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Energy Efficient Mobile Cloud Computing

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Abstract— **Smartphones have gained enormous popularity over the past few years. Smartphones are now capable of Supporting a wide range of applications, many of which demand an ever increasing computational power. Running complex Applications on smart phones could result in poor performance and shortened battery life because of their limited resources. So it creates a challenge to increase the energy efficiency and performance enhancement as these are resource-constrained devices. So in this paper we will see computation offloading to get better performance and Battery life.**

Keywords— ***Mobile cloud, Mobile cloud application Model.***

I. INTRODUCTION

We define mobile cloud computing as an integration of cloud computing technology with mobile devices to make the mobile devices resource-full in terms of computational power, memory, storage and energy [1]. If we consider a smartphone which has a processor of limited capacity and limited amount of main memory, it restricts the smartphone to carryout operations that demand more processing power and memory. Another short comings of every smartphone is its battery life as well which is very poor in all the cases. So In-order to overcome these drawbacks Mobile cloud computing can play an important role. With the help of Computation offloading process we can offload the demanding tasks that demand for more processing power as well as memory to the resource rich cloud to get it processed there and return the final output back to the device resulting in saving the energy consumption as well [1]. Cloud computing can be seen as a promising technology which can offer many benefits for mobile devices [2].

For Cloud computing the most important concern is the time and the cost of the time and the cost of transferring massive amounts of data to the cloud while for mobile cloud computing the main purpose is Energy consumption for mobile devices[2]. Mobile systems, such as smartphones, have become the primary need of the current times. Various studies have identified longer battery lifetime as the most desired feature of the mobile devices. A 2005 Study of users in 15 countries found larger battery life to be the most important feature than all other features, including cameras or storage [3].

We use smartphones to perform many tasks that we used to perform on our desktops in earlier days, such as browsing internet, send mails, Online banking, watch videos, upload on social networks, finding our ways by using GPS and communication in many ways such as video call, texting using various applications. The more we are excited and happy to install the new application introduced in the market on our device, the less happy we are with the battery life. Everyday we pay attention to conserve battery by avoiding some calls or by not watching too many videos, or by turning off the data connection, it reflects that we cannot use our device to the fullest.

According to researchers we can save energy, backup user data. Many recent works have focused on building application development models that focus on the saving energy and enhancing the performance using computation Offloading frameworks ([1], [4], [5], [6]).

In this paper we will see how mobile cloud computing computation offloading can help in increasing the battery life and performance of mobile devices.

II. RELATED WORK

All the research works done on mobile cloud computing application model involves the process of computation offloading.

The main objective behind offloading a mobile application is to save energy, to improve computational performance or both.

Computation offloading is a procedure that takes resource intensive computations from a mobile device to the resource rich cloud or server to get it processed there and return back the results to the device [1]. Computation offloading is Important for handheld devices. Certain applications are too resource demanding to run on handheld devices. One way to use those application programs is to offload all or part of the computation to a more powerful machine [7].

By offloading modules, we can achieve, at most, 75%

Savings in execution time and 56% in battery usage [8].

Various Application development model for mobile cloud computing has been developed in the recent years, some of them focus on energy efficiency others focus on the Performance enhancement and some focus on both that is energy and performance[4], [5], [6].

A. Application development models

Some of the research work done on the application development models includes the following application development models. As said earlier in the Introduction, some of these works focus on Energy efficiency others on performance and very few on both. Let us consider all three types of models respectively.

i. Energy based application development model:

Maximizing the battery lifetime is one of the most desired thing for a smartphone. The µcloud model [5] One of the energy based application model for mobile cloud computing. The advantages and disadvantages of this model are as follows:

Advantages: it supports self contained application components that are decoupled from each other.[1]

Disadvantage: It requires skilled programmers to develop the application components that are later used. Secondly in µCloud a single application partition can only execute on one orchestrator at a time. Thirdly, the data that is exchanged between the components is not provided with any security [1].

ii. Performance based application development model:

Enhancing the performance of the mobile device is the need of the hour to run the heavy resource demanding applications. So such models only deals with Offloading the tasks to improve the performance without caring about the energy efficiency. One of the performance based application development model is the Clone Cloud Model [4]. Clone cloud model as the name suggests creates a clone of the mobile device in the cloud infrastructure. The Handheld device and the clone needs to be synchronized properly for the smooth functioning.

