ENERGY SAVING MODEL AND APPLICATION FOR SMART PHONES

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Abstract

Energy on the mobile phones is a remarkable resource. This resource only decides the utility time of mobile device. Generally smart phone uses wireless technologies like 2G, 3G, 4G, GSM, Wi-Fi, Bluetooth & other upcoming technologies. So it is important to understand these energy consumption characteristics. So in this paper I designed an application which is measurably enhance the battery life. Along this application in this paper I present a model which enhanced the utility of mobile phones in the concern of mobile battery life. Our model enhance the battery life up to certain percentage as this elaborated as a concept in this paper.

Keywords:-*Mobile Devices, Smartphone, Android, Energy Consumption*

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1. INTRODUCTION

With the recent appearance of smart phones there are large numbers of new and innovative applications have appeared. However many applications in smart phones which provide services like audio chatting, video chatting, playing games, weather information, news feed, software updates etc, these services imply a heavy load on device's processor due to which a large amount of energy is consumed. In today smart phones use rechargeable electrochemical batteries, mainly lithium-ion batteries, these batteries work as a portable source for smart phones. After fully charged these lithium-ion batteries gives a back up for a few hours.

So the energy consumption has emerged as a demerit of energy management of these portable energy sources. These batteries work on electrochemistry means chemical reactions inside the battery which are responsible for charging and discharging. Applications run on smart phones imply a heavy workload on processor, so battery consumption increases.

We can decrease the load on battery either by enhancing the battery or at operating system level by developing an energy saving application. Enhancing the battery includes making more efficient the materials used to create it, inside the battery and the electrochemistry which includes the chemical reactions responsible for charging and discharging of battery. At operating system level we can make an application for smart phones which will stop the unnecessary application running in background, implying heavy workload on processor.

In this paper we give an energy saving model which includes analysis of lithium-ion battery construction, shapes, electrochemistry- charging and discharging procedure, and a solution in software mode. Our main contribution is to analyze and give a short summary of lithium-ion battery used by smart phones and give a solution in at operating system level by developing an application for increasing the battery life up to a certain percentage for smart phones.

2. RELATED WORK

Many papers [2] [3] [4] have mentioned that the energy consumption has become a very important problem in smart phones. As we have mentioned in the introduction energy consumption can be reduced by two ways. According to a user study conducted in 2012 the world's largest custom market research specialist, the most wanted feature in the future mobile device is "one day of battery life during active use" [6]. At present days smart phones have only energy profiler which shows the energy consumption of processes and services.

- By enhancing the battery construction. In the first way we are analyzing the lithium-ion battery. At the start "nickel cadmium (NiCd)" batteries were used for mobile devices. Those batteries performed better in extreme temperatures; however they were prone to "memory effect". After that "nickel metal hydride (NiMH)" came in the market, but after some time these batteries were showing memory effect too. Lithium-ion is the newest technology in portable power; in 1991 Sony and Asahi Kasei release the first commercial lithium-ion battery. It is completely immune to memory effect. This work was related to the enhancement of batteries. In 2014 batteries stated to have 20% capacity than those previously available, with a silicon anode rather than graphite (carbon) anode, were being delivered to smart phone manufacturers.
- At operating system level. Applications and operating system both are responsible for energy consumption [2]. Till today energy management work is done on wireless interface and internet protocols which are more energy drainers in a smart phone [2].

The work by Balasubramanian goes a bit deeper in the analysis of IEEE 802.11 standard and cellular networks (using exclusively Nokia Energy Profiler as measurement tool). He develops a Tail Ender protocol that reduces energy consumption of modern mobile handsets. This work was limited to the internet users [2].

Mr. Narseo Vallina-Rodriguez and Jon Crowcroft gave a survey that energy reduction in mobile phones can be achieved at different levels [4]:

1. Energy aware operating system.
2. Energy measurement and power models.
3. User interaction with applications and computing resources.
4. Wireless interfaces and protocol optimizations.
5. Sensor optimizations.
6. Computation off-loading.

