# GPS Test Performance: Elastic Execution Applications between Mobile Device and Cloud to Reduce Power Consumption

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**Abstract**
Mobile systems, such as smart phones, have become the primary computing platform for many users. Smartphones stimulate growth of Global Position Systems. However, smartphone mobile computing faces challenges because of the limited battery capacity. Therefore, it is necessary to offload the computation-intensive part by careful partitioning of application functions across a cloud. Mobile applications can be executed in the mobile device (known as mobile execution) or offloaded to the cloud clone for execution (known as cloud execution), with an objective to save energy for mobile device. In mobile cloud computing, application offloading is implemented as a solution for augmenting computing potentials of smart mobile devices.in this paper; we propose a new elastic application model that enables transparent use of cloud resources to augment the capability of resource constrained mobile devices. The significant features of this model include the partition of a single application into multiple components. Its execution location is transparent it can be run on a mobile device or migrated to the cloud. Thus, an elastic application can augment the capabilities of a mobile device including computation power, storage, and network bandwidth, with the light of dynamic execution configuration according to device's status including CPU load, memory, battery level. We demonstrate promising results of the proposed application model using data collected from one of our example elastic applications.

***Keywords:***
*Cloud computing, Mobile application, Mobile cloud computing (MCC), GPS, offloading*

## 1. Introduction

Smart phones, Mobile devices and mobile applications have enjoyed rapid development in recent years [1], [2]. Compared with current PC, mobile devices still cannot run data intensive applications, such as search, large-scale data management and mining, etc., and have limitations in battery power, scream size, wireless communication etc.
[3],[4] The most attractive features of cloud computing lie on the capability in powerful computing capability and massive data storage as well as a new business model, which deliveries the computing resources as a utility. [5-8] Mobile cloud computing is defined as an extension of cloud computing in which foundation hardware consists at least partly of mobile devices. This definition recognizes the opportunity to harness collective sensing, computational capabilities of multiple networked wireless devices to create a distributed infrastructure that supports a wealth of new applications.
[9-14] It is a complex issue that mobile applications move computing power and data storage away from mobile phones into the cloud. First, it will face to the partition problem. With the changes of the mobile environment, partition algorithm should achieve elastic partition in according to context-awareness. A variety of contextual information could impact the elastic partition results, such as battery level, connection quality, device loads, etc. we proposed elastic application model, a new application model supporting applications partitioned into multiple components, each of which can run autonomously from others. We proposed the elastic partition algorithm and the partition cost module.
The rest of the paper is organized as follows. Section 2 is the discussion of related work of mobile cloud computing. Following that, respectively in the next two sections present cloud computing definitions and basic terminology of mobile cloud computing and its architectures then in section 5 present elastic partition algorithms, following that, respectively in the next two sections, would be the description of partition cost module and the evaluation. Fundamentally the conclusion lies in the last section.

## 2. Related work

To give more prospective about the performance of the compared algorithms, this section discusses the results obtained from other resources.
It was shown in [15] executes video games in the cloud and delivers video stream to resource-poor clients without interrupting the game experience. Many other examples where the cloud can augment mobile devices can be envisioned, e.g. virus scan, mobile file system indexing, augmented reality applications.
In [16] uses VM migration to offload part of their application workload to a resourceful server through either 3G or WiFi. CloneCloud was tested using Android phones with the clones executing on a Dell desktop running Ubuntu. The system is a flexible application partitioned and execution runtime. It enables unmodified mobile

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applications to offload part of their execution from mobile devices onto device clones operating in a computational cloud.

It was presented in [17] 'Hyrax' for Android smartphone applications which are distributed both in terms of data and computation based on Hadoop9 ported to the Android platform. Hyrax explores the possibility of using a cluster of mobile phones as resource providers and shows the feasibility of such a mobile cloud. As a sample application, they present 'HyraxTube'; which is a simple distributed mobile multimedia search and sharing program. The objective of HyraxTube is to allow users to search through multimedia files in terms of time, quality, and location.

in [18] The 'Cuckoo' framework that is a system to offload mobile device applications onto a cloud using a Java stub/proxy model. Cuckoo can be offloaded onto any resource that runs the Java Virtual machine, be it a commercial cloud such as Amazon EC210 or a private mini cloud comprised of laptops and local clusters. However, other mobile phones have not been mentioned as potential resource providers. Implemented for Android, Cuckoo's offloading objectives are to enhance performance and reduce battery usage.

