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Computational Offloading for Mashup Services in Mobile Cloud Computing Environment

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Abstract

The cloud system is considered as the hub of hosted services in which a particular user can access the cloud system remotely by using applications or by using the browsers. Compared to desktop devices, mobile device have inherent constraints such as limited processing power, memory, and battery capacity. With the propagation of mobile cloud applications, researches are looking for new solutions to address these limitations. One of the major solution is mobile cloud computing, which uses cloud infrastructure to enhance the capabilities of mobile device. This paper focuses on an emerging technology known as mobile offloading and mashup. The offloading uses the quality of services concept to remove mobile application limitations. Cloud services are the application programming platform where users can create new applications and mashup their functionalities. The paper describes the quality of services parameters used for offloading in mobile applications and also describes the existing approaches for mobile cloud computing.

Keywords: *Mobile cloud computing Computation offloading, Mash up services, QoS metrics, Approaches of MCC*

1. Introduction

Cloud computing is a model for "on demand" network access to a shared configurable computing resources like networks, servers, storage, applications, and services that can be released with minimal management effort or service provider interaction. [1]

The mobile cloud computing is the combination of cloud computing and mobile computing. MCC (mobile cloud computing) integrate the cloud computing into mobile devices and overcome the problems in mobile computing like performance and security *etc.*, [2]. MCC provides mobile users with the data processing and storage services in clouds. There are three major components for mobile computing. These components are: hardware, software and communication link. Hardware part implies physical portable devices like mobile phones, laptops their components and so on. Software part implies operating systems, mobile applications like antivirus, games and so on. And the last part implies infrastructure or networks which provide services like internet service, voice call service and so on to these mobile appliances and this component remains transparent to end users [3].

Augmentation approaches can increase computing capabilities of mobile devices and conserve energy. Mobile computation augmentation is the process of increasing, enhancing, and optimizing computing capabilities of mobile devices by leveraging varied feasible approaches, such as hardware and software. Hardware approaches are high-end physical components, particularly CPU, memory, storage, and battery. Software approaches can be computation offloading, remote data storage, wireless communication, resource-aware computing, fidelity adaptation and remote service request but they are not limited [20]. Mobile systems resources in some restrictions like battery life, network

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bandwidth, storage capacity, and performance of processor that all are may be alleviated by computation offloading.

Offloading is used to save energy and improve performance. The level of method to performed offloading is application, task virtual machines. It is used in mobile system like laptops, PDAs, sensor *etc.*, [21]. Offloading is a solution to augment these mobile systems capabilities by migrating computation to more resourceful computers (i.e., servers). Offloading decides to offload statically or dynamically. Static Offloading in the decision parameters are defined at the development time. Dynamic Offloading in the decision is taken by considering dynamic parameters i.e. at run-time of an application [4]. Offloading is a technique used to overcome the limitation of mobile phones in terms like computation, memory and battery [5]. Energy is a fundamental factor for battery powered devices. [22] The ability to utilize new applications functionality is directly observable, but it is more beneficial to reduce energy consumption or increased computational capacities. When mobile device is fully compared to the energy consumption, it may be difficult for the user to appreciate the energy savings gained by offloading any one application. The data offloaded is directly propositional to the cost in terms of energy consumption. The high bandwidth can overcome energy cost of communication and transfer large amount of data in short time [6].

Offloading transfers the control data and the application state information over the network to a server machine called surrogate. It will complete the computation task and send results back to the mobile client. Computation offloading is logically a way to increase the limited computing power of the mobile device. These applications can utilize mobile offloading and modify. [6] The offloading is needed mainly for two purposes: improved performance and to save energy. Offloading can improve performance when execution time includes computation and communication both and thus they can perform faster at the server. [21] The offloading can be used on mashup services.

