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User-side cloud service management: State-of-the-art and future directions

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ABSTRACT

Cloud computing is increasing in usage because of its technical and financial advantages over traditional computing paradigms and also because of the availability of an expanding number of cloud services offered by new service providers. Consistent with its growth, there has been wide research interest in the literature that focuses on increasing cloud adoption. However, the current commercial and research-oriented cloud computing research in the literature mainly deals with functionalities closer to cloud infrastructure, such as improved performance and the management of virtualized resources, as well as fundamental issues related to efficient resource utilization, such as virtual machine (VM) migrations and server consolidation. While on the one hand, such features are very important, on the other hand, other important features, such as cloud quality of service management which is important for the cloud environment to move from a basic cloud service infrastructure to a broader cloud service ecosystem, have not received the required due attention. In cloud service management, a cloud service user has several choices for service selection and the quest to achieve interoperability and compatibility in cloud computing will consequently enable the user to easily migrate between service providers. In this scenario, the user needs to make important cloud service management decisions based on QoS, in addition to other criteria such as usage cost. These issues, when considered from a user's perspective, are quite different from cloud infrastructure management issues envisioned from a cloud provider's perspective. There are several challenges in cloud service management from a user's perspective, which the current cloud service management platforms in the literature do not address. To address this drawback, this paper presents a comprehensive state-of-the-art discussion on the existing approaches to cloud service management, critically evaluates them against the factors required for the user to manage the cloud service and presents a framework that assists the cloud service user in making cloud service management decisions.

1. Introduction

Cloud computing is rapidly becoming the dominant computing paradigm of today's highly technologically dependent society. However, due to the fact that the fundamental principle behind cloud computing is the sharing of virtualized computing resources by multiple users over the Internet, it faces significant challenges in ensuring that all users receive the QoS level which they desire. The variability in computing resource utilization by multiple cloud users also leads to variability in the availability of computing resources at cloud providers' data centers. This dynamic nature of cloud computing raises important management issues from the cloud provider's as well as the user's perspectives. The effective management of cloud resources at various levels of the cloud stack is important for cloud providers to ensure Service Level Agreement (SLA) compliance, security guarantees, high availability, energy efficiency, maximum resource utilization, capacity to meet high demand, reliability and security. Traditional IT resource management solutions designed for enterprise environments are unable meet management's requirements due to multi-tenancy, large scale and dynamism and various dependent factors of cloud environments. These management tasks are performed as a part of virtual infrastructure management by software, such as OpenNebula, OpenStack, Eucalyptus, ECP, and Overt (Wen et al., 2012;

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Cerbelaud et al., 2009) which manage virtual machines across computing nodes.

Cloud users can communicate with these virtual infrastructure managers via cloud APIs (e.g. OpenStack API, Open Cloud Computing Interface and EC2 API) to create, run, monitor and terminate virtual machine instances. In addition to these CLI interfaces, there are also browser-based graphical interfaces (such as Dashboard for OpenStack and Sunstone for OpenNebula) (Wen et al., 2012). These interfaces allow users to manage their virtual resources on a cloud by utilizing the functionality in these cloud tools that are built for virtual infrastructure management at a data center level for cloud providers. However, the management issues, when looked at from a user's perspective, are quite different from the cloud infrastructure management by cloud providers.

There are several cloud management platforms (available as services) which are specifically designed to benefit users and support multiple cloud providers and underlying cloud management software. Examples of these services include Rightscale, Red Hat Cloudforms, Servicemesh Agility Platform and ElasticBox. These services allow users to manage their virtual resources acquired from several cloud providers through a single management environment. However, none of them do it from the perspective of a cloud service user and cloud service management is still an active area in industry and academia. The user's perspective on cloud service management has only recently received attention.