Other mobile cloud computing (MCC) applications as shown in [19-22]

## 3. Cloud computing VS Mobile Cloud Computing

Extensive surveys on cloud computing such as [5-10] can be found in the literature, and here we focus on the definitions and architectures of cloud computing and mobile cloud computing according to power consumption and resources consumed for running applications.

### 3.1 Cloud Computing

Computing is being transformed by a new model, cloud computing as shown in (Fig.1). In this model, data and computation are operated somewhere in a "cloud," which is some collection of data centres owned and maintained by a third party.

[19-21]Cloud computing is an emerging concept combining many fields of computing. The foundation of cloud computing is the delivery of services, software and processing capacity over the Internet, reducing cost, increasing storage, automating systems, decoupling of service delivery from underlying technology, and providing flexibility and mobility of information. Cloud computing refers to the hardware, systems software, and applications delivered as services over the Internet. When a cloud is made available in a payas- you-go manner to the general public, we call it a Public Cloud. The term Private Cloud is used when the cloud infrastructure is operated solely for a business or an organization. A composition of the two types (private and public) is called a Hybrid Cloud, where a private cloud is able to maintain high service availability by scaling up their system with externally provisioned resources from a public cloud when
there are rapid workload fluctuations or hardware failures.

In general, cloud providers fall into three categories

- Infrastructure as a Service (IaaS): offering web-based access to storage and computing power. The consumer does not need to manage or control the underlying cloud infrastructure but has control over the operating systems, storage, and deployed applications.
- Platform as a Service (PaaS): giving developers the tools to build and host web applications (e.g., APPRIO [23], software as a service provider, is built using the Force.com [24] platform while the infrastructure is provided by the Amazon Web Service [25]). the users host an environment for their applications. The users control the applications, but do not control the operating system, hardware or network infrastructure, which they are using.
- Software as a Service (SaaS): where the consumer uses an application, but does not control the operating system, hardware or network infrastructure. In this situation, the user steers applications over the network. Applications that are accessible from various client devices through a thin client interface such as a web browser.

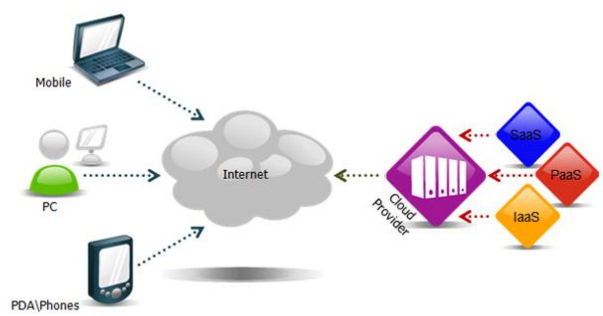


Fig. 1 Cloud services and enabling technologies

### 3.2 Mobile Cloud Computing (MCC)

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

- the term mobile cloud computing means to run an application such as Google's Gmail for Mobile6 on a remote resource rich server or Another approach is to consider other mobile devices themselves too as resource providers of the cloud making up a mobile peer-to-peer network
- Aepona [26] consider Mobile Cloud Computing (MCC) at its simplest, refers to an infrastructure where both the data storage and the 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 mobile computing to not just smartphone users but a much broader range of mobile subscribers Mobile cloud computing is a model for transparent elastic augmentation of mobile device capabilities via ubiquitous wireless access to cloud storage and computing resources, with context-aware dynamic adjusting of offloading in respect to change in operating conditions, while preserving available sensing and interactivity capabilities of mobile devices.

