

Key aspects for the development of applications for Mobile Cloud Computing

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SUMMARY

Mobile networking has changed people's lifestyles and the business world drastically. It can be widely implemented and with the ability to use this mobile computing, companies can increase their productivity greatly through this practice. Devices and mobile networks have limitations, such as battery life or processing speed, these further hinder the utilization of this method of work. Cloud Computing is an application that reduces the impact of the limitations that mobile computing presents. However, besides the characteristics of mobile computing as well as the technological advances, such as mobile TV or workplaces that implement BYOD, clearly differentiate even more Cloud Computing from traditional mobile computing. Due to the impact that this kind of computing brings to society one must rethink the solutions that developer propose while creating and developing of new applications for Mobile Cloud Computing.

Keywords: Mobile Cloud Computing, Mobile, Applications, Mobile Computing, Web Programming, Cloud Computing, Web Applications, Pervasive Networks.

1. INTRODUCTION

Mobile computing systems are those that can be physically moved without difficulty and which capabilities can be implemented while in movement. Some examples include: Laptops, PDAs, tablets, and smartphones [1]. They fall into the 3A model (Anytime, Anywhere, Anyone), even though some articles refer to them as Anyhow, Any place, and Any device [2][3]. Because of their particular purpose and way of use, different than any other kind of computing, these also need to be designed and able to operate in a different manner.

The most prevalent use for these devices is: Mobile learning, M2M (mobile to mobile communication), sensor networks, on and offline data bases, Mobile banking, Mobile commerce, GPS, home automation, management systems in disaster areas, and networks in battle grounds [4].

The importance of mobile computing is reflected in the curriculum 2013 for computer science, it modifies de areas of the career, subdividing some, and creating the PBD (Platform Based Development) area, which includes

mobile platforms as one of the possible subareas of the previously mentioned area [5]. In a number of predictions that some companies like Garnet made, its is estimated that in October of 2012 some of the most notable technologies for the company are: Mobile Device Battles, Mobile Applications and HTML5, Personal Cloud, The Internet of Things, Hybrid IT, and Cloud Computing [6]. There are a number of activities that can be done with this type of system, but that cannot be perform with standard computing platforms, this additional functionality it what gives its advantage to mobile computing.

A recent publication made by the company Debra Shinder (MVP) considers that one of the areas with the most need of specialists is: "Mobile computing and computerization integration" [7].

As far as future predictions go, IDC estimates that for the year 2015 the sales of smartphones will reach 982 million. IMS Research estimates that by 2016 the sale of devices will reach around a billion.

Mobile computing presents a number of limitations in power, processing capabilities, screen size and user interface, and Cloud Computing. In the following content a number of solutions to help this problem will be presented.

2. CLOUD COMPUTING

Cloud Computing is transforming the way in which companies use and acquire resources for information technologies. It provides higher efficiency, massive scalability, and faster and easier development of software. The new programming models and IT infrastructure will allow for new and better business models. Cloud Computing is a way of utilizing IT resources and services and facilitating the operation of the system and services provided [9]. One of the important advantages of companies that incorporate internet based services is cutting down costs of personnel, operational space, software, and maintenance costs; this way the profit is immediate, since it doesn't have any sustainability expenses.

This is all done in a secure manner, with a flexible expansion, which is capable of dealing efficiently with changes in demand, without having an increase in its management costs. The basic characteristic of this model is that all its computing resources and services, like infrastructure, platform, and applications, are all provided over the internet. Cloud Computing is set up as aaS, or as a Service, and its sometimes expressed as XaaS or EaaS

which means Everything as a Service. Cloud Computing can be divided into the following: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) [10][11]. Previous specialists have defined Hardware as a Service (HaaS) and Desktop as a Service (DaaS), even though some have also proposed Data as a Service (DaaS), Identification Administration, and Access control policies as a Service [12].

According to Frank Gens, Senior VP and Analyst Chief in IDC says: "In a recent study between IT executives, CIOs, and business colleagues it shows that Cloud Computing is closing the gap" and starting to be widely adopted at this time. The economical crisis will amplify the adoption of the Cloud. This model offers a more sustainable way to do business and acquire technology. This advantage is truly important for medium and small businesses, a key sector in any recovery plan [13].

