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Research Article

Investigating the Amount of Power Consumed by Power-Optimizing Applications on Android Smartphones

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Abstract

This paper aims at analyzing and evaluating the consumption of energy of Android power saving applications; however, the study has been done in a qualitative manner. The secondary analysis has been done by evaluating the past research papers and surveys that have been done to assess the perception of the users regarding the phone power from their battery. In addition, the study highlights an issue that the notifications regarding the power saving shown on the screen seems to exploit a lot of battery. Therefore, the study has been done to reflect the ways that could help the users to save the phone battery without using any power from the same battery in an efficient manner. The goal of the study was also to provide a simple insight into four main research questions. As to the research question about energy saving features that could aid in energy resistance, it includes the flight mode, do not interrupt, power off Wi-Fi and data connections. Furthermore, with regard to the research questions about the fact that power saving application consumes a lot of electricity, past studies clearly indicate that there is a lot of battery depletion due to several factors and these problems have become a major problem for smartphone users and manufacturers. The study offers a good insight into many ways that could be used to more effectively conserve smartphone energy.

Keywords: Android smartphones, Android applications, Power-saving, Battery.

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Introduction and Background

Power management has been considered as one of the basic features in the mobile phones; however, mobile companies have been urged in introducing advanced power management features and different power interface and advanced configuration (Datta, Bonnet and Nikaein, 2012). Not only the computer engineers but the mobile phone application developers have been seen to show their interest in encouraging power saving features that must be advanced and must not incur power of the phone. Android version of phone holds the Linux Kernel and has put forward its power management systems including Google I/O (Zhuang, Kim and Singh, 2010). Moreover, it has been reported in the research that there are around 400,000 devices of Android which have activated the power management systems but for some of the individuals, these applications have become an issue. The developers of power management systems and applications have been seen to be very sophisticated thus the hardware components available in the applications have been seen to consume a lot of battery power and also the storage of the mobile phones. High drain of power from the energy saving applications has become a major issue for the users thus they are having really bad experience. Moreover, there are some of the important components such as GPS, Wi-Fi and OLED which are consuming high energy level and power (Paek, Kim and Govindan, 2010). As per another study and research, in the power saving applications there is a role of third party advertisements that aim at consuming around 30% of the total power consumed by application (Ravi et al., 2008). This is the reason that the persistent usage of the applications could increase the advertisements and automatically decrease the uprightness of the battery. Android aims at developing an aggressive policy and application for the power saving that includes wake locks and helps in conserving the battery life but this is not enough and sufficient for saving the battery. In addition, there are several applications in the Google play store that provide the users to get facilitated with the power saving applications. In order to understand its consistency and power saving modes without wasting the power of the phone, the researcher has done an in-depth analysis to check its operating principle. It has been explored that most of the current power-saving-applications tend to control the features of a smartphone including Wi-Fi, 2G and 3G, brightness level, GPS as they have a significant impact in making the battery life prolong. In addition, the deep analysis also revealed that the use of power-saving modes is statically significant which also controls the features of smartphone. There are several mobile phones which have a pre-define control on saving the battery life. With the changing patterns of smartphone usage, the idea of dissipation of power has been seen to be varied (Ravi et al., 2008). In order to deal with the threats regarding the investigation of the research, it is clear that there are various aspects of android battery saving development which have identified major semantic bugs and syntactical errors. These errors play a major role in destroying the capability of the power saving applications in showing up their capability (Payet and Spoto, 2012).

In this contemporary world, the increase in the application developers have also showed an increase in uncovering various vulnerabilities. This is the reason that several developers have urged in developing the criteria to save the power. For this, the researchers and developers have done research by performing every step statically and ensured that there could be an android application code that might help the users in ensuring high scalability and save the power of the mobile phones (Moran et al., 2015) (Arzt et al., 2013). At that time, the study remained incomplete because of severe obstructions in the specific Android features and the biggest hindrance in the completeness of analysis made the researcher dissatisfied in proposing a mode of power saving (Li et al., 2015) (Lu et al., 2012). One of the common barriers that have been confronted by Android is the lack of the main point of entry or the construction of call graph. These

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issues regarding the introduction of saving modes without compromising the battery of the mobile devices might be controlled if the handlers of Android and other mobile phones work more efficiently.