### 3.3 Architectures of MCC

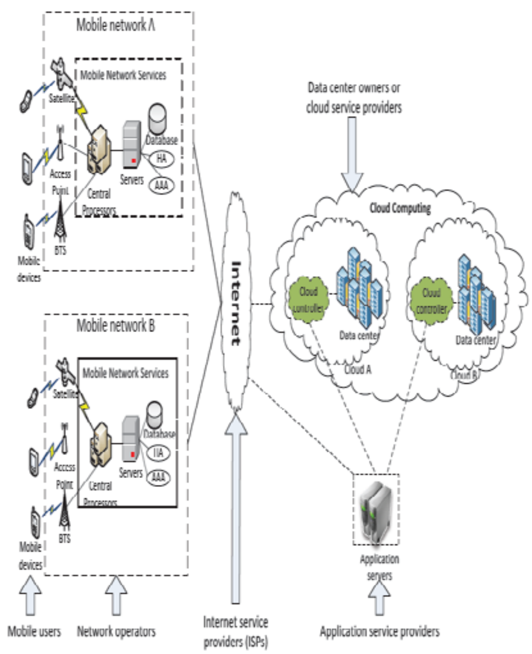


Fig.2 Mobile Cloud Computing (MCC) architecture

From the concept of MCC, the general architecture of MCC can be shown in (Fig. 2) that 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 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). This architecture is commonly used to demonstrate the effectiveness of the cloud computing model in terms of meeting the user's requirements [9-22].

## 4. Elastic Partition Algorithm

[18] There are two major approaches in mobile cloud computing research based on issues related to Operational level issues:

Application partition and offloading technology. These two approaches play an important role for the implementation of elastic applications.

Application partition decompose complex workload to atomic ones, thus can be processed concurrently. Offloading application can free burden of mobile devices. The concept of offloading data and computation in cloud computing is used to address the inherent problems in mobile computing by using resource providers other than the mobile device itself to host the execution of mobile applications. Such an infrastructure where data storage and processing could happen outside the mobile device could be termed a 'mobile cloud'. By exploiting the computing and storage capabilities of the mobile cloud, computer intensive applications can be executed on low resource mobile devices. To achieve whole and clear migration and offloading, each application should be partitioned into components. Application partition should consider resource consumption and data dependency. Offloading task from client to cloud can reduce energy consumption of mobile device [13]. The problem is the choice of offloading precent and methods. Should we put all applications to cloud?

## 5. Implement and Evaluation

Sequence steps for our framework application as shown in (fig 3) Snapshot of elastic GPS application on Samsung Galaxy Grand as shown in (Fig 4)

We use a mobile smartphone SAMSUNG GALAXY GRAND 1.2 GHz Dual Core CPU, and Android 4 Operating Systems in which performance data is collected and tested. In the experiments, the GPSTestPerformance application smartphone calculate distance between two points or more till 100 points. For our experiment, we calculate the effects of Sending computation to another machine and studying the Offloading computation to save energy on power consumption for smartphone mobile in case of running all processes of application on mobile or by partition and offloading processes on cloud

**In first step: Firstly;** Comparison is conducted using two different types of GPS mode (using mobile GPS), and using mobile network .for each type of GPS, we can get latitude and longitude for each point (is can be calculated by mobile GPS satellite or by mobile network)

**In second step**: After selecting GPS mode of operations, we have to choose between manual or automatic calculation to get latitude or longitude for each point

- If automatic calculation is selected, we have to enter number of points and system get points every thirty second
- If manual calculation is selected, we have to click to get points