The clone cloud model supports the augmented execution technique that offloads parts of the Application execution to the nearby cloud infrastructure. At the time of execution the data is transferred to the clone on the cloud and the handheld goes in the sleep mode till the processed data is returned from the clone of the device from the cloud.

Advantages: 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. 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 [1],[4].

Disadvantage: 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.[1],[4].

iii. Energy and performance based application development model:

These are the application models that are concerned with the Performance as well as Energy Efficiency of the Mobile cloud application. One of the Multi-Purpose application model is MAUI [6]. This model provides offloading application with minimum possible intervention of the programmer. This is a plus point as programming to offload is not preferable in the cases of mobile phones. MAUI is more focused towards the energy efficiency so it offloads all the heavy tasks to the cloud or nearby infrastructure to save energy.

MAUI works on the History based approach while making decisions to offload the task. It uses a profiler to make decisions. Profiler is an optimization engine that takes the decision whether offloading is more efficient or performing on the local resource is more efficient. It takes these decisions based on the History based approach i.e. based on the some previous database about the performance and energy requirements [6].

The application partitioning is dynamic and the offloading is done on the basis of methods instead of complete application modules to minimize the offloading delay. However, MAUI creates two versions of smartphone application, for local and remote execution using Microsoft .NET Common Language Runtime (CLR) [1].

Advantages: Independent methods can be marked for remote execution in MAUI programming environment. Secondly it uses dynamic methods to partition in order to reduce the burden on the programmers [1], [6].

Disadvantages: MAUI uses history for the offloading decisions. if a new independent task comes for execution it is not considered by MAUI. Secondly MAUI Profilers consumes energy, processing power and Memory that are already less in a smartphones [1], [6].

III. RESEARCH PROBLEM

Based on the current study of the literature of mobile cloud computing we have seen application development models based on Energy, performance or both. Every application development model has its own advantages and disadvantages.

Problem statement:

There should be an Application Development Model which should shorten the response time and save battery as well. An offloading framework that aims to shorten response time and reduce battery life as well is the need of the hour.

We had performed this experiment on a Matrix multiplication application that we have offloaded to the cloud for execution from an android application from a smartphone.

IV. DESIGN OF PROPOSED SYSTEM:

Proposed Model:

The flow of applciaiton execution in a Mobile system is as shown in figure 1. The application is either executed by the CPU ,Co-processor or in the cloud as shown in the figure 1 . The data S_{input} as shown in the figure 1 represents the data stored on the memory that is to be processed to get the required output S_{output}. So here the data to be processed is transmitted to the CPU, Co-processor or in the cloud . So in our model if the data is supposed to consume more energy and time on the device we will tramit the data to the cloud

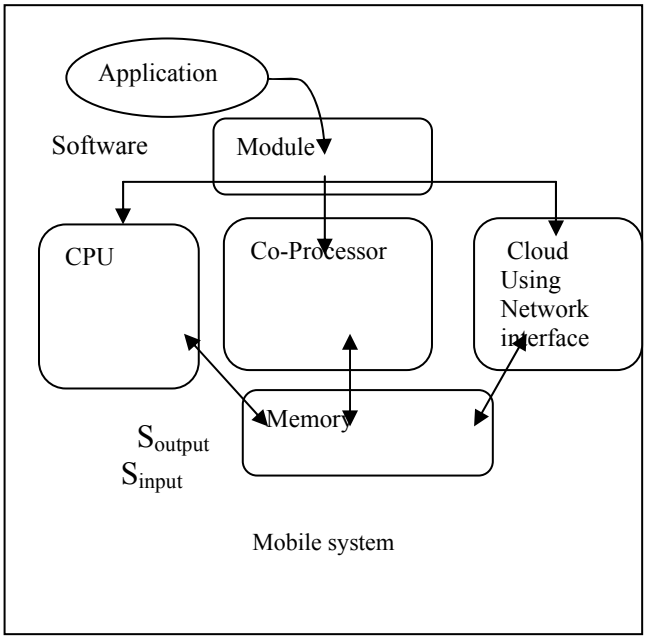


Figure 1: Flow of application execution.

for the execution. So here it takes some Time to transmit the data to the cloud. Suppose the time required by the cloud is T_{cloud}. We will divide the time reqiured by the cloud in two parts. The first part is the tansmission time t_{trans} and the second part execution time t_{exec} that gives the exact execution time by the cloud . Consider the speed of the network to tranmit the data to the cloud is "A". consider P_{cloud} as the power consumed by the network interface to transmit and receive the data from the cloud.