Mashup services are websites or applications that combine service from more than one source into an integrated application. Mash up service is a new web application model that use existing web services to create composite service. The mashup services provide flexible and dynamic services [7]. One of the challenging issues of cloud services mash up is how to find the optimal paths for services [8]. QoS aware service routing problem is typically NP-hard [7] [8]. The QASM (QoS Aware Services Mash up) model is used for selecting the best path and selects optimal path which is a NP complete problem. The algorithm in QASM model finds the route and the data flow of route is extracted through resource requirement. The translated data is forwarded to the routing engine. The routing engine takes care of processing the inputs received from the mash up platforms and forwarding them to the right recipient. The routing is the part of the on-demand services mash up layer. The QASM model for choosing and composing different cloud services into a service path that is satisfies the user's quality requirements. Multiple QoS constraints are response time, availability and resource requirements are CPU ratio and bandwidth ratio [7]. EXACT and Fully Polynomial Time Approximation Scheme (FAPTS) algorithms are QoS aware service composition algorithms that are used to optimize user's experiences for Cloud service access and these explain the QoS Aware Services Mashup (QASM) Model. These algorithms introduce the concept of cloud computing. [8]

2. Research Method

2.1. Research Questions

This review aims at summarizing the mobile cloud offloading and mash up research by proposing answers to the following questions:

1. What is the use of offloading in mobile cloud computing?

2. What are the types of applications suitable for offloading to mobile cloud environment?
3. Why Mash up is required in mobile cloud computing?
4. What are the important QoS metrics to be considered for performing mobile offloading?
5. What are the existing approaches of mobile cloud computing?

2.2. Sources Of Information

We searched widely in electronic source. Most of the information is covered by educational sites, relevant journals and research papers. The sites are:

IEEE Explore (<ieeexplore.ieee.org>)
Springer (<www.springer.com>)
Google Scholar
Elsevier journals (<www.elsevier.com/journals>)

2.3. Study Selection

The paper has been organized as follows: In section 3 use of offloading in mobile cloud computing is explained. The Section 4 gives the information related to types of application and services suitable for offloading in MCC. This section defines the application and suitable service in which offloading is possible and after offloading these applications can be used in MCC. In Section 5 need of Mash up in MCC is described the importance of mash up is explained. The section 6 is about QoS metrics that perform offloading in MCC. This section describes the services of offloading. The Section 7 describes the approaches of mobile cloud computing and describes the framework and tools.

2.4. Related Work

Roelof Kemp in [15] presented Cuckoo framework for computation offloading for smart phones, a recently rediscovered technique, which can be used to reduce the energy consumption on smart phones and increase the speed of compute intensive operations. Cuckoo integrates with the popular open source Android framework and the Eclipse development tool. It provides a simple programming model, familiar to developers that allows for a single interface with a local and a remote implementation.

Juntunen Antero in [25] define the mobile cloud computing, may result in transferring data and computation from mobile devices into the cloud using either browser-based applications residing in the cloud or native mobile applications that may be partly offloaded into the cloud. Author examined the latter case, which is realized by an enabling technology called mobile computation offloading (MCO).

Aki Saarinen in [26] describes the feasibility of using method offloading technique with popular apps to save energy. A set of open source apps to show that offloading using existing frameworks is often blocked by constraints, while also missing opportunities for saving energy. Author defines the tool kit of propose for initial solution. Author defines the two open source android application framework that are suitable for offloading methods. The open source android applications are AND Tweet and K-9 mail.

Jorge Luzuriaga in [24] describes the offloading computation from mobile devices to cloud computing infrastructure can be done safely only if user have a guaranteed availability of a stable channel. Author defines the face reorganization that is used in mobile device services and they can offload.

Sehoon Park in [10] defines the offloading architecture provides a highly efficient way of increasing the performance of mobile devices. The built-in proxy system detects heavy computational function codes from the out bound web servers by programmer annotations. Offloading method Reduces the response time of Java Script based web

applications and minimizes CPU utilization of mobile devices. This approach is more useful for low-cost devices. It eliminates the hardware performance limitations of low-end devices, since the heavy loaded computational applications on the client side will be offloaded to the server side. The framework reduced the response time the turn-based gaming application. It provided an early constant performance, irrespective of the network bandwidth environment.

Milos Stojmenovic in [12] describes the biometric applications. These applications are used in mobile cloud computing for security purpose and these can offload. It would reduce the cost of biometric security devices since they would not have to be physically connected to the network in order to function. The intended real time performance of face recognition scheme also leads toward novel applications such as instant name recognition with camera placed in eye glasses.

Dr. Atul M. Gonsai in [13] analysis for mash up applications as services on web platform as well as on mobile or smart-phones platform; moreover author propose idea of service platform for mash up application for android mobile users, and author implement the service mash up app for smart-phone.

