Mobile Cloud Computing Framework for Elastic Partitioned/Modularized Applications Mobility

Salah M El-Sayed[1,] Hatem M. Abdul Kader[2], Mohie M. Hadhoud[3], Diaa Salama AbdElminaam[4]
(Corresponding author: Hatem M. Abdul Kader)

Scientific Computing Department, Faculty of Computers and Informatics, Banha University
ms4elsayed@fci.bu.edu.eg

Information Systems Department, Faculty of Computers and Informatics, Menofyia University
hatem6803@yahoo.com

Information Technology Department, Faculty of Computers and Informatics, Menofyia University
mmhadhoud@yahoo.com

Information Systems Department, Faculty of Computers and Informatics, Banha University
Diaa.salama@fci.bu.edu.eg

(Received Jan. 27, 2014; revised and accepted May 4, 2014)

Abstract

Mobile applications are becoming increasingly ubiquitous and provide ever richer functionality on mobile devices. At the same time, such devices often enjoy strong connectivity with more powerful machines ranging from laptops and desktops to commercial clouds. Despite increasing usage of mobile computing; using its full potential is difficult due to its inherent problems such as limited resource. Cloud computing can address these problems by executing mobile applications on resource providers external to the mobile device. 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

In this paper, we developed an architecture that uses cloud to do computations that consume resources badly on mobiles. It aims at finding the right spots in an application automatically where the execution can be partitioned and 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 memory, and battery level. We demonstrate results of the proposed application model using data collected from one of our elastic application.

Keywords —Cloud computing, GPS, Mobile cloud computing (MCC), offloading, Partitioning and migration

1 Introduction

Mobile cloud computing is the cloud structure where the computation and hardware are moved departed from mobile devices .Mobile devices and applications acquire enjoyed rapid development in past years but mobile devices comfort cannot run data qualifier applications, much as search, large-scale information management and defense, etc., and have limitations in battery cognition, screen situation, wireless communication etc.

In primary, the energy render from the controlled battery ability [1] has been one of the most stimulating arrangement issues with mobile device. Thence, program decisions for mobile applications have to accept considerateness of the resource regulating in the pattern.

The emerging cloud computing field [2] offers a tense the capabilities of mobile device for energy-hungry salient applications. Different cloud-assisted mobile platforms acquire been planned, specified as cloudlet [3], cloud copy [4], and etc. In primary, each design is related with a system-level clone in a structure.

The mobile clone, which runs on a virtual Machine (VM), can effect mobile applications on behalf of the mobile device. This structure requires both a performance to apply task offloading and a contract to adjudicate when to offload applications. Existing investigate [5, 6, 7, 8] has proposed a show of application-offloading mechanisms. Nonetheless, the search on best policies for remedy offloading to cloud process is constricted in that they mostly take an unchangeable computing planning in the device and a fixed bandwidth model for the wireless canalize [9]. Mobile cloud technology (Figure.1) brings new types of services and facilities for mobile users to take full advantages of cloud computing. This paper introduces the basic terminology of cloud computing and mobile cloud computing, its background, key technology, current research status, and its further research perspectives as well. We focused on the problem of energy-optimal application execution in the cloud-assisted mobile platform. The objective is to minimize the total resources consumed by the mobile device such as memory, time, and power consumed.

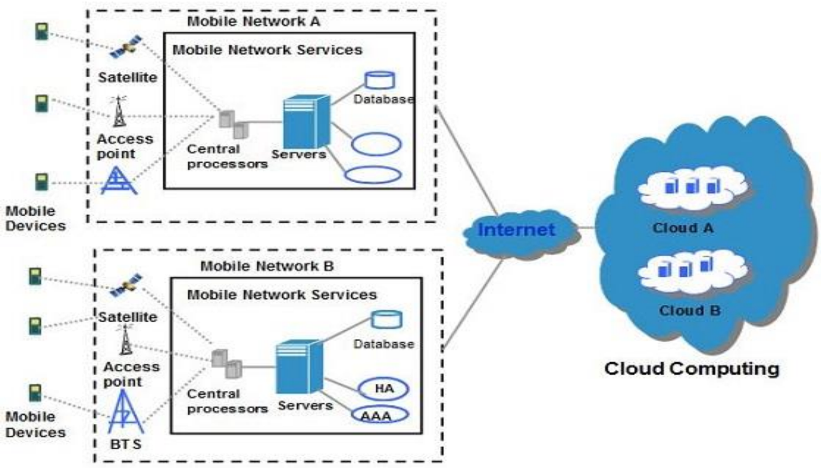


Figure 1: Mobile Cloud Computing (MCC)

The rest of the paper is organized as follows. Section 2 present cloud computing definitions and basic terminology of mobile cloud computing and its architectures Following that, respectively in the next section the discussion of related work of mobile cloud computing. Following that, respectively in the in Section 4 present problem definitions and system model, and the description of partition cost module and the evaluation. Finally, the conclusion lies in the last section.

