Mobile Cloud Computing: Approaches and Issues

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Abstract: During the last few years, there is a revolutionary development in the field of mobile computing, multimedia communication and wireless technology. Together with an explosive growth of the mobile computing and excellent promising technology 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 opportunities and its issues related to this environment (e.g., heterogeneity, scalability, and availability), performance (e.g., storage, battery life, and bandwidth), and security (e.g., reliability and privacy). This paper will give brief introduction of Mobile Cloud Computing and its architecture. It will also discuss various applications present currently to implement MCC, advantages of MCC, various issues related to MCC and solutions, if any present for solving these issues.

Keywords: Cloud Computing, Mobile, Mobile Cloud, Applications

1. INTRODUCTION

Mobile devices (e.g., smartphone, tablet pcs, 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) becomes a powerful trend in the development of IT technology as well as commerce and industry fields. However, with mobility come its inherent problems such as resource scarceness, finite energy and low connectivity.

Real time applications demand high levels of responsiveness, which in turn, demand intensive computing resources. Some mobile applications, such as location based social networking, process and make use of the phone’s various sensor data which is expensive in terms of energy and this limits the mobile phone in providing the user a better service.

Furthermore, consider applications that require extensive processing—image processing for video games, speech synthesis, natural language processing, augmented reality, wearable computing—all these demand high computational capacities thus restricting the developers in implementing applications for mobile phones.

In recent years, this problem has been addressed by researchers through cloud computing. Cloud computing can be defined as a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using Internet technologies [1].

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 will introduce MCC in brief in first section along with its advantages. The third section will discuss various application models or approaches used to implement MCC. Fourth section will present several issues associated with MCC and approaches to solve them. Finally, we summarize and conclude the paper in section five.

2. OVERVIEW OF MOBILE CLOUD COMPUTING

Cloud computing is called as ‘on demand computing’, ‘utility computing’ or ‘pay as you go computing’, the concept behind cloud computing is to offload computation to remote resource providers.

The key strengths of cloud computing can be described in terms of the services offered by cloud service providers: software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS). The concept of offloading data and computation in cloud computing is used to address the inherent problems in mobile.

Mobile Cloud Computing Forum defines MCC as follows [2]:

“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”.

MCC can be described as a new paradigm for mobile applications whereby the data processing and storage are moved from the mobile device to powerful and centralized computing platforms located in clouds. These centralized applications are then accessed over the wireless connection based on a thin native client or web browser on the mobile devices. The mobile devices do not need a powerful configuration (e.g., CPU speed and memory capacity) since all the complicated computing modules can be processed in the clouds.

Key Requirements for MCC
There are some key features of Mobile Cloud Computing that make it possible to implement seamless service delivery in across the network environment. From the perspective of the enterprise solution provider or web/mobile application developer, the objectives of the Mobile Cloud Computing platform are:

- Simple APIs offering transparent access to mobile services and requiring no specific knowledge of underlying network technologies.
- The ability to deploy applications across multiple carrier networks, under a single commercial agreement.
- Seamless handling of each carrier’s specific network policy, such as chosen mobile subscriber confirmed opt-in / confirmed opt-out and privacy management principles.

**Figure 1. Overview of MCC**

The above diagram [3] gives brief idea about how MCC works. Several application models or approaches have been proposed to implement MCC. Next section will discuss some of those models.

### 2.1 Advantages of MCC

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

1) **Extending battery lifetime:** Battery is one of the main concerns for 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.

In addition, many mobile applications take advantages from task migration and remote processing.

2) **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) [4] which supports file storage service. Flickr [5] is also the successful mobile photosharing applications based on MCC. Facebook [6] is the most successful social network application today, and it is also a typical example of using cloud in sharing images.

MCC also helps reducing the running cost for compute-intensive applications that take long time and large amount of energy when performed on the limited-resource devices.

3) **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 also inherits some advantages of clouds for mobile services as follows:

   a. **Dynamic provisioning:** Dynamic on-demand provisioning of resources on a fine-grained, self-service basis is a flexible way for service providers and mobile users to run their applications without advanced reservation of resources.

   b. **Scalability:** The deployment of mobile applications can be performed and scaled to meet the unpredictable user demands due to flexible resource provisioning. Service providers can easily add and expand an application and service without or with little constraint on the resource usage.

   c. **Multi-tenancy:** Service providers (e.g., network operator and data center owner) can share the resources and costs to support a variety of applications and large number of users.

   d. **Ease of Integration:** Multiple services from different service providers can be integrated easily through the cloud and the Internet to meet the users’ demands.

### 3. Application Models for MCC

Several models have been proposed to implement MCC. They are discussed in this section.

