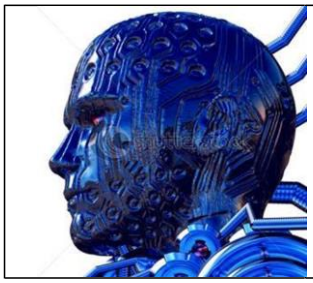

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Analyzing and Evaluating the Amount of Power Consumption Used by Current Power-Saving-Applications on Android Smartphones

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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 has 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.

Keywords: Android smartphones, Android applications, Power-saving

1. Introduction

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 following questions:

- Does 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?

Background

Power management has been considered as one of the basic feature in the mobile phones however, mobile companies have been urged in introducing advanced power management

features and different power interface and advanced configuration [1]. 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 [2]. Moreover, it has been reported in the research that there are around 400,000 devices of Android who has 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 and 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 is consuming high energy level and power [3].

As per to another study and research, in the power saving applications there is a role of third party advertisements that aims at consuming around 30% of the total power consumed by application [4]. 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 provides 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 phone, the researcher has done an in-depth analysis to check its operating principle. It has been explored that most of current power-saving-applications tends 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 who 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 [4].

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 [5]. 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 a 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 [6][7]. 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 [8][9]. Some of the common barriers that has been confronted by Android is the design and implication of the tools of performance that includes the supporting tools like Dalvik Byte code and other translation software. In addition, another barrier is the lack of the main point of entry or the construction of call graph. All these 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 phone will work more efficiently.

Not only are this there several other challenges carried by the mobile application that includes the support of Java programs. Java reflection statements helps in dealing with the dynamic code loading however, major support of Java application would be helpful in obtaining a hype on power saving solution [6]. 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 an negative impact on their phones thus it is exploiting their battery usage adversely [9] [5].

It has been noticed that the use of mobile phones and smartphones have become really popular and there are millions of users who have been using smartphones, tablets and mobile phones. The popularity of the smartphones and its features have been seen to be growing but the issues and concerns regarding an impact of battery on an extensive use of mobile phone application is major. Smartphones have been playing really well and has been providing useful and innovative capabilities to the users. The fact about using smartphone is that it is energy constrained and its life relies on limited use of battery supply [11]. 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 [10].

2. 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. This increase can be seen in Figure.1.

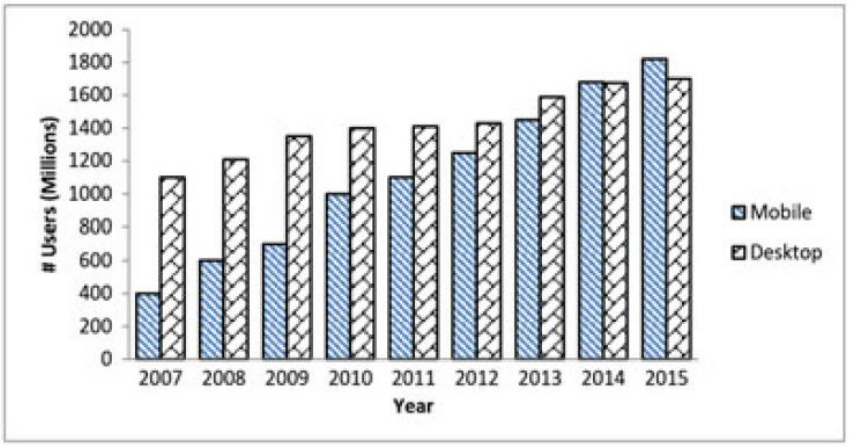

Figure 1: Worldwide mobile phone users.
Source: A survey of the estimation of energy and power modeling for applications of smartphones [18]

It has been forecasted that by 2016, the users of smartphones are going to rise to 1.82 x 109 globally due to their expansion of attractive applications features, enhanced adoption, and accessibility. Smart Insights stated in their study that due to the ever growing rate in the percentage of downloads of application smartphone application markets are going to generate around 77$ billion worth of revenue.

Despite the popularity of smartphones, their application is limited as per the composition of the battery. Smartphones are known to intake an unusual amount of electricity budget of the world due to the repeated charging of battery [18]. Besides that, a report provided by Barry Flscher [19] 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 [20]. 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:

1. Computation of system usage, for instance processer data accessible from OS level
2. Consumptions of power computation for each system call construct to OS
3. 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 [21] 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. [22] 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 [23] 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 is utilized for measuring the energy operation of application API calls. Utilizing genetic algorithms [24], 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 overelaborated.

AppScope [25] 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 [26], and equipment resource utilization examining is taken by loading extra modules into the Linux kernel. For estimating the utilization data of each traces, application, and inter-process communication are examined, showing a significant overhead. Moreover, this equipment is not managing the multi-core processors.

Figure.2 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.

