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Mobile Cloud Computing: Open Issues

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ABSTRACT
Fast advancement in mobile computing and cloud computing brings new paradigm shift from conventional mobile computing services to Mobile Cloud Computing.MCC will provide many exciting new opportunities and innovative applications to mobile users, mobile cloud vendors, and businesses It is believed that mobile cloud computing will completely change the current way of delivering mobile computing and communication services to global mobile users and also alter their working and life styles with seamless global mobile resource sharing and accesses. This paper presents an overview of MCC, its architecture and various issues related to MCC.

Keywords: *Mobile Computing ;Cloud Computing; Access Point*

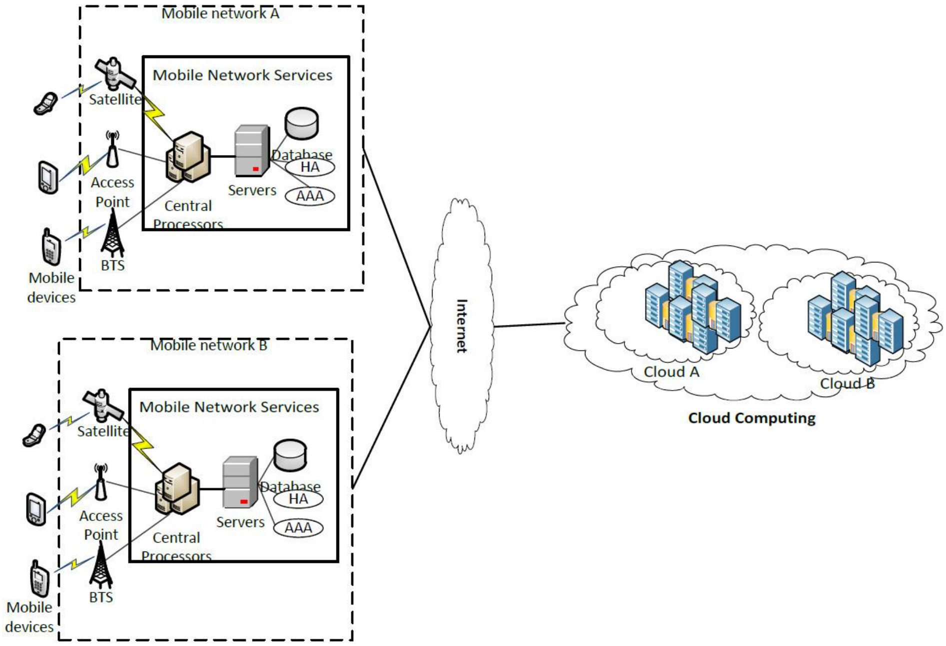
1. Introduction

Smartphones are capable of supporting wide range of applications. Although there is explosive growth of the mobile applications but its potential is still underutilized due to its inherent problems such as resource scarcity, frequent disconnections, and mobility[1]. Cloud computing is known to be a promising solution for mobile computing since cloud can be used to overcome obstacles in mobile computing .
Cloud computing (CC) which gives its users the possibility to host and deliver services over the internet by dynamically providing computing resources[10].Cloud Computing is a type of computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications. Cloud computing can be considered as a model that can provide network access to a shared pool of resources, such as storage and computing power, that can be rapidly provisioned and released with minimal management effort. Cloud Computing helps in energy saving by consolidating local network software, pictures, videos, emails and documents on remote servers than keeping them on personal computers [2]. Cloud computing (CC) has been widely recognized as the next generation's computing infrastructure.

2. Mobile Cloud Computing

Mobile Cloud Computing can be defined as integration of two computing technologies mobile web and cloud computing. Mobile Cloud Computing (MCC) is to extend cloud computing functions, services and results to the world of future mobile applications. MCC will solicit research beyond the scopes of traditional Internet Clouds or Mobile Computing technologies .Mobile Cloud Computing, refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device[9]. 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". [4]: Unlike mobile computing, mobile cloud computing leverages emergent cloud infrastructures and resources to deliver innovative mobile cloud infrastructures, platforms, and software-as-as-services, as well as mobile enabled applications services to global mobile device users at any-time and anywhere. It allows mobile users to use low-end mobile devices to access diverse and scalable cloud computing resources (such as IaaS, PaaS, SaaS, and DaaS) and globally connected mobile enabled resources (such as, devices, tags/barcodes/sensors, and wireless networks) to receive unlimited mobile application services.

