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ABSTRACT:
In spite of great advances in the mobile devices as a computing platform, applications is still very limited due to the poor computing capability of mobile devices and limited battery life. In order to overcome these obstacles compute intensive task are offloaded to the cloud to accelerate the computation on the mobile devices and thus improve the performance of application and extend the battery life of Smartphone.

Keywords: Mobile Devices, Cloud, offload, compute intensive, processing speed, energy.

I. INTRODUCTION

In our day todays life smartphone have become the common entity in our life. These Smartphones provide us with very exciting applications which require large computing capacity and energy to sustain this computations. These Smartphone’s houses many sensors like cameras, GPS, inertia and motion sensors, even these constantly add to energy consumption.

Even though we see great improvement in the battery technology, smartphones still suffers from the battery life problems. According to survey conducted by the changewave research [1] it is found that short battery life is the serious concern for many mobile users.

We can overcome these obstacles faced by the mobile devices by successfully shifting the compute intensive part of the mobile application to the remote servers then getting the result back to the mobile devices. However setting up and managing these servers is not a easy task. In such a case cloud computing provides the clean solution.

Cloud computing [2] delivers the vision of computing as a utility (such as water, electricity, gas, and telephony) and provides “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”. For example Amazon EC2 [2] provides on demand computational power and scalable storage to its users.

Recently, with great advances in the wireless technologies , cloud computing , ubiquitous computing devices , location based services and mobile web has given rise to new platform called mobile cloud computing. Which allows the user to access the unlimited computing power and storage space. There are three types of MCC ways.

1. Allow user to access the cloud services on mobile devices through web browser.[3]

2. Group of mobile devices collaborate to act as virtual mobile cloud. This type of cloud acts back up service when the network access to the actual cloud is lost.[3]

3. The cloud storage and processing capabilities are used for applications running on mobile devices. This is done by offloading selected compute
intensive task on mobile devices to the cloud resources.[3]

The rest of the paper is structure is organized as follows. First, we begin with how Mobile Cloud Computing works. Second, we discuss the process of general computation offloading. Third, we discuss the how computation offloading saves energy. Fourth, we discuss existing computation offloading application models and frameworks. Fifth, we discuss the challenges and issues in computation offloading. Then we finish with conclusion.

II. RELATED WORK

Earlier work in this area is Internet Suspend and Resume[4] where they move whole VM or OS image along with the running process. But it faced the problem of large amount of data to be transferred over the network. These limitation were overcome in the VM synthesis approach[5] where part of VM is send from mobile to nearby cloud that already holds base VM of same type.

Then automatic partitioning of application is used in the Coig[6] to reduce communication cost of partition components. Where this Application is partitioned stastically. Which did not provide the better user experience as application is run in changing environmental conditions. In systems like CloneCloud[7], these limitations overcome by partitioning the application dynamically at binary level by taking various environmental conditions into account. An analysis is done offline to decides which binary pieces are to be migrated to the cloud.

MAUI[8] enables fine-grained energy-aware offloading, provides a graph of program’s methods and divides those methods into local and remote groups. Meanwhile it uses online profiling and a history-based approach to decide whether a method should be executed remotely. However, it provides a server for each application, which is inefficient when handling many new applications.

III. HOW MOBILE CLOUD COMPUTING WORKS

![Figure 1: Mobile Cloud computing architecture.[9]](image)

Figure 1: Mobile Cloud computing architecture.[9]

Figure 1 shows the architecture of the Mobile Cloud computing where mobile devices connects to the mobile networks via base station or(satellite, access point) which is responsible for establishing and controlling the connection between them. Central processors transmit's the information requested by the mobile user to the servers providing mobile network services like authentication, authorization, and accounting base on home agent and subscriber data stored in the databases. After this mobile user requests are forwarded to the Cloud Controller which does necessary processing to provide mobile user with required Cloud services from data centers.[9]

IV. COMPUTATION OFFLOADING PROCESS

Based on above representative architecture given in figure 1, we discuss how mobile devices can use the cloud to overcome the constraints of mobile devices. This done by offloading compute intensive parts of application i.e. (application codes and associated data) to the cloud then getting result of execution back on mobile device. Since cloud contain abundant resources, execution of larger task in the cloud is considerably faster than that of mobile device. [3]

1. STAGES IN COMPUTATION OFFLOADING
1.1. PROGRAM PARTITIONING

![Diagram showing program partitioning](image)

Before offloading the mobile application to the cloud, offloadable parts of the application are identified. This is achieved by partitioning a program[10]. There are various ways to partition the program:

