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OFFLOADING APPROACH IN MOBILE CLOUD COMPUTING

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ABSTRACT

There are so many applications which are computationally heavy and need large energy consumption, running these applications on mobile device is not a good idea because mobile devices have limited resources, limited computational capacity and have very less battery power. So the solution of running these power hungry applications on mobile devices is mobile cloud offloading. Offloading is a technique through which heavy applications can offload to the cloud to run and the result is returned back to the mobile device. Mobile cloud offloading is a way to reduce execution time and energy consumption of any task on mobile device. The basic idea of offloading is to migrate heavy computations from mobile device to the cloud to save energy.

The objective of this paper is to explore the concept of mobile cloud offloading, how the decision of offloading is made, why we need offloading and its types. Here the architecture of offloading is also proposed.

INTRODUCTION

Mobile Cloud Computing

Mobile Cloud Computing is a service that allows resource constrained mobile users to adaptively adjust processing and storage capabilities by transparently partitioning and offloading the computationally intensive and storage demanding jobs on traditional cloud resources by providing ubiquitous wireless access [1]. Some organizations, such as Google, see Mobile Cloud Computing as a new paradigm for mobile applications whereby most of the processing and data storage associated with the applications is moved off the mobile device to powerful, centralized computing platforms located in the Cloud [2].

According to research by the year 2011 the number of mobile subscribers in all over the world is 5.6 billion. ABI Research predicts that there will be about 1 billion end users accessing 'mobile cloud' by 2014 [3]. Now company users do not need to spend a lot of money on hardware and software, they can share it on the cloud. The operating system of mobile phones does not have any impact on the application because cloud computing applications go via a browser. Mobile device does not need to have large storage capacity and powerful CPU speed. All data processing is performed outside the mobile devices on a centralized computing platform located in clouds. Mobile cloud computing is a technique or model in which mobile applications are built, powered and hosted using cloud computing technology. A mobile cloud approach enables developers to build applications designed specifically for mobile users without being bound by the mobile operating system and the computing or memory capacity of the Smartphone.

Aepona [4] describes MCC as a new paradigm for mobile applications whereby the data processing and storage are moved from the mobile device to powerful and centralized computing platforms located in clouds. The mobile devices do not need a powerful configuration (e.g., CPU speed capacity) because all the complicated computing modules can be processed in the clouds. There are many limitations in mobile devices like limited processing power, low storage, less security, unpredictable Internet connectivity, and less energy. To augment the capability, capacity and battery time of the mobile devices, computationally intensive and storage demanding jobs should be moved to cloud. Besides of all these advantages there are some issues in using MCC related to the bandwidth, access schemes , security etc.

Mobile Cloud Offloading

Mobile cloud computing refers to an infrastructure where resource constrained applications like data storage and processing can happen outside the mobile device. Mobile Cloud computing is integration of cloud computing and mobile computing. Mobile cloud computing means using the features of cloud computing through mobile devices. In today's environment everyone has mobile devices but due to limited processing power, network

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bandwidth, storage capacity and battery life time of mobile devices, some of the computational intensive applications are not able to be executed on these mobile devices. People are using the cloud computing to store their data on cloud to remove the problem of storage capacity, but there is one more problem with mobile devices that sometimes some applications or task are so heavy that these take so much time and energy of the mobile phones that it become difficult to run some other applications parallel on that phone so there should be some mechanism to execute these task on cloud and then take the result from that, this mechanism is known as offloading.

Some of the applications which need high computational resources, battery power are like:

- Playing games which need quick computations
- Image processing
- Downloading heavy applications and installing these
- File search applications

So, it is common practice for mobile devices to offload computationally heavy tasks off to the cloud which has greater computational resources than mobile device itself. Offloading refers to transfer of certain computational tasks or applications to an external platform like cluster or cloud. It is necessary due to hardware limitations of mobile devices. We can overcome the constraints of mobile phone devices by offloading complex modules on cloud.

Mobile cloud offloading system can be organized as a two or three-level hierarchy:

Two-Level Offloading

In two levels offloading only two entities are involved mobile device and the cloud. The resource intensive mobile device which is not capable of running heavy multimedia applications locally on the device request the cloud to run that application on it. A mobile device can offload parts of its workload to a powerful cloud server via one or more communication networks, taking advantage of the abundant cloud resources to help gather, store, and process data. This offloading scheme depends on the availability of that particular resource on the cloud[5]. But in this scheme there is a problem, offloading any application on the cloud needs high network bandwidth and network access latency.

