Continuous Service Optimization as Cloud Brokerage Service

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Abstract: As cloud service ecosystems evolve, cloud service brokerage systems have emerged as intermediaries between cloud service consumers and cloud providers to preserve and enhance user expectations. In this paper, we describe the functionalities of a cloud brokerage tool that assist cloud brokers to ensure an optimized cloud service selection both during cloud on boarding and operation phases. To this end, we present an optimisation lifecycle providing customized continuous optimisation of cloud service selection and we explain the role of the cloud broker within this service optimization loop.

1 INTRODUCTION

As cloud adoption increases, cloud service providers broaden the range of their offered cloud services in an effort to fulfill user expectations and stay competitive in the cloud market. As a result, users are offered with a wide spectrum of competitive services that are difficult to evaluate and select. This difficulty gives ground to the emergence of new business roles in the cloud market landscape, such as cloud brokers that act as intermediaries between the cloud provider and the cloud consumer, to facilitate cloud service selection and preserve the benefits of the user.

In that respect, the problem of optimally selecting cloud services can be seen as part of a broader cloud brokerage system that aims to bridge the gap between user expectations and service provider's offerings. Although existing approaches tackle this problem by using multi-objective optimization strategies and considering user preferences (Garg, Versteeg and Buyya 2011), (Han, et al. 2009), they have several limitations. First, most of existing solutions have primarily focused on the interaction between the cloud consumer and the cloud provider without analyzing the involvement of the cloud broker in the optimization process. Secondly, existing works focus on the automatic adaptation of services in Infrastructure as a Service (IaaS) layer (Pawluk, et al. 2012), (Lawrence, et al. 2010) and do not analyze the effect of dynamic conditions such as change in user preferences, price etc. on the service optimization process. Moreover, a number of multiple-criteria decision making (MCDM) methods proposed in the literature (Garg, Versteeg and Buyya 2011), (Han, et al. 2009) capture user preferences by applying quantitative techniques that cannot always depict the vagueness of the qualitative aspects.

In this paper, we argue that the problem of cloud service optimization needs to be addressed during the whole service lifecycle across the different service layers from IaaS to Software as a Service (SaaS) layer. To this end, we introduce a holistic approach that involves actively the cloud broker in the optimization process and leverages optimization goals to the specific application needs. Our approach considers service optimization both during cloud service on boarding and operation phases including design as well as runtime service optimization.

2 RELATED WORK

Up to now, cloud services optimization has been primarily investigated from a cloud provider's perspective as a multi-objective constrained optimization problem (Moon, Chi and Hacigümüs 2010), (J. Z. Li 2011). Although these approaches aim to satisfy user requirements, they typically consider user satisfaction as a constraint rather than as the actual optimization goal. To this end, services optimization problems in cloud brokerage systems have the fundamental difference (with respect to the

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optimization problems from a cloud providers' perspective) that they consider the fulfillment of user expectations as the sole optimization goal.

From the perspective of the cloud consumer or potentially the cloud broker, Han et al. (Han, et al. 2009) proposed a service recommender framework using network QoS and Virtual Machine (VM) platform factors for assisting user's decisions when it comes to the selection of cloud provider. However, in their work they do not consider user preferences and they limit their evaluation criteria only to IaaS specific factors. Closer to our goal, Pawluk et al. (Pawluk, et al. 2012) have recently presented the STRATOS cloud brokerage framework which addresses the problem of dynamically selecting resources from multiple cloud providers at runtime. Furthermore, in (Lawrence, et al. 2010) the authors propose the use of a so-called service optimizer (SO) that continuously tests the compliance of service execution with Service Level Agreements (SLAs) through the use of dynamic SLAs. However, both of these works focus mainly on the automatic cloud service adaptation in IaaS layer.

An approach for cloud service ranking is provided by SMICloud (Garg, Versteeg and Buyya 2011) which is a framework for comparing and ranking cloud services. SMICloud is based on a set of quantifiable measures, formally defined as SMI attributes that model several quality dimensions of cloud services. SMICloud uses an Analytical Hierarchical Process (AHP) ranking mechanism to solve the multi-criteria decision making problem of finding the optimal cloud service. Similarly, Godse et al. (Godse and Mulik 2009) applied an AHP algorithm for ranking SaaS products.