In this paper, we discuss cloud computing from the viewpoint of the QoS being received at the user-side. In the next section, we summarize the background of cloud service management and discuss the challenges in cloud service management from a user's perspective. In Section 3, we present the state-of-the-art in this area and present a critical evaluation of the existing work in Section 4, to highlight the research gaps in user-side cloud service management. In Section 5, we define user-side cloud service management, its different constituting parts and present the User-side Cloud Service Management framework in Section 6. We also explain in detail each part of the framework and discuss how it addresses the research gaps raised in Section 4. In Section 7, we conclude the paper along with a discussion on our future work.

2. Background

As mentioned in the previous section, the dynamic nature of cloud computing raises important management issues from cloud providers' as well as users' perspectives and that traditional IT resource management solutions designed for enterprise environments are unable to meet management's requirements due to multi-tenancy, large scale and dynamism and various dependent factors of cloud environments. Furthermore, the management issues, when looked at from a user's perspective, are quite different from the cloud infrastructure management by cloud providers.

There are several cloud management platforms (available as services) which are specifically designed to benefit the users and support multiple cloud providers and underlying cloud management software. Examples of these services include Rightscale, Red Hat Cloudforms, Servicemesh Agility Platform and ElasticBox. These services allow the users to manage their virtual resources acquired from several cloud providers through a single management environment. However, none of them do it from the perspective of a cloud service user and cloud service management is still an active area in industry and academia. The user's perspective in cloud service management has only recently received attention. The next section focuses on the challenges of user-side cloud service management.

2.1. Challenges in cloud service management from the user's perspective

There are several challenges in cloud service management from the user's perspective which the current management platforms do not address. The existing approaches only provide basic service management functionality to the user and do not assist in actual decision making which is vital for effective service management.

From a user's perspective, cloud service management has two possible scenarios: the first is the case where a user wants to select a cloud service provider to initiate a service for the first time; and in the second scenario, a user, who is already using a cloud service, wants to monitor the performance of his selected service as well as the other available services to assess whether or not it continues to provide the same level of quality of service as at the time of service selection and to consider service migration if another service, that offers the same or better QoS at a lower cost, becomes available.

Thus, cloud service management has two temporal phases (pre-interaction phase and post-interaction phase) as shown in Fig. 1 and it comprises three basic components, service selection in the pre-interaction period, service monitoring in both periods and service management, which includes several tasks, in the post-interaction period. In the next sub-section, the challenges in the pre-interaction phase are highlighted.

2.1.1. Service selection in the pre-interaction period

In the cloud computing environment, there are several cloud service providers, each of which offers more than one service with similar functionality but different levels of QoS and cost. The user has to make a decision in favor of one such service after considering his requirements, the nature and quality of the services on offer and their cost.

Making a decision in such a scenario is not easy as users have different requirements, thus a service deemed appropriate for one particular user may not be able to fulfil the requirements of another user. Furthermore, the cost of a service also needs to be considered as different users have different financial priorities. Additionally, the user's priorities are subject to changes with time. On the other hand, a cloud service is characterized by several specification parameters which reflect the possible performance in terms of different hardware components e.g. CPU type, CPU speed, memory size and throughput.

Furthermore, as cloud computing envisions a paradigm wherein the physical computing resources are shared by many users as virtualized resources, due to this sharing of resources among multiple users, the actual performance of a service cannot be determined by its specifications as there is considerable variability in QoS which needs to be monitored over a long time interval.

2.1.2. Cloud service monitoring

As mentioned in the previous sub-section, the long term monitoring of cloud services is needed to assess the variability in

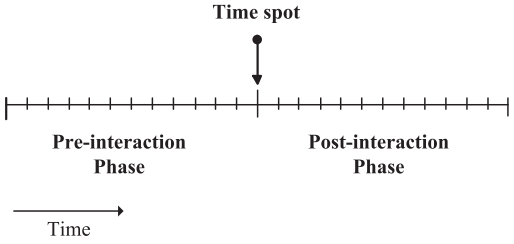

Fig. 1. Pre-interaction and post-interaction phases in loud service management from the user's perspective.