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Mobile Cloud Computing Architecture, Application Model and Challenging Issues

Gourav Kumar
Dept. of Computer Science
Punjab Technical University
Jalandhar, India
gouravkhurana777@gmail.com

Eshaan Jain
Dept. of Computer Science
HMR Inst. of Tech. & Mgmt.
New Delhi, India
eshaanjain26@gmail.com

Shruti Goel
Dept. of Computer Science
Mahraja Surajmal Inst. of Tech.
New Delhi, India
shrutigoel1991@gmail.com

V.K. Panchal
Defence Terrain Research Lab
DRDO
Delhi, India
vkpans@gmail.com

Abstract: **In the era of this growing technology, Mobile Cloud Computing (MCC) has become a major discussion thread for transforming the internet computing infrastructure. For IT world, MCC provides a vast platform where mobile users can explore their data anywhere anytime using Cloud services. Mobile Cloud Computing integrates the advantage of cloud computing, internet technology and mobile computing. That facilitates it to become more users friendly to store their data at cloud with a great ease. Despite a lot of advancement is achieved by the MCC, but still it is below the user expectations due to privacy and security issues of the regulated data. Significantly the thrust of the research is focused on exterminating various critical issues of MCC to make it more reliable and secure. In order to better understand the challenging issues, we have surveyed the existing work and classify the various application models in new perspective of used operating platform.**

Keywords: Mobile Cloud Computing, MCC architecture, Cloud computing, MCC Challenging issues, MCC application models

I. INTRODUCTION

Cloud computing is a cluster of servers and personal computers grouped together to provide various services including software services, hardware services and application services on the internet. In other words, we can say that cloud computing concentrates all the computing resources together, therefore people can use the various services anywhere anytime using the internet surf.

The concept of cloud computing can be linked back with the 1950s, when large-scale mainframe computers were seen as the future of computing, and were greatly available in academia and corporations fields [1]. In the 1990s, telecommunications companies began to provide virtual private network (VPN) services with comparable quality of service at a lower cost. In early 2008, Eucalyptus became the first open-source, AWS API-compatible platform for deploying private clouds [2]. Since then several big corporations like IBM, Rackspace Hosting and NASA are engaging themselves for the creation of efficient cost effective clouds.

Mean while there was rapid growth in mobile services and wireless networking system that forced the cloud services to be used by these mobile devices. So, the electronic devices like tablets, smart phones and cloud computing resources are converting in a new rapid emerging field of Mobile cloud computing (MCC) [3]. MCC is the combinational computing strategy in which mobile computing, cloud computing and internet technology are tied together to present a new platform for users that they can make use of IT services at anywhere using mobile internet through cloud.

Due to this astonishing advancement achieved by MCC, the demand for mobile application also increases and give birth to some new mobile based applications like Google drive based Gmail, Maps & Navigation system for mobile, MobileMe from apple, Live Mesh from Microsoft, etc using cloud platform like Google AppEngine, Amazon EC2 and Microsoft Azzure etc.

Started from the history of Cloud Computing and Mobile Cloud Computing, the rest of the paper is presented as follows: Section II describes the concept Mobile Cloud Computing and its basic architecture; Section III presents the classification of application Models with a new operating system perspective; Section IV describes some challenging issues that make users to reduce the use of MCC; Section V gives the conclusion.

II. MOBILE CLOUD COMPUTING

Mobile Cloud Computing is also known as 3+ combination technologies, which is the combination of Cloud computing, Internet technology and Mobile computing [4]. But Cloud computing is a method of computing where massively scalable IT related capabilities are provided as a service across the internet to multiple external customers. Internet technology is the communication method by making use of internet, the essence of which is to give real time network resources and services to clients. Mobile computing is a technology that share data of intelligent devices such as smart phones.