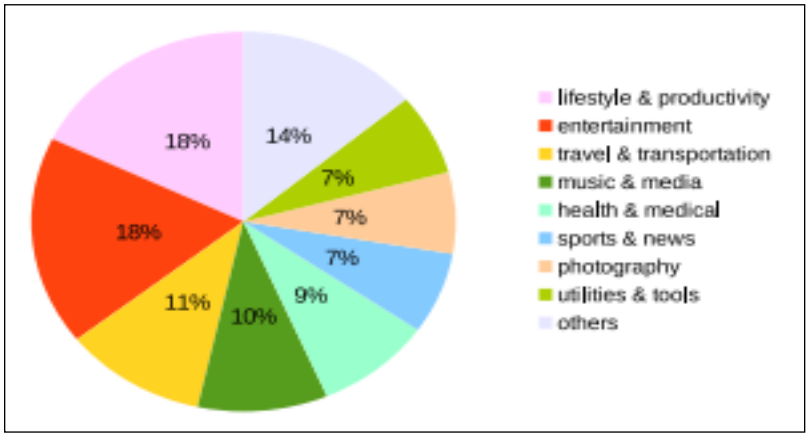

Figure 2: Applications and consumption of battery in Smart phones [26]

Figure.3 points out the list of non-idle energy and their percentage 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 of Internet, UI and Camera that seems to consume a lot of battery.

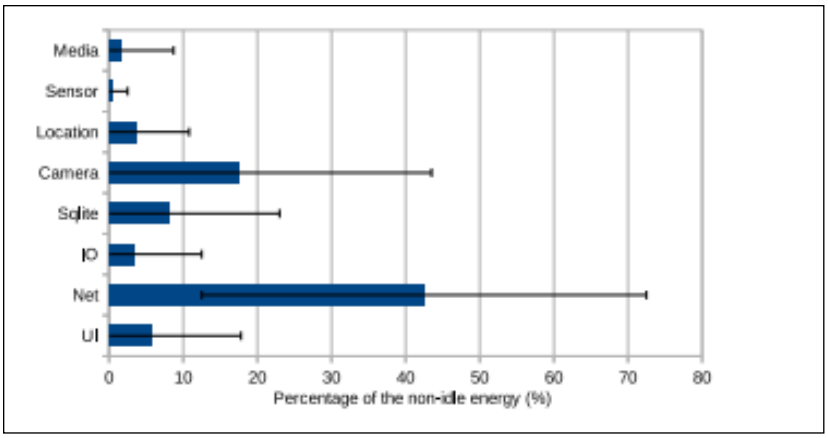

Figure 3: Percentage of non-idle energy (%) [26]

Besides that, the method described in Kim et al. [27] provided an expanded online power approximation method for multi-core smartphones which are utilizing an external meter of power. These power models are taken from the association of subsystem utilization and their consumption of power. Although the Central processing unit power framework is built and validated only for dual-core Central processing unit and the Wi-Fi model does not discriminate among dispatched and given data of the interface of wireless.

Present power models, as concluded in Figure.4 are lacking one or more than one attributes 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 of application program interface calls.

Comparison of previous work related to power modeling.

	CPU		Display unit	Memory	Network
	Cores	Auto-scaling			Wi-Fi
CloneCloud (Chun et al., 2011)	On–Off model		x		On–Off model
MAUI (Cuervo et al., 2010)	Single-core tested				Simplified[a]
Power Tutor (Zhang et al., 2010)	Single-core	2 freq. supported	x		Simplified[a]
AppScope (Yoon et al., 2012)	Single-core	x	x		Simplified[a]
PowerProf (Kjrgaard and Blunck, 2012)	Single-core	Not mentioned			Simplified[a]
Online Estimation (Kim et al., 2012)	Dual-core	x	x		Simplified[a]
Into the Wild (Shye et al., 2009)	Single-core	2 freq. supported	x		Simplified[a]
Our work	Multi-core support	x	x	x	Detailed[b]

[a] Wi-Fi simplified model does not differentiate between Send and Receive states.
[b] Wi-Fi detailed model takes into account Send, Receive, Tail and Idle states.

Figure 4: Mobile device power models for energy efficient dynamic offloading at runtime [27].

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).

3. Previous Researches 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 [13], Juice Defender [12], and Central Processing unit tuner [14]. 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 [12]. 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 application utilizes all or a subset of these characteristic in their profiles of power saving.

Power saving Applications and its operations

It is essential to know the operating principle of the applications for investigating their restrictions:

- **Future Direction in Power Management:** 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 [15]. 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 minimum. Other present Central Processing Unit administrator are mentioned in [15]. 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 aims 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 [16]

- **Exploring Battery Saving features:** By exploring the battery saving features, it is clear that there is various ROM s 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. There are some of the manufacturers of Android phones such as Samsung and Huawei that has an efficient mode of power saving. 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 [17]
- **Limitations of previous researches**: There are several limitations regarding the previous researches such as:
    - The survey done on analyzing the power saving modes have been statically gathered during the development of application and have 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.

4. Conclusion

We believe that we have implemented a deep qualitative study that derived us to a set of results which can support our main unique idea of proposing a preventive power saving methodology which saves the energy of smartphone battery without the need to consume any of the energy of the same battery. Although there are various improvements in the area of smartphones applications development in terms of power saving, the inclusion of many other factors which are

mainly related to using habits of smartphones users, may cause for example pop up advertisements and other interrelated factors which forces the smartphone user to consume energy form the battery.

The study also aimed at highlighting a clear insights on four main research questions. As per to research question regarding the battery saving features that could help in resistance of battery includes the flight mode, do not disturb, powering off Wi-Fi and data connections.

Moreover, with respect to the research questions regarding the fact that power saving application consumes a lot of energy it is clearly stated by the past studies that due to many factors there is a lot of battery exploitation and these issues have been becoming a major issue for smartphone users and manufactures.

Thus, we defend that this study provides a clear insight that there are several ways which could be used to save the power of smartphones more efficiently.

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