Not only is this, there are several other challenges carried by the mobile application that include the support of Java programs. Java reflection statements help in dealing with the dynamic code loading; however, major support of Java application would be helpful in obtaining a hype on power saving solution (Moran et al., 2015). According to the recent survey and analysis, securing the mobile phone from viruses is the only way to use it for long term; however, responses from multiple smartphone users indicated that downloading and using power saving applications caused a negative impact on their phones thus it is exploiting their battery usage adversely (Lu et al., 2012) (Payet and Spoto, 2012). The fact about using smartphone is that they are energy constrained and their life relies on limited use of battery supply (Li and Halfond, 2014). The researchers have been playing very well in showing up advanced battery technology that could help in saving the consumption of battery and helps in alleviating the limitations in using the phone. It is important to improve the capability of the developers to construct an energy saving methodology which could be used as an essential source of reducing effect of energy constraints (Hao et al., 2013).

Research Aim and Questions

The primary aim of this study is to give a unique idea regarding the battery saving without the consumption of any power from the battery. The study looks into the following questions:

- Do power saving applications also consume a lot of power?
- What are the issues regarding current power management applications?
- What are some of the proposed ways that could help in saving power of the phone?
- What are some of the battery saving features that could help in improving battery resistance?

Related Work

In the present era, smartphone devices are taking the first place among other technology platforms as users now prefer them for different life purposes. In the past few years this trend has increased, and there has been a significant increase in the number of smartphone users. Smartphones are known to intake an unusual amount of electricity budget of the world due to the repeated charging of battery (Ahmad et al., 2016). Besides that, a report provided by Barry Flscher (Fischer, n.d.) showed that the volume of energy it takes in charging iPhone 5 smartphones globally is equal to the accumulated power utilized by 54000 United States households for each year. Following this report, the power demanded by iPhone 5 each year is ranging from 3.5 to 4.9 kWh. Furthermore, the financial expense for charging an iPhone 5 per year is $0.41. Another approach through which the electricity budget can be minimized globally is through energy estimation.

Power models for mobile devices

The task of modeling consumption of power could be divided along two aspects (Kjærgaard and Blunck, 2012). Initial aspect is related to the approach through which measurements are collected for designing the framework. These calculations can be gathered through utilizing an internal battery interface or through external equipment. The second aspect is the sort of data through which the framework was built. Such a power framework can be planned from: computation of system usage, for instance processer data accessible from OS level, consumptions of power computation for each system call construct to OS and consumption of power computations each application program interface call constructed in a particular language of programming. Numerous research attempts have been managed on the gathering of power models for various hardware building elements of a cell phone device for assisting application developers for estimating energy needs of the mobile application.

Power Tutor (Zhang et al., 2010) utilizes data taken from voltage drop for determining the battery discharge rate to approximate the consumption of power. These frameworks are assembled and approved for single-core mobile processors. The calculations identified that application of the identical model for contemporary high-performance multi-core mobile devices would be somewhat incorrect. Moreover, the Wi-Fi model is unable to discriminate among the energy consumed while sending and receiving states producing not so precise results. Shye et al. (Shye, Scholbrock and Memik, 2009) provided a solution in which he used a background logger which was monitoring the resource usage by emphasizing various hardware elements of the cell phone device periodically. A linear regression framework was planned through accumulating present calculations with an external device, with OS described statistics of battery operating voltage and logger information. Even though, the framework is developed for a sole core Central processing unit, and lower Central processing unit frequencies are not considered while planning the model of power whereas it is rather imprecise for the offloading utilize case. Powerprof (Kantardzie, 2005) also uses a smart battery to calculate the consumption of power at the length of time they take to run through a particular Application Program Interface (API) and such data are utilized for measuring the energy operation of application API calls. Utilizing genetic algorithms (Yoon, 2012), an energy usage profile is identified for every method call. This method is implacable solely when a smart battery applying that particular Application Program Interface is accessible, and it supposes that every time a way is called, the similar quantity of power will be utilized, which is usually over-elaborated. AppScope (Jung et al., 2012) is an energy based on an Android mentoring system that utilizes power frameworks and usage facts or data for every hardware element. Linear regression power frameworks are built utilizing DevScope (Kim, Kong and Chung, 2012), and equipment resource utilization examining is taken by loading extra modules into the Linux kernel. For estimating the utilization data of each trace, application, and inter-process communication are examined, showing a significant overhead. Moreover, this equipment is not managing the multi-core processors. Figure.1 clearly illustrates that there are certain categories of applications which are more towards the consumption of battery in smart phones. However, those categories include Entertainment, lifestyle and productivity, travel and transportation, music and media applications, camera, utilities and other tools.