Based on the above analysis, it is evident that existing work has mainly focused up to now on the optimization methodologies rather than on the optimization process as a whole. Existing work on the adaptation of service optimization (Pawluk, et al. 2012), (Lawrence, et al. 2010) mainly focuses on automated service adaptation in IaaS layer and does not consider the variety of changing conditions that may occur in a cloud service ecosystem. Therefore, our approach presented in the next section aims to give an insight on the service optimization process by proposing a continuous cloud service optimization cycle, where cloud broker plays an active role. Moreover existing optimization methodologies consider only quantitative metrics by assigning definite quantitative measures in user preferences and in service characteristic evaluation. Real world examples show that quantitative models cannot always reflect the ranking among the services accurately (Doyle and Thomason 1999). To this end, in this paper we also motivate the need for qualitative metrics to better model the imprecise ranking among services.

3 SERVICE OPTIMIZATION

Our approach provides a holistic view on the optimization process to help the user select the right service. It includes the main design principles of an autonomous system (Huebscher and McCann 2008), i.e. it is based on a MAPE-K (Monitor, Analyse, Plan, Execute, Knowledge) adaptation loop. The lifecycle shown in Figure 1 consists of two different concurrent iteration cycles, similar to the visualization of adaptation mechanisms for service-based applications in (Bucchiarone, et al. 2009). The right cycle concerns the analysis, design, development and deployment of the monitoring and optimization mechanisms that constitute the control layer which efficiently adapts the system in continuous changes in the environment. The left cycle applies the optimization and monitoring mechanisms of the control layer by continuously adapting the service provisioning layer. Both cycles are applied both during cloud service on boarding, i.e. initial cloud service migration as well as during cloud service operation phase.

In more detail, the design time optimization cycle sets the scope of the optimization with respect to the application characteristics and the user requirements. After the design of the appropriate optimization and monitoring tools for the targeted application, the optimization mechanisms will be deployed in the system put into operational mode. The optimization mechanisms are applied in the continuous optimized service selection process depicted in the left cycle. To this end, we have identified four different steps that adapt the service selection to current dynamic conditions. The same four steps could be applied for the initial service deployment, i.e. the cloud service on boarding as well as for the continuous optimization of service selection during the cloud service operation phase after initial service deployment. Table 1 summarizes the different information used before and after deployment during the proposed four step process.

The proposed service optimization mechanism is driven through the identification of optimization opportunities. This step typically relies on the automatic detection of the relevant information for the optimization problem. In particular, during initial cloud service on boarding, the optimization

