A User's Experience in Optimizing Smartphone Performance Using Overclocking and Memory Cleaning Techniques

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Abstract

Nowadays, a smartphone is an indispensable tool for everyday living and smartphone enthusiasts are eager to upgrade the performance of their devices. In this paper we present an approach to improve the performance of a smartphone. The approach involves two main techniques: increasing the speed of the device by overclocking it and optimizing memory usage by deleting unnecessary apps while replacing apps with more efficient ones. Detailed procedures of these optimization steps are provided which ordinary users can apply. Using these same techniques, we performed optimizing experiments on an Android phone and included the results. The overclocking effect showed significant performance improvements and stable functioning with a minor increase in device temperature. Memory cleaning also showed significant savings in terms of memory space in the device.

Keywords: Performance Upgrade, Rooting, Overclocking, Memory Cleaning

1. Introduction

During the last several decades, technological advances in computers, the Internet and mobile communications have dramatically changed our lives. Such advancements have improved the depth, ease and speed with which people now interact globally. Recently, manufacturers have begun incorporating various state-of-the art digital and information technologies into their small personal communication devices or 'cell-phones'. This in turn has made mobile phones ever smarter and more powerful. Naturally, people now call these devices 'smart phones.'

A smartphone is an attractive technology for many people because it synthesizes a small mobile phone, a fast and easy-to-use pc, and a high-quality digital camera into one device. Although basic and extended services may be expensive, the device itself is almost free after cost. This has led to explosive growth in smartphone usage and a dramatic change in how people interact. Nowadays, smartphones are indispensable tools for business, education and personal use, especially for young and working people. In effect, the smartphone has become an icon of digital life in the 21st century.

A smartphone is a high-end mobile phone with more advanced communication and processing capabilities. It includes a powerful CPU and a GPU with a high-resolution touchscreen, and it allows high-speed data access via Wi-Fi or mobile broadband [1, 2]. Nowadays, smartphones have combined functions from several digital devices that allow users to do gaming, surf the web, watch TV, navigate by car, take high-quality pictures, and run all pc applications, as well as to perform traditional phone functions. Moreover, advanced application programming interfaces (APIs) also allow third-party applications to be better integrated with

the phone's OS and hardware. Therefore, more and more apps are being developed for smartphones [3, 4].

Since the release of Apple's first iPhone in 2007, the smartphone market has grown very rapidly. The most popular mobile operating system is the Android introduced by Google. The Android OS is based on the Linux OS and was first released in 2008. It is an open-source platform backed by Google and served by major hardware and software developers, such as Intel, ARM, Motorola, HTC, Samsung and LG, which form the Open Handset Alliance (http://www.openhandsetalliance.com/). Google itself launched the 'Nexus One' smartphone using the Android OS in January 2010. Currently, major phone manufacturers such as Samsung, HTC, and LG are making various Android phone models, and Android's worldwide market share has risen explosively from 3.4% in Q3 2009 to 25.3% in Q3 2010, and to 52.5% in Q3 2011 [5, 6] (Figure 1). Because of the open nature of Android, many third-party applications are currently available via the Android market which began in October 2008.
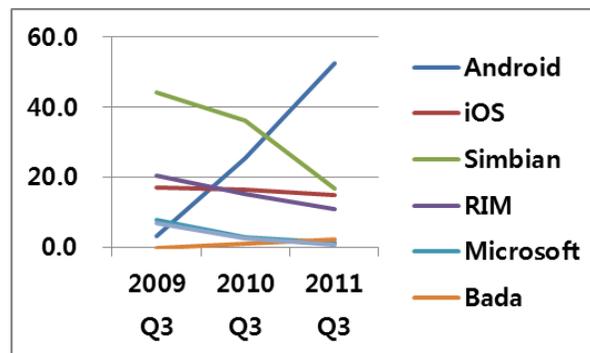

Figure 1. World-wide Smartphone Market Share (%)

According to the Korea Communication Commission, in June 2010, there were 15.7 million smartphone users in Korea, of which 11.0 million used Android. At the end of October 2011, there were over 20 million smartphone users accounting for 40% of all cell phone users. Android's market share in the Korean market stood at over 70%. This figure is continually increasing.

