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MOBILE PHONES USING CLOUD COMPUTING INFRASTRUCTURES FOR EFFICIENT PERFORMANCE

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Abstract

Cloud computing is emerging as one of the most important paradigm for providing seamless applications on mobile devices. Combination of Mobile computing and Cloud computing which is termed as Mobile cloud computing model is envisioned as solution to this problem. In this model, users make use of cloud resources for their storage, processing and communication requirements. In this paper, we consider mobile nodes that access the cloud resources through cellular towers (hereby referred as access points) that are connected to the Internet. These nodes can be any kind of mobile devices like cell phones, tablets with cellular data, laptops with USB modems, etc. Mobile nodes communicate with access points (i.e., cell towers) using wireless communication, and access points communicate with the cloud servers over fixed wired network. Cloud provides the ability for data storage and processing services for mobile users on the platform of the cloud. The rapid development of mobile devices has opened up possibility of new applications like location-based services, information sharing, etc. Location-based services which previously had only basic information about a service can now include more details like photographs, videos, detailed description of those services tagged with geo-locations, etc. Because of mobile phones size and thermal constraints, they have certain limitations in areas of battery life and computational capabilities. Our study presents a novel computing mode consisting of mobile computing and cloud computing, which provide cloud based services to users through the Internet and mobile devices.

Keywords: Cloud computing, Mobile computing, Mobile applications, Mobile devices.

Introduction

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. Mobile devices like iPhones, Blackberry, Android phones are becoming popular clients to consume any Web resources, especially Web Services (WS). In any mobile device for application execution, two basic significant requirements are of; processing

power and memory capacity of such device capable of supporting that corresponding application. Scenario of Cloud Computing " provides us this opportunity to execute our applications on servers instead of running them locally and favors us to overcome the handset's limitation of limited resources to a great extent. And also there will be no need for Mobile application developers to create many versions of same application. It's just the starting of a new phase of mobile application development; there is still a long way to go to achieve a new mobile world infrastructure involving cloud computing in its base. Combination of Mobile computing and Cloud Computing which is termed as Mobile cloud computing model is envisioned as solution to this problem. In this model, users make use of cloud resources for their storage, processing and communication requirements. Mobile devices retain only a thin client for user interface and display of the results. According to recent study, subscribers for this computing paradigm are expected to grow rapidly in the years to come (ABI, 2009 and Juniper, 2010).

Over the past few years, development of mobile wireless technology has increased at a rapid pace with introduction of sophisticated features like built-in cameras, improved processing capabilities, increased storage capacity, better communication capabilities, etc. But these developments have failed to keep pace with the software demands for storage and processing (Vemulapalli, 2014). Coupling of mobile computing with cloud computing is envisioned as a solution to these constraints in mobile computing. Significantly, in the last decade, mobile Internet access has become ubiquitous, even though some research problems pertaining to efficiency of wireless networks remain. Thus, the foundation is laid for considering how the processing and storage needs of mobile devices can be exported to the cloud servers (Satyanarayanan, 2010, ABI, 2009) while the mobile devices retain only a thin client to display results or files. Two good examples, of such thin clients are the YouTube and Facebook apps in smart phones. Figure 1 represents the general architecture of Mobile cloud computing.

