Journal of Network and Computer Applications 47 (2015) 47–60

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

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

Review

A Study on the Critical Analysis of Computational Offloading Frameworks for Mobile Cloud Computing

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ARTICLE INFO

Article history:
Received 17 January 2014
Received in revised form
24 August 2014
Accepted 26 August 2014
Available online 17 September 2014

Keywords:
Mobile Cloud Computing
Distributed Systems
Computational offloading
Resource-Intensive
Lightweight

ABSTRACT

Despite substantial technological advancements in recent years, Smart Mobile Devices (SMDs) are still low-potential computing devices. Therefore, Mobile Cloud Computing (MCC) can deploy computational offloading for augmenting SMDs. The contemporary Computational Offloading Frameworks (COFs) implement resource-intensive procedures for computational offloading, which involve the overhead of transmitting application binary code and deploying distributed platforms at runtime. As a result, the energy consumption costs and turnaround time for the mobile applications and the overhead of data transmission can be increased. Nevertheless, the resource -limited nature of SMDs requires lightweight techniques for leveraging the application processing services of computational clouds. This paper critically analyzes the resource-intensive nature of the latest existing computational offloading techniques for MCC and highlights technical issues in the establishment of distributed application processing platforms at runtime. A prototype application is evaluated with different computation intensities in a real MCC environment. Analysis of the results shows that additional computing resources are utilized in the deployment of distributed application processing platforms at runtimes. For example, 31.6% additional energy is consumed, 39% additional time is required and 13241.2 KB of data are transmitted for offloading different computational intensive components of the prototype mobile application. Finally, we highlight technical issues in the existing computational offloading techniques for MCC, which draw attention to future research possibilities for computational offloading for MCC and which may assist in developing lightweight procedures for computational offloading in MCC.

Contents

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http://dx.doi.org/10.1016/j.jnca.2014.08.011
1084-8045/

1. Introduction

The latest developments in mobile computing technology have changed user preferences for computing. A report from Juniper Research states that the consumer and enterprise market for cloud-based mobile applications is expected to increase by $9.5 billion by 2014 (Holman, 2011), highlighting the increasing use of MCC. Recently, a number of computing and communication devices are being replaced by smartphones in a movement towards all-in-one ubiquitous computing devices, that include PDAs, digital cameras, Internet browsing devices, and Global positioning systems (Prosper Mobile Insights, 2011). Human dependency on contemporary smartphones has been increased rapidly in various domains, including enterprise, e-learning, entertainment, gaming, management of information systems, and healthcare (Albanesius, 2011). Mobile devices are predicated to be the dominant future computing devices with the highest user expectations for accessing computationally intensive applications like those of powerful stationary computing machines. However, in spite of all the advancements in the recent years, the mobile applications on the latest generation of smartphones and tablets are still restricted by the battery power, CPU potentials and the memory capacity of the SMDs (Shiraz et al., 2013). The latest developments in cloud computing facilitates have aimed to increase the computing capabilities of resource-constrained client devices by accessing leased infrastructure and software applications. Computational clouds employ diverse IT business models for provisioning computing services, such as on-demand, pay-as-you-go, and utility computing (Buyya et al., 2009; Armbrust et al., 2009). For example, Amazon web services are utilized to store personal data through their Simple Storage Service (S3) (Amazon S3, 2011), and Elastic cloud computing is employed for application processing services. MCC enables computationally intensive and ubiquitous mobile applications by leveraging the services of computational clouds.

MCC utilizes the application processing services of computational clouds for the processing of computationally intensive mobile applications. Recently, a number of COFs have been proposed for the processing of computationally intensive mobile applications in MCC (Cuervo et al., 2010; Zhang et al., 2011; Hung et al., 2012; Shiraz and Gani, 2013). For instance, the Apple iCloud (Apple iCloud, 2013) and Amazon Silk (Introducing Amazon Silk, 2013) browser are the latest mobile applications to leverage the services of computational clouds for application processing. Computational offloading is employed as a significant application layer solution for enabling intensive applications on SMDs (Shiraz et al., 2013). For instance, MAUI saves 27% energy for the video game and 45% for chess in this way (Cuervo et al., 2010). Similarly, by employing the ASM framework (Shiraz and Gani, 2013) for computing offloading, RAM utilization on mobile devise is reduced by 72%, CPU utilization is decreased by 99%, the turnaround time of the application is reduced by 45% and the energy consumption costs of the application are reduced by up to 33%.

