Investigating “overclocking” an Android mobile phone with a designed experiment

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Abstract

Obtaining additional computational speed from a central processing unit by means of driving a computer system at clock frequencies higher than the default settings has long been used as a method to inexpensively “boost” the performance of a computer. With the emergence of so called smart-phones and the openness of the Android operating system, such tweaks have recently been applied to mobile handsets. This paper investigates the performance gains to an off the shelf handset with the custom Skatie Rom (C3C0, 2012) via means of a statistically designed experiment. A Taguchi Orthogonal Array was used to investigate 5 factors, each at 3 levels on the performance as measured with Aurora Softworks Quadrant application. Unsurprisingly the core CPU speed had the largest effect on overall performance, but we demonstrate that CPU Governor (lagfree) and the I/O Scheduler (noop) were also significant at p=0.000, whilst the size of the SD Card Cache is significant to p=0.065.

Introduction

Overclocking has a considerable history in desktop computer circles. (Wikipedia, 2012) defines overclocking as:

“the process of making a computer or component operate faster than specified by the manufacturer by modifying system parameters.”

The exact process of overclocking a device varies, but the most common and from which the process derives its name is to run the system clock at a higher rate than expected, so that the processor completes more instructions (hence calculations) in a given time period. The purpose of overclocking is to force the device to operate at a higher speed and to improve performance for little or no cost outlay. (nerdparadise, 2002) draws the similarity between overclocking and tuning a car – both are designed to achieve the maximum performance of the hardware you possess.

As central processing units and computer systems in general have increased in speed and number of cores, the need to overclock hardware as fallen. (Google, 2012) shows how the number of searches on Google for “Overclocking” and “PC / Computer / CPU” have fallen dramatically:

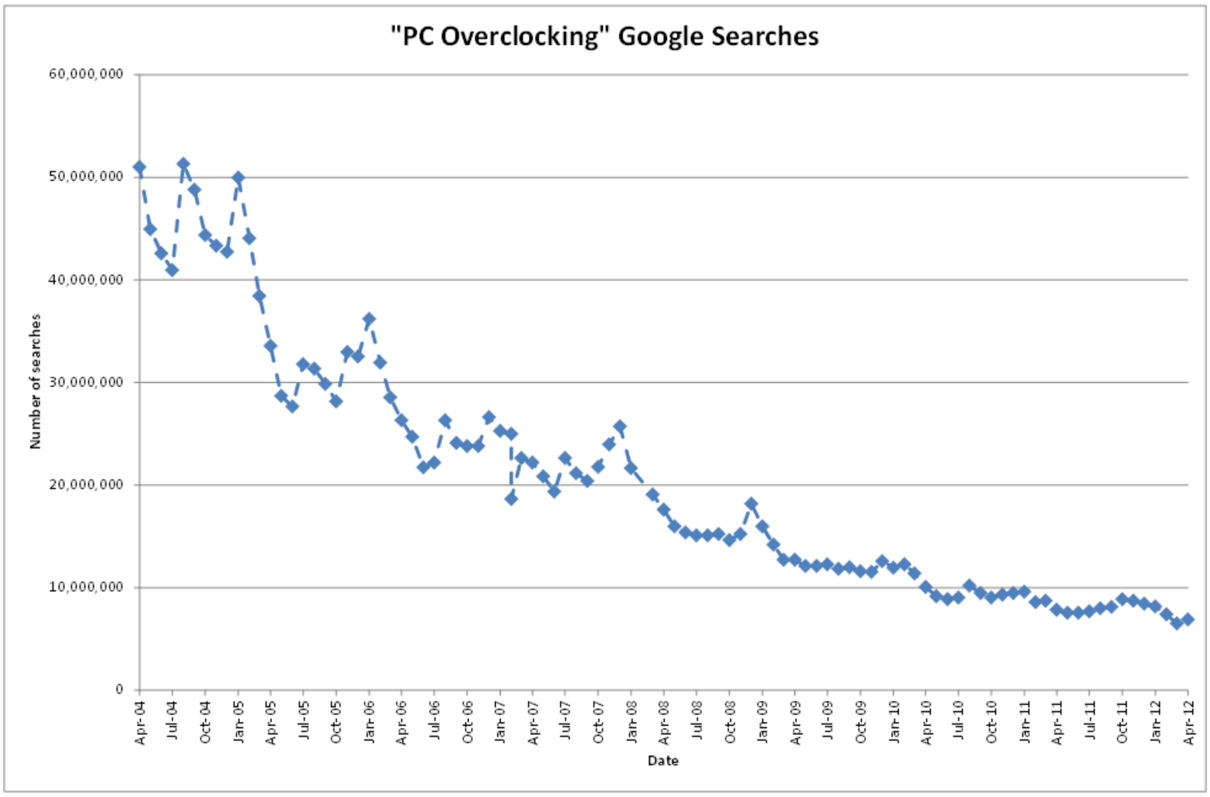
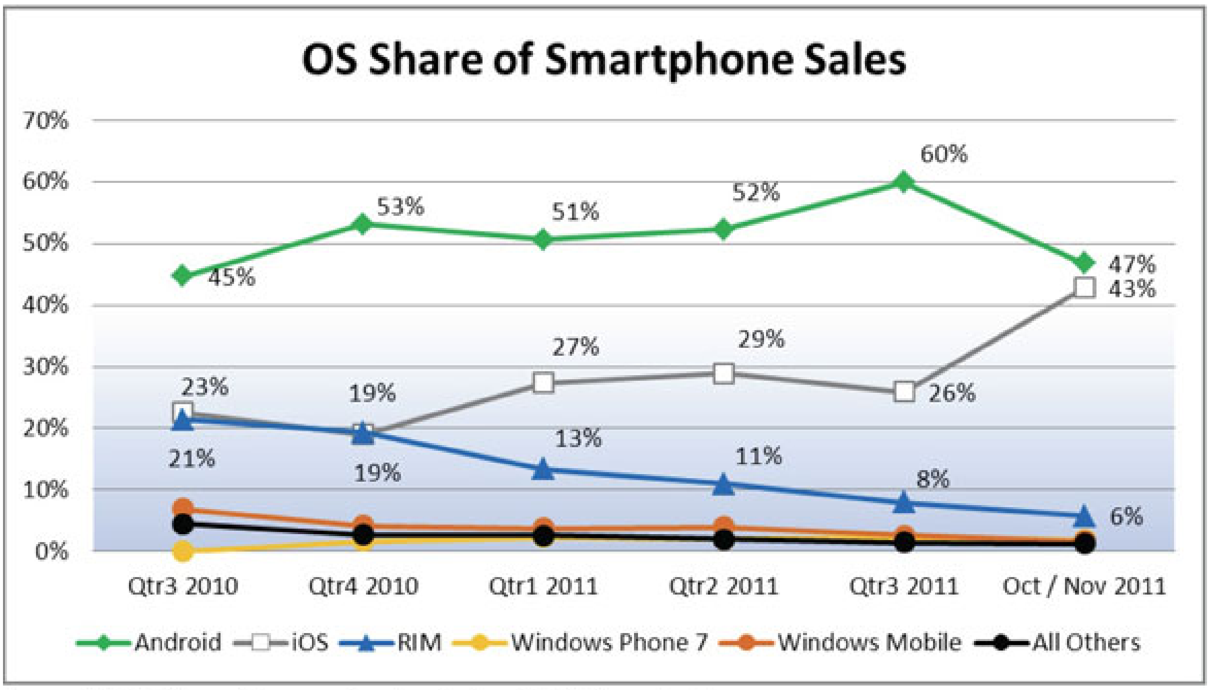


Figure 1: PC Overclocking (source, Google)

During April 2004, some 50,000,000 searches per month were recorded by the search engine Google. As of April 2012, that had fallen to (a still healthy) 6,500,000 searches per month.

As mobile technology has evolved, the current crop of smartphones behave in essence as a small hand held computer, capable of many of the same tasks as their laptop or desktop cousins. (Business Insider, 2012) shows that 90% of the smartphone operating systems are shared almost equally between Apples iOS and the Android platform.