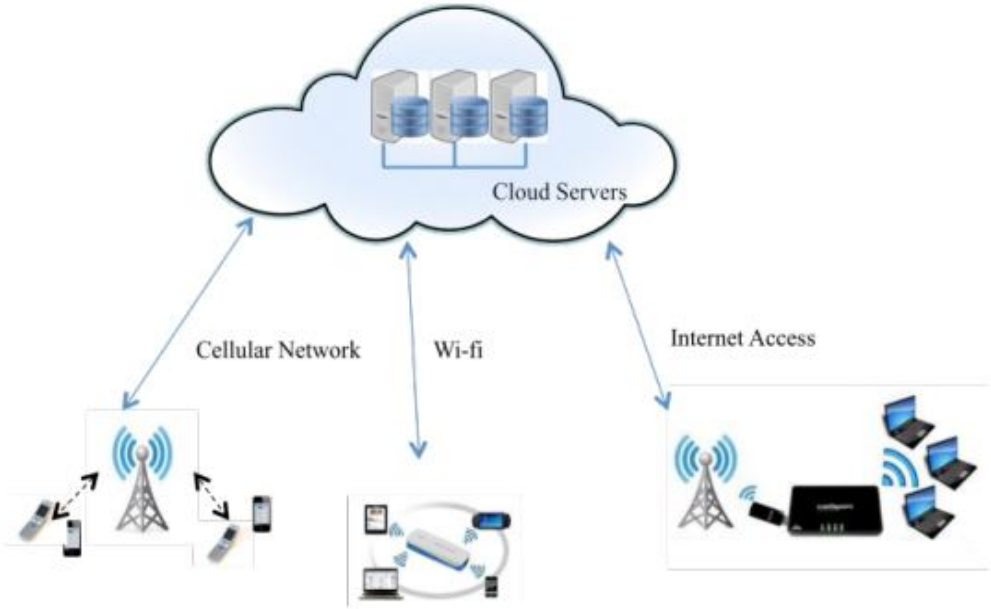

Figure 1: General Architecture of Mobile Cloud Computing. Source: (Vemulapalli, 2014)

The mobile phone is the new personal computer (Allen et al, 2010) and its functionality is continually increasing (Carroll & Heister, 2010) Mobile phones are increasingly used for web browsing, email and multimedia, to mention but a few areas (Nurminen, 2010). However, the portability and small size of the device has its limitations or constraints when it comes, for example, to battery life (Miettinen & Nurminen, 2010) and computational performance and capabilities. Cloud computing has been suggested to improve mobile phones in various ways, but two common areas are battery life extension and computational offloading (Kumar and Lu, 2010). The rapid development of mobile devices has opened up possibility of new applications like location-based services, information sharing, etc. Location-based services which previously had only basic information about a service can now include more details like photographs, videos, detailed description of those services tagged with geo-locations, etc. Similarly, information shared among mobile users can also be more detailed. For example, a person who likes a restaurant in particular location may take photographs, video clipping of the restaurant, write a brief review of the restaurant and upload them to the cloud. Another mobile user who is in same location or coming to same location and looking for a good restaurant, may find this information very helpful (Vemulapalli, 2014). Satyanarayanan, 2010, mentioned how mobile devices with cameras can also be used to remap an entire location during disaster recovery. What all of these applications have in common is that they are data-intensive. All these applications of Mobile cloud computing involve uploading and downloading information from the cloud. So, latency becomes an important performance parameter when dealing with images and video clips.

The aim of this paper is to contribute along these directions discuss how the cloud can be used to improve the performance of mobile phone application functions faster by offloading the task to the cloud, in comparison to executing such functions on the mobile phone. This paper discusses cloud computing as a recent paradigm of delivering remote mobile applications to mobile devices via the internet providing solutions to the inadequate resources in mobile devices and also a new level of security is achieved by centralizing maintenance of security-critical software. It provides mobile world a new ad hoc infrastructure where data storage and processing is performed outside the mobile device and cloud computing gets an extended feature of mobility. Mobile cloud computing is the usage of cloud computing in combination with smart mobile devices. Cloud computing exists when tasks and data are kept on the internet rather than on individual devices, providing on-demand access of such data or task. Applications are run on a remote server and then sent to user due to the advanced improvement in mobile browsers (Mell & Grance, 2009). The paper also discussed mobile cloud computing, its concept and principles. We also discussed mobile computing and its features as well as its challenges. However, challenges and possible solutions of mobile cloud computing is discussed in respect to mobile device, network, mobile applications and security. Finally, some research issues like; data delivery, task division and better service are discussed before the final conclusion of the paper.