#### 3.1 Augmented Execution

One of the proposed models for mobile cloud computing is Augmented Execution. Augmented execution refers to a technique used to overcome the limitations of smartphones in terms of computation, memory, and battery.
1) CloneCloud: Chun and Maniatis [7] propose an architecture called as CloneCloud that addresses these challenges via seamlessly offloading execution from the phone to computational infrastructure (cloud) where cloned replica of the smartphone's software is running. Because non-mobile devices often have significantly more computational power, this enables much better performance from smartphones. This could enable a broader spectrum of applications and could ease the burden of software developers to create ultra-efficient software for a more limited platform.

2) Cloudlet: Similar approach of using virtual machine (VM) technologies executing the computation intensive software from mobile device is presented by Satyanarayanan et al. [8]. In this architecture, a mobile user exploits VMs to rapidly instantiate customized service software on a nearby cloudlet and uses the service over WLAN. A cloudlet is a trusted, resource rich computer or a cluster of computers well connected to the Internet and available for use by nearby mobile devices. Rather relying on a distant cloud, the cloudlets eliminate the long latency introduced by wide-area networks for accessing the cloud resources. As a result, the responsiveness and interactivity on the device are increased by low-latency, one-hop, high bandwidth wireless access to the cloudlet. The mobile client acts as thin client, with all significant computation occurring in a nearby cloudlet.

3.2 Elastic Partitioned/Modularized Applications
Running applications in heterogeneous changing environments like mobile clouds requires dynamic partitioning of applications and remote execution of some components. Applications can improve their performance by delegating part of the application to remote execution on a resource-rich cloud infrastructure. Elasticity in software can be observed as the ability to acquire and release resources on demand. Modules are units of encapsulation and units of deployment that compose the distributed application. The underlying runtime module management platform hides most of the complexity of distributed deployment, execution, and maintenance. Zhang et al. [9], develop a reference framework for partitioning a single application into elastic components with dynamic configuration of execution. The components, called Weblets, are platform independent and can be executed transparently on different computing infrastructures including mobile devices or IaaS (Infrastructure as a Service) cloud providers. The application is split down to a UI component, Weblets, and a manifest describing the application. Weblets are autonomous functional software entities that run on the device or cloud, performing computing, storing and network tasks. An elasticity manager component decides on migration, instantiation and migration of the Weblets. These processes are transparent to the running application. The advantage of using such independent functional units – weblets - is that weblets are not tied to one particular programming language or specification, allowing wider range of applications.

3.3 Ad-hoc Mobile Clouds
An ad-hoc computing cloud represents a group of mobile devices that serve as a cloud computing provider by exposing their computing resources to other mobile devices.

Hadoop1 ported on mobile device is used for distributing of processing tasks and storage. Communication is based on the Extensible Messaging and Presence Protocol (XMPP).

The Hyrax project [10] employs a similar approach of using the Hadoop framework on mobile devices to share data and computation. Hyrax allows client applications to conveniently utilize data and execute computing jobs on networks of smartphones and heterogeneous networks of phones and servers. By scaling with the number of devices and tolerating node departure, Hyrax allows applications to use distributed resources abstractly, oblivious to the physical nature of the cloud.

4. ISSUES IN MOBILE CLOUD COMPUTING:
4.1 Challenges Regarding mobile communication:

1) 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.

2) Resource poverty of Mobile Devices: Comparison of desktop pc with any mobile device shows that on what cost this feature of mobility is being achieved. So in general we can say that this resource deficiency is one of the major reason for the adoption of mobile cloud computing. In order to overcome this limitation of mobile devices, resources are added to the cloud infrastructure.
and can be used anytime on requirement, providing a seamless user experience for advanced applications. Even after continuous improvements in mobile device performances, the disparity between the resource constraints of mobile and fixed devices will remain and must be accounted for in the types of application selected for mobile cloud computing [11].

4.2 Challenges regarding network

1) Inherent Challenges of Wireless Network: Wireless network is base for carrying out cloud computing and it has its own intrinsic nature and constraints. Fixed broadband is supported by consistent network bandwidth while wireless connectivity is characterized by variable data rates, less throughput, longer latency and intermittent connectivity due to gaps in coverage. Subscriber mobility and uncontrollable factors like weather are also responsible for varying bandwidth capacity and coverage [12].

2) Various Network Access Schemes: For implementing cloud computing to mobile devices basic requirement is to have an access to network. In mobile world there are heterogeneous access scenario with different access technologies like WiMAX, WLAN, 3G, GPRS and so on, each one with their own schemes, policies, offerings and restrictions. Due to the existence of different access schemes we need seamless connection handover schemes (to avoid connection failure and connection reestablishment) when we move from one network access point to another network access point.