Mobile Cloud Computing was defined in 2010 in the presence of the concept of cloud computing in the Open Gardens blog [5]. The essence of mobile cloud computing is to let clients obtain the precise, valuable and real time information at any time, at any place. Due to its 3+ combination it can also be defined as cloud computing in internet technology. Mobile Cloud Computing is made up of local network infrastructure, foreign network infrastructure, complex networks, application service provider, developers and end users who are connected through the Internet. In MCC, the concept of private cloud and public cloud has emerged in order to provide more efficient services to users.

A. Mobile Cloud Computing Architecture

There must be architecture of MCC based on the reliability, effectiveness, validity and security to support the mobile users. The architecture of mobile cloud computing is shown in the fig

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1, which is divided into four layers named as control layer, management layer, virtual layer and physical layer.

Different layers perform different functions for mobile computing. Control layer also known as access layer controls the services interface to the clients, reasonable service access and service registration. Management layer manage he services in the cloud computing system architecture. Virtual layer includes the virtual system, virtual environment, virtualization of resources like network, storage and computing. Physical layer provides the detail of physical devices like mobile phones, tablets, smart phones, desktop etc.

As shown in the fig 1, the mobile devices are connected to the wireless network based stations. User request is sent through the wireless network to access the cloud server by AAA mechanism (Authentication, Accounting and Authorization mechanism). This request is processed by central processors having a direct contact with the servers. By taking the input from the stored information in the database, AAA services are provided by the mobile network operator to the users. The user can get the access of different services like databases, virtualization, applications, computing resources and storage services in the cloud.

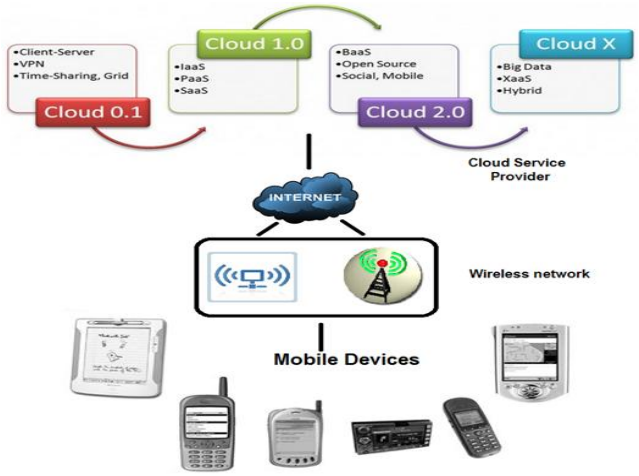

Fig 1: Mobile Cloud Computing Architecture

III. Classification of Application Models For Mobile Cloud Computing

Mobile Cloud Computing models are designed to accomplish a particular objective like improved application performance, executing applications having lesser resources, achieving energy efficiency on the mobile devices. Some of them can achieve a single objective but some models have the features to achieve the multiple objectives simultaneously. To achieve these objectives, different computing model are designed and for different model to design they need the different platforms as per the user requirements. A platform can be defined as any software technology which is treating as the base of the application models. So, we have classified these models on the basis of different platform like Android, Java, .Net, Web services, Virtual Machines etc. These classifications are as below:

A. Android based Models

Android is a Linux kernel based operating system and was designed for the touch screen tablets and smart phones that accept the touch inputs. Based on this Linux operating system, there are three application models as below:

1) *Clone Cloud Model*: Clone Cloud model is introduced by Chun et al. in 2010 [6]. He tested this prototype for three primary tasks including virus scan, image processing and behavior profiling and the results shown by his testing was having 21.1% improvement in performance. It is based on the technique of augmented execution that offloads the parts of application execution to any nearby cloud or infrastructure. The main advantage of using Clone Cloud is that Clone can be used as a backup for data recovery in case phone has been lost. Clone cloud model supports various types of augmented execution including Primary function outsourcing, background augmentation, mainline augmentation, hardware augmentation and augmented throughput multiplicity. In Clone cloud fully dynamic application partitioning process is used. For the conversion of applications, Clone cloud does not require any programmer support.

