

Augmentation of Energy Efficiency for Smart Phones in Cloud Environment

Nancy Arya^a, Sunita Choudhary^a, S. Taruna^b

^aBanasthali Vidyapith, Rajasthan, India, ^b JK Lakshmipat University, Rajasthan, India

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ABSTRACT

The usage of technology of mobile phones has increased enormously from the last one decade and it has impacted the human life. Now, smart mobile phones have enough capability to run high number of complex and intensive applications results shortened power capacity and less performance. However, these smart mobile phones are facing few challenges such as limited data storage capacity, less power capacity, security, poor performance and limitations on computing power. Power limit is the serious constraint for mobile devices because it depends on a fixed mobile battery. Thus, it is very important to conserve the battery to the extent it is possible. The technology of Mobile Cloud Computing is the newly emerging paradigm combines the concept of cloud computing and mobile computing to resolve the issues of smart mobile phones. Hence, Mobile Cloud Computing employs computational offloading also known as augmented execution that migrates the computations from smart mobile phones to cloud. The paper focused on the approach to achieve energy optimization for resource hungry applications in mobile cloud environment.

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1. Introduction

The innovations in the technology of mobile cloud computing has lead to the advanced mobile devices. Mobile Cloud Computing is the potential technology to resolve the challenges related to performance, environment and security [8]. According to Allied Business Intelligence (ABI), the business of smart phones push the profit to \$5.2 billion. Energy saving, high computation capacity and storage capacity are the most required features of a smartphone [9]. The performance of the mobile devices such as processor power, bandwidth, and storage can be augmented with the integration of cloud computing platforms. Smart mobile phones are now capable to process several complex applications that drains the power quickly. These applications can be local or internet-based applications. Thus, Power limit remains a key restricting factor in the development of portable applications. These restrictions may be resolved by the computational offloading that transfers the computational data to cloud server for processing and then return the results back to the mobile client. This concept is useful to overcome the issue of resource poverty on mobile side [2,3]. Computational offloading depends on various parameters such as the data transfer bandwidth, task or application type, amount of data exchanged etc. [4]. These parameters help to decide the part of computation which needs to be offload. Offloading can be static as well as dynamic. Several offloading approaches exist to optimize the energy consumption of smart mobile phones in mobile cloud environment but mostly do not focused on the additional overhead of partitioning. Thus, the main focus is to explore the optimum solution to offload computational applications along with proper usage of resources so that the overall efficiency of energy and performance can be better. The paper is organized into three different sections excluding the section of Introduction. Section II describes the Related Work of offloading in mobile cloud-based environment. Section III describes Proposed Work with features and results. Finally, Section IV is Conclusion.

2. Related Work

The main objective of computation offloading is to overcome the resource constraints such as battery life, CPU power and storage that are associated with the device. Although, many research works have been done to implement the offloading in cloud-based environment. By offloading the modules on cloud, approximate 75% execution time can save and 56% battery can optimize [13]. Energy is an important factor for mobile devices [10]. μ cloud [6] is energy aware framework basically designed for self-contained decoupled modules. But this model executes only a single application partition on orchestrator at a particular time. Authors in [14] made several experiments on offloading approaches. The results obtained from the conducted experiments that the remote execution of the application is helpful to optimize the energy consumption. HyFog (Hybrid Fog) model [15] allows mobile devices to choose between the local computing environment, remote computing or a hybrid of both. It solves the problem of optimal selection by using a minimum weight matching problem over three-layer graph. Author in [16] designed a framework HODA for multi user task offloading and optimum utilization of resources in cloud by offloading the computational tasks to the edge networks by converting the problem to a sub module problems. Author proposed in [7] an energy cost framework for distributed application which saves 5% of the actual battery power consumption. Energy-Efficient Multi-Site Offloading (EMSO) algorithm is proposed [12] to manage the number, size and dependency of tasks in a mobile application to augment the energy efficiency. MAUI framework [5] designed is to reduce the energy usage by offloading the components of mobile games in cloud; it saves approximate 27% of energy of the mobile device. The disadvantage is MAUI does not address the issue related to scalability, Quality of Service (QoS) and transmission latency. Author proposed in [17] a heuristic algorithm for joint optimization problems to reduce the energy consumption and the execution delay for mobile applications. Author [11] designed a model for task offloading in ultra-dense network. This framework is capable to reduce 20% in the execution time and 30% in the battery consumption. Author proposed [13] an application development energy aware framework for matrix multiplication application to augment energy and performance both by using speedy stable data connections. EECOF (Energy Efficient Computational Offloading Framework [1] designed for the computation of intensive mobile applications by using the cloud services with a smaller number of instances of applications at execution time. This framework reduces the data transmission size by 84 % and energy utilization by 69.9. MobiCloud [10] is designed to integrate the cloud computing with mobile ad-hoc networks by using the MANET as service-oriented architecture.

