IS 747 – CLOUD COMPUTING

Midterm Project

# MOBILE CLOUD COMPUTING

Fatih Özlü
1777762
Information Systems
Middle East Technical University

**04.06.2012**

fatihozlu@aselsan.com.tr

# TABLE OF CONTENTS

# MOBILE CLOUD COMPUTING

## 1. INTRODUCTION

### 1.1. Overview

This document is prepared as a project for IS 747 lecture. The document starts with an introduction to mobile cloud computing with a definition, architecture, and advantages/disadvantages. At the next sections, continues with the applications of MCC, detailed challenges in mobile environment and solutions. Lastly the document concludes the main issues about the mobile cloud computing with the conclusion part.

### 1.2. Definitions, Abbreviations and Acronyms

| | |
|---|---|
| CC | Cloud computing |
| IAS | Integrated Authenticated Service |
| ISP | Internet service providers |
| MC | Mobile Computing |
| MCC | Mobile Cloud Computing |
| PDA | Personal Digital Assistant |
| SOAP | Simple Object Access Protocol |

### 1.3. Introduction to MCC

Mobile services have gained speed by the emerging cloud computing technologies, as these devices take an important role in the human life as both communication and entertainment, not bounded by time and place. The mobile computing (MC) becomes powerful and rapid in the development of IT technology within commerce and industry fields, as well. On the other hand, the mobile devices are facing up with many struggles in their resources (e.g., battery life, storage, and bandwidth) and communications (e.g., privacy, mobility and security) [1]. These challenges affect the improvement of service qualities badly.



Cloud computing (CC) started to be widely used and brought many opportunities in the means of resources like servers, networks, and storages, platforms and software at very low costs. This ease of use and low cost of CC can lead mobile applications to be more widespread and provide variety of services in the mobile environment. The mobile applications can be thought a new way from the cloud providers' perspective; it can be integrated with the existing cloud system without needing any additional costly infrastructure, but new types of services and facilities for the mobile users.

## 1.4. Definition of Mobile Cloud Computing

The Mobile Cloud Computing (MCC) term was introduced after the concept of Cloud Computing. Basically, MCC refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device [2]. Regarding the definition, mobile applications move the computation power and storage from the mobile phones to the cloud.

It can be thought as a combination of the cloud computing and mobile environment. The cloud can be used for power and storage, as mobile devices don't have powerful resources compared to traditional computation devices.

Today, there are already lots of good examples of MCC applications including Gmail, Google Maps, and such applications. However, the most of applications still do most of the calculation and data storage on the mobile devices themselves, not in the cloud. In a few years, that could change [2].

