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Mobile Cloud Computing: Architectures and Challenges

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***Abstract*—The mobile cloud is Internet-based data, applications and related services accessed through smart phones, laptop computers, tablets and other portable devices. Mobile cloud computing is differentiated from mobile computing in general because the devices run cloud-based Web apps rather than native apps. Users subscribe to cloud services and access remotely stored applications and their associated data over the Internet. Mobile cloud computing is a technique, or a model, which allows mobile applications to be built, powered and hosted using cloud computing technology. In this model, the cloud performs the resource-hungry activities such as processor-intensive tasks and storing massive chunks of data. Mobile cloud computing or MCC integrates the cloud computing into the mobile environment and overcomes obstacles related to the performance (e.g., battery life, storage, and bandwidth), environment (e.g., heterogeneity, scalability, and availability), and security (e.g., reliability and privacy) discussed in mobile computing. The proposed model aims to free mobile devices from performing these tasks; thereby, allowing the devices to run cooler and with less power than would have been otherwise required. This article discusses the proposed model and aims to illustrate the manner in which mobile device users would be able to use the cloud application and also take advantage of energy savings not only in terms of power consumed, but also most importantly – time.**

***Index Terms*— mobile computing, cloud computing, offloading, internet.**

I. INTRODUCTION

Mobile cloud computing refers to the availability of cloud computing services in a mobile environment. It incorporates the elements of mobile networks and cloud computing, thereby providing optimal services for mobile users. In mobile cloud computing, mobile devices do not need a powerful configuration (e.g., CPU speed and memory capacity) since all the data and complicated computing modules can be processed in the clouds (http://www.smartdevelopments.org;http://www.readwriteweb.com) Mobile cloud computing is the usage of cloud computing in combination with smart mobile devices. Cloud computing exists when tasks and data are kept on the internet rather than on individual devices, providing on-demand access of data.
Applications are run on a remote server and then sent to user. Because of the advanced improvement in mobile browsers thanks to Apple and Google over the past couple of years, nearly every mobile should have

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a suitable browser according to the need. This means that the developers will have a much wider market and they can bypass restrictions created by mobile operating system. Mobile Cloud Computing has three components, mobile device, wireless communication channel and cloud. Mobile devices have resource constraint in terms of battery power, memory, processing power and have different types of hardware, operating system, and input -output interface.

Wireless communication channel has different radio access technologies such as GPRS, 3G, WLAN and WiMax with variable network conditions in terms of limited and unstable bandwidth. Cloud Computing is facing various security and privacy challenges. Security and privacy issues in mobile cloud computing are inherited from cloud computing and mobile computing. Because of resource constraints, heavy security algorithm can't be run on mobile device. We need to do efficient task portioning between cloud and mobile to resolve the security and privacy issues in Mobile Cloud Computing [4] (Sapna Malik et al, 2012). As an inheritance and development of cloud computing, resources in mobile cloud computing networks are virtualized and assigned in a group of numerous distributed computers rather than in traditional local computers or servers, and are provided to mobile devices such as smartphones, portable terminal, and so on.(see Figure. 1).

Some of the key questions needing to be answered are: How does mobile cloud computing differ from cloud computing? What approaches have been made towards mobile cloud computing and how do they differ from each other? How can computation be offloaded and distributed to the cloud efficiently and in which ways does this differ from traditional distributed computing? What incentives can be used to persuade surrounding surrogate devices to participate in sharing the workload? How can context information be used in a beneficial way? How does mobility affect the performance of a mobile cloud? The goal of this paper is to discuss in detail the current research that addresses these issues. We review the proposed solutions, and explore the upcoming research challenges in mobile cloud computing.

