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Mobile Cloud Computing: Features, Application, and Challenges

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ABSTRACT- Mobile Cloud Computing is a very important trendnowadays. It merges the cloud computing technologies with mobile devices to overcome the limitation of these devices such as limited battery life time limited processing and storage capabilities. the tasks that needed massive computations can be performed on the cloud efficiently and the result will be sent back to the mobile device , this way , the mobile battery and cloud computing and efficient architecture and application. Also we will present several important features and challenges for mobile cloud computing system including resilience, security, scalability andavailability.

Keywords—Mobile systems applications; cloud computing; cloudlet; efficiency; security; resilience.

I.INTRODUCTION

The mobile devices plays major role in our daily life. We continuously use our smart phone and tablets during the day and night.A survey showed that a normal person checks his mobile around 110 times a day [1]. We use them to create andshare documents, store and play movies, for social media, andinternet shopping.In addition to that, the original use of thesedevices for voice/ video calls and messaging. With the growingdemand on mobile devices and the increase of usefulapplications installed on them with sophisticated computations,there is a growing challenge and related efficiencyrequirements that need to be addressed [2]. For example, thereis a need on speeding up complex tasks such as imageprocessing and computer vision to avoid long delays to meetthe high expectations of the mobile device users.

Cloud computing involves distributing the load on the computer resources connected to each other over the internet.Also, it is based on virtualization of modern data centers whichinvolve thousands of interconnected servers with capability ofincluding a large number of applications. These resources areavailable to the user as on- demand services with many benefitssuch as scalability, mobility and availability.

The concept of Mobile Cloud Computing (MCC) provides
the mobile devices users with data storage and processing
services from the cloud. MCC is an integration of cloud
computing and mobile environment offering the smart phonesuser's new facilities and services on their devices that wasdifficult to be achieved without the existence of the cloud. Asan example, multimedia applications that require highprocessing capabilities are executed on the cloud systems andthe final results are returned back to the mobile device.Additionally, MCC inherits some advantages of clouds such asscalability and support multi users and the integration ofsecurity services such as confidentiality and integrity.

There are three basic components in Mobile Cloud Computing: mobile device, wireless communication channel
and cloud as illustrated in figure1. [4]. The mobile device is aresource constrained and have many different hardware manufacturers, storage devices, and operating systems whichmight create compatibility issues at integration that mightcause system unavailability. Achieving availability by storingand backing up the users data on the cloud servers. This willreduce the data loss chances and avoids a single point of failure.

Wireless communication channel has several radio access
technologies such as 3G, WLAN, GPRS and WiMax, and eachonehas its networ$_K$configurations.In this paper we are going to discuss the Mobile Cloud Computing architectures and deployments, challenges and
limitations, applications of Mobile Cloud Computing,

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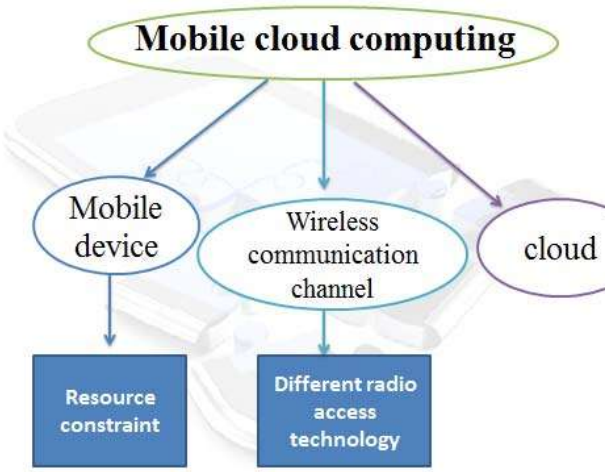
and
features including resilience, security and scalability.



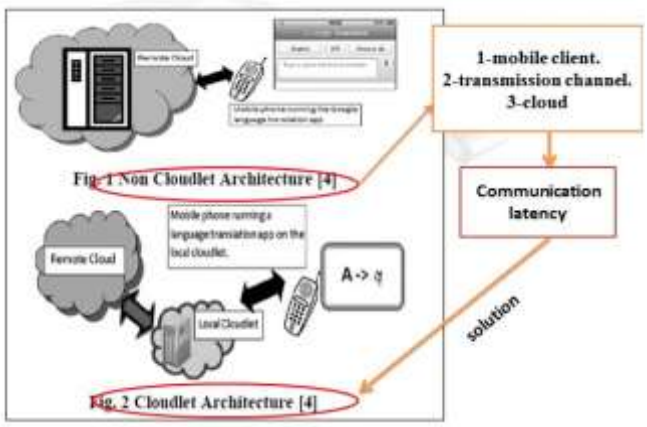
Mobile Cloud Computing components.
The rest of this paper is organized as follows: Section II
provides an overview of Mobile Cloud Computing architecture and efficient deployments. Section III presents.
MCC features and challenges with their solutions. Section IVpresents cloud testing, and finally section V concludes thispaper.

