A Survey on Energy aware offloading Techniques for Mobile Cloud Computing

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Abstract— **Mobile Cloud computing is a new transdisciplinary research area based on traditional mobile computing and Cloud computing. MCC has inherited the high mobility, scalability, and become a hot research topic. We hope this paper will help interested researchers to get a better understanding of MCC definitions and architecture. It then analyses the core challenges of MCC: seamless connectivity, enhancing energy efficient offloading techniques and computing issues. This paper provides an overview of research areas to develop the capabilities of MCC.**

Keywords— **Mobile Computing, Cloud Computing, Offloading, Mobile cloud.**

I. Introduction

Smart phones and other mobile devices are heavily used in daily life as they are convenient communication tools. Mobile devices allow users to run powerful applications that take advantage of the growing availability mobile internet and number of mobile applications (mobile phones with dominate the pc's as the most common web access devices [1].Advancements in mobile computing technology have expanded the usage of desktops to a wide range of web access devices [1]. However, computation on mobile devices has some limitations. Mobile devices face many challenges in available resources. Like cpu, available memory, battery energy, consumption and bandwidth.

Cloud Computing (CC) technology that has emerged with the industry offers a solution to these problems. CC eliminates the requirement for users to plan ahead for acquiring different resources such as storage is compilation power. CC delivers its services over the internet by dynamically providing computer resources [2] with the explosion of mobile applications and the computing model has laid a foundation for well computing model called MCC. The client of MCC can access to unlimited computing power and storage space.

In this paper we describe what is mobile cloud computing (section II) and its architecture (section III) application of MCC (section IV). In (section V) current developments and research challenges outlined. Finally, we conclude the survey in (section VI).

II. Mobile Cloud Computing

Mobile Cloud Computing (MCC) is a blend of three foundations of Cloud Computing, Mobile Computing and networking [3]. Before we explore the research finding it is important to establish a common understanding of what "mobile cloud means. This section provides an overview of MCC including definitions architecture and applications.

A. Cloud Computing?

CC has become popular since 2007; many users feel that the PCs they bought cannot keep pace with the development of software now a days. They need higher speed cpu, a longer capacity hard disks and higher performance operating system. R.buya [4] define CC has the perspective of making that CC is a parallel and distributed capturing system. C.hewitt [5] defines the CC system is storing data on the cloud server and uses of cache memory technology in the client to fetch the data. CC is internet-based computing, where resources, softwares information are provided to captures and devices on demand. CC is a kind of distributed computing. In CC, the cloud is a group of computers or servers which are integrated together.

The national institute of standard and technology (NIST) of defines CC as a model for enabling convenient on-demand network access to a standard pool of configurable computing resources [6]. Some of the characteristics of CC are on-demand self service, broad network access and resource pooling.

CC provides multiple services of infrastructure as a service (IaaS), platform as a service (PaaS), software as a service (SaaS).cloud vendors provide services and APIs that intensify heterogeneity of cloud load scale and create interoperability.

B. Mobile Computing?

Mobile computing involves mobile communication, mobile hardware, and mobile software. Communication issues include ad-hoc and infrastructure networks as well as communication properties, protocols, data formats and concrete technologies. Hardware includes mobile devices or device components. Mobile software deals with the characteristics and requirements of mobile applications.

Mobile devices (e.g., Smartphone and tablet PC) are increasingly becoming an essential part of human life as the most effective and convenient communication tools not bounded by time and place. Mobile users accumulate rich experience of various services from mobile devices applications (e.g., iPhone apps and Google apps), which run on the devices and/or on remote servers via wireless networks. The rapid progress of mobile computing (MC) [8] becomes a powerful trend in the development of IT technology as well as commerce and industry fields. However, the mobile devices are facing many challenges in their resources (e.g., battery life, storage, and bandwidth) and communications (e.g., mobility and security) [9]. The limited resources significantly impede the improvement of service qualities.

C. What is Mobile Cloud Computing?

The term mobile cloud computing 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 [10].

Mobile cloud computing at its simplest refers to an infrastructure where both the data storage and 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 MC to not just Smartphone users but a much broader range of mobile subscribers.

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 [11]. These centralized applications are then accessed over the wireless connection based on a thin native client or web browser on the mobile devices.