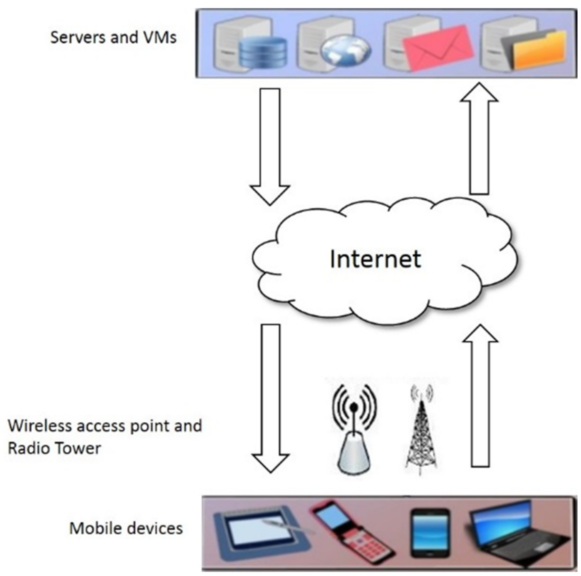

Figure 1: Mobile Cloud Computing

II. Mobile Cloud Computing

A. Definitions

There are several existing definitions of mobile cloud computing, and different research alludes to different concepts of the 'mobile cloud':

1. Commonly, the term mobile cloud computing means to run an application such as Google's Gmail for Mobile6 on a remote resource rich server (in this case, Google servers) while the mobile device acts like a thin client connecting over to the remote server through 3G. Some other examples of this type are Facebook's location aware services, Twitter for mobile, mobile weather widgets etc.

2. Another approach is to consider other mobile devices themselves too as resource providers of the cloud making up a mobile peer-to-peer network as in [5]. Thus, the collective resources of the various mobile devices in the local vicinity, and other stationary devices too if available, will be utilized. This approach supports user mobility, and recognizes the potential of mobile clouds to do collective sensing as well.

3. The cloudlet concept proposed by Satyanarayanan [6] is another approach to mobile cloud computing where the mobile device offloads its workload to a local 'cloudlet' comprised of several multi-core computers with connectivity to the remote cloud servers. PlugComputers8 can be considered good candidates for cloudlet servers because of their form factor, diversity and low power consumption. These cloudlets would be situated in common areas such as coffee shops so that mobile devices can connect and function as a thin client to the cloudlet as opposed to a remote cloud server which would present latency and bandwidth issues.

Mobile cloud computing would also be based under the basic cloud computing concepts. As discussed by Mei et al. in [9] there are certain requirements that need to be met in a cloud such as adaptability, scalability, availability and self-awareness. These are also valid requirements for mobile cloud computing.

And in order for mobile users to efficiently take advantage of the cloud, a suitable method of self-assuming one's own quality is needed—since the internal status and the external environment is subject to change. However, in addition to the similar requirements, a mobile cloud needs to consider other aspects such as mobility, low connectivity and finite source of power as well.

B. Architecture of mobile cloud computing

From the concept of MCC, the general architecture of MCC can be shown in Figure 2. In Figure 2, mobile devices are connected to the mobile networks via base stations (e.g., base transceiver station, access point, or satellite) that establish and control the connections (air links) and functional interfaces between the networks and mobile devices. Mobile users' requests and information (e.g., ID and location) are transmitted to the central processors that are connected to servers providing mobile network services. Here, mobile network operators can provide services to mobile users as authentication, authorization, and accounting based on the home agent and subscribers' data stored in databases. After that, the subscribers' requests are delivered to a cloud through the Internet. In the cloud, cloud controllers process the requests to provide mobile users with the corresponding cloud services. These services are developed with the concepts of utility computing, virtualization, and service-oriented architecture (e.g., web, application, and database servers).

