Smartphone, where does the power go?

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Abstract

The number of smartphone users is increasing rapidly. For the time being, the expanded network connectivity provided by the phone will satisfy benign users' expectation. Users seeking more powerful applications on the phone will contribute to the emergence of higher performance devices and eventually, consuming more power. Considering the smartphone battery as the limited resource, we should try to reduce unnecessary power usage of them to extend the service time of the phone. Optimizing energy consumption of the smartphone requires profiling application's energy usage as its first step. We have performed energy profiling for representative applications such as KAKAO talk, YouTube and Google Map on a recent Android phone. Applications are carefully selected considering their usage of smartphone hardware such as Wi-Fi, display, GPS, and audio. As the first step, we have measured power consumption of the test applications. We have shown how each hardware component contributes to the application's total power consumption. Finally, we compare each application's power consumption and discuss about the results.

Keywords: smartphone battery, energy consumption, energy analysis, low power.

1. Introduction

Since their first appearance, smartphones have been proliferated dramatically in recent years. With the support from the mobile eco system including Application Store and open development platform, utilization of the device is ever increasing. Apple announced in April, 2010, there are more than 185,000 iPhone applications and about 4 billion downloads were recorded in their AppStore(Apple preview, 2010).

Phone manufacturers are adding more hardware components such as high-resolution camera, gyroscope, GPS receiver, besides the newly added Wi-Fi wireless interface following the current trend of convergence. With these increased hardware capability, naturally application software becomes more complex than ever for their new types of applications exploiting new hardware.

As a mobile device with limited battery capacity, its efficient use is the utmost importance both to the users and manufacturers. Each product has nominal usage time for each different application such as video streaming, mp3 player, and even for stand-by mode. However, most of us might have experienced that their battery ran much shorter than their nominal lifetime. Because users have limited understanding on the underlying hardware and operating system's control mechanism, we are using the device with blindfolded for the power consumption perspective. If we can fully understand about them, we can somehow use our smartphones "smarter" in the sense of usage lifetime. In this paper, we report our initial work of power consumption analysis on the state-of-the-art smartphone.

There are various tools that can monitor battery status on smartphones. iPhone has its own berry lifetime monitor in the typical fashion and various applications are available on the internet(Apple iPhone, 2010). Various battery monitoring applications for Andoid platform are developed as well(Lide, 2010). However, we could not find one application that can provide with accurate result from the all available hardware platforms.

In this paper, we report our recent work on power consumption analysis on a smartphone. We use the power monitoring tool already available in public domain. We have performed a power consumption analysis on the recent smartphone and explained how much power each application consumes on it. Popular applications such as "KAKAo talk", YouTube, and navigation applications are analyzed and will be reported. We

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explain the activities of each application on each hardware component on the phone.

2. Power Analysis Setup

Power analysis is performed using a mobile application called "PowerTutor"(PowerTutor). It is an online power estimation system that is developed for Android platform smartphone. It contains accurate power model of the smartphone and uses Android's activity log data to analyze power consumption. It computes power consumption of hardware components such as CPU, display, GPS, Wi-Fi and audio while it is running in parallel to the test applications.

For the analysis, we have selected six representative applications as our power benchmark. They are carefully selected to reflect each major hardware component of a smartphone. These are the applications we have chosen:

i) *MyPeople* : This is an internet phone application. It is selected to analyze Wi-Fi traffic and power consumption.
ii) *KAKAo-Talk* : This is a social network application based on messenger service. This is one of the most popular applications in Korea and that is the reason to be selected. Wi-Fi traffic and its impact on power consumption will be analyzed.
iii) *YouTube* : This is a well-known and world-popular video streaming application. We expect to see multimedia operation and its energy consumption.
iv) *Angry Birds* : This is a world famous game for the smartphone. Multimedia intensive activities and their relationship to the hardware components are exploited.
v) *Web browser* : A webkit-based browser is selected as a representative web browser.
vi) *Google Maps* : This is chosen to monitor GPS-related power consumption.

The six applications are executed on Galaxy-S smartphone and PowerTutor is executed to compute energy consumption of each hardware component. Table 1 shows the hardware components of Galaxy-S. It contains the S5PC111 single core processor based on ARM Cortex A8 running at 1 GHz.

Table 1: Specification of Samsung Galaxy-S smartphone

Item	Samsung Galaxy-S
CPU	S5PC111(Cortex A8 1GHz)
GPU	PowerVR SGX540
OS	Andriod 2.1+Haptic UI
Memory	512 MB RAM/8 GB ROM
Display	4inch Super AMOLED(800x600)
Wi-Fi	802.11b/g/n
DMB	Terrestrial
Battery	1500 mAh. LiPo
GPS	Y

3. Power Usage Analysis

We have actively used each of the six test application on the Galaxy-S phone with PowerTutor running behind. The intension was to measure maximum power consumption of each application. Here are the power usage analysis results of some of the test applications.

i) KAKAo-Talk
Figure 1 shows the total power consumption measured during 5 minute operation. It shows a few peak values which corresponds to the Wi-Fi transmission. Most of the power is consumed by LED display and Wi-Fi consumption is almost ignorable over the measurement period. Figure 2 shows better view of each hardware component's power consumption for the five minutes. As we have seen in Figure 1, 65% of the power is due to the LED display.