3. TOWARDS MOBILE CLOUD COMPUTING

Within the last few years the mobile market has grown at an increasing speed, wireless technologies, mobile devices markets, and its constant evolution has revolutionized the way users work and communicate. In this context, the coming together of the web technology and mobile technology has resulted in Mobile Internet. This has brought about a new dimension to traditional applications, and has turned these applications into ones accessible from mobile devices [14]. These types of applications are designed with the purpose of organizations being able to provide a way to access their services to their employees, clients, and providers, independently of their location, through mobile devices. Mobile Solutions, also known as Ubiquitous Solutions, creates a platform to access web based content and applications to mobile devices fast and at a low cost. These applications allows users to access data bases, applications, and web content in a fast and easy way through their mobile devices at all time, regardless of their connection [15]. The requirements and needs of the users at both social and professional level have changed and have increased. The main requirements of mobile services are: functionality, accessibility, and security. However, the needs of the users change at the same pace as technology and it requires localization, speed, and personalization [16]. Due to the needs and the limited characteristics of mobile devices, the cloud is indispensable for the distribution of the services to the mobile devices. Mobil application developers face the difficulty of multiple operation systems and devices with heterogeneous characteristics. This creates a problem of inefficiency, due to the fact that the application must be written for one operating system or multiple versions must be created. The coming together of Cloud Computing and Mobil Internet has allowed for the development of the Mobile Cloud Programming, which is a work technology. The Mobile Cloud Computing could be defined as cloud computing services in a mobil format [17].

Mobile applications will begin to store data in the cloud instead of the mobile device itself and applications will be more powerful due to the processing power from the cloud. Clouds simplify development of mobile applications and also its utilization. This works by using a platform which works with different operating systems and the application runs on it. The Mobile Cloud applications eliminate the need of storing data in the devices and having them in the cloud. This way, the

applications can be used in a variety of mobile devices, regardless of their operating system [10]. According to the research conducted by ABI Research about "Mobile Cloud Computing" [18], the cloud will be a dominant player in this area. Using cloud technologies, new and more sophisticated applications can be created and can be use by a greater amount of users. The number of subscribers that use cloud computing mobile reached 42.8 million in 2008, and its being predicted that by 2014 it will reach 998 millions. ABI's report research companies that are cloud based and offer PaaS, including development and use of software, such as Google Checkout, Amazon Web Services, and Force.com. Jupiter Research predicted a great growth in mobile cloud computing, predicting that in 2014 there will be 130 million users in the business sector. The success reached by iPhone and the App Store with its applications has gained popularity in the business sector. Cloud providers have open programming interfaces, and this has made developing a much easier job.

The limitation that most users complain about is the battery life of the devices. In a study done in 15 countries researchers found that battery life is one of the most concerning and important features that users look for, including camera quality, and storage capacity [20]. Many applications are very heavy to be executed in mobile systems. If a mobile user tries to execute such applications, its better to execute them in a cloud. Other applications like voice recognition, games, and navigation can easily run in the mobile system. However these applications consume a significant amount of battery. There are a variety of alternatives to save battery, but the more efficient and easier one its moving part of this to the cloud.

4. ADVANCES AND EXAMINATIONS

Due to the quick and constant evolution of technology some questions come up, like: How can something so small evolve so much? Does this evolution eliminate the limits between the different devices that were there before? How can I make predictions to guarantee that I have a technology and service that will last as long as possible?

In the following the advances that will impact mobile cloud computer the most and create profound changes in the IT department of organizations will be described. These are: The mobile workforce, BYOD, mobile multimedia content, mobile computing systems, and augmented reality.

Mobile Workforce

Mobile workforce is a business strategy that is being strongly implemented in companies. This consists in the employees being able to use mobile devices to make sales, make orders, realize business transactions, etc. There are many definitions of mobile work, one of the definitions is: "The mobile workforce is defined as those workers which work at least 10 hours per week out of their home and their main workplace, for example they travel for work in stores or the country side and they connect online to send in their work" [21]. In that case the administration systems for mobile work should take in account the variety of styles of mobile workers, and if these systems are taken to the cloud should support all these possible varieties.

