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ANALYSIS OF ENERGY PROFILERS IN SMARTPHONE ENVIRONMENT

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ABSTRACT

With the rapid growth of smartphones became essential part of everyone life. Smartphone makes user's life more sophisticated through mobile apps. The battery backup of smartphone is not sufficient to the evolution of mobile Apps. Modern apps necessitate more energy but the growth of battery technology is not satisfying the energy demand. This problem triggers the researchers and developers to concentrate on energy efficient developments both the mobile apps design as well as architecture development. First of all, the researchers must know about the root hole of how and where the energy drains? There are several energy monitoring tools (Herewith we called as energy profiling apps) and softwaresavailable in the market to monitor the energy consumption of smartphone components. These tools are very handy to the researchers to explore the energy drain like a mirror. This paper is a comparative analysis of 4 (Trepn Profiler, ARO, Intel Performance Analyser, and PowerTutor) energy profiling mobile apps and it highlights their pertinent features and gives some suggestions to the researchers to carry one.

Keywords : Energy Profiler, Energy Log, Power Profiler

I. INTRODUCTION

Usage of Smartphone is tremendously grown every year. In 2015,3.4 billion users having smartphones and it will grow upto6.3 billion in the year 2021[3]. In the meantime the battery backup is not proportionate to the energy demand. The battery and its energy backup is the core of mobile devices. Lack of battery backup suffers user experience [2]. So that the situation reveals that there is a need of energy efficiency in smartphone developments.

Thus energy drain has become a more and more important issue of mobile devices. To meet the requirements of saving energy, the research people must understand and identify the energy consumption scenarios with the help of monitoring tools and profiling Apps. These profiling apps explore the energy consumption of various components of mobile devices.

This paper organized into three chapters. First, it gives the fundamentals of energy profiling and its issues and its terminologies. Second, it exploresthe functionalities of widely used energy profilers which are publicly available. Third, it compares various attributes of the profilers with real time data.

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1.1 Software-basedEnergy Profiling

This paper argues on software-enabled solutions for analyzing and measuring smartphone energy consumption. The main aim of this software is explore the information's about battery usage. These kinds of software measure and analyses the energy consumed by the whole device or by each hardware components (CPU, I/O, Display, Memory, Radio etc.) and applications running on the device. The paper categorize or name this functionality is energy profiling, and which the software doing this called energy profiler.

2.1 Profiling Obstacle

Smartphone energy profiling is not at all an easy task; it's a mysterious one because it arise multi-faced problem. The issues are

- The smartphone manufacturers are numerous; and each manufacture hardware's behave differently. So there is a riddle to develop a generic application programs to measure accurate power consumption.
- Vast majority of the smartphones does not report power consumption of the system (and individual subcomponents) by default. Whether it total power consumption or at a particular moment of time.
- Very difficult to understand how the total energy consumption is distributed among the different hardware components.

II. ENERGY PROFILER

2.1 Trepn Profiler

Trepn profiler is a power monitoring tool developed by Qualcomm. It's a one of the essential tool to the researchers who are focusing research on radio networks. It profiles CPU frequency & usage, memory usage, radio network activities, Bluetooth and Wi-Fi states, screen state and apps log in user defined time duration[1].

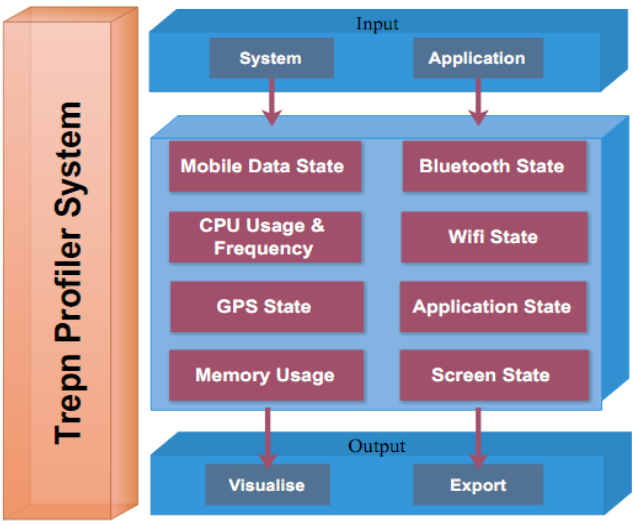

Fig 1. Functional Units of Trepn Profiler

This tool provides an advanced graphical user interface with live chart facilities. The profiled data can be exported to target location as .csv or .db file (see Fig.1).

