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Network-centric performance analysis of runtime application migration in mobile cloud computing ☆

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ABSTRACT

Mobile cloud computing alleviates the limitations of resource-constrained mobile devices by leveraging the cloud resources. Currently, software-level solutions, also known as computational offloading, migrate the cloud-based mobile applications at runtime to the cloud datacenter to optimize the application execution time. However, the application execution frameworks mainly focus on migrating the application without considering the various critical network-centric parameters, such as traffic load and mobility speed, in application migration decision. In this paper, we analyze the effect of network-centric parameters on the application migration process. The performance of the migration process is analyzed by simulating the migration process in OMNeT++. The effects of various parameters, such as number of users in a WLAN, size of a file containing the application and its running states, traffic load on the wireless access point, message length, number of hops to the cloud, and mobility speed, are studied on the application performance metrics such as application migration time and packet drop ratio. Our analysis shows that the application and its running states migration time is affected by the changes in the network conditions. Based on our research findings, we recommend application execution framework designers to incorporate the network-centric parameters along with other parameters in the decision process of the application migration.

1. Introduction

Recent developments in mobile and wireless technologies have changed the mobile user preferences that have given novel directions to application designers of distributed mobile computing. As a result, a number of rich mobile applications are emerging. Mobile users executing an application on a resource-constrained mobile device want to achieve an application performance similar to that when running the similar application on a stationary resource-rich system. However, in spite of all advancements in mobile device technologies, mobile devices always lagged in application performance (responsiveness) and resources (battery lifetime, memory capacity, and CPU speed) compared with their stationary counterparts [1].

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Therefore, mobile applications are staggering to reduce the disparity in the execution performance. Likewise, node mobility [2–4], heterogeneity across wireless networks [5], and variable reliability [6] are some of the common factors that negatively affect the execution of mobile applications in mobile cloud computing (MCC). Currently, MCC has synergistically integrated mobile computing, wireless technologies, and the cloud to leverage the cloud potential for augmenting mobile resources [7,8]. MCC facilitates the mobile user in various perspectives, such as enhancing processing power and data storage capacity; extending battery lifetime; and improving reliability [9]. MCC augments the smart mobile device potential without requiring new hardware resources by migrating the application at runtime to the cloud datacenter. The migrated application leverages the higher processing power and data storage resources available at the cloud. The battery lifetime of a smart mobile device is extended by migrating computation- and data-intensive applications in the cloud. The reliability of data is improved by providing the backup for the smart mobile device in the cloud. Despite a number of advantages given by MCC, the seamless execution of the cloud-based mobile applications is an open research challenge because of complex runtime application migration process [9], intrinsic limitations of wireless technologies [10,30,31], heterogeneity across networking technologies [11], and highly dynamic network conditions [12,13]. We have defined the seamless application execution in [14] as "an uninterrupted application execution with minimal user involvement and interaction to deliver enhanced performance, compared to the local application execution".

State-of-the-art application execution frameworks [8] do not incorporate the network dynamic parameters in the migration decision of the applications. To the best of our knowledge, this is the first research effort to analyze the effect of the network-centric parameters on runtime application migration. The purpose of the analysis is to highlight the significance of the network-centric parameters, such as traffic load on the wireless access point, size of file containing the application and its running states, number of users in the WLAN, message length, number of hops to the cloud, and mobility speed, in application migration process. The incorporation of these network-centric dynamic parameters in the application migration decision can help cloud-based mobile application execution frameworks (CMAEFs) in taking the accurate application migration decision. The contribution of the paper is manifold. We have implemented optical character recognition (OCR) application in MCC environment. Thereafter, we have collected data traces for the application and used these traces to find the probabilistic distribution. The parameters for the probabilistic distribution are estimated. We also implement the OCR application execution in MCC by using these probabilistic distributions in OMNeT++. By using the simulation environment of OMNeT++, we have investigated the effect of network-centric parameters on the runtime application migration and on the execution of application in MCC.

The rest of the paper is organized as follows. Section 2 provides the background information on MCC, cloud-based mobile applications, and cloud-based mobile application execution process to help the reader in understanding the domain. The section also provides the motivation for the need to investigate the effect of network-related parameters on the runtime application migration process. Section 3 discusses the related work in the domain of MCC by highlighting the main focus of the current research work on the application migration process. Section 4 presents the performance evaluation by discussing the network model, performance evaluation parameters, and the results. Finally, we conclude and provide the research directions in Section 5.

2. Background information

This section provides the background information on MCC, cloud-based mobile application, and cloud-based application execution process to provide fundamental knowledge to readers to help them in understanding the problem. The section also provides the motivation for the need to analyze the effect of network dynamic parameters on the runtime application migration process.

2.1. Mobile cloud computing

MCC is an emerging computing model that extends the vision of computational clouds to resource-constrained smart mobile devices. Cloud computing provides the centralized resources and on-demand services in the cloud datacenters [32,33]. MCC provides a distributed computing model that enables the execution of computation-intensive mobile applications on resource-constrained mobile devices. With the vision of resource augmentation of mobile devices, mobile users transparently access the resources and services of a computational cloud to leverage the available resources at low cost on the fly. The attributes of scalability of services, on-demand access to widespread service on the move, unlimited availability of resources, and centralized management are the motivating elements for leveraging cloud resources and services for mobile devices. MCC is an appealing computing model from business perspective because of profitable business options that lessen the cost (development and execution) of mobile applications. MCC also enables mobile users to use new technology on a demand basis and on the fly. The augmentation of smart mobile devices can be employed in various manners, such as storage augmentation, screen augmentation, and application augmentation of smart mobile device [8]. MCC synergestically integrates three technologies, namely, mobile computing, wireless technologies, and the cloud, to augment the capabilities of smart mobile device. The mobile devices leverage cellular networks, e.g., 3G, or data networks, e.g., Wi-Fi, to access the services of the cloud in MCC environment. Fig. 1 shows the architecture of MCC where smart mobile devices leverage the cloud resources via wireless networking technologies.