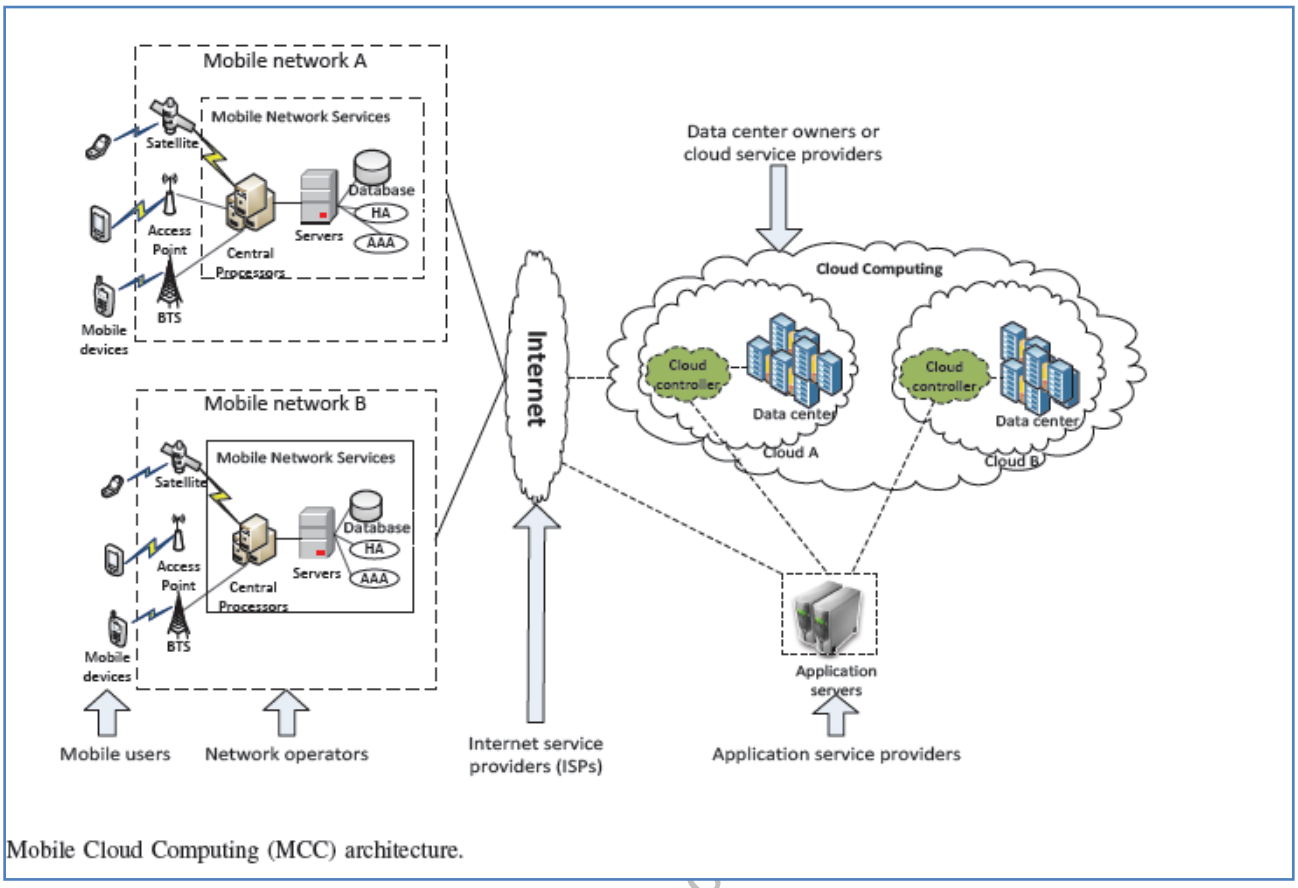
## 1.5. Mobile Cloud Computing Architecture

The Mobile Cloud Computing architecture is basically shown in the Figure 1. The main architecture is composed from the components: mobile users, mobile operators, internet service providers (ISP), cloud service providers, respectively [3].



Mobile devices generally mobile phones communicate with the mobile networks with the help of base stations, access points and/or satellite. The information sent from the mobile devices are operated on the central processors, servers and database on the mobile network provider side. The main communication is composed from both stakeholders. Generally, the mobile network provider is like a middleware with SOAP or RESTful WS services and delivers the service result taken from the cloud providers to the mobile client. There are also different applications of MCC by using the cloud services without using network provider, directly through the internet [3].

The mobile network operator delivers the mobile clients' requests to the cloud through the internet. In the cloud, cloud controllers process the requests to navigate to corresponding cloud services to provide mobile users. The architecture provides effectiveness by using the advantages of the cloud computing.




Mobile Cloud Computing (MCC) architecture.

**Fig. 1 MCC Architecture**

## 1.6. Mobile Cloud Computing Advantages/Disadvantages

There are many reasons to use cloud computing with mobile applications. MCC provides some solutions to the obstacles which mobile subscribers are usually face up with. These advantages are:

- Battery Life:

  Battery life is one of the main concerns in the mobile environment. There are already several solutions for extending battery life by enhancing CPU performance, using disk and screen in an efficient manner to reduce power consumption. But these solutions generally require changes in the mobile devices' structure or a new hardware which means increasing the cost. Computation or data offloading techniques are suggested to migrate the huge and complex computations from limited resource devices like mobile devices to powerful machines like servers in clouds. This avoids taking a long application execution time on mobile devices which results in large amount of power

and/or read-write time consumption [4]. There are many evaluations to show effectiveness of these techniques.

