IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Special Issue, 4, Feb 2019 E-ISSN: 2347-2693

Versatile Distributed Computing Taxonomy

J. Mary Ramya Poovizhi

Department of computer science, Immaculate College for women, India

Corresponding Author: mrp.jamesanto@gmail.com

Available online at: www.ijcseonline.org

***Abstract*—**As indicated by NIST meaning of distributed computing, it has five attributes: on-request self-benefit, broad network access, asset pooling, rapid elasticity, and measured services, while mobile computing figuring centers around gadget portability and setting mindfulness considering systems administration and versatile asset/information get to. Portable distributed computing is normally viewed as expanding on distributed computing and versatile registering; be that as it may, it has some one of a kind highlights, for example, benefit offloading, migration, composition Versatile distributed computing advances portable figuring innovations and use bound together flexible assets of fluctuated mists and system advances. This part gives a review of different vital ideas that are very identified with versatile distributed computing and outline their relations through genuine models.

***Keywords*—** Data collection , Measurement sensor, Radiocommunication, Distributed system Network, protocol Energy consumption, Taxonomy

I. INTRODUCTION

MCC has originated from mobile computing and cloud computing, but there are significant differences between MCC and cloud computing, and between MCC and mobile computing. Here in this paper we are going to see an overview of MCC, cloud computing, and mobile computing. The two important topics about mobile cloud are mobile cloud infrastructure and mobile cloud offloading, which will be discussed after the overview of MCC. Mobile cloud applications, including application programming platforms, will be presented at the end.

II. CLOUD COMPUTING

In order to support the maximum number of user and elastic service with the minimum resource, the Internet service provider invented the cloud computing. within a few years, emerging cloud computing has become the hottest technology.

The National Institute of Standards and Technology (NIST), which is an agency of the US Department of Commerce, gives its definition of cloud computing [1]:

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

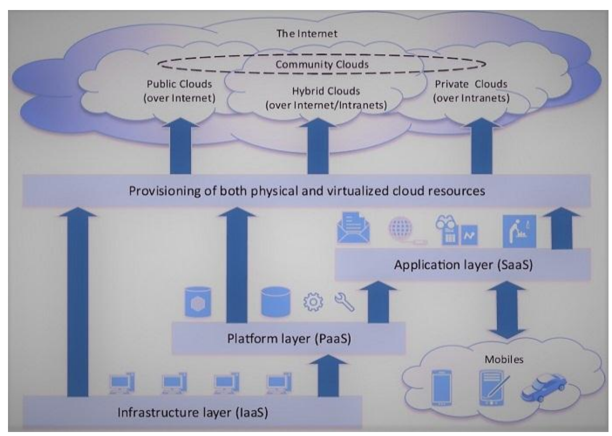

Figure 1 Cloud computing classification

The NIST definition of cloud computing is composed of five essential characteristics, three service models, and four deployment models. The essential characteristics are:

On-demand self-service:A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

Broad network access:Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

Resource pooling:The provider's computing resources are pooled to serve multiple consumers using a multitenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, Software as a Service (SaaS): The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based e-mail), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

Platform as a Service (PaaS): The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

Infrastructure as a Service (IaaS): The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

Cloud computing is usually deployed in four scenarios according to how the cloud infrastructure is constructed. The four deployment models are:

Private cloud. The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

Public cloud. The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.

Hybrid cloud. The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

Community cloud. The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.

III. MOBILE COMPUTING

The Idea of mobile computing has only been around since the 1990s. Since then, Mobile computing has evolved from two-way radios that use large antennas to communicate simple messages to three-inch personal computers that can do almost everything a regular computer does. People can’t go to their local Starbucks and not see a laptop linked up to a hotspot Static network. This actually used to mean radio transmitters that operated on a stable base, usually with the help of large antennas. 2-way radios used by police officers were also considered mobile technology but now, it means people can connect wirelessly to the internet or to a private network almost anywhere. As long as a person has one of the devices capable of wirelessly accessing the internet, they are participating in mobile computing. Chances are, you have done it with a laptop computer or a personal digital assistant or PDA.So they decide to come up with an idea of portable devices These days, Pocket PCs are another way to conveniently access the internet on the earth devices that have been developed for mobile computing have taken over the wireless industry. This new type of communication is a very powerful tool for both businesses and personal use. The portable computer has change computing world conferred to hundred years’ back. from huge machines that could not do much more than word processing to tiny hand-held device. It offers the opportunity to bring people together and give everyone access to a greater wealth of information and knowledge, and to share their knowledge with others.

