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Survey on Mobile Cloud Computing

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Abstract: ***Cloud services can greatly enhance the computing capability of mobile devices. Mobile users can rely on the cloud to perform computationally intensive operations such as searching, data mining, and multimedia processing. In this paper, we propose a new mobile cloud framework called MobiCloud. In addition to providing traditional computation services, MobiCloud also enhances the operation of the ad hoc network itself by treating mobile devices as service nodes. The MobiCloud framework will enhance communication by addressing trust management, secure routing, and risk management issues in the network. A new class of applications can be developed using the enhanced processing power and connectivity provided by MobiCloud. Open research issues for MobiCloud are also discussed to outline future research directions.***

Keywords: MCC, SAAS, PAAS, IAAS, BTS

1. Introduction

We know that mobile devices are constrained by their processing power, battery life and storage. However, cloud computing provides an illusion of infinite computing resources. Mobile cloud computing is a new platform combining the mobile devices and cloud computing to create a new infrastructure, whereas cloud performs the heavy lifting of computing-intensive tasks and storing massive amounts of data. In this new architecture, data processing and data storage happen outside of mobile devices.

a) **Trends and demands**: customers expect the convenience of using companies websites or application from anywhere and at anytime. Mobile devices can provide this convenience. Enterprise users require always-on access to business applications and collaborative services so that they can increase their productivity from anywhere, even when they are on the commute.
b) **Improved and increased broadband coverage:** 3G and 4G along with WiFi, femto-cells, fixed wireless and so on are providing better connectivity for mobile devices.
c) **Enabling technologies:** HTML5, CSS3, hypervisor for mobile devices, cloudlets and Web 4.0 will drive adoption of mobile cloud computing.
d) **Security :** Along with these features security is needed at any cost. Cloud brokers sell their cloud storage to public however the cloud storage is needed to be very effective and robust.

The mobile cloud is Internet-based data, applications and related services accessed through smart phones, laptop computers, tablets and other portable devices. Mobile cloud computing is differentiated from mobile computing in general because the devices run cloud-based web apps rather than native apps. Users subscribe to cloud services and access remotely stored applications and their associated data over the Internet. Typically, mobile devices run a mix of Web-based and native apps. However, the trend is increasingly toward the mobile cloud. According to ABI Research, the number of mobile cloud computing subscribers is expected to reach 998 million by 2014.With the development of cloud computing and mobility, mobile cloud computing has emerged and become a focus of research. By the means of on-demand self-service and extendibility, it can offer the infrastructure, platform, and software services in a cloud to mobile users through the mobile network. Security and privacy are the key issues for mobile cloud computing applications, and still face some enormous challenges. In order to facilitate this emerging domain, we firstly in brief review the advantages and system model of mobile cloud computing, and then pay attention to the security and privacy in the mobile cloud computing. By deeply analyzing the security and privacy issues from three aspects: mobile terminal, mobile network and cloud, we give the current security and privacy approaches.

Rest of the paper is organized as follows. Section 2 presents the overview of mobile cloud computing. Section 3 presents the advantages of mobile cloud computing. Section 4 covers the applications of MCC. Section 5 gives the security requirements. Section 6 concludes the paper.

2. Overview of Mobile Cloud Computing

The term “mobile cloud computing” was introduced not long after the concept of “cloud computing” launched in mid-2007 [1]. It has been attracting the attentions of entrepreneurs as a profitable business option that reduces the development and running cost of mobile applications, of mobile users as a new technology to achieve rich experience of a variety of mobile services at low cost, and of researchers as a promising solution for green IT [7]. The Mobile Cloud Computing Forum defines MCC [8] as “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 [5] 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.