- Data storage capacity/Process power:

  Another obstacle is storage capacity of mobile devices. Mobile devices are generally have limited storage. To overcome this problem, MCC can be used to access, query or store the large data on the cloud through wireless networks. There are several examples which are widely used such as Amazon Simple Storage Service (Amazon S3) to provide file storage on the cloud.

  In addition, MCC reduces the time and energy consumption for compute-intensive applications, which is too applicable when thinking of the limited-resource devices.

- Reliability:

  With the help of CC paradigm, reliability can be improved since data and application are stored and backed up on several numbers of computers on the cloud. This provides more confidentiality by reducing the chance of data lost on the mobile devices. In addition, copyrighting digital contents and preventing illegal distributions like music, video can be more available in this model. Also security services like virus detection applications can be easily provided and used in an efficient way without effecting mobile device performance.

  Furthermore, CC scalability, elasticity advantages can be used in MCC, as well since cloud flexibility is applicable as a whole infrastructure, in the same way.



- Privacy:

  Privacy is an important issue, when thinking about private data. As in the CC era, the same trust problem comes out with the mobile network providers and cloud providers. They can monitor at all the communication and data stored in the cloud or network provider, although there is encryption mechanisms to crypt data communicated or stored. So from this perspective, it is a big headache to be solved.

- Communication:

  The communication is composed from multiple parts from mobile subscriber to the cloud provider. Therefore there can be some problems like poor network speed or

limited bandwidth. It can be a big concern because the number of mobile and cloud users is dramatically increasing.

## 2. APPLICATIONS OF MOBILE CLOUD COMPUTING

Mobile applications have been used widely and have a huge share in a global mobile market, because of the millions of subscribers, hundreds of networks providers and cloud providers. There are several mobile applications that started to use CC advantages; in this part some typical examples are briefly explained.

### 2.1. Mobile Commerce

Mobile commerce is the ability to provide commerce using a mobile device, such as a mobile phone, a Personal Digital Assistant (PDA), a smartphone, or other emerging mobile equipment such as dashed mobile devices [5]. The m-commerce applications fulfill many tasks that require mobility functions like mobile transactions and payments, mobile messaging, and mobile ticketing. Some services and products are mobile ticketing, Mobile vouchers, coupons and loyalty cards, Location-based services, Mobile banking, Mobile brokerage, Mobile marketing and advertising [5].



As the m-commerce have several products and applications, there are various challenges like low network bandwidth, high complexity of mobile device configurations, and security/privacy. As a result, m-commerce applications are navigated into cloud computing environment to solve these problems. Some security solutions are based on PKI (public key infrastructure). This mechanism uses an encryption-based access to ensure subscribers' private and secure access to the cloud stored data.

### 2.2. Mobile Healthcare

Medical applications in the mobile environment called as mobile healthcare applications and used for medical treatment, patient tracking, etc. The purpose of applying MCC in medical applications is to decrease disadvantages of traditional medical applications like small physical storage, security and privacy, and medical errors.

Mobile healthcare provides these facilities:

- Health monitoring services for patients to be monitored at anytime and anywhere

through internet or network provider.
- Emergency management system for emergency vehicles to reach or manage vehicles effectively and in time, in case of receiving calls from incidents and accidents.
- Healthcare mobile devices for detecting pulse-rate, blood pressure, and level of alcohol integrated with a system to alert in case of emergency.
- Store healthcare information of patients to use in medical experiments or researches.

Mobile healthcare applications provide users easiness and quickness by accessing resources at any time, from anywhere. By the help of cloud, mobile healthcare applications offer a variety of on-demand services on clouds rather than standalone applications on local computers and servers. However, there have to be proposed solutions to protect participant's health information to increase the privacy of the users, as have to be done in the traditional applications.

## 2.3. Mobile Learning

Mobile learning is learning across contexts and learning with mobile devices. It's design is based on electronic learning (e-learning) and mobility. Traditional m-learning applications have limitations because of high cost of devices and network, low network transmission rate, and limited educational resources. Cloud-based (mobile learning) m-learning applications are introduced to solve these problems. As an example, with the help of powerful processing ability and cloud's large storage capacity, the applications provide learners with much richer services in terms of data (information) size, faster processing speed, and longer battery life.