2 Background

In order to help us better understanding of Mobile Cloud Computing, let’s start from the two previous techniques: Mobile Computing and Cloud Computing followed by mobile cloud computing.

A. *Mobile Computing*
B. *Cloud Computing*
C. *Mobile Cloud computing*

A. *Mobile Computing*

Mobility has become a very popular word and rapidly increasing part in today’s computing area. An incredible growth has appeared in the development of mobile devices such as, smartphone, PDA, GPS Navigation and laptops with a variety of mobile computing, networking and security technologies. In addition, with the development of wireless technology like WiMax, Ad Hoc Network and WIFI, users may be surfing the Internet much easier but not limited by the cables as before. Thus, those mobile devices have been accepted by more and more people as their first choice of working and entertainment in their daily lives. So, Mobile computing can described as a form of human-computer interaction by which a computer is expected to be transported during normal usage [10]. Mobile computing is based on a collection of three major concepts: hardware, software and communication. The concepts of hardware can be considered as mobile devices, such as smartphone and laptop, or their mobile components. Software of mobile computing is the numerous mobile applications in the devices, such as the mobile browser, anti-virus software and games. The communication issue includes the infrastructure of mobile networks, protocols and data delivery in their use. They must be transparent to end users. Mobile computing has the following Feature:

- Mobility
- Diversity of network conditions
- Frequent disconnection and consistency
- Dis-symmetrical network communication
- Low reliability

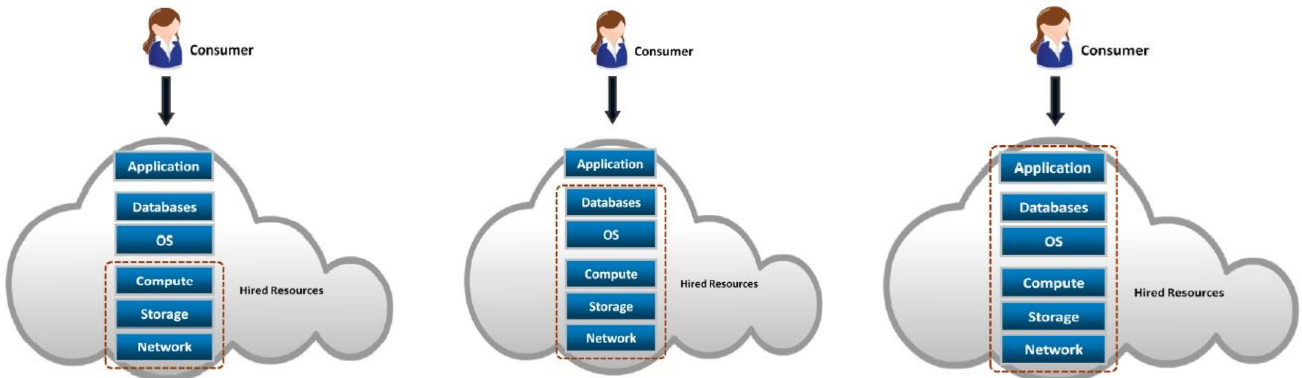
B. *Cloud Computing*

Cloud Computing is a general term used to describe a new class of network based computing that takes place over the Internet, basically a step on from Utility Computing. In other words, this is a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).Using the Internet for communication and transport provides hardware, software and networking services to clients (Figure 2).These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing very simple graphical interface or

API (Applications Programming Interface). In addition, the platform provides on demand services that are always on, anywhere, anytime and anyplace. Pay for use and as needed, elastic (scale up and down in capacity and functionalities). The hardware and software services are available to the general public, enterprises, corporations and businesses markets. 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 as shown in Figures 2(a), 2(b), and 2(c) (that show the comparison of different type of services provided by cloud computing):

- *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 [11], software as a service provider, is built using the Force.com [12] platform while the infrastructure is provided by the Amazon Web Service [13]). 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.



(a) Infrastructure as a Service (IaaS): (b) Platform as a Service (PaaS): (c) Software as a Service (SaaS)

Figure 2: The cloud computing services models

C. *Mobile Cloud computing*

There are several definitions of mobile cloud computing [14, 15], and different research refers to different concepts of the 'mobile cloud.The term mobile cloud computing means:

The combination of cloud computing and mobile networks to bring benefits for mobile users, network operators, as well as cloud providers. Cloud computing exists when tasks and data are kept on the Internet rather than on individual devices, providing on-demand access. Mobile cloud computing can involve other mobile devices and/or servers accessed via the Internet. A related notion is cloudlets, which has been viewed in different ways [16, 17]. Applications are run on a remote server and then sent to the user. Because of the advanced improvement in mobile browsers thanks to Apple, Google, Microsoft and Research in Motion, nearly every mobile should have a suitable browser. This means developers will have a much wider market and they can bypass the restrictions created by mobile operating systems. Mobile cloud computing gives new company chances for mobile network providers. Several operators such as Vodafone, Orange and Verizon have started to offer cloud computing services for companies [18].