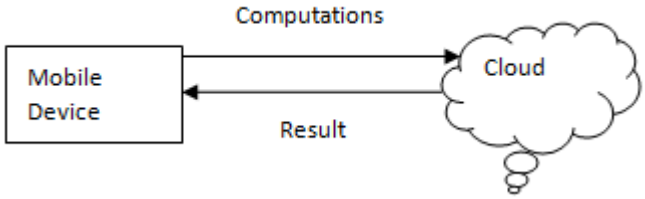

Fig.1. Two-level Offloading

Three-Level Offloading

In three level offloading there are one more entity known as cloudlet. A cloudlet is a small-scale data center or cluster of computers designed to quickly provide cloud computing services to mobile devices, such as smartphones, tablets and wearable devices, within close geographical proximity [6]. Rather than relying on a remote cloud, the resource poverty of a mobile device can be addressed by using a nearby resource-rich cloudlet via a WLAN hotspot to decrease latency and lower battery consumption. A cloudlet is viewed as a trusted, resource rich computer or cluster of computers that is well-connected to the internet and is available for use by nearby mobile devices [7]. In this scheme firstly the application is offloaded from mobile device to the cloudlet and then from cloudlet to the remote cloud. This scheme saves the battery of the mobile device by using WiFi, which consumes less energy than other schemes [8].

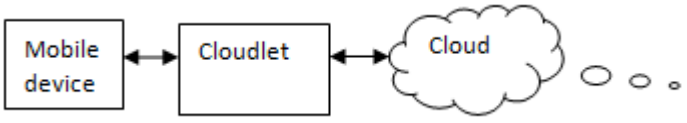

Fig.2. Three-level Offloading

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This paper is organized in many sections. Section 2 of this paper defines the architecture of mobile cloud offloading. Section 3 describes the need of offloading. Section 4 shows the various factors which affects the offloading decision. Section 5 explains how the offloading decision is made. Section 6 describes the types of offloading: static and dynamic scheme. Finally conclusion and future research work is explained in Section 7

ARCHITECTURE OF OFFLOADING

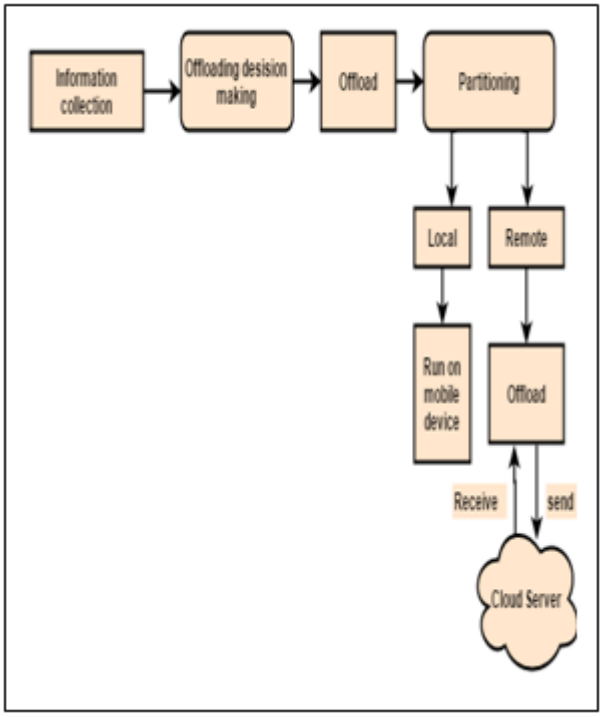

Fig.3. Architecture of Offloading

Fig.3. shows the general architecture of the offloading process. In offloading first the information is collected about the device and network characteristics. This information is related to the computation and communication cost of execution then on the basis of this information decision for offloading is made like what, when, where and how to offload the application on the cloud, once the decision is made then offloading process starts. During this step type of offloading is decided static or dynamic then partitioning of the application is performed. Partitioning can be local or remote, in local partitioning the application is run locally on the mobile device while in remote partitioning the application is offloaded to the cloud server by discovering whether a cloud is available or not. Once the application is offloaded to the cloud server it runs over there and then the result is transferred back to the mobile device.

NEED OF OFFLOADING

The computational offloading is necessary to offload heavy tasks off to the cloud to save energy of the mobile devices. A lot of applications are needed to be run simultaneously on the mobile device, sometime some applications need more energy and processing power which reduces the power and speed of mobile device, so it is a good practice to offload such kinds of task outside the mobile device, these tasks will execute over there and then the result is sent back to the device, by this technique a lot of energy of mobile device can be saved.
So, we can say that offloading is a technique which overcomes some of the limitations of mobile phones. Some of the advantages of using offloading are:

- **Improve Performance:** Using offloading on mobile devices improve the overall performance of it by executing or saving some heavy tasks outside the mobile device.

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- **Save Energy:** Offloading may extend battery life time of the mobile device by migrating the energy intensive jobs off to the cloud.

The computational offloading is necessary to offload heavy tasks off to the cloud to save energy.

FACTORS AFFECTING OFFLOADING

Offloading reduces the limits of mobile phones, but sometimes it become very difficult to offload any application or code to cloud because of some factors. When we need to offload any code to the cloud some of the questions are needed to be answered like:

1. Why do we need offloading? Will it improve the performance and energy or not
2. When we need to offload the application?
3. What kind of mobile device is going to use the offloading feature, like laptop, PDA's etc.
4. What kind of application is needed to be offload?
5. What kind of infrastructure is needed to offload?

