A SURVEY ON MOBILE CLOUD COMPUTING PROBLEMS AND SOLUTIONS

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ABSTRACT: Today, with the use of mobile devices everywhere and with the success of cloud computing, the concept of mobile cloud computing (MCC) has been introduced. MCC is an incorporation of cloud computing into the mobile environment. In MCC, computing resources such as memory, processing and storage are not actually present at the device of user. Instead, these resources are moved on to a remote location known as cloud and are owned by some service provider. The user accesses these resources through internet. The advantages associated with MCC are low initial investment by a user, low cost of operation and maintenance. There are also several problems related to the MCC which are limited battery life, storage and bandwidth, diverse operating systems of mobile devices and security. Various solutions for MCC problems have been developed with their own advantages and disadvantages. This paper presents a survey of MCC, its architecture, its problems and existing solution of those problems and advantages and disadvantages of different solutions.

Keywords: Mobile Cloud Computing (MCC), MCC Advantages, MCC Disadvantages

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INTRODUCTION

Cloud Computing refers to shifting storage and processing resources, which are needed for computation, from a user's device to the remote location controlled by third party service providers. The remote location where data and applications are stored is known as cloud. A user can later access resources or applications stored at cloud through internet without having to install applications at its terminal device. When cloud computing is combined with mobility then it is termed as mobile cloud computing (MCC). MCC is used for remote computation and storage of data related to handheld mobile devices like PDA, iphone, cell phone etc [Kumar *et al.* (2010), Kottari *et al.* (2013)]. In (Walsh *et al.*, 2010) Gartner predicted that by 2013, use of mobile phone for accessing web will exceed when compared to PCs. So, according to predictions and surveys, there is need to work on MCC to make efficient use of mobile devices in daily life events. A major reason of shifting computation and storage rich applications on to the cloud is the limited power and memory of mobile device and high loss rate of data stored on device (Kottari *et al.*, 2013).

A lot of research is being done on exploring MCC domain and problems to universally deploy MCC everywhere. Although, MCC greatly enhance the capability of mobile devices and support features through cloud which cannot be otherwise accessed on mobile device, if used alone. But there are certain problems associated with MCC which are major hindrance towards its universal use. These are bandwidth required to transfer data from mobile device to the cloud, need of continuous internet connection while communicating with cloud, need of security of data during communication and after storage on cloud, improved users' quality of experience and reliability of cloud service provider [Kottari *et al.* (2013), Huang, D. (2011), Chetan, *et al.* (2013)].

Several solutions for the problems in MCC have been proposed. The proposed solution for issue of security and privacy of data is to encrypt data before transmission. But this technique requires decryption of data before processing. So, another solution is to use stenographic techniques, which converts data into such a form which does not requires to expose original data before processing (Kumar *et al.*, 2010). The solution to reliability problem is to take backup of data frequently. So, in case of loss of data from cloud server, it can still be recovered from backup copy (Kumar *et al.*, 2010). The solution for requirement of continuous network connection is to maintain some data in cache of mobile device (Huang *et al.*, 2011). Sometimes, it takes more resources of mobile device to transfer data on to the cloud than to compute that task on the device. So, resource requirement computation is also required to determine that whether a certain computation should be transferred on to the cloud o it should be performed on the mobile device (Özlü *et al.*, 2012). Other problems are diverse devices from different vendors, requirement of controlling infrastructure and high price of network access (Özlü *et al.*, 2012). Some MCC Problems and their solutions are summarized in Table 1. Although researchers have investigated most of the problems of

MCC and also presented their solutions. But there are still problems which are unexplored and there are still risks associated with the solutions presented.

In this paper, firstly we aim to study the mobile cloud computing, its advantages, major issues, which are major hindrance in deployment of mobile clouds and solutions of those issues. We, then attempt to present the possible causes of performance degradation related to MCC and an analysis of performance of MCC.

The paper is organized as follows. Section II presents a literature survey of mobile cloud computing which includes detailed discussion of MCC technology. In Section III we present the factors causing performance degradation in MCC. Section IV consists of concluded remarks and future directions.

Table1. High-level View of Mobile Cloud Computing Problems and Solutions.

Problem	Solution
Security and Privacy of data	Encryption, Stenography
Reliability	Backup of data
Continuous Network connection availability	Caching of data on mobile device, use of Ad Hoc Network
More resource requirement for transfer on the cloud	Determination of resource requirement before start of computation
Diverse devices with different operating systems	Common interface on devices to access cloud

LITERATURE SURVEY

History of Cloud Computing: Cloud computing has become possible from progress in an array of fields. First of all computers were evolved then software and later on, the communication networks were developed and some rules and standards were defined for communication among the computers. These communication rules and standards sequentially affected the development of Internet software that made cloud computing possible. In past industries produced their own electricity by wind and water mills to power their machines. With the passage of time electricity through power lines became cheaper and reliable so there was no need of producing electricity by industries. The same thing is happening now, but the difference is that we are moving towards cloud computing (Hamrén *et al.*, 2012).

In (Toffler, A., 1981) Toffler has mentioned that there are many waves of development in civilization. First wave was about the agricultural societies, second was related to industrial age and the third one is related to information age. These developments in different areas led to development in mobile cloud computing (Hamrén *et al.*, 2012).

In early 60's virtualization was introduced by IBM. The concept of virtualization is that many instances of operating systems can run on a single server. Usually, in ordinary servers, one service is running on one server in order to meet the resource requirements of different applications requiring the same resources. But this is not an efficient way as it would require a lot of servers for large number of applications available. So, the problem is solved by concept of virtualization, which makes it possible to run several applications on the same server, with the illusion of one dedicated server per application (Hamrén *et al.*, 2012). Next, the idea of utility computing was also introduced in sixties. The idea behind utility computing is that different services are offered by different vendors and users of the service pay for the usage. The availability of service is guaranteed after payment. In utility computing the payment is only done for the amount of service being used (Hamrén *et al.*, 2012).

In Cambridge dictionary outsourcing is defined as "If a company outsources, it pays to have part of its work done by another company" (Cambridge Dictionary). For example a company hires another company for their IT department supports who look after their IT related problems. The difference between outsourcing and cloud computing is that for outsourcing, length agreements are signed by both companies and for the cloud computing, predefined solutions are given according to the requirements of the customer (Hamrén *et al.*, 2012).

In 1990's the concept of grid computing evolved. This idea refers the concept of making computing accessible in the same way as power grid works. Grid computing is an implementation of supercomputer that is made up of group of networked or internetworked computers to perform large tasks. The large task is divided into several smaller tasks and is distributed among different computer which are networked with the grid. A prominent example of gris computing is the SETI@home project (Dinh *et al.*, 2011). The difference between grid computing and mobile computing is that in grid computing only a few requests can be processed and others have to wait in a queue while in mobile cloud computing a lot of small allocation request are processed in real time (Hamrén *et al.*, 2012).

Many cloud service providers offers services similar to grid computing by the pay-per-use model and perceived unlimited computing resources. However, cloud computing should be viewed as a step away from the grid utility model (Cambridge Dictionary). The fields overlap each other on several points, but a difference

between the two of them is how data is processed. In grid computing the user usually makes few but very large requests. Only a few of these requests can be processed at any given time and others might be queued. Cloud computing users, on the other hand, does a lot of small allocation requests where allocations happen in real time (Hamrén *et al.*, 2012).

Architectures of Mobile Cloud Computing

General architecture of MCC: The general architecture of MCC is shown in Fig.1. In Fig.1, base stations are used to connect mobile devices to mobile networks (e.g. satellites) that controls all the requests made by mobile devices. Central processors are connected to the servers providing services to mobile network. They receive the requests and personal information (location and Id) from mobile users. The process of authentication, accounting and authorization are provided by the network operators of mobile. Information is stored in databases. After the authentication process the request is forwarded to the cloud through internet. Cloud controllers within the cloud provide the specific requested service to the mobile subscriber (Dinh *et al.*, 2011).

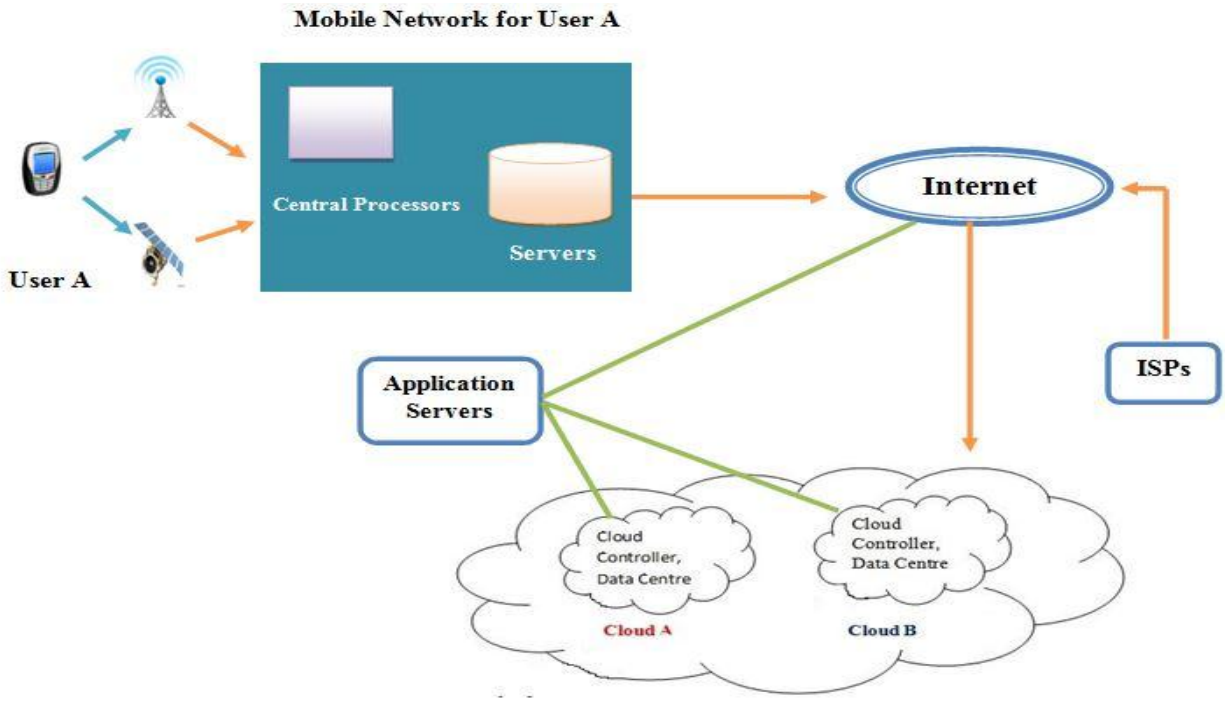

Fig-1: General Architectures of Mobile Cloud Computing

Layered Architecture of Cloud Computing: This architecture consists of following four layers as shown below:

First layer is **Data centers layer** that provides the hardware facility and clouds' infrastructure. To provide services to customers, many servers are attached to high-speed networks to increase efficiency (Dinh *et al.*, 2011).

Second layer is **IaaS**, stands for **Infrastructure as a Service**. IaaS can be placed anywhere above data layer means not exactly on its top. IaaS provides the facility of hardware, servers, networking, and storage components. In this layer, user only pays for the resources they use only. Depending on the number of requests, it can expand or shrink. For example, Simple Storage Service (S3) and Amazon Elastic Cloud Computing (Dinh *et al.*, 2011).

Third layer is **Paas**, stands for **Platform as a Service**. Testing and deploying of customer's applications are done by PaaS layer. For example, Google App Engine, Google Maps etc. (Dinh *et al.*, 2011).

Fourth layer is **Saas**, stands for **Software as a Service** layer supports the distribution of software with the specification of requirements. It is used to access requested application and required information through the internet. Examples are Salesforce and Microsoft's Live Mesh (Dinh *et al.*, 2011). Layered Cloud Computing infrastructure is shown in Fig.2.

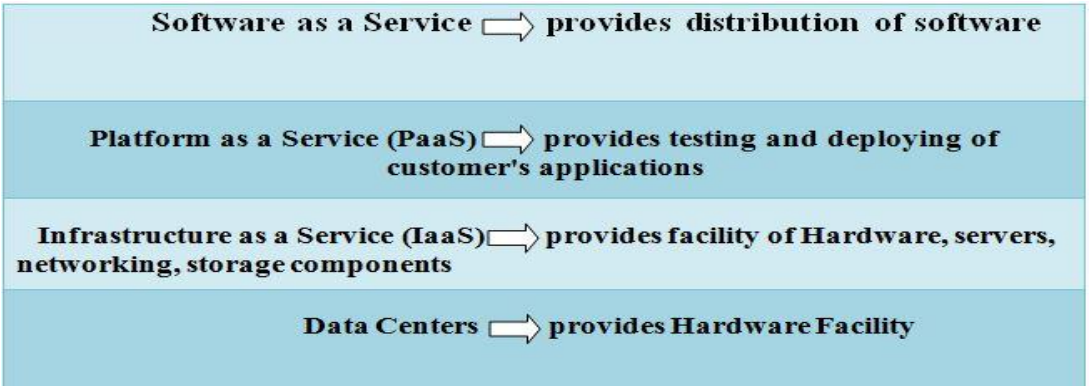

Fig-2: Layered Architecture of Cloud Computing

Advantages of mobile cloud Computing

Increased battery time: Mobile devices are of no use without battery. So, Battery time of mobile should be large enough to perform all the mobile computation without interruption. MCC helps in increasing battery power by transferring all the heavy computations to cloud server [, 10].

Improving data storage capacity and processing power: Storage capacity is also a restriction for mobile devices (Dinh *et al.*, 2011). MCC helps in overcoming the limitations of mobile devices in particular of the processing power and data storage. In MCC the large amount of data is stored on the cloud. MCC is developed to enable mobile to transfer heavy data files to the clouds so that mobile data storage can be saved. Like if a mobile user captures images, they are saved in the clouds and the user take them from the clouds whenever needed thus, saving the memory space. Examples of the services that make use of the data storage/access to or from the clouds are Amazon Simple Storage Service and Image Exchange. ShoZu and Flicker are the famous apps used for MCC photo sharing. Facebook with which we are all familiar with, is a typical network application that makes use of clouds in photo sharing [Kottari *et al.* (2013), Dinh *et al.* (2011)].

Reliability in User's data: In clouds, running applications or storing data is an efficient way to improve reliability as the important data is not only stored in mobile phones but backed up in clouds that is on several numbers of computers. This reduces the chance of data lost if some error occurs in mobile phones. Researchers have shown that MCC can be designed as "data security model" for users and providers, providing services. The data is more secured in clouds and is saved from any unauthorized access to the data [Kottari *et al.* (2013), Dinh *et al.* (2011)].

Access of multiple services provided by diverse vendors: Different service providers have multiple services and they can be integrated easily through Internet and cloud to meet user requirements (Dinh *et al.*, 2011).

Issues in MCC

Less Bandwidth: Bandwidth is a big issue because compared to wired networks, wireless networks are tougher to handle and have limited bandwidth as all the mobile users use the shared medium (Dinh *et al.*, 2011).

Availability of Service: It becomes a big problem if multiple users are trying to connect to a cloud and due to network failure, out of signal or traffic congestion, they are not able to connect to the cloud. The already proposed solution is to detect the computer systems (nodes) which are inactive or unable to access the service through cloud. After detection of node, its service provider is changed to the most feasible one. Then its connection is made to the cloud through neighboring nodes instead of a direct link. Computers are linked in an ad-hoc manner so this solution is applicable (Dinh *et al.*, 2011).

Increase in Price: Price is increased with MCC as it involves both the mobile and cloud service provider services. If a user wants to run an application on mobile which is not free, the price is distributed in three parts that is application provider, mobile network provider and cloud provider (Özlü *et al.*, 2012).

Heterogeneous Networks: Various networks such as WCDMA, GPRS, WiMAX and WLAN are used in mobile environment at the same time. Handling these various heterogeneous networks while keeping in mind the mobile computing requirements, is very difficult (Özlü *et al.*, 2012). The proposed solution for this problem is using messaging protocols and standardized interfaces to distribute and manage material (Özlü *et al.*, 2012).

Performance: The user that is far from the cloud providers may have a lack of performance. The user may suffer from high delays which affects the performance (Kottari *et al.*, 2013).

Security: In MCC as mobiles are involved and mobiles are more vulnerable to security attacks. More secure transmission protocols are needed as well as encryption of data can reduce this problem but may increase time delay (Kottari *et al.*, 2013).

MATERIALS AND METHODS

Based on our study of mobile cloud computing, we present a survey of problems in mobile cloud computing, the solutions for those problems proposed by researchers and advantages and disadvantages of each solution. The summary of this survey is presented in Table2.

An obvious problem associated with MCC is the requirement of continuous network connection during the use of cloud. If connection loss occurs, even for a moment then it can affect the quality of service (QoS) badly. In (Dinh *et al.*, 2011) Hoang T. Dinh has presented the two different approaches proposed by Huerta-Canepa and Lee, Zhang *et al.* for the solution of this problem. The first solution is the formation of ad hoc network by discovering neighboring nodes of the user, who has lost connection with the cloud. Through this discovery mechanism, a path from the user node to the cloud is formed and user gets connection with the cloud indirectly through these nodes. There were certain drawbacks with this approach. This approach was unable to handle the mobility of devices. Also, it was not considering the capabilities like battery life, bandwidth etc. of the nodes which were used in ad hoc network and also the privacy of nodes.

The second solution presented in (Dinh *et al.*, 2011) and proposed by Zhang *et al.* is the formation of multihop networking system (MoNet) based on WiFi with the objective of overcoming the drawbacks of approach presented by Huerta-Canepa and Lee. MoNet is based on the moving neighboring nodes around a cloud user. Each node in such scenario, sends broadcast control messages containing the information about the status of its bandwidth, disk space and power supply. Based on these broadcast messages, a capability list of neighboring nodes is maintained on each node. So, on need, the nodes having the shortest path length from cloud user to the cloud provider and with the highest status of resources is selected to form the path up to the cloud.

Another problem associated with MCC is the low bandwidth available to the cloud users which is the cause of low performance of cloud services. If a user interacts with a cloud, which is farther away from the user device, then it involves latency due to data transfer between cloud service user and cloud provider. In (Joy *et al.*, 2013) Preetha Theresa & K. Poulose has presented solution of low bandwidth problem by forming a cloudlet based on caches. In this approach, beside the use of local cache of user, a cloudlet is formed having multiple VM each having its cache. When a user gets services from the cloud, then the most frequently used data is stored in local cache of user and if local cache overflows then data is stored in VM cache associated with that cloud. So, in future, upon subsequent requests for data, firstly local cache is checked for data and if data is not found the VM cache is searched to satisfy user request. If request cannot be fulfilled from VM cache, then in the last, request for data is forwarded to cloud. The advantage of this approach is the efficient retrieval of data from cache and increase in battery life of mobile device as wireless communication is reduced due to data caching.

For using MCC, applications are transferred from the mobile device to the cloud and heavy computation is performed on the cloud instead of mobile device which saves battery life of mobile device. But offloading is not always the affective way of saving energy of device. Sometimes offloading of computation to the takes more power than performing computation on the mobile device itself. For example, it takes more power to compile a code on the cloud rather than on the mobile device. So, in (Dinh *et al.*, 2011), Hoang T. Dinh has presented solution of this problem, which was proposed by Kumar and Lu. The solution is based on determining the energy consumption of a program before executing it. The total required energy is the sum of communication energy and computation energy.

Total energy required to execute a program = communication energy + computation energy

The determination of communication energy varies depending on the quality of wireless link. So, the final decision of energy requirement is done dynamically at run time.

Security of data from threats and viruses is always an issue for the users connected to the internet. So, in MCC users are very much concerned about the security of their data stored on mobile and on clouds. To secure data stored on mobile device, if antivirus software is installed in mobile device, then it will cause a lot of power consumption of mobile device. So, in (Dinh *et al.*, 2011), Hoang T. Dinh has presented the use of cloudAV platform as a solution of data security proposed by Oberheide *et al.* cloudAV platform runs the antivirus program on cloud. This platform has host network service components & host agent. Host agent inspects the file activity on system and if any suspicious file is found, it sends it to the in-cloud network service for verification. So, mobile device just needs host agent, which is for detection of suspicious files. All other security related work is done on cloud (Dinh *et al.*, 2011).

Another security issue is Integrity of data stored on cloud i.e., to protect user data from any unauthorized change. For this purpose, the use of MAC (message authentication code) has been proposed by W. Itan *et al.* and presented in (Dinh *et al.*, 2011) by Hoang T. Dinh. In this technique when mobile sends a file on cloud, it

calculates MAC and saves it locally as well as sends it to a trusted third party for future verification. When user wants to update any file, cloud sends it the file and asks trusted crypto coprocessor (TCC) to send that actual MAC and TCC sends it to mobile to verify if any changes have not been occurred (Dinh *et al.*, 2011).

Reliability maintenance is also a problem in MCC. As user data is stored on cloud, so it is the responsibility of cloud provider to ensure reliability. So, for this purpose different backup techniques are used by different cloud vendors. Not a single backup technique is feasible at all time. Different backup techniques have some advantages and disadvantages. Among all backup techniques Parity Cloud Service (PCS) is most reliable and cost effective. It uses virtual disk in user system for data backup and also stores parity information with data in order to recover from errors(Sharma *et al.*, 2012).

Another technique is High Security Distribution and Rake Technology (HSDRT) which uses encryption and distributed data transfer mechanism. It consists of three major components, which are data centers, supervisory server and different client nodes. For data backup, first of all, data centers encrypt the data. After that data is shuffled and divided into small fragments. After this data is duplicated and sent to different client nodes for storage along with the keys required for decryption. For data recovery, supervisory server gathers the data from all clients, combines the data in proper order and decrypts the data (Sharma *et al.*, 2012).

Another technique for preventing data loss and taking backup of data is the Linux Box. It consists of a simple hardware box named as Linux Box. It runs a simple application that performs backup of data stored on cloud into its local drives. For secure transmission of data from cloud to the Linux Box, encryption and secured channel interface is used between the two. Linux Box also checks the cloud for data updates and accordingly updates its local storage (Sharma *et al.*, 2012).

Conclusion: The MCC is a new and emerging field. A lot of research is being done to solve issues of it. MCC enables the application developers to develop applications which run on cloud and utilizes processing power and memory of cloud devices. The user having mobile device gains access of these application through internet and with little usage of battery life of mobile device. The contribution from this survey is to present problems and solutions to problems of MCC and also the advantages and disadvantages of the presented solutions.

Table2. Mobile Cloud Computing (Problems, Solutions, Advantages and Disadvantages).

Problem	Solution	Advantages	Disadvantages
Continuous network connection availability requirement	Providing connection to the cloud through the use of ad hoc network	Uninterrupted service access to the cloud	No consideration of mobility, capability of devices and privacy of neighboring nodes
	WiFi based multihop networking system (MoNet)	Forming ad hoc network by selecting nodes with shortest hop length and highest role level based on bandwidth, power supply	Overhead associated with broadcasting control messages and local content updation
Low performance due to low bandwidth	Use of Co-operative cache framework	Faster response of system, efficient retrieval of information, even in case of low bandwidth, increased battery life	Extra cost involved in deploying Virtual machines for caching data
Offloading computation to the cloud, not effective always	Program partitioning based on the estimation of the energy consumption (communication energy and computation energy) before the program execution	Optimal use of battery life and bandwidth of network connection	Requirement of execution of program for portioning before processing of each client request
Security threats on mobile device, increased power consumption in case of running antivirus program on mobile device	Adding threat detection capabilities to cloud by using CloudAV platform.	Multiple antivirus engines can be used in parallel by the use of virtualized containers	Mobile agent should be improved to detect the suspicious files and may consume more memory
Integrity of data stored on cloud	Use of Message authentication code (MAC)	Authorized access to data and updation of data	More tough the encryption algorithm, more complex computation and more

			power consumption of mobile device
Reliability of data stored on cloud	Parity Cloud Service (PCS)	Reliable, fast recovery of data, reduced cost	Difficult to Implement, more complex
	Security Distribution and Rake Technology (HSDRT)	Used for Portable devices, privacy maintenance	Higher deployment cost, increased data redundancy
	Linux Box	Cost effective, secure and encrypted data transmission	High bandwidth requirement

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