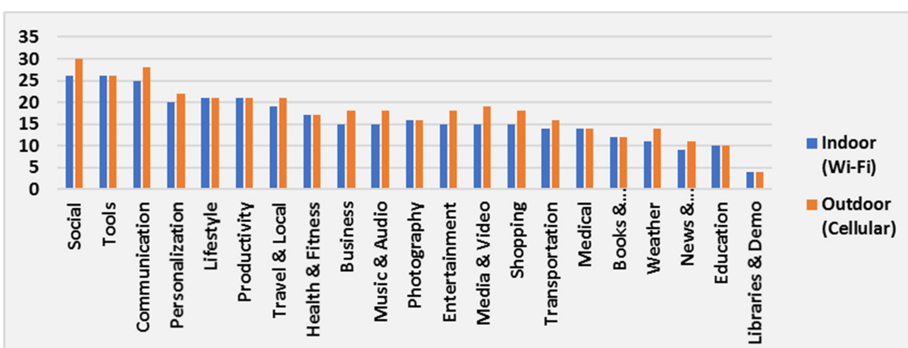

Fig. 1: Average Amount of Power Consumption for Google Play Applications Categories mAh

Figure.2 points out the list of components in an average smartphone and their amount of consumption of battery. Non-Idle energy refers to the power that is active or in-use, however the most common and active energy includes the power consumed by the GPS, the application processor and the flash light that seems to consume a lot of battery.

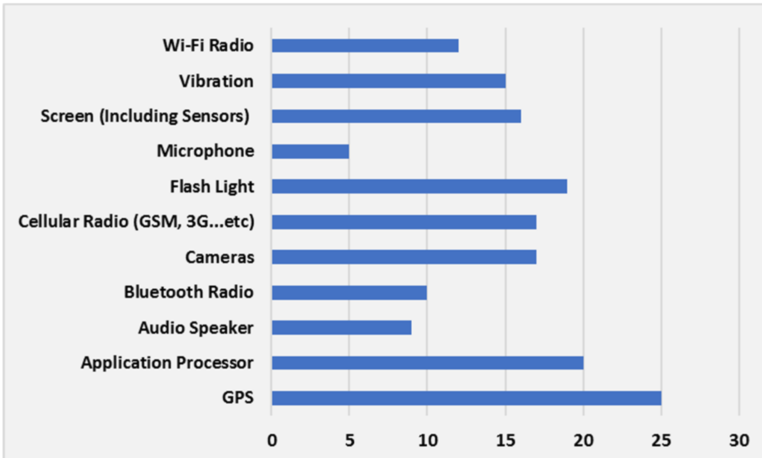

Fig. 1: Amount of Energy Consumed by Each Component of An Average Smartphone mAh

Besides that, the method described in Kim et al. (Ali et al., 2016) provided an expanded online power approximation method for multi-core smartphones which are utilizing an external meter of power.

Present power models, as concluded in Table1, are lacking one or more than one attribute of present mobile hardware: they are outlined for single core Central Processing Units, disregarding the energy proportionality of Central Processing unit frequency scaling or it does not discriminate among the various energy states of network interface cards. Furthermore, specialized hardware and software application program interfaces are needed for measuring the power consumption of the application program interface calls.