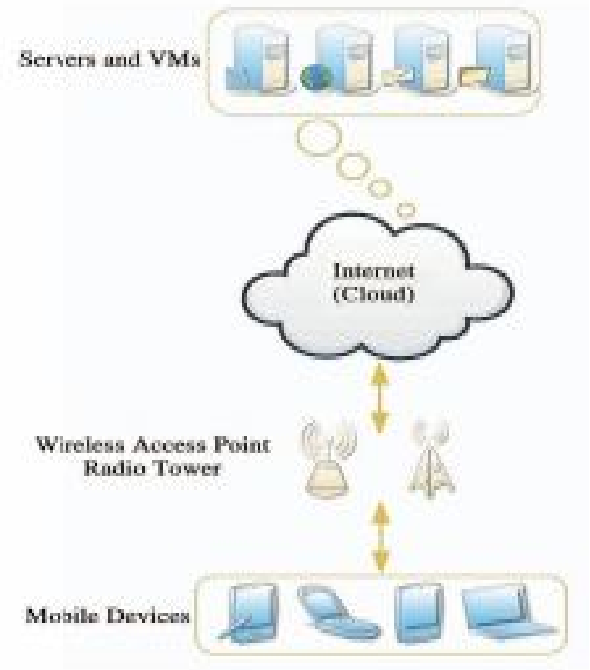

Figure 2: Mobile Cloud Computing. Source: (Qi & Gani, 2012).

Mobile Cloud Architecture

In this paper, we consider mobile nodes that access the cloud resources through cellular towers (hereby referred as access points) that are connected to the Internet. These nodes can be any kind of mobile devices like cell phones, tablets with cellular data, laptops with USB modems, etc. Mobile nodes communicate with access points (i.e., cell towers) using wireless communication, and access points communicate with the cloud servers over fixed wired network. In this scheme, one of the key assumptions we make is that the access points have a small server with limited memory and processing capabilities. This concept of access points having processing capabilities is first articulated by (Satyanarayanan, Bahl, Caceres & Davies, 2009).

Mobile Cloud Computing

The term cloud computing has many different definitions that are constantly evolving due to the wide area the concept is covering, and depending on which area of it the describer tries to define. The cloud has historically been used as a metaphor for the Internet and is commonly used in network diagrams to represent connections between entities, connected through the Internet (Mather, Kumaraswamy & Latif, 2009; Rittinghouse & Ransome, 2010).

Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (DoD, 2005). In layman's language, we can say that it is the ability to acquire parts of bulk resources quickly and easily according to the requirement and the client is charged for those resources on usage basis. It's a web-based processing, whereby shared resources, software, and information are provided on demand to computers, smart phones, and other similar devices allowing users to adjust their computing capacity depending on how much is needed at a given time or for a given task (ZTE Communication Vol. 9, 2011).

At this time, both hardware and software of mobile devices are experiencing greater improvement than before, for instance smart phones such as iPhone 4S, Android series, Windows Mobile serials and Blackberry, are no longer just traditional mobile phones with conversation, SMS, Email and internet browsing. It is common for those smart phones to support, various sensing modules like navigation, optics, gravity, orientation, and so on which brings a convenient and intelligent mobile experience to users. In 2010, Google CEO Eric Schmidt described mobile cloud computing in an interview that 'based on cloud computing service development, mobile phones will become increasingly complicated, and evolve to a portable super computer (B. Marapese, 2010). With the myriad of various mobile cloud services provided by Microsoft, Apple, Google, HTC, and so on, users may be confused about what mobile cloud computing exactly is, and what its features are.

A. Mobile Computing

Mobility has become a very popular word and rapidly becoming part of today's computing era. An incredible growth has appeared in the development of mobile devices such as, smartphone, PDA, GPS Navigation and laptops with a variety of mobile computing, networking and security technologies. In addition, with the development of wireless technology like WiMax, Ad Hoc Network and WIFI, users may be surfing the Internet much easier but not limited by the cables as before. Thus, those mobile devices have been accepted by more and more people as their first choice of working and entertainment in their daily lives. However, what is mobile computing? So, what is Mobile computing exactly? Mobile computing is based on a collection of three major concepts: hardware, software and communication. The concepts of hardware can be considered as mobile devices, such as smartphone and laptop, or their mobile components. Software of mobile computing is the numerous mobile applications in the devices, such as the mobile browser, anti-virus software and games. The communication issue includes the infrastructure of mobile networks, protocols and data delivery in their use. They must be transparent to end users.

