Approaches for Managing the Smart Phone Battery Efficiently

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***Abstract*— Modern mobile devices have been connecting people using its sensing and communication capabilities. Mobile devices spend a lot of its battery for the sensing and communication. Therefore, battery plays an important role in the mobile devices. The limited battery life is thus one of the major concerns in mobile communications. Hence, managing battery life in the mobile devices is a challenge and needs to be addressed with some of the ways in which the battery life can be efficiently utilized. The management of the energy available in mobile devices helps to extend the battery life and also to maximize the usage of enhanced features in the modern mobiles. The different ways to save the battery life will help the mobiles, the today's smart phones to make use of the device when really in need. Hence, in this paper, we give different ways and approaches to save the battery life and use the energy efficiently for the smart phones.**

Keywords- Smart phones, Battery life, Energy Efficiency, Managing Battery life

I. INTRODUCTION

The past decade has witnessed a huge growth in smart-phones' popularity. The rapid growth of smart phones combined with millions of apps makes them a favorite means of communication among users, but their functionalities are constrained by a number of challenges concerning battery life, bandwidth, and security. Battery life, which is one of the most significant users experience for mobile devices, strongly restricts the functional design of hardware architecture and application. Even though a lot of enhancement has been made in the past [1], [2], [3], [4], [5], [6], [7] the low battery lifetime problem is still a main issue of our society. Finite electrical battery life is encouraging companies and researchers to come up with new ideas and technologies to drive mobile devices for an enhanced period of time .The rate of energy density improvement of batteries has been very slow. In case of Li-ion battery, the energy density has only barely doubled over the last 15 years from 300Whr/litre in 1995 to 600Whr/litre in 2010[8]. Thus we are facing a serious problem in the imbalance between demand and supply of battery power. One technique is improving the energy density of rechargeable battery which however takes a backseat as it is time-consuming and tedious due to the difficulty of developing new innovative electrode materials. Batteries add to size and their disposal adds to environmental pollution.

The subject of research on battery life has motivated by to find different ways of saving the energy of the mobile devices. The paper mainly concentrates on the extending smartphone battery life by different approaches which are simple to use. The approaches defined here are to be used by the mobile device end users, so that they can save the draining of the battery and hence increase the life of the mobile device. With the aforementioned backdrop, this paper makes the following contributions in the areas of switching off the Wi-Fi and mobile data, controlling the ads on WebPages, using the less brightness on the screen of the device and other suggestions to save the battery life of the mobile device. The rest of the paper is organized as follows. The related work and background are presented in Section II. Section III describes the problem statement about the battery life of smart phones. Section IV describes the proposed methodology and overview of battery consumption in the smart phones. Finally, SectionV lists some conclusions of this paper and recommendations for future work.

II. RELATED WORK

Battery power is one of the major limitations of mobile communication. Hence, managing battery life can be looked from two aspects: "harvesting and managing" [17]. Harvesting energy from the surrounding environment is very interesting and promising direction. Therefore it is necessary to manage the energy available in mobile devices efficiently to extend the battery life and also to maximize the usage of enhanced feature of the modern mobiles . The paper they give an overlook into ambient energy harvesting and energy consumed by mobiles. Energy harvesting is the process by which the energy is derived from the environmental sources like thermal energy, wind energy, solar energy, kinetic energy etc. captured and stored. The technology [17] offers two significant advantages over battery-powered solutions:

- Virtually inexhaustible sources.
- Little or no adverse environmental effects

Task offloading from smart phones to the cloud is a promising strategy to enhance the computing capability of smart phones and prolong their battery life [18]. However, task offloading introduces a communication cost for those devices. Therefore, consideration of the communication cost is crucial for the effectiveness of task offloading. To make task offloading beneficial, one of the challenges is to estimate the energy consumed in communication activities of task offloading. Accurate energy estimation models will enable these devices to make the right decisions as to whether or not to perform task offloading, based on the energy cost of the communication activities. Simply put, if the offloading process consumes less energy than processing the task on the device itself, then the task is offloaded to the cloud. To design an energy-aware offloading strategy, we develop energy models of the WLAN, Third Generation (3G), and Fourth Generation (4G) interfaces of smart phones. These models make smart phones capable of accurately estimating the energy cost of task offloading. It validates the models by conducting an extensive set of experiments on five smart phones from different vendors. The experimental results show that the estimation models accurately estimates the energy required to offload tasks.

