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A Heuristic Algorithm for Multi-Site Computation Offloading in Mobile Cloud Computing

Nur Idawati Md Enzai[1]*and Maolin Tang[2]†

[1] nuridawati.mdenzai@hdr.qut.edu.au
[2] m.tang@qut.edu.au

Abstract

Due to limitation of mobile device in terms of battery life and processing power, Mobile Cloud Computing (MCC) has become an attractive choice to leverage this shortcoming as the mobile computation could be offloaded to the cloud, which is so-called *mobile computation offloading*. Existing research on mobile computation offloading considers offloading a mobile computation to a single cloud. However, in the real world a computation service could be provided by multiple clouds and each computation service. Thus, a new and interesting research problem in mobile computation offloading is how to select a computation service for each of the computation tasks of a mobile computation such that the computation time of the mobile computation, the energy consumption of the mobile device and the cost of using the computation services are minimized. This is so called multi-site computation offloading in mobile cloud computing. In this paper we formulate the multi-site computation offloading problem, propose a heuristic algorithm for the multi-site computation offloading problem and evaluate the heuristic algorithm.

Keywords: Computation offloading, mobile cloud computing, scheduling, heuristic algorithm

1 Introduction

Cloud computing provides services to clients in forms of processing and storage without the need for clients to install hardware on their side. As the number of mobile users increases, the concept of Mobile Cloud Computing (MCC) emerges. Dinh, Lee, Niyato, and Wang define MCC as the cloud provisioning of data processing and storage services for mobile users [6]. High processing speed and powerful memory capacity of mobile device are not essential because clouds can process all the complicated computing modules. Therefore, mobile device can take advantage of cloud services to perform large amounts of computation (instructions), which is so called

*N. I. Md Enzai is with School of Electrical Engineering and Computer Science, Queensland University of Technology, 2 George Street, Brisbane, Australia and Faculty of Electrical Engineering, Universiti Teknologi Mara (UiTM), 23000 Dungun Terengganu, Malaysia

†M. Tang is with School of Electrical Engineering and Computer Science, Queensland University of Technology, 2 George Street, Brisbane, Australia

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Computation Offloading. Kumar and Lu prove that computation offloading is beneficial with computation-intensive tasks [10].

To cloud improve the performance of a mobile computation, the tasks of the computation could be offloaded to multiple clouds. A main motivation for multi-cloud is the ability to offer different prices at different performances such as computation time [11]. Moreover, application designers may aim to achieve different performance objectives (e.g. throughput, reliability, cost). This can be achieved by utilizing the resources in cloud providers that have different performance capacities and charged prices. Multi-cloud resource allocation also benefits from the best combination of computation services from multi-cloud providers [14].

To our knowledge, most computation offloading works only consider one single cloud provider [4, 5, 8, 9]. Wu and Huang proposed mobile cloud service composition and Heo, Kim, and Suh distribute task sharing to multiple clouds to reduce delay for online gaming, but both works do not address scheduling problem [7, 15]. Meanwhile other multi-cloud resource allocation and scheduling works do not consider mobile device in the problem [3, 2, 13, 14]. Our work also takes into account multiple objectives instead of dealing with them separately.

Even though multi-site computation offloading has been addressed, only one cloud provider is considered. Even if multi-cloud is considered, only the assignment or mapping part is covered. Whereas, in the case of computational tasks workflow, the tasks need to be scheduled as well. Current multi-cloud offloading works also do not address energy, computation time and price simultaneously.

We aim to assign the workflow of computational tasks to services provided by clouds or mobile device as well as schedule them while minimizing overall mobile user requirements namely energy, completion time and price. From the computational point of view, computational tasks workflow assignment and scheduling problem is a typical constrained combinatorial optimization problem. Even though clouds are assumed to always be able to cater the execution of tasks due to its multi-tenancy features, mobile device on the other hand is assumed to be able to handle only a particular number of tasks at a time.

An example of MCC application scenario is when a mobile user travels to foreign country and lost his or her way. As Global Positioning System (GPS) alone may not be enough, the user may capture short video or images and send them to the cloud to be processed to obtain information of the whereabouts. This involves high processing power to extract features and match with large repository [16]. The processed data will give the user some information on his or her location. The user may also want to make use of social media for example automatic blogging as addressed in [12] and translation services as provided by [1]. However, a mobile user is constrained in terms of mobile device battery life, timing and monetary budget. Instead of relying to a single cloud provider, a mobile user may include more cloud providers with more services and varying capacities to choose from.

Since this is our preliminary research on the problem, we propose a heuristic algorithm to further improve the quality of solutions. Different from the existing multi-site computation offloading algorithm, this new heuristic algorithm also schedules the computational tasks at cloud providers and mobile device as well as addresses three criteria namely energy consumption of mobile device, tasks completion time and charged price at the same time.

The remainder of the paper is organized as follows. First of all, we formulate the research problem in Section 2. After that, we present our heuristic algorithm and evaluation results in Section 3 and Section 4, respectively. This research is finally concluded and future work is discussed in Section 5.