II. MOBILE CLOUD COMPUTING ARCHETUCTRE AND DEPLOYMENT

In the typical MCC model, the mobile devices are directly connected to the Enterprise Cloud (EC) through known
technologies such as 3G/4G/LTE. This connection consumesthe mobile device battery, and in most cases there is a networklatency encountered. Taking in consideration that not all ofthese mobile devices do need to use the EC all the time toperform complex tasks, there should be another MCC model tosave the energy and reduce the latency.

The Mobile Cloud Computing Model based on the cloudlet
is proposed to solve the energy/latency problems [6]. Cloudletis a trusted computer or a group of computers-cluster have ahigh capabilities and connected to the internet. It allows theuser to get the services from the cloudlet instead of the clouditself. Consequently there will be low latency, one hopwireless access point, high bandwidth and real time response.

shows two types of architectures in mobile cloud computing: Cloudlet and Non-Cloudlet Architectures. In NonCloudlet Architecture, there are three components: mobiledevice, communication channel and cloud. The mobile devicesends a request to the Enterprise Cloud (EC) and the cloudprovides the service. In this scenario, there is a noticeable highlatency due to the fact that the EC services thousand of requestsat a time. The proposed solution is to use the cloudletarchitecture where the mobile device communicates first withthe local cloudlet requesting for the service. If not found, orthe cloudlet don't have the processing capability to provide it,then the mobile user will be forwarded to the EC. It is worthmentioning that the connection between the mobile and theuser is through available cheap technologies such as WiFi not 3G/LTE. More details about the Cloudlet-based mobile cloudcomputing model and deployment at large scale are presented



Types of Architectures in MCC

III. MOBILE CLOUD COMPUTING FEATURES

This section presents main features and benefits of MCC.
1) Improving reliability using Mobile Cloud Computing
By storing data or running applications on clouds we achieve a high reliability since data and applications are storedand backed up on several computer, this will reduce the chanceof data loss.
2) Reducing Energy Consumption and Extending battery
life timeEnergy efficiency is a major issue in Cloud computinginfrastructure, and the battery life time is one of the mainconcerns for mobile users. By using mobile cloud computingthe complex computations that need intensive processing willmove from source limited devices to resourceful servers in thecloud system. As a result, the execution time will be shortenedand power consumption will be reduced.Extending battery lifetime is very important

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feature inmobile devices [7]. Users prefer to use real-time andinteractive applications. But such applications require highcomputing resources and consumes huge amount of power.The cloud service providers and developers focus on energyissues and challenges. There are many techniques used to savepower in mobile cloud computing systems [8], [9].[10], [11].One approach to reduce the power consumption of the mobiledevices is through user profiling [8].Another approach to reduce power consumption at large scale, is by optimizing consumption at the data centers [9]. Thelarge power consumption is mainly attributed to the largenumber of modern data centers operating within. Developingthese data centers includes dynamically expanding theirinfrastructures to meet the ever-increasing demand for hugecomputation, large storage, and massive communication.Energy conservation through optimization of resources andmanagement policies in the Cloud are a viable solution. Usingvirtualization to save power and employing such practices asusing Virtual Machines (VMs), Server Consolidation, and VM

Furthermore, the mobile cloud systems based on the cloudlets was originally proposed to reduce the power consumption and latency [6]. This task will be more difficult

when large scale cloudlet systems are deployed. It will force

different cloudlets to cooperate in order to meet the users

demands for different types of services. This cooperation willrequire routing of user requests from the local cloudlet to aremote cloudlet. As a result, the total power consumption perrequest which will be the summation of the user to the localcloudlet power consumption and the power consumption forrouting the request to a remote cloudlet. The work in [11]address the problem of optimizing the power consumption forlarge scale cooperative cloudlets deployments and proposeefficient mathematical model for power consumption underdifferent realistic scenarios.

On the other side, the designers aim to design powerefficient operating system and applications. And since the

programs on our smart phones are either OS-related or

applications, we should ask the question: who will be responsible for energy management? There are three management approaches, application will do the managementbut the problem is there is no main entity responsible formonitoring and supervising resource consumption. The otherapproach is that the OS monitors and manage energy resourcesbut this approach has the scalability problem. The last approachis hybrid in which the OS and the application will be aware of

the resource utilization and supervision and that will help us toimprove performance.