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A. Profile setting options

Trepn offers two kinds of mode to monitor the mobile components that are

1. Preset mode
2. Advanced Mode

In the preset mode, there are 5 predefined profiling templates are available, that are CPU Frequency Overlay, Mobile Data Detective, Performance Graph, CPU Usage Monitor, CPU Load Overlay and Network Activity.
The advanced mode allows the user to explicitly made profiling template through pick the mobile devicedata points like CPU, Memory or Mobile Data etc. Through setting preference, the user can customize profiling options like

- ✓ *General settings*– the user can choose storage mode, show deltas, profiling interval, and preference based settings etc.
- ✓ *Data Points* – it's the place to choose various profiling components.
- ✓ *Overlays* – the overlay options are select by the user among chart, voltmeter, bar chart, CPU usage and mobile data usage.

B. Visual Elements

Trepn profiler provides high graphic visualization through icons, navigation menus, charts and overlays etc. The notable feature of this tool is customizable charts and overlays. The overlays are displayed on the smartphones home screenand showing real time data through graph or charts. Whenever the user clicks on the overlay it diverts the focus to main profiling system. The graph visualizes real time profiling data. The tool provides facility to zoom-in and zoom out the graph values and the user can show more than one data points simultaneously (like comparison of values).

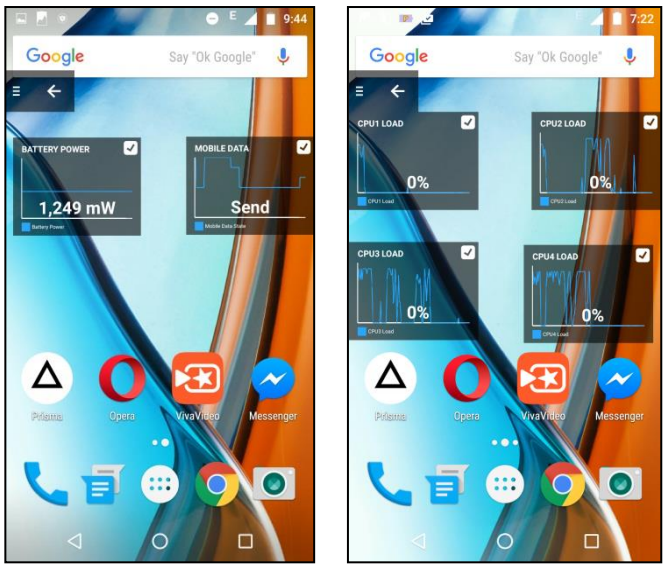

Fig.2. Trepn Profiler Overlay option

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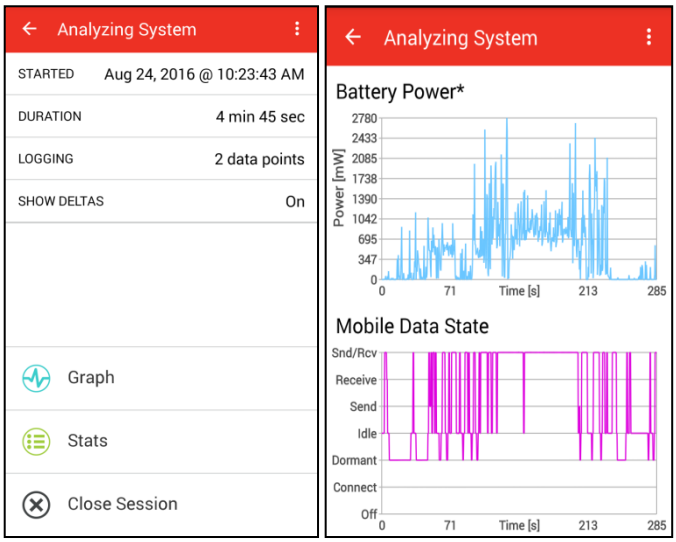

Fig.3.Trepn profiler analyzing system

C. Data Export and Analysis

The profiling data temporarily stored in RAM while profiling. When the user wants to stop profiling the tool export saved data into either .csv (comma separated values) or .db (database file)the profiling data exported to local memory or SDcard memory. This is a very useful option for the researchers to keep the data safe and future use.