WHY MOBILE COMPUTING

Mobile computing is all about portable and small computers, which includes PDAs (Personal Digital Assistants) like mobile phones, palmtops, laptops etc. In this growing technological world, people are much bound to work on computers and Internet. People are attracted towards mobile devices because of their major features such as-Mobile computing can be defined as the ability to use technology that is not physically connected to any static network. Nowadays, most laptops and personal digital assistants(PDA) all have wireless cards or Bluetooth interfaces built into them for very Good mobile internet access. Mobile computing is "taking a computer and all necessary files and software to the next Level.

They are wireless devices. Mobile devices are portable that enables easy to carry and work with while you are on the move. Has attractive user interface.Provide many features like wireless LAN to access Internet from any part of the world.Enables voice and typical data transmission. Enables one to one contact to have conversations. Though the mobile computing devices have drawbacks such as low bandwidth, lack of security, loss of connectivity and battery backup issue, people still prefer mobile computing devices to desktops.

They are wireless devices.Mobile devices are portable that enables easy to carry and work with while you are on the move.Has attractive user interface.Provide many features like wireless LAN to access Internet from any part of the world.Enables voice and typical data transmission Enables one to one contact to have conversationsThough the mobile computing devices have drawbacks such as low bandwidth, lack of security, loss of connectivity and battery backup issue, people still prefer mobile computing devices to desktops.

IV. MOBILE CLOUD COMPUTING

In recent years, as a result of the tremendousdevelopments in mobile networks andtechnologies, mobile computing (MC) has become an emerging area of research. In the pastdecades, people used computers for computing purposes. According to the recent surveys, people are willing to use mobile devices such as laptops, Smartphones, personal digitalassistants (PDAs), tablets, i-Pads, and so on, rather than the immobile desktop computers.

The current smartphone user base already has reached the 1 billion mark. So, computingthrough mobile devices has become a more feasible concept than the conventional approach.But still some drawbacks such as lack of storage, computational power, and limited batterylife of mobile devices have become the challenges for MC technology.To overcome these challenges, cloud can be a useful solution. Cloud is the combinationof virtualization of a high amount of resources with a distributed computing paradigmincorporated with software as a service (SaaS), platform as a service (PaaS), and infrastructureas a service (IaaS). Various cloudproviders such as Microsoft Azure and AmazonEC2 provide seamless elastic storage and processing in an "On demand," "Pay as youuse" manner. So, integration of mobile computing with cloud computing (CC) has givenbirth to a newer and better technological approach called mobile cloud computing (MCC),as shown in Figure 2. In a simple sense, MCC is nothing but cloud computing in whichmobile devices are involved as the thin clients. Here, data will be offloaded into cloud frommobile devices for computation or storage.

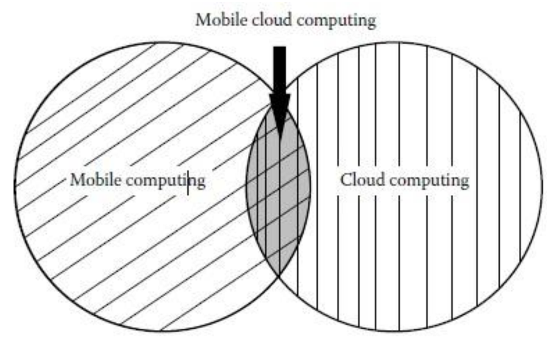

Figure 2.Mobile Cloud Computing

Researchers usually use a computational augmentation approach, by which resource-constrained mobile devices can utilize computational resources of varied cloud-based resources through offloading functions from mobiles to clouds. In general, there are four types of cloud-based resources, namely Internet clouds where immobile clouds are accessed through the Internet, proximate immobile computing entities, proximate mobile computing entities, and hybrid (combination of the other three models). Internet clouds such as Amazon EC2 [2] are in the distant immobile groups, whereas Cloudlet [3] or its surrogates are members of proximate immobile computing entities. Smartphones, tablets, handheld devices, and wearable computing devices are part of the third group of cloud-based resources, which is proximate mobile computing entities.

