TITLE

QUANTITATIVE RESEARCH PAPER ON SMARTPHONE APPLICATION OFFLOADING BY CLOUD COMPUTING.

BY

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CHAPTER 1

1.0 INTRODUCTION

1.1 Overview

A mobile phone is a device just like a personal computer when comparing some of the operations. Mobile phone evolution has taken place a rapid it was expected at the advent of mobile phone technology. Each passing phase introduces an arrival of more sophisticated smartphones as reffred to. At the advent of mobile phone technology, phones could only be used to make voice calls, writing of short text messages, playing basic games like *Teris*, with majority having inbuilt calendars and clocks. The current phone more so the smartphone, is a multi-purpose communication tool, serving in complex operations including banking and transferring of money over the phone within a fraction of a minute. Among other uses of mobile phones are web browsing, email and multimedia and many more depending on individual differences. The continuous development of mobile phone technology has made a notably complex tool of operation, increasingly reduced limitations of the primitive phone and increased the advantages of the device together with increased speed. Its size is an added advantage over the use of larger other computer devices in as much as the developed softwares for the current phones are concerned. Unfortunately due to its small size, the mobile phones have a limited computational performance and battery life which is of disadvantage. Cloud computing has been claimed to have the ability to increase battery life and offers computational offloading.

Over the recent past, advances in network based computing technology and mobile phone application requirements have had an outrageous demand thereby to an increased outgrowth of mobile phone application models such as cloud computing softwares. Cloud computing as a spectacular application model has been researched on by various scientific and industrial groups since the year 2007. The so called cloud computing is described as a range of services provided by Internet based cluster systems. These internet cluster systems consist of a group of low-cost servers or Personal Computers (PCs) including smartphones, organizing the various resources of the computers according to a certain management strategy, and offering a safer, reliable, faster, transparent and convenient services such as data storage, accessing and computing to clients more so the smartphones. According to the top ten strategic technology trends for 2012, according to Cooney (2011), provided by Gartner (a famous global analytical and consulting company), cloud computing has been on the top of the list, which means cloud computing is likely to have an improved impact on technology.

Smartphones are a representative of various mobile devices because they have Internet connection from the rapidly growing wireless network technology. The core technology of cloud computing is centralizing computing, services, and specific applications to users. Therefore, the combination of mobile network and cloud computing generates a new computing mode, namely Mobile Cloud Computing. Resources in mobile cloud computing networks are virtualized and assigned in a group of numerous distributed computers rather than in traditional local computers or servers, and are provided to mobile devices such as smartphones. Various applications based on mobile cloud computing have been developed and given a good service to users, such as

Google Gmail, Map and Navigation systems for Mobiles, Voice Search, and some of the applications on the android platform, MobileMe from Apple, Live Mesh from Microsoft, and Moto Blur from Motorola. Cloud computing-based mobile software and application are expected to rise up to 88% annually from 2009 to 2014 according to research.

Generally speaking cloud computing has been agued out as just another byword that is being used to market an existing technology. However, Cloud computing has the potential of transforming the whole IT industry according to Armbrust, *et al*., (2009). This research aims at investigating whether it is likely to upsurge smartphone computational supremacy and speed of mobile phones through offloading heavy application functions to the cloud. This study will also evaluate the degree of applicability of cloud computing in the area of mobile phone application. Therefore, the study will be focused on evaluating how cloud computing has the ability to transform the usability, computational performance and addressing the drawback of mobile phones.

Cloud computing offers a safe approach to store user's data while users do not get concerned about the issues such as software updating, leak patching, virus attacks and data loss. If failure happens on a server or VM, the cloud computing systems transfer and backup those data to other machines, and then delete those failure nodes from the systems automatically in order to make sure the whole system has normal operation. Meanwhile, cloud can be extended from horizontal and vertical in a large-scale network, to process numerous requests from thousands of nodes and hosts. 'Cloud' is a virtual resource pool where all bottom layer hardware devices are virtualized. Users access desired resources through a browser and get data from cloud computing providers without maintaining their own data centers. The cloud system is automatic, transparent and provides a safe and highly efficient services.

1.2 The history of cloud computing

Cloud computing has been possible through development in a variety of fields. Carr contends that what we are seeing today is very much alike to what happened amid the modern time. Amid the mechanical period numerous commercial ventures needed to give their own power by wind or water factories to power their machines. As power through force lines got to be less expensive, more accessible and more solid there was no requirement for the commercial enterprises to create their own vitality. Carr contends that the organizations of today stage the same move as the ones amid the modern range, aside from today the movement is to distribute computing as appropriate (Carr, 2009).

Toffler contends that a human progress experiences diverse waves of improvement. The principal wave is the rural social orders; the second one is the modern age and what we now are bothering is the third wave, the data age Toffler, (1984). These real waves are then separated into a few sub waves according to clients' needs.

Virtualization on the other hand was presented in the early sixties by IBM Hurwitz, *et al.*, (2010), which made it conceivable to run a few working framework occurrences on one server. Virtualization makes it conceivable to run a few working frameworks on one server all the while, yet differentiates them as though they were all alone server. This makes it conceivable to exploit the server's assets to a more prominent degree, by running a few administrations on the same server. Customarily, one administration are run on one server in light of the fact that working frameworks like Windows and Linux experience issues to designate assets between applications that needs the same assets Hurwitz *et al*., (2010). This is not an issue if there are simply a couple of uses required. The arrangement has been to put each application on a different server. Anyhow if there is numerous distinctive applications this turns into an issue due to the boundless measure of servers that then are required. It can likewise be extremely wasteful to simply have one application every server, something that virtualization tries to unravel.

Amazon offers the likelihood to set up virtual servers all alone's system. The client has the likelihood to, for instance, pick which working framework and storage room they need. The virtual servers are then imparted to others on Amazon's physical servers so that the servers' abilities are utilized all the more proficiently. There is additionally a plausibility to scale figuring assets up or down.

Utility computing characterized by procurement of computational and stockpiling assets as a metered administration, like those gave by a conventional open service organization" Rittinghouse & Ransome, (2010). The thought of utility registering is to pay for the sum that we utilize and it ought to be accessible to us.

Organizations can outsource parts, or their entire IT office, on organizations particular on that specific field. For instance an organization that outsources the setup, support and capacity of their servers so they don't need to have them on location, on their organization compound. This is like Paas or Iaas were distributed computing merchants deal with the stage and/or foundation. The similitudes are striking yet the distinctions lie in the rate of giving the administrations and understandings that accompanies it. Not at all like customary outsourcing that obliges protracted gets that normally simply bear on the length of the agreement concede to, distributed computing offers a predefined arrangement that matches the need of the client's application Rittinghouse & Ransome, (2010). There is generally no starting expense, and the client pays for what is consistently utilized and nothing more.

1.3 Previous research

Cloud computing on smartphones is not a new topic. A lot of research has been carried out. More of this literature focuses on investigates the possibility of offloading mobile phone functions into the cloud in order to extend battery life, mainly through reducing the computational load of the mobile phone more so the smartphone for that matter.

Miettinen & Nurminen have explained in detail that energy efficiency is of fundamental consideration in as much as mobile phones are involved and points out that cloud computing presents the potential of saving energy via offloading Miettinen & Nurminen, (2010). The energy cost of the computation must however be greater than the communication transfer cost to the cloud. There is however another interesting poi to note. That energy consumption is greater if the data sent to the cloud is divided into smaller bits other than by sending similar data in one large mass. Miettinen & Nurminen present a remarkably basic.

Palmer et al. also investigated the importance of mobile phones in collaboration with cloud computing. The computational clout of smartphones is stated to be the main or major limitation of smartphones. These constraints call for or make it desirable to offload computational tasks to the cloud where resources are “unlimited”. But there are also problems related to the connection between the mobile phone and the cloud in forms of latency, connection interruption and network provider costs that needs to be considered Palmer *et al*., (2009).

Carroll & Heiser, 2010 carried out a research that investigated parts of mobile phones that consume more energy by measuring the different parts of a mobile phone while the phone was in operation. The result showed that data transmission, phone calls and the display are the parts that utilize more energy. This means that sending and receiving data from the cloud is a remarkably energy-consuming task in comparison to other mobile phone related functions Carroll & Heiser, (2010).

Yang, Ou, & Chen, 2008 have as well acknowledged the limitations of mobile phone and critique that the small size combined with the portability of this devices make it hard to run applications that require a lot of computational power Yang, Ou & Chen, (2008). Mobile phone users desire to run even complicated applications that they use on more powerful computers on their smartphones. Therefore Yang et al. point out that cloud offloading offers a credible solution. The authors conducted an experiment in which they used a text translate application. The application reads the text through a mobile phone camera and translates it into German language. They compared the results of performing the translation task locally on the mobile phone and by offloading it on computers that represented the cloud. The results indicated that it is beneficial to offload the task. Yang et al. raise some fundamentally important questions about the privacy related to offloading. When performing the translation task, the image of the text is sent to a computer that the user does not control, which means that they no longer possess the control over the data and that third-party members could access it. Another interesting point is an offloading decision engine, as part of the application, that determines if it is suitable to offload a task or not. If the conditions are favorable, for example with a good mobile phone connection, it might be beneficial to offload the task to the cloud. However if the conditions are not beneficial then the application rather executes the task locally on the mobile phone.

