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Review

Application optimization in mobile cloud computing: Motivation, taxonomies, and open challenges

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ABSTRACT

In Mobile Cloud Computing (MCC), migrating an application processing to the cloud data centers enables the execution of resource-intensive applications on the mobile devices. However, the resource-intensive migration approaches and the intrinsic limitations of the wireless medium impede the applications from attaining optimal performance in the cloud. Hence, executing the application with low cost, minimal overhead, and non-obtrusive migration is a challenging research area. This paper presents the state-of-the-art mobile application execution frameworks and provides the readers a discussion on the optimization strategies that facilitate attaining the effective design, efficient deployment, and application migration with optimal performance in MCC. We highlight the significance of optimizing the application performance by providing real-life scenarios requiring the effective design, efficient deployment, and optimal application execution in MCC. The paper also presents cloud-based mobile application-related taxonomies. Moreover, we compare the application execution frameworks on the basis of significant optimization parameters that affect performance of the applications and mobile devices in MCC. We also discuss the future research directions for optimizing the application in MCC. Finally, we conclude the paper by highlighting the key contributions and possible research directions in cloud-based mobile application optimization.

Contents

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1. Introduction

During the last decade, the advancements of network technologies and the growth of computational devices have turned the dream of ubiquitous computing into reality. The favourable developments have provided a driving force for a number of emerging e-applications such as e-learning, e-commerce, e-tourism guides, e-health, and internet gaming. Recently, with the advent of wireless technologies (Chin et al., 2014; Ahmed et al., 2015b,c) and mobile devices, e-application paradigm is shifted towards m-application paradigm. Hence, a range of m-applications, such as m-learning (Motiwalla, 2007), m-health (Cruz and Barros, 2005), m-guides (Oppermann and Specht, 1999), m-gaming (Ballagas et al., 2007), and mobile worker applications (Mazzoleni and Tai, 2007), are now part of mobile user's application suit. The mobile users expect to run m-applications with identical performance level as they get for the similar applications running on the stationary computer systems. However, the mobile devices are resource-constrained devices that cannot provide the same level of user experience.

In this context, the computation migration is endeavoured as a significant software-level solution that mitigates resource constraints of mobile devices by migrating applications to available stationary computers (Huerta-Canepa and Lee, 2010; Marinelli, 2009; Goyal and Carter, 2004; Cuervo et al., 2010; Kovachev et al., 2012b; Verbelen et al., 2012b; Fesehaye et al., 2012; Yang et al., 2008; Chun and Maniatis, 2009). The computational migration is handled by the application execution frameworks. Similar to other research areas such as communication networks (Shamshirband et al., 2015; Zheng, 2008) and distributed systems such as cloud computing (Ning et al., 2013), the optimization techniques are also widely used in application execution frameworks of MCC. The execution frameworks consider diverse optimization objective functions as follows: saving processing power, efficient bandwidth utilization, and minimizing energy consumption. In short, the frameworks are designed to optimize the execution cost. The overall aim of all such approaches is to enable the compute-intensive mobile applications on resource-constrained mobile devices. The execution of compute-intensive components of a mobile application in mobile cloud computing (MCC) involves the complex application partitioning at different granularity levels and component migration to the cloud server node (Ahmed et al., 2015a). Such delay-inducing and resource-intensive mechanisms adversely affect the user experience. Therefore, it is imperative to employ lightweight procedures for optimal execution of intensive mobile applications in MCC. The optimal execution refers to the state of the application execution in MCC that can deliver enhanced performance as compared to local execution with minimum cost and low overhead. The effective design of an application ensures that the finished design incurs low cost, high reliability, and the excellent performance. The efficient deployment ensures that non-collocated components of mobile application in MCC have minimal dependency on each other; thereby, reducing the operational overhead and execution cost.

Although several survey papers (Abolfazli et al., 2013; Fernando et al., 2013; Dinh et al., 2013; Kumar et al., 2013; Khan et al., 2014; Rahimi et al., 2014) have studied different aspects of leveraging the cloud services to augment the capabilities of mobile devices, application execution optimization in MCC is still not investigated. In Abolfazli et al. (2013), we have comprehensively studied cloud-based mobile augmentation and discussed various methods to augment the potential of mobile devices. In Kumar et al. (2013) and Khan et al. (2014), the authors have reviewed state-of-the-art distributed application offloading frameworks for smart mobile devices. The research works in Fernando et al. (2013), Dinh et al. (2013), and Rahimi et al. (2014) present the comprehensive surveys on MCC that cover the application, architectures, open issues, and challenges. However, this paper is the first research effort that surveys the state-of-the-art application execution frameworks to identify optimization approaches employed by the application designers, classify the optimization approaches, and highlight the challenges involved in attaining the application optimization.

The contribution of the paper includes (a) survey of the state-of-the-art application execution frameworks in MCC; (b) identification of optimization approaches related to application design, deployment, and execution in MCC; (c) classification and presentation of identified approaches in the form of taxonomies; (d) comparison of the state-of-the-art application execution frameworks; and (e) identification of open research challenges in optimizing the application design, deployment, and execution of application in MCC. The comparison highlights the commonalities and differences among the state-of-the-art application execution frameworks on the basis of significant parameters that affect the performance of application. Some of the parameters are transmission delay, Quality of Service (QoS) support, profiler overhead, scalability, and operational cost. We also present different application migration metrics that are usually optimized in migration decision. Finally, we discuss the future research required to optimize the application design, deployment, and execution in MCC.

The paper is organized into the following sections. Section 2 introduces the fundamental concepts of MCC, cloud-based mobile application and its execution in MCC, and application execution optimization. Section 3 discusses the real-life scenarios that highlight the requirements of application optimization in MCC. Section 4 presents the literature survey for current application execution