Digital Content Service

Mobile TV and the digital video contents represent an important business for the future, and the demand will grow notably in the next few years. Its main focus is towards the entertainment industry but it can be very useful for training and teaching. In these cases restrictions of QoS should be taken into account and also Cloud Computing should support these restrictions.

Work and personal networking has increased the number of video and multimedia in the web. Networking applications will continue increasing the use of multimedia resources.

Because of the increase of use of multimedia and the new styles of mobile work, the demand of mobile infrastructure and WiFi has increased. Other tendencies are the capabilities that are integrated into devices, commonly found in camera and high definition videos.

The more bandwidth, 4G, and WiFi are available, the more applications that will stream HD content.

The experience in tablets and smartphones are typically much better than previously, but it is expected that better quality will be available in the future. Communication and networking devices like Cisco Cius™ will allow to better handle the needs of video and networking of mobile devices in HD [22].

BYOD

Lately BYOD (Bring Your Own Device) has been mentioned a lot; to use personal devices as an element of work. This provides lots of advantages but it also has its disadvantages regarding security.

According to Cisco, nowadays many companies have entered in a post-PC era, where networks must adapt to every option and layers in the protocol stack. This includes traditional elements, such as mobility and social applications and operational systems; many server architectures and many mobile devices include smartphones, tablets and other mobility tools [23].

The term BYOD has been replaced by the more recent term “Bring Your Own Technology” (BYOT), which includes the hardware and the software [24].

The use of the term BYOD is better for the following reasons:

78% of office employees in the USA use some kind of mobile device (such as laptops, smartphones, tablets) in their jobs. Besides, 65% of these employees require mobile connectivity to do their job. Cisco IBSG considers that telecommuting one a week will save \$2,500 dollar per employee annually.

Some companies are adopting this new method and some of them are avoiding it. BYOD may potentially save money and help employees to be more happy and to be more productive. But it also has its risks, from security to compatibility.

The problems that may arise are: exposure of confidential data of the company, passwords are in the real world, productivity diminishes for the wrong use of the equipments, compatibility problems, the Mobile Device Management (MDM) may be difficult, wireless networks may turn into bottlenecks, viruses may appear, compatibility may be complex, the autonomy of use for the employees may have unwanted effects. In case of BYOD being implemented in Cloud, first it has to be

considered every aspect of security that obviously is different from the non-mobile Cloud.

Augmented Reality

Augmented reality (AR) is the term used to define a direct or indirect view of a physical environment of the real world, which elements are combined with virtual elements for the creation of a mixed reality in real time. It consists of a combination of devices that provide virtual information to the physical existing one, which means, to add something virtual to the reality. This is the main difference with the virtual reality, since it does not replace physical reality, but it overprints the computing data to the real world.

Augmented reality is a life view of the real world with certain elements that modify (or augmented) by computers. The followings are the three main properties of the augmented reality: (1) combines reality with virtual; (2) is interactive in real time; (3) is registered in three dimensions (3- D) [25].

AR applications require to access information from a large scope in physical places in mobile devices without any latency. This distributed information needs to be combined with the nature of AR in a company that is not owner of extreme solutions and needs the information and applications to be delivered from the Cloud to optimize the solution. Users will not only demand these applications to be accessible from mobile devices since these devices may be the main or the only interface to the business information. New technologies such as cloud rendering, combined with AR; it has the potential to be an innovative application.

Many changes may arise and entrepreneurs may take advantage of AR and make it real through the creation of new experiences that show the technological excellence, create new business models, and make it a real pleasure to interact with the company software.