Ahmed Dheyaa Basha in [9] defines the suitable solutions for mobile cloud computing have also been discussed so that the readers can have a better understanding of the mobile cloud computing and its applications. Some critical and

Challenges issues that exist in mobile cloud computing and the solutions for those issues by some experts have also been presented.

Chathura M. Sarathchandra Magurawalage in [14] describes an offloading algorithm for deciding whether and where to offload is applied on top of the new architecture. The decision-making takes into account the availability of two types of wireless network Wi-Fi and 3G with the aim of saving battery life for mobile devices while satisfying the response time constraints of applications. Author explains the efficiency of the proposed architecture by comparison with conventional offloading architectures in simulations.

3. Use of Offloading in Mobile Cloud Computing

Processors in Mobile cloud computing are faster and devices contain more sensors, a Smartphone's ability to consume energy for outstrips the battery's ability to provide it. The battery life of mobile devices remains a key limiting factor in the design of mobile applications. The two main contributors are limited battery capacity and an increasing demand from users for energy-hungry applications. User demand is increasing day by day for resource intensive applications, like video games, streaming video and sensors equipped on mobile devices that produce continuous streams of data about the user's environment. Several solutions have been proposed to enhance the CPU performance and to manage the resources available optimally in order to reduce power consumption. These solutions requires changes in the structure of mobile devices and thus have cost premium over standard devices. Computation offloading techniques transfer the large computations and complex processing from resource limited devices to resourceful devices, thus avoiding mobile devices to take a large execution time [23]. Offloading is refers to a technique used to overcome the limitations of mobile phones in terms of computation, memory, battery, bandwidth, latency and coverage.[5] Computation offloading using as a case study a facial recognition application for smart phones where recognition is a service in the cloud. Face recognition is used a sample application to evaluate the trade off of offloading computation with the idea of the required intensive calculus puts in commitment the hardware features of the mobile device[24]. More data in mobile cloud computing needs to be offloaded, it is more costly in terms of energy consumption. The mobile network technologies are complement of mobile offloading, which advances in mobile networking, such as 3GPP Long Term Evolution (LTE) that are instrumental for the viability of mobile offloading. WLAN (Wireless LAN) access points and local

surrogates can help provide excellent conditions for offloading but the availability of these access points is currently limited. [25]

4. Types of Application Suitable for Offloading in MCC

The mobile cloud computing is basically a combination of cloud computing, wireless communication infrastructure, computing devices, location-based services, and mobile Web. Applications consist of software that runs on a mobile device and performs certain tasks for the user of the mobile phone like e-mail or chatting needs *etc*.. There are many mobile cloud applications such as web browsing, email access, video playback, Cisco's web EX on the iPad, document editing, image editing, Google's Map, Gmail for iPhone, *etc*.. These applications or services can offload. These applications are using the software as a service model [9]. Mobile applications can adaptively split and divided parts can offload are called elastic mobile applications. In mobile computing one model is android application model that is for development of "off loadable" applications. In this a lightweight application is partitioning and a mechanism for seamless adaptive computation offloading. Android applications are use the Mobile Augmentation Cloud Services (MACS) middleware is proposed by MCC. These services are beneficial for offloading of computation-intensive parts of the application into nearby or remote clouds [5].

4.1. Mobile Commerce

Mobile Commerce is a business model for commerce using mobile devices. The mobile commerce application is required for some tasks like mobile payment, mobile transaction, mobile messaging, and mobile ticketing.

4.5. Mobile Learning And Mobile Healthcare

Its design is based on e-learning and mobility. Cloud based mobile learning applications solve some limitations like high cost of devices and network, low network transmission rate and limited educational resources. Mobile healthcare offers hospitals and healthcare organizations variety of on-demand services on clouds rather than owning standalone applications on local servers [19].

4.6. Android Applications

Open source Android applications are And Tweet and K-9. First And Tweet is a popular open source Twitter client, and offload methods which send or receive network packets from the Twitter servers, using the Think Air framework. Second, user take a look into the feasibility of offloading network-intensive methods in one of the most popular open source Android email clients K-9 Mail [26].