3 Related Works

To give more prospective about the Mobile Cloud Computing, this section discusses the results obtained from other resources.

It was shown in [19] 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 [20] 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 applications to offload part of their execution from mobile devices onto device clones operating in a computational cloud.

It was presented in [21] 'Hyrax' for Android smartphone applications which are distributed both in terms of data and computation based on Hadoop 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.

AlfredO [22] is a middleware platform to automatically distribute different layers of application in smartphones and cloud, respectively, by modeling applications as a consumption graph, and finding the optimal modules. The test result shows that such platform improves the performance of applications in cloud computing effectively. AlfredO system consists of three bundles (the interface encapsulation on Java classes and services): AlfredOClient and Renderer on the client and AlfredO Core on the server (shown in Figure 3). There are several of researches about Mobile Cloud Computing can be found in [23, 24, 25]

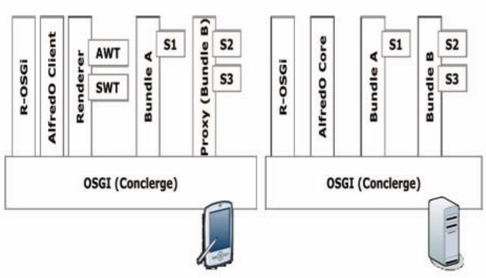


Figure 3: AlfredO Architecture

4 Problem Definition and System Model

In this section, we present a model for application execution on the cloud-assisted mobile application platform. Application system architecture as shown in Fig.5, First, we define a mobile application profile. Then, we calculate consuming resources for application execution, including resources consumed for computation on mobile execution and a transmission computation to cloud execution. The following Sequence steps for our framework application as shown in (Figure 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 PartotionMigrate2Cloud application smartphone calculate some of GPS calculations such as distance between two points or more till 100 points using different algorithms. For our experiment, we calculate the effects of Sending computation to cloud web service and back with results 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 to cloud.

In first step: 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 (it can be calculated by mobile GPS satellite or by mobile network).in this research we implement the two mode of operations

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.

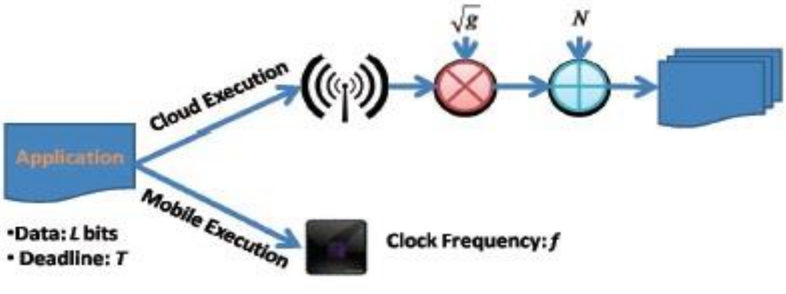


Figure 4: Mobile Application excuted in two alternative modes mobile Excution (lower) and the Cloud excution (upper)

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 will take GPS reading and perform calculations over certain period of time:
   1). GPS reading to determine latitude and longitude for each point either by GPS for mobile (smart phone) or from mobile network.
   2). Then calculate the distance between two point or more using different algorithms.
   3). 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 Migrations activities or methods to cloud, in this steps application is partition and migrate activities to cloud to consider this application as platform as a services (PaaS) and mobile considered as thin client 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.
   1). 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).
   2). Then data (longitude and latitude for each point) is migrated to cloud server to perform calculation on cloud.
   3). The distance between two point or more using different algorithms calculations performed on cloud the distance between two point or more using different algorithms.
   4). 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 Mathematical Calculation

5.1 Distance Using Haversine Formula

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 .The formula assumes that the earth is a sphere, (we know that it is "ellipse " shaped) – giving an ‘as-the-crow-flies’ distance between the points (ignoring any hills, of course!).

– haversine Formula

$$a = \sin^2(\Delta\varphi/2) + \cos(\varphi1).\cos(\varphi2).\sin^2(\Delta\lambda/2)$$
$$c = 2.\text{atan2}(\sqrt{a}, \sqrt{(1-a)})$$
$$d = R.c$$

$\Delta\varphi$ is latitude difference (lat2− lat1), $\Delta\lambda$ is longitude difference (long2− long1), R is earth’s radius(mean radius = 6,371km).