3. PROPOSED WORK

As in the introduction energy efficiency in smart phones can be increased either by enhancing the battery or at the operating system level by designing an application. In this paper we are giving an analysis and classification of rechargeable lithium-ion batteries which are used by smart phones after that giving an energy saving application for smart phones. This paper contains the following attributes:

1. Measurement
2. Devices and tools
3. Battery classification (Li-ion)
4. Application development

4. MEASUREMENT

We conduct a measurement study with the following goals:

1. Analyze the variation of energy with several mobile operations such as calling, messaging, internet surfing, downloading, uploading, chatting, playing games etc. and device components such as display, Bluetooth, camera, touch sensors etc.
2. We will develop a simple energy model to quantify the energy consumption over several mobile operations described above.
3. There are many android applications in the market which are downloaded by android users. There are several categories which are downloaded by users. Figure 1 shows some categories.

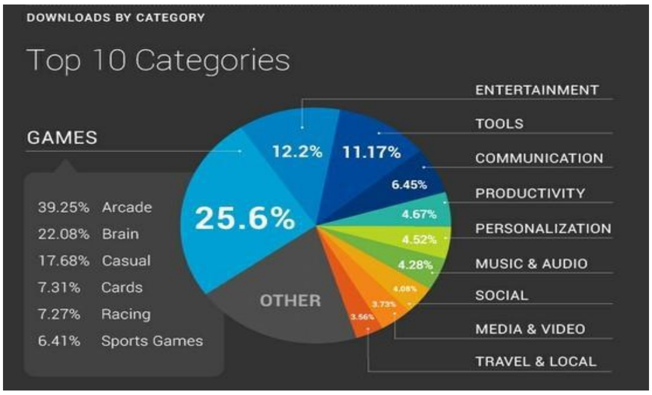


Fig 1. Apps downloaded by users

The top categories are:

a. Games
b. Entertainment
c. Tools
d. Communication
e. Productivity
f. Personalization
g. Music
h. Social
i. Media and video
j. Travel and local

These applications are highly energy drainer.

4. There is a list of smart phone's components which are also responsible for high energy consumption.

a. Accelerometer, gyroscope, magnetometer etc.
b. Display
c. Wi-Fi [7]
d. Bluetooth
e. GPS
f. CPU
g. Camera
h. Sensors
i. Microphone etc.

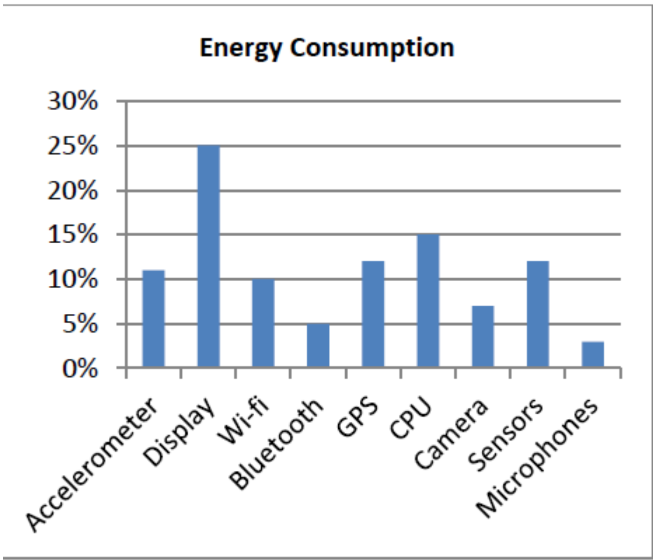
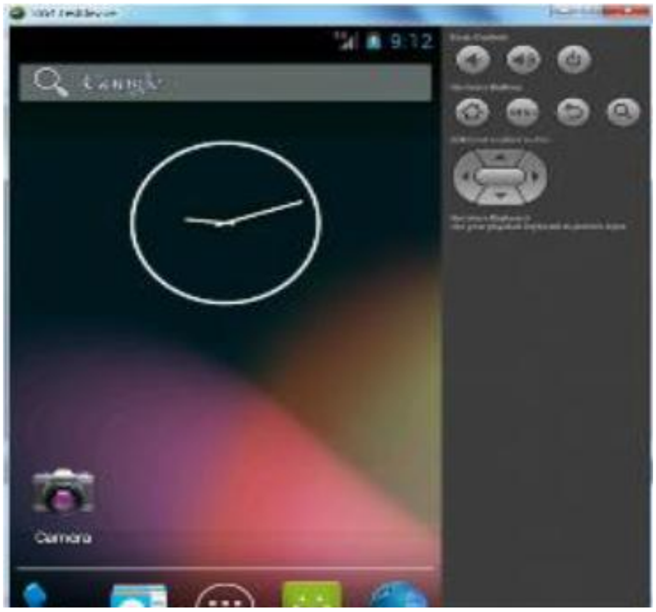