2.2 Application Resource Optimizer

ARO (Application Resource Optimizer) is power performance monitoring tool which is developed by AT&T. It analyzes and profiling mobile and web application performance, Network activities, RRC states, TCP layer, HTTP layer etc. This tool provide detailed informations to performance optimization, efficient battery usage and efficient network usage [4].

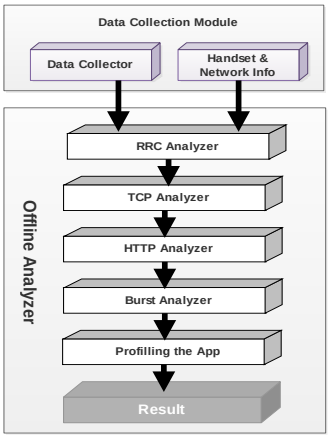

Fig.4. Architecture of ARO

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ARO perform its core functions by two modules that is an online data collector which is run on the mobile device, and an offline module which is run on the PC (see figure 4). To profile an application, an ARO user simply starts the data collector, which incurs less than 15% of runtime overhead, and then runs the application for a desired duration as a normal application user. The collector captures packet traces, system and user input events, which are subsequently processed by the analysis module on a commodity PC[4].

2.3. PowerTutor

PowerTutor [6] is an energy profiler for Android that was developed at the University of Michigan, with the help of Google. The key feature of PowerTutor is that it can measure the actual energy that applications consume through hardware, where most profilers are only able to give information about the usage of hardware components per application. PowerTutor is also able to list applications according to the amount of energy they use on different components (3G, Wi-Fi, CPU or screen) and can generate log files. It has several ways of visualizing the data, such as a graph that plots the amount of energy a component uses per time-unit, or a pie chart comparing the relative energy used by different components.

PowerTutor can generate a list of all applications running on the phone, sorted on the relative amount of energy PowerTutor estimates these applications use. It can also visualize how much an application uses hardware components.

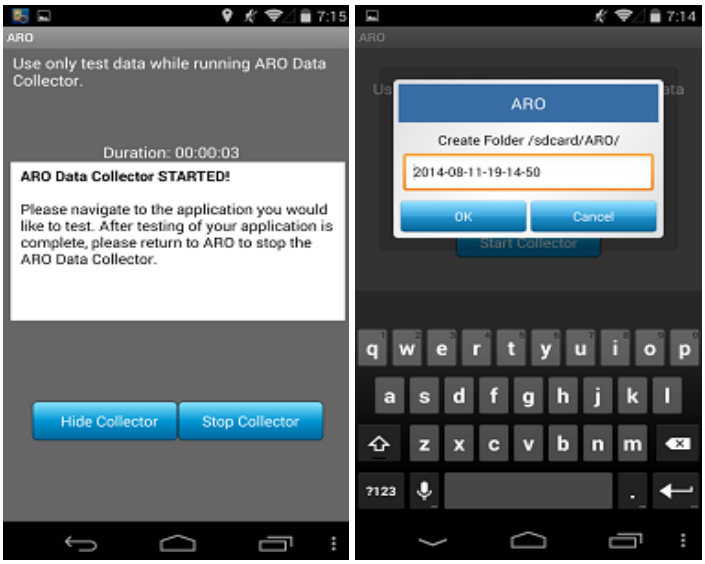

Fig 5. ARO Tool

2.4 Intel mobile performance viewer(IMPV)

Inter mobile performance viewer (IMPV) [5] is a handy tool to monitors mobile environments. This tool is developed by Intel Corporation. It is a handy tool to monitors CPU, Memory, and internet activities. This tool collects information about the system, hardware, storage, power usage and displays it in a real-time graph. The graph is displayed as a semitransparent overlay graph. The profiler can be used for profiling Bytes sent, Bytes received battery voltage. On rooted devices, the profiler can also gather low-level hardware performance data.

