirement A3774OOJ.

5 Conclusion

Existing research concerning requirements for cloud-based service focuses on individual services and tends to address the more technical aspects of cloud computing. Business-related aspects are overlooked. We propose in this paper modelling requirements for integrating cloud services as part of the organizational design. The unifying meta-model for enterprise modeling is extended with the Requirements View (RV), a composite view that covers components involved in describing requirements. The unifying meta-model enables relating requirements to other parts of the organizational design. The modelled systems can describe cloud-based services and thereby offer a mechanism for automated service provisioning at the enterprise-design level and contributing to achieving the envisioned global cloud marketplaces.

An example business case illustrated the use of the proposed RV with the help of a prototype tool. The requirements models can be transformed into a platform-specific integration solution that supports integrating different cloud services. The modularity of the unifying-meta model allows the RV to be extended with new modeling components that capture additional details about the requirements.

References

1. AlZain, M.A., Pardede, E., Soh, B., Thom, J.A.: Cloud Computing Security: From Single to Multi-Clouds. In: Proceedings of the 45th Annual Hawaii International Conference on System Sciences (HICSS), pp. 5490-5499. IEEE (2012)
2. Armbrust, M., Fox, A., Griffith, R., Joseph, A.D., Katz, R., Konwinski, A., Lee, G., Patterson, D., Rabkin, A., Stoica I., Zaharia, M.: A View of Cloud Computing. Communications of the ACM 53(4), 50-58 (2010)
3. Atkinson, C., Kühne, T.: Model-Driven Development: A Metamodeling Foundation. IEEE Software 20(5), 36–41 (2003)
4. Bubenko, J. A., jr., Persson, A., Stirna, J. (2001). *D3: User guide of the Knowledge Management Approach Using Enterprise Knowledge Patterns*. Royal Institute of Technology (KTH) and Stockholm University: Stockholm, Sweden.
5. Buyya, R., Yeo, C.S., Venugopal, S., Broberg J., Brandic, I.: Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility. Future Generation Computer Systems 25(6), 599–616 (2009)
6. Creeger, M.: CTO Roundtable: Cloud Computing. Queue - Distributed Computing 7(5), 1-17 (2009)
7. Koitz, I.T., Glinz, M.: StakeCloud Tool: From Cloud Consumers' Search Queries to New Service Requirements. In: IEEE 23rd International Requirements Engineering Conference (RE), pp. 286-287. IEEE (2015)
8. Kourtesis, D., Bratanis, K., Friesen, A., Verginadis, Y., Simons, A.J.H., Rossini, A., Schwichtenberg, A., Gouvas, P.: Brokerage for Quality Assurance and Optimisation of Cloud Services: An Analysis of Key Requirements. In: Lomuscio, A.R., Nepal, S., Patrizi, F., Benatallah, B., Brandić, I. (eds.) ICSOC 2013 Workshops, LNCS 8377, pp. 150-162. Springer (2013)
9. Leimeister, S., Riedl, C., Böhm, M., Krcmar, H.: The Business Perspective of Cloud Computing: Actors, Roles, and Value Networks. In: Proceedings of the 18th European Conference on Informtion Systems (ECIS 2010), paper 56. AIS (2010)
10. Mell, P., Grance, T.: The NIST Definition of Cloud Computing. Technical Report, National Institute of Standards and Technology (2011)
11. Ross, D. T., Schoman, K. E.: Structured Analysis for Requirements Definition. IEEE Transactions on Software Engineering 3(1), 6–15 (1977)
12. Stieninger, M., Nedbal, D.: Characteristics of Cloud Computing in the Business Context: A Systematic Literature Review. Global Journal of Flexible Systems Management 15(1), 59-68 (2014)
13. Takabi, H., Joshi, J.B.D., Gail-Joon, A.: Security and Privacy Challenges in Cloud Computing Environments. Security & Privacy 8(6), 24-31 (2010)
14. Young, J.D., Anton, A.I.: A Method for Identifying Software Requirements Based on Policy Commitments. In: 18th IEEE International Requirements Engineering Conference (RE), pp. 47-56. IEEE (2010)
15. Zardari, S., Bahsoon, R.: Cloud Adoption - A Goal-oriented Requirements Engineering Approach. In: Proceedings of the 2nd International Worshop on Software Engineering for Cloud Computing (SECLOUD'11), pp. 29-35. ACM (2011)
16. Zhang, Q., Cheng, L., Boutaba, R.: Cloud Computing: State-of-the-Art and Research Challenges. Journal of Internet Services and Applications 1(1), 7-18 (2010)
17. Zikra, I., Stirna, J., Zdravkovic, J.: Bringing Enterprise Modeling Closer to Model-Driven Development. In: PoEM 2011, LNBIP 92, pp. 268–282. Springer (2011)