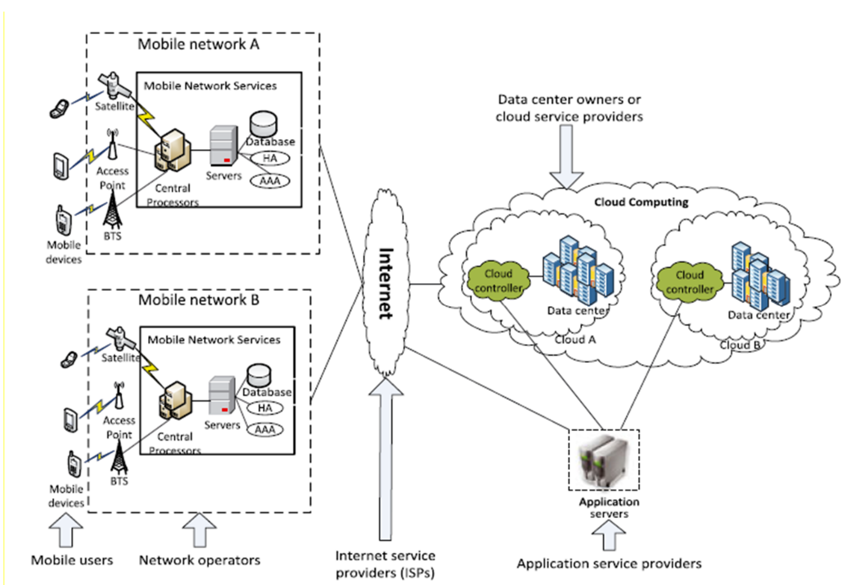

Figure 2: Mobile Cloud Computing Architecture

There are two types of Architecture in Mobile Cloud Computing –

1) In Non Cloudlet architecture, there are three components Mobile client, Transmission channel and Cloud. Mobile client requests desired service from cloud and cloud provides the service. Cloud is

owned by an organization or cloud provider and services thousands of users at time. In this architecture, main disadvantage is communication latency for getting service from distant cloud. The solution to this problem is cloudlet architecture.

2) In Cloudlet architecture, a local cloudlet contains cached copy of data. It is installed between client and cloud. The cost of installation is less as compared to cloud as it is only a data center at business premises. A cloudlet services only a few users and has less communication latency as compared to cloud. Cloudlet is owned by local business (Satyanarayanan et al,2009).

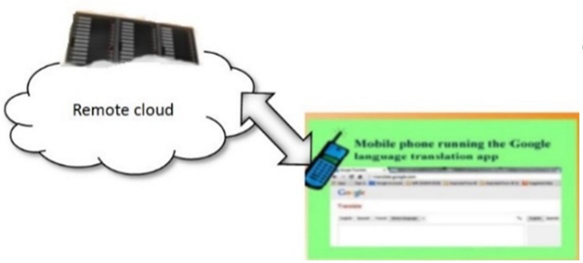

Figure 3: Noncloudlet architecture

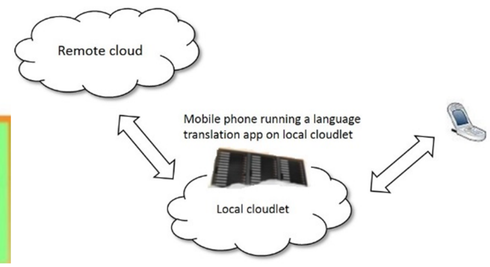

Figure 4: Cloudlet architecture

C. Proposed system

For an operational cloud, that shares the available resources and connects to appropriate cloud resource within minimum time, we propose an architecture such as shown in figure 5. As shown in figure 5, when a mobile user wants to access the cloud based application, they first connect our proposed model and this model then connects the user to proper cloud resource within little time using our proposed algorithm and mobile user then easily connects to cloud based application.

In our proposed model, mobile devices are connected to the mobile networks via base stations (e.g., base transceiver station (BTS), access point, or satellite) that establish and control the connections (air links) and functional interfaces between the networks and mobile devices. Mobile users' requests and information (e.g., ID and location) are transmitted to the central processors that are connected to servers providing mobile network services. Here, mobile network operators can provide services to mobile users as AAA (for authentication, authorization, and accounting) based on the home agent (HA) and subscribers' data stored in databases. After that, the subscribers' requests are delivered to our proposed model CM (Cloud Manager) and it connects the proper cloud location through the Internet.

