

# Application Optimization in Mobile Cloud Computing

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## Abstract:

With a rapid growth of the mobile applications and development of cloud computing concept, mobile cloud computing (MCC) has been introduced to be a potential technology for mobile services. MCC integrates the cloud computing into the mobile environment and overcomes obstacles related to the performance, security etc discussed in mobile computing. This paper gives an overview of the MCC including the definition, architecture, and applications. The issues, existing solutions and approaches are presented.

*Keywords* — **Mobile Cloud Computing, Cloud Computing, Mobile Computing.**

## INTRODUCTION

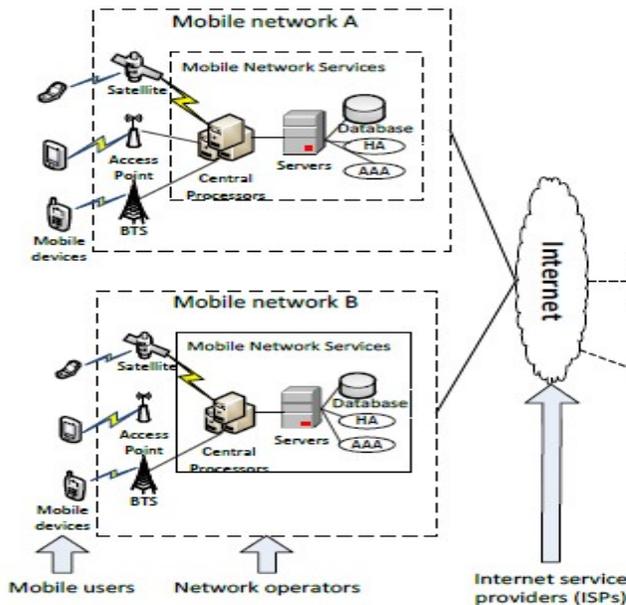
Mobile devices (e.g., smartphone, tablet etc) are increasingly becoming an essential part of human life as the most effective and convenient communication tools not bounded by time and place. Mobile users accumulate rich experience of various services from mobile applications (e.g., iPhone apps, Google apps, etc), which run on the devices and/or on remote servers via wireless networks. The rapid progress of mobile computing (MC)[1] becomes a powerful trend in the development of IT technology as well as commerce and industry fields. However, the mobile devices are facing many challenges in their resources (e.g., battery life, storage, and bandwidth) and communications (e.g., mobility and security)[2]. The limited resources significantly impede the improvement of service qualities. Cloud computing (CC) has been widely recognized as the next generation's computing infrastructure. CC offers some advantages by allowing users to use infrastructure (e.g., servers, networks, and storages), platforms (e.g., middleware services and operating systems), and softwares (e.g., application programs) provided by cloud providers (e.g., Google, Amazon, and Salesforce) at low cost. In addition, CC enables users to elastically utilize resources in an on-demand fashion. As a result, mobile applications can be rapidly provisioned and released with the minimal management efforts or service provider's interactions. With the explosion of mobile applications and the support of CC for a variety of services for mobile users, mobile cloud computing (MCC) is introduced as an integration of cloud computing into the mobile

environment. Mobile cloud computing brings new types of services and facilities for mobile users to take full advantages of cloud computing. This paper presents a comprehensive survey on mobile cloud computing. Section II provides a brief overview of MCC including definition, architecture, and its advantages. Section III discusses the use of MCC in various applications. Then, Section IV presents several issues that arise in MCC and approaches to address the issues. Finally, we summarize and conclude the survey.