Kumar & Lu has also investigated the energy constraint of mobile phones and argue that many applications are to computation intensive to be run on mobile phones. Cloud offloading is dependent on the wireless bandwidth capacity, the amount of computation and the amount of data that need to be transmitted. Kumar & Lu points out that the material that needs to be processed seldom is considered. For example, if an application transforms an image the image itself needs to be uploaded to the cloud server before the processing can take place, and depending on the image size it can add up to quite an amount of data that needs to be transmitted. There are also several challenges in using the cloud in mobile phone applications. Privacy and security issues needs to be considered when data are sent to servers managed by other people or companies. Reliability is another issue; the cloud servers must always be accessible for the application to work. If the servers are down for maintenance, the applications relying on it will not function. Finally, "real-time data" or latency is addressed. For example, in a GPS navigation application the information must be updated frequently. When using the cloud to conduct data transformation there will be some latency while sending the data back and forth from the mobile device. If the latency is great enough the information will already be obsolete when reaching the mobile device. These are some issues with cloud computing which needs to be considered Kumar & Lu, (2010).

1.4 Background of the Study

Cloud computing is becoming increasingly hot topic across the Information technology sector and more so in the sector of smart phones with cloud computing g being implicated with the power to transform the IT industry according to Armbrust, *et al.*, (2009). There is a section of critiques claiming that the cloud technology is a 'catchword' and is likely to have been around for years, for example as grid work out and computing as a utility Reese,(2009); Rittinghouse & Ransome, (2010). It is therefore thought as an attempt to market and package an existing technology in a new way Krishnan, (2010). There is also confusion on the actual meaning of the term cloud or includes (Rittinghouse & Ransome, (2010); Armbrust *et al*, (2009) since it covers a remarkably wide area of information technology. With the claim that cloud computing is here to stay and that it has a great potential in the technology Chow, *et al.*, (2009); Krishnan, (2010); Reese (2009); Rittinghouse & Ransome, (2010), it is important to investigate the claims and verify whether it's a new technology or merely a new slogan for an already existing technology.

1.5 Statement of the Problem

There is increased euphoria on cloud offloading in the smartphone sector with claims that it does improve on mobile phone efficiency and computing. It is important that this claims are investigated.

1.6 Purpose

The purpose of the thesis is to investigate whether cloud computing improves mobile phone computational performance and usability, including aspects of increasing the application speed. The computational capacities of mobile phones are limited al phone level and depending on the mobile phone capacity and application model, cloud computing could be an answer to improve the mentioned area.

1.7 Research objectives

Decent research is often inspired by formulation of achievable objectives. This research is not an omission and it sought to investigate the following objectives.

Main objective

To understand whether utilization of cloud offloading increases the usability of smartphones.

Specific objectives.

1. To evaluating the extent of use of smartphone cloud offloading
2. To determining the advantages of exploiting mobile phones as computational devices
3. To examine whether the use of cloud computing technology on smartphones has any notable advantages
4. To determining the applicability of mobile phones in cloud computing

1.8 Research questions

Major research question

Can cloud computing technology increase the computational power of smartphones compared to smartphone local or inherent computational power?

Specific questions

1. Which features are essential in a smart phones in order to guarantee that cloud computing will improve the mobile phones' executional power?
2. Can cloud computing increase the computational power of smartphones?

1.9 Hypotheses

Alternative hypothesis

Offloading of application data of smartphones to the cloud increases speed and performance.

Null hypothesis

Offloading of application data of smartphones to the cloud does not increase speed and performance.

1.10 Research plan

This was a qualitative research that was carried out to assess the boosting capability of smartphone offloading to the cloud. Performance results were compared for both local performance and performance attained after offloading to the cloud. This was determined statistically and the influence of cloud offloading compared based on demands of mobile computing requirements.

The following table represents the work plan durating of the study

Table 1: Study Plan

Month Task	Oct.	Nov	Dec	Jan	Feb	Mach
Developing Proposal Document						
Application and collection of the Research relevant documentation designing of the necessary tools.						
Data Collection						
Data cleaning and Analysis						
Dissertation Writing						
Finalizing of Dissertation Writing and submission.						

1.11 Limitations

Due to time constraints, this study was not in a position to assess all the operating systems in the market due to limited manpower, resources and time. There are also several models and sizes of smartphones available in the market today. This is further complicated by the continuous arrival of new smartphones with improved operating systems, modified shapes and sizes with claims of heightened performance. For this reasons this application will only evaluate the android version. Other factors such as battery life influence the performance of mobile phones and were not taken into account in this research.

1.12 Scope of the project

This study project was done on android smartphones only. Phones with other operating systems will not be considered in this research. This will be conducted on smartphone users who concept to be involved in the study and whose phones meet the criteria for inclusion in the study.

1.13 Chapter summery

Mobile phone users desire to run even complicated applications smartphones. It is important to note that cloud offloading can be of important. The mobile phone assesses whether it is beneficial to offload the task to the cloud if the conditions are not beneficial then the application executes the task locally on the mobile phone this means that a smartphone should have a an appropriate application in order to utilize cloud computing. However, to verify the claims that cloud computing in deed does offer any benefit to the performance of the mobile phones, this study formulated the research questions which this study intends to investigate.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Cloud Computing

The development of software represents increased CPU speed, a hard disk with an increased capacity and increased performance Operation System (OS). Hewitt, (2008), describes cloud computing as a system of storing data on the cloud servers, and uses of cache memory technology in mobiles to fetch data. These mobiles include PCs, laptops, and smartphones e.t.c. Buyya, 2008, describes cloud computing as a parallel and distributed computing system, that is combined by a group of virtual machines which have internal links. These systems continuously offer computing applications from service providers depending on Service level Agreements (SLA). According to Youseff (2008), cloud computing is not a completely new concept. Cloud computing is a combination of many existing and a few new concepts in many research fields, such as distributed and grid computing, Service-Oriented Architectures (SOA) and virtualization.

2.2 Mobile cloud computing

In recent years, hardware and software of mobile devices get greater improvement and are not just old-fashioned mobile phones with conversation, SMS, Email and website browser, but are mini personal computers providing a wide variety of applications to users. These smartphones include various sensing modules like navigations, optics, gravities, orientations, and many more applications that bring a convenient and intellectual mobile experience to the users. In 2010, the Google CEO Eric Schmidt, claimed that cloud computing service development, presented mobile phones with an increasingly complicated, and evolved portable super computers.

2.3 Essential characteristics of cloud computing

Mell & Grance, 2009 described five essential characteristics of cloud computing but this differs from one researcher to another, each researcher therefore adds and removes the characteristics that adequately present their subjective ideas or areas of study on cloud computing. The basic concept is to sub-divide the term cloud computing into more understandable fragments, which commonly are defined as:

1. Self- provision of resources and elasticity. Cloud computing users are capable of acquiring any quantity of computing capabilities without human assistance. Good examples include, unlimited network storage, processing competencies or software, which are available anytime and anywhere.
2. Pay-per-use. The cost of cloud computing services are centered on usage. For example, an hourly or monthly rate, traffic load or the numbers of users.
3. On demand availability. Cloud services are always accessible, platform independent and are commonly accessed through a web browser or web service API.
4. Scalability. Computation resources are perceived to be unlimited in the sense of matching any resource demands that the user have. For example, bandwidth, computational abilities or storage space. The cloud services should instantly be able to adapt to the demanded usage.
5. Resource pooling. Data and resources are divided on a vast amount of servers that usually are spread geographically; the resources needed are then directed based on the computational need of the service.

The definitions of cloud computing characteristics have got many different variations for example Armbrust *et al*. (2009), Hurwitz, *et al.,* (2010), Mather *et al*. (2009), Mell & Grance (2009), Reese (2009), Rittinghouse & Ransome (2010) and many other authors. The definitions differ from one researcher to another but they generally cover analogous areas Hamrén, (2012).

2.4 Service models of cloud computing

12.1.1. The Software as a Service or "SaaS"

Software as a Service or SaaS refers to: The competency provided to the consumer is to use the provider's applications running on a cloud infrastructure. (Mell & Grance, 2009). The traditional method of purchasing software requires the customer to locally install an application on their computer or smartphone and use a licenses to authorize the usage. With SaaS the customer pays for the software on a subscription level and does not need to install any software on their mobile devices. The application is accessed via Internet, through a web browser Mather *et al*., (2009). An example of this is Google Docs which is a word processing application offered online. The user accesses the application through a web browser, creates documents and uses all the features of the application Google Docs, (2012). What differentiates SaaS from PaaS and IaaS is that the user will not alter the application nor the hardware that the application runs on, or the network configuration. Other characteristics of cloud computing do apply here as well, that the application always should be accessible and that no specific platform is needed.

