Mobile Cloud Computing the Necessity of Future with its Architecture, Advantages and Applications

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***Abstract*—** Mobile cloud computing is the combination of both cloud computing and mobile networks to bring benefits for mobile users, network operators, as well as cloud computing providers[1][2]. The main goal of MCC is to enable execution of rich mobile applications on mobile devices, with a rich user experience [3]. In the recent years, cloud computing has cultivated the outsourcing of computing resources like IT infrastructures, service platforms, and software. With the emergence of ultra-fast 4G mobile networks and highly-featured smartphones and tablets, the prerequisites are now met for bringing cloud computing to the mobile domain. Future applications of mobile cloud computing will have an impact on almost all activities of our social and business life, and include, but are not limited to, mobile marketing, social networks, smart cities, health care, and business processes.

Keywords- *Mobile cloud computing, computing layers, offloading, mobile services, Research Directions.*

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A. INTRODUCTION

Mobile devices like smartphones, tablet pcs, etc, are increasingly becoming an essential part of today's human lifestyle as the most effective and convenient communication tools not bounded by time and place. Users of Mobile are now accumulate rich experience of various services from mobile applications (e.g., iPhone apps, Google apps, etc). Mostly this services run on the devices and on remote servers via wireless networks. The rapid progress of mobile computing (MC) [4] becomes a powerful trend in the development of IT technology as well as commerce and industry fields. But it is also true that, the mobile devices are facing many challenges in their resources containing battery life, storage, and bandwidth and communications containing mobility and security issues [5]. The limited resources significantly impede the improvement of service qualities.

Now the Cloud computing (CC) has been widely recognized as the next generation's computing infrastructure [6]. CC offers many advantages by allowing users to use infrastructure like servers, networks, and storages, platforms containing middleware services and operating systems, and softwares for application programs. This advantages are provided by cloud providers like Google, Amazon, and Salesforce at low cost. In addition, CC enables users to elastically utilize resources in an on-demand fashion which increases its attraction. As a result, mobile applications can be rapidly provisioned and released with the minimal management efforts and service provider's interactions.

Figure 1: Increasing scenario towards Mobile Cloud Computing

With the explosion of mobile applications and the support of CC for different variety of services for mobile users, mobile cloud computing (MCC) is introduced as an integration of cloud computing with the mobile computing. Mobile cloud computing environment brings new types of services and facilities for mobile users to take full advantages of cloud computing services.

This paper presents a comprehensive survey on mobile cloud computing. Section II provides a brief overview of MCC with its definition, and. Section III discusses architecture of MCC in various services and applications. Then, Section IV presents several advantages

of Mobile Cloud Computing (MCC) to address the issues of the future research directions. Finally, we summarize and conclude the survey of MCC in Section VI.

II. DEFINITION

What is Mobile Cloud Computing?

There are many ways to define Mobile Cloud Computing, out of that the Mobile Cloud Computing Forum defines MCC as follows [8]:

"Mobile Cloud Computing at its simplest, refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smartphone users but a much broader range of mobile subscribers".

Aepona [9] describes MCC as "a new paradigm for mobile applications whereby the data processing and storage are moved from the mobile device to powerful and centralized computing platforms located in clouds. These centralized applications are then accessed over the wireless connection based on a thin native client or web browser on the mobile devices".

III. ARCHITECTURES OF MOBILE CLOUD COMPUTING

From the concept of MCC, mobile devices are connected to the mobile networks via base stations that establish and control the connections (air links) and functional interfaces between the networks and mobile devices. Mobile user's requests and information are transmitted to the central processors that are connected to servers providing mobile network services. Here, mobile network operators can provide services to mobile users as three AAA's like for authentication, authorization, and accounting. The subscriber's requests are delivered to a cloud through the Internet. In the cloud environment, cloud controllers process the requests to provide mobile users with the corresponding cloud services. These services are accepted in Wireless Communications and Mobile Computing developed with the concepts of utility computing, virtualization, and service-oriented architecture like web, application, and database servers.

The details of cloud architecture in different contexts may be different. For example, a four-layer Architecture that is SaaS, PaasS, IaaS to compare cloud computing with grid computing. Alternative to this, a service oriented architecture, called Aneka, is introduced to enable developers to build .NET applications with the supports of application programming interfaces (APIs) and multiple programming models. The architecture for creating market-oriented clouds, and an architecture for web delivered business services. In this paper, we focus on a layered architecture of cloud computing. This architecture is commonly used to demonstrate the effectiveness of the cloud computing model in terms of meeting the user's requirements [10].

Software as a Service (Microsoft's Live Mesh)
Platform as a Service (e.g., Google App engine, Microsoft Azure)
Data centers (H/W, Infrastructure support)
Infrastructure as a Service (e.g., EC2, S3)

Fig. 2. Service-oriented cloud computing architecture.