With the rapid advancement of mobile devices, people have become more attached to them than ever. The rapid growth combined with millions of applications (apps) make smart phones a favorite means of communication among users. In general, the available contents on smart phones, apps, and web, come in two versions: 1) free content that is monetized via advertisements (ads) and 2) paid content that is monetized by user subscription fees. However, the resources, namely, energy, bandwidth, and processing power, on-board are limited, and the existence of ads in websites and free apps can significantly increase the usage of these resources. These issues necessitate a good understanding of the mobile advertising eco-system and how such limited resources can be efficiently used. In the paper [19], they present the results of a novel web browsing technique that adapts the WebPages delivered to smart phone, based on the smart phone's current battery level and the network type. WebPages are adapted by controlling the amount of ads to be displayed. Validation tests confirm that the system can extend Smartphone battery life by up to 30% and save wireless bandwidth up to 44%.

Recently, there have been several studies that focused on better mobile web browsing experience. The key benefits of using the smart phone accelerometer for human mobility analysis [20], with or without location determination based upon GPS, Wi-Fi or GSM is that it is energy-efficient, provides real-time contextual information and has high availability. Using measurements from an accelerometer for human mobility analysis presents its own challenges as all carry our smart phones differently and the measurements are body placement dependent. Also it often relies on an on demand remote data exchange for analysis and processing; which is less energy-efficient, has higher network costs and is not real-time. They [20] present a novel accelerometer framework based upon a probabilistic algorithm that neutralizes the effect of different Smartphone on-body placements and orientations to allow human movements to be more accurately and energy efficiently identified. Using solely the embedded Smartphone accelerometer without need for referencing historical data and accelerometer noise filtering, our method can in real-time with a time constraint of 2 seconds identify the human mobility state. The method achieves an overall average classification accuracy of 92% when evaluated on a dataset gathered from fifteen individuals that classified nine different urban human mobility states.

III. PROBLEM STATEMENT

"Mobile devices are getting smarter, not the user which is one of the major limitations of smart phone users at the battery end". We are taking about the mobile devices. confusion starts whenever it is the legacy fan or smart phones. My main motivation is for smart phone because of its different usability and applications. We refer to smart phones which use different applications and functionalities. With all the above stated, the major concern ends up in saving the mobile device battery life. The draining of the battery for the mobile device has to be addressed by energy optimization. This can be achieved by efficiently using the energy that is available. Thus, the proper management of energy which is battery life can help to increase the usage of mobile devices for today never ending needs. From a Smartphone point of view, the energy consumed involves usage of different features of the mobile device. Here, usage would mean to say to keep some or many features switched on, without actually being used by the user. Hence, we need to optimize the utilization of the battery by different ways of managing the features that are in use. With a major concern on the battery life of mobile devices which plays a vital role in our day to day life .Battery life time, which is one of the most significant users experience for mobile devices, strongly restricts the function design of hardware architecture and application. As per our perspective there are mainly two problems with the mobile batteries:

- The lifetime of batteries is very limited, even low power batteries requiring impractical, periodical battery replacement.

- The use of commercial batteries usually over kills the power requirement, adding size and weight while creating the problem of environmental pollution due to the deposition of these batteries.

IV. METHODOLOGY AND OVERVIEW OF BATTERY CONSUMPTION

The different ways and approaches are described here for an optimized utilization of the battery life of the mobile device. Before moving to the various strategies of energy management, let us look into the major consumers of battery power in a mobile or a smart phone [17]. **C**urrent mobile/smart phones integrate sensors such as GPS, a multi-core CPU, touch screen and several types of wireless interfaces and LAN cards which are sources of high power consumption not only while sending or receiving data but also in idle state . Furthermore, applications such as video streaming being in need of continuous usage of LCD display or push type cloud computing services will also increase power consumption which cannot be compensated by the batteries. Table 3. shows the energy and power consumption by different aspects of the mobile device.