2) *µCloud Model:* µCloud is proposed by March et al. in 2011 exploring the property of decoupled application components that are independent from each other [7]. The main center of attention for this model is the composition of applications from assorted components to support reusability, flexibility and configurability. There is the need of some expert programmers for the MCloud to develop the application components that are further used by the layman users for applications development.

3) *Cuckoo Model*: Cuckoo model is developed by Kemp et al. in 2012, is based on the property of partial offloading of applications to nearby cloud or infrastructure and is designed with the intention to make the programming easy for the developers [8]. The main advantage of using Cuckoo is that it supports partial offloading of the applications and uses well known tools for development. In Cuckoo based applications Java Virtual Machine (JVM) can be used to offload their data and computation that is residing on the nearby cloud or infrastructure.

B. Hadoop based Model

Hadoop is an open source platform used for storage and large scale processing of big data present at the cloud. In MCC, it plays a vital role to store data and applications at big level. The MCC application models based on Hadoop framework are explained as follows:

1) *Canepa and Lee Model*: In 2010, Canepa and Lee propose a model based on an Ad-hoc computing strategy [9]. They present the guidelines to create a virtual mobile cloud

using the nearby mobile devices. Hadoop ported on the mobile device is used for distribution of processing tasks and storage.

2) *Hyrax et al. Model*: Hyrax et al. also propose a similar approach of using Hadoop platform on mobile devices to share data and computation [10]. The major problem in this model is the implementation on the mobile devices because Hadoop is essentially designed for deployment on many servers

C. Java based Models

Java is a set of various computers based software products that provide a system for developing application software and was developed by Oracle Corporation. Based on this, software capability the applications models of MCC are as below:

1) *Giurgiu et al. Model*: In 2009, Giurgiu propose a distributed layer based model that have the capability to automatically allocate different layers of an application between the server and the device while optimizing several parameters such as data transfer, cost, latency etc [11]. The major focus of this model is to partially offload the applications on the nearby cloud or infrastructure. The main advantage of using this model is that it supports heterogeneous client side environment and distributes functional layers between the smart phone and the server to the optimize latency.

2) *ThinkAir Model*: In 2011, Kosta et al. propose a model named ThinkAir model [12] that supports method-level offloading to a smart phone clone executing in the cloud. It is designed to achieve the desired Quality of Service by executing multiple clones of smart phone in parallel [13]. The offloading decisions are based on the Optimization engine (named Profiler) and uses energy model to estimate energy consumption. The main advantage of using ThinkAir model is that during the instant of offloading decisions and on-demand resource allocation process, it takes into account the energy consumption to reduce execution delays.

D. .Net (Dot Net) based Models

.Net is a software environment and was primary developed for windows by Microsoft. In the field of mobile cloud computing there exist two application models as below:

1) MAUI Model: MAUI model is developed by Cuervo et al. in 2010 [14]. It is a system that enables the fine-grained offload of the mobile code to the cloud infrastructure. The main goal of the MAUI is to minimize the energy consumption and maximize the battery life of the device with code offload. MAUI uses an Optimization engine (named profiler) that analyzes energy consumption during the execution of code at both local and global level. Moreover, in MAUI the offloading of application partitioning is completed on the basis of various methods involved instead of complete application modules. As compared to Giurgiu et al. model, MAUI permits a fine grained offloading mechanism on the level of individual methods involved, whereas in Giurgiu et al. model the offloading process is completed by the complete software modules.

2) Zhang et al. Model: In 2009, Zhang et al. develops a model that is based on elastic application techniques [15]. This reference model was developed to distribute the individual applications into elastic components with their respective dynamic execution configuration. These components are well-known as Weblets that can be executed on different platform including mobile devices or IaaS cloud provider. The main advantage of using these Weblets is that they are not coupled with any particular language or specification, allowing a wider range of application area.