1) Features of mobile computing: the features of mobile computing are explained as follows (Qi & Gani, 2012).

a) Low reliability: due to signals susceptible to interference and snooping, a mobile computing network system has to be considered from terminals, networks, database platforms, as well as applications development to address the security issue.

b) Mobility: mobile nodes in mobile computing network can establish connection with others, even fixed nodes in wired network through Mobile Support Station (MSS) during their movement.

c) Dis-symmetrical network communication: servers and access points and other Mobile Support System (MSS) enable a strong send/receive ability, while such ability in mobile nodes is quite weak comparatively. Thus, the communication bandwidth and overhead between downlink and uplink are discrepancy.

d) Diversity of network conditions: normally the networks used by mobile nodes are not unique, therefore, such networks can be a wired network with high-bandwidth, or a wireless Wide Area Network (WWAN) with low-bandwidth or even in status of disconnected.

e) Frequent disconnection and consistency: as the limitation of battery power, charge of wireless communication, network conditions and so on, mobile nodes will not always keep the connection, but disconnect and consistent with the wireless network passively or actively.

2) Challenges of mobile computing: Compared with the traditional wired network, mobile computing network may face various problems and challenges in different aspects, such as signal disturbance, security, hand-off delay, limited power, low computing ability, and so on due to the wireless environment and numerous mobile nodes. In addition, the Quality of Service (QoS) in mobile computing network is much easier to be affected by the landforms, weather and buildings.

***B. Cloud Computing*:** Cloud Computing has become a popular phrase since 2007. However, there is no consensual definition on what a Cloud Computing or Cloud Computing System is, due to dozens of developers and organizations described it from different perspectives. (C. Hewitt, 2008) introduces that the major function of a cloud computing system is storing data on the cloud servers, and uses of cache memory technology in the client to fetch the data. Those clients can be PCs, laptops, smartphones and so on. (R. Buyya, C. Yeo and S. Venugopal) gives a definition from the perspective of marking that cloud computing is a parallel and distributed computing system, which is combined by a group of virtual machines with internal links. Such systems dynamically offer computing resources from service providers to customers according to their Service level Agreement (SLA). However, some authors mentioned that cloud computing was not a completely new concept (Youseff, Butrico & Da Silva, 2008) from UCSB argue that cloud computing is just combined by many existent and few new concepts in many research fields, such as distributed and grid computing, Service-Oriented Architectures (SOA) and in virtualization.

1) Cloud Computing framework: cloud computing paradigm can actually 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 (See figure 3).

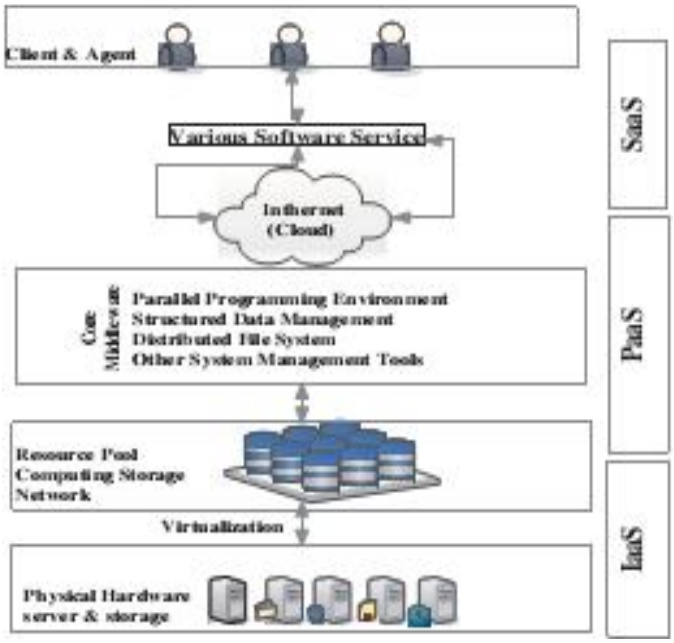

Figure 3: The framework of cloud computing

a). Infrastructure Layer: these include 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 to the users in order to install operation system (OS) and operate software application. Thus it is denoted as Infrastructure as a Service (IaaS). Typical example of services in this layer is Elastic Computing Cloud of Amazon (Shankar, 2009).

b). Platform Layer: this layer is considered as the core layer in cloud computing system that 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 Platform as a Service (PaaS). The typical examples of such services are Google App Engine (Zahariev, 2009) and Azure from Microsoft (Online, 2016).

