Chapter 85
Communication Aspects of Resource Management in Hybrid Clouds

Luiz F. Bittencourt
University of Campinas, Brazil

Edmundo R. M. Madeira
University of Campinas, Brazil

Nelson L. S. da Fonseca
University of Campinas, Brazil

ABSTRACT

Organizations owning a datacenter and leasing resources from public clouds need to efficiently manage this heterogeneous infrastructure. In order to do that, automatic management of processing, storage, and networking is desirable to support the use of both private and public cloud resources at the same time, composing the so-called hybrid cloud. In this chapter, the authors introduce the hybrid cloud concept and several management components needed to manage this infrastructure. They depict the network as a fundamental component to provide quality of service, discussing its influence in the hybrid cloud management and resource allocation. Moreover, the authors present the uncertainty in the network channels as a problem to be tackled to avoid application delays and unexpected costs from the leasing of public cloud resources. Challenging issues in the hybrid cloud management is the last topic of this chapter before the concluding remarks.

INTRODUCTION

Increasing hardware capacity and Internet connectivity have resulted in a new computing and communication scenario in which high performance computers are connected via the Internet (Kandukuri, Paturi, & Rakshit, 2009). This has facilitated the emergence of the new computational paradigm of *Cloud Computing,* in which computational resources (processing power, storage, applications, and so on) are allocated on demand according to user requests, with such allocation

DOI: 10.4018/978-1-4666-6539-2.ch085

subject to charges in a pay-per-use business model (Kaufman, 2009). In cloud computing, resources are available as services, and they can be dynamically leased and released (Zhang, Cheng, & Boutaba, 2010), as can any other utility, such as electricity and water (Jing & Jian-jun, 2010). Furthermore, in cloud computing, users can share both data and distributed resources in a scalable and flexible fashion via the Internet (Jensen, Schwenk, Gruschka, & Iacono, 2009).

The new cloud computing paradigm has several advantages for small, medium, and large corporations (Zhang, Cheng, & Boutaba, 2010):

- **Lower Upfront Investment:** Startup and expanding companies do not need to make large upfront investments in computational infrastructures in order to satisfy peak demands; they can lease resources from cloud providers only when necessary, and thus reduce unnecessary expenditure for equipment.
- **Scalability and Elasticity:** Computational power can be rapidly expanded or contracted, as needed. This elasticity in computational power is an important feature that avoids the prolonged installation of new equipment and software when a corporation's computing pool has proved inadequate, and it also avoids low utilization and hardware depreciation during periods of low computational demand.
- **Accessibility:** Services made available in the cloud can be accessed anywhere and at any time through the Internet.
- **Reduction in Maintenance Costs:** Cloud clients only need to manage the services they lease while the maintenance of the hardware is the responsibility of the cloud provider. In this way, corporations can focus on their main business and not worry about such management overhead.
- **Reduction in Running Costs:** Since cloud resources are leased and released on-demand, there is no need to employ personnel to manage computational resources, and datacenter running costs are reduced.

Many companies are investing in the cloud computing model for the offering of diverse services (Khajeh-Hosseini, Sommerville, & Sriram, 2010). One of the main actors is Amazon Web Services (AWS – http://aws.amazon.com/), which offers a variety of services such as database, electronic commerce, storage, and computing services. On a different scope, Google provides the Google Apps (http://www.google.com/apps/), which offers applications as services, and the Google Application Engine (GAE – http://code.google.com/appengine/), which allows developers to implement their own Web applications using Google's API. Other major actors in the cloud industry include Microsoft Azure (http://www.microsoft.com/windowsazure/), Salesforce.com (http://www.salesforce.com/), Rackspace (http://www.rackspace.com/), Globus Nimbus (http://workspace.globus.org/), and Eucalyptus (Nurmi, Wolski, Grzegorczyk, Obertelli, Youseff, & Zagorodnov, 2009).

In *hybrid clouds*, resources are connected by Internet links which bandwidth availability impacts the quality of service provided to clients. This chapter describes main communication aspects which affect service provisioning. It is organized as follows. First, basic concepts are introduced. Then, both resource and workload management aspects in hybrid clouds are presented. Next, scheduling of applications, virtual machine allocation, network virtualization, and green aspects of resource allocation are described. Then, the lack of precise knowledge about bandwidth availability in links connecting the resources of a hybrid cloud is emphasized. The chapter ends with a discussion about research challenges in hybrid clouds.