Recent Developments in Mobile Cloud Computing

Rashmi Girirajkumar Patidar, Subhash Bhalla

Department of Information Systems,
University of Aizu, Aizu-wakamatsu, Fukushima, Japan
{d8202102, bhalla}@u-aizu.ac.jp

Abstract: Mobile Cloud Computing uses APIs and services for utilizing mobile and cloud resources. In this study, we consider Multi-Cloud Mobile Computing with major examples such as, G-drive/Cloud for Google, One drive for Microsoft, Amazon AWS Cloud and Sales Force. This paper emphasizes the importance of the future developments in 5G networks, the architecture, services, and security issues of Mobile Cloud Computing.

Keywords: Mobile-Cloud Computing, Multi-Cloud Mobile Computing, 5G network

1. Introduction

In today's world, people access various applications (apps) that have been downloaded from Mobile Stores (Google Play and Apple Store). These applications run on the device itself. Alternatively these may run on remote servers connected via wireless networks.

There are many challenges faced by the mobile devices. Their resources such as battery life, storage, and bandwidth are limited. These devices must also consider problems connected with mobility and security. These problems of limited resources and communications hamper the growth and improvement of services.

Cloud Computing (CC) has helped to overcome the above problems. It has been allowing users to use the servers, networks, storages, operating systems and few middleware at affordable prices. With the increase in number of users, Mobile Cloud Computing (MCC) has been introduced which integrates with the cloud environment. MCC provides new services for the mobile users so that they can fully utilize the power of cloud-based systems. [1]

2. Mobile Cloud Computing

The MCC forum defines MCC as follows: 'Mobile cloud computing refers to an infrastructure where both the data storage and 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 MC to not just smartphone users but a much broader range of mobile subscribers'. [1]

MCC is defined as a new model for mobile applications by Aepona [1] where the data processing and storage are in the clouds on their centralized computing platforms instead of the mobile device. These apps can then be accessed by the wireless devices on the browsers or thin clients.

Similarly, MCC can be described as a combination of CC and the mobile web. MCC is the most widespread tool to access applications and services for mobile users on the internet.

Mobile web refers to the use of the internet through mobile devices [2]. Concisely, MCC provides users faster processing speed and storage as all the computing modules are located in the clouds, so the mobile devices do not need a powerful system configuration.

The major goal of MCC is to provide a better experience for the mobile users whose devices have

limited resources or capabilities (storage, battery, processing speed). [3]

Some examples of applications using cloud storage

- **iCloud for iPhone and iPad** stores not only the mail backup but also data such as images and videos on the cloud and they can be restored at any point of time [4].
- **Box** has storage facilities for all operating systems and mobile operating systems. It has software tools from Microsoft, Google, IBM, Slack, Salesforce and more such organizations. It uses secure and encrypted cloud storage [5].
- **WhatsApp** also runs on IBM's soft layer cloud storage but soon will migrate to Facebook's cloud servers or data centers [6].
- **Digital Locker Scheme** in India – documents are digitally verified and are stored on a cloud service purchased by the Indian Government [7].
- **Google Drive** is a hybrid of cloud storage and cloud computing. It can store documents, images, audio, video files, and folders, etc [8].
- **OneDrive** is a cloud storage owned by Microsoft. It stores files securely on its cloud and they can be accessed virtually from anywhere [9].
- **Dropbox** is an online storage solution and uses the cloud computing model IaaS (infrastructure as a service). It enables users to store documents in remote cloud servers. It offers ability to share files in a synchronized file format [10].

Figure 1 shows Google Drive, OneDrive and Dropbox synchronized with a mobile device on a cloud server. The files in these drives can be accessed via a mobile device.

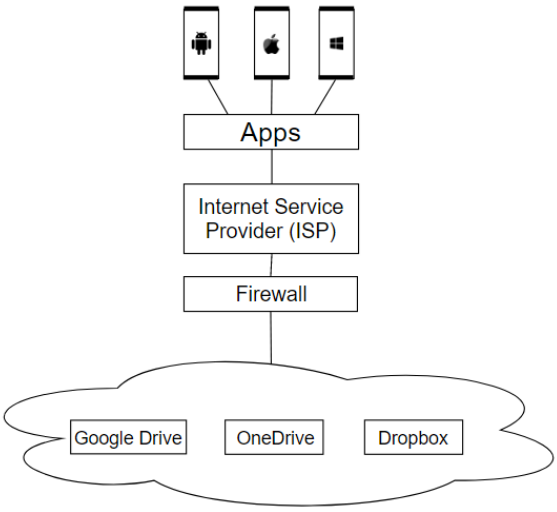

Figure 1: Google Drive, One Drive and Dropbox on a Cloud Server accessed by a Mobile Device