In the MCC landscape, an amalgam of mobile computing, cloud computing, and communication networks (to augment smartphones) creates several complex challenges such as mobile computation offloading, seamless connectivity, long WAN latency, mobility management, context-processing, energy constraint, vendor/data lock-in, security and privacy, elasticity that hinder MCC success and adoption. As shown in Fig. 3, although significant research and development in MCC is available in the literature, efforts in the following domains still need significant investigation:

• Situation-awareness issues. Situation-aware computing possesses inseparable traits of contemporary handheld computers. To achieve the vision of mobile computing among heterogeneous converged networks and computing devices, designing resource-efficient, use-behavior sensing, and secure/privacy-aware MCC application running environment is an essential need.

• Architectural issues. A reference architecture for heterogeneous MCC environment is a crucial requirement for unleashing the power of mobile computing towards unrestricted ubiquitous computing. A current trend is to transit from a cloud- and network-centric service model to a user-centric model, where situation-awareness on real-time sensing and supporting users' need is the key factor to make MCC applications success.

• Function and service migration issues. Executing resource-intensive mobile application via function/service offloading involves encapsulation of functions and services and migrating them from mobiles to the cloud or other mobiles, which is a challenging task due to additional overhead of deploying, managing, and interfacing for different application/service providers.

• Energy-efficient transmission. MCC requires frequent transmissions between cloud platform and mobile devices, due to the stochastic nature of wireless networks, the transmission protocol should be carefully designed.

• Mobile communication congestion issues. Mobile data traffic is tremendously hiking by ever increasing mobile user demands for exploiting cloud resources, which impact on mobile network operators and demand future efforts to enable smooth communication between mobile and cloud endpoints.

• Trust, security, and privacy issues. Trust is an essential factor for the success of the burgeoning MCC paradigm. The challenge is how to enable mobile devices and cloud services to collaboratively build new MCC applications by composing resource, functions, and services. Federated identity administration and management (IDM) should be established for MCC applications. In addition, security and privacy sharing the similar challenge when running MCC application across multiple administrative domains.

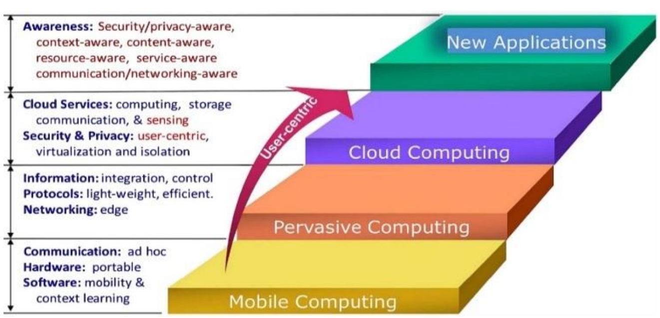

Figure 3:Security and Privacy

V. Cloud-Based Mobile Service Platforms

In this section, we present some of current cloud service platforms that support mobile applications/services, in which a few application examples are presented to help readers get basic ideas of how a mobile cloud application works.

Google Services

• Maps is a Google satellite, which gives an in-depth accurate map of almost every city in the world. Google maps gives directions from how to get from one point to the other, figures out the quickest route possible, and gives an Earth/Satellite/Street view. Maps is available on browsers as well as mobile phones, allowing custom maps as well as saved directions to be saved on Google Accounts and later be accessed from all devices.

The map itself is downloaded from the cloud server when the user browses it. If user would like to know the route to some destination, the cloud server calculates the best route and sends it to users' devices.