Smartphone lovers are enthusiastic about 'tuning up' their mobile phones. Some want to improve performance by speeding up the phone's processor and by making more memory available to run apps faster. Others want to upgrade older models with newer versions of the operating system.

In this paper, we present a simple approach to improve the performance of a smartphone. This approach, one that mobile phone enthusiasts would apply on their devices, involves two techniques: overclocking and memory cleaning. We also describe the results of our tuning experiments on a popular mobile phone model.

This paper is organized as follows: Section 2 describes firmware customization activities and related research; Section 3 discusses performance improvement techniques smartphone enthusiasts use; Section 4 reviews experimental procedures we used to apply those techniques to a smartphone model; Section 5 presents our research results in the experiment; and Section 6 provides an overview of our findings and suggestions for further study.

2. Firmware Customization Activities

Today, mobile phone programs, from applications to operating systems, are stored and released in flash memory which allows devices to be updated regularly. Such programs are commonly referred to as 'firmware' or 'ROM'. In many cases, third parties often create unofficial versions of an OS to provide enhanced features to smartphones. These enhancements are called 'customized firmware' or 'custom ROM', whereas the official programs are known as 'stock firmware (ROM)'.

There are many reasons for mobile phone users to use customized firmware instead of stock firmware. Some want to tune up their smartphones to make them work at their maximum potential; some want to upgrade the OS of their older phones which manufacturers are generally not willing to do; and others want to run apps performing some functions that are not allowed normally when running stock ROMs [7, 8].

Customized firmware for the Android operating system was released soon after the first Android phone appeared in September 2008. Most firmware hacks have been free and open source software. For example, 'CyanogenMod' (http://www.cyanogenmod.com/) is the most popular Android firmware distribution.

'XDA developers' (http://www.xda-developers.com/) is a huge community of Windows Mobile and Android experts. It is currently one of the best sources for Android development news, since world-wide Android experts actively participate in forum discussions and post the latest releases. Most of their activities consist of application developments, and only about 8 percent of developers are working on custom firmware distribution. Among those 8 percent, the majority of firmware improvements come from functional upgrades and enhancement to user-interfaces, themes, and camera apps. Engineers of device manufacturers are very active participants in XDA forums too, especially HTC mobile phone engineers.

In Korea, there are many smartphone developer forums. Most focus on apps; only a few experts release custom firmware through personal blogs. 'Tegrak' (http://pspmaster.tistory.com/) and 'Kyuhyuk ROM' (http://kyuhyuk.kr/) are among the most popular releases of Android firmware. Kyuhyuk ROM first released a fast custom ROM for Motoroi's Motoroi. Since then, it has become quite popular in Korea as a means of upgrading firmware for mobile phones and improving their smartphone performance. Unfortunately, Kyuhyuk recently stopped providing new releases. By contrast, Tegrak has released firmware versions mainly using overclocking techniques to improve hardware performance for mobile devices.

3. Performance Optimization Approach

Improving the overall performance of smartphones can be done mainly in two ways: one is to increase the speed of the CPU by overclocking, and the other is to increase the free memory available by cleaning apps installed in the smartphone. Both can be applied only on a rooted phone. By increasing device performance, a user can obtain faster reactions for all active apps. Also, by having more free memory in the device, a user may run smooth certain heavy-load apps or have more apps running at the same time.

To achieve this, a user must first 'root' the device in advance. In general, rooting a phone is necessary for the user to perform certain jobs freely on his device. For example, these might include installing a customized version of an operating system, removing or replacing pre-installed apps, or running a custom-built application which performs forbidden functions on the device.

In this section, we provide an overview of the following techniques: rooting, overclocking, and memory cleaning. We also discuss tools needed to apply these techniques.