3. MCC Architecture

The architecture of cloud computing consists of platforms named cloud clients [1]. These platforms can then connect with the cloud through the internet via a web browser or a virtual session. The clients include tablets, mobile devices, thin clients, fat clients, and zero clients. The MCC architecture can be summarized as follows. The user has the mobile device which is connected to the network from the base stations of their respective mobile providers. These include base transceiver stations (BTS), satellite and access points. In this way, the user's requests and input information are sent to the processors connected to the relevant mobile provider's servers and the user's requests are channeled through the internet to a cloud where cloud controllers process the user's requests and provide them with the relevant cloud services required. Cloud computing can be described as a distributed system of a very large scale. It is implemented by depending on the servers in a data center. The most common form of MCC architecture is shown in Figure 2 below:

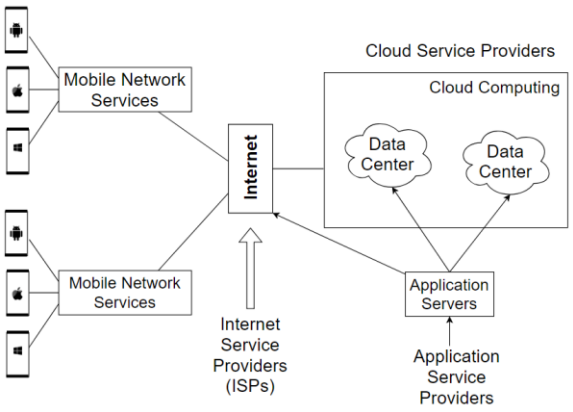

Figure 2: MCC Architecture

The cloud services are generally classified by using a layering concept. In the layers, there are stacks arranged in a certain order [11]. For instance, you can have Software as a Service (SaaS), Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) stacked in layers. [1]

3.1 Infrastructure as a Service (IaaS): is the virtual conveyance of computing resources in the manifestation of hardware, systems administration, and storage administrations. It might likewise incorporate the conveyance of operating systems and virtualization to administer the assets. As opposed to purchasing and instating the needed assets in their own particular server, organizations lease these assets as required. [1]

3.2 Platform as a Service (PaaS): is a way to lease hardware, operating systems, storage and network capacity over the Internet. The administration conveyance allows the client to lease virtualized servers and associated administrations for running existing applications or improving and testing new ones. [12]

3.3 Software as a Service (SaaS): is a software conveyance strategy that gives access to software and its capacities remotely as a Web-based administration. Software as a Service permits organizations to access business functionality at an expense typically less than paying for authorized applications. Also, because the software is remotely hosted, clients don't have to spend for resources or additional hardware [13].

4. Limitations and Security Issues

The major issue in MCC is that mobile devices have limited resources. That is, these have less computational power, small display, less battery life, and limited storage capacity as compared to laptops or desktops. For these reasons, offloading computations to cloud resources can be a solution to this problem. [11]

High latency of network and limited bandwidth is another issue in MCC. 3G cellular network's bandwidth maybe limited in some areas due to low power reception. The upgradation to 4G or even 5G could be a solution to this problem. WiFi can also be a solution to this problem but with a limited number of users because as the users increase the WiFi bandwidth decreases. Cloudlets also could be used to overcome this problem [11]. Cloudlets are small clusters of computers designed very quickly to provide MCC services to mobile devices [14].

There are two types of security concerns that one has to take into consideration – mobile device security and cloud security. In the present era, smart phones have built in security applications or user can also purchase a paid app for security of his mobile device. If a mobile device is stolen or lost, Google Device Policy Application helps a user to remotely lock or clear contents of his mobile device. For the enhanced security of smartphones and clouds – cloud access protection or embedded device identity protection methods are adopted.

5. Types of Clouds

There are 3 types of Clouds - Public, Private an Hybrid Clouds [15].

5.1 Public Cloud

In a Public Cloud, resources such as servers and storage are owned by a third party and are delivered over the internet. All infrastructures are maintained

by the cloud provider, so the user pays only for the services. For example, Microsoft Azure [15].

5.2 Private Cloud

A private cloud is maintained by a business or organization that takes care of the entire infrastructure, so the cloud services are dedicated to the organization. [15] For example, Cisco and Dell [16].