12.1.2. The Platform as a Service or "PaaS"

In this model, the vendor offers a development environment to application developers, who develop applications and offer those services through the provider's platform" Mather et al., (2009). The application already exists, and is usually owned by the cloud provider, PaaS offers a possibility to create and modify applications. It is a development of the SaaS application delivery model Rittinghouse & Ransome, (2010).

To aid the developer, different tools are provided like programming languages and Application Programming Interfaces (API). The user does not control the virtualization instance or network configuration of the cloud server Mell & Grance, (2009). An example of PaaS is Google App Engine that offers the possibility to create Java, Python and Go applications on servers hosted by Google Google App Engine, 2012; Reese, (2009).

12.1.3. Cloud Infrastructures as a Service or IaaS

This is the delivery of computer hardware (servers, networking technology, storage, and data center space) as a service. It may also include the delivery of operating systems and virtualization technology to manage the resources." Hurwitz *et al*., (2010). The actual network infrastructure of the cloud servers does not lay in the hands of the user, but rather network options like firewalls, storage, operating systems etcetera Mell & Grance, (2009). An example of IaaS is Amazon EC2, where virtual servers can be set up and configured over a web based interface within minutes Amazon EC2, (2012); Hurwitz *et al*., (2010). The customer can choose operating system, database and application development environment which gives the customer greater control over the hardware in comparison to PaaS. The customer has the possibility to configure the servers based on their needs, which generally includes more maintenance in comparison to PaaS but also more options Hamrén, (2012).

These three service models constitute the general model of cloud computing. It is a broad concept. SaaS, PaaS and IaaS are the most encountered in cloud computing literature and are basically divided by hardware abstraction level.

2.5 Deployment models of cloud computing

12.1.4. Public Cloud

Public clouds are available to the public in general, or large organizations, and are owned by a third party organization that offers the cloud service Mell & Grance, (2009). Google, Amazon and Microsoft are examples of public cloud vendors who offer their services to the public at large Mather *et al*.,(2009). Data created and submitted by customers are usually stored on the servers of the third party vendor.

12.1.5. The Private Cloud

This Cloud Infrastructure is operated solely for an organization. However, it may be managed by the organization or a third party and may exist on premise or off premise. Mell & Grance, (2009). The cloud infrastructure is accessed only by the members of the organization and/or by granted third parties. The purpose is not to offer cloud services openly to everybody but to use it within the organization. For example an enterprise that wants to make customer data available to their different stores.

12.1.6. The Hybrid Cloud

This infrastructure is a composed of more than one clouds that are distinct entities but are merged together by regulated exclusive technologies that enables data and application portability Mell & Grance, (2009). For example, an enterprise that have their HR and CRM applications in a public cloud like Saleforces.com, but then have confidential data in their own private cloud Sarna, (2011).

12.1.7. The Community Cloud

This cloud infrastructures are shared by large number of organizations and supports specific communities that have common concerns (e.g., the missions, security exceptions, policy requirements, and compliancy) Mell & Grance, (2009). The idea is that the costs are spread on several organizations that all are in need of the same services Hamrén, (2012)

2.6 The Cloud Computing Framework

Cloud computing systems actually can be considered as a collection of different services, thus the framework of cloud computing is divided into three layers, which are infrastructure layer, platform layer, and application layer

a) Infrastructure layer: it includes resources of computing and storage. In the bottom layer of the framework, physical devices and hardware, such as servers and storages are virtualized as a resource pool to provide computing storage and network services users, in order to install operation system (OS) and operate software application. Thus it is denoted as "Infrastructure as a Service" or IaaS. Typically services in this layer such as Elastic Computing Cloud of Amazon S. Shankar,

(2009).

b) Platform layer: this layer is considered as a core layer in cloud computing systems, which includes the environment of parallel programming design, distributed storage and management system for structured mass data, distributed file system for mass data, and other system management tools for cloud computing. Program developers are the major clients of the platform layer. All platform resources such as program testing, running and maintaining are provided by the platform directly but not to end users. Thus, this type of services in a platform layer is called the “Platform as a Service” or PaaS. The typical services are Google App Engine Zahariev (2009) and Azure (2011), from Microsoft.

c) Application layer: this layer provides some simple software and applications, as well as costumer interfaces to end users. Thus we name this type of services in the application (Hamrén, (2012).

2.7 Cloud Computing features

a) Virtualization: the ’Cloud’ is a virtual resource pool B. Rochwerger *et, al*, (2009) where all bottom layer hardware devices is virtualized. End users access desired resources through a browser and get data from cloud computing providers without maintaining their own data centers.

b) Reliability, usability and extensibility: cloud computing offers a secure approach to store the clients’ data worries about software upgrading, leak fixing, destruction of data by viruses and data damage. If failure happens on a server or VM, the cloud computing systems transfer and backup those data to other machines, and then delete those failure nodes from the systems automatically. G. Boss, *et al*, (2007).

c) Large-scale: in order to possess the capability of supercomputing and mass storage, a cloud computing system normally consists of thousands of servers and PCs. Google Cloud Computing, for example, has already controlled 2% of all servers or about 1 million servers located in 200 different places in the world, and will move upward to 10 million servers in the next decade Cohen, (2010).

d) Autonomy: a cloud system is an autonomic system, which automatically configures and allocates the resources of hardware, software and storage to clients on-demand, and the management is transparent to end users.

2.8 Mobile phones and cloud computing

Smartphones have become a universal interface to online services and cloud computing applications according to Giurgui *et al*., (2009). Mobile phone applications usually run locally on the mobile phone whereby the application is normally downloaded and then executed on the mobile phone. The downloaded application will usually interact with servers on the Internet to access the required information that the application needs, but the computation and the processing of data is chiefly carried out on the mobile phone, which has limitations that are based on mobile phone hardware.

On the other hand, cloud computing mobile phone application is downloaded in a similar manner like the local mobile phone application the difference is that it executes on a server rather than on the mobile phone. This application the functions as a communicator with the cloud server whose function is to display the data received on to it. Another approach is to access the applications through the mobile phone's web browser. For example Google Docs that is a word processor accessed through a web browser Google Docs, (2012). In this case there is no need to download any application, the application is available directly through the web browser.

The other substitute could be a hybrid mobile phone application that would in part operate at cloud level and partly at mobile phone level at the same time. The best representative is a mobile phone application that runs on the mobile phone but saves generated files in the cloud. Chen, *et, al*., describe how mobile phone applications could offload computational tasks to the cloud if the condition for doing so would be beneficial Chen *et al*., (2004; Miettinen & Nurminen, (2010). Applications that save data, generated by it, in the cloud are another example. Pictures, game scores, phone contacts etcetera could all be saved in the cloud to make them available to other devices. This is a development trend that might become more and more common while mobile phone manufacturers often attempt to integrate mobile phones with other devices they are manufacturing, for example Google TV (Google TV, (2012)).

2.9 Open research issues

Although some projects of mobile cloud computing have already been deployed around the world, there is still a long way for business implementation, and some research aspects should be considered in further work.

A. Data delivery: Due to the feature of resource-constrains, mobile devices have potential challenges in cloud accessing, consistent accessing, data transmission, and so on. Such challenges can be solved using: special application (service) and middle-ware (provide a platform for all mobile cloud computing systems).

B. Task division: Researchers divide tasks (applications) from mobile devices into multiple sub-tasks and deliver some of them to run in cloud, which is a good solution to the resource limited mobile devices. However, we do not have an optimal strategy or algorithm on how to divide these tasks, which one should be processed by cloud and which one by devices.

C. Better service: The original purpose of mobile cloud computing is providing PC-liked services to mobile terminals. However, as the existing different features between mobile devices and PCs, we cannot directly transplant the services from PCs' platform to mobile devices. Therefore, further research should try to identify the method on how to provide suitable and friendly interactive services for mobile devices.

12.2 Chapter summery

Cloud computing is a system of storing data on the cloud servers, and uses cache memory technology in mobiles to fetch data. In literature, Google CEO Eric Schmidt, (2010), claimed that cloud computing service development, presented mobile phones with an increasingly complicated, and evolved portable super computers. In this chapter, five essential characteristics of cloud computing are described. The chapter also describes the different models of cloud computing and together with their deployments. The chapter also describes the various researches that have been carried out concerning cloud computing and possible gaps that need investigations for proper justification.

CHAPTER 3

3.0 METHODOLOGY

3.1 Introduction

A research method defines, in detail, the process on how a study is to be conducted or how a study was conducted. The rest of the chapters try to justify and evaluate the suitability of the methods that have been used to extrapolate on the subject of the research. Research methodology is meant to address four areas according to Backman, (2008):

1. Subjects of concern. What kind of are the persons are involved in the study, what is their sample size, and what are there demographic features?
2. Material requirements. This covers the kind of materials that will be required in conducting the research either machinery or measurement instrument.
3. Procedures. This looks into the types of steps taken in carrying out the study observations, as well as the controls.
4. Data analysis. This looks into the kind and procedures used by the researcher to process the generated data. This covers the statistical methods together with kind of software used.