III. ARCHITECTURE OF MCC

Mobile devices are connected to the mobile networks via base stations (e.g., base transceiver station, 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., IDand 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 authentication, authorization, and accounting based on the home agent 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. The details of cloud architecture could be different in different contexts.

For example, four-layer architecture is explained in [12] to compare cloud computing with grid computing. Alternatively, a service-oriented architecture, called Aneka, is introduced to enable developers to build. Microsoft .NET applications with the supports of application programming interfaces (APIs) and multiple programming models [13].

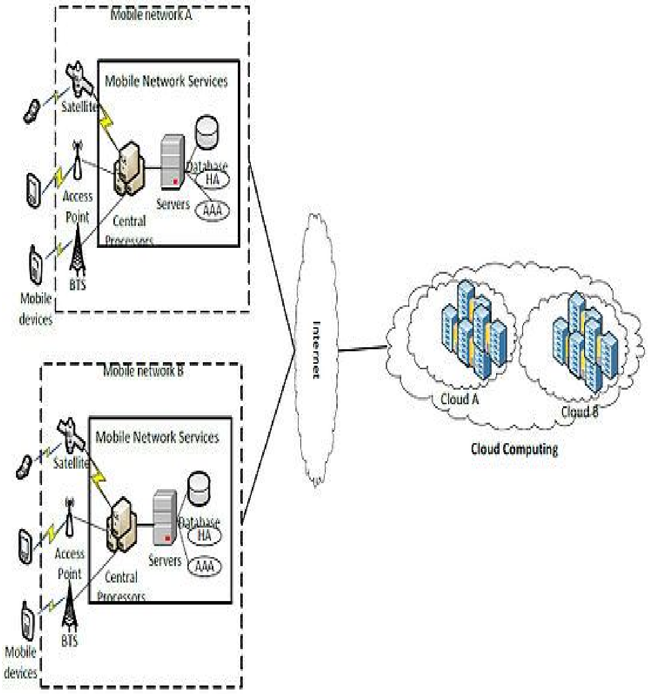

Fig.1: Architecture of Mobile Cloud Computing

IV. Applications of MCC

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

A. Mobile commerce

Mobile commerce (m-commerce) is a business model for commerce using mobile devices. The m-commerce applications generally fulfil some tasks that require mobility (e.g., mobile transactions and payments, mobile messaging, and mobile ticketing). The m-commerce applications can be classified into few classes including finance, advertising, and shopping. M-commerce applications are integrated into CC environment to address these issues. Yang *et al.*[14] proposes a 3G E-commerce platform based on CC. This paradigm combines the advantages of both third generation (3G) network and CC to increase data processing speed and security level [15] based on public key infrastructure (PKI).

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 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). Mobile healthcare (m-healthcare) provides mobile users with convenient helps to access resources (e.g., patient health records) easily and efficiently. 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 to the server in the cloud, and gamers only interact with the screen interface on their devices.

V. Computing issues in MCC

In mobile devices offloading the multimedia code increases the time for playing games by saving energy [17].Cuervo *et al.* [16] proposes a system that enables fine-grained energy aware offloading of mobile codes to a cloud. 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. The results demonstrate that MAUI not only helps energy reduction significantly for mobile devices, but also improves the performance of mobile applications.

A. Offloading in static environment

It is found that offloading the code is not always effective for saving energy [18]. For a code compilation, offloading might consume more energy than that of local processing when the size of codes is small.

A framework was proposed by Li Z et al [20] to facilitate task partitioning, in which a program is divided into server and client tasks. Statically, under our execution model, a task corresponds to a procedure (or a function) call site. Dynamically, a task is a single invocation of the corresponding procedure.

After the partitioning, all the tasks mapped to the same host can share the program state as they do in the original program. The issue of coherence arises, however, when one deals with data shared between two tasks which end up in different hosts. At the present, we maintain the program state coherence in a conservative way. A piece of data can be shared by both hosts only if the program transformations and message passing can guarantee the correct dependence.