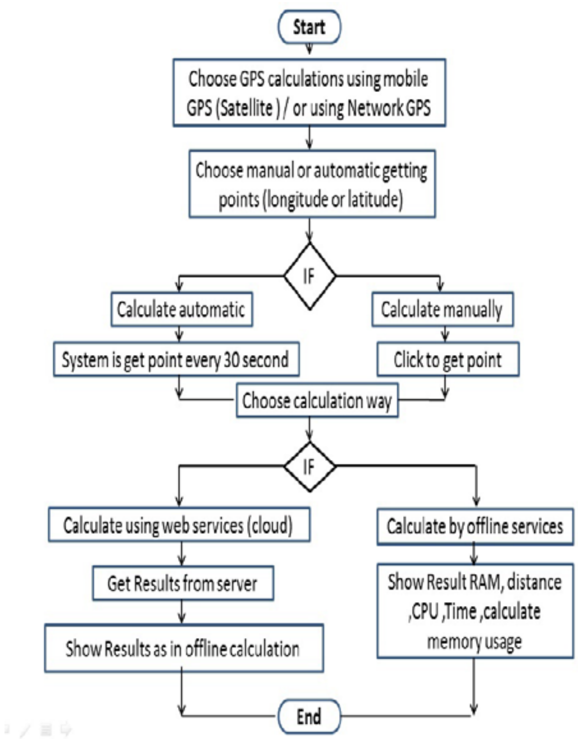


Fig. 3 The road map for experiments steps

**In third step**: After selecting method to get points either manually or automatic, we have to choose between calculation way on mobile or by partition and offloading to perform part of calculation on mobile and part on cloud server

a) In case calculation on mobile , calculation is conducted in case of getting points manually or automatic Mobile Application –Android- will take GPS reading and perform calculations over certain period of time

I. GPS reading to determine latitude and longitude for each point either by GPS for mobile (smart phone (satellite) ) or from mobile network
II. Then calculate the distance between two point or more using Haversine algorithm
III. The Application will perform all calculations on smart phone device and calculate the results and the consuming resources such as Memory consumed , CPU usage , Time consumed for calculation , battery consumed to perform the processes, time consumed for calculations and for getting points

b) In case of partition and offloading calculation on cloud and mobile , We implement cloud clone application that enables the mobile applications developers to take decision of performing all application processes on an android mobile device or to divide the application processes to execute on mobile & cloud

I. GPS reading to determine latitude and longitude for each point either by GPS for mobile (smart phone (satellite) ) or from mobile network (this step execute on mobile device )
II. Then data(longitude and latitude for each point) is transmitted to cloud server to perform calculation on cloud
III. the distance between two point or more using Haversine algorithm calculation performed on cloud the distance between two point or more using Haversine algorithm
IV. The Application will perform distance calculations on cloud server and calculate the results and the consuming resources such as Memory consumed for sending and receiving results , Memory consumed for distance calculations only , Memory consumed for all process from getting points till receive results, CPU usage , Time consumed for calculation , battery consumed to perform the transmitting data, time consumed for calculations and for getting points

## 5.1 Distance Calculation

for our experiment ,distance calculations between two point using the ‘haversine’ formula to calculate the great-circle distance between two points – that is, the shortest distance over the earth’s surface – giving an ‘as-the-crow-flies’ distance between the points (ignoring any hills, of course!).

**Haversine formula:**

$$a = \sin^2(\Delta\varphi/2) + \cos(\varphi_1).\cos(\varphi_2).\sin^2(\Delta\lambda/2) \quad (1)$$
$$c = 2.\mathrm{atan2}(\sqrt{a}, \sqrt{(1-a)}) \quad (2)$$
$$d = R.c \quad (3)$$

***φ is latitude, λ is longitude, R is earth's Where radius (mean radius = 6,371km)***

***note that angles need to be in radians to pass to trig unctions!***

The haversine formula 'remains particularly well-conditioned for numerical computation even at small distances' – unlike calculations based on the spherical law of cosines. The 'versed sine' is 1-cosθ, and the 'half-versed-sine' (1-cosθ)/2 = sin²(θ/2) as used above. It was published by Roger Sinnott in Sky & Telescope magazine in 1984 ("Virtues of the Haversine"), though known about for much longer by navigators. (For the curious, c is the angular distance in radians, and a is the square of half the chord length between the points). A (surprisingly marginal) performance improvement can be obtained, of course, by factoring out the terms which get squared.