Mobile Computing Applied to Health

Recently mobile computing has been applied to support health applications. Medical assistance is unique, since it has several limitations and requirements to which the application must adapt. The more evident problems are the patient's confidentiality and the doctor-patient relationship. Since medical information is confidential, various methods and strategies of security must be applied. Health data is critical and errors introduced by the application may lead to fatal consequences. For example, in the case of a tool of medical prescription, a miscalculation or an error on the printing of the dose of any drug to be administrated could have serious consequences on the patient. The clinical environment is “highly mobile”, with doctors moving constantly, seeing one patient after another one while working. This constantly moving limits the form and performance of the computing devices that may be used in such surrounding. Many organizations have tried to implement computing solutions to help doctors while working every day using a desktop network. In practice, these solutions have not reached final users, and they only helped the administration systems. The big issue about this is that in an environment highly mobile, doctors make decisions where the patient is, and they do not have the time to go and update the information in a desktop based application. Therefore, the ideal platform for the doctor's use in such environment is the PDA, a tablet or a

smartphone, that doctors can take everywhere and use it when they need it [26].

Applications Depending on Context

Advances on mobile and ubiquitous computing as well as the technologies of mobile positioning and sensor networks, have give room to a new kind of applications, which are services dependent on the context of the use of the application and adapt their performance to the context with a minimal intervention of the user. This computing is a model in which the applications may discover and take advantage of the contextual information (such as the user's location, hour, computing characteristics and communication, close friends, objects, and devices, user's activities and their objective). Such applications are capable of adapting their performance and functionality according to the situation of the user, with his minimal intervention.

Context-sensitive computing is a new field, and is the main focus of many researches and developments.

The first studies made on context sensitive computing were carried out in 1992 in the lab of Xerox PARC and Olivetti Reseach Ltd., resulting in one of the first context sensitive applications, the Active Badge Location System [27]. There are many problems to solve: How can context be internally stored? How frequently these changes have to be stored? Which sensors and infrastructure are necessary? How is possible to create a generic system independent of the hardware? This kind of applications will have a strong impact on Mobile Cloud Computing, since these systems will require a great background (Cloud servers), to give support to the variety of applications that can appear in the future.

Networks: PAN, BAN y NFC

Besides some 3G networks and other networks of mobile phones, there are some short scope networks that offer specific services such as: NFC (Near Field Communication) which is a short scope wireless network that allows devices to communicate and make transactions safely. It has been used for years in offices and public services such as transportation, but a growth is expected due to the sell of NFC-enabled devices.

On December, 2010, Google Nexus has been released, the first smartphone with NFC support. This network is in its beginning, but it offers numerous possibilities.

This connectivity variety with Wi-Fi, WiBree and bluetooth provides the user with multiple alternatives, but it also makes it more difficult for the programmer.

Security

The loss and theft of smart phones and tablets constitute an important risk, besides forensic analysis of devices many times can recover a great part of the data of the previous user. If it has no security programmes, a lost or stolen device can lead easily to the violation of the stored business records, including emails, contacts, register of customers, passwords and company services. Lost devices also make roof for entering the networks and company services. A smart phone set up with Wi-Fi or with access to a VPN may lead to the system, avoiding the security of the system.

The mobile devices security and the network risks are aggravated by the mobile malware. Unlike the PCs that in general have an antivirus installed, the users of mobile

devices in general do not have a security application and all the applications added to the mobile are download from Internet.

Some studies show that a regular smartphone in US has 41 apps downloaded. Although many of those applications are downloaded from trusted websites such as Apple Store or Google's Play Store, mobile malware is increasing rapidly, specially the ones for the Android.

Even some apps have access to sensitive information and services, such as contact and location. In fact, malware is spread by the exploitation of OS mobiles and the vulnerability of the applications. The mobile systems are less prepared than the desktops and laptops regarding security infrastructure. When a security patch is applied due to a weakness, a solution has to be agreed first with the manufacturer of the mobile and then with the mobile operators before offering such mobiles to the users, which makes the process more bureaucratic and slow.

And the last responsible for the security is the user, who tends to ignore the updates, warnings and indications to create a new or replace de password to access.

Security in Cloud involves all the aspects that make Cloud Computer safe. Many of these aspects not only belong to Cloud as a weakness to the attacks where the information is not considered where it is storage.

Therefore, security in Cloud Computing embodies all the computing security topics, including design of architectures of surface and efforts in the control of access. But there are some security aspects in Cloud Computing that are specific to their domain [28]. Besides, Mobile Cloud Computing has some specific security aspects such as MDM to manage devices or certain services of authentication.