Implementation of remote execution is prediction [21] and we must predict when the cost of performing remote execution will not outweigh its benefits. The cost of a remotely executed operation consists of the time to transfer data (and possibly code) from the device to the target, the time to transfer result information, e.g., data, status, rendered graphics, etc., from the target back to the device, and the time to execute the operation at the target. The cost of a locally executed operation is the local execution time. These costs can be decomposed or translated to consider other metrics, e.g., battery consumption, response time, application fidelity. However, regardless of their form, these values must reflect what the costs will be when the operation is eventually performed.

A new framework was proposed and it was consists of three components [22]: the mobile hosts, base station and a wireless channel. It is assumed that the server is AC-powered and has a much larger computational capability than the client. We also assume that the client services only its own local tasks and receives no request for remote processing from the server. This is a reasonable assumption since the AC-powered high-performance server is much more powerful from a processing point of view and has no energy limit, and thus it will execute its own tasks (in addition, it will execute tasks sent to it by the mobile hosts.) This also means that the server has all the hardware and software resources required to execute the tasks that are sent to it by the remote clients. Furthermore, for the same reasons, the server does not turn down any request for remote processing.

B. Offloading in dynamic environment

Dynamic offloading environment can cause additional problems due to changing connection status and bandwidth.

The analysis of performance in offloading in wireless environments [19] three cases was taken in executing an application, thereby estimating the efficiency of offloading. They are the cases when the application is performed locally (without offloading), performed in ideal offloading systems (without failures), and performed with the presence of offloading and failure recoveries. In the last case, when a failure occurs, the application will be re-offloaded. This approach only re-offloads the failed subtasks, thereby improving the execution time. However, this solution has some limitations. That is, the mobile environment is considered as a wireless ad hoc local area network (i.e., broadband connectivity is not supported). Also, during offloading execution, a disconnection of a mobile device is treated as a failure.

Mobile devices already have wireless communication capabilities, and we expect most future systems to have such capabilities. There are two main differences between mobile and desk-top computing systems, namely the source of the power supply and the amount of available resources. Mobile systems operate entirely on battery power most or all the time by Kremer U et al [23]. The resources available on a mobile system can be expected to be at least one order of magnitude less than those of a “wall-powered” desk-top system with similar technology. This fact is mostly due to space, weight, and power limitations placed on mobile platforms. Such resources include the amount and speed of the processor, memory, secondary storage, and I/O.

In implementing MAUI, Kremer U et al [23] discovered a number of unforeseen challenges to implementing program partitioning for mobile applications. One such challenge is that using power-save mode (PSM) when transferring state remotely can hurt the overall energy consumption of the application when the latency to the server is low. Moreover, PSM mode helps save energy but only when latencies approach the sleep interval (today's hardware uses 100 ms). Another unforeseen challenge is related to using profiling to estimate the energy savings of code offload. On one hand, profiling the state transfer overhead of a method each time it is called can provide the freshest estimate; on the other hand, the cost of this profiling is not negligible and it can impact the overall application's performance.

Power dissipation has become one of the crucial design challenges of current and future computer systems [23]. In a mobile environment, power savings are important to prolong battery life. Power and energy management addresses both of these issues. However, in the context, prolonging battery life is the main objective.

C. Low bandwidth

Although many researchers propose the optimal and efficient way of bandwidth allocation, the bandwidth limitation is still a big concern because the number of mobile and cloud users is dramatically increasing. We consider that fourth generation network and Femtocell are emerging as promising technologies that overcome the limitation and bring a revolution in improving bandwidth.

D. Quality of service

Mobile users need to access to servers located in a cloud when requesting services and resources in the cloud. However, the mobile users may face some problems such as congestion due to the limitation of wireless bandwidths, network disconnection, and the signal attenuation caused by mobile users' mobility. They cause delays when the users want to communicate with the cloud, so QoS is reduced significantly.

VI. CONCLUSIONS

Mobile cloud computing is one of the mobile technology trends in the future because it combines the advantages of both MC and CC, thereby providing optimal services for mobile users. That traction will push the revenue of MCC to $5.2 billion. With this importance, this article has provided an overview of MCC in which its definitions, architecture, and advantages have been presented. The applications supported by MCC including m-commerce, m-learning, and mobile healthcare have been discussed which clearly show the applicability of the MCC to a wide range of mobile services. Finally, the issues and related approaches for MCC (i.e., from communication and computing sides) have been discussed.

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