## 6. Experiment

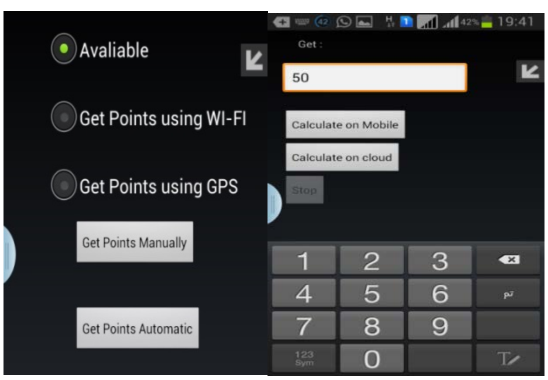


Fig. 4. Snapshot of elastic GPS application on Samsung Galaxy Grand

Experimental results are shown in( Fig 5) ,( Fig 6) , (Fig 7) , and (Fig 8) for different data calculation using automatic calculations getting longitude and latitude for each point rang from calculating distance between two points till fifty points in case of distance range from approximately 100 meter till 16 kilo meter in case of all calculation done on mobile device or application is partitioned and offloading on cloud to perform distance calculation on cloud.

(Fig. 5) shows the results of execute all application processes on mobile smart phone only. The results include the following matrices

- Memory consumed in bytes for GPS calculation only (getting longitude and latitude for each point)
- Memory consumed in bytes for calculating distances between points
- CPU usage to execute application in Mega Hertz
- Total Memory consumed to execute application in Mega Hertz.

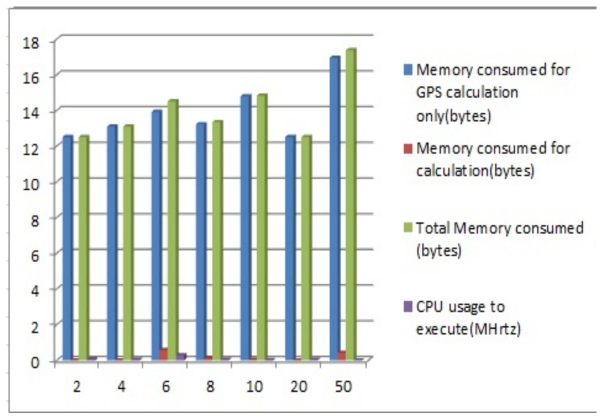


Fig. 5 Resources consumed for execution application on mobile

(Fig. 6) shows the results of portioned and offloading application and getting latitude and longitude for each point on mobile smart phone and execute distance calculations on cloud. The results include the following matrices

- Memory consumed on mobile (bytes) for GPS calculation only (getting longitude and latitude for each point)
- Memory consumed on cloud ( bytes) for calculating distances between points on cloud
- Memory consumed for send points longitudes and latitudes to server or receive results from server to mobile smart phone
- Total Memory consumed to execute application in Mega Hertz

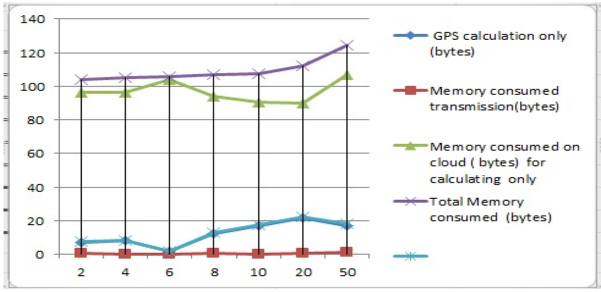


Fig. 6 Resources consumed for execution application on cloud

From the previous two figures (Fig. 5), and (fig.6), The performance of execute application on mobile or cloud in terms of Power consumption and memory consumed using different distance and number of points are shown in (Fig 7), and the performance of execute application on mobile or cloud in terms of time consumed are shown in (Fig 8)

