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Mobile Cloud Computing

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Abstract: Together with an explosive growth of the mobile applications and emerging of cloud computing concept, mobile cloud computing (MCC) has been introduced to be a potential technology for mobile services. MCC integrates the cloud computing into the mobile environment and overcomes obstacles related to the performance (e.g., battery life, storage, and bandwidth), environment (e.g., heterogeneity, scalability, and availability), and security (e.g., reliability and privacy) in mobile computing. MCC has become one of the industry buzz words and a major discussion thread in the IT world since 2009. As MCC is still at the early stage of development, it is necessary to grasp a thorough understanding of the technology in order to point out the direction of future research. This paper gives a survey of MCC, which helps general readers have an overview of the MCC including the definition, architecture, applications, recent research work, and future research trends. The issues, existing solutions and approaches are presented.

Keywords: Mobile Cloud Computing, API, Femtocell, Conecloud, MSP, CSP.

INTRODUCTION

Over the last few years, there have been an increased number of applications that have migrated to the cloud, and new cloud-based applications that have become popular .As a major application model in the era of the Internet, Cloud Computing has become a significant research topic of the scientific and industrial communities. The end mobile device user will eventually be the benefactor of the Mobile Cloud Computing. Nature of cloud applications also is advantageous for users since they do not need to have very technical hardware to run applications as these computing operations are run within the cloud. This reduces the price of mobile computing to the end users. They could see a huge number of new features enhancing their phones due to Mobile Cloud Computing. Meanwhile, various applications based on mobile cloud computing have been developed and served to users, such as Google's Gmail, Maps and Navigation systems for Mobile, Voice Search, and some applications on an Android platform, MobileMe from Apple, Live Mesh from Microsoft, and MotoBlur from Motorola. According to a research, the cloud computing based mobile software and application are expected to rise 88% annually from 2009 to 2014, and such growth may create US 9.5 billion dollars in 2014.

CONCEPT AND PRINCIPLE

The Mobile Cloud Computing Forum defines MCC 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 smart phone users but a much broader range of mobile subscribers".

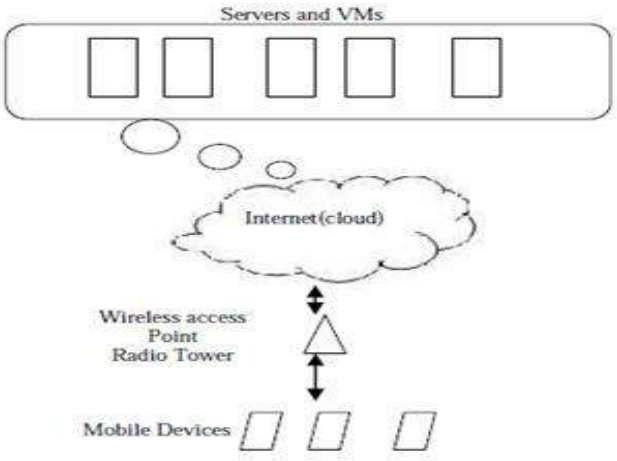
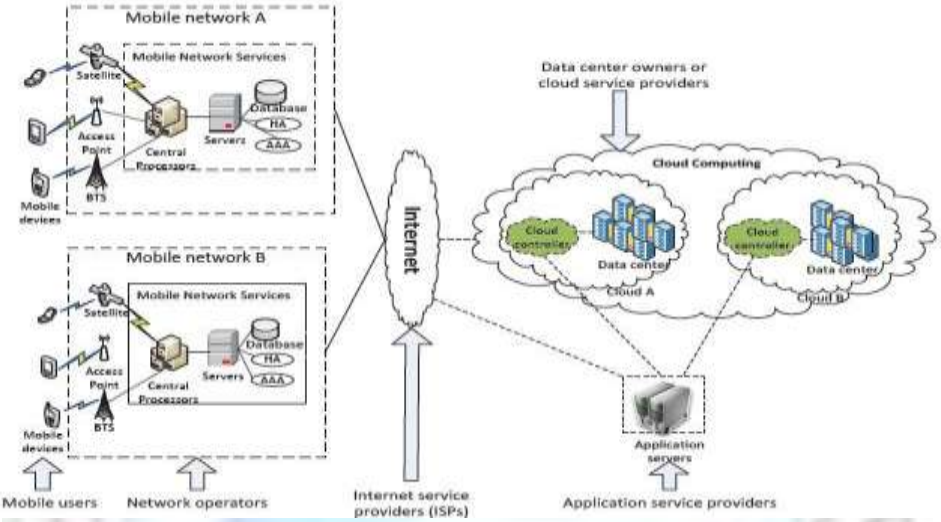


Fig.1: Mobile Cloud Computing

On one hand, the mobile cloud computing is a development of mobile computing, and an extension to cloud computing. In mobile cloud computing, the previous 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 mode of mobile applications have been totally changed. On the other hand, the terminals which people used to access and acquire cloud services are suitable for mobile devices like Smartphone, PDA, Tablet, and iPad but not restricted to fixed devices (such as PC), which reflects the advantages and original intention of cloud computing. 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.