Quantitative methodology was used in this study. Mobile phone users submitted data from their hand sets. The mobile phone was treated like individual entities capable of being influenced.

Based on other reseachers, like Carroll & Heiser, (2010), Miettinen & Nurminen, (2010) and Yang *et al*., (2008) who have investigated similar topics and used quantitative approaches, this study is also quantitative. This has in turn influenced the research questions and data gathering process for this paper. Previous researches have focused on cloud computing as a means of extending the battery life of mobile phones, e.g. Miettinen & Nurminen, (2010). To increase the speed in executing tasks is considered important but not as important as battery capacity. The reason this research paper is focusing on speed rather than battery consumption is due to limitations in both time and knowledge as measuring battery consumption accurately is a rather daunting task Carroll & Heiser, (2010)).

3.2 Data collection

Cell phone applications from diverse producers were utilized to examine on the off chance that it was conceivable to viably offload the individual application capacities, utilizing cloud engineering. A cellular telephone application that could execute an assignment provincially on the cell telephone and then execute the same undertaking utilizing distributed computing was assembled. The two undertakings were timed and the results contrasted in place with clarify whether distributed computing was quicker than neighborhood processing. The motivation to fabricate an application and not to utilize the effectively existing applications was focused around the need prescient control over different designers applications focused around the suspicion that there would be a plausibility that the undertakings performed on the cell telephone and in the cloud would be diverse. One critical playing point of utilizing a cellular telephone application is that it can be imparted to countless telephone clients, particularly those utilizing the same sort of cell telephone that the application runs on, hence making it conceivable to accumulate a tremendous measure of information.

3.2.1 Choosing target mobile phone devices and programming language

There exists a wide range of mobile phone manufacturers. Different mobile phones run different operating systems which are programmed in different programming languages. Android mobile phones use the Android operating system and their applications are written in Java. Since Android based mobile phones are common and there is a lot of documentation to help developers, the application was written in Java for Android mobile phones.

3.2.2 Choosing tests

Three tests were chosen and are described below.

A first test was chosen that made it possible to calculate prime numbers within a certain range (Javadb.com, 2012). It was possible to alter the range that the prime numbers should be calculated within, making it possible to increase or decrease the workload. The source code was implemented and generated correct results over various Android devices. The range of numbers to find prime numbers within ranged from 0 to 10000.

The second test used an integrated Java class because they are nicely coded, perform well, are stable, and are be available in every Java SDK from the version it was added. Here the java.util. Collections (docs.oracle.com, 2012) class was chosen and the idea was to use it to shuffle a list of 1500 words, and then sort them in an alphabetical order.

The third test was designed to replicate a typical task of a mobile phone to investigate its offloading possibilities. Mobile phones have cameras and the idea was to change the size of a photograph to a 75-pixel height and 100-pixel width and then rotate the picture 180 degrees.

The three chosen tests covered different areas. The first test was to perform heavy computational tasks, the second test was to be fast and tightly integrated within the Java SDK and the third test was a typical task conducted on a mobile phone. Another function was also added which measured the bandwidth of the mobile phone. The bandwidth is an important factor when communicating with the cloud servers and therefore it was measured.

3.2.3 Choosing cloud vendor

An assortment of cloud sellers exist. Cases incorporate Amazon, Microsoft and Google. Cloud merchants are distinctive in administrations that they offer and this influenced the decision. Google App Engine was picked in light of the fact that it had a plausibility of making servlets in Java and it was likewise the main merchant that, to a certain degree, offered their administration for nothing. Different merchants did not have this favorable circumstances. Workload on the cloud servers was anticipated to be moderately low since Java servlets were utilized.

3.2.4 Building the mobile phone application and cloud servlets for the study

Shroud IDE was utilized to assemble the application since it had a decent backing for Java advancement and simple mix with Android SDK and Google App Engine SDK. Three tests were created and executed in a Java environment. At the point when the execution was finished, the clock class was created to quantify the milliseconds that each one test took to execute.

After completion of the tests and the clock class, three servlets were created and transferred to Google App Engine as separate applications. At the point when going to a servlet with a web browser, the test joined with it executed. On the off chance that a user case in point visits the prime number ascertaining servlet with a web browser, the test executed and then reported what number of prime numbers it found between 0-10000. The rundown sorting tests obliged a content document of words to be transferred and then sorts and yields the rundown in order request. The picture change test obliged a picture to be transferred, which are changed and returned. At the point when the servlets were working accurately on Google App Engine three Java classes were created to communicate with the servlets. As opposed to transferring and getting a picture to the picture change test at App Engine, the methodology was created automatically. The clock capacity was associated with the three connection classes so the time it took to complete the task could be figured.

The application executed every one of the three tests provincially on the computer and on the cloud. The clock capacity measured what number of milliseconds each one test took however the application did just chip away at computers as a Java program. Improvement an Android application started execution of all tests as a component of a cellular telephone application. The application executed all the three tests automatically and the application just expected to load, execute and transfer results. At the point when making the application extra data and peculiarities were included as well. This made the interface of the application direct.At the point when beginning the application a stacking screen is shown while the content rundown and other gimmicks are stacked into the memory of the cell telephone. At the point when this is carried out at the beginning and a passageway button are shown. The begin button executes the tests and presentations the advancement of which test is consistently executed. The passageway button stops the application. To measure the bandwidth proportion the telephone association sort was enlisted and a class that transfers and downloads the picture in the Assets organizer was made. The transfer/download class transferred a picture to a Google App Engine servlet and then downloaded it to the telephone. The methodology of transferring and downloading the picture is timed and the kilobyte every second proportion is computed. The variant of the working framework, telephone display, the network association was spared furthermore with a remarkable telephone distinguishing proof number. The thought of the distinguishing proof number was that if a cell telephone would run the tests more than once it would be taken note. No data about the telephone's holder was put something aside for honesty reasons.

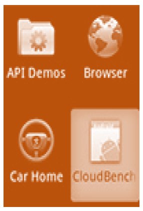
A control test was incorporated to guarantee that the three tests got the right comes about, for instance when 1500 words were sorted in sequential request the number hundred expression must be the right one. To increase the security of the servlets and preclude the likelihood to send false comes about, numerical keys were produced and were obliged to execute the tests on Google App Engine. Each time the application runs it sends a password to the servlet, permitting it to be used. At long last the results from the three tests, the data about telephone model and were transferred and spared in a database in the Google App Engine.

To keep the servlets prepared for incoming movement automatically executed tasks, cron employments, were made as a component of the servlets to keep them dynamic. The cellular telephone application was then marked and transferred to a server where it could be downloaded by any individual who was intrigued. A minor bug was found when attempting to introduce the application on some Android gadgets. Therefore a second form was created where the issue was settled.

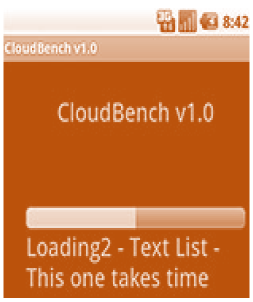
3.2.5 Steps in operating the android smart phone

Major steps that constituted the application:

1. The application icon is displayed on the mobile phone application window,



Picture 1: Mobile Phone Application of the Display.

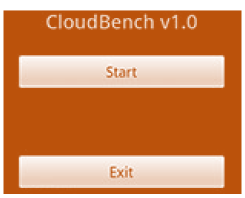


2. Once selected, the loading screen is shown and once started,

a) The application gathers the mobile phone information.

b) The application gets the text file from the Assets folder and loads it into memory.

c) The application gets the image file from the Assets folder and loads it into memory.



Picture 3: Mobile Phone Display of the Start or Exit Button

3. The start and exit button is shown which gives the possibility to start the tests or exit the application.

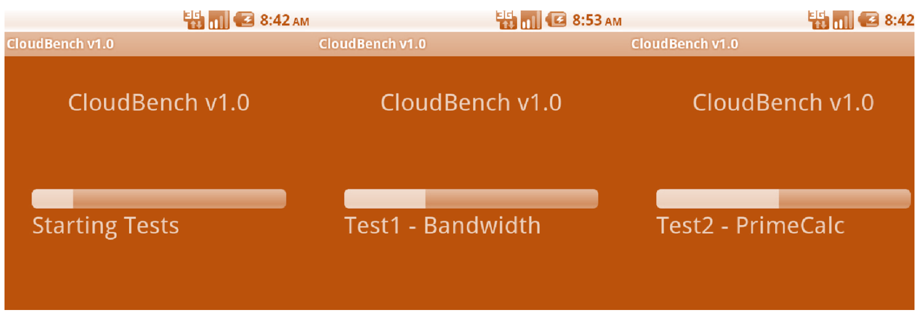
4. If the start button is pressed a progress bar is shown.

a) The data saver class is initiated and the mobile phone information is saved in it.

b) The download and upload class are initiated and the download/upload ratio of the mobile phone is saved in the data saver class. In addition, eventual error messages are saved which is also done for the following steps.

c) The timer class is started and the local prime number calculation test is executed. When finished, the result is saved.

d) The cloud based prime number test is executed, timed and saved.