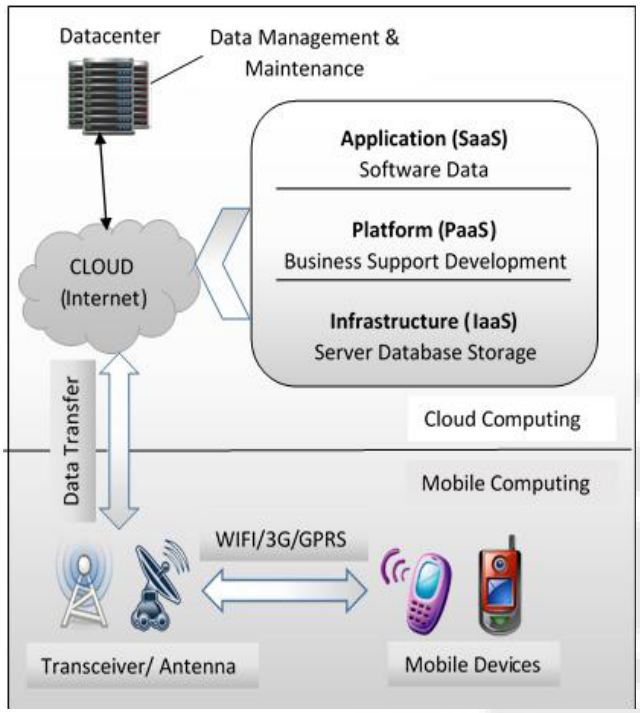
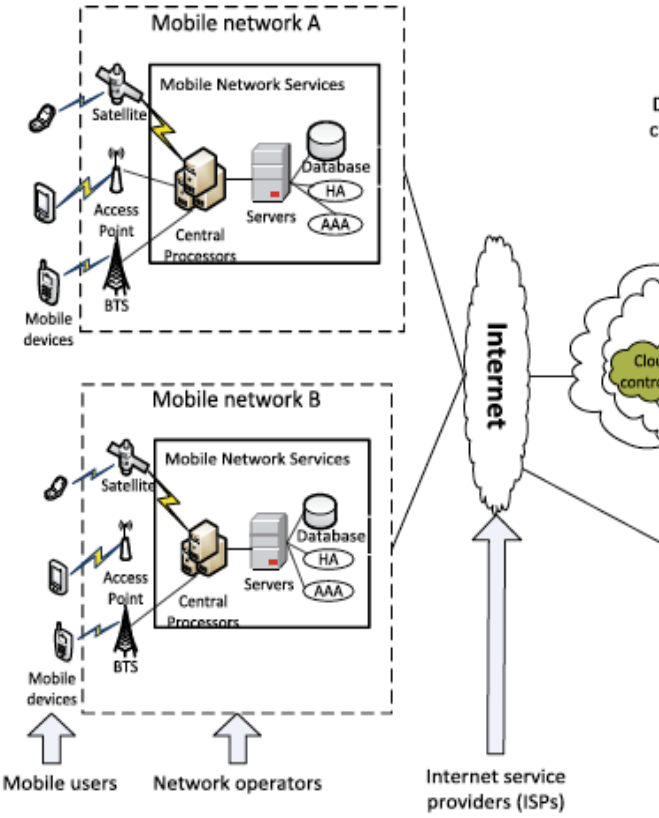
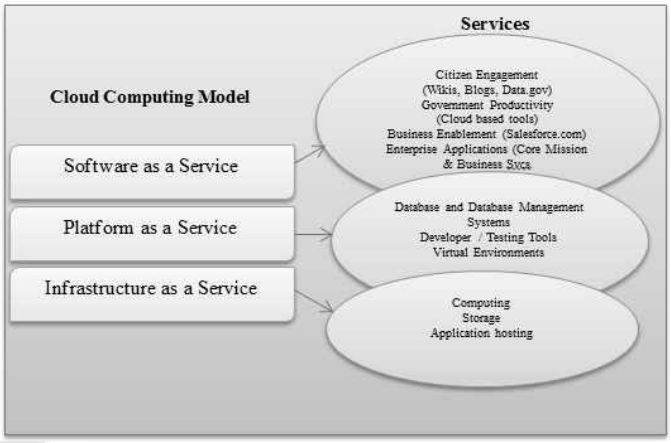


Figure 1.1: Architecture of Mobile Cloud Computing



Mobile devices are connected to the mobile networks via base stations (base transceiver station (BTS), accesspoint, or satellite) that establish and control the connections and functional interfaces between the networks and mobile devices.Mobile users requests and information (ID and location) 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 AAA (for authentication, authorization, and accounting) based on the home agent (HA) and subscribers data stored in databases. Then subscribers requests are delivered to a cloud through the Internet. In the cloud, cloud controllers process the requests to provide mobile users with the corresponding cloud services. Generally, a cloud computing is a large scale distributed network system implemented based on a number of data centers. The cloud services are based on a layer concept

3. Cloud Computing Models



- **SAAS**: To use the provider's applications running on a cloud infrastructure and accessible from various client devices through a thin client interface such as web browser.
- **PAAS**: To deploy onto the cloud infrastructure consumer created application using programming languages and tools supported by the provider.
- **IAAS:** To provision processing, storage, networks and other fundamental computing resources where consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

4. Advantages of Mobile Cloud Computing

Cloud computing is known to be a promising solution for mobile computing due to many reasons (e.g., mobility, communication, and portability . In the following, we describe how the cloud can be used to overcome obstacles in mobile computing, thereby pointing out advantages of MCC [1].