TABLE I. ENERGY AND POWER CONSUMPTION IN MOBILE DEVICES

Technology	**Action**	**Power (mW)**	**Energy (J)**
Wireless Data	Bluetooth	12 - 432	----
	Wi-Fi	26 - 1629	0.4 – 8.2
	2G	500 - 1389	2.4
	3G	591 - 1400	2.5
Miscellaneous	2%-100% CPU usage	55 – 612	2.2 – 56.2
	Memory	560-612	
Mobile Services	Voice (2G)	612.7 – 683.6	
	(3G)	1224.3 – 1265.7	
	SMS (2G)		1.72 –3.15
	(3G)		2.24 –4.42
	Video	2145-2210	

The various strategies that can be followed to reduce the energy consumption in mobile devises are:

A. Reduce power consumption by wireless interface.

Battery domain is a general problem in any portable device and wireless interface plays the first and the foremost role on it. It consumes max power of mobile system. There are many alternatives that play an important role in power optimization for example:

- LTE can reduce the energy cost per transmitted bit.
- Bluetooth low energy.
- Low power Wi-Fi technique.

By switching off the Wi-Fi not the user does not need, would be a good idea to save the battery life of the mobile device [17]. Though Bluetooth also can also be put off when not really needed, but it consumes lesser energy.

Mobile data usage also eats up a lot of energy, draining the battery life. Good idea is to put it off when not in need.

B. User interaction and application

Improving battery lifetime is highly related to a better understanding of how users interact with their battery and their resources [17]. Any energy-aware system must be able to know when, where and how the user drains the battery and when there will be future charging opportunities.

C. Sensor optimisation

Mobile application often needs location data to update locally relevant information to provide a service requested by the user. Modern smart phones includes different types of location sensors with different resolution and energy demands: GSM, Wi-Fi based and GPS location sensors have an average error in the order of 400m, 40m and 10m11 respectively. GPS is often preferred over its alternatives such as GSM/Wi-Fi based positioning system because it is known to be more accurate despite its higher energy demands. Mobile application is becoming more contexts aware, especially location aware. Consequently, support for energy efficient continuous sensing became a demand of mobile developers to provide richer applications [17].

There are two types of solution which can be used to save some power by these sensing devices:

- System that combines multiple sensors to reduce the energy consumption while minimising the error.
- Methodologies that rely exclusively on probabilistic models of user location to infer future location to reduce the number of sensing read

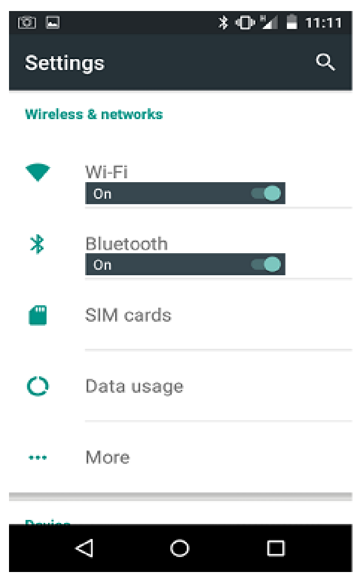

Figure 1. Settings displaying the Wi-Fi and Bluethood is th on state

D. Opportunist access to computing resources available in nearby devices

By considering the social activity of mobile phone users, we can see that large portions of a user's daily life are spent in close proximity of other mobile phone users with devices that incorporate similar hardware resources. Indeed, if we consider a commuter travelling by bus and using a location-based service on her mobile phone, there is a high probability that a significant number of co commuters are also using their phone's GPS and cellular networks to interact with similar services [17]. Also, in social events such as music concerts or sport events, large numbers of co-located users may use their phone to access the internet simultaneously. Motivated by this observation, we believe that there is a clear opportunity for improving the energy efficiency of mobile phone usage while making acceptable compromises in the QoS, by trying to aggregate, share and coordinate resources of multiple users at close proximity. A mobile device can clearly save energy by accessing a resource like GPS remotely from a nearby handset rather than accessing the local GPS receiver (although the device sharing the resource sacrifices itself in the short-term in order to share its resources to others). Performing a Bluetooth scan and connecting with a nearby device takes 11.5 seconds on average while retrieving the first position on the GPS receiver can take from 4 seconds to the order of minutes depending on the availability of the orbital data for the GPS satellites.Nevertheless, results clearly indicate that it is possible to achieve significant energy savings in other scenarios (such as public places or urban and rural locations) with more stationary nodes and more chances of establishing opportunistic connections with nearby devices. Table 4 shows the power consumption of several embedded hardware devices in modern smart phones [16].