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Rooting is the acquiring of administrator privileges on a device, and may void the warranty of the device.Intel mobile Performance Viewer is unable to log and save the data it collects.

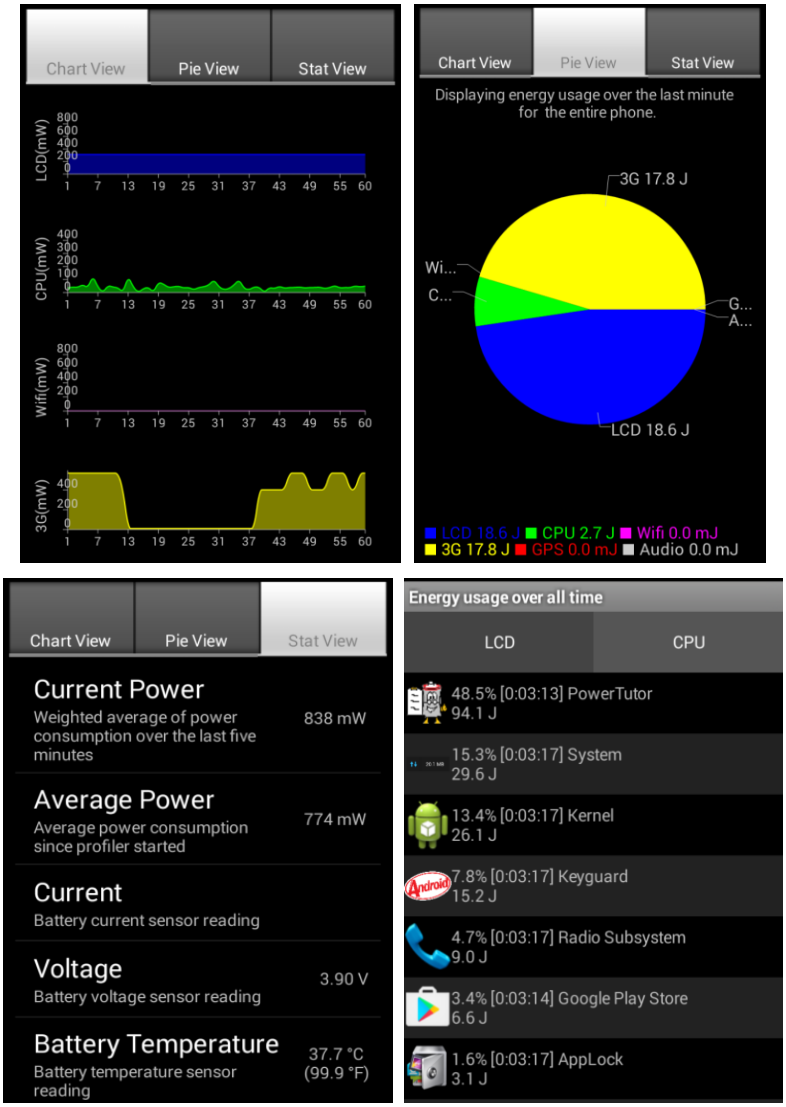

Fig 6.Powertutor Functionalities

III. COMPARATIVE ANALYSIS

3.1 High-level functionality

In this section we will discuss what functionalities profilers offer. On a very low level, functionalities are almost exclusively binary; for instance, either a profiler is ableto track CPU usage per application, or it is not. Since atable listing all functionalities for all profilers would become unnecessarily large and unreadable, we have decidedto group functionalities in meaningful groups.

A. Per Application Level

The ability to profile individual applications is a very important aspect for developers, as this can help them to write applications that utilize resources more efficiently. Android Operating Systems provides basic informations about application energy consumption and data usage but its not sufficient for developer. All of the

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inspected profilers offer some functionality in this area. Intel Performance Viewerand Trepn offer a comparable set of functionality in this area. All are able to track roughly the same set of data points. A developercan get a general idea of how much an application usesmost of the hardware components in a device using any ofthese profilers.

PowerTutor is a good profiler for determining the amount of energy that an application uses. It calculates an estimate of how much energy each application uses, and is able to break this down per component. It collects information about the energy usage of components, and builds a model with this information that it uses to calculate the energy usage per application.