ARCHITECTURE



The general architecture of MCC proposed can be shown in the figure. Mobile devices are connected to the mobile networks via base stations (e.g., base transceiver station (BTS), access point, or satellite) that establish and control the connections (air links) and functional interfaces between the networks and mobile devices. Mobile user's requests and information (e.g., 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 (Authentication, Authorization, and Accounting) based on the home agent (HA) and subscriber's data stored in databases. After that, the subscriber's requests are delivered to a cloud through the Internet. In cloud, the cloud controllers process the requests to provide mobile users with the corresponding cloud services. These services are developed with the concepts of utility computing, virtualization, and service oriented architecture (eg.web application, and database servers).

KEY REQUIREMENTS

From the perspective of the enterprise solution provider or web/mobile application developer, the objectives of the Mobile Cloud Computing platform are:

1. Simple application programming interfaces (APIs) offering transparent access to mobile services, and requiring no specific knowledge of underlying network technologies.

2. The ability to deploy applications across multiple carrier networks, under a single commercial agreement.

3. Seamless handling of each carrier's specific network policy, such as chosen mobile subscriber confirmed opt-in / confirmed opt-out and privacy management principles.

ADVANTAGES

Mobile cloud computing is one of the mobile technology trends in the future since it combines the advantages of the integration of both mobile computing and cloud computing, thereby providing optimal services for mobile users.

1) Extending battery lifetime

Battery is one of the main concerns for mobile devices. Several solutions have been proposed to enhance the CPU performance and to manage the disk and screen in an intelligent manner 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.

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) which supports file storage service. Another example 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 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. Also, the cloud can remotely provide to mobile users with security services such as virus scanning, malicious code detection, and authentication. Also, such cloud-based security services can make efficient use of the collected record from different users to improve the effectiveness of the services.

APPLICATIONS

A. 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.

B. 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. 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.

C. Mobile Health Care

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). 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.

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 demonstrates that offloading (multimedia code) can save energy for mobile devices, thereby increasing game playing time on mobile devices.

LIMITATIONS

Cloud Mobile Media (CMM) applications, unlike other cloud applications, will need to overcome the challenges of the wireless network, including limited bandwidth and impact on user experience. Moreover, many of the CMM applications will be very compute and network bandwidth intensive, and hence will have major implications on cloud and network costs incurred per user, and the ability to scale to millions of users as mobile cloud computing becomes popular. In this section, we discuss in more details about the challenges.

A. Cloud Service Cost and Scalability

One of the primary advantages of using cloud services is to eliminate capital expenses, and depend on the elasticity of cloud computing, and the cloud utility or on-demand pricing model, to scale to varying capacity needs. However, as we show in this section, there will be challenges faced by computing and bandwidth intensive CMM applications like cloud based mobile gaming, in terms of prohibitively high operating expenses when using on-demand cloud pricing models.

B. Mobile Network Cost and Scalability

Besides the potentially high cloud operating expenses, and cloud scalability concern, CMM applications can have very high demand on wireless network bandwidth, having implications on the capacity of the mobile networks, in particular during peak demand periods, potentially negatively impacting network latency, packet loss, and response time, with the consequent negative impact on user experience. Moreover, the high wireless bandwidth requirement may prohibitively increase the wireless data bills of mobile users, making CMM applications impractical.

C. Availability

Service availability becomes more important issue in MCC than that in the cloud computing with wired networks. Mobile users may not be able to connect to the cloud to obtain service due to traffic congestion, network failures, and the out-of-signal.

D. Heterogeneity

MCC will be used in the highly heterogeneous networks in terms of wireless network interfaces. Different mobile nodes access to the cloud through different radio access technologies such as WCDMA, GPRS, WiMAX, CDMA2000, and WLAN. As a result, an issue of how to handle the wireless connectivity while satisfying MCC's requirements arises (e.g., always-on connectivity, on-demand scalability of wireless connectivity, and the energy efficiency of mobile devices).

E. Issues in computing offloading

Offloading is one of the main features of MCC to improve the battery lifetime for the mobile devices and to increase the performance of applications. However, offloading is not always the effective way to save energy. For a code compilation, offloading might consume more energy than that of local processing when the size of codes is small. For example, when the size of altered codes after compilation is 500KB, offloading consumes about 5% of a device's battery for its

communication while the local processing consumes about 10% of the battery for its computation. In this case, the offloading can save the battery up to 50%. However, when the size of altered codes is 250KB, the efficiency reduces to 30%. When the size of altered codes is small, the offloading consumes more battery than that of local processing.

F. Security for Mobile Users

Mobile devices such as cellular phone, PDA, and Smartphone are exposed to numerous security threats like malicious codes (e.g., virus, worm, and Trojan horses) and their vulnerability. In addition, with mobile phones integrated global positioning system (GPS) device, they can cause privacy issues for subscribers.

CONCLUSION

Mobile cloud computing is one of mobile technology trends in the future since it combines the advantages of both mobile computing and cloud computing, thereby providing optimal services for mobile users. According to a recent study, more than 240 million businesses will use cloud services through mobile devices by 2015. That traction will push the revenue of mobile cloud computing to $5.2 billion. With this importance, this article has provided an overview of mobile cloud computing in which its definitions, architecture, and advantages have been presented.

The applications supported by mobile cloud computing including mobile commerce, mobile learning, and mobile healthcare have been discussed which clearly show the applicability of the mobile cloud computing to a wide range of mobile services. Then, the issues and related approaches for mobile cloud computing (i.e., from communication and computing sides) have been discussed. Finally, the future research directions have been outlined.

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