3. Proposed Work

The current research is based on task offloading from mobile to cloud to reduce the consumed energy during the task execution by utilizing the cloud services. Conventional offloading frameworks employs profiling and partitioning technique to offload the mobile device application. However, it increases the turnaround time and power consumption of applications on local device. The energy can be optimized by reducing the additional overhead at run time. To reduce the additional overhead, least instances of computational application should offload to the cloud at runtime rather than component. Benchmarking of the computation is important so that the system learns the complexity of the computation time and energy involved in it before taking any decision on offloading. The decision to either process the computation on mobile or offload to the remote cloud server (partially or completely). The assigned set of task executes locally on the mobile environment, if the decision comes in the favor of the mobile otherwise it is offloaded to the cloud. Partitioning the assigned set of tasks into various subtasks which are then distributed across the mobile and remote environments. Then, the obtained results from the respective environment are combined. The partitioning decision depends on several different parameters of cloud and mobile device like type of task, time spent in execution, total resource utilization, processing load, bandwidth usage, storage, energy consumption and type of data connection etc. Energy efficiency is measured in reduction of energy consumption. The energy calculation in the case of mobile and cloud execution includes energy consumed for reading data from memory e_m , energy consumed in execution state e_s , energy consumed for writing data to memory e_w , energy consumed in network transmission e_n , energy consumed in part execution e_p . Thus, the total energy (E) required for the execution of task completely is:

$$E = e_m + e_s + e_n + e_w + e_p$$

Energy can be optimized for computational application by reducing the total energy consumption. The research work evaluated the experiment with the applications Merge sort and Quick sort on android smart mobile phone Xiaomi Redmi note 4 in the simulated environment to verify the energy consumption. The mobile phone is equipped with processor snapdragon 625 Max 2.0 GHz, 3.00 GB of RAM, 4100mAh battery and interface of Wi-Fi 802.11 a/b/g/n. Benchmarking is performed on a large data (> 10 N) and average values are utilized for the decision making. Merge sort and Quick sort are well known sorting algorithms used for sorting a data set. The time complexity of merge sort is $O(n \log n)$. Merge sort has the advantage that it can be partitioned easily and executed parallel on two or more processors. The second computation experiment that has been used is quicksort. The time complexity of quick sort is also same as merge sort but in worst case, it is $O(n^2)$. In an average case, Quick sort is slightly slower than merge sort but with same time complexity. Different size of data is used to see the decisions taken by the offloading algorithm and also the total energy used in every case. Fig.1. (a) and (b) shows the comparison of energy reduction between mobile, complete execution on cloud and partial offloading by proposed work. It

clearly shows that the offloading is useful in improving the performance of computational task. It also reduces the overall energy required to carry out the computations. The actual benefit of offloading is achieved around the data size of 4000000. However, the impact of benefit is less for small size of data but as the data size increases, impact becomes high.