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 layer as Software as a Service (SaaS). Users use client software or a browser to call services from providers through the Internet, and pay costs according to the utility business model (like water or electricity) (McCarthy, 1961). The earliest SaaS is the Customer Relationship Management (CRM) (Online, 2009) from Salesforce, which was developed based on the force.com (a PaaS in Salesforce). Some other services provided by Google on-line office such as documents, spreadsheets, presentations are all SaaS.

2). Features of cloud computing: the features of cloud computing are as follows:

a). Virtualization: the 'Cloud' can be considered as a virtual resource pool (Rochwerger et al, 2009) where all bottom layer hardware devices are virtualized. End users access desired resources through a browser and get data from cloud computing providers without maintaining their own data centers. Furthermore, some virtual machines (VMs) are often installed in a server in order to improve the efficiency to use resources; and such VMs support load migration whenever there is a server over-load.

b). Reliability, usability and extensibility: cloud computing provides a safe model to store user's data while users do not need to worry about technical 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 continue normal operation (Boss et al, 2007). Meanwhile, cloud can be extended from horizontal and vertical (Mei, et al., 2008) in a large-scale network, to process numerous requests from thousands of nodes and hosts.

c). 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.

d). 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 two hundred different places in the world, and will move upward to 10 million servers in the next decade (Cohen, 2010).

3). Challenges of Cloud Computing: first of all, cloud computing needs an improved mechanism to provide a safe and high efficiency service as the numerous invoked third-party software and infrastructures are implementing in computing. In addition, due to the nature of data centers of resource use of large volume of electricity, efficient resource scheduling strategy and methods are required in order to save energy. Furthermore, as a Service Level Agreement (SLA) is established between users and service providers in cloud computing, so the performance and analysis of services are necessary to be monitored. Lastly, simple and convenient application interfaces are indispensable for service providers in cloud computing, thus a uniform standard is required eagerly (Qi & Gani, 2012).

C. Concept and principles of Mobile Cloud Computing

Like cloud computing, there are many but no consensual definitions of what mobile cloud computing is. In this paper, we propose a novel computing model consisting of mobile computing and cloud computing, which provide cloud based services to users through the Internet and mobile

devices. On one hand, mobile cloud computing is a development of mobile computing, and an extension to cloud computing. In mobile cloud computing, the traditional mobile device-based intensive computing, data storage and mass information processing have been transferred to 'cloud' and thus the requirements of mobile devices in computing capability and resources have been reduced, so the developing, running, deploying and using model of mobile applications have been totally changed. On the other hand, the terminals which people used to access and consume cloud services are supported by mobile devices like Smartphone, PDA, Tablet, and iPad this reflects the advantages and original notion of cloud computing of ubiquitous and device agnostic. Therefore, from both aspects of mobile computing and cloud computing, the mobile cloud computing is a combination of the two technologies, a development of distributed, grid and centralized algorithms, and have broad prospects for application (Qi & Gani, 2012).

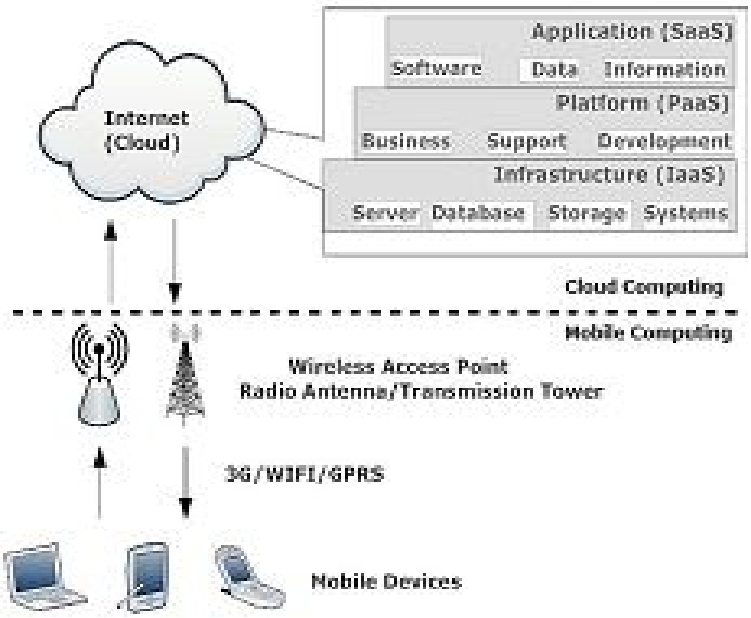

Figure 4: Mobile Cloud Computing simple architecture. Source(Qi & Gani, 2012)