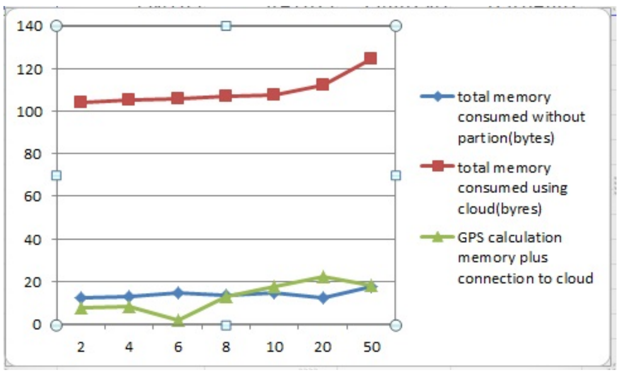


Fig. 7 Resources consumed for execution application on cloud

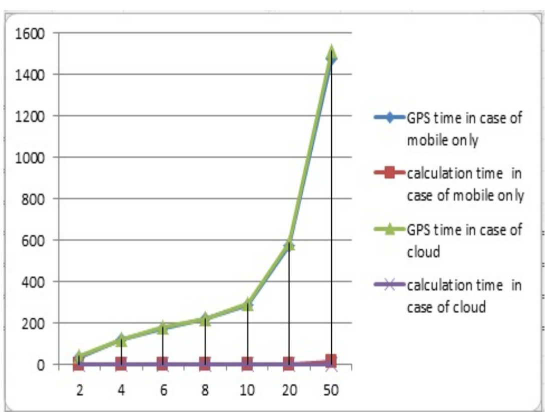


Fig. 8 Resources consumed for execution application on cloud

- ***RESULTS ANALYSIS***

-in case of performing all calculation on mobile smart phone most of resources consumed for getting GPS points (latitude and longitude for each point) as shown if (Fig.5). in case of partition and offloading application most of resources consumed on cloud and minimize the resources consumed in mobile smartphone as shown in (Fig 6),and (Fig.7) and time for calculation or getting point in mobile smartphone or cloud still as the same (fig .8)

## 7. Conclusion and Future Work

In mobile cloud computing, application offloading is implemented as a software level solution for augmenting computing capabilities of smart mobile devices. In this paper, we present a survey of the energy-efficient technologies in mobile cloud computing, provide the definitions and architectural designs of MCC. We summarize related works in energy-efficient wireless transmission.

In this paper, we proposed the elastic partition algorithm and partition cost module. Sending computation to another machine is a good idea. Cloud vendors thus provide computing cycles, and users can use these cycles to reduce the amounts of computation on mobile systems and save energy. Thus, cloud computing can save energy for mobile users through computation offloading. Virtualization, a fundamental feature in cloud computing, lets applications from different customers run on different virtual machines, thereby providing separation and protection. We conclude that there are two main optimization approaches in MCC, which are focusing on the limitations of mobile devices, and division applications services. Firstly, using virtualization and , and immigrate task from mobile device to cloud .secondly , deploying an effective elastic application division mechanism is estimated to be the best solution to guarantee the application service in MCC.We believe that there are still great opportunities for researchers to make ground-breaking contributions in this field, thus bringing significant impacts to the development in the industry. We hope our work will provide a better understanding of design challenges surrounding energy-efficient MCC

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## Reference

[1] Zhang, X., Jeong, S., Kunjithapatham, A., Gibbs, S.: *Towards an Elastic Application Model for Augmenting Computing Capabilities of Mobile Platforms.* In: The 3rd

International ICST Conference on Mobile Wireless Middleware, Operating Systems, and Applications (MobileWare), vol. 48(4), pp. 161–174 (2010)

[2] Fan, X., Cao, J.: *A Survey of Mobile Cloud Computing*. ZTE Communications 9(1), 4–8 (2011)

[3] Armbrust, M., Fox, A., Griffith, R., Joseph, A.D., Katz, R.H., Konwinski, A., Lee, G., Patterson, D.A., Rabkin, A., Stoica, I., Zaharia, M.: *Above the clouds: A berkeley view of cloud computing*. Technical Report UCB/EECS-2009-28, University of California, Berkeley (February 2009)

[4] Giurgiu, I., Riva, O., Juric, D., Krivulev, I., Alonso, G.: *Calling the Cloud: Enabling Mobile Phones as Interfaces to Cloud Applications*. In: Bacon, J.M., Cooper, B.F. (eds.) Middleware 2009. LNCS, vol. 5896, pp. 83–102. Springer, Heidelberg (2009)

[5] Daniela,E. P., Alina.M. L., “Mobile Cloud Computing”, Book Chapter in “New Trends in Mobile and Web Development 2012”, Publication series of Lahti University of Applied Sciences, ISBN 978-951-827-141-6, Chapter 10, pp. 287-336, 2012

[6] Le Guan, Xu, K. , Meina ,S. , and Junde ,S., “A Survey of Research on Mobile Cloud Computing”, IEEE/ACIS 10th International Conference on Computer and Information Science (ICIS), 2010, pp. 387-392.