1.1.1. PRE-DEFINED INTERFACE: In this level of partitioning, the developer has predefined interface in the system when the class implements this interface, it is marked as offloadable.[11]

1.1.2. VM-MIGRATION: The complete state of the VM would be migrated into the remote server. There is an alternative approach called VM synthesis where the smaller state (VM overlay) is transferred, which causes more computation to be performed locally.[11]

1.1.3. METHOD LEVEL: The program is partitioned at the method level. As the method is called for the remote execution, the state associated with this method is transferred. The method is required to be marked as off loadable, which are analyzed during static analysis phase for making offloading decisions.[11]

1.1.4. THREAD LEVEL: In this level of partitioning, it requires less state to be transferred between the client and server machine. The conventional thread migration techniques use the following approach to migrate a thread:

1. Execution of the current thread is suspended.
2. The Java stack, program counter, data state are captured, and then this state is send to the target.
3. Then the thread is rescheduled for execution. [11]

1.2. STATIC OR DYNAMIC DECISIONS

The offloading decision[10] are used to decided whether or not to offload the application according to environmental conditions like network bandwidth etc. The offloading decision can be static or dynamic. When the decision is static, the program is partitioned during development. Static partition[10] has the advantage of low overhead during execution. However, this approach is valid only when the parameters can be accurately predicted in advance and decide how the application is offloaded. In contrast, dynamic decisions[10] can adapt to different run-time conditions, such as fluctuating network bandwidths and accordingly partition the program. Then decide to offload the program or not according to situation. They incur higher overhead because the program has to monitor the run-time conditions.[10]

V. HOW COMPUTATION OFFLOADING SAVE ENERGY

Mobile systems share the computing cycles with cloud to reduce the amount of computation on the mobile systems. By this it is able to save energy on the mobile system through computation offloading.[12]

1. ENERGY ANALYSIS FOR COMPUTATION OFFLOADING

The energy saved when the mobile code is offloaded to the server is given by the formula.

\[ P_c \times C/M - P_i \times C/S - P_{tr} \times D/B \] ........ (1)

Where the \( P_c \times C/M \) is the energy consumed when the mobile code with the instruction C executes on the mobile system and \( P_i \times (C/S) + P_{tr} \times (D/B) \) is the energy consumed when the same code executes on the server. The power consumed, by mobile system in watts, for computing is \( P_c \), for being idle is \( P_i \), and for sending and receiving data is \( P_{tr} \). Here the S and M are the speeds of the cloud server and mobile device respectively. The time taken to execute code on the server is \( C/S \) seconds and that on the mobile system is \( C/M \) seconds. The mobile device and sever exchange the D bytes of data.
and B is the network bandwidth then the D/B is the time taken to transmit and receive data . [12]

VI. COMPUTATION OFFLOADING FRAMEWORKS

1. CUCKOO

Cuckoo[13] is a computation offloading framework made for the Android platform. This programming model made for the remote and local execution. Programmer uses the AIDL interface to write the program or partition the application into compute intensive and interactive parts. It takes the offloading decision to based on the availability of a server locally otherwise it will execute the code locally. The main advantage of Cuckoo is that it supports partial offloading of the applications to the cloud and uses well-known tools for application development. Cuckoo does not support asynchronous callback and state transferring from remote resources. Cuckoo does not support asynchronous callback and state transferring from remote resources. Another shortcoming of Cuckoo is that it requires programmers support for the modification of applications.

2. SMARTDIET:

SmartDiet[14] is a tool kit, to assist mobile application developers in creating code which is suitable for energy-efficient offloading, constraint identification and software structure analysis. The energy analysis tool finds and visualizes the parts of a given application that could yield energy savings when offloaded. The constraint identification tool automatically identifies constraints in the source code, determines which methods can be offloaded as such and points out trouble spots in the code. The idea for the software structure analysis tool is that it analyzes the program code to find opportunities to save energy through restructuring.

3. COCA:

We propose and build a new programming framework called COCA[15], which offloads computation from smartphones to the cloud using Aspect Oriented Programming. Aspect oriented programming (AOP)[16] suggests that development and design of programs focus on "aspects". AOP, an aspect of a program is a particular functionality, e.g., accounting, environment checking, logging, security, etc., that horizontally cross-cuts a plural number of threads of logical flow in a program. COCA works for Java applications running on Android, but in principle, it can be extended to any other programming systems where there is AOP support. COCA allows the application programmer to choose which target objects or functions to offload. COCA consists of three stages, namely, profile, build, and register. The result of profiling is summarized in a report presented to the user, who can then decide which functions to offload based on the report. Build stage, will divide original java source code into two parts namely, those to and not to be offloaded. The register stage is the final stage. Where the user needs to have account in the cloud then COCA server can be easily run in the Cloud. After these three stages, COCA is set up and ready for offloading. COCA will make computation offload requests to the server daemon in the cloud.