Picture 4: Mobile Phone Display of the Execution Test Running

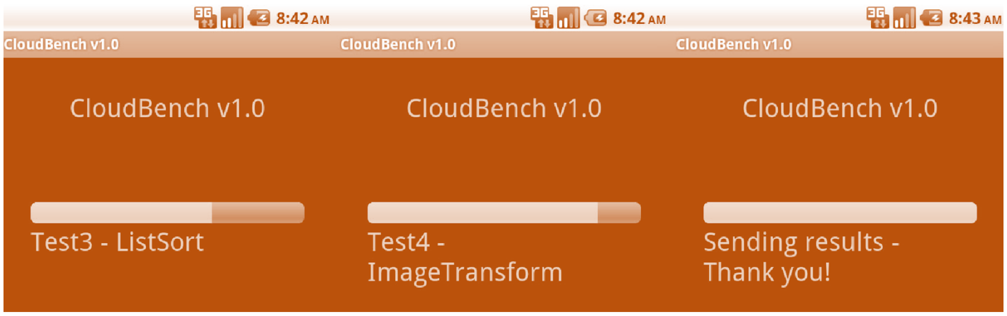
e) The local list sorter test is executed, timed and saved.

f) The cloud based list sorter test is executed, timed and saved.

g) The local image transformation test is executed, timed and saved.

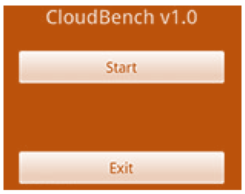
h) The cloud based image transformation test is executed, timed and saved.

i) All data are now gathered and are sent to Google App Engine.



Picture 5: Mobile Phone Display of the Progressing Test

5. The start and exit button are once again showed.



Picture 6: Mobile Phone Display of the Start or Exit Button as it Completes the Test

3.2.6 Application Distribution to study users

A website was built where the application and source code could be downloaded from. To shorten and simplify the address Bit.ly was used to generate an alternative link. The site was monitored by Google Analytics to follow the traffic of the webpage and the site was added to Google's search index so that it would show up in search results.

The application was at first spread to a couple of persons that could go for the application, give criticism about how the application was functioning and report consequent lapse messages that they would experience. At the point when no lapses where experienced the application was presented on Facebook on spread it to relatives and companions. After the Facebook dispatch it was spread to distinctive Android designers' gathering like Swedroid.se, Androidforums.com, Anddev.org and Android.net to get as many as possible to use the application. Google Play was not used to disperse the application because of the methodology and expense of getting it endorsed. Notwithstanding the application a few guidelines were presented on illuminate the use of it. Users were asked to introduce the application and use it amid different circumstances, while being outside or performing other tasks in the meantime.

3.3 Chapter Summery

This chapter outlines in detail the process undertaken to address the research questions. It describes the processes of setting up the research, selecting the instruments of study, the data collection process including the tools and methodologies used and finally, data analysis techniques.

CHAPTER 4

4.0 Data Analysis Procedures and Conclusions

4.1 Introduction

This chapter of the research study presents a discussion and analysis of the challenges and issues associated with cloud computing. Data that was obtained during the study was coded and the phone model replaced by a unique character. In order to divide the data into separate divisions for ease of analysis a small Java program was then written to separate the data. The coded data was then copied from the Google Application Engine to a Microsoft Excel spreadsheet and arranged into separated columns as follows alphabetically:

Network connection type – Phone model - Date – A timestamp when the application was executed. – Error Message - Eventual error messages reported during application execution. - Fingerprint - A unique identification for every mobile phone that executed the application. – Image Transformation Cloud Result - The time in milliseconds it took to execute the cloud based image transformation test. – Image Transformation Local Result - The time in milliseconds it took to execute the local based image transformation test. – List Sorter Cloud - The time in milliseconds it took to execute the cloud based list- sorting test. – List Sorter Local - The time in milliseconds it took to execute the local based list- sorting test. – Network Connection -The mobile phones data connection. Was presented in four different states.

- Phone0 – The mobile phone is connected to a GPRS or a 3G network.

-WIFI1 – The mobile phone is connected to a WLAN connection.

-NetworkError1: Network == null? – The network state could not be read.

-NetworkError2: Some other connection? – The network connection could not be identified. - PhoneModel - The mobile phone model, for example HTC Desire. – Prime Calculation Cloud Result - The time in milliseconds it took to execute the cloud based prime number calculation test. – Prime Calculation Local Result - The time in milliseconds it took to execute the local based prime number calculation test. - SDK – The Android operating system version, e.g. 9. - speedDownload - The Download ratio measured in KB/s. - speedUpload – The Upload ratio measured in KB/s. - testData – Controls that the results from the cloud tests is equal to the results from the local based tests. If something goes wrong with a test, making the result corrupted, it is shown in this column.

4.2 Statistical methods

SPSS 15 was used as statistical software because of previous knowledge in using the software. The statistical tests were divided into two parts, the first to answer the main research question and the second to answer the first sub question.

4.1.1 Statistical method for comparing the test results

To answer the main research question the data from the three local based tests were compared to the data of the three cloud based tests. Because there are only two groups and because the data is matched, two different tests were considered, the paired T-test and Wilcoxon signed- rank test.

To use the paired T-test the sample needs to be normal distributed or big enough to approximate normal distribution by the central limit theorem, $n > 30$ (Anderson, *et al.,* 2009). If the sample is small, an estimation of the normal distribution cannot be done. In that case the Wilcoxon signed-rank test can be used instead of the paired T-test (Moore, *et al.*, 2009). The research question was transformed into a null and alternative hypothesis:

H0: The is no difference between the test results, $\mu = \mu 0$

Ha: Execution time of the local tests is slower than the execution time of the cloud tests. $\mu < \mu 0$

Cloud tests were faster than local tests and it was necessary to have an additional alternative hypothesis:

Ha: Execution time of the cloud tests is slower than the execution time of the local tests. $\mu < \mu 0$

The paired T-test formula:

$$t = (\bar{X} - \bar{Y})\sqrt{\frac{n(n-1)}{\sum_{i=1}^{n}(\hat{X}_i - \hat{Y}_i)^2}}\,.$$

and the Wilcoxon signed-rank test

$$W = \left| \sum_{i=1}^{n} [\operatorname{sgn}(x_{2,i} - x_{1,i}) . R_{i}] \right|$$

were used. The level of significance was 95%, ɑ=0.05 and $P < ɑ$

4.1.2 Comparison of download and upload ratio to the cloud based test results

To examine if the download/upload ratio affects the cloud based test data, a multiple linear regression was used. $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p + \varepsilon$

Y= the cloud test as it is presumed that the download and upload ratio affects it.

X_1= the download ratio and

X^2 represents the upload ratio.

Hypotheses

H0: Neither of the variables are related to y, $\beta 1 = \beta 2$

Ha: At least one of β1 or β2 is related to y, $\beta 1 \neq \beta 2$

4.3 Results

Paired T-Test and CI: imageTransformCloudResult; imageTransformLocalResult

```
Paired T for imageTransformCloudResult - imageTransformLocalResult

                            N   Mean  StDev  SE Mean
imageTransformCloudResul   56  12550  12069     1613
imageTransformLocalResul   56    310    212       28
Difference                 56  12240  11969     1599


95% upper bound for mean difference: 14916
T-Test of mean difference = 0 (vs < 0): T-Value = 7.65  P-Value = 1.000
```

Figure 1: Test results for image transformation

Paired T-Test and CI: listSorterCloudResult; listSorterLocalResult

```
Paired T for listSorterCloudResult - listSorterLocalResult

                        N  Mean  StDev  SE Mean
listSorterCloudResult  56  1428   1409      188
listSorterLocalResult  56    54     44        6
Difference             56  1375   1398      187


95% upper bound for mean difference: 1687
T-Test of mean difference = 0 (vs < 0): T-Value = 7.36  P-Value = 1.000
```

Figure 2: Test results for list sorting

4.1.3 Comparison of phone performance to local based test results

simple linear regression was used ($y = \beta_0 + \beta_1 x_1 + \varepsilon$)

It was assumed that the time it takes to perform the local tests are affected by the mobile phones performance. Y represents the local test results and X_1 mobile phone performance.

The hypotheses were:

H0: The variable is not related to y, $\beta 1 = 0$

Ha: The variable is related to y, $\beta 1 \neq 0$

4.1.4 Comparison of cloud-based and local based test results

The first series of tests investigated if the cloud-based tests were executed faster than the local based tests. As previously mentioned there where a total of three tests. Every test were run twice on the mobile phone, by using cloud computing and by not using it.