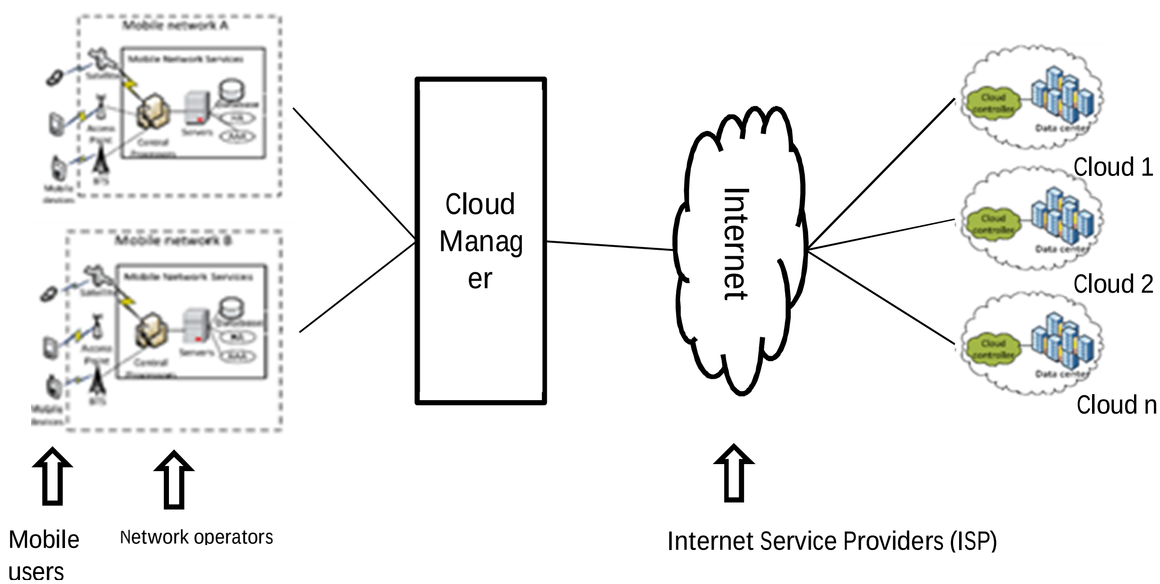

Figure 5: Proposed architecture of mobile cloud computing

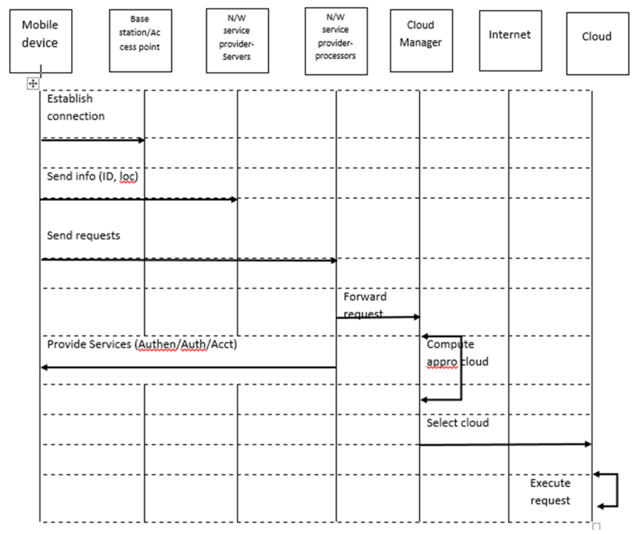

Figure 6: sequence diagram for cloud manager in MCC

D. Algorithm

1) CM (Cloud Manager) stores all information about Cloud Nodes like capacity, IP address, and shortest node distance and any kinds of information about the nodes.
2) All Cloud nodes send periodic information to CM.
    a. Channel capacity
    b. Storage space

    Both of the information vary time to time and also area to area.
1) Now for t=0, compare channel capacity if the channel capacity >0, continue; else stop
2) Compare channel capacity, choose the maximum one.
3) If the channel capacity of the two Cloud nodes to handover is same,
4) Compare the signal strength. Choose the lowest signal strength of same channel capacity, Else go back to 4
5) Repeat 4-6 every time while choosing a new cloud node to handover.
6) Make a list of the available cloud node and store it to CM.
7) Now, If a new Remote cloud node (RCN) wants to handover, signal strength decreases under a certain level i.e. threshold level, it sends a Handover Request to CM via its current cloud node containing
    a. IP address of the current cloud node.
    b. IP address of the adjacent satellite, If RCN/RCN1 is connected to CN/RCN2 through more than one Data Center by ISLs.
    c. IP address of RCN
    d. Position of RCN
    e. The direction of the RCN
8) CM again makes a list of available RCNs.
9) Comparing the first list and second list it chooses the best cloud node to handover.
10) Once the cloud node is selected, CM sends RCN the IP address of the new cloud node.
11) Now the connection is established.