3) Security and privacy

Protecting the data users information from adversaries is

essential to guarantee customer trust in the mobile cloud

computing environment. Mobile cloud computing security

issues can be classified into two categories. The first one is

Mobile users security: Mobile devices are exposed to varioussecurity threats like malicious codes and other applicationsrelated vulnerabilities. For example, GPS applications cancause some privacy issues. It is recommended that mobile usersshould install and run security software to detect threats. The second category is securing data on the cloud servers. it is thecase when the users have no control on data and they don’tknow anything about its location even. Maybe the data will belost due to physical damage or a malicious insider. Example of Mobile cloud computing risks might be internal were a customer can put a virus into cloud server

which may compromise data of other customers and unfortunately cloud will not be able to track him/her due to

privacy policy.Other security risks might be due to a technical error. Forexample in IaaS a security threat might happen because of lackisolation of virtualization in case of having several virtualmachines hosted on a single server.

4)Scalability

Mobile applications can be scaled up and scaled down to meetunpredictable user demands. In contrast the service providercan easily scale and expand services. The work in [13]presents scalable mobile cloud computing model.

5)Management

Mobility allows users to move from place to another and

accordingly, there coverage area will change too. In MCC, themobile device must keep track of the previous, and currentclod systems dealing with. This is important because thecurrent cloud needs the data from the previous cloud to continue working on it. There are two main management

methods in MCC cloudbased model as shown in Table.

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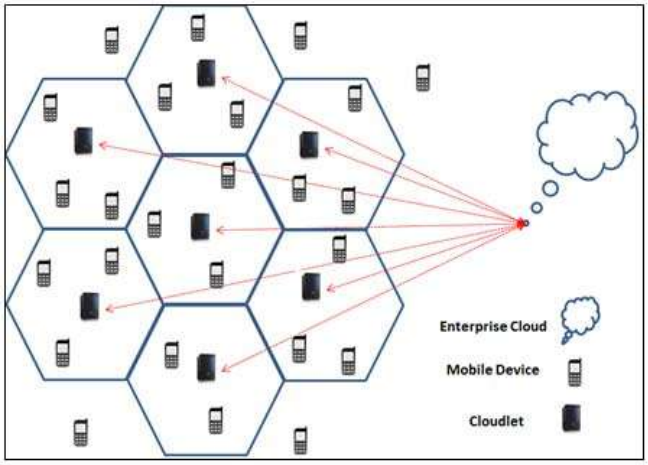
As an example, lets assume that we have one enterprise cloudand 6 cloudlets that will serve a number of mobile devices. Toreduce the overhead on the enterprise cloud we can say one ofthe six cloudlet will elect itself to be a master –aggregate thecloudlet requests then send a one request to the enterprisecloud. The master cloudlet must change periodically todistribute the overhead just like that the cloudlet that has notbeen a master cloudlet for a long time is more likely to electitself than a cloudlet serving just recently. Furthermore, ifthere are only few cloudlets, then the expected distancebetween the mobile device and the cloudlet becomes longerand therefore the mobile have to spend more energy to reachits cloudlet. On the other hand, if there are many cloudlets,there will be more energy expensive transmissions fromcloudlet to the enterprise cloud and less aggregation

6)Faulttolerance

Most existing research and implementations put the light on architecture specific solutions to introduce fault tolerance [14]. Users who are using cloud computing they are more concerned about it's reliability. The fault tolerance is a very important feature that should be incorporated in cloud computing systems to avoid significant commercial and reputation loss. As an example, when Amazon faced a failurein Elastic Block Storage (EBS) drivers and network configuration [15], the problem shot down thousands of hostedapplications and websites and this cost the company a lot ofmoney. In result, the applications need fault tolerance abilitiesso they can be such robust to overcome the impact of a singlepoint of failure and execute the functions correctly [16].Nowadays, the application developer of cloud delivery modelsmust build reliable software that can handle environmentspecific features. Even though, there are some limitations such that the user needs to know about configuration, selection andintegration of applications with available fault tolerance framework. Also, another limitation facing fault tolerance implementation is having an abstraction layers in cloud architecture results in non-transparent and non-flexible environments that requires too much effort by developers since there is no details about the infrastructure.