## I. MOBILE CLOUD COMPUTING

The term "mobile cloud computing" was introduced not long after the concept of "cloud computing" launched in mid-2007. Mobile Cloud Computing (MCC) is the state-of-the-art mobile distributed computing paradigm comprises three heterogeneous domains of mobile computing, cloud computing, and wireless networks aiming to enhance computational capabilities of resource-constrained mobile devices towards rich user experience.[3, 4] The ultimate goal of MCC is to enable execution of Rich Mobile Application on plethora of mobile devices with rich user experience.[5] MCC provides business opportunities for mobile network operators as well as cloud providers.[6] More comprehensively, MCC can be defined as "a rich mobile computing technology that leverages unified elastic resources of varied clouds and network technologies toward unrestricted functionality, storage, and mobility to serve a multitude of mobile devices anywhere, anytime through the channel of

Ethernet or Internet regardless of heterogeneous environments and platforms based .



### B. Architecture of Mobile Computing

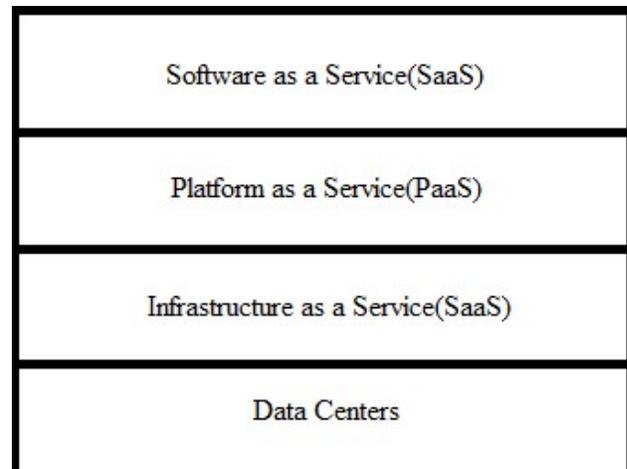
From the concept of MCC, the general architecture of MCC can be shown in Fig. 1. In Fig. 1, mobile devices are connected to the mobile networks via base stations (e.g., base transceiver station (BTS), access point, or satellite) that establish and control the connections (air links) and functional interfaces between the networks and mobile devices. Mobile users' requests and information (e.g., ID and location) are transmitted to the central processors that are connected to servers providing mobile network services. Here, mobile network operators can provide services to mobile users as AAA (for authentication, authorization, and accounting) based on the home agent (HA) and subscribers' data stored in databases. After that, the subscribers' requests are delivered to a cloud through the Internet. In the cloud, cloud controllers process the requests to provide mobile users with the corresponding cloud services. These services are developed with the concepts of utility computing, virtualization, and service-oriented architecture (e.g. web, application, and database servers). Service-Oriented Cloud Computing Architecture Generally, a cloud computing is a large-scale distributed network system implemented based on a number of servers in data centers. The cloud services are generally classified based on a layer concept (Fig. 2). In the upper layers of this paradigm, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are stacked.

on the pay-as-you-use principle." [7] MCC realizes its vision leveraging computational augmentation approaches by which resource-constraint mobile devices can utilize computational resources of varied cloud-based resources. [3] In MCC, there are four types of cloud-based resources, namely distant immobile clouds, proximate immobile computing entities, proximate mobile computing entities, and hybrid (combination of the other three model). [3] Giant clouds such as Amazon EC2 are in the distant immobile groups whereas cloudlet or surrogates are member of proximate immobile computing entities. Smartphones, tablets, handheld devices, and wearable computing devices are part of the third group of cloud-based resources which is proximate mobile computing entities [8].

### A. What is Mobile Computing?

"Mobile Cloud Computing at its simplest, refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smartphone users but a much broader range of mobile subscribers". Alternatively, MCC can be defined as a combination of mobile web and cloud computing [10, 11], which is the most popular tool for mobile users to access applications and services on the Internet.

- **Data centers layer:** This layer provides the hardware facility and infrastructure for clouds. In data center layer, a number of servers are linked with high-speed networks to provide services for customers. Typically, data centers are built in less populated places, with a high power supply stability and a low risk of disaster.