4.7. Web Services And Web Centric Device

Mobile service providers or mobile manufacturers need platform-independent offloading systems to enhance the compatibility of the mobile platform. Many applications are combined into a web browser which is a common environment among the different mobile operating system platforms. Mobile applications are run on web browsers. Mobile devices mainly use the JavaScript based platform. These devices reduce the cost and extend the battery lifetime. The main problem with their capacity is limited to utilizing complicated web resources such as a rich UI (user interface) or highly computational JavaScript applications. The issue of the limited resource so flow end devices. With offloading technique, the low- end devices are able to support complicated UI and high computational web resources. This offloading system reduces the level of CPU utilization and energy consumption of mobile devices. [10]

4.8. Social Mobile Network

In mobile network data is stored and transferred directly between nodes in an ad hoc fashion until the deadline arrives and if required nodes access the cellular infrastructure to download or upload the data. In the case of redundant data e.g. measurement of pollution levels, the traffic on the cellular infrastructure can be drastically reduced through opportunistic offloading [11].

4.9. Biometric Application

Biometric applications are dedicated to fingerprint, face or iris scanning, verification and identification systems. Mobile devices can bring biometric evidence back to the laboratory to be processed. Software dedicated to fingerprint, face, iris or any other biometric scanning which identifies and verifies individuals typically works in a laboratory setting where the client computer has unlimited access to the throughput and computational resources of the network. In these applications offloading is used for throughput and computation. [12].

Table 1. Off Loadable Applications

Years	Off loadable applications		
	Author	***application***	***Issue for offload***
2012	Aki Saarinen[18]	Android application	Energy and network packets
2013	Sehoon Park[19]	Web services and centric device	CPU utilization, energy, power
2014	Marco Valerio Barbera [20]	Social mobile network	Data offloading
2013	Milos Stojmenovic [21]	Biometric application	Throughput and computation

5. Need of Mashup in MCC

Mashup is a Web-based network resource that composes existing services resources. It is content, data or application functionality from more than one resource in enterprise environments by allowing the actual end-users to create the individual information centric and situational applications. In internet there are many available web services with various QoS (Quality of Service) providing the same functionality to specific tasks. So a selection needs to be made. Services mashup have to search for an optimal set of services to construct a composite service and result in a best QoS, under user's QoS constraints and resource requirements [7]. Mashup enables user to develop a new application based on a configuration of contents retrieved from external applications or services. Service mash up requires communication with web services and processing power. In cloud computing cloud services have application program platform where users can create new application and mashup the functionality offered by any others. The mashup services through create large scale internet services or web services [13].

5.1. Qos Metrics

In mobile cloud computing offloading in some services are used which are called quality of services. Cloud systems automatically controls and optimizes resource used by leveraging a metering capability at some level of abstraction appropriate to the type of service like storage, processing, bandwidth, and performance *etc.*. [8] In mobile cloud computing main issues is bandwidth, limited storage, low capability and reliability which

are alleviated by offloading and mash up. The offloading removes the issues in mobile cloud computing and improves the quality of services [3].

5.2. Battery Life Time

The main concern for mobile devices is Battery. Several solutions have been proposed to enhance the CPU performance and to manage the disk and screen in an intelligent manner to reduce power consumption. In the structure of mobile devices required changes through these solutions. The objective of Computation offloading technique is migrate the large computations and complex processing from resource-limited devices to resourceful machines *i.e.*, servers in clouds. On the mobile device this avoids taking a long application in execution time which results in large amount of power consumption [19].

5.3. Reliability

Data is being stored on cloud seems effective as data needs to be saved and without cloud it is required to be stored on number of computers. It helps to save data and applications on mobile devices. For example the cloud can be used to protect copyrighted digital contents (*e.g.*, video, clip, and music) from being misused and unauthorized distribution. The cloud remotely provides various services to mobile system such as security services such as virus scanning, malicious code detection, and authentication. Collected records from different users are also beneficial to improve different services of cloud [19].