5.2 Distance Using Spherical Low of Cosines

When Sinnott published the haversine formula, computational precision was limited. Nowadays, most modern computers & languages use IEEE 754 64-bit floating-point numbers, which provide 15 significant figures of precision. With this precision, the simple spherical law of cosines formula gives well-conditioned results down to distances as small as around 1 metre:

– spherical law of cosines formula

$$\mathbf{d = acos(\sin(\varphi_1).\sin(\varphi_2) + \cos(\varphi_1).\cos(\varphi_2).\cos(\Delta\lambda)).R}$$

5.3 Distance Using Equirectangular Approximation

If performance is an issue and accuracy less important, for small distances Pythagoras’ theorem can be used on anequirectangular projection:

– Formula

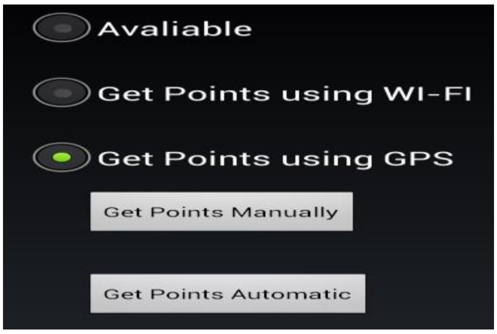
$$\mathbf{x = \Delta\lambda.\cos(\varphi)}$$
$$\mathbf{y = \Delta\varphi}$$

$$d = R.\sqrt{(x^2 + y^2)}$$

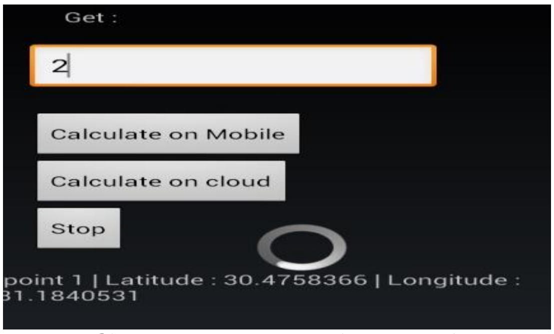
6 Experiment (Automatic Calculations)

6.1 Getting Points Using GPS Satellite

Figures 5(a) and 5(b) show the main interface for all steps of the application in case of getting points automatic using GPS satellite.



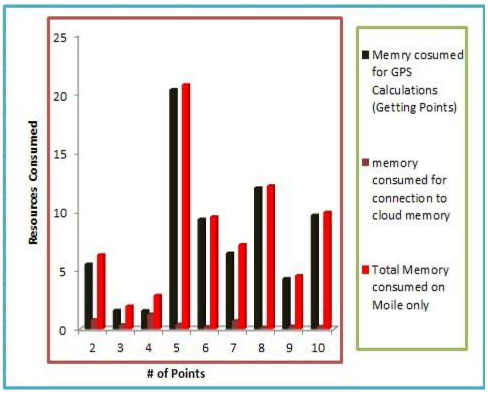
(a) Getting points (latitude and Longitude) using Mobile GPS Satellite



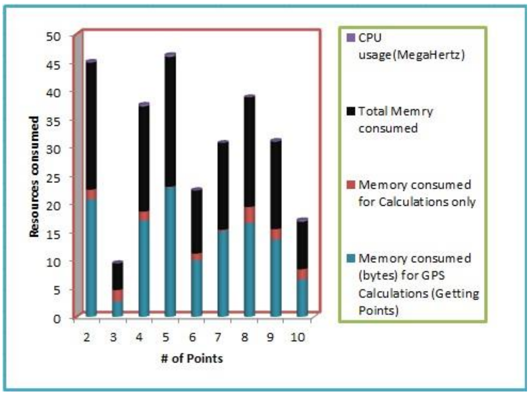
(b)Getting Points Automatic(every 30 Sec)

Figure 5: Snapshot of elastic GPS application on Samsung Galaxy Grand

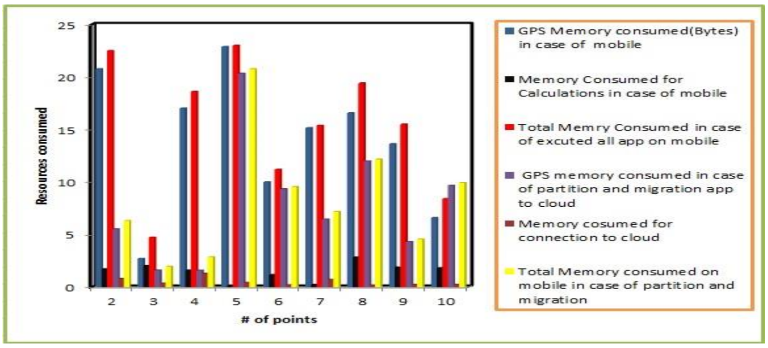
Table 1 shows resources consumed in case of automatic calculation in case of getting longitude and latitude for each point automatically every 30 second using GPS satellite for execution application on cloud web services and the for different number of points range from two points till ten points (GPS calculation on mobile smartphone and calculation migrated to cloud and return results to mobile).



(b)Resources consumed for execution app on mobile



(b)Resources consumed for execution app on mobile



(c) Memory consumed for execution application on mobile and cloud

Figure 6: Resources consumed for automatic calculation for Getting Points using GPS satellite

Figures 6(a), 6(b), and 6(c) show the experimental results for different data calculations using automatic method for getting longitude and latitude for each point rang from calculating distance between two points till ten points in case of distancing range from approximately 50 meter till 200 meter in case of all calculation done on mobile device or application is partitioned and offloading on cloud to perform distance calculation on cloud.

