

Modeling and Performance Analysis of Resource Provisioning in Cloud Computing using Probabilistic Model Checking

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Cloud computing consists of an advanced set of technologies that allow cloud providers to offer computing resources such as infrastructure, platforms and applications to be accessible over the Internet as services. Cloud computing relies on virtualization of resources in the cloud data centers, where a set of Virtual Machines (VMs) are deployed on Physical Machines (PMs) to provision and serve user requests. Due to the dynamic nature of cloud environments and complexity of resources virtualization, as well as the diversity of user's requests, developing effective techniques to evaluate and analyze the performance of cloud centers has become highly required. In this paper, we propose the use of probabilistic model checking as an effective framework for the evaluation and the performance analysis of resource provisioning in the cloud. Based on an analytical model for resource provisioning in Infrastructure-as-a-Service (IaaS) cloud, we build a stochastic model using the probabilistic model checker PRISM and analyze it against a useful set of probabilistic and reward properties that help to measure and analyze cloud performance in an efficient way.

Povzetek: Analizirane so razne komponente računanja v oblaku, npr. modeliranje in performance virov.

1 Introduction

Cloud computing is a novel information technology that provides access to different IT services on demand over the Internet. The services provided through the cloud range into three main categories: Infrastructure as a Service (IaaS), where infrastructure resources such as: servers, storage, network components are provisioned. Platform as a Service (PaaS), which provides an environment for developing, running and managing applications efficiently by reducing the complexity related to infrastructure. Software as a Service (SaaS), which represents the largest cloud market, in which the task of managing software is moved to third-party services. Cloud computing has been treated from different aspects such as: security [22], load balancing [24], storage[7] and consistency [21].

In cloud computing literature, we refer usually to service providing by the technical term, provisioning. In this regard, Vaquero et al. [23] defined cloud as: the provision of computing infrastructure, which aims to shift the location of the computing infrastructure to the network in order to reduce the costs associated to management and maintenance of hardware and software resources. These resources are offered to the customer by cloud providers based on specific legally binding contracts called Service Level Agreements (SLAs), which state Quality of Service (QoS) parameters, such as time, cost, availability and security that should be guaranteed by service providers in or-

der to meet customer's needs and execute service requests. Buyya et al. [5] defined the cloud as: "A Cloud is a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreements (SLA) established through negotiation between the service provider and the customers".

In IaaS cloud, virtualization plays a crucial role in enabling cloud computing services, in fact, it is a principal mechanism that enables cloud providers to cope with multiple requests of users through virtualization of physical machines(PMs). Virtualization refers to the abstraction of computing resources in a way that a single physical machine can run a set of virtual machines(VMs)[3].

However, due to dynamic nature of cloud computing environments and the complexity related to managing infrastructure resources from a side, and the diversity in customers requests from another, addressing the effective ways to instantiate, provision and deploy infrastructure resources to handle user requests and meet QoS requirements is considered as a big challenge and very critical issue in cloud computing. Therefore, performance analysis and evaluation of cloud computing environments have attracted recently much attention and formed an active research area.

Cloud performance analysis is beneficial for both cloud providers and consumers because it helps to get a deep insight on the infrastructure resources and how they should