7) Seamless connection handover

When we are moving from one access point to another access point or from WiFi to 3G, our applications willterminate or return errors. As illustrated in figure 3, the AP represents a cell, and when we are moving from one AP to another the service and connection quality might vary. We canobserve the neediness of using variety of access networks tomake services available to users. The key technique here ishow we can accomplish a seamless heterogeneous handover.Obviously the performance of vertical handover willimmediately impact the assurance of quality of service.Handover faces a lot of challenges, and the availablehandover algorithms don't have a high efficiency andfeasibility



Cloudlet-based Mobile Cloud Computing

8) Resilience and Bandwidth:

Cloud business rely on infrastructure and services deliveredthrough the internet. But there are many risks facing thisbusiness such as they are vulnerable to network outages.Internet can be considered high resilient, but the difficultiescame from a physical damage or form a local providers withservers gone down. It doesn't matter if we are using privatecloud or public cloud, the important thing is that the cloudinfrastructure must be right resilient. The bandwidth is notunlimited so in public cloud computing users may suffer somelatency especially in peak demand

IV. CLOUD AND MOBILE APPLICATIONS TESTING

Testing-as-a-service (TaaS) is a new model to provide testingcapabilities to the end users, developers and businesses. Userscan reduce the cost

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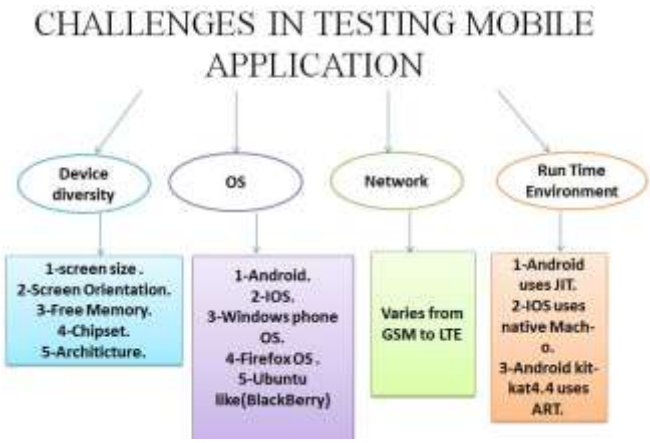
of complicated maintenance and updatedeffort. Service providers can update their services withouteffecting the end-users. With the testing services users cancompare product reliability. The ease of detecting and solvingbugs will also minimize the time between detection and thefinal bug fix [19]. There are many types of testing. Figure 2shows some of them
:
Functional testing: that include control tasks:

1- load/performance: to check response time, max load.
2- Compliance: Standard in terms of data handling.
3- Latency: Due to communication problems, databases,
input/output.
4- Endurance: Should be one hindered availability.

Performance testing: The major types of performance test
are: loads, stress, reliability, scalability, volume and interoperability. In traditional performance testing scenario
there is the application to be tested located at the lab with a
load controller and then the load generators located at variousremote locations. Many testing technology tools available likeload storm, load impact, push to test and platform lab. Thereare many challenges facing testing in the cloud environmentsuch as: lack of standards, security and privacy concerns, lackof control and Internet dependency

Mobile applications became a part of our daily life, and hence we are looking for best quality applications, the needfor testing rises to ensure that. Testing a mobile applicationdiffers than a traditional application due to device diversitysince every mobile device have different screen size, screenorientation, the available memory, chipset, OS, and architecture.
Mobile applications testing challenges illustrated in figure 5.
There is a different type of cloud testing: stress, compatibility,load, performance, browser performance, latency andfunctionality. There is a different automatedtestingtools thatthat can be used



Challenges in cloud testing

On the other hand, people spent most of their time checking
their mobile applications and moving from one application to
another [23]. There is a wide range of useful mobile cloud
computing applications such as: Mobile Commerce and
banking which is estimated to be about $ 23 billion by 2016.
Mobile Learning, is also a useful application to facilitate
access to the education systems. Also, mobile healthcare,
image processing, social networking, and gamming.

V. CONCLUSION

Mobile cloud computing is a highly promising trend and it
became one of the top research topics nowadays. Mobile cloudcomputing integrates the advantages of both cloud computingand mobile devices (mobility). In this paper, we viewed MCCefficient architecture that was proposed based on cloudlet tosave energy and reduce network latency. Also, we presentedmain challenges and issues related to MCC such as security,resilience, fault tolerance, and reliability. Also, we addressedcloud and mobile applications testing. We conclude that MCC
will continue spreading and at the same time more challengesand requirements will continue to appear. Some of these issuesand challenges have solutions and but others need more effortand research to solve them.

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