• Google Translate is an online translating tool, which translates text from one language to the other instantly for a user.
The phone does not store all the language mappings. Words or statements are sent to the cloud server to be calculated to the target language, in which processes, the machine learning and natural language processing techniques, are used to enhance the translation accuracy, which cannot be achieved using the limited resources on smartphones.

• Google Docs are online applications, which allow people to create, edit, or view different types of documents. In addition to word documents, Google Docs also support PowerPoint slides and Excel spreadsheets. Google Docs can be synchronized across all devices through a user's Google account. This allows the user to access his/her documents on any device as long as he/she can access Google Docs' server using a browser, and edit and share them without time and location restrictions.

The users collaborate on the same document, which requires the cloud to maintain the global document state and synchronize the document state to mobile devices.

Dropbox, cloud storage

Dropbox is a popular cloud-based storage service which supports mobile devices. It can help users store photos, docs, videos, and other files in clouds. Files in Dropbox are tracked with a version control system, each version is backed up, and users can access them using their mobile devices. It provides an easy approach to share a large file by sharing their Dropbox' URL even if a user does not have a Dropbox account. A Drobox client is required to be installed on mobile devices in order to manage files in the cloud. Compared to the desktop Dropbox client, the mobile version only downloads the files to mobile devices as the user instructs it to do so. When some files are added, deleted, or updated, new versions of files are synchronized to the cloud storage and all devices having the same Drobox account will perform an update. In this way, the new version is pushed to every device controlled by the same user and his/her file sharing peers.

The Dropbox API v2[3] is a set of HTTP endpoints that help your app integrate with Dropbox. The officially supported SDKs, which are programming language wrappers of the HTTP API, include .NET, Java, JavaScript, Python, Swift, and Object-C. The Dropbox HTTP API allows developers to work with files in Dropbox, including advanced functionality like full-text search, thumbnails, and sharing. Dropbox also provides Business API that allows apps to manage the user lifecycle for a Dropbox Business account and perform API actions on all members of a team.

Office365, cloud based collaboration

Microsoft Office365 is made for company employees to work together, sharing similar features with Drobox and Google Docs. Users can share docs with their working partners right from a phone and tablet. Mobile version Office365 along with Microsoft Azure provides:

- Easily sharing documents with the cloud-connected applications;
- Tracking changes, comment and mark-up docs so that everyone knows documents' change history;
- Sharing documents with others by simply e-mailing an URL.

Yelp, cloud based virtual augment

Yelp application has a feature called Monocle, which is an applicationlication of cloud-based virtual augmentation. When the user points the phone camera to one direction, the shops and restaurants are displayed as an additional layer in front of the background photo. The Monocle applicationlicationcaptures the location and direction, fetches the data from the cloud, and organizes shop information on the photo, such as the notes to the real environment.

Internet of things, cloud mirroring

The Internet of Things (IoT) is the network of physical objects—devices, vehicles, buildings, and other items which are embedded with electronics, software, sensors, and network connectivity, which enables these objects collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy, and economic benefit; when IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation, and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

The IoT objects cumulatively build the main sensing capability for mobile cloud computing and they have to be managed well for MCC applications. However, due to the large amount of objects, small systems cannot handle huge data collected through IoT devices. To address this issue, cloud-based storage services come into the picture. IoT objects can be continuously mirrored by using cloud-based monitoring and storage services; while individual or group of IoT device(s) can be virtualized and manipulated in the cloud for MCC applications, and then control or data operation functions can be executed on physical devices.