2.1. Architecture of MCC



In above 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 users' requests and information (e.g., ID and location) are transmitted to the central processors that are connected to servers providing mobile network services[7]. 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. After that,the 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. These services are developed with the concepts of utility computing, virtualization, and service-oriented architecture (e.g.,web, application, and database servers).

2.2. Advantages of MCC are

a) **tending battery lifetime**:
Battery is one of the main concerns for 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.

b) **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.

c) **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.

d) **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.

e) **Scalability:**

The deployment of mobile applications can be performed and scaled to meet the unpredictable user demands due to flexible resource provisioning.

f) **Multi-tenancy**:
Service providers (e.g., network operator and data center owner) can share the resources and costs to support a variety of applications and large number of users.

g) **Ease of Integration:**
Multiple services from different service providers can be integrated easily through the cloud and the Internet to meet the users' demands.

2.3. Applications of Mobile Cloud Computing

Mobile applications gain increasing share in a global mobile market. Various mobile applications have taken the advantages of MCC. Some typical MCC applications are

a) **Mobile Commerce**
Mobile commerce (m-commerce) is a business model for commerce using mobile devices.

b) **Mobile Learning**
Mobile learning (m-learning) is designed based on electronic learning (e-learning) and mobility.

c) **Mobile Healthcare**
The purpose of applying MCC in medical applications is to minimize the limitations of traditional medical treatment

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.

2.4. Various Issues Related to Mobile Cloud Computing

The mobile usage of cloud computing services is still in the early stages of development and several open issues need to be addressed. With the mobility of users and their devices, several problems arise that need to be taken into account, when making use of cloud computing services on mobile devices.

a. **Mobility and resource discovery**
The first being, that cloud computing resources are widely spread around the globe and offer a lot of different services to their users. Mobile devices that want to make use of those resources should be able to automatically discover cloud computing resources that preferably are nearby their current location.

b. **Supporting continuous mobility while ensuring connectivity to the cloud:**
While mobile devices connecting to remote cloud servers to run apps such as Google translate can connect while mobile, this depends on the user's 3G connection. Even if the reception is sufficient, data costs and latency has a huge impact on these kinds of mobile cloud computing apps.

c. **Technical characteristics**
The offloading of computer-intensive applications onto ubiquitous, (theoretically) unlimited computing resources in the 'cloud,' requires special considerations in network design and application deployment.Cloud service 'distance' matters (especially for immersive applications). The latency of a mobile broadband network, or the service distance to access application or content, is typically 'long.' With the trend toward data center consolidation among large enterprises and major Internet content providers, content and application sources are often located far away from end devices. This 'long' service distance is more pronounced for mobile devices, where 'last mile' network latency in terms of round trip time can be 200 ms (versus 50 ms for fixed networks). On top of longer latency and lower throughput (25 Mb/s nominal data rate for fiber versus 2 Mb/s for HSDPA), mobile broadband networks generally require longer execution times for a given application to run in the cloud.
Although network latency of 200 ms may not be so noticeable for web browsing, it becomes critical for highly interactive and immersive applications, where even modest network latency can result in a noticeably degraded user experience. Similarly, for content-heavy applications like video streaming, transmission delays at 2 Mb/s (HSDPA) versus 25 Mb/s (fiber) can be quite significant; for example, 40 seconds against 3.2 seconds to stream a 5-minute, 10MB video at standard YouTube quality. For cloud services, especially those requiring highly immersive user interactions, content/application data centers must be close to end users to alleviate bandwidth and latency issues.

d. **Overhead due to use of cloud**

Along with the remote execution of application parts comes the problem that those parts need to be transferred to the cloud resource first, before an execution can take place. The overhead produced by this transfer also needs to be taken into account, when dealing with computation offloading and possibly related time and energy savings.

e. **Reliability**

The ability of the cloud computing system to perform and maintain providing its resources under unexpected failures, of e.g., storage, network connectivity and computing power, for a supported predefined amount of time. This ability can be by e.g., (1) supporting replication of objects and services, (2) using redundant communication (more than one communication paths used for the dissemination of the same information), (3) using redundant processing (more than one processing entities used to process the same action).