- **Infrastructure as a Service (IaaS):** IaaS is built on top of the data center layer. IaaS enables the provision of storage, hardware, servers and networking components. The client typically pays on a per-use basis. Thus, clients can save cost as the payment is only based on how much resource they really use. Infrastructure can be expanded or shrunk dynamically as needed. The examples of IaaS are Amazon EC2 (Elastic Cloud Computing) and S3 (Simple Storage Service).
- **Platform as a Service (PaaS):** PaaS offers an advanced integrated environment for building, testing and deploying custom applications.

#### Examples:

- ❖ **ISSN: 2312-7694** Prabhsimran et al, / International Journal of Computer and Communication System Engineering (IJCCSE), Vol. 2 (2), 2015, 255-259
- ❖ **257** | P a g e © IJCCSE All Rights Reserved Vol. 02 No.02 April 2015 www.ijccse.com
- ❖ PaaS are Google App Engine, Microsoft Azure, and Amazon Map Reduce/Simple Storage Service.
- **Software as a Service (SaaS):** SaaS supports a software distribution with specific requirements. In this layer, the users can access an application and information remotely via the Internet and pay only for that they use. Salesforce is one of the pioneers in providing this service model. Microsoft's Live Mesh also allows sharing files and folders across multiple devices simultaneously.

## II. ADVANTAGES OF MOBILE CLOUD COMPUTING

Cloud computing is known to be a promising solution for mobile computing due to many reasons (e.g. mobility, communication, and portability [12]). In the following, we describe how the cloud can be used to overcome obstacles in mobile computing, thereby pointing out advantages of MCC.

- ✓ **Extending battery lifetime:** Battery is one of the main concerns for mobile devices. Several solutions have been proposed to enhance the CPU performance [13], [14] and to manage the disk and screen in an intelligent manner [15], [16] to reduce power consumption. However, these solutions require changes in the structure of mobile devices, or they require a new hardware that results in an increase of cost and may not be feasible for all mobile devices. Computation offloading technique is proposed with the objective to migrate the large computations and complex processing from resource-limited devices (i.e. mobile devices) to resourceful machines (i.e., servers in clouds). This avoids taking a long

application execution time on mobile devices which results in large amount of power consumption.

- ✓ **Improving data storage capacity and processing power:** Storage capacity is also a constraint for mobile devices. MCC is developed to enable mobile users to store/access the large data on the cloud through wireless networks. First example is the Amazon Simple Storage Service (Amazon S3) [17] which supports file storage service. Another example is Image Exchange which utilizes the large storage space in clouds for mobile users [18]. This mobile photo sharing service enables mobile users to upload images to the clouds immediately after capturing. Users may access all images from any devices. With cloud, the users can save considerable amount of energy and storage space on their mobile devices since all images are sent and processed on the clouds. Flickr [19] and ShoZu [20] are also the successful mobile photo sharing applications based on MCC. Facebook [21] is the most successful social network application today, and it is also a typical example of using cloud in sharing images.
- ✓ **Improving reliability:** Storing data or running applications on clouds is an effective way to improve the reliability since the data and application are stored and backed up on a number of computers. This reduces the chance of data and application lost on the mobile devices. In addition, MCC can be designed as a comprehensive data security model for both service providers and users. For example, the cloud can be used to protect copyrighted digital contents (e.g., video, clip, and music) from being abused and unauthorized distribution [22].

## III. APPLICATIONS OF MOBILE CLOUD COMPUTING

- ❖ **Mobile Commerce:** Mobile commerce (m-commerce) is a business model for commerce using mobile devices. The m-commerce applications generally fulfill some tasks that require mobility (e.g., mobile transactions and payments, mobile messaging, and mobile ticketing). The m-commerce applications can be classified into a few classes including finance, advertising and shopping.
- ❖ **B. Mobile learning:** Mobile learning (m-learning) is designed based on electronic learning (e-learning) and mobility. However, traditional m-learning applications have limitations in terms of high cost of devices and network, low network transmission rate, and limited educational resources [23],[24],[25]. Cloud-based m-learning applications are introduced to solve these limitations. For example, utilizing a cloud with the large storage capacity and powerful processing ability, the applications provide learners with much richer services in terms of data

(information) size, faster processing speed, and longer battery life. Presents benefits of combining m-learning and cloud computing to enhance the communication quality between students and teachers.