Source: The NPD Group, Consumer Tracking Service, Mobile Phone Track

Figure 2: Smartpone OS (source, Business Insider)

Whilst the success of all things "Apple" cannot be underestimated, and the marrying of mobile technology with iTunes led to the explosion of "Apps", it is the Android operating system that is drawing considerable attention from system hackers, due in part to its open source nature, based on the Linux operating system (Android, 2012).

Due to the relative newness of the Android operating system and the emergence of the smartphone as a computing platform, overclocking handsets is in its infancy. However, as can be seen in the following figure, growth in online searches is rapidly increasing.

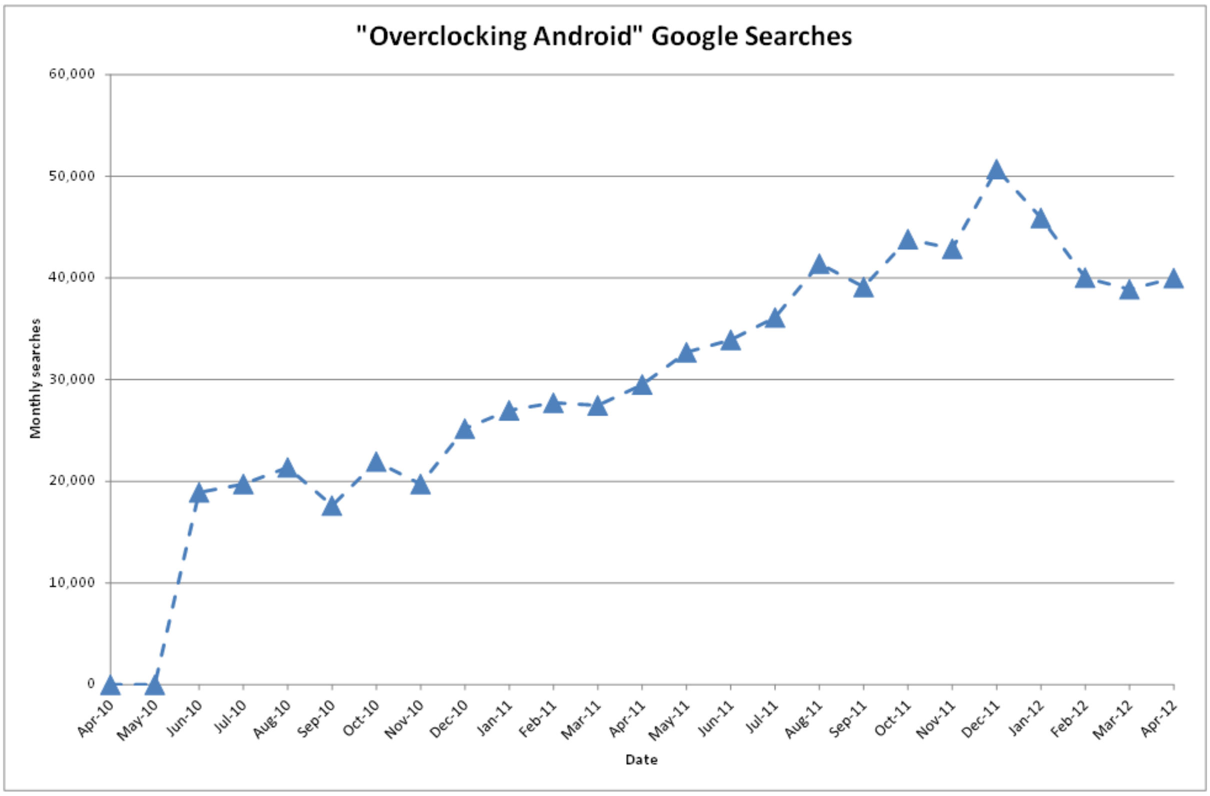


Figure 3: Overclocking Android (Source, Google)

Over the period April 2010 to April 2012, Google reported a growth from 0 to upwards of 40,000 uniques searches per month for terms including both “Android” and “Overclock**”

The open source nature of Android and the relative ease of coding for the Linux environment has led to nearly 100 Apps being available to overclock an Android based handset (Google, 2012). The handset must first be “rooted” or have a custom version of Android loaded which allows you to access the core system parameters, (akin to jailbreaking an iPhone device).