3.1. CPU Overclocking

A smartphone must first be rooted in order to install a customized version of an operating system or application. Only after rooting can a CPU be overclocked to speed up the phone and clean up the main memory by removing any apps installed by device manufacturers or telecom operators.

Rooting allows a smartphone owner to attain privileged control (i.e., 'root access') over his Android phone. Since the Android OS is based on Linux, rooting an Android phone is similar to acquiring administrative permission on Linux. By rooting a phone, a user can then install unofficial software including custom ROM to optimize performance, run some apps that require special permission, and alter or replace system applications and settings. While the process of rooting varies widely by device, it usually exploits a similar security weakness [9]. Unfortunately, however, it should be noted that such actions may cause damage to a device if not carefully applied, and may also void the warranty of the device.

Overclocking is the process of making a computer or component to operate faster than specified by its manufacturer. This involves modifying the system parameters of the device [10]. For mobile phones, overclocking is a simple procedure frequently used by smartphone enthusiasts to tune up their mobile devices. The most common technique is running a mobile phone's CPU at a higher clock rate in order to increase its operating speed.

However, this method can cause damage to the device, reduce its reliability and shorten the battery's life. More specifically, increasing the clock speed can cause the temperature of the device to increase which in turn may compromise the overall stability of the device. Therefore, it is important to increase the clock speed step by step and carefully check the device temperature, functional stability, and performance improvements during the experimental process.

3.2. Memory Optimization

Cleaning up memory and having more free memory available is another useful technique to improve the overall performance of a mobile phone. Phone manufactures and telecom system operators often install basic apps for user convenience. However, not all users find these pre-installed apps to be useful. In some cases, users may wish to substitute them for more efficient ones bearing similar or better functions. Therefore, a smartphone owner might opt to delete factory installed apps that are not needed, or seek to replace certain apps with more user-appropriate alternatives. To do this, a user must first root the mobile phone. Afterwards, apps can be deleted or modified using the Root Explorer.

3.3. Tools Needed

The tools needed for rooting, overclocking, and memory optimization are as follows:

1. Ubuntu running on VMware installed on your PC. Ubuntu is a computer operating system based on the Debian Linux distribution and distributed as free and open source software, using its own desktop environment.

2. Odin: An indispensable Android tool running on a Linux to patch or to flash a mobile phone (i.e., overwrite the phone's flash memory using a custom ROM).

3. Root Explorer: Root Explorer is a file manager for root users (similar to Windows Explorer). With it, you can access the entire Androids file system including the elusive data folders. However, to use a Root Explorer, the smartphone must first be rooted.

4. Quadrant: A benchmark software tool for mobile devices, capable of measuring CPU, memory, I/O and graphics performance. The Quadrant app can be downloaded from the Android Market (Figure 2).
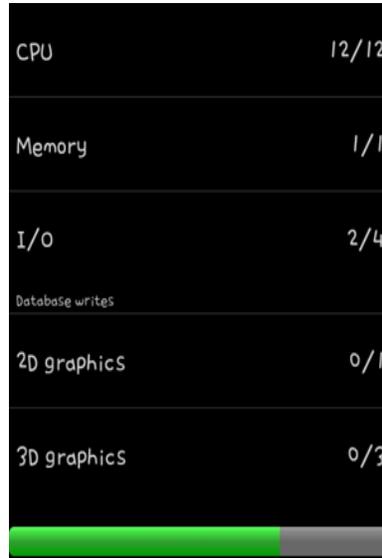

Figure 2. Quadrant Software Running

4. Experimental Procedures to Optimize an Android Phone

In this section, we describe the experimental settings used. We also review the experimental process by which we upgraded the performance of an Android phone. These steps involve first rooting the device to gain full control, then applying an overclocking technique to improve the performance of the phone, and finally applying a memory optimization technique to obtain additional available memory.

4.1. Experimental Settings

In this section, we describe the settings and conditions used for the experiments.