1) **Extending battery lifetime**: Battery is one of the main concerns for mobile devices. Several solutions have been proposed to enhance the CPU performance [8], and to manage the disk and screen in an intelligent manner [10], to reduce power consumption. However, these solutions require changes in the structure of mobile devices, or they require a new hardware that results in an increase of cost and may not be feasible for all mobile devices. Computation offloading technique is proposed with the objective to migrate the large computations and complex processing from resource-limited devices (i.e., mobile devices) to resourceful machines (i.e., servers in clouds). This avoids taking a long application execution time on

mobile devices which results in large amount of power consumption. [11]evaluate the effectiveness of offloading techniques through several experiments. The results demonstrate that the remote application execution can save energy significantly. Especially, evaluates large-scale numerical computations and shows that up to 45% of energy consumption can be reduced for large matrix calculation. In addition, many mobile applications take advantages from task migration and remote processing. For example, offloading a compiler optimization for image processing [12] can reduce 41% for energy consumption of a mobile device. Also, using memory arithmetic unit and interface (MAUI) to migrate mobile game components [13] to servers in the cloud can save 27% of energy consumption for computer games and 45% for the chess game.

2) **Improving data storage capacity and processing power:** Storage capacity is also a constraint for mobile devices. MCC is developed to enable mobile users to store/access the large data on the cloud through wireless networks. First example is the Amazon Simple Storage Service (Amazon S3) [14] which supports file storage service. Another example is Image Exchange which utilizes the large storage space in clouds for mobile users [15]. This mobile photo sharing service enables mobile users to upload images to the clouds immediately after capturing. Users may access all images from 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. Flickr and ShoZu are also the successful mobile photo sharing applications based on MCC. Facebook is the most successful social network application today, and it is also a typical example of using cloud in sharing images. MCC also helps reducing the running cost for compute-intensive applications that take long time and large amount of energy when performed on the limited-resource devices. Cloud computing can efficiently support various tasks for data warehousing, managing and synchronizing multiple documents online. For example, clouds can be used for transcoding, playing chess or broadcasting multimedia services to mobile devices. In these cases, all the complex calculations for transcoding or offering an optimal chess move that take a long time when perform on mobile devices will be processed quickly on the cloud. Mobile applications also are not constrained by storage capacity on the devices because their data now is stored on the cloud.
3) **Improving reliability:** Storing data or running applications on clouds is an effective way to improve the reliability since the data and application are stored and backed up on a number of computers. This reduces the chance of data and application lost on the mobile devices. In addition, MCC can 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 (e.g., video, clip, and music) from being abused and unauthorized distribution [16]. Also, the cloud can remotely provide to mobile users with security services such as virus scanning, malicious code detection, and authentication [17]. Also, such cloud-based security services can make efficient use of the collected record from different users to improve the effectiveness of the services.

5. Applications of Mobile Cloud Computing

Mobile applications gain increasing share in a global mobile market. [1]Various mobile applications have taken the advantages of MCC. In this section, some typical MCC applications are introduced.

Mobile Commerce: Mobile commerce (m-commerce) is a business model for commerce using mobile devices. The m-commerce applications generally fulfill some tasks that require mobility (e.g., mobile transactions and payments, mobile messaging, and mobile ticketing). The m-commerce applications can be classified into a few classes including finance, advertising and shopping. The m-commerce applications have to face various challenges (e.g., low network bandwidth, high complexity of mobile device configurations, and security). Therefore, m-commerce applications are integrated into cloud computing environment to address these issues. [18] Proposes a 3G E-commerce platform based on cloud computing. This paradigm combines the advantages of both 3G network and cloud computing to increase data processing speed and security level [19] 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. In [20], a 4PL-AVE trading platform utilizes cloud computing technology to enhance the security for users and improve the customer satisfaction, customer intimacy, and cost competitiveness.