Anecdotal evidence points to the benefits and drawbacks of overclocking your Android handset (Tested, 2010), (xdaDevelopers, 2011) – these include:

Benefits:

- Higher performance
- More responsive phone
- Less “lag” – menu transitions, application starting

Disadvantages:

- More heat generation
- Faster battery consumption
- Instability of phone operation
- Potential hardware damage

However, there is no evidence in the literature of a systematic assessment of the performance gains to be achieved by varying system parametes.

This paper sets out to assess how the performance of a ZTE Skate is affected by varying the following parameters:

- Min / Max CPU speed
  - The speeds between which the CPU can operate, measured in MHz
- CPU Governor
  - The method by which processor speed moves up and down in accordance with the demands put upon the processor
- I/O Scheduler
  - The algorithm used to control writing to memory
- SD Card Cache Size
  - The size of the SD card read / write buffer, measured in kilo bytes.

Experimental Technique

Each of the 5 factors above was investigated at 3 different levels, leading to 3^5 or 243 combinations being required to fully map the experimental space. Operating 3 repeats for each condition would require 729 experiments to be carried out.

Instead a Taguchi Orthogonal Array (L27) (with 3 replicates) was used to map the Main Effects of each factor.

Min	Max	Governor	I/O	SD
1	1	1	1	1
1	1	1	1	2
1	1	1	1	3
1	2	2	2	1
1	2	2	2	2
1	2	2	2	3
1	3	3	3	1
1	3	3	3	2
1	3	3	3	3
2	1	2	3	1
2	1	2	3	2
2	1	2	3	3
2	2	3	1	1
2	2	3	1	2
2	2	3	1	3
2	3	1	2	1
2	3	1	2	2
2	3	1	2	3
3	1	3	2	1
3	1	3	2	2
3	1	3	2	3
3	2	1	3	1
3	2	1	3	2
3	2	1	3	3
3	3	2	1	1
3	3	2	1	2
3	3	2	1	3

.

The factors and levels were coded as follows:

Min	Value	Max	Value	Governor	Value	I/O	Value	SD	Value
1	200	1	806	1	lagfree	1	cfq	1	1024
2	245	2	864	2	smartassv2	2	noop	2	2048
3	320	3	921	3	ondemand	3	vr	3	3072

Phone preparation and software used

A stock ZTE Stake as branded Monte Carlo was obtained from Orange UK (Orange UK, 2012). The custom Skatie ROM was installed (C3C0, 2012) – to allow both root access and to remove any Orange applications that might affect the benchmarking.

No-frills CPU control (Sineo, 2012) was used to control Min, Max, Governor and I/O

SD Speed Increase (Stamigni, 2012) was used to control the SD cache size.

Quadrant Standard Edition (Softworks, 2012) was used to measure a benchmark performance – only the “Overall” performance was recorded.