Offloading is an advantage in Mobile cloud computing but it also has some issues. Some of the factors which affect the decision of offloading are:

- **Latency Rate:** It is delay between offloading the application on the cloud and the result coming back to the mobile phone. This latency rate basically depends upon the distance between the mobile phone and the cloud. If the mobile phone is very far away from the cloud then the application will take very much time to offload and to send back the result.

- **Bandwidth:** bandwidth means the speed of data transfer on the network. Offloading any application on the cloud needs high speed of data transfer. The bandwidth depends on the wireless link between the mobile device and the cloud. Different users use different kind of network which affects the bandwidth requirement of the offloading. When the wireless connection is excellent, a large amount of application execution and data should be offloaded to the cloud, but when it is poor, only a small amount can be offloaded during limited time [9]. If the network connectivity is poor then the application should run locally and if the network speed is stable and high then the application should run on the cloud server because offloading needs high bandwidth of the network.

- **Heterogeneity:** Heterogeneity means the different kinds of the wireless networks used by the mobile devices and different types of mobile devices using the offloading. Sometimes the network becomes so poor that it becomes very difficult to offload any application on the cloud and to get the result back. Mobile cloud computing has diverse network, infrastructure, mobile device technologies, cloud architectures and communicating networks which increases heterogeneity in Mobile cloud computing environment[10].

- **Size of application:** The size of application also affects the offloading decision. If we need to offload a large application on the cloud then it needs high network bandwidth, less latency rate, better network connectivity and high processing capacity of the cloud server. It is also very difficult to partition a large application and to decide which part of the application should run locally on the mobile device and which part remotely on the cloud.

OFFLOADING DECISION MAKING

The benefits of offloading majorly depends on the timing of the offloading decision whether it is done on the right time and on the right way. Offloading decisions may involve multiple factors such as resource and component availability, connectivity intermittence and network capacity. It is very difficult to take a decision for offloading like whether offloading will be beneficial or not, which part of application is required to offload. Offloading decisions can be made in different ways:

- **What to offload:** What means the name of the candidate tasks to be offloaded? We need to decide the task or application name which is needed to offload through partitioning scheme.

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- **Where to offload:** Where means to select the target space where the application is going to offload. It describes the type of surrogate and choosing the appropriate offloading target (e.g. local, cloudlet and cloud) in which the application has to be offloaded.
- **How to offload:** How means to select the proper strategy which can be use to offload the application on to the cloud. How introduces offloading plans that enable the device to schedule offloading operations.
- **When to Offload:** When means to decide the time for offloading. When considers the offloading conditions and dynamic changes of context, since sometimes offloading may not be worthwhile at all.

TYPES OF OFFLOADING

It is very difficult to find out when to offload any application on the cloud because a wrong decision of offloading may result into the overall degradation of the performance. We need to determine the answers of the following questions for taking the offloading decisions.

1. Why we need to offload the application? What is the motive of offloading?
2. When do we need to offload? At what time offloading will be effective?
3. Which type of mobile system is being used for performing offloading?
4. What type of application is needed to offload?

There are two types of offloading techniques:

1. Offloading in static environment
2. Dynamic offloading

a) Offloading in static environment

Static scheme determined beforehand which parts of the application should run locally and which part should be offloaded. In static type of offloading, the application is partitioned during its development. Through this scheme the overall performance of the device may increase if the decision of partitioning is taken at accurate time. Static partitioning can only be done if some of the parameters are known in advance. A number of partitioning schemes can be used to increase the performance of the device. [11] shows a polynomial time algorithm to find optimal program partitioning.

[12] Provides a scheme to decide which components of java programs should be offloaded. [13] Presents a task partitioning and allocation scheme to divide the distributed multimedia processing between server and handheld device.

In static scheme large heavy computations are performed on the cloud and rests of the tasks are executed on the mobile device itself and then the result is transferred from the cloud to the device. This scheme is also known as partial offloading [14].

b) Dynamic Offloading

In this scheme the decision of offloading is done at run time. This decision depends on the network bandwidth. This scheme incurs higher overhead because the program has to monitor the run time conditions.

In this scheme which parts of application is needed to offload is also identified during program development. Partitioning a program during its execution is a difficult task. It is required to dynamically and optically determine which application modules should be deployed on cloud server and which should execute on mobile device to achieve a particular performance target. Due to changing in requirements of resources optimal partitioning decisions are done dynamically at run time to achieve the desired goals. Dynamic partitioning scheme seems more appropriate but it also has a number of issues like high network bandwidth, high signaling overhead. Offloading also depends on the channel conditions, server state, delay constraints and so on [14].

CONCLUSION

The concept of mobile cloud offloading allows the resource constrained and less battery power enabled mobile devices to run the heavy applications by offloading the part of the application on to the cloud by partitioning

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scheme. The decision of offloading is based on four questions: what, where, how, when. What defines the name of the task which we need to offload, where means choosing the appropriate target in which task has to be offloaded, how explains the mechanism used for offloading and when defines the type of offloading: static or dynamic. A lot of research is under process in offloading. In future work can be done on techniques used under static and dynamic offloading techniques. Various partitioning schemes and their comparison can also be defined.

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