VI. MOBILE CLOUD OFFLOADING FRAMEWORK

MAUI

MAUI [8] is a framework that considers energy saving on smartphones as the main objective function for the offloading process. MAUI is a highly dynamic offloading framework because of a continuous profiling process. The framework hides the complexity of a remote execution from the mobile user and gives the impression as if the entire application is being executed on the mobile device. In MAUI, partitioning is done based on developer annotations to specify which components can be executed remotelyand which cannot.In the preparation step, two requirements should be met: application binaries must be in both mobile and server sides and (2) proxies, profilers and solvers must be installed on both the mobile device and server sides.At the beginning, MAUI profiler measures the device characteristics. Then, it keeps monitoring the program and network characteristics during the whole execution time because these characteristics can often change, and any old or inaccurate measurement may lead MAUI to make the wrong decision. The offloading decision is taken at runtime. The frameworkchooses which components should be remotely executed according to the decision of the MAUI solver. The decision is based upon the input of the MAUI profiler.On the smartphone,the framework consists of the following components: a proxy,a profiler, and a solver. Each time a method is called, the MAUI profiler evaluates it for its energy-saving potential and profiles the device and the network to obtain the statusinformation. Then, the MAUI solver works on the results provided by the profiler and determines the destination where the method will be remotely executed; the proxy is responsible for control and data transfer between the server and the smart phone. On the server side, the profiler and the server proxy perform similar roles as their client-side counterparts. The MAUI controller is responsible for authentication and resource allocation for incoming requests [8]. The authors present different experiments in order to com- pare the energy consumption of running three applications standalones on the smartphone versus using MAUI for remote execution to servers that are located elsewhere. The face recognition application can achieve strong energy savings when using MAUI. On the one hand, the results of the conducted experiments showed that the energy consumed when offloading code using 3G is 2.5 times higher than offloading code to a close server. On the other hand, the energy savings for both video and chess game are less strong but they are still important; when offloading to a close server, MAUI saves 45% for chess and 27% energy for the video game

CloneCloud

CloneCloud[4] is a system that automatically transforms mobile applications to benefit from the cloud. The system is a flexible application partitioner and execution runtime that enables unmodified mobile applications running in an application-level virtual machine to seamlessly offload part of their execution from mobile devices onto device clones operating in a computational cloud. CloneCloud uses a combination of static analysis and dynamic profiling to partition applications automatically at a fine granularity while optimizing execution time and energy use for a target computation and communication environment. At runtime, the application partitioning is effected by migrating a thread from the mobile device at a chosen point to the clone in the cloud, executing there for the remainder of the partition, and reintegrating the migrated thread back to the mobile device.
The advantage of this model is that when a smartphone is lost or destroyed, the clone can be used as a backup for the recovery of data and applications [6]. Moreover, CloneCloud augments execution of the smartphone applications on the cloud by performing a code analysis for application partitioning, taking into consideration the offloading cost and constraints.

CloneCloud also supports fine-grained thread-level migration that is more beneficial compared to the traditional suspend–migrate–resume mechanisms. Considering the shortcomings, the model is only capable of migrating at points in the execution where no native heap state is collected. Moreover, CloneCloud requires the development of cost model for every application under different partitions, where each partition is executed separately on the mobile device and the cloud. Therefore, the execution of partitions on mobile device for the development of cost model may consume extra energy. Furthermore, to fit all of the proposed augmentation types, basic and fine-grained synchronization is required between the smartphone and the clone that may be resource intensive in terms of bandwidth utilization and energy consumption. Nevertheless, the authors assume that the cloud environment is secure, which is not always the case.

In CloneCloud, the privacy of data and piracy of applications is of high concern from the clones' perspective. For example, if an adversary gets a clone of the smartphone from the cloud, then the clone can be easily installed on the same model of the smartphone. Therefore, the adversary may use the clones' data and installed applications that may lead to data privacy and application piracy issues.

ThinkAir

ThinkAir [5] is a framework that makes it simple for developers to migrate their smartphone applications to the cloud. ThinkAir exploits the concept of smartphone virtualization in the cloud and provides method-level computation offloading. Advancing on previous work, it focuses on the elasticity and scalability of the cloud and enhances the power of mobile cloud computing by parallelizing method execution using multiple VM images.
The main advantage of ThinkAir is that it takes into account the energy consumption when making the offloading decisions and supports on-demand resource allocation and parallelism to reduce execution delays [6]. The model offloading decisions are based on the profilers, and it uses an energy model to estimate energy consumption. ThinkAir's energy model is inspired by PowerTutor [7] that accounts for all parameters of the supported profilers. Nevertheless, it does not require separate application servers for the distribution of the applications. Considering the shortcomings, ThinkAir does not support unmodified applications and requires programmer support for the demarcation of offloadable methods. Therefore, if any offloadable methods are left unmarked, then ThinkAir will not be able to offload those methods, which may affect the performance of the applications. Nevertheless, the profiling process of the model incurs an overhead on the smartphone because it consumes computation power, memory, and energy.