f. **Scalability**

The ability of the cloud computing system to expand the amount of resources and services to large scales to satisfy rapid increases in service demand. This ability can be satisfied by e.g., (1) support for massive sharing of content, (2) flexible, fault-tolerant and distributed data bases, (3) fast and consistent content replication support.

g. **Data Ownership**

Another issue that arises from mobile cloud computing relates to the ownership of purchased digital media. With cloud computing it becomes possible to store purchased media files, such as audio, video or e-books remotely rather than locally. This can lead concerns regarding the true ownership of the data. If a user purchases media using a given service and the media itself is stored remotely there is a risk of losing access to the purchased media. The service used could go out of business, for example, or could deny access to the user for some other reason.

h. **High availability**

The ability of the cloud computing system to provide and support a large amount of different resources that are easily accessible and that are operating in optimal performance conditions for a predefined agreed amount of time.

i. **Security and privacy**

The ability of the cloud computing system to protect itself and its provided resources from security and privacy attacks. Different security and privacy aspects need to be considered when running foreign code on remote resources that maybe also used by several users at the same time [8]. The main security solutions are e.g., related to (1) data integrity, where the unauthorized modification of information incoming and outgoing the cloud should be detected, (2) confidentiality to secure the data access and transfer. The main privacy solutions should ensure that the identity of the cloud computing clients should not be revealed to unauthorized entities.

j. **Limited battery life**

Another significant barrier in mobile cloud computing is the limited battery life of mobile devices. Smartphones are often charged daily, based on moderate use of messaging, web browsing, phone calls and accessing social networking and other Internet applications. The forecast increase in mobile computing and display technologies makes the use of more sophisticated and immersive applications highly likely, based on past trends. Given the unlikelihood of significant leaps in battery technology, it is crucial to consider battery-saving strategies in the context of more sophisticated and immersive applications running on mobile devices.In general, more execution in the cloud means more battery savings, as the application execution burden is offloaded. For any application, however, execution offload is linked to device functions and cannot be completely transferred to the cloud. For instance, user-facing functions like user/sensor input and display output naturally need to run on the device.For immersive applications, execution offload flexibility is even more constrained, as separate application functions running on servers and devices are tightly coupled. For this reason, the battery-saving strategy for immersive applications typically comes down to finding the least costly path to the cloud servers and minimizing latency to maintain high interactivity. For smartphones, Wi-Fi represents the less costly path, with 23% less energy consumption versus GPRS in a web browsing scenario.[3] If maintaining the GPRS connection can be discounted (for example, for non-phone devices like tablets), then the power consumption of GPRS versus Wi-Fi is even more stark, with Wi-Fi using just one third of the energy of GPRS.

3. Cloud application feasibility matrix

An application fit for a certain mobile cloud infrastructure can be gauged, based on application requirements against the cloud infrastructure characteristics along the compute, network bandwidth and latency vectors (Table 1).

Applications	Cloud infrastructure attributes: Compute intensity (High – required for compute-intensive apps)	Network bandwidth (High – required for content-heavy, large data transfer apps)	Network latency (Low – required for high interactivity
Web-mail (Yahoo!, gmail)	Low	Low	High
Social networking (Facebook)	Low	Medium	Medium
Web browsing	Low	Low	High
Online gaming	High	Medium	Low
Augmented reality	High	Medium	Low
Face recognition	High	Medium	Low
HD video streaming	High	High	Low
Language translation	High	Medium	Low

Table 1. Application and cloud infrastructure mapping

For example, loosely coupled, low-content applications like web search would likely work fine on a 3G network with relatively low compute servers at a 'distant' data center. In contrast, a hugely immersive and content-rich application like real-time face recognition would likely require a high-bandwidth/low-latency network like Long Term Evolution (LTE) to transfer large image content quickly between, and seamlessly interact with, the servers running the face recognition algorithm and the user-facing devices[8]. This type of high-demand application will require 'nearby' data centers to minimize transmission and latency delays. For a highly immersive application that requires very low latency, the mobile cloud infrastructure may even call for Wi-Fi offload to minimize latency further.

4. Conclusion

Mobile cloud computing aims to empower the mobile user by providing a seamless and rich functionality, regardless of the resource limitations of mobile devices. Although it is still in its infancy, mobile cloud computing could become the dominant model for mobile applications in the future resulting in new and interesting usage scenarios and offering execution speedups and energy savings to mobile

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