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Towards cloud-based resource management for big data applications ✧

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ABSTRACT

In the age of information technology, analyzing data in the cloud through efficient resource management is recognized as an effective solution to meet the quality-of-service needs of users. In this regard, this paper proposes a fuzzy selector-based approach to improve the virtual machine (VM) migration process that provides a balance between servers during the processing of tasks. The proposed approach is a hierarchical resource prediction that includes local and global parts for processing requests. Evaluations demonstrate the superiority of the proposed approach over state-of-the-art methods. The results show that the proposed approach reduces the cost by 10% compared to FAHP.

1 Introduction

Cloud computing as a new technology has brought significant advantages in providing medical services electronically. However, there are many challenges in this field that can be referred to as efficient resource management [1]. The purpose of resource management in cloud computing is to use resource allocation to meet application requirements and reduce operating costs. The dramatic growth of Internet services has led to an imbalance of resources in cloud computing. Hence, resource management is an important factor in improving the performance of cloud environments [2].

Several approaches to efficient resource management can be referred to as VM migration. The migration technique in the cloud is defined as the transfer of VMs from one physical server to another. Due to resource constraints and heterogeneity, resource allocation is an NP-complete problem [3, 4]. An appropriate resource allocation method effectively reduces the execution time of tasks and resource productivity.

This paper presents a migration-based fuzzy selector approach to managing resource allocation for data processing in cloud-based applications. The proposed fuzzy system manages the load balancing of servers during efficient data processing through migration technique. The main contributions to this work can be summarized as follows:

- Improving the VM migration process using a fuzzy selector approach.
- Efficient cloud resource management for data analysis in cloud-based applications.

The rest of the paper is organized as follows: Section 2 discusses a literature review. Section 3 presents the proposed approach. The discussion of simulations and comparisons is reported in Section 4, and finally, Section 5 concludes this paper.

2 Literature review

Hitherto, various methods such as Min-Min and metaheuristic algorithms have been used for efficient resource allocation in the cloud environment. However, little research focuses on the processing of various data in cloud-based applications [1]. One of the most

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famous load-balancing algorithms in the cloud environment is the Min-Min algorithm [5]. This algorithm performs the task scheduling based on the minimum time between all tasks on each resource. In [6], we presented a hybrid resource provisioning approach for multi-layered applications, in which the concepts of automatic computing are integrated with the Fuzzy Analytic Hierarchy Process (FAHP). This method uses support vector machine technique and linear regression to predict the workload, while FAHP decides on the amount of increase or decrease of resources.

In [7], the Imperialist Competition Algorithm (ICA) and K-means are used for clustering workloads sent by end users (ICA-K-Means). ICA-K-Means is equipped with a decision tree algorithm for the efficient allocation of resources based on the two criteria of productivity and workload. In [8], a hybrid scheduling strategy for managing medical data in cloud VM resources is presented, which is a combination of genetic algorithm and particle swarm optimization. In [9], a resource allocation solution is presented with the help of cloud computing and the Internet of Things for real-time and batch processing of health data.

In [10], an improved resource allocation approach is proposed for health domain data processing in the cloud computing environment. Here, a fuzzy selector-based approach is introduced for migration that can provide balance during task processing. Our work is extended from this study. The main difference between our work and the study presented in [10] is the use of the Auto-Regressive Integrated Moving Average (ARIMA) algorithm based on the combination of Auto-Regressive (AR) and Moving Average (MA) in order to estimate the available resources.

3 Proposed approach

The proposed approach is a FAHP-based resource management technique that uses the ARIMA model to determine the optimal cloud and resource prediction. This approach optimizes the resource utilization process and achieves optimal load balancing, thus reducing execution time. Load balancing during task processing is provided by the VM migration technique based on the fuzzy selector, where the migration is done live. This technique migrates VMs from overloaded servers to underloaded servers with the aim of reducing the number of overloaded servers as much as possible.

The proposed architecture consists of local and global parts that analyze requests hierarchically. First, the user request is received by the local part and then the request for resource allocation is analyzed and monitored. The ARIMA algorithm estimates the number of resources available and executes the user request if resources are available. ARIMA is a combination of AR and MA forecasting models. When the broker (i.e., cloud data center) is not able to provide the resources required by the request, the FAHP model selects another suitable cloud to provide the resources. Each cloud data center as a broker includes request monitoring, resource estimator, resource management, and cloud selector components. Fig. 1 shows the structure of a broker with its components.