Plots for local image image transformation results

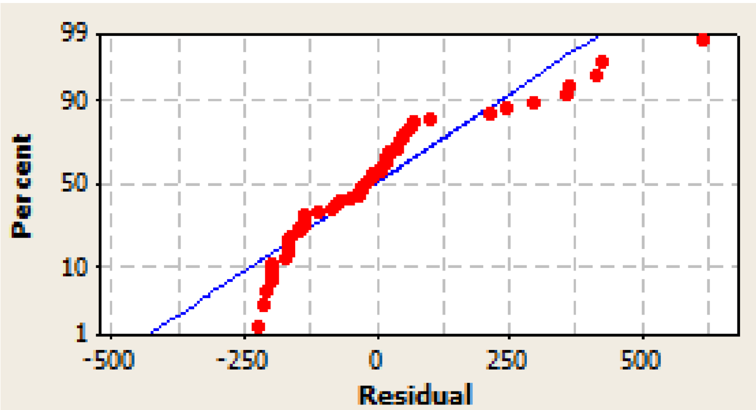


Figure 3: The Normal Probability Plot

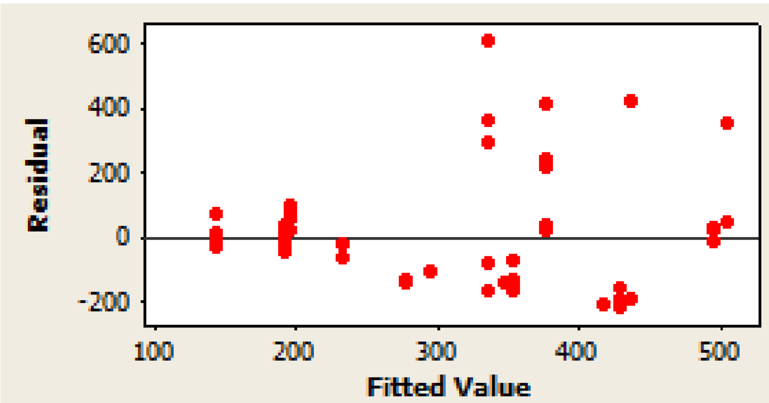


Figure 4: The Versus Fits

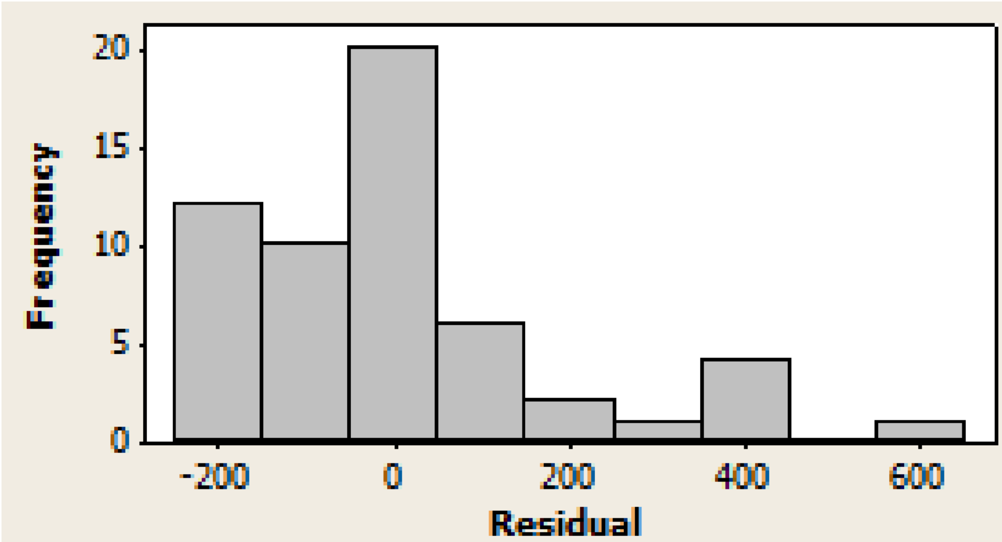


Figure 5: Histogram for image transformation local test

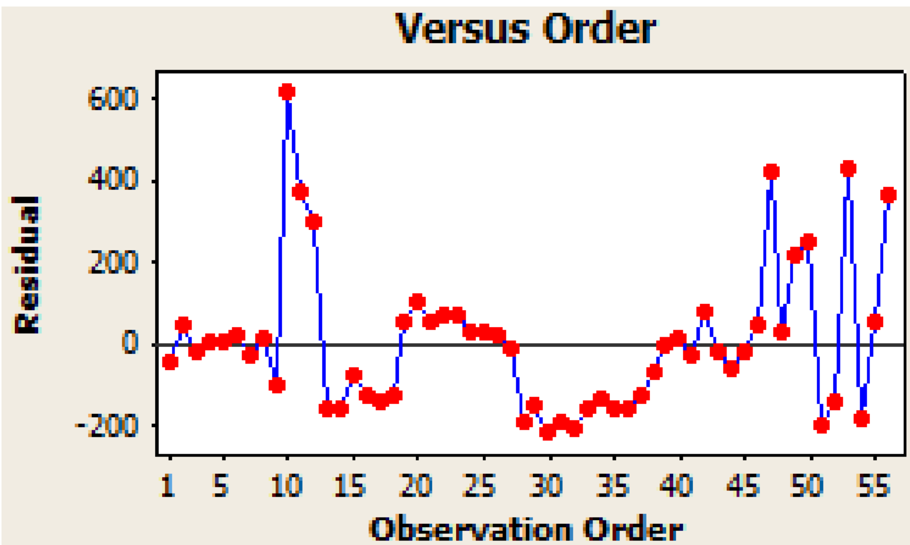


Figure 6: Versus Order for image transformation on local tests

Regression Analysis: imageTransformCl versus speedDownload; speedUpload

The regression equation is
imageTransformCloudResult = 26423 - 27,2 speedDownload - 83,6 speedUpload

Predictor	Coef	SE Coef	T	P
Constant	26423	2381	11,10	0,000
speedDownload	-27,23	14,41	-1,89	0,064
speedUpload	-83,61	21,58	-3,87	0,000

S = 8922,26   R-Sq = 47,3%   R-Sq(adj) = 45,3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	3792110335	1896055167	23,82	0,000
Residual Error	53	4219152799	79606657		
Total	55	8011263134			

Source	DF	Seq SS
speedDownload	1	2596820878
speedUpload	1	1195289456

Unusual Observations

Obs	speedDownload	imageTransformCloudResult	Fit	SE Fit	Residual
28	276	3354	-7346	3837	10700
46	38	47942	24302	2085	23640
47	35	48106	24383	2098	23723
49	36	48111	24356	2093	23755
50	38	48722	24302	2085	24420

Obs	St Resid
28	1,33 X
46	2,73R
47	2,74R
49	2,74R
50	2,81R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Figure 7: Image Transformation Cloud Test and Upload-, Download Ratio.