Fig 2: Energy Consumption by components

5. DEVICE AND TOOLS

The majority of our experiments are performed using android based mobile phones (smart phones) use rechargeable lithium-ion battery. We will analyze and classify the latest lithium-ion battery in the market. For developing energy saving application for smart phones we will use "adt-bundle-windows-x86-20131030" [1]. This bundle includes 'eclipse' as an android developing tool figure 3(a) which is used to write code, to run the program on emulator or on a real device. Figure 3 (b) shows an AVD emulator.

(a) ADT



(b) AVD emulator

Fig 3: (a) Android Developer Tool used to develop android application, (b) Android Virtual device emulator to run application

6. BATTERY CLASSIFICATION

Battery classification is as follows:

- Introduction A lithium-ion battery is a member of rechargeable batteries family. In Li-ion battery lithium ions moves from the negative electrode to positive electrode during discharging and back when charging. Figure 4 shows simple lithium-ion battery. Lithium-ion batteries are common in consumer electronics. These are the one of the most popular types of rechargeable battery with one of the best energy densities, no memory effect. However new studies shown signs of memory effect in these batteries. By 2013 the lithium rechargeable battery had progressed to a lithium vanadium phosphate battery to increase energy efficiency in the forward and reverse reaction.

Fig 4: A Samsung Li-Ion battery

- Construction There are three primary functional components of a lithium-ion battery
  1. Positive electrode It is a metal oxide. It is generally one of three materials: a layered oxide (such as lithium cobalt oxide), a polyamine (such as lithium iron phosphate) or a spinal (such as lithium manganese oxide).
  2. Negative electrode It is of a conventional lithium-ion cell is made from carbon. The most commercially popular negative electrode is graphite.
  3. Electrolyte It is lithium salt in an organic solvent. It is typically a mixture of organic carbonates such as ethylene carbonate or diethyl carbonate complexes of lithium ions.

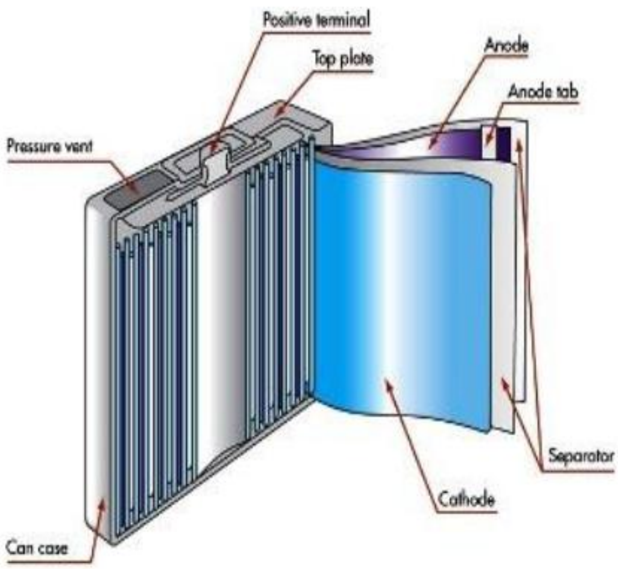


Fig 5: Internal structure of Li-ion

- Electrochemistry Both positive and negative electrode allows lithium ions to migrate towards and away from them. During insertion, ions move into the electrode.

During the reverse process, extraction, ions move back out. When a lithium-based cell is discharging, the positive ion is extracted from the negative electrode and inserted into the positive electrode. When the cell is charging, the reverse occurs.