Other Considerations

There are many applications such as vehicular systems: fleet tracking or intelligent transportation, M2M in general and specific applications of ubiquitous computing, etc. For each e- there is a corresponding m-, for example, e-commerce and m-commerce, e-banking and m- banking, e-learning and m-learning, etc. Each one of them has its own characteristic and determines the changes that Cloud is going to have to provide the necessary services.

Therefore, many investigators have proposed to build specific Clouds for Mobile Computing that considers those characteristics. Cloudlet concept was proposed by Satyanarayanan [29], which is an approximation to mobile cloud computing. Downloads to mobile devices of their upload of work are made form a "local cloud" compound by many computers of many cores with connectivity to the servers of the remote Cloud. Plug Computers may be considered good candidates for servers Cloudlet due to their variety, diversity and low consumption. As they have the same general structure of a normal computer, but they are less powerless, smaller and less expensive, therefore they are ideal for small scale servers. These Cloudletss would be in common areas, such as restaurants or coffee shops so mobile devices can connect and work as a quick customer to the cloudlet in opposition to a Cloud server which presents latency and broad band issues.

There are many challenges: to give support to the continuous mobility while connectivity to a cloud is ensured, to create the conditions for the users who

cooperate and share their resources with others, for which is necessary to offer an economical or social incentive, and the security in mobile clouds that has been analysed.

5. APPLICATIONS DEVELOPMENT

Internet has had a considerable impact in the software industry. It can be accessed from a desktop as well as from a mobile device. However, in recent years, desktops and mobile devices have evolved in different ways. In desktop computers, the most popular application to access internet is the browser, and the mobile devices access internet through personalized applications.

The developers of mobile applications for the cloud face the challenge of the different mobile and devices operational systems with different characteristics. Because of this, it can only be written for only one operational system or create several versions of the same application, which creates a big issue of inefficiency [31]. Building applications for mobile computing implies considering that devices can vary, therefore, the application might have a short life, and if the application has two parts (client and server) this dependency may be more problematic. Therefore, to develop ubiquitous apps it is necessary to have an independent interface from the code of the applications. This may be achieved by using the MVC pattern (Model-View-Controller). MVC is a software architecture pattern which separates data of an application, the user's interface and control logic in three different components. MVC pattern is frequently seen in Web applications, in which the view is the HTML page, and the code that provides dynamic data to the page, the controller is the database management system and the model is the data model.

- Model: is the specific representation of the information with which the system works.
- View: represents the model in a proper format to interact, usually in the user's interface.
- Controller: responds to events, usually the actions of the user and produces changes in the model and probably in the view as well.

In this way, the logic of the application will be developed and it will be the user's interface which must adapt to the device of access that is used. According to what has been mentioned before, the main objective is to change the concept of web-based applications to Cloud-based applications where virtualization is a fundamental aspect as well as the platform of development used. In this way, it will be possible that users can work, cooperate, keep in contact and connect from anywhere, through mobile devices.

Besides, programmers will have to choose between two types of available technologies for its development: native apps and open apps.

Personalized native apps have resulted from the dominant form in which users consume the internet services. For example, iPhone and iPad devices, as well as in Android devices of Google, users typically access on Facebook, Twitter and many other services of social networks that use native apps built before the browser. Those native apps are not really web apps, however, they use the same protocols to access the services backend as the browsers do.

On the other hand, web apps may be built with technologies that are open, accessible and interoperable

as possible, and must work according to the rules of the browser compatible without plug-ins, extensions, or runtimes [32].

6. CONCLUSION

As it has already been mentioned before in this work, companies are investing in Cloud Computing and it is becoming more popular the use of mobile devices and the applications capable of making complete use such devices. Therefore, it will be necessary the development of mobile apps, storage in the cloud, which may be accessed clearly by the user no matter which mobile device they are using. Based on what has been analysed, Mobile Cloud Computing is different from the traditional Cloud Computing; besides the new developments and strategies will modify the development of applications for Mobile Cloud Computing. Programmers will demand the service provider to offer the necessary tools for the variety of applications that has been detailed, through API or specific libraries such as MDM or AR APIs, in order to make use of them. They also have to consider the limitations of mobile computing, so the resources used by the users may be optimized from the server.

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