Table 1 and Figure 6(a) show the results of execute all application processes on mobile smartphone only. The results include the following matrices:

- Memory consumed for GPS calculation only (getting longitude and latitude for each point).
- Memory consumed for calculating distances between points.
- Total Memory consumed to execute app.
- Time consumed and CPU usage for calculations.

Figure 6(b) shows the results of partitioned and migrate activities to web services. The results include the following matrices:

- Memory consumed on mobile for 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 web services or receive results from web services to mobile smart phone.
- Total memory consumed on mobile smartphone for calculations.

Table 1: Resources consumed for execution application on mobile smartphone and cloud web services (getting points using gps satellite)

Automatic calculation for Getting Points using GPS Satellite																		
	Mobile Calculations								Cloud Calculations									
	Memory Consumed(bytes)			Time(sec)		Battery(percent)		CPU		Memory Consumed(bytes)				Time(sec)		Battery(percent)		
# points	GPS Calculations (Getting Points)	Calculations	Total Memory	GPS Calculations (Getting Points)	Calculations	Battery used for Calculations	Total Battery consumed	CPU usage(Megahertz)	# of points	GPS Calculations (Getting Points)	connection to cloud memory	Memory consumed for calculation only	Total Memory on Mobile	GPS Calculations (Getting Points)	Connection to Cloud	GPS Calculations (Getting Points)	Connection to Cloud	Total Battery
2	20.769531	1.71875	22.488281	30	1	0.0%	0.0%	0.18474126	2	5.5117188	0.8046875	104.21875	6.3164063	30	2	0.0%	0.0%	0.0%
3	2.703125	2.03125	4.734375	60	1	0.0%	0.0%	0.08333331	3	1.5898438	0.3671875	103.22875	1.9570313	60	1	0.0%	0.0%	0.0%
4	17.019531	1.5898438	18.6093748	90	1	0.0%	1.0%	0.33726683	4	1.5742188	1.2851563	105.0625	2.8593751	90	5	1.0%	0.0%	1.0%
5	22.875	0.11328125	22.98828125	120	1	0.0%	0.0%	0.3783784	5	20.3320031	0.421875	105.0859375	20.753906	120	1	0.0%	0.0%	0.0%
6	10	1.1825	11.1825	150	1	0.0%	0.0%	0.09859155	6	9.3359375	0.203125	105.9140625	9.5390625	150	1	0.0%	0.0%	0.0%
7	15.15625	0.23046875	15.38671875	180	1	0.0%	1.0%	0.034909904	7	6.4580313	0.70703125	105.9140625	7.16506255	180	1	1.0%	0.0%	1.0%
8	16.5703125	2.8425	19.4128125	210	1	0.0%	1.0%	0.07042256	8	11.9921875	0.171875	106.765625	12.1640625	180	1	1.0%	0.0%	1.0%
9	13.6210938	1.875595	15.4970438	240	1	0.0%	2.0%	0.1722334	9	4.3007813	0.24609375	106.765625	4.54687505	240	2	2.0%	0.0%	2.0%
10	6.5976563	1.8164063	8.4140626	300	1	0.0%	1.0%	0.30555555	10	9.675781	0.23828125	107.6171875	9.91406225	300	1	1.0%	0.0%	1.0%

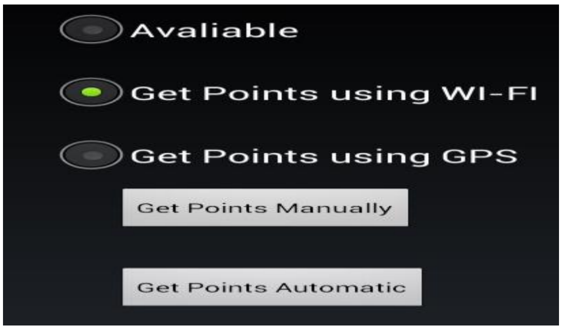
The performance of execute application on mobile or cloud in terms of memory consumed using different distance and number of points are shown in Fig 6(c).the total memory consumed on mobile in the case of cloud or in the case of executed all the application on mobile only. According to partition and migrate app to cloud, most of resources consumed on mobile smartphone will decrease approximately to the half as shown in Figure 6(c). In case of partition and offloading application most of resources consumed on cloud and minimize the resources consumed in mobile smartphone.

6.2 Getting Points Using Network GPS

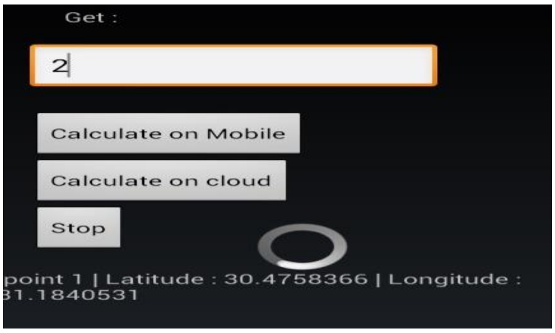
Figures 7(a) and 5(b) show the main interface for all steps of the application in case of getting points automatic using network GPS. Table 2 shows resources consumed in case of automatic calculation in case of getting longitude and latitude for each point automatically every 30 second using network GPS for execution application on cloud web services and the for different number of points range from two points till ten points.