Mobile Learning: Mobile learning (m-learning) is designed based on electronic learning (e-learning) and mobility. However, traditional m-learning applications have limitations in terms of high cost of devices and network, low network transmission rate, and limited educational resources [21]. Cloud-based m-learning applications are introduced to solve these limitations. 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 (information) size, faster processing speed, and longer battery life. [22] Presents benefits of combining m-learning and cloud computing to enhance the communication quality between students and teachers. In this case, a smartphone software based on the open source JavaME UI framework and Jaber for clients is used. Through a 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. In addition, a contextual m-learning system based on IMERA platform [23] shows that a cloud-based m-learning system helps learners access learning resources remotely. Another example of MCC applications in learning is "Cornucopia" implemented for researches of undergraduate genetics students and "Plantations Pathfinder" designed to supply information and provide a collaboration space for visitors when they visit the gardens. The purpose of the deployment of these applications is to help the students enhance their understanding about the appropriate design of mobile cloud

computing in supporting field experiences. In [24], an education tool is developed based on cloud computing to create a course about image/video processing. Through mobile phones, learners can understand and compare different algorithms used in mobile applications (e.g., de-blurring, de-noising, face detection, and image enhancement).

6. Mobile Healthcare

The purpose of applying MCC in medical applications is to minimize the limitations of traditional medical treatment (e.g., small physical storage, security and privacy, and medical errors [25],. Mobile healthcare (m-healthcare) provides mobile users with convenient helps to access resources (e.g., patient health records) easily and quickly. Besides, m-healthcare offers hospitals and healthcare organizations a variety of on-demand services on clouds rather than owning standalone applications on local servers. There are a few schemes of MCC applications in healthcare. For example [26] presents five main mobile healthcare applications in the pervasive environment. Comprehensive health monitoring services enable patients to be monitored at anytime and anywhere through broadband wireless communications. Intelligent emergency management system can manage and coordinate the fleet of emergency vehicles effectively and in time when receiving calls from accidents or incidents. Health-aware mobile devices detect pulse-rate, blood pressure, and level of alcohol to alert healthcare emergency system. Pervasive access to healthcare information allows patients or healthcare providers to access the current and past medical information. Pervasive lifestyle incentive management can be used to pay healthcare expenses and manage other related charges automatically . Similarly, [27] proposes @Health Cloud, a prototype implementation of m-healthcare information management system based on cloud computing and a mobile client running Android operating system (OS). This prototype presents three services utilizing the Amazon's S3 Cloud Storage Service to manage patient health records and medical images. Seamless connection to cloud storage allows users to retrieve, modify, and upload medical contents (e.g., medical images, patient health records and biosignals) utilizing web services and a set of available APIs called REST. Patient health record management system displays the information regarding patients' status, related bio-signals and image contents through application's interface. Image viewing support allows the mobile users to decode the large image files at different resolution levels given different network availability and quality. D. Mobile Gaming Mobile game (m-game) is a potential market generating revenues for service providers. M-game can completely offload game engine requiring large computing resource (e.g., graphic rendering) to the server in the cloud, and gamers only interact with the screen interface on their devices. [28] demonstrates that offloading (multimedia code) can save energy for mobile devices, thereby increasing game playing time on mobile devices. [13] proposes MAUI (memory arithmetic unit and interface), a system that enables fine-grained energy-aware offloading of mobile codes to a cloud. Also, a number of experiments are conducted to evaluate the energy used for game applications with 3G network and WiFi network. It is found that instead of offloading all codes to the cloud for processing, MAUI partitions the application codes at a runtime based on the costs of network communication and CPU on the mobile device to maximize energy savings given network connectivity.

7. Security Requirements

Security measures assumed in the cloud must be made available to the customers to gain their trust. There is always a possibility that the cloud infrastructure is secured with respect to some requirements and the customers are looking for a different set of security. The important aspect is to see that the cloud provider meets the security requirements of the application and this can be achieved only through 100% transparency. Open Cloud Manifesto exerts stress on transparency in clouds, due the consumer's apprehensions to host their applications on a shared infrastructure, on which they do not have any control. Access control is a key concern, because insider attacks are a huge risk. A potential hacker is someone who has been entrusted with approved access to the cloud. Anyone considering using the cloud needs to look at who is managing their data and what types of controls are applied to these individuals. User identity will have identifiers or attributes that identity and define the user. The identity is tied to a domain, but is portable. There must be a strong authentications and ID Management for both the cloud provider and the client. In order for the clients to access the cloud computing services, it must be first authenticated, not only using a mere username and password but a digital ID's.

8. Conclusion and Future Scope

Mobile cloud computing is one of mobile technology trends since it compile the advantages of both mobile computing and cloud computing. Cloud computing brought many benefits in computing world. Along with these benefits, there are some security issues that needs to be address to give assurance that indeed it is safe and reliable internet service. In this paper we discussed the overview of cloud computing it's applications and security requirements of mobile cloud computing. It is essential to keep in mind that the designing of future framework solutions should be more cost effective and should provide security against unauthorized acess.

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