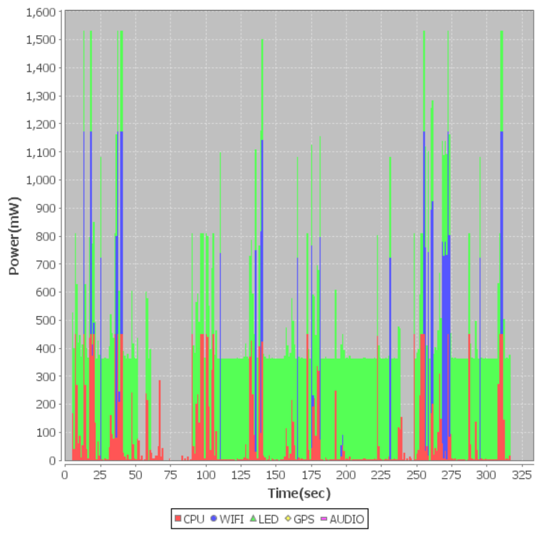

Figure 1: KAKAo-Talk : Power consumption for 5 minute intensive use.

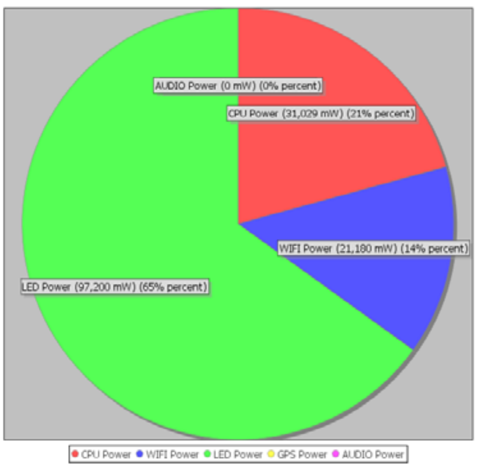

Figure 2: KAKAo-Talk : Accumulated power consumption of hardware components.

ii) YouTube
YouTube is a video streaming application and it utilizes various multimedia hardware participating in the operation. Figure 3 shows the measurement results. Overall, it consumes more power than KAKAo-Talk and it is due to the audio components which consumes almost same as the display. A few blue spikes show Wi-Fi activity for buffering the video stream. The accumulated contribution of the hardware components is shown in figure 4. LED takes 51% and Audio is 32%.

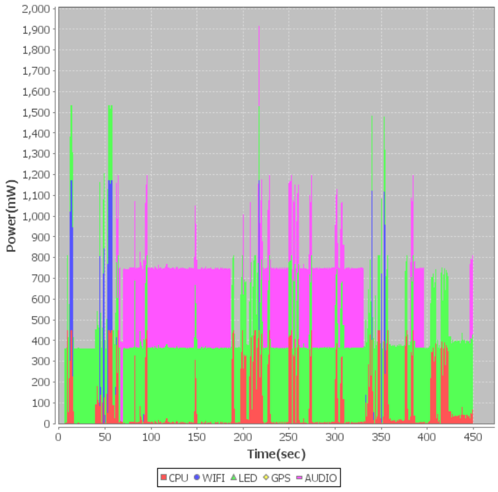

Figure 3: YouTube : Power consumption for 5 minute operation.

Figure 4: YouTube : Power consumption of Hardware components.

iii) Angry Birds
Angry Bird is a game application which expected to show more involvement of CPU and multimedia. Comparing to other applications, it is obvious that this shows more CPU related activity which would be the graphic processing and computations. Figure 5 shows the total power consumption and this is by far the largest consumption more than 1,500mW frequently. CPU percentage is now over 34% which is the main cause of larger power consumption. A few Wi-Fi spikes are observed and this activity is due to the advertisement pushed from the game site.

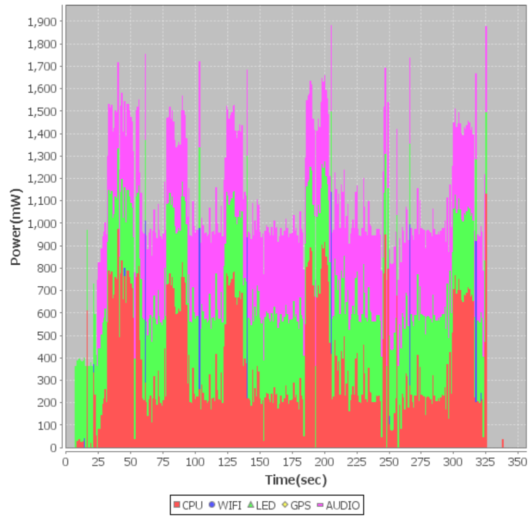

Figure 5: Angy Bird : Power consumption for 5 minute operation.