4. A GAME THEORETIC APPROACH:

This approach consists of three tier architecture of local tier mobile nodes, middle tier of cloudlets, remote tier of distant cloud servers. In this architecture, mobile nodes have the choice of offloading their computation to a nearby resource-constrained cloudlet or to a remote tier of resourceful cloud servers. When short response times is required the computation offloading from the mobile to the cloudlets is carried out. This approach tries to formulate the mobile computation offloading problem as a Generalized Nash Equilibrium Problem[18-20]. The target of each user (actually of the mobile node) is to determine whether and where to offload a task based on the impact this has on his/her usage experience, expressed through suitable Quality of Service (QoS) measures (power consumption and application performance are the most important quality factors in a mobile scenario). This problem is solved as a set of equations which is optimized for the power consumption and response time. With this optimization it is able to find out the convenient computation offloading strategy.[17]

VII. ADVANTAGES OF MOBILE CLOUD COMPUTING

1. Extending battery lifetime by offloading energy intensive tasks to cloud.
2. Improving data storage capacity and processing power of mobile device.
3. Improving the reliability by creating the backup of application and data.
4. On demand provisioning of Cloud resources.
5. Scalability, multi-tenancy and ease of integration.[21]

VIII. ISSUES IN THE MOBILE CLOUD COMPUTING

Though cloud computing assist the mobile computing in saving energy and improve the application performance the designer must face several issues privacy, security, reliability, availability etc.

1. SECURITY:
   For the user to trust the mobile cloud computing platform the privacy of the user and security of the data/application are the top priority. Because smartphones are sometimes exposed to malicious program code. They have to be secured from malicious program code that could be offloaded on the system. Installing and running security software are used to detect threats on the device and avoid offloading. But due to limitation of mobile devices they are computation is shifted to security server in the Cloud. The user has to be able to trust that the computation performed on the surrogate is trustworthy and that the privacy and integrity of the offloaded data is not compromised. The approaches used to ensure privacy is to encrypt the data but the encryption has its on limitations. Another technique to ensure privacy and security is to use steganography. Steganographic techniques can be used to transform the data so that operations can be performed without exposing them. Along with this security and privacy of the data the integrity, authenticity of data also done.[21]

2. RELIABILITY:
   Mobile Cloud Computing depend on the wireless network and cloud service. This is because Computation offloading to Cloud may not be possible, energy efficient when the wireless connectivity is limited or absents. Mobile Cloud Computing to depend on the cloud service to perform the computation offloading to Cloud. This could become the problem when the service outage.

3. AVAILABILITY:
   In Mobile Cloud Computing service availability becomes a important issue due to traffic congestion, network failures and the out of signal. In order to overcome this problem mobile nodes have to connect to near by nodes whose link to the cloud is present without interruption.[21]

4. HETEROGENEITY:
   In Mobile cloud computing mobile nodes will be exposed to different wireless network interfaces (like WCDMA, GPRS, WiMAX, CDMA2000 and WLAN) to connect to the Cloud. While connecting through these networks they have to maintain the Mobile Cloud Computing requirements (e.g. always-on connectivity, on demand scalability of wireless connectivity and the energy efficiency of mobile devices). Which becomes an issue in mobile cloud computing. The solution is to use intelligent network access strategy to handle dynamics and heterogeneity of available network access.[21]

5. LOW BANDWIDTH
   Bandwidth is one of the issue in Mobile Cloud Computing due to scarcity of radio resources for wireless network and increase in the number of mobile and cloud users. This issue can be overcome by sharing bandwidth among mobile users located in the same and using same containt. [21]

IX. CONCLUSION
   By combining two technologies like mobile computing and cloud computing we can easily overcome the constraints of the mobile devices like battery life, processor speed, memory capacity by offloading compute intensive part of mobile application to the Cloud. This improves the user experience of the application and save energy on the mobile device. Then we have discussed how the computation offloading process is carried out in stages and how it save energy. Though offloading in mobile cloud computing has several advantages it is accompanied by several issues like security, privacy, reliability, availability, heterogeneity, low bandwidth etc.

X. REFERENCES


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