(1) Android phone:

- Model: Samsung Galaxy S2(SHW-M250S)

- Operator: SK Telecom

- CPU: ARMv7 1.2GHz Dual Core Application Processor

- RAM: 1GB

- GPU: ARM Mali-400 MP

- Software: Android, Root Explorer, Quadrant

(2) Stock firmware for the Samsung Galaxy S2

(3) Development PC

- OS: Windows7 Home Premium K SP1 32bit

- JAVA JDK

- Eclipse IDE for Java Developers, Indigo Service Release 1

- Android SDK

- Odin3 v1.85

- VMware 7.1.4

- Linux Ubuntu 11.10

(4) Testing environments

- Room Temperature: 23C

- Networking: Wi-Fi

- Fan Controller (Thermometer): Sentry LX.

4.2. Rooting a Phone

First, we rooted the test device by connecting it to a Windows PC with Ubuntu OS running. This enabled us to become a 'super user' of the device, which we could completely control. Next, we applied an overclocking technique to increase the performance of the device speed before applying a memory optimization technique.

In this section we describe the detailed steps to install Ubuntu on a PC and the procedures required for rooting a phone.

[Step 1: Preparation]

1. Install 'Ubuntu' at your PC.

2. Download the stock ROM ('SHW-M250S EJ04') from Samsung Mobile (http://opensource.samsung.com/)

[Step 2: Rooting] Attain a root privilege through Ubuntu:

1. Open a Ubuntu terminal window

2. $ sudo passwd root

3. $ <password>

4. $ <Confirmation of the password >

5. $ su root

6. $ <Password>

[Step 3] Use Odin3 v1.85 to flash the rooted kernel to the device: (See Figure 3.)

1. Enter to 'download mode' on the device:

    i. Power off

    ii. Press simultaneously: 'Power + Home key + The Key located lower part of 'volume' key'.

2. Connect the phone to the PC using a USB interface while in the download mode.

3. Execute Odin3 v1.85.

4. Click the 'PDA' button

5. Select the rooted kernel above

6. Click 'Start' and wait for the process to finish.
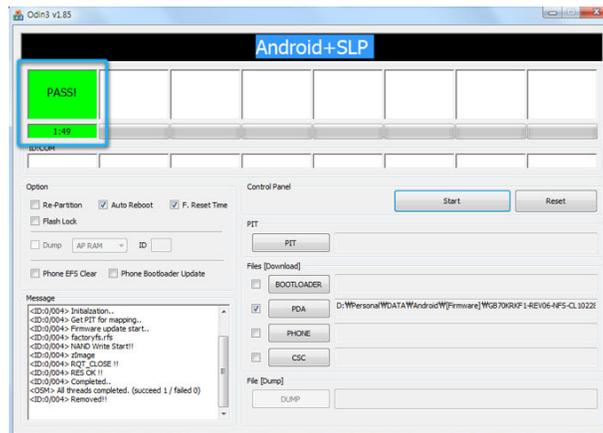
7. Once completed, the phone will reboot.

Figure 3. Flashing the Rooted Kernel to the Device

4.3. CPU Overclocking

This section describes steps to perform overclocking experiments with the Root Explorer and Eclipse program, as well as steps to measure device performance.

[Step 1] Execute the Root Explorer

1. Download Root Explorer from the Android Market.

2. Run the Root Explorer and acquire CPU related information:

    -   cpuacct.freq: frequency values(maximum and minimum values)

    -   cpuacct.stat: basic information

    -   cpuacct.usage: usage value

    -   cpuacct.power: voltage value

3. Extract the file containing system information and analyze.

[Step 2] Execute Eclipse Indigo and set the clock values

1. Execute Eclipse Indigo.

2. Analyze the source code

3. Reset the CPU clock values

[Step 3] Run Quadrant benchmark app to measure the Quadrant score of the phone.