However, the establishment of ad-hoc distributed application processing platforms and runtime component migration in current COFs can result in additional computing resource utilization on SMDs. Runtime intensive component offloading involves the cost of migration of the components of the mobile application (Cuervo et al., 2010; Zhang et al., 2011; Hung et al., 2012; Shiraz and Gani, 2013; Giurgiu et al., 2009), which includes computational resource utilization in transferring the application's binary file and the data file of the running instances of the mobile application. Similarly, a number of application offloading frameworks implement dynamic application profiling and partitioning techniques for application offloading (Cuervo et al., 2010; Giurgiu et al., 2009, which increase the memory allocation, application turnaround time and energy consumption on a mobile device. This paper critically analyzes the resource-intensive nature of existing computational offloading frameworks (Hung et al., 2012; Shiraz and Gani, 2013) for MCC and highlights technical issues in the establishment of distributed application processing platforms at runtime. Computational offloading is employed in a real distributed MCC environment, and the prototype application is evaluated with different computational intensities.

The following are significant components of this paper: (a) Establishing the fact that additional computing resources are utilized in the deployment of a distributed application processing platform at runtime, which increases the size of data transmission, the energy consumption costs and the turnaround time of the application. Analysis of the results shows that 31.6% additional energy is consumed, 39% additional time is required and 13241.2 KB of data are transmitted in offloading different computationally intensive components of the prototype mobile application. (b) Highlighting the addressable technical issues in the deployment and management of distributed application processing platform in computational offloading for MCC, which assists in exploring optimal solutions for leveraging the application processing services of computational clouds for augmenting SMDs.

The paper is classified into the following sections. Section 2 explains fundamental background concepts and terminology, including MCC, computational offloading, runtime component migration, and distributed application processing platform. Section 3 presents a review of the current offloading frameworks for MCC. Section 4 discusses the methodology used for experimentation and the evaluation of the overhead in runtime computational offloading. Section 5 presents the analytical findings by evaluating the experimental results. These experimental results are categorized in three different sections for each measurement parameter. Section 5.1 analyzes the energy consumption costs, while Section 5.2 investigates timing cost and Section 5.3 presents the data transmission costs of offloading three components of the prototype application at runtime. Section 6 highlights the technical issues of computational offloading from the perspective of the deployment of delegated mobile applications on the cloud server node and the resource-intensive features of current COFs. Finally, Section 7 contains concluding remarks and future directions.

2. Background

Mobile cloud computing (MCC) is the latest distributed computing model which extends utility computing vision of computational clouds to SMDs. MCC bridges the disparity between the computing resources of SMDs and processing requirements of intensive applications on SMDs. Recently, a number of computational offloading algorithms have been proposed for outsourcing intensive applications to remote servers. The best examples of distributed models for offloading algorithms are: the decentralized virtual cloud computing environment for mobile devices, the centralized cloud computing environment for mobile devices, and the centralized cloud computing datacenters based cloud computing environment (Shiraz et al., 2013). In the first two cloud computing paradigms, mobile devices are enabled to provide distributed computing services, while in the third cloud computing paradigm, traditional cloud services are leveraged such that diverse service models of the computational cloud are utilized for mitigating resources limitations in SMDs. Centralized applications, services and resources are accessed using wireless network technologies by employing web browsers on the SMDs. MCC has attracted the attention of businesspersons as a profitable business option that reduces the development and execution costs of mobile applications, allowing mobile users to acquire latest technology conveniently on an on-demand basis. MCC can