As shown in Figure 4 above, mobile cloud computing can simply divided into cloud computing and mobile computing. Those mobile devices can be laptops, PDA, smartphones, and so on which connect with a hotspot or base station using 3G, WIFI, or GPRS. As computing and major data processing phases are migrated to 'cloud', the capability requirement of mobile devices is reduced, some low-cost mobile devices or even non-smartphones can also achieve mobile cloud computing by using a cross-platform mid-ware. Al-though the client in mobile cloud computing is changed from PCs or fixed machines to mobile devices, the main concept is still cloud computing. Mobile users send service requests to the cloud through a web browser or desktop application, and then the management component of cloud allocates resources to the request to establish connection, while the monitoring and calculating functions of mobile cloud computing will be implemented to ensure the QoS until the connection is completed (Qi & Gani, 2012).

D). Deployment of Mobile Cloud

(Oskar Harmen, 2012) in his research work on mobile phones and cloud computing built an application and cloud servlet then offloaded it to the cloud. He used IDE to build the application Eclipse because of its good support for java development and easy integration with Android SDK and Google App Engine SDK. He built an application for image transformation, where test

required an image to be uploaded, which are transformed and returned. The upload/download class uploads an image to a Google App Engine servlet and then downloaded it to the phone. He timed the process of uploading and downloading the image using kilo byte per second ratio calculation.

The Five Essential Characteristics of Cloud Computing.

The "five essential characteristics" that Mell & Grance mentions differs from one cloud computing researcher to another, adding and removing characteristics that represent their subjective idea or area of the topic. The idea is to divide the term cloud computing into more graspable parts, which generally are defined as:

- Self-provisioning of resources and elasticity. Cloud computing users are able to, without human assistance; acquire any amount of computing capabilities. For example, network storage, processing capabilities or software, which are available anytime and anywhere.
- Pay-per-use. Costs of cloud computing services are based on usage. For example, an hourly or monthly rate traffic load or numbers of users.
- On demand availability. Cloud services are always accessible, platform independent and are commonly accessed through a web browser or web service API.
- 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.
- 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 definition of the characteristics of cloud computing has many different variations for example by Armbrust et al. (2009), Hurwitz, Bloor, Kaufman & Halper (2010), Mather et al. (2009), Mell & Grance (2009), Reese (2009), Rittinghouse & Ransome (2010) among others. The definitions differ from one researcher to another but they generally cover similar areas.

Benefits and Challenges of Cloud/Mobile Computing

Using cloud computing concept in mobile world is all about supplying mobile applications and services in the cloud, enabled through cloud service providers and then deliver it to end -users‟ mobile handsets over the Internet when required. So in making remote applications available to mobile devices by the use of cloud computing, main entities of this arrangement are (Qi & Gani, 2012).

- Mobile device:
- Network (through which mobile devices are accessing cloud)
- Mobile Applications
- Security

Some of the benefits of deploying cloud services to improve the performance of mobile devices.

Benefits/advantages

1). Resource poverty of mobile devices: Comparison of desktop pc with any mobile device shows that on what cost this feature of mobility is being achieved. As compared to a fixed device, mobile devices in general have:

- 3 times less processing power
- 8 times less memory
- 5 times less storage capacity
- 10 times less network bandwidth

So in general we can say that this resource deficiency is one of the major reason for the adoption of mobile cloud computing. In order to overcome this limitation of mobile devices, resources are

added to the cloud infrastructure and can be used anytime on requirement, providing a seamless user experience for advanced applications. Even after continuous improvements in mobile device performances", the disparity between the resource constraints of mobile and fixed devices will remain and must be accounted for in the types of application selected for mobile cloud computing (Mun, 2010).