Table 1: Mobile device power models for energy efficient dynamic offloading at runtime

Auto scaling	Power Tutor (Zhang et al.,2010) AppScope (Yoon et al., 2012) PowerProf (Kjrgaard and Blunk, 2012) Online Estimate (Kim et al.,2012) Into the Wild (Shy et al., 2009) Dynamic Offloading (Ali et al., 2016)
Cores	Dynamic Offloading (Ali et al., 2016)
Display Unit	CloneCloud (Chun et al., 2011) Power Tutor (Zhang et al.,2010) AppScope (Yoon et al., 2012) Online Estimate (Kim et al.,2012) Into the Wild (Shy et al., 2009) Dynamic Offloading (Ali et al., 2016)
Memory	Dynamic Offloading (Ali et al., 2016)

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Network	CloneCloud (Chun et al., 2011) MAUI (Cuervo et al., 2010) Power Tutor (Zhang et al.,2010) AppScope (Yoon et al., 2012) PowerProf (Kjrgaard and Blunk, 2012) Online Estimate (Kim et al.,2012) Into the Wild (Shy et al., 2009) Dynamic Offloading (Ali et al., 2016)

This power model manages with all these restrictions. Moreover, it is proven for multi-core Central Processing Units, and all assisted frequencies are contemplated. In addition to that, Wi-Fi power framework precisely discriminates among various conditions of the wireless interface card. There is no need for specific software or hardware support, and there is no requirement of extra overhead in the analysis of various traces. This framework also observes the power consumption because of memory acquired to the application (RAM).

Previous Research on Power Saving Modes and Applications

For extending the battery life of Android smartphones, developers have offered many applications which are accessible in the Google Play Apps store. Many such applications were analyzed at the time of the survey for understanding the power saving methods. They study how these applications increase efficiency of power saving, their principles and restrictions of operating that gather different ways in encouraging the improvements. It was identified that these energy saving applications have two different methods for managing the consumption of the energy of smartphones. The following sections are discussing the efficiency of energy consumption, operation and limitations of set Central Processing Unit for Root Users (Kang, Seo and Hong, 2011), Juice Defender (Pathak, Hu and Zhang, 2012), and Central Processing unit tuner (Pathak, Hu and Zhang, 2012). These applications are selected on the basis of their high user rating, positive feedback of the user and their popularity.

Increase in the efficiency of power saving

Many hardware elements such as GPS, Wi-Fi of tablets and smartphones take very extraordinary energy (Pathak, Hu and Zhang, 2012). Hence, energy can be saved by turning them off when they are not being utilized. Moreover, there are various characteristics like auto sync, frequency of recent notifications which uses the hardware and other connectivity. Reducing the rate at which notification occurs (mainly of Gmail, Facebook) also reduces the utilization of smartphone elements and extends the battery life. The listing is not comprehensive.

- Fastening command on Bluetooth, Wi-Fi, auto-sync, GPS, auto screen lock, airplane mode, USB, screen-always-on, mass storage, 2G, torch, 3G, 4G/Wimax (if available) and the cell phone data (APN).
- Fluctuate the brightness level of cell phone's display
- Vibration and volume management
- Screen alteration time value
- Development – night, peak, weekend.
- Timeout of setting Wi-Fi
- Getting a home screen with dark wallpaper for organic light-emitting diode (OLED) display.
- The stated three applications utilize all or a subset of these characteristic in their profiles of power saving.

Power Saving Applications and their Operations

It is essential to know the operating principle of the applications for investigating their restrictions. When the app is installed in a rooted smartphone and the root permissions are given then there are sliders which allow the management of the Central Processing Unit frequency done by hands (Rahmati, Qian and Zhong, 2007). After that, Central Processing Unit administrator must be chosen. It manages how the frequencies of Central Processing unit are scaled among the utmost and minimum set frequencies. Mostly kernels considered as smartphones have 'performance' and 'on demand'. The moment central processing unit load gets to a threshold, on demand increases the frequency instantly and decreases the frequency when the load is on its minimum. Other present Central Processing Unit administrator is mentioned in Rahmati, Qian and Zhong, (2007). A few of them have expert condition controlling attributes. The profiles design the application to set the Central Processing Unit frequency in certain situations. Furthermore, there is a "monitor with condition" which repeatedly monitors the situations set in profiles. If such a situation is true, then a particular profile is activated. For instance, the profile "Battery <" is place when battery level decreases below a provided level. The profile "Time" is activated for a specific time frame. Specific priority is given to all the profiles. If situations of many profiles are correct, then the priority of these profiles is inspected. The profile with the most priority is triggered. In the mobile saving applications, there are various profiles that aim at controlling over the smartphone features, thus the developers must keep a deep focus on creating an application that could be able to be fully customized by the users which might be helpful in making a deep focus on saving high consumption of battery (Wood et al., 2008).