Table 2: Resources consumed for execution application on mobile smartphone and cloud web services (Getting points using GPS SATELLITE)

	Automatic calculation for Getting Points using Network GPS																	
	Mobile Calculations								Cloud Calculations									
	Memory Consumed(bytes)			Time(sec)		Battery(percent)		CPU		Memory Consumed(bytes)				Time(sec)		Battery(percent)		
# points	GPS Calculations (Getting Points)	Calculations	Total Memory	GPS Calculations (Getting Points)	Calculations	Battery used for Calculations	Total Battery consumed	CPU usage(Megahertz)	# of points	GPS Calculations (Getting Points)	connection to cloud memory	Memory consumed for calculation only	Total Memory on Mobile	GPS Calculations (Getting Points)	Connection to Cloud	GPS Calculations (Getting Points)	Connection to Cloud	Total Battery
2	11.7503125	1.1914063	12.9417188	30	1	0.0%	1.0%	0.22927971	2	1.7539063	0.5742187	103.8984375	2.328125	30	3	1.0%	0.0%	1.0%
3	13.464844	0.53125	13.996094	60	1	0.0%	0.0%	0.04198918	3	4.78215	0.08203215	103.8984375	4.86418215	60	3	0.0%	0.0%	0.0%
4	10.5078125	8.167969	18.6757815	90	1	1.0%	1.0%	0.029733963	4	6.234375	0.1328215	104.8515625	6.3671965	90	1	1.0%	0.0%	1.0%
5	5.7890625	0.12109375	5.91015625	120	1	0.0%	0.0%	0.0833334	5	4.421875	0.07206275	104.8515625	4.49393775	120	1	0.0%	0.0%	0.0%
6	4.2109375	0.29296875	4.50390625	150	1	0.0%	1.0%	0.10329509	6	3.316406	0.0585937	105.828125	3.3749997	150	1	1.0%	0.0%	1.0%
7	4.273437 5	0.15625	4.429683 75	180	1	0.0%	1.0%	0.280092882	7	1.890625	0.332031 25	105.727315	2.222656 25	180	1	1.0%	0.0%	1.0%
8	6.6757813	0.03125	6.7070313	210	1	0.0%	1.0%	0.097793005	8	5.980469	0.0546875	106.796875	6.0351565	180	1	1.0%	0.0%	1.0%
9	12.5117188	10.40625	22.9179688	240	1	0.0%	1.0%	0.054054 06	9	11.453125	1.234375	107.2578125	12.6875	240	3	1.0%	0.0%	1.0%
10	4.0429688	0.390625	4.4335938	270	1	0.0%	2.0%	0.49080235	10	3.5703125	0.3046875	108.25	3.875	270	1	2.0%	0.0%	2.0%



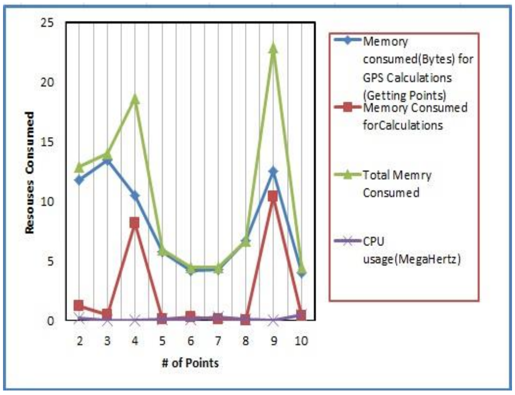
(a) Getting points (latitude and Longitude) using Mobile Network GPS



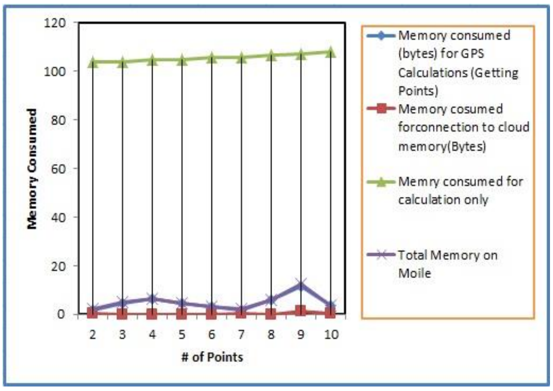
(b)Getting Points Automatic(every 30 Sec)