2).Reducing network latency: factors responsible for overall delay response of applications are:

- Processing time at the data center
- Processing time on the device
- Network latency
- Data transport time

Processing time involved is based on application and we can't do so much for it. But yes measures can be taken to improve the network latency. Keeping the applications as close to the users can reduce latency delay as latency is significantly affected by distance. Heavy data like video and podcasts if kept closer to the device then it will save bandwidth and cuts transmission delay. Similar is the case with highly immersive apps, such as real-time translation. Latency can be positively improved by allowing service providers to re-route internet traffic logically based on the location and cache capabilities, and can save bandwidth effectively (Qi & Gani., 2012).

3). Mobile cloud convergence: In order to achieve advantage of mobility by integrating cloud computing to mobile world, Data distribution is the key issue. Limitation of mobile devices for their computing power makes task distribution very important as the computing power of mobile devices is not powerful enough for making these devices to be the main computing platform. Mobile cloud convergence provides performance improvement, longer battery life, and a solution to the computation power problem. Basic approach of mobile cloud convergence is to partition application such that parts that need more computation run on the cloud and remaining parts which is associated with the user interface r un on the mobile device. As a single process is being partitioned here so IPC (inter-process communication) is very important to realize this convergence. An improved and optimal PI calculation algorithm can be achieved by optimizing mobile cloud convergence. Wireless technologies, advanced electronics and internet are overlapped and integrated to achieve pervasive and ubiquitous computing. (Choi, 2011).

4).Cloud application flexibility: An application is going to be supported by certain mobile cloud infrastructure or not, can easily be judged on the basis of its requirements against the cloud infrastructure characteristics along the device, network bandwidth and latency vectors. Different applications" needs are different for its respective cloud infrastructure attributes (computation intensity, network bandwidth, and network latency). For example, a loosely coupled and low-content application like web search will provide optimal result on a 3G network with relatively low compute servers at a „distant" data center. But if we talk about a hugely immersive and content-rich application like real-time face recognition it will require a high-bandwidth/low-latency network like LTE so that large image content can be transferred quickly and seamlessly to the servers running the face recognition algorithm and the user-facing devices. In high-demand applications transmission and latency delay can be minimize by considering nearby data centers. And for a highly immersive application mobile cloud infrastructure can go for Wi-Fi offload that reduced latency further which is generally required by such applications (Mun, 2010).

Challenges

1). Limitations of mobile devices: While discussing mobile devices in cloud the first thing is resource-constrain. Though smartphones have been improved obviously in various aspects such as capability of CPU and memory, storage, size of screen, wireless communication, sensing

technology, and operation systems, still have serious limitations such as limited computing capability and energy resource, to deploy complicated applications. By contrast with PCs and Laptops in a given condition, these Smartphones like iPhone 4S, Android serials, Windows Mobile serials decrease 3 times in processing capacity, 8 times in memory, 5 to 10 times in storage capacity and 10 times in network bandwidth. Normally, Smartphone needs to be charged everyday as dialing calls, sending messages, surfing the Internet, community accessing, and other internet applications. According to past development trends, the increased mobile computing ability and rapid development of screen technology will lead to more and more complicated applications deployed in Smartphone. If the battery technology cannot be improved in a short time, then how to effectively save battery power in Smartphone is a major issue we meet today. The processing capacity, storage, battery time, and communication of those Smartphone will be improved consistently with the development of mobile computing. However, such enormous variations will persist as one of major challenges in mobile cloud computing (Qi & Gani, 2012).

2). Inherent challenges of wireless network: Wireless network is best for carrying out cloud computing and it has its own limitations and constraints. These challenges complicate its design for mobile devices even more in comparison to the fixed cloud computing. Fixed broadband is supported by consistent network bandwidth while wireless connectivity is characterized by variable data rates, less throughput, longer latency and intermittent connectivity due to gaps in cove rage. Subscriber mobility and uncontrollable factors like weather are also responsible for varying bandwidth capacity and coverage (Mun, 2010).