Regression Analysis: listSorterCloudR versus speedDownload; speedUpload

```
The regression equation is
listSorterCloudResult = 3048 - 5,89 speedDownload - 5,46 speedUpload


Predictor        Coef  SE Coef      T      P
Constant       3047,7    283,7  10,74  0,000
speedDownload  -5,889    1,717  -3,43  0,001
speedUpload    -5,455    2,571  -2,12  0,039


S = 1063,09   R-Sq = 45,1%   R-Sq(adj) = 43,1%


Analysis of Variance

Source          DF         SS        MS      F      P
Regression       2   49257111  24628556  21,79  0,000
Residual Error  53   59898741   1130165
Total           55  109155852


Source         DF    Seq SS
speedDownload   1  44169100
speedUpload     1   5088011


Unusual Observations

Obs  speedDownload  listSorterCloudResult   Fit  SE Fit  Residual  St Resid
 28            276                    350  -291     457       641      0,67 X
 46             38                   4937  2753     248      2184      2,11R
 47             35                   4889  2771     250      2118      2,05R
 49             36                   4847  2765     249      2082      2,01R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Figure 8: List Sorting Cloud Test and Upload-, Download Ratio.

4.1.5 Sample size

During the sixth of december 2014 till the sixth of january 2015, the mobile phone application ran a total of 56 times, n=56. 28 different mobile phones were used with 15 different Android models.

4.4 Discussion

According to test results, it may not be faster to use cloud to offload mobile phone application functions. Especially those utilized in this study. In this study, local tests were all executed faster. The first alternative hypothesis, "*Ha: The execution time of the local tests is slower than the execution time of the cloud tests.* $\mu < \mu 0$", was rejected. Rephrasing the alternative hypothesis as, "*Ha: The execution time of the cloud tests is slower than the execution time of the local tests.* $\mu < \mu 0$", was factual.

The answer to the main research question, "*Can cloud computing be used in mobile phone applications to execute functions faster in comparison to mobile phone applications that do not use cloud computing?*", was: No. based on the smartphone functions settings and circumstances used in the study, it was not beneficial to offload to the cloud. It is faster to solely let the phone execute this type of functions.

The tests speak to a certain part of conceivable undertakings that could be offloaded to the cloud. Case in point, the tests did exclude greatly extensive processings where the limit of cell telephones would be unfathomably inadequate. The tests were planned so cellular telephones could execute them. For instance, a wordlist with 1500 words were utilized rather than 15000000. One element is the span of the errand; if the assignment is huge enough it might be valuable to offload to the cloud. The tests in this stydy did not perform compelling assignments. The performed errands could be viewed as "ordinary" as in they could be executed by a cell telephone. One fascinating point for further research would be to research when it is advantageous to just utilize the cloud.

An alternate imperative component to thoughtful is the cloud servers and cloud merchant. Distinctive cloud merchants offer diverse sorts of administrations with diverse limits. The one utilized as a part of this research is not the speediest and does not have the best transfer speed or reaction time, and this influenced the execution time of the cloud tests. The results may have been diverse if distinctive cloud merchant would have been utilized. It would be ideal to come close cloud sellers to check whether the results would vary. The source code was the same for the cloud and the neighborhood tests. The results could subsequently have been distinctive if concurrency had been utilized.

4.5 Chapter summery

Use of cloud computing depents on the amount and kind of functions that a client is considering. The more the data and the more the rcomplex the function the more beneficaial it is to use cloucomputing especially when there is a sufficient ant and fast internet connection.

CHAPTER 5

5.0 Conclusion/ Summary

The measurable results couldn't be utilized to make any serious inferences. The clock capacity begins before the association with the cloud servers are made and stops when all information is exchanged back. Case in point, a 1000 KB pictures would take longer time to download if the association permitted 30 kb/s download degree in correlation to 300 kb/s. This illustration does likewise request the cloud tests in this research paper.

The coefficient of determination, R-sq, is additionally low. Rsq decides what number of percent of the variability in the perception can be clarified by the straight relationship Anderson *et al*., (2009). In the event that this number is low then the result just clarifies a little parcel of the perceptions. Its likely that nearby test outcomes most presumably are influenced by the cell telephones' execution. The tests are all reckoning serious undertakings and ought to subsequently be influenced by the cellular telephone's CPU and RAM. CPU and RAM qualities are both piece of the Passmark's benchmark test and ought to accordingly influence the estimation of the neighborhood based tests. A shortcoming with the Passmark qualities is that it is not totally clear what the qualities speak to which makes the factual comes about much more flighty. There were no factual conclusions to be drawn about the transfer/download proportion impact on the cloud test outcomes or the Passmark benchmark impact on the neighborhood test outcomes. In this way the accompanying proclamations are just focused around individual sentiments and reflections.The first sub question stated: "*Do mobile phones with slow computational capabilities and* *strong Internet connections benefit by using cloud computing based mobile phone applications, in terms of improved execution time, in comparison to mobile phones with great computational capabilities and slow Internet connection?*".

In principle cellular telephones that could be viewed as moderate, or old, would be more suitable for offloading capacities to the cloud. Reckoning overwhelming errands would take long to execute on account of inadequate equipment. In the event that the system association were great, quick, then it would rush to exchange information to the cloud servers, where it would be transformed. Then again there are quick cell telephones with moderate system association. For this situation the cell telephone can all the more effectively complete computational substantial assignments. Exchanging the errand to the cloud servers would take longer time due to the moderate system association. Hence quick telephones with a terrible association would be less suitable for cloud offloading. Everything relies on upon elements like computational assignment, cellular telephone sort and system association. Eventually the errands are too huge for the cell telephone to execute. On the off chance that the cellular telephone is moderate or quick, and relying upon moderate or quick system association, it will be pretty much suitable to offload to the cloud.

The second specific inquiry was: "*Which peculiarities of cell telephone applications would profit to utilize distributed computing to enhance the execution time of cellular telephones?".*As at one time said, computational substantial undertakings could profit from cloud offloading. The test outcomes demonstrated that "typical" or regular assignments are most likely not worth offloading as the cellular telephone has sufficient reckoning ability to complete the errands. A cement case that could be suitable for offloading is feature altering. To include feature impacts or believer feature to different organizations are computational substantial assignments actually for howdy execution stationary machines. Consequently, it is not an extremely suitable errand for cellular telephones and cloud offloading could be a conceivable arrangement.

Little simple computational undertakings not advantageous to offload to the cloud. It takes longer time to exchange the undertaking to the cloud servers in correlation to execute the errand on the cellular telephone.The third sub question stated: "*What are the other possible advantages and disadvantages of using cloud computing in mobile phone applications?*".

Execution time and battery life expansion are by all account not the only conceivable favorable circumstances with distributed computing. Reinforcement of pictures and contact data is one focal point of the cloud. The likelihood to impart documents to different gadgets are an alternate. An inconvenience is that outsider associations may have the capacity to get to the records, as they are put away on their servers. Cloud server uptime is an alternate concern. In the event that a cell telephone application depends on distributed computing to work, and the cloud servers are down for upkeep, then the application will be futile. Distributed computing brings a considerable measure of chances. All new innovation has side- impacts and downsides. Today there are as of now very numerous cellular telephone applications that utilization distributed computing to some degree and there is nothing that indicate a decrease in this pattern. Hence I accept that distributed computing will get to be significantly more coordinated with cell telephones later on.The principal variable for attention is the capacity or assignment to be performed by the cellular telephone. On the off chance that the undertaking obliges a higher computational capacity, the telephone then has a restricted capacity to perform the errand. What this implies then is that, offloading to the cloud is prone to offer an answer i.e. it will build the computational ability of the telephone. Notwithstanding, if the assignment is basic, then offloading to cloud will of a weakness. This will incorporate time misfortune and dormancy as the telephone transfers to the server. From my supposition, this means if the assignment obliges moderate computational prerequisites, then offloading to the cloud will spare time and data transmission just if the errand surpasses the computational capacity of the telephone. On the other hand, a quick telephone with poor web association will be distraught because of low rates of information exchange contrasted with the rate of calculation.

Chapter summery