Figure 7: Snapshot of elastic GPS application on Samsung Galaxy Grand

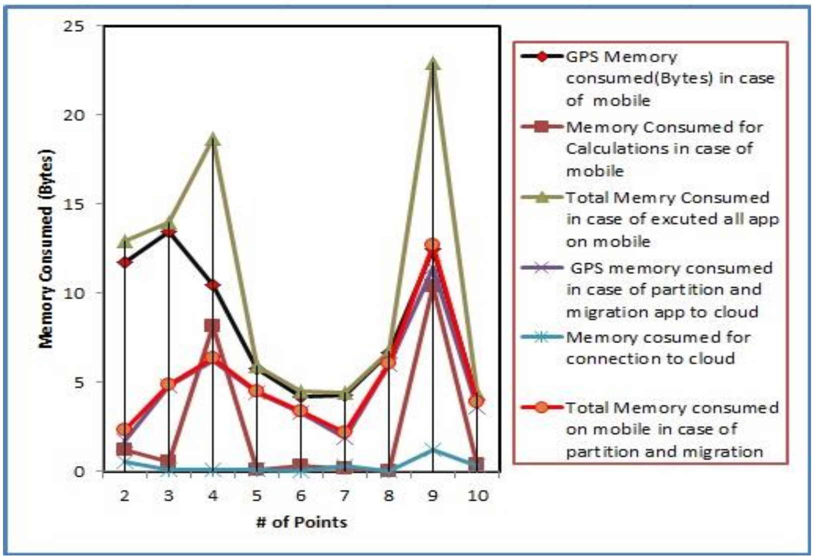
Figures 8 shows the experimental results for different data calculations using automatic method for getting longitude and latitude for each point rang from calculating distance between two points till ten points in case of distance range from approximately 50 meter till 200 meter in case of all calculation done on mobile device or application is partitioned and offloading on cloud to perform distance calculation on cloud.



(b)Resources consumed for execution app on mobile



(b)Resources consumed for execution app on mobile



(c) Memory consumed for execution application on mobile and cloud

Figure 8: Resources consumed for automatic calculation for Getting Points using Network GPS

- Figure 8(a) shows the results of execute all application processes on mobile smartphone only. The results include as the same as in case of getting point using GPS Satellite such as memory consumed for getting points only, memory consumed for calculations only, CPU usage for calculation, and Time consumed.
- Figure 8(b) shows the results of partitioned and offloading application on cloud. The results include as the same as in case of getting point using GPS Satellite.
- Figure b(c) shows The performance of execute application on mobile or cloud in terms of memory consumed using different distance and number of points .According to partition algorithm, most of resources consumed on mobile smartphone will decrease approximately to the half. In case of partition and offloading application most of resources consumed on cloud and minimize the resources consumed in mobile smartphone.

7 Conclusion and Future Work

In this paper, we proposed the elastic partition algorithm and partition cost module. Partition and migrate activities and method from mobile smartphone to cloud web services is a good idea and may reduce resources on mobile. Thus, cloud computing can save energy for mobile users through computation offloading. Cloud computing can used for extending battery lifetime (Computation offloading migrates large computations and complex processing from resource-limited devices (i.e., mobile devices) to resourceful machines (i.e., servers in clouds)). Remote application execution can save energy significantly. Also CC can help in improving data storage capacity and processing power. MCC enables mobile users to store/access large data on cloud. It can help in reduce the running cost for computation intensive applications. Those results by mobile applications are not constrained by storage capacity on the devices because their data now is stored on the cloud.

In future we will consider smartphone devices as thin clients and migrate all app automatically to cloud web services that can help in improving reliability and availability (Keeping data and application in the clouds reduces the chance of lost on the mobile devices). CC can also increase scalability (Mobile applications can be performed and scaled to meet the unpredictable user demands, Service providers can easily add and expand a service).

Acknowledgments

This study was supported by the Faculty of computer and informatics (Benha University, Menofyia University). The authors gratefully acknowledge the anonymous reviewers for their valuable comments.

References

[1]. A. P. Miettinen and J. K. Nurminen, ”Energy efficiency of mobile clients in cloud computing,” *In Proceedings of the 2nd USENIX conference on hot topics in cloud computing*, Berkeley, CA, USA, 2010.

[2]. M. Armbrust, A. Fox, R. Griffith, A. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, ”A view of cloud computing”, *Communication of the ACM, vol.* 53, no. 4, pp.50-58, 2010.

[3]. M. Satyanarayanan , P. Bahl, R. Caceres , and N.Davies,”The Case for VM-based Cloudlets in Mobile Computing,” *IEEE Pervasive Computing*, Vol. 8, No. 4, pp. 14-23, Oct.-Dec. 2009.

[4]. B. G.Chun, and P.Maniatis,”Augmented Smartphone Applications Through Clone Cloud Execution,” *In Proceedings of the 12th conference on Hot topics in operating systems*, Berkeley, CA, USA, 2009.

[5]. R. K. Balan,”The Case for Cyber Foraging,” *In Proceedings of 10th ACM Special Interest Group on Operating Systems European Workshop(SIGOPS),* ACM Process, pp. 87-92, 2002.