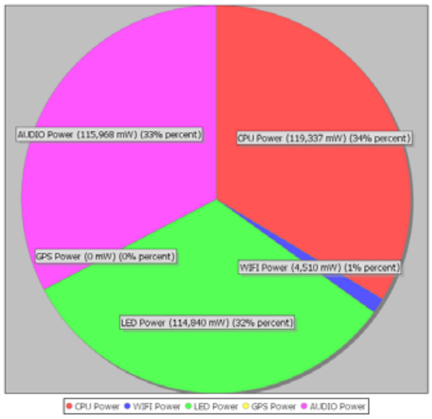

Figure 6: Angry Birds : Power consumption of Hardware components.

iv) Google Map
To measure the GPS related power consumption, we turned the GPS ON and executed Google Map application. It initializes by identifying device's current position. Figure 7 and 8 shows the measured results. This time GPS consumes more power than the display. When the device tries to transmit wireless data, it consumes the largest power of 1900mW. As figure 8 shows, GPS takes the largest percentage of 40%, which is larger than the LED's 34%.

Figire 9 shows the maximum power consumption value observed for each hardware components. LED display has the largest value which is almost twice than CPU. WiFi is next and GPS and Audio also plays important part in power.

Figure 10 shows the average power consumption of our test applications. MyPeople, an internet phone application consumes the largest power and it is because it uses all the Wi-Fi bandwidth during the call in addition to the LED. AngryBird is next and this is due to its intense use of computation of CPU, display and Audio. The next one is the navigation which is involved with GPS operation.

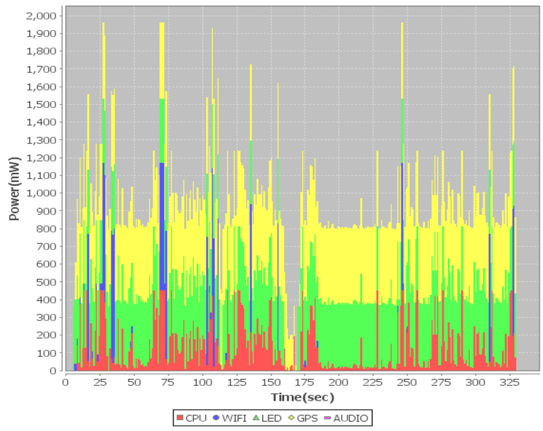

Figure 7: Google Map : Power consumption for 5 minute operation.

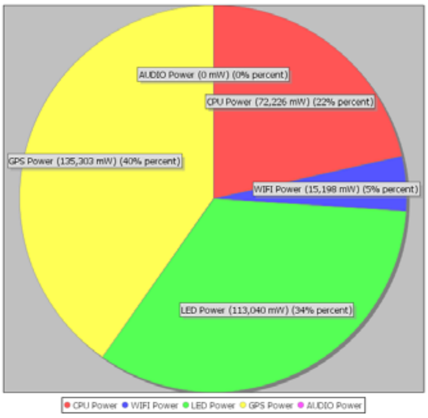

Figure 8: Google Map : Power consumption of Hardware components.

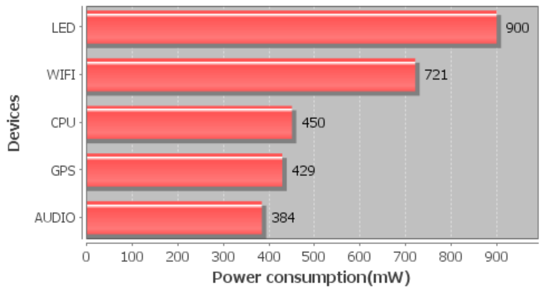

Figure 9 : Power model used for each hardware component.

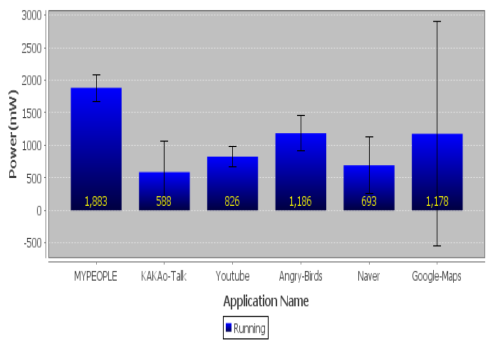

Figure 10: Average power consumption of test applications.

4. Conclusion

In this paper, we have reported our first power consumption analysis on smartphone. We used available tool to get an idea on the power consumption of application related to each hardware component. Internet phone application consumed the largest amount of power and game was the next. The most power hungry hardware is LED and Wi-Fi, CPU, GPS and audio also consumes significant amount of power. Hence, efforts for reducing power consumption in mobile devices should also focus on these major components considering their behavior implemented in applications.

Acknowledgement

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