TABLE II. DETAILED POWER CONSUMPTION ON A MODERN SMART PHONE(OPENMOKO NEO FREERUNNER)

Energy consumption per hardware module		
Bluetooth	Near(30 cm) Far(10 m)	36.0mW 44.9mW
Wi-Fi	Idle Full Capacity	8.0mW 720.0mW
GSM	Idle Full Capacity	58.0mW 620.0mW
GPS		143.1mW

E. Reducing the brightness of the smart phones

One of the major consumers of the battery is the smart phones is brightness. There are various levels for adjusting the phones brightness like high, medium, low and automatic. This brightness can be reducing in order to save the available battery life of the mobile device. Lessening the brightness or keeping it to minimum would help to save the battery life.

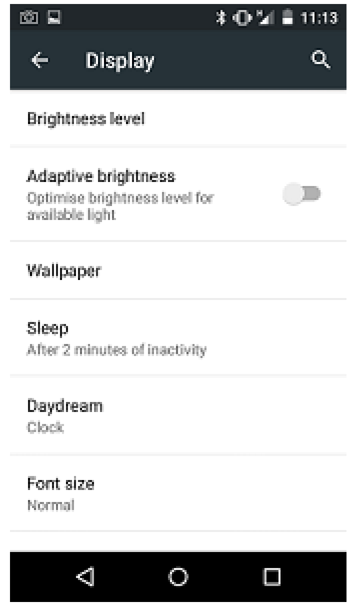

Figure 2. Screen shot to display the brightness adjustment

F. Ringtone setting changes for energy efficiency

Ringtone setting or the sound setting is another aspect which can be handled by the used to make the energy level go up. The ringtone volume and alters volume can be reduced, when the user wants to save the battery life of the smart phone. The vibration mode is the next consumer of the battery, so this also can be set off, unless it required.

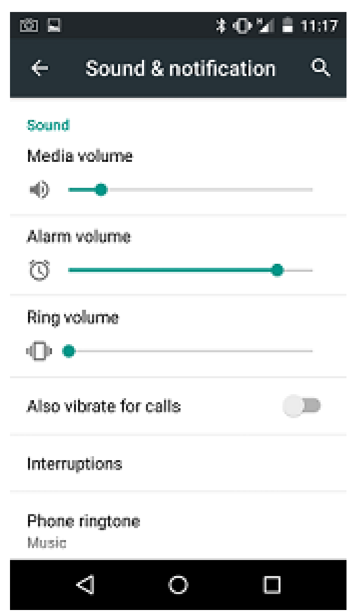

Figure 3. Screen shot to show sound settings

G. Battery saving mode

Thinking of the battery all this time, user can always keep an eye on the battery level indicator. When the user has less chance for charging the smart phone, better to look into the battery level indicator. If the indicator is below 50%, then switch on for the battery saving mode. This would in turn switch off several other features that are eating up huge battery. Several services would be automatically stopped in order to help preserve the battery. For example, the emails are not received automatically as the application will not be running in the background. But the user can use the emails and work on emails manually. For instance, in Nokia Lumia 510, there is at feature *Battery saver*, which has two options. One option is to always turn on the battery saver when low battery and the other are to turn on battery saver now until the next charge. Thus, by using the battery saving mode by looking at the battery indicator go down, helps to stop the draining of the battery life further.