Cuckoo

Cuckoo Kemp et al. present in [8] the Cuckoo framework for computation offloading for smartphones. This framework offloads mobile device applications onto a cloud server using a Java stub model. Cuckoo’s objectives were to enhance mobile’s performance and reduce battery usage. The framework integrates the Eclipse development tool with the open source Android framework In the partitioning step, Cuckoo takes advantage of the existing activity model in Android which makes the separation between the intensive and non-intensive components of the application. This activity presents a graphical user interface to the user andis able to bind to services. The framework can offload intensive components to any resource running a Java Virtual machine

(JVM).As a preparation, the framework requires the developer to write offloadablemethods twice - one for local computations and one for remote computations. For this purpose, a programming model is made available to application developers. This programming model is used for dropped connection, supports local and remote execution, and combines all codes in a single package so the user will have a compatible remote implementation.Cuckoo is a dynamic offloading framework as it takes the offloading decision at runtime and offloads the well-defined components of the application. In case the remote resources are not reachable (i.e. network connection is not available) then the application can be executed on local resources (the mobile device).

VII. CONCLUSION

As per NST five attributes of versatile distributed computing is discussed in this paper. along with the three main concepts: (1) Mobile computing, (2) Cloud computing, and (3) Mobile cloud computing. More specifically, it presents existing frameworks for computation offloading along with the various techniques used toenhance the capabilities of smartphone devices based on theavailable cloud resources. The paper investigates the different issuesof benefit offloading, migration, composition. Offloading frameworks and highlights challenges that still obstruct these frameworks in MCC. Moreover, the paper shows the different approaches that are used by the frameworks to achieve offloading. Some of these approachesuse static offloading while others employ dynamic offloading.

REFERENCES

[1] P. Mell, T. Grance, The NIST definition of cloud computing, 2011.

[2] Y. Cui, X. Ma, H. Wang, I. Stojmenovic, J. Liu, A survey of energy efficient wireless transmission and modeling in mobilecloud computing, Mobile Networks and Applications 18 (1) (2013) 148–155.

[3] M. Satyanarayanan, P. Bahl, R. Caceres, N. Davies, The case for VM-based cloudlets in mobile computing, Pervasive Computing, IEEE 2009;8(4):14–23.

[4] B.-G. Chun, S. Ihm, P. Maniatis, M. Naik, A. Patti, CloneCloud: elastic execution between mobile device and cloud, Proceedings of the Sixth Conference on Computer Systems. ACM; 2011:301–314.

[5] S. Kosta, A. Aucinas, P. Hui, R. Mortier, X. Zhang, ThinkAir: dynamic resource allocation and parallel execution in the cloud for mobile code offloading, 2012 Proceedings IEEE INFOCOM. 2012:945–953.

[6] A.R. Khan, M. Othman, S.A. Madani, S.U. Khan, A survey of mobile cloud computing application models, Communications Surveys & Tutorials, IEEE 2014;16(1):393–413.

[7] K.M. Saipullah, A. Anuar, N.A. Ismail, Y. Soo, Measuring power consumption for image processing on android smartphone, American Journal of Applied Sciences 2012;9(12):2052.

[8] R. Kemp, N. Palmer, T. Kielmann, H. Bal, Cuckoo: a computation offloading framework for smartphones, in: Mobile Computing,Applications, and Services, Springer, 2010, pp. 59–79.

[9] Amazon EC2, https://aws.amazon.com/ec2/.

[10] E. Abebe, C. Ryan, Adaptive application offloading using distributed abstract class graphs in mobile environments, Journal of Systems and Software 2012;85(12):2755–2769.