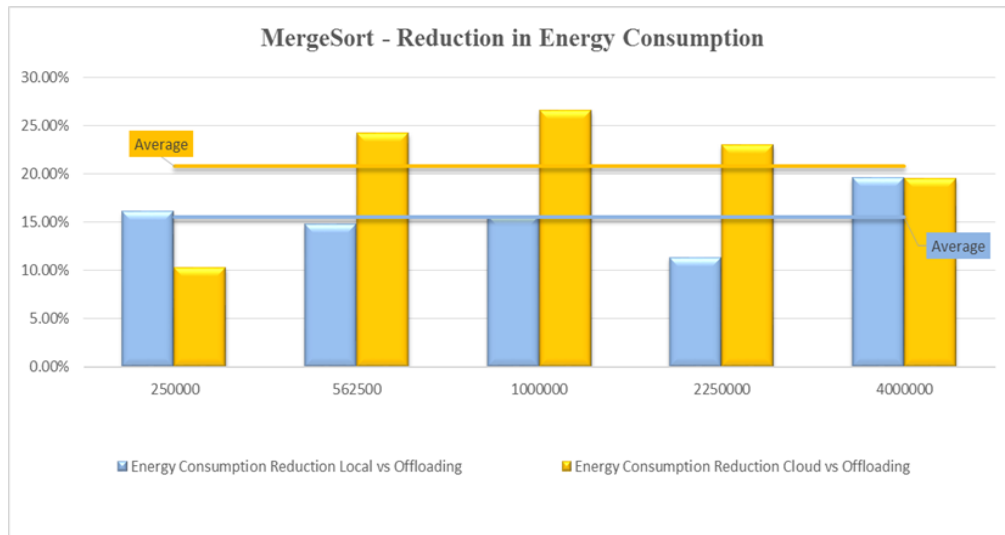


Fig. 1. (a) Reduction in Energy Consumption in Merge Sort

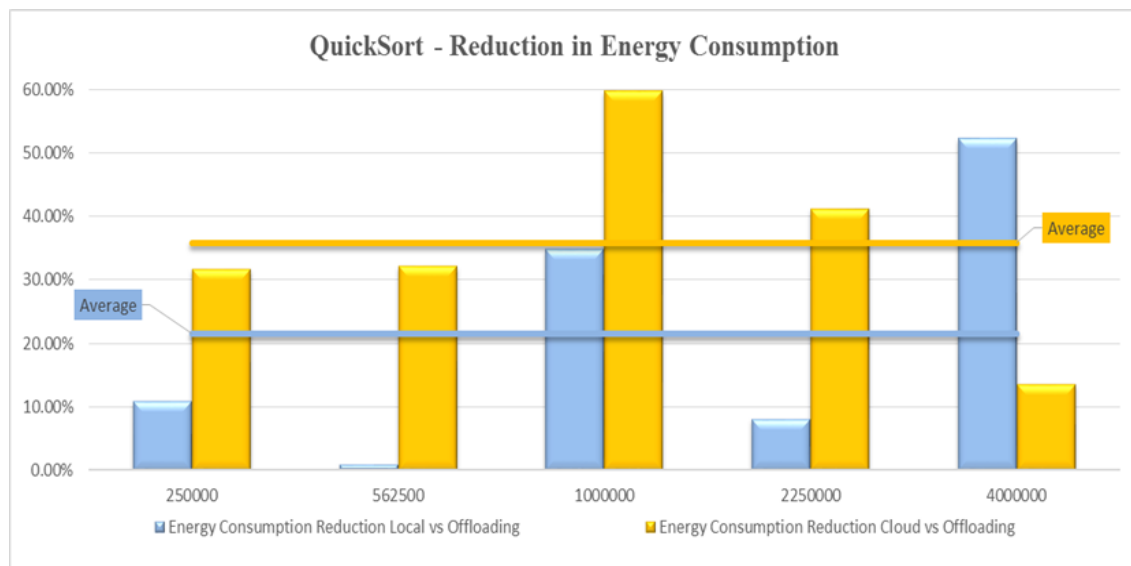


Fig. 1. (b) Reduction in Energy Consumption in Quick Sort

As can be seen from Fig.1. (a), an energy reduction benefit is upto 19.8% for different data sizes as compared to the pure execution on mobile and upto 26.4% when complete cloud execution and distributed execution are compared. Fig.1. (b) shows, there is an advantage upto 52.4%, when compared to mobile execution and upto 59.9% when compared with cloud execution.

4. Conclusion

The technology of mobile cloud computing is helpful to reduce the energy consumption by offloading the mobile applications from mobile device to cloud. Energy efficiency and performance can be improved by reducing an amount of additional overhead at execution time. To achieve this, only limited instances of computational task should offload to the cloud server. By reducing the total consumption of energy, performance and energy efficiency may be augmented gradually. Merge sort and Quick sort both applications are used for offloading. It was found in both cases, there is an impact of offloading on energy consumption. However, the impact is less for small data and high for large data sets.

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