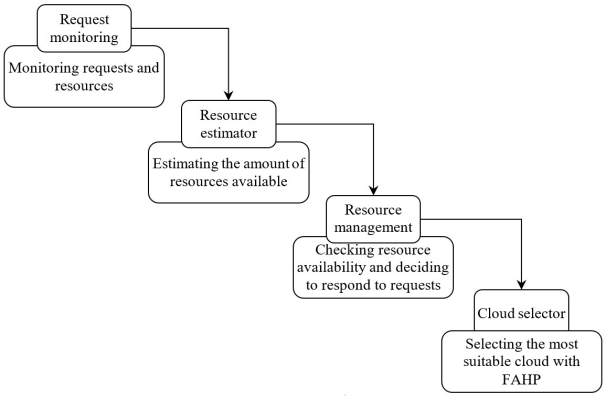

Fig. 1. Broker structure with its components

The resource monitoring component is responsible for monitoring the number of user requests as well as the number and amount of resources available in cloud data centers. At the same time, this component stores information about the number of requests, the number of resources, and the number of available resources. The resource estimator component is responsible for estimating the number of resources required using the ARIMA algorithm. The resource management component examines the availability of resources and decides whether to service the new request. When the required resource requirements are not available, the cloud selector component is applied. This component is responsible for selecting a suitable cloud to execute the user request using the FAHP model.

4 Numerical results

The proposed approach is simulated with Cloudsim and the results are compared with FAHP [5] and ICA-K-Means [7] algorithms. The evaluation is based on drug use data from different US states from 2015 to 2018, which is available at https://downloads.cms.gov/medicare/2018Med2000_flatfiles.zip. The comparison results based on utilization and total cost criteria prove the superiority of the proposed approach. Processor utilization rate and total cost are calculated by Eqs. (1) and (2), respectively.

$$U_i(\Delta t) = \frac{\sum_{i=1}^{Num_i(\Delta t)} VM_i \; Requested \; MIPS}{\sum_{i=1}^{Num_i(\Delta t)} VM_i \; Total \; MIPS} \quad (1)$$

$$Total \; Cost = VM \; Cost + Penalty \; Cost \quad (2)$$

Results of the Comparison for different timelines are reported in Fig. 2 and Fig. 3. As illustrated, the

proposed approach requires less total cost for data processing and offers better utilization than other algorithms because it uses prior knowledge of cloud computing infrastructure.

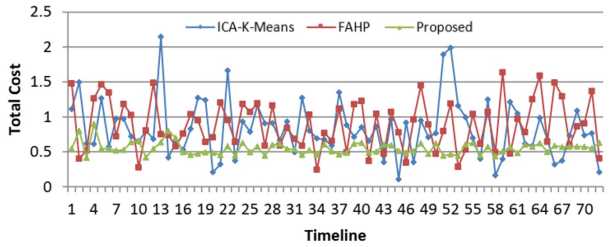

Fig. 2. Comparison of different algorithms based on the total cost

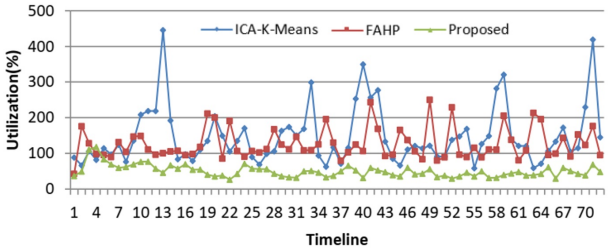

Fig. 3. Comparison of different algorithms based on utilization

5 Conclusion

In recent years, the use of cloud computing has become more common due to the significant growth in the production of various data. Efficient resource allocation in cloud computing can improve the quality of service and reduce service breaches on various cloud applications. This paper proposes a fuzzy-based approach to efficient resource management that improves utilization and total cost compared to equivalence algorithms.

Conflict of interest

The authors declare that they have no conflict of interest.

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