The cloud services are generally classified based on a layer concept (Fig. 2). In the upper layers of this paradigm, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are stacked. We see the functioning of all the layers in brief:

- Software as a Service (SaaS):

  SaaS supports a software distribution with specific requirements. Users can access an application and information remotely via the Internet and pay only for that they use in this layer. Although the cloud computing architecture can be divided into four layers as shown in Fig. 2, it does not mean that the top layer must be built on the layer directly below it. Also, some services are the part of more than one layer. For example, data storage service can be viewed as either in IaaS or PaaS. The users can use the services flexibly and efficiently, with this architectural model.

- Platform as a Service (PaaS):

  As accepted in Wireless Communications and Mobile Computing PaaS offers an advanced integrated environment for building, testing and deploying custom applications. The examples of PaaS are Google App Engine, Microsoft Azure, and Simple Storage Service.

- Data centers layer:

  This layer that provides the hardware facility and infrastructure for clouds. In datacenter layer, a number of servers are linked together with high-speed networks to provide services for Customers. Mostly, data centers are built in less populated places, with a high power supply stability

and a low risk of disaster.

- Infrastructure as a Service (IaaS):

IaaS is built on top of the data center layer. IaaS enables the storage, hardware, servers and networking components. The client have to pay as per-use basis. Thus, clients can save cost as the payment is only based on how much resources they are using. Infrastructure can be expanded or shrunk dynamically as needed. The examples of IaaS: Amazon EC2 (Elastic Cloud Computing) and S3 (Simple Storage Service).

IV. ADVANTAGES OF MOBILE CLOUD COMPUTING

Cloud computing is known to be a promising solution for mobile computing due to many reasons as we see earlier the mobility, communication, and portability [11]. In the following, we also describe how the cloud can be used to overcome obstacles in mobile computing, thereby pointing out advantages of MCC.

A. Extending battery lifetime:

Battery is one of the main concerns for mobile devices. Several solutions have been proposed to enhance the CPU performance [12] and to manage the disk and screen to reduce power consumption. These solutions changes the structure of mobile devices. In addition, many mobile applications take advantages from task migration and remote processing. For example, offloading a compiler optimization for image processing, migrate mobile game components to servers in the cloud can save 27% of energy consumption for computer games and 45% for the chess game.

B. Improving the processing power and capacity of data storage:

Storage capacity is also a constraint for mobile devices[13]. MCC is developed to enable mobile users to store and access the large data on the cloud through wireless networks. First example is the Amazon S3[14], that supports file storage service. Another is Image exchange which utilizes the large storage space in clouds for mobile users. This mobile photo sharing service enables mobile users to upload images to clouds immediately after capturing. Users may access all these images from anywhere with any devices. With cloud, the users can save considerable amount of energy and storage space on their mobile devices since all images are sent and processed on the clouds. Facebook [15] is the well-known and the most successful social network application today, and it is also a typical example of using cloud in sharing images.

C. Improving reliability:

Storing data on clouds or running applications is an effective way to improve the reliability. Because the data, application and back up is stored on a number of computers. This reduces the chance of losing data and application on the mobile devices. MCC can also be designed as a comprehensive data security model for both service providers and users. For example, the cloud can be used to protect copyrighted digital contents like video, clip, and music from being abused and unauthorized distribution. Also, the cloud can remotely provide mobile users with security services such as virus scanning, malicious code detection, and authentication. Such a cloud-based security services can make efficient use of the collected record from different users to improve the effectiveness of the services.

In addition, MCC also inherits some advantages of clouds for mobile services as dynamic provisioning: Dynamic on-demand provisioning of resources on a fine-grained, self-service basis is a flexible way for service providers and mobile users to run their applications without advanced reservation of resources.

V. APPLICATIONS OF MOBILE CLOUD COMPUTING

Mobile applications gain increasing share in a global mobile market and various mobile applications have taken this advantages of MCC. Some typical applications of MCC are:

A. Mobile Commerce

Mobile commerce called as “m-commerce” is a business model for commerce using mobile devices. The m-commerce applications generally fulfill some tasks with mobility (e.g., mobile transactions and payments, mobile messaging, and mobile ticketing). The m-commerce applications includes a few classes including finance, advertising and shopping.

The m-commerce applications have to face various challenges also. For example, low network bandwidth, high complexity of mobile device configurations, and security,etc. Therefore, m-commerce applications are integrated into cloud computing environment to address these challenges [16]. This paradigm combines the advantages of both 3G network and cloud computing to increase data processing speed and security level based on PKI (public key infrastructure). The PKI mechanism uses an encryption-based access control and an over-encryption to ensure privacy of user’s access to the outsourced data. cloud computing technology utilizes to enhance the security for users and improve the customer satisfaction, customer intimacy, and cost competitiveness.