B. Online profiling

3 out of 4 profilers that were investigated are able to measure performance in real-time, and thus give insight in how a phone uses resources as a developer is testing it(see Table 1).

Intel Performance Viewer and Trepn are able to show overlay graphs displaying information on the usage of hardware components. Overlay graphs are graphs that can be displayed on top of other applications. This is useful, as it allows developers to look at the usage of certain hardware components as the application is being used.

Table 1.Functionality Comparison

	Trepn	PowerTutor	ARO	IMPV
Per App power usage	✓	✓	✓	✓
Online Profiling	✓	✓	×	✓
Per App data Usage	✓	✓	✓	✓
RRC State	✓	×	✓	×
Export Log file	✓	✓	✓	×
Total Battery Power	✓	✓	✓	✓

Table2.Component LevelComparision

	3G	WiFi	CPU	GPS	Screen	Battery Status
Trepn	Yes	Yes	Yes	Yes	Yes	Yes
Power Tutor	Yes	Yes	Yes	Yes	No	Yes
ARO	Yes	Yes	Yes	Yes	Yes	Yes
IMPV	Yes	Yes	Yes	No	No	No

Trepn is unique in the respect that it is able to show information about just the application that is running in the foreground. This makes it a good tool for detecting spikes in CPU, 3G usage while using the application.

PowerTutor also able to show real-time information about the phone, but do not have anoverlay function. This means that one can only look atreal-time information about the device from within theseprofilers.

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C. Data Storage

Some profilers are able to save their results in some way,for example in a log file or as a snapshot, for later analysis.Logging data can be useful for developers in many cases,as it enables them to look at the stored data in more detail,or at a later time.

When Trepn runs, it is able to store all information relatedto this run as either a .csv or a .dbfile. When storinga run in a .csvfile, it is stored in a way that can easilybe read by spreadsheet programs. Trepn is unable to read.csvfiles itself, so in order to be able to analyse a runwithin Trepn later on, the run has to be stored in the .dbformat.

PowerTutor is able to store a detailed power trace of allapplications running on the device. It stores the energyconsumption of each hardware component every one second, both in total and decomposed per application.

Even though PowerTutor only stores information relatedto energy consumption (rather than, for instance, CPUload or frequency), developers can use this information togain valuable insight in the way their application consumesenergy.

3.2 Component-level

In this section, we will discuss in more detail what hard-ware components each of the profilers are able to analyse.An overview of what components each profiler can analyseis provided in Table 2.

A. Intel Performance Viewer

Intel Performance Viewer is able to analyse CPU, memory,Wi-Fi/3G, and storage data. In terms of Wi-Fi/3G, it disable to measure how much kB's are being sent and receivedper application. It does not differentiate between Wi-Fiand 3G.

B. PowerTutor

PowerTutor is able to analyse the energy used by appli-cations on several components, and on components as awhole. For applications, it can analyse the energy usagein the CPU, display, Wi-Fi and 3G. It can also analyse theenergy usage on audio and GPS, but cannot trace theseto individual applications.

C. Trepn

Trepn is able to analyse the usage of CPU, 3G, Wi-Fiand GPS. Additionally, and unlike the other profilers under investigation, Trepn is able to analyse GPU (graphicsprocessing unit) usage, should a device have one. In termsof Wi-Fi and 3G Trepn can analyse the amount of datathat is sent and received.It is able to profile individual applications, or the systemas a whole.

IV. CONCLUSION

The analysis of energy profilers in Smartphone are accomplished by comparing the sample energy profilers (Trepn Profiler, ARO, Intel Performance Analyser, and PowerTutor) used in Android smart-phones by a thorough search based on its functionalities.

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From the comparison made it was concluded that based on the usage, logging method and GUI; they differs each other. For the purpose of measuring the amount of energy that components and Application use, PowerTutor is the best choice. For measuring the usage of components, Apps and mobile data, Trepn is a good choice. It is able to analyse the usage of some components that other profilers are unable to log (notably GPU and GPS), and offers the best visualization and database. If the developer wants in depth data about the radio network activity ARO is the best choice, because it account all the activities of networks like packet capture, state transition and energy consumption.

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