E. Virtual Machine based Model

Virtual Machine is software based machine that implements the software and execute the programs like a physical machine. Considering this virtual environment into account, we can explore the following MCC application models:

1) eXCloud Model: This model is developed by Ma et al. dates 2011 [16]. It is also known as Extensible Cloud model. It works in the Java based Virtual environment using standard Java libraries and Java Virtual Machine. eXCloud model supports VM instance level computation offloading process and uses Stack-On Demand (SOD) on the top of the virtual machine system to migrate the top stack frames to the cloud.

2) Satyanarayanan et al. Model: In 2009, Satyanarayayan et al. propos a model based on the concept of virtual machine and uses the technique of augmented execution [17]. In this model, a mobile user exploits Virtual Machines to rapidly instantiate customized service software on a nearby cloudlet and uses the service over WLAN network. The main advantage of using this model is that the Virtual Machine based approach is less frail as compare to the process of migration and software virtualization.

F. Web Services based Model

In Mobile Cloud Computing, a Web service is a method to communicate between two mobile devices and use the various applications by making use of cloud services. The application models based on these web services are explained as:

1) *Web Model*: In case of online application it is to be assumed that the internet connection between the mobile devices and backend servers is available most of the time. Smart phones have the well used due to the power and utility of their applications, but there are the problems of cross-platform. The web technology applications can overcome this problem.

2) *Cao et al. model*: In 2009, Cao et al. propose a middleware model that permits the access from the mobile devices to a packet of multimedia services exposed from other mobile nodes [18]. These Mobile nodes can host web based services that are accessed by other mobile nodes, thus exploring peers in an ad-hoc cloud.

G. Other Platform based Model

Apart from the entire above model, there are some other models that are explained as follows:

1) Native Model: Most of the Mobile based applications are fall under this category. These are fat client that process the

data and applications locally on the mobile devices with data downloaded from the backend systems. A fat client is a networked application with mostly local resources and maintains synchronization with the backend system. The main advantage of using this model is that we can access the applications any time anywhere without any network problem.

2) Åhlund et al. Model: It is proposed in 2009 by Åhlund et al. based on the peer to peer system and is context aware, decentralized model [19]. In this model, a novel context aware architecture is presented to support application mobility called the Application Mobility Manager (A2M). A2M addresses the aforementioned issues and presents itself as a capable architecture to provide application mobility. Due to its property of decentralization and p2p network paradigm, it minimizes application loss.

IV. Challenging Issues Of Mobile Cloud Computing

A. *Limited resource availability in mobile devices*

Availability of Limited Resources in mobile devices is the major issue of mobile cloud computing. Generally the mobile devices have insufficient storage capacity, insufficient battery, poor display and computing power as compare to desktop computers. One of the solutions of this problem is to make use of the concept of offloading computation [20]. But more energy is required for handling security, reliability and computation. Fig 2 and fig 3 define the performance comparison of mobile devices and fixed devices.