1.   Download Quadrant benchmark app from the Android Market

2.   Run the benchmark tests and check the performance, stability and device temperature.

Note: After each test in overclocking the CPU, the smartphone must be carefully examined before moving on to the next step. Specifically, the device temperature and functional reliability should be safely in check.

4.4. Memory Cleaning

This purpose of this technique is to remove unnecessary apps installed by manufacturer and telecom operators and/or replace them with more efficient ones, if available. Starting from an initial state where no app deletion or replacement has occurred, we optimized the memory usage of the Android phone in three steps:

1. Remove unnecessary apps installed by the device manufacturer.

2. Remove unnecessary apps installed by the telecom operator.

3. Replace certain apps with more efficient ones, if available.

After each step, we checked for the amount of memory space saved.

[Step 0: Assess the initial state of the device memory]

[Step 1] Remove unnecessary apps installed by the device manufacturer- Samsung Electronics Co., (Figure 4).

Figure 4. Step 1 of Memory Cleaning

[Step 2] Remove unnecessary apps installed by the telecom operator- SK Telecom (Figure 5).

Figure 5. Step 2 of Memory Cleaning

[Step 3] Replace removed apps with ones that have same or better functions but are more memory efficient.

Steps 1 and 2 involve removing apps that are seldom used, most of which are installed by the device manufacturer and the telecom operator. Step 3 involves replacing the apps helpful to users with more efficient ones that have similar or better functions. To do so, the user will need to search on-line for more efficient apps. As a result, the degree of improvement in memory usage may vary from user to user, depending on the quality of replacement app(s) selected. In this experiment, we selected the following replacement apps: 'Power AMP' for music listening, 'Vignette' for camera, 'MX Player' for video viewing, and 'GO SMS' for SMS service.

5. Experimental Results

5.1. CPU Overclocking

After rooting the device, we performed a series of experiments to overclock the smartphone's CPU. This involved changing the CPU clock values. We used Quadrant benchmark software to measure the performance of the device after altering the clock rate. Quadrant computed the benchmark value of 5 areas: CPU, Memory, I/O, 2D, and 3D Graphics.

The factory set clock rate of the Android phone was 1204MHz with a voltage of 1250mV. Initially, the phone's Quadrant score measured 3105. From the base state, we measured this value 4 times by increasing the clock rate in increments of 50MHz. The results are shown Figure 6.
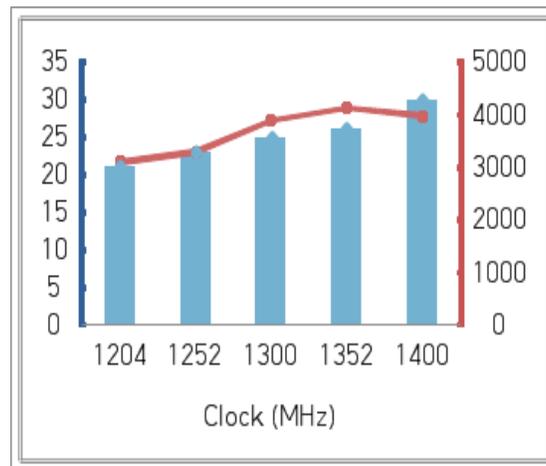

Figure 6. Quadrant Scores Measured (Score in red and temperature in blue)

The Quadrant scores measured were 3302 at 1252 MHz, 3899 at 1300 MHz, 4173 at 1352 MHz, and 3982 at 1400 MHz. Figure 6 shows trends in the Quadrant score and device temperature. In the first 3 tests after the base state, we observed that the scores increased as the clock rate increased. However, it should be noted that the Quadrant score decreased when the clock rate increased from 1352MHz to 1400MHz in the 4th test. This can be attributed to the effect of the GPU used in the smartphone. Also note that in the 4th test, the device temperature soared to 30 centigrade. At this point, we stopped further testing to the CPU clock.

From our analysis, we determined that maximum performance of the device with continuous and stable functions could be achieved at a clock rate of 1352MHz.