5.4. Scalability

The deployment of mobile applications can be performed and scaled to meet the unexpected user demands due to flexible resource providing. An application can easily add and establish through Service providers and service may be little constraint on the resource usage. [19]

5.5. Energy Efficiency

In mobile cloud computing most popular applications involve comprehensive communication that consumes a significant part of the overall energy. The energy efficiency is important in mainly expand always on line connectivity, high speed wireless communication, high definition multimedia and rich user interaction. Energy consumption of a mobile device is concerned by complete end to end chain and defines computation offloading. [22]

5.6. Low Bandwidth and High Latency

A mobile device user may offload code or data to a devoted clone cloud directly. The mobile device interacts with the clone using a cellular network through the Internet. This can be improved by offloading because it uses networks with low bandwidth and high latency. [14]

6. Approaches of Mobile Cloud Computing

6.1. Mobile Agent Based

A mobile agent is a software program with mobility which can be sent out from a computer into a network and range among the computer nodes in the network. When mobile agents use an application then they send request for service to remote server. It collect the required information and passes it to the agents execution environment.[15] Mobile agents have generally active in semantic web services, e-commerce based

applications, sensor networks and wireless networks. Mobile agents can provide better solution for mobile cloud application in mobile cloud computing.

In Figure: 2 illustrate usage of mobile agents in cloud computing. Traditionally user requests are sent directly from cloud to WWW which leads to increase in network traffic and increased response time. If mobile agents are employed for providing various services, then network traffic may be reduced while at the same time reducing response time. Mobile Agent can transmit over the network from one machine to the other and perform the operations locally on the distant machines rather than sending requests and waiting for the response. [16]

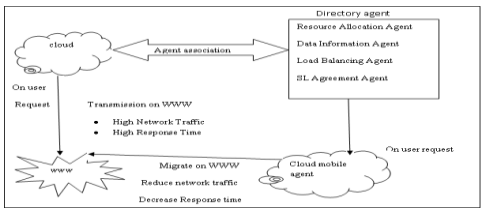

Figure 1. Combination of Mobile Agents in Cloud Computing

6.2. Cuckoo Offloading Framework

Cuckoo is focus on the Android platform. Cuckoo is a very simple programming model that is available for Mobile Environments. This model supports both local and remote execution of application technique to keep applications working when cloud resources are not available. [18] Cuckoo associate with existing development tools that are familiar to developers and mechanize large parts of the development process. This programming model is specifically support remote implementations to be different from the local implementation. Parallelization can be used at the remote implementation to get the full performance out of a remote multiprocessor resource. Cuckoo framework is a Resource Manager application that runs on the smart phone. [27]

6.3.Client Server Based

Applications running in the heterogeneous environments of the mobile clouds require segment of applications dynamically and remote execution of some components. In this accession the battery life of device can be maximized with code offload. In MAUI (Memory Arithmetic Unit and Interface) a fine grained offloading mechanism on single level technique is allowed, here the complete software modules are offloaded. [17] Figure 3 provides a high-level overview of the MAUI architecture. On the smart phone, the MAUI runtime consists of three components an interface to the decision engine. A proxy, which handles control and data transfer for offloaded methods. A profiler, which instruments the program and collects measurements of the program's energy and data transfer requirements and the MAUI coordinator, which handles authentication and resource allocation for incoming requests to instantiate a partitioned application.

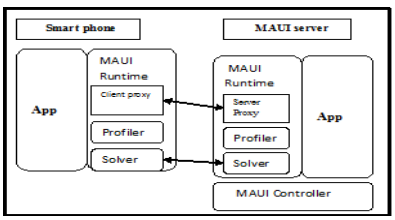

Figure 2. MAUI Architecture

7. Open Issues and Future Scope

In the mobile cloud computing there exists lot of limitations like low bandwidth, power consumption, energy *etc.* exists and these limitations can lead to many problems in mobile cloud computing. In the case of web services energy, bandwidth problem can occur in some cases. In the web services two particular characteristics of a smart phone are restricted, power supply and low-end hardware resources, compared to high-end servers. Here solutions for some of the problems are given but these issues are not solved properly, still they have some problems. These problems are required to be analyzed, researchers have been working on them but still there exists various areas covered which are required to be debunked and enhanced.

8. Conclusion

As given above various authors have discussed the offloading and mashup services which are used in mobile cloud computing. In this paper literature survey was reviewed to know about quality of services and offloading in mobile application. This paper discusses about mobile cloud computing applications and their approaches. In the mobile cloud computing some problems do occur. These problems are preventing through the offloading technique. The offloading technique is used for mashup services for prevent mobile device and improve their performance and quality. The offloading makes the application perfect in mobile device for cloud computing. Offloading architecture provides a highly efficient way of increasing the performance of mobile devices.

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