## 2.4. Mobile Gaming

Mobile games tend to be small in scope and often rely on a simple play rather than graphics, because of the lack of processing power of the mobile devices. Mobile game is a potential market generating revenues for service providers, because games can completely offload which means that huge computing resources like graphic rendering can be operated on the cloud, the clients can only deals with the interface of the game on their mobile devices. This paradigm brings many advantages like energy saving, increasing game playing speed because of cloud's processing power.

While the performance for the games increase in case of steady communication infrastructure, on the other hand, the costs of network communication is a parameter to prevent gamers. In addition, games have to be developed and implemented by thinking of such a multiple paradigm which is already well known in the cloud era.

# 3. CHALLENGES IN MOBILE CLOUD COMPUTING

As mentioned in the previous section, Mobile Cloud Computing has many benefits and good application examples for mobile users and service providers. On the other hand, as mentioned in some parts, there are also some challenges related to cloud computing and mobile networks communication. This section gives some explanation about these obstacles and solutions.

## 3.1. Mobile Side Challenges

In the mobile network side, main obstacles and solutions are listed below:

- Low Bandwidth:

  Bandwidth is the one of important issues in mobile cloud environment because mobile network resource is much smaller compared with the traditional networks. Therefore, P2P Media Streaming for sharing limited bandwidth among the users who are located nearby in the same area for the same content such as the same video [6]. By this method, each user transmits or exchanges parts of the same content with the other users, which is resulted in improvement of content quality, especially for videos.

- Availability:

  Network failures, out of signal errors, or high traffic related poor performance problems are main threats to prevent users to connect to the cloud. But there are some solutions to help mobile users in the case of any disconnection from the clouds. One of them is Wi-Fi Based Multihop MANET. It is a distributed content sharing protocol for the situation without any infrastructure [7]. In this mechanism, nearby nodes are detected in case of the failure of direct connection to the cloud. In this case, instead of having a link directly to the cloud, mobile user can connect to the cloud through neighboring nodes. Although there are some considers about security issues for such mechanisms, these issues can also be solved.

- Heterogeneity:

  There are types of networks which are used simultaneously in mobile environment such as WCDMA, GPRS, WiMAX, CDMA2000, and WLAN. As a result, handling like heterogeneous network connectivity becomes very hard while satisfying mobile cloud computing requirements such as connectivity which is always on, on-demand scalable connectivity, and the energy efficiency of mobile devices. This problem can be solved

by using standardized interfaces and messaging protocols to reach, manage and distribute contents.

- Pricing:

  Using multiple services in mobile requires with both mobile network provider and cloud service provider. However, these providers have different methods of payment and prices for services, features and facilities. Therefore, this has possibility of leading to many problems like how to determine price, how the price could be shared among the providers or parties, and how the subscribers can pay. As an example, when a mobile user wants to run a not free mobile application on the cloud, this participates three stakeholders as one of them is application provider for application licence, second one is mobile network provider for used data communication from user to cloud, and third one is cloud provider for providing and running application on the cloud.

## 3.2. Computing Side Challenges

In the cloud side, main obstacles and solutions are listed below:

- Computing Offloading:

  As mentioned previous parts, offloading is one of the key features of MCC to improve the battery life time and to increase the applications' performance by using the cloud [4]. Although this solution is very useful in the means of process power and storage, it can be ineffective in some situations. For example, the mobile devices can consume more energy for an application by using the cloud rather than local processing. For a critical threshold, using the mobile device instead of cloud might be more effective.

  Therefore, a problem arises that the optimum way of trade-off between the communication and calculation costs have to be estimated or calculated for mobile applications. The communication cost mainly depends on the size of transmitted data and the bandwidth of network, while the computation cost can be defined by the means of computation time. The optimal decisions of a program partitioning can be made at a runtime dynamically, by using and operating cost algorithms [8].

  As an example, an approach for deciding which components of Java programs should be offloaded can be given. In this approach, a Java program is divided into methods and uses several parameters like size of methods or line of codes to calculate execution

costs for these methods. Then, this approach compares the local execution costs of each method with the remote (cloud) execution costs to make an optimal execution decision [8].