[7] Xiaopeng F, Jiannong C, and Haixia M, "A Survey of Mobile Cloud Computing", ZTE Communications, Special Issue on Mobile Cloud Computing and Applications, Vol.9, pp.4-8,No. 1, 2011

[8] Niroshinie F, Seng W. L, Wenny R, Mobile cloud computing: A survey, Future Generation Computer Systems, Volume 29, Issue 1, January 2013, pp. 84-106.

[9] Chun, B.-G., Maniatis, P.: Augmented smartphone applications through clone cloud execution.In: USENIX HotOS XII (2009)

[10] Zhang, X., Schiffman, J., Gibbs, S., Kunjithapatham, A., Jeong, S.: Securing elastic applications on mobile devices for cloud computing. In: Proc. of ACM Cloud Computing Security Workshop (2009)

[11] Huerta-Canepa, G., Lee, D.: A virtual cloud computing provider for mobile devices. In: Proc. of the 1st ACM Workshop on Mobile Cloud Computing & Services: Social Networks and Beyond (2010)

[12] Satyanarayanan, M., Bahl, P., Caceres, R., Davies, N.: The Case for VM-Based Cloudlets in Mobile Computing. In: Proc. IEEE Pervasive Computing, vol. 8(4), pp. 14–23 (2009)

[13] Kovachev ,D. , Tian Y ; Klamma, R. "Adaptive Computation Offloading from Mobile Devices into the Cloud," Parallel and Distributed Processing with Applications (ISPA), 2012 IEEE 10th International Symposium on , vol., no., pp.784-791, 10-13 July 2012.

[14] Gu, X., Messer, A., Greenberg, I., Milojicic, D., Nahrstedt, K.: Adaptive offloading for pervasive computing. IEEE Pervasive Computing, 66

[15] OnLive Inc., “OnLIve.” [Online]. Available: http://www.onlive.com

[16] Byung,G C., Sunghwan ,I., Petros ,MClonecloud: elastic execution between mobile device and cloud, in: Proceedings of the Sixth Conference on Computer Systems, EuroSys’11, ACM, New York, NY, USA, 2011, pp. 301–314.

[17] Marinelli E.E., Hyrax: cloud computing on mobile devices using MapReduce, Masters Thesis, Carnegie Mellon University, 2009.

[18] Kemp R, Palmer N., Kielmann T., Bal H., Cuckoo: a computation offloading framework for smartphones, in: Proceedings of The Second International Conference on Mobile Computing, Applications, and Services, MobiCASE’10.

[19] Vallina- N R, Crowcroft, E J: achieving energy savings in mobile OS, in: Proceedings of the Sixth International Workshop on MobiArch, MobiArch’11, ACM, New York, NY, USA, 2011, pp. 37–42.

[20] Xinhui .L, Ying. L , Tiancheng,L , , The method and tool of cost analysis for cloud computing, in: Proceedings of IEEE International Conference on Cloud Computing, CLOUD’09, pp. 93–100.

[21] Kumar K , Lu Y, Cloud computing for mobile users: can offloading computation save energy? Computer 43 (2010) 51–56.

[22] Dean .J , Ghemawat. S , MapReduce: simplified data processing on large clusters, Communications of the ACM 51 (2008) 107–113.

[23] APPRIO Homepage : last accessed 13, October , 2013 http://www.appirio.com/

[24] Force.com Homepage : last accessed 13, October , 2013 http://www.salesforce.com/platform/

[25] Amazon Web Services : last accessed 13, October , 2013 http://aws.amazon.com/

[26] Tang. M. H., et.al “A dynamic mechanism for handling mobile computing environmental changes,” in InfoScale, no. 7, pp. 1-9, May 2006.

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