- ❖ **C. Mobile Healthcare:** The purpose of applying MCC in medical applications is to minimize the limitations of traditional medical treatment (e.g., small physical storage, security and privacy, and medical errors [26, 27]). Mobile healthcare (m-healthcare) provides mobile users with convenient helps to access resources (e.g., patient health records) easily and quickly. Besides, m-healthcare offers hospitals and healthcare organizations a variety of on-demand services on clouds rather than owning standalone applications on local servers.
- ❖ **D. Mobile Gaming:** Mobile game (m-game) is a potential market generating revenues for service providers. M-game can completely offload game engine requiring large computing resource (e.g. graphic rendering) to the server in the cloud, and gamers only interact with the screen interface on their devices.
- ❖ **E. Other Practical Applications:** A cloud becomes a useful tool to help mobile users share photos and video clips efficiently and tag their friends in popular social networks as Twitter and Facebook. MeLog [28] is an MCC application that enables mobile users to share real-time experience (e.g., travel, shopping, and event) over clouds through an automatic blogging. The mobile users (e.g., travelers) are supported by several cloud services such as guiding their trip, showing maps, recording itinerary, and storing images and video.

#### IV. ISSUES AND APPROACHES IN MCC

As discussed in the previous section, MCC has many advantages for mobile users and service providers. However, because of the integration of two different fields, i.e., cloud computing and mobile networks, MCC has to face many technical challenges. This section lists several research issues in MCC, which are related to the mobile communication and cloud computing. Then, the available solutions to address these issues are reviewed.

- ❖ **Low Bandwidth:** Bandwidth is one of the big issues in MCC since the radio resource for wireless networks is much scarce as compared with the traditional wired networks.
- ❖ **Availability:** Service availability becomes more important issue in MCC than that in the cloud computing with wired networks. Mobile users may

not be able to connect to the cloud to obtain service due to traffic congestion, network failures, and the out-of-signal.

- ❖ **Security:** Protecting user privacy and data/application secrecy from adversary is a key to establish and maintain consumers' trust in the mobile platform, especially in MCC. In the following, the security related issues in MCC are introduced in two categories: the security for mobile users and the security for data.
- ❖ **Security for Mobile Users:** Mobile devices such as cellular phone, PDA, and smartphone are exposed to numerous security threats like malicious codes (e.g., virus, worm, and Trojan horses) and their vulnerability. In addition, with mobile phones integrated global positioning system (GPS) device, they can cause privacy issues for subscribers.
- ❖ **Securing Data on Clouds:** Although both mobile users and application developers benefit from storing a large amount of data/applications on a cloud, they should be careful of dealing with the data/applications in terms of their integrity, authentication, and digital rights
- ❖ **Quality of services:** It is important for the service provider to fulfill mobile user's satisfaction by monitoring their preferences and providing appropriate services to each of the users. A lot of research work try to utilize the local contexts (e.g., data types, network status, device environments, and user preferences) to improve the quality of service (QoS).

#### V. CONCLUSIONS

Mobile cloud computing is one of mobile technology trends in the future since it combines the advantages of both mobile computing and cloud computing, thereby providing optimal services for mobile users. According to a recent study by ABI Research, a New York-based firm, more than 240 million business will use cloud services through mobile devices by 2015. That traction will push the revenue of mobile cloud computing to \$5.2 billion. With this importance, this article has provided an overview of mobile cloud computing in which its definitions, architecture, and advantages have been presented. The applications supported by mobile cloud computing including mobile commerce, mobile learning, and mobile healthcare have been discussed which clearly show the applicability of the mobile cloud computing to a wide range of mobile services. Then, the issues and related approaches for mobile cloud computing (i.e., from communication and computing sides) have been discussed.

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