5.3 Hybrid Cloud

Hybrid Cloud is a combination of both Public and Private Clouds. Thus, an organizations can gain the advantages of both kinds of clouds. Applications and data can be moved between public and private clouds. Also additional resources can be added anytime, so flexibility is more [15]. For example, Google Cloud Platform [17].

6. Fault Tolerance in MCC

Occurrence of a fault means that a system will discontinue its operations' due to hardware or software failure. Fault Tolerance in MCC means that if in case any cloud's infrastructure fails, the services will continue to work in spite of the failure.

For example, if Facebook application fails, its services may stop temporarily for a short time. It will restore backup from an emergency cloud or mirrored server and resume its services quickly by avoiding delays.

7. VoLTE

VoLTE stands for Voice over Long-Term Evolution which is a standard for high-speed wireless communication for mobile phones and data terminals - including IoT devices and wearables. Utilizing IP Multimedia Subsystem (IMS) technology, it is a digital packet voice service that is delivered over IP via an LTE access network. Thus, it means that your voice quality won't reduce even if your data is turned on while making and receiving a call.

VoLTE is a voice call over 4G LTE network instead of 2G or 3G connections. 4G is often thought to be used only for downloading, streaming videos or browsing the web. These are its main purpose of utilization. It can also be used for improving call quality [18].

Advantages of VoLTE

i. Superior call quality
ii. Improved coverage and connectivity
iii. Better battery life
iv. Video calling

Limitations of VoLTE

i. Both devices should support VoLTE
ii. Network interoperability may not be possible
iii. Requires 4G coverage
iv. VoLTE is an expensive service
v. Most of the existing handsets do not support VoLTE

7.1 Brute Force Attack in MCC

In the Cyber-crime world, brute force attack is a method in which there are successive repeated attempts to try various password combinations to break any server, website or anything that is password protected. Hackers also install bots in some computers to boost the computing power to run such kind of attacks. A bot (robot) is an automated program that runs over the internet [19].

In MCC, the possibility of brute force attack is less and data is more secure. It can be said that MCC is 99.9% secure.

With changes in Technology, and new techniques being introduced, the MCC are not completely secure. Security is at the level best in MCC but there can be exceptional case of 0.1% [1].

8. Virtualization over Multi-Clouds

Multi-Clouds are similar to interclouds or cloud of clouds. Multi-Cloud environment controls several cloud and thus avoids dependency on a single cloud. It can use two or more computing methods at the same time such as, IaaS, PaaS or SaaS.

Multi-Clouds help organizations to locate computational resources close to their location to

achieve optimal performance and high latency, thereby accessing different services and features on cloud. It is used as users do not want to rely on a single cloud for their data in order to prevent downtime [20].

The major disadvantage of Multi-Cloud is be that a specialized staff would be needed to manage the cloud resource. Cloud resources need application management and workload management.

An example of multi-cloud is a service by a mix of the major cloud providers such as Google, Microsoft, Amazon Web Services (AWS) and IBM [20].

9. Network Generations Comparison

Table 1 gives a comparison of 3rd Generation (3G), 4th Generation (4G) and 5th Generation (5G) services in brief [21].

Table 1: Comparison of 3G, 4G and 5G Networks

Features	**3G**	**4G**	**5G**
Developed	2002	2010	2015
Data Bandwidth	2Mbps	2000 – 1Gbps	1Gbps and above
Standards	WCDMA	Single Unified Standard	Single Unified Standard
Service	High Quality integrated audio, video & data	Dynamic Information Access, Wearable Devices	Dynamic Information Access, Wearable Devices – AI capability
Technology	CDMA – broad bandwidth, IP tech	Unified IP & seamless combination of broadband, LAN/WAN/PAN/ and WLAN	Unified IP & seamless combination of broadband, LAN/WAN/PAN/WLAN and www
Multiplexing	CDMA	CDMA	CDMA
Switching	Packet (except air interface)	All packet	All packet
Core network	Packet Network	Internet	Internet
Handoff	Horizontal	Horizontal and Vertical	Horizontal and Vertical

10. 5G Networks

5G provide high network capacity and power accessing capability. These also provide an enhanced technology to enable a new class of rich-user-centric mobile applications and services [22].

For intelligent and smart applications 5G networks are designed as they support wireless and mobile network inter-operability better based on an all-IP network (AIPN) model. AIPN networks are the future telecommunication framework. One network transports all information and services (voice, data, and all sorts of media such as video) by encapsulating these into packets, similar to those used on the Internet [23].