B. Mobile Learning

Mobile learning (m-learning) is designed based on electronic learning (e-learning) and mobility. However, traditional m-learning applications have some limitations in terms of high cost of devices and network, low network transmission rate, and limited educational resources [17]. So this type of limitations can be solved by Cloud-based m-learning applications. For example, utilizing a cloud with the large storage capacity and powerful processing ability. The applications provide learners with much richer services in terms of data size, faster processing speed, and longer battery life. This benefits of combining m-learning with cloud computing to enhance the communication quality between students and teachers. In this case, with web site built on Google Apps Engine, students communicate with their teachers at anytime. Also, the teachers can obtain the information about student's knowledge level of the course and can answer students' questions in a timely manner.

The purpose of the deployment of these applications is mainly to help the students to enhance their understanding about the appropriate design of mobile cloud computing in supporting field experiences. In an education tool is developed based on cloud computing to create a course about image/video processing. Through mobile phones, learners can understand different algorithms used in mobile applications like de-blurring, de-noising, face detection, and image enhancement.

C. Mobile Healthcare

The purpose of applying MCC in medical applications is to minimize the limitations of traditional medical treatment which contains small physical storage, security and privacy, and medical errors. Mobile healthcare i.e. m-healthcare provides mobile users with convenient helps to access resources like patien health records easily and quickly. Besides, m-healthcare offers hospitals and healthcare organizations a variety of on-demand services on clouds.

The schemes of MCC applications in healthcare are:[18]

1) Health is monitor Comprehensively. This services enable patients to be monitored at anytime and anywhere through broadband wireless communications.
2) Intelligent emergency management system can manage and coordinate the fleet of emergency vehicles effectively and on the time when calls are receiving from accidents or incidents.
3) For Healthcare emergency system to alert health-aware mobile devices detect pulse-rate, blood pressure, and level of alcohol.
4) Access to healthcare information allows patients or healthcare providers to access the current and past medical information.
5) Pervasive lifestyle incentive management should be able to pay healthcare expenses and manage other related charges automatically .

Similarly, @HealthCloud, a prototype implementation of m-healthcare information management system is based on cloud computing and a mobile client running Android operating system.

D. Mobile Gaming

Mobile game is a potential market generating revenues for service providers of (m-game). M-game can completely offload game engine requires large graphic rendering computing resource to the server in the cloud, and gamers only interact with the screen interface on their devices. Offloading multimedia code can save energy for mobile devices, which increases game playing time on mobile devices. There are also the systems that enables fine-grained energy-aware offloading of mobile codes to a cloud. Also, number of experiments are conducted for evaluating the energy used for game applications with 3G and WiFi network. The results demonstrate that MAUI not only helps energy reduction significantly for mobile devices but also improves the performance of mobile applications.

A new cloud-based m-game using a rendering adaptation technique to dynamically adjust the game rendering parameters according to communication constraints and gamers' demands are also developed. The adaptation technique mainly bases on the idea to reduce the number of objects in the display list, Because not all objects in the display list created by game engine are necessary for playing the game and scales the complexity of operations. The main objective behind this is to maximize the user experience given the communications and computing costs.

E. Other Practical Applications

A cloud becomes a useful tool to help mobile users in many ways. By this, young generation share photos and video clips efficiently and tag their friends in popular social networks as Twitter and Facebook. An MCC application that enables mobile users to share real-time experience like travel, shopping, and event over clouds through an automatic blogging. Mostly travelers which are using mobiles, are supported by several cloud services such as guiding their trip, showing maps, recording itinerary, and storing images and video. A mobile locationing service allowing users to capture a short video clip about the surrounding buildings [19]. For that a matching algorithm is running on a cloud can uses large amount of information to search for a location of these buildings.

Another one is, One Hour Translation that provides an online translation.

service running on the cloud of AmazonWeb Services. This helps mobile users, especially foreign visitors, receive the information translated in their language through their mobile devices. A cloud becomes the most effective tool when mobile users require searching services, for searching information, location, images, voices, or video clips which are of different types.

1) *Keyword-based Searching*: This proposes an intelligent mobile search model that uses semantic in which searching tasks will be performed on servers in a cloud. This model can analyze the meaning of a word, a phrase, or a complex multi-phase to produce the results quickly and accurately.
2) *Voice-based Searching*: This technique perform a search service via a speech recognition in which mobile users just talk to microphone on their devices rather than typing on keypads or touchscreens.
(e.g., speak4it, iPizza, and JME local business search).

3) *Tag-based Searching*: This searching method introduces a photo searching technique based on ontological semantic tags. This service is designed for the images stored on private cloud computing environment. In the future, it is expected to expand this servise for searching images in a public cloud environment also.

VI. CONCLUSION

Clearly mobile cloud computing (MCC) will provide many exciting future with new opportunities and enable innovative applications to mobile users, mobile cloud vendors, and support different businesses also. It will definitely bring new computing models and infrastructures to build and deliver mobile services on mobile devices, and change the current ways. By this the delivery of mobile enabled computing resources, applications, and services to mobile users should get change. Meanwhile, there is possibility that, it will impact the ways on how to deliver, store, retrieve, process, and share mobile data and resource on mobile devices for business and private settings. These changes and impacts are put for forward new research issues and topics for both academic and industry communities.

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