- Security:

  Trust is the main issue of the subscribers in the mobile platform. When it comes to MCC, this issiue gains more importance as the stakeholders increase in the cloud environment for protecting user privacy and data/application secrecy. One of the security issue is mobile device users, other one is the data privacy and security.

  As mobile users, there are several security threats like malicious codes like virus, worm, and Trojan horses and privacy concerns when thinking of integrated global positioning system (GPS) devices that can lead subscribers to be tracked. To overcome this issue, there is security programmes can be runned on mobile devices to prevent illegal threats, but these programs use big portion of mobile device resources while running. Therefore there is some approaches moves threat detection capabilities from mobile devices to cloud. For example, Cloud AV platform provides a multiple service based on both cloud and mobile device for malware detection [10]. A simple and lightweight part of the application runs on the mobile device and it communicates with the major component of the application in the cloud. Detection capabilities are moved to the cloud, as the mobile agent application sends file parts in the background to the cloud server application.



- Authentication:

  Although both application developers and mobile users benefit from storing and processing a large amount of data/applications on a cloud, they should be careful of dealing with the data or applications in terms of rights and authentication. Users have tendency of using small passwords while accessing external resources, so there is need for more secure authentication mechanisms. As an example of authentication method, TrustCube can be given. It is a policy based cloud authentication mechanism using open standards and it integrates various types of authentication [11].

  As in the figure 2, the system architecture shows users security for authentication for accessing resources. When a web server receives a request from the mobile device,

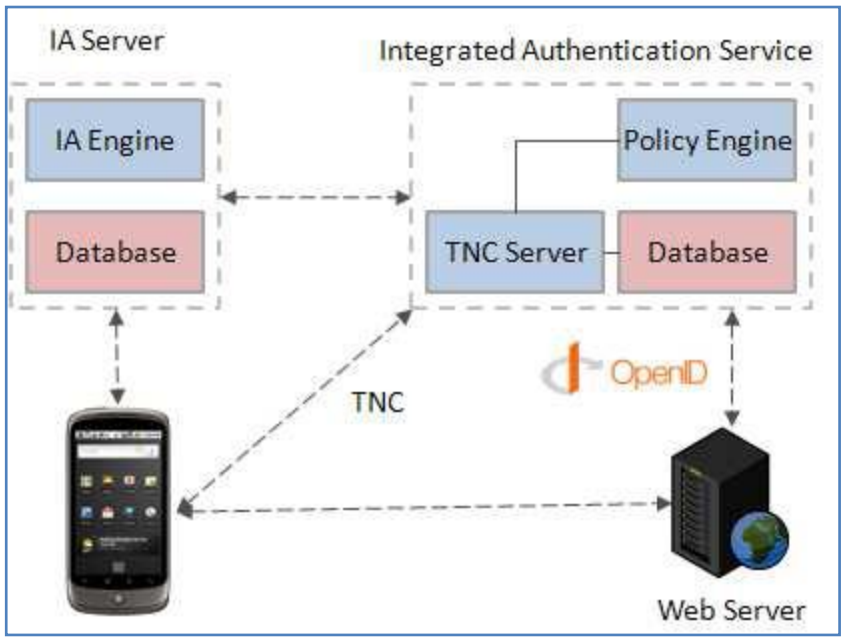



**Fig. 2 The TrustCube architecture, one implementation of the authentication framework [11]**

web server sends request to Integrated Authenticated Service (IAS) with the details of request. When IAS receives the request, extracts information and control the policies of the message. It sends an inquiry to the IA Server over a secure trusted network connection protocol (TNC). IA Server takes the inquiry and responds to IAS with a generated report about the authentication rules. IAS determines authentication result, and send this result to the web server. As a result, the user can be authenticated or not, at the end.

- Data Access:

  While cloud services are increasing, the number of data resources on the cloud rapidly increases. Therefore, dealing with these data resources in the means of storing, managing or accessing becomes very challenging. Cloud storage providers like Amazon S3, every input-output operations executes jobs generally, in file level which increases the cost of data communication and processing for mobile clients. There are some solutions that providing an efficient and less costly way of block level based I/O algorithms instead of file level. In this solution, not all the file transmitted, instead data blocks are transmitted, in case of necessity, which is very useful by the means of time and network communication cost.