3).Privacy and confidentiality: There are various policies and schemes (such as Fair Information Practice Principles (FIPP)) being proposed which require rigorous controls and procedures to protect the privacy of individuals. Organizations that collect data\information must have some policies and procedures in order to handle, store, and dispose them securely and must be implemented to maintain the privacy. Risk of privacy exposure, identity theft and fraud can be reduced by implementing enhanced protection measures for sharing data in an interconnected system, implementing, monitoring capabilities, protocols and by educating users about proper social media safe-surfing. By establishing policies regarding use of social media and implementing processes to protect their infrastructures from unauthorized use of social media an organization can protect themselves from serious legal and security-related problems. Otherwise their information infrastructure and reputation both will be irreparably damaged IA newsletter, (Vol. 13 2010). Encryption provides most effective way to maintain integrity and confidentiality of information. Encryption favors data storage and transport but it fundamentally prevents data processing. Therefore, initially it was quite useless to send encrypted data to cloud providers for processing. But this challenge has been met by homomorphic cryptography (HC) which ensures that operations performed on an encrypted text results in an encrypted version of the processed text (Peter Schoo et al, 2010).

GPS positioning devices has favored mobile users for using location based services (LBS). However, LBS raise a privacy issue when mobile users provide private information such as their current location and it becomes even worse if an adversary knows user's some other important information. Location trusted server (LTS) provides solution to this issue (Zhangwei et al., 2010). Digital rights management (DRM) provides another issue of privacy. Unstructured digital contents (e.g., video, image, audio, and e -book) have often been pirated and illegally distributed. In order to stop the piracy and illegal distribution of these unstructured digital contents (Zou, et al, 2010) proposed Phosphor; a cloud based mobile digital rights management (DRM) scheme with a sim card in mobile phone. It improves flexibility and reduces the vulnerability of its security at a very

low cost. But this approach is basically based on SIM card of mobile phone, so it cannot be applied for other kinds of accesses like a laptop using WiFi to access these contents.

4). Malicious attacks: All networks are susceptible to one or more malicious attacks. As more as external Web sites are being accessed malicious actors will have more opportunities to access the network and operational data of that organization. Implementing security controls across all Web 2.0 servers and verifying these rigorous security controls can reduce the threats to internal networks and operational data. Additionally, separating Web 2.0 servers from other internal servers may further mitigate the threat of unauthorized access to information through social media tools and Web sites (J. McCarthy, 1961). Some of the potential attack vectors criminals may attempt include:

- Denial of Service (DoS) attacks – It has been argued that a cloud is more susceptible to a DoS attack; because more than one client can access cloud at the same time, which makes DoS attacks much more damaging. For instance, Twitter has suffered a devastating DoS attack in 2009.
- Side Channel attacks – In this kind of attack a malicious virtual machine is placed in close proximity of a target cloud server to compromise the cloud security and then a side channel attack is launched.
- Authentication attacks – Authentication is one of the weak points in case of hosted and virtual services and is generally been targeted. A user can be authenticated in number of ways and these mechanisms and methods which are used to secure the authentication process are frequently been targeted by the attackers.
- Man-in-the-middle cryptographic attacks – This attack is carried out when an attacker places himself between two users. In this kind of attack attacker places himself in the communication path and after that it is up to him what to do, he can intercept and modify communication.

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 (Qi & Gani, 2012):

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 light weight middle-ware (provide a platform for all mobile cloud computing systems). Whether this middle ware completely resides on the device or split between the mobile device and the cloud infrastructure remains an open research issue.

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 real aim of mobile cloud computing is to provide 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.

Conclusion/Recommendation

Implementation of cloud computing to support mobile applications is expected to be an attractive trend in the future since it combines the advantages of both mobile computing and cloud computing, thereby providing optimal services for mobile users. According to Recent researches, by the end of 2013 there will be more than 10 thousand mobile applications that will be executed through cloud computing. Moreover, we discussed cloud computing framework, features and its challenges. We discussed challenges regarding mobile devices, network, mobile applications and security. Finally we identified some possible research issues like data delivery, task division and better service. In addition, upgrading bandwidth is envisaged to be a simple way to increase performance but it incurs additional cost to users. Therefore, deploying an effective elastic application division mechanism is deemed to be the best solution to guarantee the application service in Mobile cloud computing; its complicated, but promising high impact results. Adequate security measures have to be incorporated to support the low processing ability at the client-side. Furthermore, we would like to test the feasibility of extrapolating concepts from cloud computing in the domain of large-scale computers to the realm of mobile world. Also, the cost policy needs to be evaluated as it could prove to be a hindrance to the growth of Mobile Cloud Computing.

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