Journal of Network and Computer Applications 52 (2015) 154–172

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

Review

Seamless application execution in mobile cloud computing: Motivation, taxonomy, and open challenges

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ARTICLE INFO

Article history:
Received 27 August 2014
Received in revised form
1 December 2014
Accepted 5 March 2015
Available online 14 March 2015

Keywords:
Mobile Cloud Computing
Seamless Application Execution
Cloud-Based Mobile Application Execution Frameworks

ABSTRACT

Seamless application execution is vital for the usability of various delay-sensitive mobile cloud applications. However, the resource-intensive migration process and intrinsic limitations of the wireless medium impede the realization of seamless execution in mobile cloud computing (MCC) environment. This work is the first comprehensive survey that studies the state-of-the-art cloud-based mobile application execution frameworks (CMAEFs) in perspective of seamless application execution in MCC and investigates the frameworks suitability for the seamless execution. The seamless execution enabling approaches for the CMAEFs are identified and classified based on the implementation locations. We also investigate the seamless application execution enabling approaches to identify advantages and disadvantages of employing such approaches for attaining the seamless application execution in MCC. The existing frameworks are compared based on the significant parameters derived from the taxonomy of the seamless application execution enabling approaches. The principles for enabling the seamless application execution within the MCC are also highlighted. Finally, open research challenges in realizing the seamless application execution are discussed.

Contents

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http://dx.doi.org/10.1016/j.jnca.2015.03.001
1084-8045/

1. Introduction

The incomparable advantages of mobile cloud computing (MCC) and a diverse range of potential mobile cloud applications are provoking mobile users to leverage on the benefits of emerging mobile applications, such as m-learning (Chen et al., 2011), m-gaming (Cai et al., 2013), and m-health (Bourouis et al., 2013). In the MCC, computational migration has been introduced as a software level solution of utilizing remote cloud-based resources for augmenting application processing capabilities of the smart mobile devices. To execute the mobile applications, application execution frameworks usually migrate either part of an application (Cuervo et al., 2010; Giurgiu et al., 2009) or the entire application to the cloud (Huerta-Canepa and Lee, 2010; Satyanarayanan et al., 2009). On the successful execution, the results are sent back to the mobile device for integration with the rest of the application inside the mobile device.

The run-time migration of an application to the cloud improves the application responsiveness and energy consumption (Goyal and Carter, 2004). However, the application migration process in the MCC usually involves human interaction; thereby, impeding the smooth execution of the mobile applications. The intrinsic limitations of the mobile devices and wireless access technologies are other common factors that originate disruption in the execution of the mobile applications and inhibit seamless execution of the application in MCC (Ahmed et al., 2013a). The seamless application execution refers to the state of unobtrusive application execution with the least possible user involvement, interaction, and distraction aiming to deliver enhanced functionality, higher performance, and improved responsiveness towards a richer user experience. The seamless execution is imperative to meet the application requirements for mobile applications, particularly for delay sensitive applications, such as m-health (Bourouis et al., 2013) and augmented reality (Tsai et al., 2012). However, the realization of seamless application execution in MCC is non-trivial due to several issues, such as dynamic MCC execution environments, complex multi-objective offloading decision functions, incompatible heterogeneous wireless technologies (Ahmed et al., 2013b, 2014, 2015a), intrinsic limitations in the wireless medium, intensive authentication, authorization, and accounting processes.

Although several surveys (Fernando et al., 2013; Dinh et al., 2013; Kumar et al., 2013; Khan et al., 2014; Abolfazli et al., 2014) have studied various aspects of leveraging the cloud services to augment the computing capabilities of resource-constrained mobile devices, seamless execution of mobile applications within the MCC has not been surveyed. Contrary to our prior efforts, this study is the first effort that comprehensively surveys the seamless application execution within the MCC. It describes the seamless application execution in the MCC and comprehensively surveys the state-of-the-art cloud-based mobile application execution frameworks (CMAEFs) to investigate the suitability of the frameworks. Moreover, we identify and describe the important principles and open challenges in realizing the vision of the seamless application execution.

The contributions of the survey are manifolds. Firstly, we comprehensively survey the state-of-the-art CMAEFs to evaluate their features implemented to achieve seamlessness in execution of the mobile applications. Secondly, we classify the seamless application execution enabling approaches employed by the current frameworks to devise a taxonomy. Thirdly, we analyze and synthesize seamless application execution enabling approaches to identify advantages and disadvantages. Fourthly, we compare the state-of-the-art CMAEFs by using the thematic taxonomy of seamless application execution enabling approaches. Fifthly, we identify the principles of designing seamless CMAEFs in the MCC. Finally, we detail open challenges in realizing the seamless application execution in the MCC. This paper also enables the mobile cloud application engineers and cloud service providers to leverage on the appropriate features that can mitigate communication and computation latencies when developing applications or providing MCC services to increase the QoS for mobile-cloud users. The identified principles guide the framework designers to incorporate the specific features to efficiently realize the seamless application execution. Similarly, the identified open research challenges highlight the future research directions. For the ease of reading, we list all of the commonly used acronyms in Table 1.

The remainder of this paper is organized as follows. Section 2 introduces the MCC technology and explains the seamless application execution definition. Section 3 discusses the significance and motivation of attaining the seamless application execution in MCC. The research methodology is provided in Section 4 for the readers to give them information that how we have collected research articles for the survey and what is our selection criteria. Section 5 presents the comprehensive survey of the state-of-the-art CMAEFs and enquires the logical implications and critical aspects of the frameworks with respect to seamless application execution in the MCC. The taxonomy of seamless application execution enabling