The positive electrode half-reaction is:

$$n\mathrm{LiCoO_2} \leftrightarrows \mathrm{Li_{1-n}CoO_2} + n\mathrm{Li^+} + ne^-$$

The negative electrode half reaction is:

$$n\mathrm{Li^+} + ne^- + \mathrm{C} \leftrightarrows \mathrm{Li_nC}$$

The overall reaction has its limits. Over discharge supersaturates lithium cobalt oxide, leading to the production of lithium oxide, possibly by the following irreversible reaction:

$$\mathrm{Li^+} + e^- + \mathrm{LiCoO_2} \rightarrow \mathrm{Li_2O} + \mathrm{CoO}$$

Overcharge up to 5.2 volts leads to the synthesis of cobalt (IV) oxide, as evidenced by x-ray diffraction:

$$\mathrm{LiCoO_2} \rightarrow \mathrm{Li^+} + \mathrm{CoO_2} + e^-$$

- Charge and discharge The charging procedures for single Li-ion cells, and complete Li-ion batteries, are slightly different.

  A single Li-ion cell is charged in two stages:
  1. Constant current (CC)
  2. Voltage source (CV)

  A Li-ion battery (a set of Li-ion cells in series) is charged in three stages:
  1. Constant current
  2. Balance
  3. Voltage source

  During discharge, lithium ions Li+ carry the current from the negative to positive electrode, through the non-aqueous electrolyte and separator diaphragm.

- Charge cycle A charge cycle is the process of charging a rechargeable battery and discharging it as required into a load. Rechargeable battery life is often stated in number of charge cycles.

7. APPLICATION DEVELOPMENT

In this paper we are developing an application with the help of ADT (Android developing tool) [1] that reduces energy consumption of smart phones. Till now to make mobile phone's battery last longer, users have to perform some operations on their mobile phones [5]. These operations are as:

1. Stop searching for a signal.
2. Do not follow the method of full discharge.
3. Switch the vibrate function off on your phone, using just the ring tone.
4. Dim your phone's display light.
5. Avoid using unnecessary features.
6. Turn off Bluetooth.
7. Turn off data connection. Etc.

This application is specially designed to extend battery life and optimize using habit [5]. It saves your battery by intelligently dealing with phone's network connectivity, screen timeout and screen brightness etc. It offers you more personalized options to allow you to manage applications and adjust system settings to optimize battery efficiency. This application will be developed by using ADT bundle windows-x86-20131030 [1]. In this application we will use three stages are as follows:

- Optimizing energy consumption Application first of all will optimize how many and which type of processes and services are running in background. After that it will optimize which application and which device component is consuming how much percentage of battery [2] [3] [4].
- Giving priority to the processes Application will give the priority to the processes by using the scheduling [8]. This priority will be used to stop the process temporarily. Giving priority to the processes is very important because some processes are necessary for operating system to run.
- Blocking processes and services After optimizing energy consuming processes and services running in background, application will block the unnecessary processes and services temporarily according to their priority.

When user will use this application it will provide him 3 types of saving modes. These modes are as follows:
1. General saving mode owns the basic network control, sleep control and sleep schedule. It is a very Basic saving mode of this application.
2. Intelligent saving mode it adjusts your phone's stand by time.
3. Advanced customized mode it offers him more personalized options to allow you to manage applications and adjust system settings to optimize battery efficiency.

8. LIMITATIONS AND FUTURE WORK

This application is limited to the android users. Our application is for only smart phone's users. This application will support to android versions 2.0 (Éclair) to android version 4.3 (kitkat) and to upcoming versions.

As part of future work we can enhance the Li-ion battery materials or electrochemistry to make more efficient this battery for smart phone users. In application we can add some additional saving mode and stages to enhance this application.

9. CONCLUSIONS

This work was started by giving an introduction of energy consumption in smart phones and by discussing the work which has been in past years. After that we measure the applications which are responsible for implying workload on processor which causes high energy consumption. Then we are giving solution in two ways: by enhancing the battery or by developing an application for smart phones.

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