3) Lack of Speedy Mobile Internet Access Everywhere: In order to get speedy mobile internet access new technologies like HTML5 are being developed. They provide facility of local caching. Researchers are working to get a better way of accessing mobile web other than browser. In order to resolve connectivity problem existing with mobile devices, most of the providers are offering 4G/Long Term Evolution (LTE) services. These services provide advantages of data storage capacity, plug and play features, low latency, and they also supports both FDD and TDD using the same platform. According to the requirement, sometime LTE is also loaded on speed as it is capable of providing download peak rates of 100 Mbps and upload of 50 Mbps [11].

4) Seamless Connection Handover: In order to provide data communication using cellular network mobile operators are trying to set up Wi-Fi Aps on street so that offload traffic of Wi-Fi systems can be reduced, resulting in reduced cellular traffic congestion. But in this arrangement basic requirement is to provide seamless connection handover between access networks. Currently executing application is terminated or returns error when we move from one access point of network to another access point of network or we move from Wi-Fi network to 3G-based cellular network due to occurrence of communication failure and connection reestablishment situation.

4.3 Challenges related to Mobile Applications

1) Interoperability: It’s possible that there is an assorted mix of mobile devices including iPhone, Android phones, BlackBerry and others being used by employees in an organization or a group of people sharing a network. And in such situation according to the nature of cloud applications being used and operating system of mobile device interoperability issue can prove to be a major challenge in pulling/pushing data across multiple devices.

2) Cloud Application Flexibility: An application is going to be supported by certain mobile cloud infrastructure or not, can easily be judged on the basis of its requirements against the cloud infrastructure characteristics along the device, network bandwidth and latency vectors. Different applications’ needs are different for its respective cloud infrastructure attributes (computation intensity, network bandwidth, and network latency).

3) Mobile Cloud Convergence: In order to achieve advantage of mobility by integrating cloud computing to mobile world, Data distribution is the key issue. Mobile cloud convergence provides performance improvement, longer battery life, and a solution to the computation power problem. Basic approach of mobile cloud convergence is to partition application such that parts that need more computation run on the cloud and remaining parts which is associated with the user interface run on the mobile device. Wireless technologies, advanced electronics and internet are overlapped and integrated to achieve pervasive and ubiquitous computing [13].

4.4 Challenges regarding Security

1) Information Security: Since cloud computing basically deals with data storage and its processing so security is of paramount importance. Now days various cloud platforms offer robust built-in security measures. SSL and digital certificates provides an option to enable external security [12].

As far as mobile devices are concerned security remains a key concern. As if a device gets stolen or misplaced, crucial data may be compromised. Data misuse from stolen/ misplaced devices can be avoided by wiping of mobile device remotely. Simplest way to detect security threats (e.g., virus, worms, and malicious codes) of any mobile device is by installing and running security softwares (like Kaspersky, McAfee, and AVG antivirus programs etc.). We can move the threat detection capabilities to clouds.

2) Privacy and Confidentiality: There are various policies and schemes (such as Fair Information Practice Principles (FIPP)) being proposed which require rigorous controls and procedures to protect the privacy of individuals. Encryption provides most effective way to maintain integrity and confidentiality of information.

3) Malicious Attacks: All networks are susceptible to one or more malicious attacks. As more as external Web sites are being accessed malicious actors will have more opportunities to access the network and operational data of that organization. Implementing security controls across all Web 2.0 servers and verifying these rigorous
security controls can reduce the threats to internal networks and operational data. Additionally, separating Web 2.0 servers from other internal servers may further mitigate the threat of unauthorized access to information through social media tools and Web sites.

4) Network Monitoring: In addition to latency and bandwidth problems network performance monitoring is also an important issue which needs proper concern and care. It is critical to have a dynamic cloud performance system that can allow traffic re-routing, access swapping and handover. With all these key challenges given mobile computing is still viable business and is being preferred by more cloud users.

5) Compliance and Enforcement: For now there is no formal set of standards that should be followed for events and policies of cloud computing implementation. It may be difficult or unrealistic to use public clouds if our data is subjected to legal restrictions or regulatory compliance. We can expect providers to build and certify cloud infrastructures to address the needs of regulated markets.

6) Incident Response: Even after implementing best measures for safeguarding data and information and having users trained with best “safe-surfing” techniques, incidents will inescapably occur. Every cloud provider organization must plan and develop some measures that can be implemented as a quick response and recovery from data spill, misinformation and rumor, or from any malicious attack.

5. CONCLUSION

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 Gartner, corporate employees using smartphones and tablets for business purposes represent about 75% of the mobile cloud app market. The mobile cloud app market is expected to exceed $9 billion by 2014. With this importance, this paper has provided an overview of mobile cloud computing in which its definitions, architecture, and advantages have been presented. Next application models for implementing cloud computing in mobile devices are discussed. In the last section several issues regarding MCC and steps which can be taken to overcome these issues are presented.

References: