Exploring Challenges in Mobile Cloud Computing: An Overview

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ABSTRACT
Cloud computing has been the topic of research for quite some time now. It is a model for enabling convenient, ubiquitous, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, applications, and services including security, application development, etc.) that can be rapidly provisioned and released with minimal management effort or service provider interaction. On the other hand, the increasing technological enhancement in the field of mobile computing is demanding pervasive and ubiquitous computing (PUC), which has given birth to the idea of integrating the concept of Cloud with mobile computing. This new paradigm known as Mobile cloud computing (MCC), has emerged as an area of keen interest among researchers. Mobile Cloud Computing is a mobile computing technology that uses unified elastic resources of different clouds and network technologies to provide mobile user with high computing power and storage capacity with limited resources in hand, and is based on the "pay-as-you-use" principle. This paper analyses the MCC architecture, exploring all possible challenges surrounding it under two groups (Challenges in Mobile Computing & Challenges in Cloud Computing) and finally concluding with heterogeneity being the prime factor contributing to these challenges.

KEYWORDS
Mobile Cloud Computing, Mobile Applications, Cloud Computing, Security, Heterogeneity

1. INTRODUCTION

Today's perception of computing has significantly evolved from what it was on the day when the first mainframe was built. We have come a long way from back then to an era where main focus of research revolves around the ideology, "Ace services and computation using qualified resources", where resources include computation, storage or network. This thought led to concept called Cloud computing, which was dormant in its early phase, but it's only in the past few years that many researchers have contributed to this field and yet some of the sub domains are still left unexplored.

Technological advancement has contributed to the present world of sleek and compact smart phones. These phones have edge over laptops and notebook because of their sleek, compact and portable size. Though these handheld devices rule today's market, but at the same time in terms of computation, power and resources, smart phones have lower hand when compared with PC, laptops or notebooks.

The intrinsic limitations of mobile device gave birth to the idea of the converging concept of cloud over mobile devices. This new paradigm is known as Mobile Cloud Computing [MCC]. Though this new domain has a promising future, but it is plagued by certain challenges which need to be dealt with in order to exploit the advantage of this technology.

In this paper, we throw light on MCC architecture, explore all possible challenges around it and divide them into two categories,

- Challenges in Mobile computing
- Challenges in Cloud Computing

The relic of this paper includes literature review in Section II followed by Section III, which presents an overview of MCC architecture followed by Section IV, which discusses its major challenges, by grouping them under two sub categories as mentioned above. Section V highlights how heterogeneity is contributing to these challenges, finally leading to the conclusion.

2. LITERATURE REVIEW

Many researchers have proposed various solutions for various problems surrounding the architecture of MCC. Most of the researchers have presented challenges of MCC in generalised manner in their work, inculcating constrains offered by cloud computing only on the basis of specific sub domain.

Caytiles, discussed about only security aspect of MCC in his work [10], excluding all other parameters which pose challenges in implementation and success of MCC. On the other hand, Deepti Sahu and Shipra Sharma have brought in light all the challenges in MCC, under the detailed

classification of challenges in network, security and mobile application domain in their work. All these challenges are explained by Rajkumar Buyya in his work [15]. He has proposed solutions for the same and has also discussed heterogeneity in the mobile cloud computing environment,

3. ARCHITECTURE ANALYSIS

3.1 Cloud Computing Architecture and Mobile Cloud Services

Current cloud computing service providers allow customers to have access to different computation and storage services like server availability, networking throughput, CPU time, memory usage, storage, etc. via their cloud applications as VMs within the provider's cloud of servers. Cloud providers keep whole infrastructure transparent from the customers who are unaware of distribution of the Virtual machine instances. However, some cloud service providers also offer additional ability to choose geographically from among a small number of data centres where their VM instances will run. Main concern is to lower network latency by locating data centres near where their output will be used [11].

Cloud computing architecture comprises of three categories of cloud Services [18]

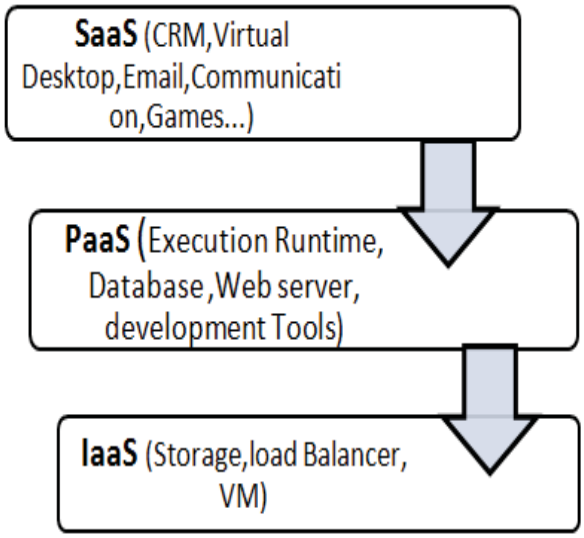

Fig. 1. Cloud Computing Services

- *Infrastructure as a Service (IaaS):* This service provide standardized virtual server that consists of services, storage and network infrastructure as well as allows customer to deploy and run arbitrary software, including operating systems and applications. The customer does not control or manage cloud infrastructure, but has control over operating systems, storage, deployed applications, etc.
- *Software as a Service (SaaS):* In the business model using software as a service (SaaS), users are provided with access to application software such as customer relationship management (CRM), collaboration and email and databases. Cloud providers manage the infrastructure and platforms that run the applications. Customers access all the information on cloud through a real time communication channel such as web browser.
- *Platform as a service (PaaS):* It is responsible for application execution services, such as runtime, storage, integration and provides computing platform. Application developers can develop and run their software on cloud without buying any tool or product thus minimizes cost and time.

With increase in requirement of services, cloud computing has emerged as a heterogeneous. Many vendors offer diverse clouds with different capabilities and protections to customers using them. Nowadays, large numbers of mobile applications are linked to server instances operating in the cloud. However, redundancies of many mobile applications like location awareness, adaptation to mobility, and computational partitioning of execution between mobile and cloud is there as they are also provided by mobile support service providers [11].

3.2 Mobile Cloud Computing System Architecture

Mobile Cloud Computing (MCC) architecture provides proxy for different mobile clients connecting to Cloud services [5]. The MCC architecture consists of following three components:
Mobile clients
Middleware
Cloud services

Mobile clients connect to cloud services which are managed and controlled by service providers through middleware. The middleware plays an important role of intermediate channel between mobile clients and cloud services. Middleware pushes updates of different services to mobile clients through hypertext transfer protocol (HTTP) or email immediately after it receives updates. It is

Figure 2: Architecture of MCC

(RESTful WS) and delivers the service result to the mobile clients. RESTful WS interface for mobile clients is provided by middleware only [5].

Following steps are used for consuming and executing web services (WS) through middleware:

1. Mobile client sends a HTTP GET request for the required service along with an identifier of a WS to the middleware.
2. The middleware forms a bridge between the client and the WS. All the interactions between the client and his desired service are implemented via middleware.
3. The middleware extracts the required service results from the original service result, and then uses it to form a new service result in JSON.
4. Middleware is also assigned the task to stores a copy of the result with the service ID in the database. After updating database, the result is optimised and finally dispatched to the client.

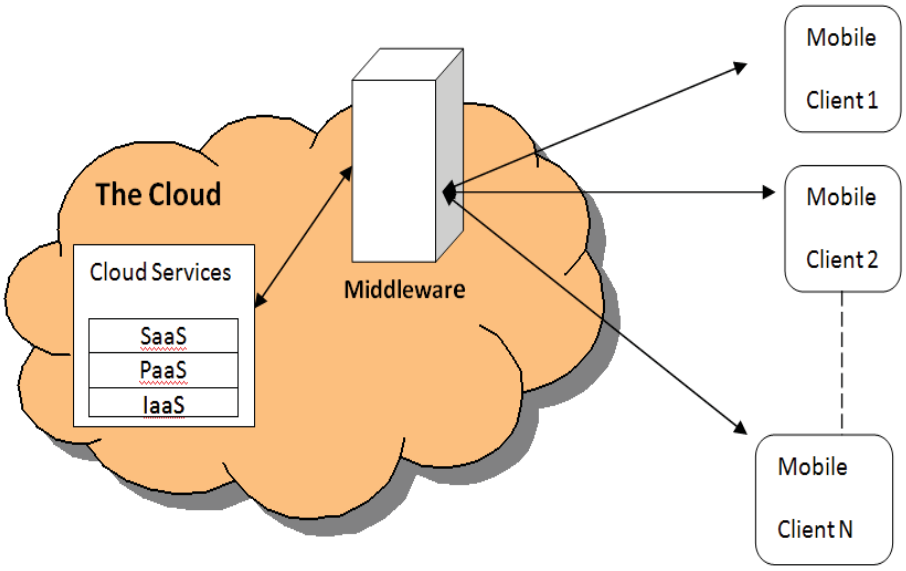

Figure 2: Architecture of MCC

4. CHALLENGES AROUND MCC ARCHITECTURE

MCC is the implementation of cloud over mobile devices. In this paper we have analysed and categorised challenges on the basis of their occurrence in two domains, Mobile Computing and Cloud Computing. The challenges explored under both domains contribute collectively in impeding the implementation of MCC.

4.1 Challenges in Mobile computing:

4.1.1 Network Security Challenges :

1. *Security for mobile applications:* Presently Mobile devices run security checks on devices itself, which costs in terms of computation and power. MCC sows the seeds of a new model where detection services are carried out on cloud, saving the device CPU and memory requirements, but demanding the increase of bandwidth. One such approach has been proposed in [4], but it has its own privacy issues to battle up.

2. *Privacy:* Providing sensitive or private information such as providing user's current location creates scenarios for privacy issues. The best example is global positioning system (GPS), which provides the use of location based services (LBS) [10].

4.1.2 Requirement of Elastic Mobile applications:

From the user's point of view, what matters is he being provided with the service he requested for, with the optimized resource utilisation and without compromising the service quality. This requirement particularly manifests in Mobile Cloud Computing due to the structural limitations of mobile devices. Elastic Mobile Apps are proposed in [6] to deal with this condition as these applications can be launched on the device or cloud, and can be switched between the two according to dynamic changes in accordance with the computing environment or user preferences. Users can access them using mobile browser.

4.1.3 Challenges in Networks:

1. *Intrinsic Constrains of Wireless Network:* Wireless network is heart of cloud computing as it forms the base for communication in Cloud. But it has its own set of issues asking for attention, like data rate constraint, not so good throughput,

longer latency delays and intermittent connectivity issues. Subscriber's dynamic change in location and atmospheric conditions contribute to the varying bandwidth capacity and coverage .These challenges complicate its design for mobile devices [12].

2. *Soft Handoff for Heterogeneous Network Access Schemes:* In MCC, wireless network is major communication media, which can be cellular, WLAN or Satellite based. This variation affects mobility causing call frequent drops. Hence we require soft handover schemes, avoiding connection failure and connection reestablishment when moving from one network access point to another.

3. *Network Latency: A*n overall delay response of applications is attributed to following factors [8]:

   - Processing time at the data centre
   - Processing time on device
   - Network latency
   - Data transport time

   To overcome some of these limitations, Satyanarayana [7] proposes cyber foraging approach. In this approach, mobile augmentation is achieved via offloading applications (entirely or partially) to resource-rich, non-mobile computing devices in the vicinity called surrogates to provide heavy functionality and to conserve local resources, especially energy.

4. *Dependency on Browser to access the Internet:* Researchers are working to get a better way of accessing mobile web other than browser. In order to get speedy mobile internet access new technologies like HTML5 are being developed, which provide facility of local caching. Technologies like OMA's Smartcard Web Server and TokTok are being introduced just to provide better access to mobile web. Through these technologies, mobile apps talk directly to the service minus the pain of launching a web browser and navigating through mobile web [8].

5. *Bandwidth:* Low bandwidth of mobile network is another cause of concern in the Cloud computing domain. So we are required to check for improvement in network bandwidth so to improve data transfer across cloud and other devices, especially in case of mobile applications, demanding high-processing capacity and minimum network latency [8].

4.2 . Challenges in Cloud computing:

4.2.1 Lack of Standards: Interoperability impedes the quick development of cloud computing, as there is no common cloud standard being followed by different cloud providers who have their own API's. A proposed solution is Open Cloud Computing Federation (abbreviated as OCCF later), which incorporates multiple CCSP's (Cloud Computing Service Provider) service to provide a uniform resource interface for the user. It serves as a base for Mobile Agent Based Open Cloud Computing Federation (MABOCCF) mechanism [1], which though solves the problem stated above but is difficult to realise.

In a paper [2] from University of California, Berkeley, author throws some light on challenges of Cloud computing, out of which following the two main problems that are the result of lack of open standards:

1. *Unreliable availability of a service*: Dependence on a single CCSP's service can result in a bottleneck in the event of a breakdown of a service.

2. *Service provider lock-in:* An absence of portability makes it impossible for data and application transfer among CCSPs; consequently, the customer is locked to a certain CCSP.

4.2.2. Cloud Security Challenges: The adoption of cloud computing as technology has become widespread, which in turn has exposed loopholes in its security domain. Few of such issues that get manifested in MCC are [3, 5, 10]:

1. *Integrity*: Every access made by user must me authenticated and verified, to ensure the integrity of their information stored on the cloud.
2. *Authentication*: Different mechanisms for keeping track on authentication must be incorporated to secure the data access suitable for mobile environments.
3. *Violation of Digital rights*: Illegal distribution and piracy of digital contents such as video, e-books, images, and audios, becomes more and more popular. One of the measures that can be taken to protect these contents from illegal access is provision of encryption and decryption keys to access these contents. A coding or decoding platform must be done before any mobile user can have access to such digital contents.
4. *Monetizing Data:* Everything being uploaded onto servers as a backup, including sensitive and exploitable personal data has led to collection of

enormous data without capital investment. This in turn is proving out to be a boon to attackers as now they potentially have colossal centralized databases available for analysis, which can also be used by advertising applications for monetary benefits [5].

5. *Mash-up authorization*: With each passing day, new services are being thought of and are being deployed over cloud, which are increasing not only options of sources of data to be used by user, but also are performing mash-ups of data. This development has probable security threat of violation of data confidentiality [5].
6. *Federal security requirements:* Cloud vendors may not be familiar with security requirements that are unique to government agencies [3].
7. *Certifying vendors*: It is very difficult for agencies to provide Security certification to vendors because of Federal Risk and Authorization Management Program had not yet reached initial operational capabilities [3].

4.2.3 Performance Unpredictability: Concept of resource (CPUs and main memory) sharing, using multiple virtual machines (VMs) is being executed very well in Cloud Computing. But the same can't be said for network and disk I/O sharing. Implementing the use of flash memory to decrease I/O interference can be thought of as one of the solutions [9].

4.2.4 Debugging: Implementation of Cloud Computing involves very large-scale distributed systems, so a common occurrence is that the errors or bugs can't be reproduced in smaller configurations. Hence the debugging must occur at a large scale in the production data centres [9].

4.2.5 Seeking for guidance: Existing federal guidance for using cloud services may be insufficient or incomplete, especially in domains including purchasing commodity Information Technology and assessing Federal Information Security Management Act security levels [3].

4.2.6 Acquiring expertise: There may be a scenario when there is absence or shortage of necessary tools or resources, such as expertise among staff, to implement cloud solutions [3].

5. HETEROGENEITY IN MCC

In this paper we have explored challenges surrounding MCC architecture. While doing so, we came across several challenges in security, access media and network. Rather grouping them as done in [8], we have grouped them into challenges in Cloud and Mobile Computing separately.

During the course of analysis, we analysed that the major challenges like open platform, access medium have their root in Heterogeneity, which occurs when we mix two components which are entirely different in characteristics with each other, i.e., even after grouping two objects, things or say technology in this case, we can easily differentiate between the two.

Heterogeneity in MCC is the existence of differentiation among building components of MCC i.e. architecture, hardware, infrastructure and technologies [15].

- *Heterogeneity in Mobile Devices*: It is caused because of technological variation in terms of OS, software, hardware, platform (android, windows, etc), features and communication medium among mobile devices.
- *Heterogeneity in Clouds*: There are numerous cloud vendors in market, who provide different cloud services with their own accustomed policies. This leads to heterogeneity among cloud as these vendors work on their respective infrastructures, platforms, and APIs, leading to interoperability and portability challenge.
- *Heterogeneity in Wireless Networks*: In MCC, wireless network is major communication media, which can be cellular, WLAN or Satellite based. This variation affects mobility, augmentation, and usability of smart phones.

Buyya argued in [15], that MCC is a more heterogeneous domain as compared to the cloud computing. He has also categorized heterogeneity of cloud computing, mobile computing, and wireless networks into two classes, namely vertical and horizontal, proposing taxonomy for how heterogeneity has its roots in MCC.

6. CONCLUSION

With the advancement of technology, every person demands for optimum service yet with minimum usage of resources. Same is the case with handheld smart phones, which undoubtedly surpass laptops, PC, Notebooks in terms of light weight, easy portability and sleek design. But at the same time, these devices are far more behind what PC or Net book could provide as service in terms of storage and computation because of poverty of resources and limited battery life.

To eliminate these intrinsic constraints, researchers have coined the idea of Mobile Cloud Computing. Since MCC, is implementation of Cloud over mobile devices, it poses various challenges. This Paper, analyses MCC architecture and explores challenges around it, dividing them into two groups of challenges based on their existence in the parent field i.e. either Mobile Computing or Cloud Computing. Though the challenges are grouped on the basis of the area of their existence, they collectively impede the implementation of MCC.

These challenges are being worked upon, but existing solutions are either not easy to realise or contain some drawbacks. Future work can be done to enhance existing solutions and research can be carried out to propose more optimum solutions.

7. REFERENCES

[1] Zehua Zhang and Xuejie Zhang. Realization of open cloud computing federation based on mobile agent. In ICIS '09: IEEE International Conference on Intelligent Computing and Intelligent Systems, 2009.,volume 3, pages 642–646, 2009.

[2] Michael Armbrust, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy H. Katz, Andrew Konwinski, Gunho Lee, David A. Patterson,Ariel Rabkin, Ion Stoica, and Matei Zaharia. Above the clouds: A berkeley view of cloud computing. Technical Report UCB/EECS-2009-28, EECS Department, University of California, Berkeley, Feb 2009.

[3] Michael Cooney, "The 7 most common challenges to cloud computing". July 11, 2012 Internet:http://www.networkworld.com/news/2012/071112-cloud-computing-challenges-260829.html?page=1, [Sep. 1, 2013]

[4] Jon Oberheide, Kaushik Veeraraghavan, Evan Cooke, Jason Flinn, and Farnam Jahanian. Virtualized in-cloud security services for mobile devices. In MobiVirt '08: Proceedings of the First Workshop on Virtualization in Mobile Computing, pages 31–35, New York, NY, USA,2008. ACM.

[5] Medhavi S.Shriwas, Neetesh Gupta, Amit Sinhal "Comparative Study of Cloud Computing and Mobile Cloud Computing". MEDHA - 2012 Proceedings published by International Journal of Computer Applications (IJCA.)

[6] Xinwen Zhang, Joshua Schiffman, Simon Gibbs, Anugeetha Kunjithapatham, and Sangoh Jeong. Securing elastic applications on mobile devices for cloud computing. In CCSW '09: Proceedings of the 2009 ACM workshop on Cloud computing security, pages 127–134, New York, NY, USA, 2009. ACM.

[7] M. Satyanarayanan, "Pervasive computing: vision and challenges,"*IEEE Personal Communications*, vol. 8, no. 4, pp. 10–17, 2001.

[8] Deepti Sahu, Shipra Sharma, Vandana Dubey, Alpika Tripathi, "Cloud Computing in Mobile Applications".*International Journal of Scientific and Research Publications*, Volume 2, Issue 8, August 2012 , ISSN 2250-3153

[9] Michael Armbrust et al., "A View of Cloud Computing", Communications of the ACM, Association for Computing Machinery, Vol. 53, No. 4, pp.50-58, Apr. 2010

[10] Ronnie D. Caytiles, Sunguk Lee, "Security Considerations for Public Mobile Cloud Computing" *International Journal of Advanced Science and Technology* Vol. 44, July, 2012

[11] Paramvir Bahl, Richard Y. Han, Li Erran Li, Mahadev Satyanarayanan, "Advancing the State of Mobile Cloud Computing", June, 2012 Available: http://www.belllabs.com/user/erranlli/publications/mCloud-MCS12.pdf,.[Sep.5,2013]

[12] Kyung Mun, "Mobile Cloud Computing Challenges". September 21, 2010Internet: http://www2.alcatel-lucent.com/techzine/mobile- cloud-computing challenges /#sthash.4Xn2m 0fM .dpuf [Sep.3, 2013]

[13] Kai Hwang, Geoffrey C. Fox, and Jack J. Dongarra (2011, Oct. 31) "Distributed System Model and Enabling Technologies" in Distributed and Cloud Computing From Parallel Processing to the Internet of Things, USA: Elsevier, 2013, ch.1, pp 11-12.

[14] Peter Mell, Timothy Grance, "The NIST Definition of Cloud Computing", *NIST Special Publication 800-145*, p. 2, sep. 2011

[15] Zohreh Sanaei, Saeid Abolfazli, , Abdullah Gani, Rajkumar Buyya, "Heterogeneity in Mobile Cloud Computing: Taxonomy and Open Challenges". *Communications Surveys & Tutorials, IEEE*, Issue:99, May 2013.

[16] Min Choi, Jonghyuk Park, Young-Sik Jeong, "Mobile cloud computing framework for a pervasive and ubiquitous environment". *The Journal of Supercomputing, Springer,* Volume 64, Issue 2, pp 331-356, May 2013.

[17] Martin Tantow,"Major Trends in Mobile Cloud Computing".2011, Internet:http://cloudtimes.org/2011/06/05/5-major-trends-in-mobile-cloud—compu ting / [Sep. 2, 2013]

[18] Bill Loeffler, "Cloud Computing: What is Infrastructure as a Service". Oct.2011 Internet: http://technet.microsoft.com/en-us/magazine /hh5 09051.aspx, [Sep.8, 2013]

[19] J Craig Mudge, "CLOUD COMPUTING: Opportunities and challenges for Australia". Sep, 2010 Internet: http://www.atse. org.au/Documents/ Publications/Reports/ICT/2010_SepATSE%20REPORT-Cloud%20Computing%20-%20Opportunities %20&%20Challenges%20for%20Australia.pdf, [Sep.6, 2013].