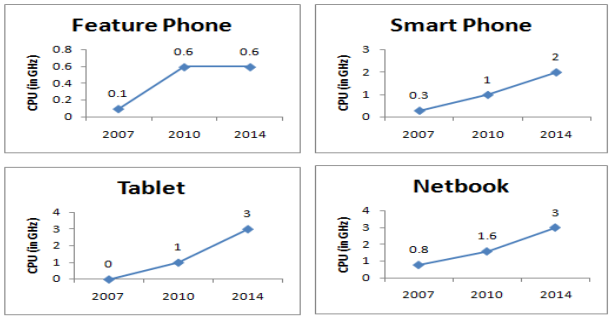

Fig 2: Comparison based on the processing speed

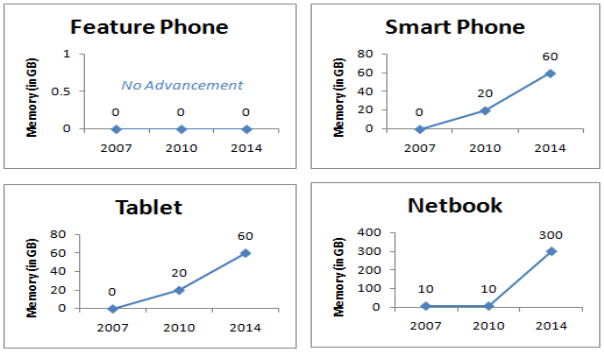

Fig 3: Comparison based on the Storage capacity

B. *Lack of Network availability*

For mobile cloud computing, a network connection must be assured in mobile devices so that user can access mobile cloud from anywhere at any time. HTML5 comes with a property of mobile caching that makes it possible to continue working with mobile cloud in case of interrupted network connectivity.

C. *Need to establish single platform access*

As in the above discussion of classification of Mobile application Models, we have classified the application models into different platform access as per their existing models. But there should be a common platform to access the mobile applications using cloud to make cloud computing an efficient part of computation.

D. *Security Issues*

The major issue of using MCC is the security of data. Due to advancement in technology, the data security risks also increases. Everyone wants to secure their private and regulated data. There is the need of security not only in the mobile device but also in cloud based storage system. Now-a-days Google provides a security to lock their data at cloud and smart phones gives various new techniques to lock their phones. Fig 4 represents the data protection risks to the regulated data. Regulated data is the sensitive and confidential data that organizations are legally required to keep safe and secure.

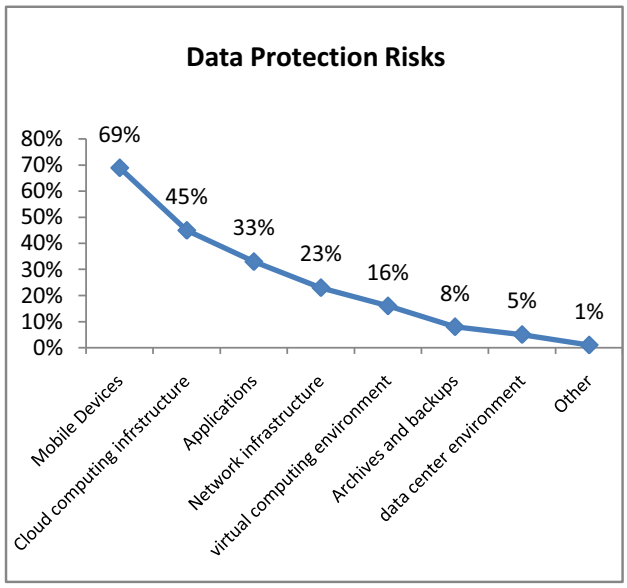

Fig 4: Data protection risks to the regulated data.

E. *Difficulties in implementing PaaS and IaaS in MCC*

There exist three basic cloud computing srvice models named SaaS (Software as a Service), PaaS (Platform as a Service) and IaaS (Infrastructure as a Service). But in Mobile Cloud Computing only SaaS is implemented to use the services of mobile software. MCC is a multiplatform computation

technique due to availability of different platforms in different mobile devices. So, PaaS is difficult to implement. Also mobile devices have not any proper infrastructure to make use of IaaS. So, MCC is limited upto the SaaS cloud service model.

F. Limited bandwidth and high latency of network

Another issue in the MCC is the availability of limited bandwidth and high latency of network. In mobile devices the network is limited upto 2G and 3G bandwidth. The solution to this problem is upgradation of network bandwidth to 4G wireless network and makes use of WiFi services.

V. CONCLUSION

In this paper, we have presented a perspective overview of the Mobile Cloud Computing, Basic architecture of MCC, Application model classification based on the different platform and various challenging issues of MCC. Here, we have given a successful new classification approach of MCC application Models based on the different platform used by the different mobile devices (like Android, Java, .Net, Web services based etc.). Mobile Cloud Computing as a development has inherited the high scalability and mobility and become a hot research topic in the last few years. But still various challenging issues (discussed in Section IV) are there, on which we need further concentration and invention to reduce the limitation of security and other issues in MCC.

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