In addition, to increase data access efficiency, mobile devices can use local storage as cache for specific parts of cloud service to increase access speed and reduce network necessity. Here, there is also a problem, as we cannot store large data on the mobile device storage cache, so some data management or data selections mechanisms have to be applied to determine which parts or amount of data can be cached or used from cloud.

# 4. CONCLUSION

The mobile world is evolving through significant transition from voice applications to data applications. In the US, more than 35% of the revenues come from data services and the data revenues will remain for over 50% of the revenues by the start of 2013 [12].

In such a data centric world, the role of cloud computing becomes more important for content sharing and accessing data. Mobile users want to the same functionalities from all their devices, in which cloud computing emerges from complementary aspect, as mobile devices have the limitations of screen size, the variability of devices, and the network latency. Therefore, the cloud computing provides optimal services and facilities for mobile devices and users.

With the new opportunities, cloud computing has also brought new challenges for the mobile environment. Luckily, there are multiple ways of solving these obstacles to use cloud computing from the mobile devices. From this perspective, MCC has a very big potential to jump in the mobile business and to become one of the mobile technology trends in the future, as it combines the advantages of both mobile computing and cloud computing.

## 5. REFERENCES

1. M. Satyanarayanan, "*Fundamental challenges in mobile computing," in Proceedings of the 5th annual ACM symposium on Principles of distributed computing*, May 1996, www.cs.cmu.edu/~coda/docdir/podc95.pdf, Retreived on May 2012

2. Sarah Perez, August 4, 2009, *Why cloud computing is the future of mobile*, http://www.readwriteweb.com/archives/why_cloud_computing_is_the_future_of_mobile.php, Retreived on May 2012

3. Qian (Andy) Wang , *Mobile Cloud Computing, A Thesis Submitted to the College of Graduate Studies and Research In Partial Fulfillment of the Requirements*, February 2011

4. http://edutechwiki.unige.ch/en/External_cognition, *External Coginition*, Retreived on May 2012

5. http://en.wikipedia.org/wiki/Mobile_commerce*, Mobile Commerce*, Retreived on May 2012

6. http://en.wikipedia.org/wiki/Streaming_media, *Media Streaming*, Retreived on May 2012

7. Lan Zhang, Xuan Ding, Zhiguo Wan, Ming Gu, and Xiangyang Li, *WiFace: A Secure GeoSocial Networking System Using Wi-Fi Based Multihop MANET*, 2011-03-18, http://wwwen.zte.com.cn/endata/magazine/ztecommunications/2011Year/no1/articles/201103/t20110318_224549.html, Retreived on May 2012

8. G. Chen, B. T. Kang, M. Kandermir, N. Vijaykrishnan, M. J. Irwin, and R. Chandranouli, *"Studying energy trade offs in offloading computation/compilation in Java-enabled mobile devices," IEEE Transactions on Parallel and Distributed Systems*, September 2004, http://ieeexplore.ieee.org/servlet/opac?punumber=71, Retreived on May 2012

9. Preston A. Cox, *Mobile cloud computing*, March 11, 2011, http://www.ibm.com/developerworks/cloud/library/cl-mobilecloudcomputing/, Retreived on May 2012

10. Jon Oberheide, Kaushik Veeraraghavan, Evan Cooke, Jason Flinn, Farnam Jahanian Electrical Engineering and Computer Science Department University of Michigan, Ann Arbor, *Virtualized In-Cloud Security Services for Mobile Devices,* www.eecs.umich.edu/fjgroup/pubs/mobivirt08-mobilecloud.pdf, Retreived on May 2012

11. Richard Chow , Markus Jakobsson , Ryusuke Masuoka , Zhexuan Song, *Authentication in the Clouds: A Framework and its Application to Mobile Users*, October 8, 2010, www.eecs.berkeley.edu/~elaines/docs/ccsw10.pdf, Retreived on May 2012

12. *US Mobile Data Market Updates*, Chetan Sharma Consulting, 2010, http://www.chetansharma.com/usmarketupdateq32010.htm, Retreived on May 2012