Exploring Battery Saving Features

By exploring the battery saving features, it is clear that there are various ROMs that could be customized like the Lineage Operating system thus these applications help in setting the menu in a manner to optimize and conserve the consumption of battery efficiently. By toggling and pinning the options, the users could easily find and use them. For example, the best thing a user could do to save the power without compromising battery is switching off Wi-Fi and data connection when it is not needed. Moreover, there are several setups in the phone such as do not disturb option that is included for the purpose of power management. In addition, there are some of the smart applications such as IFTTT that helps the user to create their own rules to save the life of a battery efficiently (AndroidPIT, n.d.). There are several limitations regarding the previous research such as:

- The survey done on analyzing the power saving modes has been statically gathered during the development of application and has not been customized as per the behavior of customers.
- The controlling part of the power saving application does not seem to be really intelligent thus the user must also focus on evolving around all the necessary steps.
- It is true that present mobile applications have been exploiting the battery and energy because of the display of adverts and other resources.
- This study focuses on a limited mindset of using the power saving applications or features without exploiting the mobile energy or power.

The power consumption of the mobile for every user is different in each survey.

Conclusion and Future Work

This study has provided a review of the existing literature regarding the different solutions, techniques and tools that have been proposed by different authors in response to battery energy consumption problems of mobile applications for smart devices running on the Android OS. Based on the review of the literature, solutions presented by prior studies in relation to the approach reveal that the average estimations that the proposed tools/techniques provide tend to conflict the actual usage habits of device and the accuracy of the power consumption measurements and simulators remain an issue of debate. Therefore, while the techniques presented herein provide some potential solutions for reducing energy consumption by mobile applications on

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Android-based smart-devices, they are limited in their usage. This study has gone through various areas of interest in order to answer all research questions asked on the introduction section. The study also has explored the literature and related works around power saving applications, the available approaches that have either not added or added a negative effect on the area of saving energy on smartphones. The study was able to classify the different levels of power-usage among different smartphone resources. That has helped us later to sort the smartphone components in terms of their level of power consumption

Based on the findings, a significant share of power consumption in these smart devices is largely caused by applications that are installed on the devices. Depending on the applications' functionality, they entail activities such as data downloading, content display, and use of built-in-sensors such as GPS (Global Positioning System) related sensors. There are various components of mobile smart devices that facilitate the above activities including; GPS sensors, device' display, the CPU, and network interfaces among others. Consequently, activities/functions of different Android smartphone applications increase the energy consumption of any of the above-mentioned components. As a result, there has been a lot of effort in the study geared towards identifying and investigating the underlying potential for energy savings in relation to these smartphone applications at applications layer and OS layer levels.

In reference to the guidelines of the European Commission regarding energy efficiency, Huge improvements in energy efficiency are occurring across the European Union. Energy efficiency policies are delivering in terms of reducing consumption. Although much attention has been given to energy conservation, there are several issues that existing researchers need to devote more attention to. The European Union has successfully managed to decouple energy demand and economic growth. In short, this means reduction in energy use is not linked to a reduction in the economic or industrial activity (European Commission Directorate-General for Energy, 2017). The economy can now grow while energy is being saved. The primary motive for potential work is to stop following the statement that "waste any power from the mobile battery under the premise of saving the same power from the same device". At the end, more efforts are required to recognize the core flaws in the battery savings that are being built and introduced in potential smartphones. Today we are seeing so-called 'energy intensity' 1 levels fall. This fall is due to several factors, including structural changes to the economy and advances in technology. But it is also a result of new national and European energy efficiency policies that have played a key role in reducing energy consumption across the bloc.

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