5.2. Memory Cleaning

Once a user becomes a 'super user', manufacturer and operator installed apps can be deleted and replaced. In this experiment, we attempted to clean the memory of the Android phone using 4 steps, after each of which we measured the memory usage of the device. Each measurement was performed after leaving the power-on of the mobile phone and letting it sit idle for 5 minutes. A separate tool to measure the RAM usage of the phone was not needed since this information can be checked by the Android OS itself. Memory optimization results are summarized in Table 1.

Table 1. Memory Optimization Results

Steps	RAM Usage (in Megabytes)	Savings (in Megabytes)	Savings (in Percent)
Step 0	447	NA	NA
Step 1	326	121	27.06
Step 2	318	8	28.85
Step 3	265	53	40.71

For comparison, we measured the base state (without being rooted). This showed a memory usage of 447MB (Step 0). Next, we decreased the memory usage to 326MB by deleting manufacturer-installed apps that are never used. This allowed us to save 121MB of memory space. Afterwards, we decreased the memory usage further to 318MB by deleting unnecessary apps installed by the telecom operator. Finally, before implementing the last measure, we replaced apps for music, camera, video, and SMS with apps using less memory but having similar or better functions. The final result of this memory optimization test was 265MB of memory usage. This means that similar or better apps were added to the device but with a 40% savings in available memory space (Figure 7).
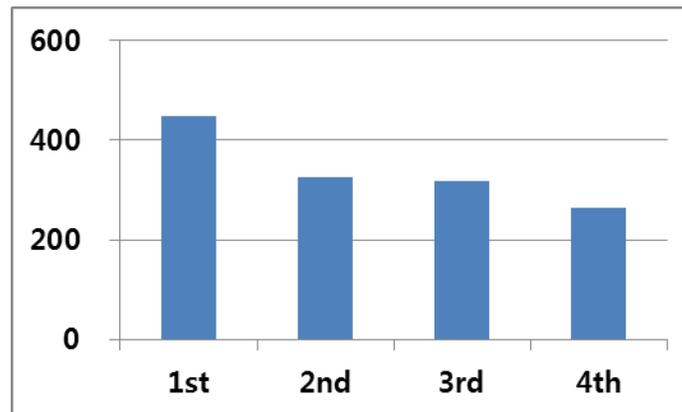

Figure 7. Memory Usage Change (in mega-bytes)

5.3. Summary

Using the overclocking technique proposed in this paper, we achieved a substantially significant performance improvement of our Android phone. Namely, we were able to increase the CPU clock rate from 1204 MHz to 1352 MHz, with only a modest temperature increase. In fact, we were able to increase CPU speed by 12.3%. The Quadrant score increased as well from 3105 to 4173, which showed a 34.4% improvement.

We applied a memory cleaning technique as well to delete unnecessary apps installed by the device manufacturer and the telecom operator. We also replaced some apps with more efficient ones. By memory cleaning, we also decreased the required memory usage from 447MB to 265MB, a near 40% improvement, from deleting and modifying unnecessary pre-installed apps (Figure 8 and Figure 9).

Figure 8. Initial Memory State

Figure 9. Memory Usage After Optimization

6. Conclusion

In this paper we described relatively simple techniques to improve the performance of an Android-based phone. This process involves using CPU overclocking and memory cleaning techniques after the mobile phone has first been rooted. In addition, we presented our experimental results from applying these techniques to a Samsung phone. By using the overclocking technique, we observed a significant CPU clock speed increase and a 34% Quadrant score improvement while maintaining functional and operational stability in the device. Also, adjustments in memory optimization yielded a 40% savings in main memory usage of the phone.

The techniques presented in this paper can be readily performed by an average smartphone user to his device. Although these techniques were developed on a Samsung phone, a similar approach can be applied to other Android-based models.

In the future, further analysis is needed of tradeoffs between performance improvements and battery usage inefficiencies in mobile phones. Moreover, the long-term effects of increased temperatures from performance enhancements should be examined in further detail.

Acknowledgements

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