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Online Cloud-Based Battery Lifetime Estimation Framework for Smartphone Devices

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Abstract

Smartphones are resource constrained external battery operated devices. The resources of smartphone devices such as a battery, CPU, and RAM are very low compared to the desktop server. However, the requirements of smartphone users are growing tremendously. As a result, smartphone applications perform rich functionality to enrich user experience. However, due to increase in the execution capacity of smartphone applications, smartphone battery lifetime minimizes. This study proposes a cloud-based framework that estimates battery lifetime of a smartphone device. Moreover, it overviews the theoretical design of computational offloading framework to present an application area for the proposed work. Finally, it presents preliminary results to evaluate the proposed framework.

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Keywords: Mobile Computing; Cloud Computing; Computation Offloading; Battery Lifetime Estimation; Energy Optimization;

1. Introduction

Nowadays, user dependency on the smartphone devices has exponentially increased owing to rich functionalities of the smartphone devices. The main features of emerging smartphone applications including context awareness,

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offline usability, ubiquity, and responsiveness, increases their battery resource requirements[1]. According to RFE/RL report, 75% of the world population has their own mobile phone devices. Usually, a smartphone application developer only considers usability, maintainability, and robustness of applications during the development process. It is reported that 80% of the application developers do not consider energy consumption as a parameter during application development[2]. As a result, the poorly written applications significantly consumes battery resource of a smartphone device[1].

Energy estimation of smartphone applications is estimated either using code analysis method or smartphone components power measurement. Code analysis based estimation considers energy cost for each operation of a smartphone application for its energy estimation[1, 3]. On the other hand, smartphone components power measurement based energy estimation considers energy consumption of each smartphone components during application execution on a smartphone device. Smartphone components power measurement-based estimation methods construct power models for smartphone components in lab setting environment. The power model for smartphone components is architecture dependent. Alternatively, the energy cost for different operations of smartphone application is profiled either by constructing test programs for each operation or by using application instrumentation method[2, 4]. Energy consumption by all applications within a smartphone device creates an opportunity to estimate the lifetime of a smartphone battery. Smartphone battery lifetime describes how long the smartphone will remain awake before it is shut down due to no charge in a smartphone device. Estimating battery lifetime of a smartphone device empowers smartphone users to take necessary actions to augment device battery lifetime. For instance, the smartphone user can turn off the energy consuming applications based on battery life estimation readings. This study is especially useful when the user is traveling across the deserts or jungle and he/she has no charging facility. In such a case, battery life framework enables smartphone user to switch the smartphone to low application execution mode. The contribution of this study includes:

i. Proposing a two-layer framework for battery lifetime estimation of a smartphone device.
ii. Evaluating framework for Google Nexus One smartphone using Power Tutor based estimation method.

The organization of this paper is as follows. Section 2 discusses related work. Section 3 discusses proposed smartphone battery lifetime estimation framework. Section 4, 5 discusses experimental method and results of the case study. In Section 6 discusses the initial results and conclusion of this study.

2. Related Research Works

Battery lifetime of a smartphone device highly depends on the number of applications it host. The energy consumption of a smartphone application depends on the smartphone components that it triggers during its execution on a smartphone device. Smartphone components such as Wi-Fi, 3G, LCD, blue-tooth, CPU, and voice encoder are the major energy consuming components. In this section, we have discussed smartphone application energy estimation and battery lifetime estimation of smartphone devices.

The energy estimation schemes for smartphone applications are categorized into two classes including code analysis based estimation and smartphone components measurements based estimation. Code analysis based estimation schemes such as[5, 6,] and[7] have considered the operational cost of software operations to estimate energy consumption of smartphone applications. The estimation schemes such as[5] has estimated execution paths of the application by running it on smartphone devices. It instrumented application to find the execution paths of application. It has considered SEEP module for energy cost estimation of software operations. Energy estimation scheme as presented in[7] has considered the effects of software and hardware issues during energy cost estimation of software operations.

There are various type of energy estimation or profiling approaches including (i) OS level estimation, (ii) low hardware modeling, (iii) simulators, and (iv) power measurements. The estimation model based on operating system measures only OS related features such as calls to OS level API, CPU frequency, and network usage[4, 8-11]. The drawback of such approaches is the workload of building model can be high and there is significant integration and modification is needed to the runtime systems. In contrast, the low-level hardware based energy estimation based on assembly instruction or microinstruction of each assembly instruction[12-14]. The disadvantage of these approaches is they cannot measure the energy of external devices such as GPS, Wi-Fi, and camera etc. These devices consume a large portion of mobile device energy. The simulators based energy estimation is built simulators for energy