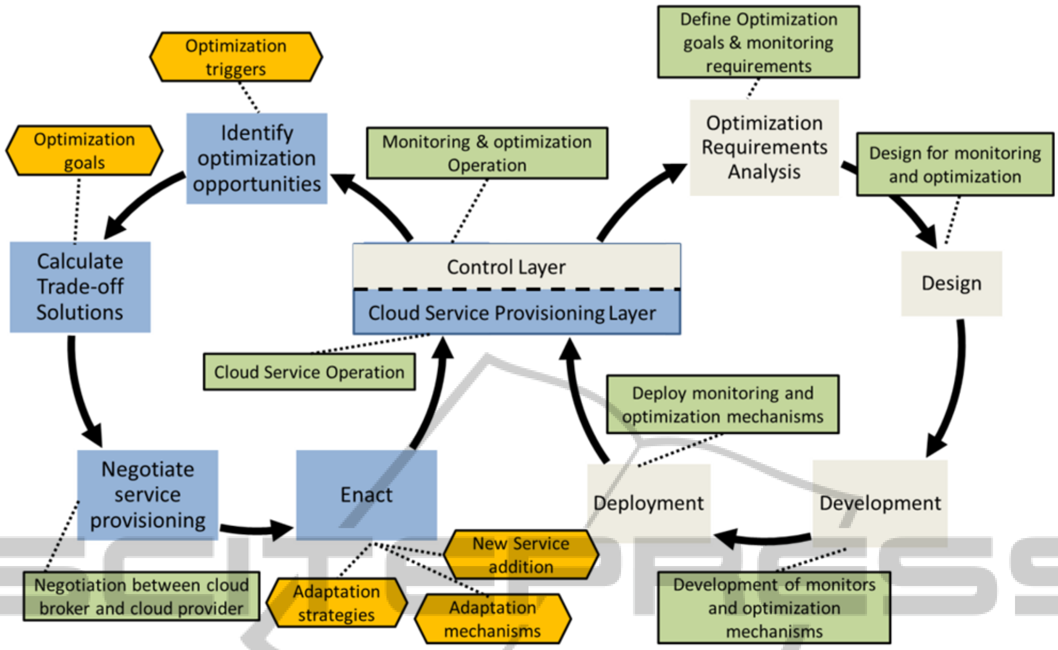

Figure 1.

opportunities relate to the information that form the conditions and input for the initial service optimization, i.e. the early user requirements and preferences and the historical data regarding the service operation. Historical data are necessary for the initial service optimization, since they constitute the main driver for the evaluation of the candidate services. In the case of the initial deployment, the multi-objective optimization mechanism will assess the candidate services through the use of Multi-Criteria Decision Making (MCDM) methods, based on the information presented in previous step. Note that according also to related work (Garg, Versteeg and Buyya 2011), (Godse and Mulik 2009), MCDM is particularly appropriate for this kind of optimization problem, since the assessment of the candidate services is usually affected be several different criteria that should be all considered before making a decision. The multi-objective optimization step will output a set of trade-off solutions that will be subject to human decision making process. During this step, the cloud broker plays an important role in preserving user benefits during the negotiation of service provisioning with the cloud service provider. After the completion of the negotiation step the initial service deployment is realized. In that step, a cloud broker acts as an auditor to guarantee the successful deployment of the new service.

The cloud service optimization process during the cloud service operation phase after the initial deployment will follow a similar process. However, the triggering events and adaptation strategies are specific to the continuous service optimization process that takes place after the initial service deployment. In detail, the identification of optimization opportunities at runtime refers to the detection of events that trigger the service optimization. These optimization triggers could be either initiated by the user or by the cloud brokerage monitoring mechanism which seeks for triggering events tailored to the targeted applications. More precisely user triggers could include changes in user requirements which refer to changes in the required quality of service or changes in user preferences which refer to changes in the perception of "value-for-money" and the prioritization of the several service characteristics. In this respect, we assume here that user experience after the service deployment could lead to re-consideration of his requirements, i.e. relax or stricken his QoS demands. In addition to the user-initiated triggers, the monitoring triggers of the envisioned cloud brokerage mechanism could be the discovery of a new service that could provide a better solution for the user, changes in the price (e.g. offers, discounts that could optimize the cost reduction for certain users) or poor service performance that could refer to SLA violations and performance degradation.

All the above triggers will lead to the calculation of the new trade-off solutions with respect to the different optimization criteria and subsequently in

Table 1.

Life-Cycle Step	Cloud service on boarding phase	Cloud service operation phase
Identify optimization opportunities	Early user requirements, user preferences, Service operation historical data	Monitoring events, Changes on user requirements, preferences Changes on service provisioning (e.g. offers, discounts)
Calculate trade-off solutions	MCDM based on initial user requirements and preferences and service historical data	MCDM with up-to-date user requirements, preferences and service monitoring data
Negotiation	Price, SLAs, commitment, service characteristics	Price, SLAs, commitment, service characteristics , trust relationship
Enact adaptation	Initial service selection and deployment	Service replacement, Service re-configuration

the negotiation step. During the negotiation between the cloud broker and the provider, prior user experience with the service provider could lead to different negotiation conditions with respect to the case of the initial service deployment. Finally, the optimization process at runtime will lead to the adaptation of cloud services. The cloud broker is again responsible for ensuring that the correct actions, e.g. new service addition, service replacement or service reconfiguration, takes place.

4 CONCLUSIONS

In this paper, we discussed the problem of optimal cloud service selection in a cloud service ecosystem. In particular, we presented a holistic approach that describes all the steps of the optimization process in a cloud brokerage system. Our proposal incorporates the following concepts: (a) it involves the cloud broker and the service user in the continuous optimization loop, (b) it expresses user preferences in an intuitive way that is understandable for the user. In our short-term future work, we plan to implement the proposed framework and validate its correctness through extensive experimentation.

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