Only use cloud computing when dealing with complex mobile phone tasks

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Appendix: Execution Results

date	errorMessage	fingerPrint	imageTransformCloudResult	imageTransformLocalResult	listSorterCloudResult	listSorterLocalResult
2012-04-06 10:30:05.561000	null	00000000-7069-fbbc-ffff-ffffbe18ff37	5302.0	143.0	656.0	75.0
2012-04-06 10:31:54.451000	null	00000000-7069-fbbc-ffff-ffffbe18ff37	5867.0	132.0	696.0	30.0
2012-04-14 10:30:47.226000	null	00000000-7069-fbbc-ffff-ffffbe18ff37	5212.0	143.0	598.0	74.0
2012-04-16 14:39:25.410000	null	ffffffff-a022-e171-ffff-ffffcb13e2bf	3334.0	191.0	409.0	49.0
2012-04-16 15:24:08.391000	null	ffffffff-a022-e171-ffff-ffffcb13e2bf	10891.0	217.0	428.0	18.0
2012-04-16 15:24:33.361000	null	ffffffff-a022-e171-ffff-ffffcb13e2bf	8822.0	186.0	429.0	29.0
2012-04-17 08:07:45.005000	null	ffffffff-a022-e171-ffff-ffffcb13e2bf	3545.0	191.0	375.0	46.0
2012-04-17 13:32:20.565000	null	ffffffff-f6a9-ab28-96c6-dea76af17e99	3354.0	231.0	350.0	70.0
2012-04-17 13:32:36.110000	null	ffffffff-f6a9-ab28-96c6-dea76af17e99	2933.0	268.0	403.0	41.0
2012-04-17 15:45:11.218000	null	00000000-5b96-e063-6b38-796d122e743a	48106.0	794.0	4889.0	56.0
2012-04-17 15:47:24.476000	null	00000000-5b96-e063-6b38-796d122e743a	11080.0	397.0	3367.0	32.0
2012-04-17 15:49:15.131000	null	00000000-5b96-e063-6b38-796d122e743a	48111.0	594.0	4847.0	37.0
2012-04-17 15:51:24.127000	null	00000000-5b96-e063-6b38-796d122e743a	47942.0	415.0	4937.0	47.0
2012-04-17 16:06:13.507000	null	00000000-5b96-e063-6b38-796d122e743a	48722.0	625.0	3409.0	36.0
2012-04-17 21:18:23.090000	null	00000000-574c-65e7-ffff-ffffa7ad1f02	7336.0	207.0	3753.0	38.0
2012-04-17 21:22:24.103000	null	ffffffff-bd13-4ee6-ffff-ffffe7b1620d	3913.0	188.0	316.0	28.0
2012-04-18 14:12:35.895000	null	00000000-4e4c-dc1f-95fa-5ae335b67a48	9305.0	249.0	443.0	80.0
2012-04-18 14:13:09.591000	null	00000000-4e4c-dc1f-95fa-5ae335b67a48	7702.0	297.0	357.0	27.0
2012-04-18 14:42:55.504000	null	00000000-0395-6f06-f1a6-a7023c29cb5b	11249.0	144.0	824.0	31.0
2012-04-18 14:50:30.294000	null	ffffffff-94d3-99bb-ada3-d5364e23836d	3645.0	249.0	387.0	51.0
2012-04-18 17:33:12.698000	null	00000000-574c-65e7-ffff-ffffa7ad1f02	11730.0	232.0	2840.0	74.0
2012-04-18 17:36:39.591000	null	00000000-574c-65e7-ffff-ffffa7ad1f02	17388.0	215.0	2885.0	46.0
2012-04-18 20:16:10.164000	null	ffffffff-fc69-c2f4-a1fc-e19a3545bb03	8414.0	551.0	427.0	50.0
2012-04-18 20:18:27.170000	null	00000000-7db4-8c6f-ffff-fffff59a1561	3927.0	234.0	219.0	22.0
2012-04-18 20:18:55.532000	null	00000000-7db4-8c6f-ffff-fffff59a1561	3321.0	167.0	409.0	15.0
2012-04-18 20:19:15.811000	null	00000000-7db4-8c6f-ffff-fffff59a1561	3477.0	189.0	201.0	16.0
2012-04-19 05:47:01.130000	null	ffffffff-dbe4-f898-198f-50720033c587	8098.0	203.0	762.0	29.0
2012-04-19 06:28:44.094000	null	00000000-3dbd-08f1-69db-6edd07000602	7504.0	133.0	256.0	52.0
2012-04-19 07:27:51.142000	null	00000000-2da4-7ad4-ffff-ffffe7e11607	14815.0	151.0	3872.0	26.0
2012-04-19 09:19:44.431000	null	ffffffff-9923-1d7e-8039-d4d2441571a4	5258.0	189.0	484.0	76.0
2012-04-19 16:03:19.113000	null	00000000-0102-d915-f199-06ae03d9f4eb	37343.0	210.0	1192.0	26.0
2012-04-22 09:44:49.510000	null	ffffffff-9c69-ea2f-c833-ca824be8b060	24747.0	164.0	1158.0	41.0
2012-04-22 09:46:25.929000	null	ffffffff-9c69-ea2f-c833-ca824be8b060	22708.0	212.0	1043.0	37.0
2012-04-22 13:04:53.779000	null	00000000-3dbd-08f1-69db-6edd07000602	4720.0	112.0	1738.0	25.0
2012-04-22 14:24:46.078000	null	ffffffff-fd15-28cb-0a89-01e73fcfcf46	3362.0	118.0	369.0	63.0
2012-04-22 14:25:21.710000	null	ffffffff-fd15-28cb-0a89-01e73fcfcf46	7936.0	215.0	661.0	16.0
2012-04-30 10:59:09.089000	null	ffffffff-a022-e171-ffff-ffffcb13e2bf	8658.0	219.0	854.0	56.0
2012-05-03 16:38:47.250000	null	ffffffff-933a-6cf0-ffff-ffface53b59	7995.0	163.0	370.0	28.0
2012-05-06 09:37:39.071000	null	ffffffff-a022-e171-ffff-ffffcb13e2bf	17927.0	279.0	619.0	39.0
2012-05-06 13:01:25.814000	null	00000000-4dce-ca68-132e-e72d028f7af5	12120.0	260.0	2039.0	93.0
2012-05-06 13:31:28.684000	null	00000000-4dce-ca68-132e-e72d028f7af5	9451.0	265.0	410.0	113.0
2012-05-06 14:46:01.917000	null	00000000-6004-bfd1-ffff-ffff85ef33d9	10566.0	703.0	2990.0	144.0
2012-05-06 14:46:43.741000	null	00000000-6004-bfd1-ffff-ffff85ef33d9	14949.0	953.0	2754.0	160.0
2012-05-06 16:23:18.797000	null	00000000-6921-cf5a-cd7a-a5443efc1666	18655.0	522.0	2807.0	47.0
2012-05-06 16:24:17.908000	null	00000000-6921-cf5a-cd7a-a5443efc1666	18293.0	479.0	3085.0	53.0
2012-05-06 16:25:56.171000	null	00000000-6921-cf5a-cd7a-a5443efc1666	18647.0	513.0	2811.0	47.0
2012-05-06 19:26:45.897000	null	ffffffff-acdb-cfff-ffff-fffa1998b2c	6950.0	636.0	525.0	28.0
2012-05-06 19:27:16.318000	null	ffffffff-acdb-cfff-ffff-fffa1998b2c	8283.0	171.0	451.0	15.0
2012-05-06 19:27:43.460000	null	ffffffff-acdb-cfff-ffff-fffa1998b2c	7067.0	171.0	489.0	13.0
2012-05-06 20:50:26.440000	null	00000000-6004-bfd1-ffff-ffff85ef33d9	7125.0	255.0	3363.0	119.0
2012-05-07 10:17:19.834000	null	ffffffff-f494-25a5-ffff-ffffcb99eb61	2497.0	200.0	267.0	34.0
2012-05-08 20:56:50.296000	null	00000000-6b4f-6903-ffff-ffffcbe826ae	8631.0	209.0	867.0	47.0
2012-05-09 06:34:16.199000	null	ffffffff-a25c-50c3-4244-3092675c5a9c	26950.0	866.0	3102.0	270.0
2012-05-09 06:28:46.794000	null	ffffffff-b2f4-8413-ffff-ffff96d4a1a3	5490.0	220.0	606.0	129.0
2012-05-11 21:19:11.202000	null	ffffffff-98d1-3670-ffff-ffff9ac0b755	4364.0	244.0	469.0	27.0
2012-05-11 21:21:05.448000	null	ffffffff-98d1-3670-ffff-ffff9ac0b755	7072.0	864.0	729.0	38.0

networkConnection	phoneModel	primeCalcCloudResult	primeCalcLocalResult	SDK	speedDownload	speedUpload	testData
Phone: 0	GT-I9001	584.0	53.0	10	91.0	185.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT-I9001	1405.0	68.0	10	18.0	74.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT-I9001	549.0	84.0	10	150.0	90.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC Incredible S	386.0	51.0	10	120.0	159.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC Incredible S	834.0	84.0	10	330.0	85.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC Incredible S	287.0	80.0	10	239.0	83.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC Incredible S	223.0	69.0	10	279.0	175.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC Desire	201.0	78.0	15	276.0	314.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC Desire	204.0	66.0	15	338.0	181.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	LG-P350	540.0	141.0	8	35.0	13.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	LG-P350	282.0	136.0	8	36.0	13.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	LG-P350	369.0	137.0	8	36.0	13.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	LG-P350	491.0	136.0	8	38.0	13.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	LG-P350	380.0	137.0	8	38.0	13.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC Desire	837.0	67.0	8	98.0	95.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	GT-I8150	2451.0	73.0	10	377.0	221.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	GT-I9100	489.0	111.0	15	356.0	83.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	GT-I9100	187.0	146.0	15	299.0	87.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	Galaxy Nexus	444.0	34.0	15	197.0	90.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	GT-I9100	334.0	87.0	15	282.0	109.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	HTC Desire	491.0	75.0	8	149.0	55.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	HTC Desire	542.0	70.0	8	48.0	76.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	ZTE Blade	798.0	111.0	15	238.0	87.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	Galaxy Nexus	453.0	57.0	15	308.0	157.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	Galaxy Nexus	449.0	51.0	15	383.0	206.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	Galaxy Nexus	206.0	51.0	15	376.0	268.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	Nexus S 4G	761.0	45.0	15	98.0	97.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC One X	261.0	95.0	15	282.0	108.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	HTC One X	494.0	42.0	15	23.0	48.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	Galaxy Nexus	333.0	54.0	15	277.0	190.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	Galaxy Nexus	1314.0	54.0	14	74.0	25.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	HTC Sensation Z710e	470.0	95.0	15	58.0	30.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	HTC Sensation Z710e	1494.0	84.0	15	69.0	30.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC One X	1563.0	43.0	15	184.0	199.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	HTC One X	536.0	63.0	15	372.0	221.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError: Network == null ?	HTC One X	661.0	80.0	15	121.0	105.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	HTC Incredible S	540.0	65.0	10	129.0	96.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	Galaxy Nexus	468.0	38.0	15	277.0	86.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	HTC Incredible S	593.0	70.0	10	153.0	129.0	1229==1229&enterentropy==enterentropy&75100==75100
NetworkError2: Some other connection?	GT-I9100	533.0	112.0	15	102.0	87.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT-I9100	327.0	112.0	15	173.0	75.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT-I9000	545.0	333.0	7	90.0	108.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT-I9000	1648.0	264.0	7	164.0	117.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT540	470.0	278.0	7	129.0	30.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT540	265.0	248.0	7	182.0	31.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT540	523.0	258.0	7	133.0	31.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	GT-I9000	383.0	45.0	10	191.0	98.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	GT-I9000	205.0	54.0	10	96.0	97.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	GT-I9000	538.0	57.0	10	109.0	97.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT-I9000	338.0	251.0	7	116.0	132.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	Galaxy Nexus	253.0	60.0	14	259.0	281.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	Nexus One	768.0	64.0	10	100.0	106.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	ZTE-BLADE	652.0	647.0	7	45.0	36.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	GT-I9100	564.0	105.0	10	280.0	149.0	1229==1229&enterentropy==enterentropy&75100==75100
WIFI: 1	X10	640.0	52.0	10	182.0	240.0	1229==1229&enterentropy==enterentropy&75100==75100
Phone: 0	X10	609.0	48.0	10	131.0	101.0	1229==1229&enterentropy==enterentropy&75100==75100