[6]. M.Satyanarayanan, ”Pervasive Computing: Vision and Challenges,” *IEEE Personal Communication*, Vol. 8, No. 4, pp.10-17,2001.

[7]. B.G.Chun, S.h.Ihm, P.Maniatis, M.Naik, and A.Patti, ”CloneCloud: Elastic Execution between Mobile Device and Cloud,” *In Proceedings of the 6th European Conference on Computer Systems* (EuroSys 2011), April 2011.

[8]. X. W. Zhang, A. Kunjithapatham, S. Jeong and S. Gibbs, ”Towards an Elastic Application Model for Augmenting the Computing Capabilities of Mobile Devices with Cloud Computing,” *Mobile Network Applications*, vol 16, pp. 270-284, 2011.

[9]. K. Kumar, and Y. H. Lu,”Cloud Computing for Mobile Users: Can Offloading Computation Save Energy?” *IEEE Computer*, Vol. 43, No.4, pp. 51-56, April 2010.

[10]. M. Satyanarayanan, ”Fundamental challenges in mobile computing”, *in: Proceedings of the Fifteenth Annual ACM Symposium on Principles of Distributed Computing*, PODC’96, ACM, New York, NY, USA, pp. 1–7, 1996.

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

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

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

[14]. E. P. Daniela, 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

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

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

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

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

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

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

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

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

[23]. G.H. Canepa, D.Lee, ”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.

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

[25]. D.Kovachev ., Y.Tian, R.Klamma . ”Adaptive Computation Offloading from Mobile Devices into the Cloud, ” *Parallel and Distributed Processing with Applications (ISPA), IEEE 10th International Symposium*, pp.784-791, 10-13 July 2012.

Salah M. Elsayed, Dean, Faculty of Computers and Information, head of Scientific Computing Department, Benha University, Benha, Egypt. His PhD degree, in Numerical Analysis from the department of Numerical, Theory and Algorithms of Numerical Linear Algebra, and numerical methods of ordinary and partial differential equations (multi-integral and finite difference methods. A domain decomposition method and chebychev pseudo spec trail methods. Prof Salah obtain Egyptian incentive prize of science in mathematics 2002,and Scopus prize of Best Author have higher citation and H-Index in Scopus 2008 in the last ten years. Prof. Salah has published more than 150 papers in international journals, international conferences, local journals and local conferences. His fields of Interest: Numerical Analysis, numerical methods of ordinary and partial differential equations, and Information security and data hiding.

Hatem. M. Abdul-kader vice Dean of Faculty of Computers and Information, Menoufia university, Shebin Elkom, Egypt. Prof Hatem obtained his BSC. And M.SC. (by research) both in Electrical Engineering from the Alexandria University, Faculty of Engineering, Egypt in 1990 and 1995 respectively. He obtained his Ph.D. degree in Electrical Engineering also from Alexandria University, Faculty of Engineering, in 2001 specializing in neural networks and applications. Since 2009 he is the Head of the department of Information Systems (IS). Prof. Hatem has published more than 100 papers in international journals, international conferences, local journals and local conferences. He is currently a Professor in Information systems department, Faculty of Computers and Information, Menoufya University, Egypt since 2004.

Mohiy Mohamed Hadhoud, Former vice president of Menoufia university for education and student affairs and former dean of Faculty of Computers and Information, University, Shebin Elkom, Egypt. Currently, he is the dean of Canadian International College (CIC) in New Cairo. He is a member of National Promotion committee for professors, he is a member of National Computers and Informatics Sector Planning committee, and is the University training supervisor. Prof Hadhoud graduated from the department of Electronics and Computer Science, Southampton University, UK, 1987. Since 2001 he worked as a Professor of Multimedia, Signals and image processing and Head of the department of Information Technology (IT), He was a member of the university council. He is the recipient of the university supremacy award for the year 2007. He, among others are the recipient of the Most cited paper award from the Digital signal processing journal, Vol.18, No. 4, July 2008, pp 677-678, ELSEVIER Publisher. Prof. Hadhoud has published more than 160 papers in international journals, international conferences, local journals and local conferences. His fields of Interest: Digital Signal Processing, 2-D Adaptive filtering, Digital Image Processing, Digital communications, Multimedia applications, Information security and data hiding.

Diaa Salama Abdul-Minaam was born on November 23, 1982 in KafrSakr, Sharkia, Egypt. He received the B.S from Faculty of Computers &Informatics, Zagazig University, Egypt in 2004 with grade very good with honor, and obtains master degree in information system from faculty of computers and information, menufia university, Egypt in 2009 and submitted for PhD from October 2009. He is working in Benha University, Egypt as teaching assistance at Faculty of Computer and informatics. Diaa has contributed more than 18+ technical papers in the areas of wireless networks, wireless network security, Information security and Internet applications in international journals, international conferences, local journals and local conferences. He majors in Cryptography and Network Security. (Mobile: +20166104747 E-mail: ds_desert@yahoo.com).