

Chapter 9

Resource and Energy Efficient Virtual Machine Migration in Cloud Data Centers

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ABSTRACT

Cloud computing service has been on the rise over the past few decades, which has led to an increase in the number of data centers, thus consuming more amount of energy for their operation. Moreover, the energy consumption in the cloud is proportional to the resource utilization. Thus consolidation schemes for the cloud model need to be devised to minimize energy by decreasing the operating costs. The consolidation problem is NP-complete, which requires heuristic techniques to get a sub-optimal solution. The authors have proposed a new consolidation scheme for the virtual machines (VMs) by improving the host overload detection phase. The resulting scheme is effective in reducing the energy and the level of Service Level Agreement (SLA) violations both, to a considerable extent. For testing the performance of implementation, a simulation environment is needed that can provide an environment of the actual cloud computing components. The authors have used CloudSim 3.0.3 simulation toolkit that allows testing and analyzing Allocation and Selection algorithms.

INTRODUCTION

According to Mell et al. (2011), Cloud computing is “a model for enabling ubiquitous, convenient and 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.”

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The services offered by the cloud computing model can be classified as:

- **Software as a Service (SaaS):** “The potentiality provided to the user is to use the provider’s applications and programs carrying out on a cloud infrastructure. The applications are accessible from several client devices through either a client interface, such as a web browser or a program interface. The user neither manages nor controls the fundamental cloud infrastructure, including storage, networks, servers or operating systems, with the exception of limited application configuration settings.”
- **Platform as a Service (PaaS):** “The potentiality provided to the user is to deploy user-developed applications created using programming languages, and tools supported by the provider onto the cloud infrastructure. The user neither manages nor controls the fundamental cloud infrastructure, including storage, networks, servers or operating systems, but has control over the deployed applications and configuration settings for the hosting environment.”
- **Infrastructure as a Service (IaaS):** “The potentiality provided to the user is to provision processing, storage, networks, and other underlying computing resources where the user is able to deploy and run discretionary software, which can include operating systems and applications. The user neither manages nor controls the fundamental cloud infrastructure, but has control over storage, operating systems, and deployed applications; and limited control of select networking components (e.g., host firewalls).”

These services are made available to the cloud service users by creating instances of Virtual Machines (VMs) and then consolidating the resource allocation periodically. After virtualization, users’ applications can run on the same hardware managed by their own operating system.

Traditionally, organizations have had to own and deploy the hardware, network resources and also run them efficiently. Cloud computing has changed this approach drastically. According to Buyya et al. (2009), the organizations can outsource their computational requirements to the cloud service providers and use the services over the internet, to reduce infrastructure and maintenance costs, instead of dealing with the cost and process of purchasing expensive IT infrastructure and then with periodic upgrades of the same. They can now pay only for the cloud resources they actually use.

A cloud data center consists of a large number of servers and switches for transmitting data between servers or between servers and clients. The infrastructure energy consumed in a data center includes the energy used for computational tasks, the energy used for transmission of data and the energy required for cooling the data center. According to Belady et al. (2007), the cost incurred due to this infrastructure energy has been estimated to be much more than the IT costs. The rise in the use of cloud computing has resulted in the setting up of more and more number of data centers, which has led to a huge increase in the consumption of energy. According to Huang et al. (2014), data centers consume around 110 Billion kilowatt hours of energy per year. This humongous increase in the infrastructure energy consumption in recent times has resulted in a sharp increase in the CO₂ emissions, which contributes towards global warming, according to Hanne (2011). Thus it is imperative that energy consumption in the cloud data centers be reduced, by improving the way in which the cloud resources are provisioned. Some of the ways in which the resource provisioning in the cloud has been improved is by the use of the virtualization technology and live migration techniques, as suggested by Hwang et al. (2013) and Bobroff et al. (2007) respectively.

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