The infrastructure of 5G network supports more network interfaces by using autonomous radio access technologies. This helps in data retrieval from various mobile devices that are available. Similarly, large amount of sensing data is obtained from different types of mobile devices.

The sensing applications require more bandwidth and the bandwidth for 5G network is more than 1GB/s which is considered to be sufficient. This can support almost 65,000 connections simultaneously. Thus, with such fast and large bandwidth, the acquisition velocity of sensing data satisfies the requirement of big data analysis system. 5G also provides services dedicated to wearable devices with (Artificial Intelligence) AI capabilities [23].

11. Summary and Conclusions

This paper gives a brief overview of Mobile Cloud Computing along with various examples. The architecture of MCC is discussed concisely and Security issues are well highlighted. Virtualization over multi-clouds, types of clouds and VoLTE services with its advantages and disadvantages are

discussed. A short comparison of Generation of networks and 5G Network in detail is emphasized.

Mobile Cloud Computing will help users who are using mobile devices with limited capabilities as all computing is done on the cloud. MCC has certain limitations but they can be solved and with the advent of 4G, 5G networks and VoLTE networks being implemented, they can be solved. MCC is a Fault Tolerant system so any failure will not affect it. It is a good model for the future generations which are totally mobile dependent. MCC is 99.9% secure as the possibility of brute force attack is less and for the enhanced security cloud access protection or embedded device identity methods are adapted.

References

1) Dinh, H. T., Lee, C. , Niyato, D. and Wang, P. (2013), A survey of mobile cloud computing: architecture, applications, and approaches. Wirel. Commun. Mob. Comput., 13: 1587-1611.
2) https://www.techopedia.com/definition/23588/mobile-web
3) Maturana, Francisco P., and Douglas H. Norrie. "Multi-Agent Mediator Architecture For Distributed Manufacturing". Journal Of Intelligent Manufacturing, vol 7, no. 4, 1996, pp. 257-270. Springer Nature
4) https://www.apple.com/icloud/
5) https://www.box.com/platform
6) https://blog.whatsapp.com/
7) https://digilocker.gov.in/
8) https://www.google.com/drive/using-drive/
9) https://support.office.com/en-us/onedrive
10) https://www.dropbox.com/pro?cid=d2f3d8127891bb980a77557958ff6ca3L
11) S. S. Qureshi, T. Ahmad, K. Rafique and Shuja-ul-islam, "Mobile cloud computing as future for mobile applications - Implementation methods and challenging issues," *2011 IEEE International Conference on Cloud Computing and Intelligence Systems*, Beijing, 2011, pp. 467-471.
12) C. Venish Raja, K. Chitra, M. Jonafark, "A Survey on Mobile Cloud Computing ", International Journal of Scientific Research in Computer Science, Engineering and Information Technology (IJSRCSEIT), ISSN : 2456-3307, Volume 3, Issue 3, pp.2096-2100, March-April.2018
13) Monsalve, Saul Alonso et al. "A heterogeneous mobile cloud computing model for hybrid clouds." *Future Generation Comp. Syst.* 87 (2018): 651-666.
14) https://searchcloudcomputing.techtarget.com/definition/multi-cloud-strategy
15) https://azure.microsoft.com/en-gb/overview/what-are-private-public-hybrid-clouds/
16) https://www.networkworld.com/article/3007991/private-cloud/3-types-of-private-clouds-which-one-s-right-for-you.html
17) https://www.networkworld.com/article/3233132/cloud-computing/what-is-hybrid-cloud-computing.html
18) https://www.gsma.com/futurenetworks/technology/volte/
19) https://techterms.com/definition/bot
20) https://searchcloudcomputing.techtarget.com/definition/cloudlet
21) FAGBOHUN, Olumuyiwa Oludare. "Comparative studies on 3 G , 4 G and 5 G wireless technology." (2014).
22) M. Chen, Y. Zhang, Y. Li, S. Mao and V. C. M. Leung, "EMC: Emotion-aware mobile cloud computing in 5G," in *IEEE Network*, vol. 29, no. 2, pp. 32-38, March-April 2015.
23) Q. Han, S. Liang and H. Zhang, "Mobile cloud sensing, big data, and 5G networks make an intelligent and smart world," in *IEEE Network*, vol. 29, no. 2, pp. 40-45, March-April 2015.