Results & Discussion

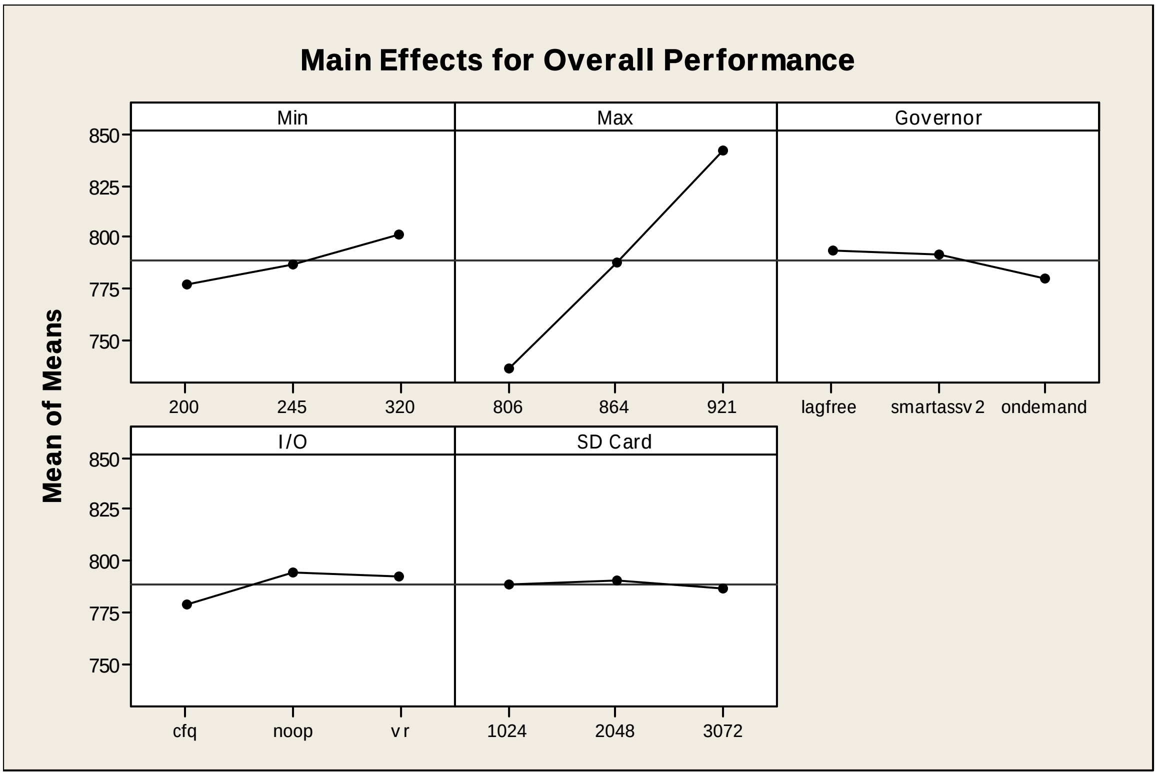


Figure 4: Main Effects for Performance

Min and Max CPU

Overall, the Maximum CPU MHz has the largest effect on system performance – this is not surprising as this control the highest clock speed available to the handset. The Minimum CPU MHz also contributes positively to the overall performance – again, unsurprisingly as with higher Min CPU, the processor would need to scale up less when jumping to higher speeds. Both of these results are statistically significant with a p=0.000 indicating that the variance between the repeats is insignificant when compared to the variation between the levels of factors.

Governor

Whilst the magnitude of the Governor factor effect is small compared to Mix/Max CPU it is still significant to p=0.000, so we can conclude that lagfree is the optimum setting to maximise performance.

I/O

Again, small in magnitude, but still significant to p=0.000, the I/O scheduler noop provides optimal performance. However, the difference between noop and vr is slight and not significant.

SD Cache

The significance of the SD Cache is p=0.065, and as such is greater than the critical value of p=0.05 – we cannot conclude that SD Cache is significant in determining overall performance of the phone.

Discussion

The performance benchmarks are just that – benchmarks measured in an artificial manner, using a closed source application. It is likely that alternative benchmarking programs will return different results as the algorithms they employ will be dependent on different aspects of CPU and processor control.

However, it is likely that the magnitude and importance of the Min / Max CPU setting will remain the largest contributor to handset performance.

The Governor setting, whilst significant but low magnitude is likely to play an important role in the perception of performance of the user, as it is more closely linked to changes is processor speed (up or down) and is tied to the actual use of the hand set. Lagfree for example, switches more quickly to higher speeds facilitating a quicker “return from sleep” experience than other governors – however, the overall performance of the handset is only marginally affected.

As mobile phones used solid state memory the I/O scheduler is less important than when considering moving hard disk technology. Most solid state media has a “controller” processing built in removing the need for the CPU to control the read / write process. This is supported by the “noop” I/O schedule being the fastest.

Conclusions

This paper has presented a quantitative assessment of mobile handset overclocking and has clearly identified the min / max CPU as the single most effecting tweak in determining performance. The lagfree governor and I/O scheduler “noop” are significant to $p=0.000$, however the magnitude of performance gains is small compared to CPU speed.

Extensions

Possible extensions to this project would be to compare the perceptions of performance from handset users to specifically address the Governor setting as the author believes this may well be more important than benchmarked numbers.

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