E. Open issues and future research directions

1) Low bandwidth -

    Although many researchers propose the optimal and efficient way of bandwidth allocation, the bandwidth limitation is still a big concern because the number of mobile and cloud users is dramatically increasing. We consider that fourth generation (4G) network and Femtocell are emerging as promising technologies that overcome the limitation and bring a revolution in improving bandwidth.

2) Network access management –

   An efficient network access management not only improves link performance for mobile users but also optimizes bandwidth usage.

   Cognitive radio can be expected as a solution to achieve the wireless access management in mobile communication environment [7]. Cognitive radio increases the efficiency of the spectrum utilization significantly, by allowing unlicensed users to access the spectrum allocated to the licensed users. When this technique is integrated into MCC, the spectrum can be utilized more efficiently.

3) Quality of service –

   In MCC, mobile users need to access to servers located in a cloud when requesting services and resources in the cloud. However, the mobile users may face some problems such as congestion due to the limitation of wireless bandwidths, network disconnection, and the signal attenuation caused by mobile users' mobility. They cause delays when the users want to communicate with the cloud, so QoS is reduced significantly. Two new research directions are CloneCloud and Cloudlets that are expected to reduce the network delay.

   a. CloneCloud- CloneCloud brings the power of CC to your smartphones [8]. CloneCloud uses nearby computers or data centers to increase the speed of running smartphone applications. The idea is to clone the entire set of data and applications from the smartphone onto the cloud and to selectively execute some operations on the clones, re-integrating the results back to the smartphone.
   b. *Cloudlets*- A cloudlet is a trusted, resource-rich computer or cluster of computers which is well connected to the Internet and available for use by nearby mobile devices. Thus, when mobile devices do not want to offload to the cloud (maybe due to delay and cost), they can find and use a nearby cloudlet.

4) Pricing –

   Using services in MCC involves both mobile service provider (MSP) and cloud service provider (CSP). However, MSPs and CSPs have different services management, customers' management, methods of payment, and prices. Therefore, this will lead to many issues; that is, how to set price, how the price will be divided among different entities, and how the customers pay. For example, when a mobile user runs mobile gaming application on the cloud, this involves the game service provider (providing a game license), mobile service provider (accessing the data through base station), and CSP (running game engine on a data center). The price paid by the game player has to be divided among these three entities such that all of them are satisfied with the division. It is clear that the business model including pricing and revenue sharing has to be carefully developed for MCC.

5) Standard interface –

   Interoperability becomes an important issue when mobile users need to interact and communicate with the cloud. The current interface between mobile users and cloud are mostly based on the web interfaces. However, using web interfaces may not be the best option. First, web interface is not specifically designed for mobile devices. Therefore, web interface may have more overhead. Also, compatibility among devices for web interface could be an issue. In this case, the standard protocol, signaling, and interface for interacting between mobile users and cloud would be required to ensure seamless services.

6) Service convergence –

The development and competition of CSPs can lead to the fact that in the near future, these services will be differentiated according to the types, cost, availability and quality. Moreover, in some cases, a single cloud is not enough to meet the mobile user's demands. Therefore, the new scheme is needed in which the mobile users can utilize multiple clouds in a unified fashion. In this case, the scheme should be able to automatically discover and compose services for user.

III. CONCLUSIONS

Mobile cloud computing is one of the mobile technology trends in the future because it combines the advantages of both MC and CC, thereby providing optimal services for mobile users. With this importance, this article has provided an overview of MCC with its definitions, architecture. In this paper, we have given overview of MCC architecture that will help the mobile user to search and connect the required cloud resource in a short time. Then, the issues and related approaches for MCC (i.e., from communication and computing sides) have been discussed. Finally, the future research directions have been outlined.

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