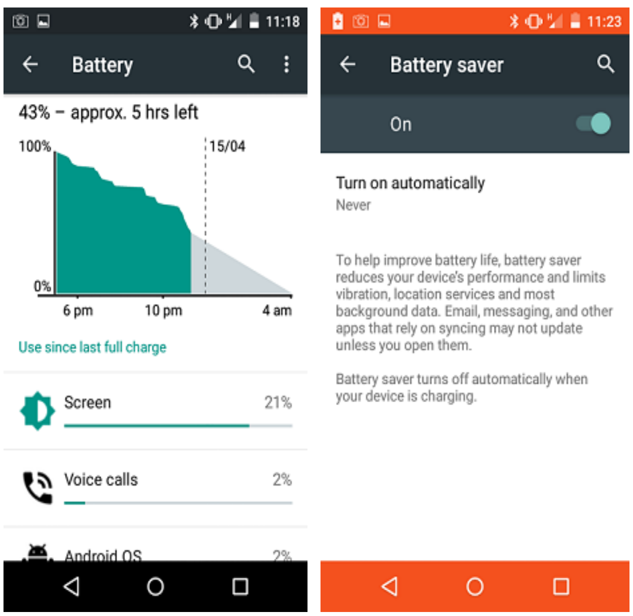

Figure 4. Display screens for Battery saver screens

H. Ads on web pages eat up the battery of the mobile device Unnecessarily

Today's smart phones are majorly used for browsing. When the user is on the browser, it different web pages. Meanwhile by the side of it, there are lots of popup. These pop ups would be related to advertisements. These may be least interested to the users. One can suppress such ads, by blocking the pop ups on the web browser. When these unnecessary pop ups are blocked, it adds to small savings in the battery life of the smart phones. Blocking different alters on the web browser helps to increase the life of the battery.

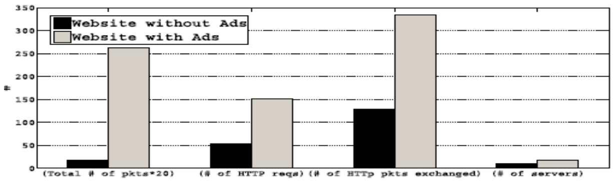

Figure 5. Graphs showing battery consumption with and without ads in websites

I. Applications running in the background lead to battery draining

Users use multiple applications of the smart phones every minute. All the applications will be running in the background, user being unaware of the opened applications. Many a times user does not close these application and they will be running in the background. It would drain the battery as the applications are running in background. One can close such applications running in background and save the battery life.

J. Camera flash

Another prominent feature of today's smart phones is its camera. Yes! Camera and photos keeps the memories of one's lifetime! What about the life of the smart phone battery when using the camera flash all-time? Thinking about the camera flash, it needs huge amount of battery for the flash when being used. On a day's tour the camera is the heart to capture the snaps. But when flash of the camera is on, the battery expended is more. In order to save the battery, it's a good option to put the camera flash to automatic. Camera flash also adds to the reason for maintaining energy efficiency in the smart phones.

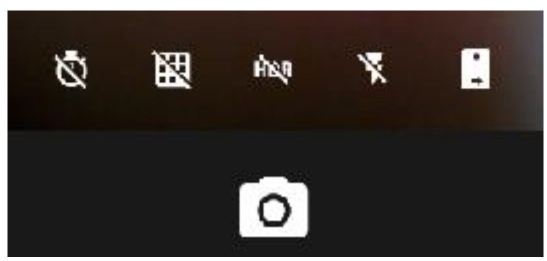

Figure 6. Camera display screen shot with flash switch off to save battery life

II. Conclusion

The paper, we gave an insight into various ambient sources which can provide new energy saving approaches for mobile devices within the energy management system. We also provided an overview of the power consumed by various components of a mobile phone which can be helpful for optimization of battery power. We see that the network interfaces (GSM, GPS, and Wi-Fi) are the major energy drainers of mobile battery. The different approaches suggested in the paper will optimize the battery life of a mobile device. The methods also help the users of mobile devices to stop the draining of the mobile device battery for features that are not in actual use. Hence, energy saving strategies for a play an important role for increasing the battery life of the device. The future work on the managing of the battery life of the smart phones could be done on developing new and different applications and tools that help to save the battery life of the smart phones.

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