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A Learning Automata-based Ensemble Resource Usage Prediction Algorithm for Cloud Computing Environment

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Abstract

Infrastructure as a service (IaaS) providers are interested in increasing their profit by gathering more and more customers besides providing more efficiency in cloud resource usage. There are several approaches to reach the resource usage efficiency goal such as dynamic consolidation of virtual machines (VMs). Resource management techniques such as VM consolidation must be aware of the current and future resource usage of the cloud resources. Hence, applying prediction models for current cloud resource management is a must. While cloud resource usage varies widely time to time and server to server, determining the best time-series model for predicting cloud resource usage depend not only on time but the cloud resource usage trend. Thus, applying ensemble prediction algorithms that combine several prediction models can be suitable to reach the mentioned goal. In this paper, an ensemble cloud resource usage prediction algorithm based on Learning Automata (LA) theory is proposed that combines state of the art prediction models, and it determines weights for individual constituent models. The proposed algorithm predicts by combining the prediction values of all constituent models based on their performance. The extensive experiments on CPU load prediction of several VMs gathered from the dataset of the CoMon project indicated that the proposed approach outperforms other ensemble prediction algorithms.

Keywords: *prediction, learning automata, ensemble algorithm, virtual machine, cloud computing environment*

1 Introduction

Today, cloud computing technology provides a wide variety of services over the Internet. While the Internet becomes faster and more accessible around the globe, cloud computing customers become more and more interested in using their cloud services [1]. In the cloud computing environments, customers' demands execute in the form of VMs that are allocated on low-level computing servers provided by IaaS providers. The virtualization technology provides scalability for cloud users, which means demanding more or fewer resources over time [2]. This makes efficient usage of cloud services more challenging. Predicting the future of users' demands and cloud resource usage can be applied to handle this issue.

1.1 Research motivation and challenges

The resource management and scheduling is a challenging issue while a cloud data center consists of hundreds or thousands of resources [3][4]. Most of the approaches for accurately allocation, provisioning, and scheduling of cloud resources need to be a predicted. Effective prediction in cloud computing because of its dynamic characteristic remains as an important issue. There are monitoring tools that gather and track hardware and software information to tackle this challenging problem. However, this information is not necessarily enough to accurately predict the resource future status and behavior, which is necessary for cloud resource management [2].

Monitoring and predicting VM resource usage such as CPU load, memory usage, and disk space can be effective to tackle this problem. The resource under provisioning, which means resources requested are more than resources available, may be happened due to allocating several requests to a VM. Consequently, it

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