Now the total time by the cloud is given by

T_{cloud} = time spend on fetching data from and writing back to the memory +Network transmission time +time spend on the cloud.

So by using the above formula we can give the total amount of time by the cloud to execute the given data. So as the time required is reduced the performance of battery increases gradually. So time required is directly proportional to the performance as well as the battery consumption. So using this designed model by reducing the response time will help us to reduce the energy consumption of the device.

V. Matrix Multiplication Application Case Study:

We have designed a Matrix multiplication application based on the above proposed model that reduces the response time and offloaded the calculations to the cloud to test the amount of energy that can be preserved on various stable and unstable internet connections such as Edge, 3G, Wi-Fi of various Bandwidth.

We have performed this experiment on Samsung Galaxy S3 I9300. We adopted Samsung galaxy S3 I-9300, which is a popular and powerful smart phone, as our Device under test. I-19300 is equipped with a Quad-core 1.4 GHZ cortex A9 processor, a 1GB RAM, and a Wi-Fi IEEE 802.11 a/b/g/n interface. The operating system used in I-9300 is Android 4.3 Jellybean. It has a standby time of up-to 590 hours on 2G and up-to 790 hours on 3G. It has a data speed of 21Mbps on HSDPA, and 5.76 Mbps on HSUPA and a Li-Ion 2100 mAh battery.

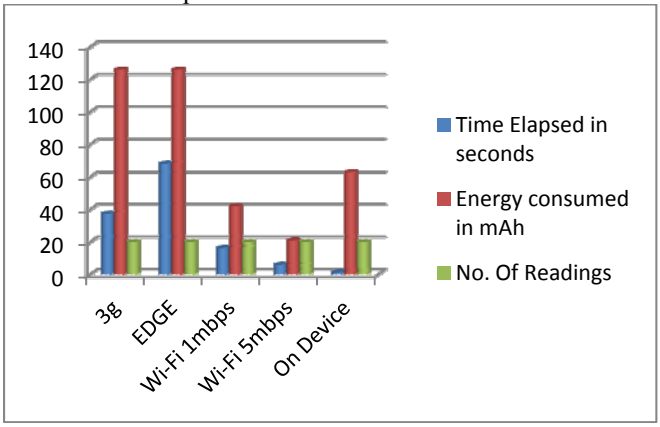
We have taken twenty standard readings on each technology number of times, and found that there is a lot of variations in the execution times on the Edge and 3G connections as these connections are not stable because there are network variations with respect to place. In contrast to this we found that there were negligible variations on Wi-Fi connections as these connections are Stable in terms of Bandwidth and speed as well.

Below is the table that shows Time elapsed in milliseconds and total energy consumed in mAh during our testing on various technologies.

Connection Type	Total Time Elapsed(ms)	Energy consumed
3G	37421	6%
Edge	68195	6%
Wi-Fi(1Mbps)	16307	2%
Wi-Fi(5Mbps)	6001	1%
On Device	1317	2%

Table 1: Summary of Test Cases

The graphical representation of the above test cases is as shown in the Graph below.



Graph 1: Graphical representation of results.

As we can see the results above that the energy and time consumed on unstable connections is more as more as compared to Stable Wi-Fi connections and secondly as the speed or bandwidth of the Wi-Fi connection is increasing the amount of time as well as the amount of battery consumed is reducing. Means if we are using mobile cloud computing on a high speed internet stable connections such as of 10Mbps or 100Mbps in the near future. It will be more convenient than performing the operation on the device itself.

VI. Conclusion

In this paper we have carried out the experiment to prove that Mobile cloud computing can save Energy as well as time of the smartphone by offloading its tasks to the cloud using high speed stable internet connections.

We also conclude that in mobile cloud computing framework Energy and Time is directly proportional to the speed of the Internet connection and its stability.

As performing a task on the device itself consumes the main memory, Processor or CPU as well as the energy of the smartphone, Computation Offloading is a Better alternative to it.

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