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Mobile Cloud Computing Perspectives and Challenges

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Abstract— Mobile Cloud Computing (MCC) is an infrastructure where the data and the processing of data are outsourced. The Mobile Cloud applications move the computing power and data storage away from the mobile devices and are processed in centralized computing platforms located in clouds over a wireless or radio connection [8]. MCC integrates cloud computing into the mobile environment and overcomes obstacles related to performance (e.g. battery life, storage, and bandwidth), environment (e.g. heterogeneity, scalability, availability) and security (e.g. reliability and privacy) [4]. This paper presents a review on the background and principle of MCC, characteristics, challenges and recent research work.

Keywords— Mobile cloud computing, Offloading, Challenges in MCC, Research areas in MCC

I. INTRODUCTION

In traditional computing, the Mainframe computers are expected to lead the future computing and were also used to implement various tasks and applications. But nowadays, the same task is been done in a flexible, cheaper and portable manner with the help of either desktop computer or mobile devices to a various connected servers called Cloud Computing System (CSS) [6]. Cloud computing allows users to use infrastructure, platforms & software by cloud providers at low cost and on-demand elastically. Cloud computing provides IT services and resources through public network specifically internet. The Cloud computing services and infrastructure are owned by a third party called Cloud Service Providers. Since mobility and ubiquity are the key features of the next generation network, a combination of electronic devices like smartphone, computing, resources are converging together to emerge as a new field of Mobile Cloud Computing[5].

Mobile Cloud Computing provides mobile users with all resource-intensive computing to be performed in clouds, without having the need to have a powerful configuration (such as CPU, Speed, Memory capacity etc.). According to a recent study by ABI Research, more than 240 million business will use cloud services through mobile devices by 2015. This traction will push the revenue of Mobile Cloud Computing is a highly promising trend for the future of Mobile Computing. Unlike conventional Mobile Computing, the Mobile Cloud Computing resources are virtualized and performed with numerous distributed computers rather than local computers or servers [8]. Many applications are developed on Mobile Cloud Computing basis and served to users, such as Google's gmail, Maps and Navigation system for mobile, Voice search on Android Platform, MobileMe from Apple, LiveMesh from Microsoft, Motoblur from Motorola and Amazon's Web Browser Silk etc [10].

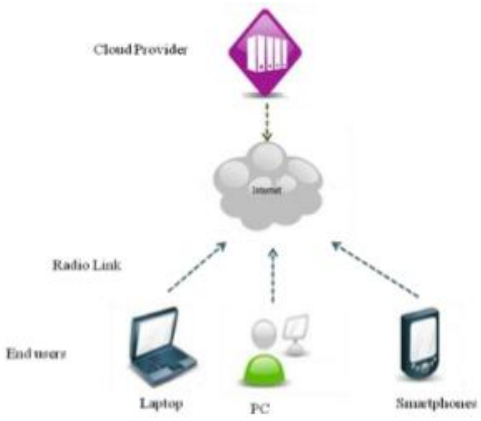

Fig. 1 Mobile Cloud Computing

II. BACKGROUND

As a development and extension of Cloud Computing and Mobile Computing, Mobile Cloud Computing, as a new phrase, has been coined since 2009. To better understand Mobile Cloud Computing, let's review the two previous techniques separately: Mobile Computing and Cloud Computing [1].

A. Mobile Computing

The design of small, powerful devices such as, smartphone, PDA, wearable computers, GPS Navigation and laptops enables mobility in wireless networks that supports a trend toward computing on the go with the help of wireless technology like WiMax, Ad Hoc Network and WIFI, known as mobile computing [12]. Satyanarayanan [11] describes the vision of mobile computing as "information at fingertips anywhere, anytime".

According to an Alcatel-Lucent Bell Labs analysis, 2.5 billion people or 35 percent population of the world will own at least one smartphone by 2015. It is not surprising that global mobile data traffic will grow thirteen-fold from 2012 to reach 134 Exabyte (1 followed by 18 zeros) in 2017, as CISCO finds [1].

1) Features of Mobile Computing:

i) Mobility: mobile nodes in mobile computing network can establish connection with other mobile nodes, even fixed nodes in wired network through Mobile Support Station (MSS) during their moving.
ii) Diversity of network conditions: The mobile node's networks are not unique, such networks can be a wired network with high-bandwidth, or a wireless Wide Area Network (WWAN) with low-bandwidth, or even in status of disconnected.
iii) Frequent disconnection and consistency: Due to the limitation of battery power, charge of wireless communication, network conditions and so on, mobile nodes will not always keep the connection, but disconnect and consistent with the wireless network passively or actively.
iv) Dis-symmetrical network communication: Servers and access points and other MSS enable a strong send/receive ability, while such ability in mobile nodes is quite weak comparatively. Thus, the communication bandwidth and overhead between downlink and uplink are discrepancy.
v) Low reliability: Since signals are susceptible to interference and snooping, a mobile computing network system has to be considered from terminals, networks, database platforms, as well as applications development to address the security issue [1].

2) Challenges: Due to the wireless environment and numerous mobile nodes, Mobile Computing network may face various problems and challenges in different aspects, such as signal disturbance, security, hand-off delay, limited power, low computing ability, and so on. In addition, the Quality of Service (QoS) in mobile computing network is much easier to be affected by the landforms, weather and buildings [1].

B. Cloud Computing:

Cloud computing is a computing technology that leverages cloud's resources for "enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction", as NIST[9] describes. The International Data Corporation's (IDC) Market Predictions for 2013 reveals that 70 percent of CIOs will consider and embrace a "cloud first" strategy in 2016[9].

1) Services of Cloud Computing:

Cloud computing[13] can be viewed as a collection of services, which can be represented as a layered cloud computing architecture, as shown in Fig.2

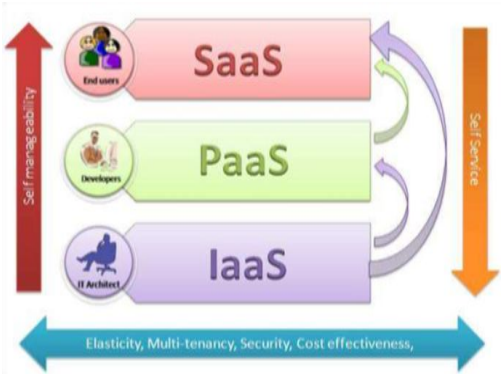

Figure 2: Layered Architecture of Cloud Computing

i) Software as a Service (SaaS): It models software deployment whereby the provider licenses an application to the customers for use as a service on demand. The applications are accessible from various client devices through a thin client interface such as a web browser. The end users does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user specific application configuration settings. Companies providing SaaS are Google, Salesforce, Microsoft, Zoho, etc.

ii) Platform as a Service (PaaS): It is the delivery of computing platform and solution stack as a service. The end users can deploy onto the cloud infrastructure created or acquired applications created using programming languages and tools supported by the provider. The end user does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage. PaaS providers offer a predefined combination of OS and application servers, such as WAMP platform (Windows, Apache, MySql and PHP), LAMP platform (Linux, Apache, MySql and PHP), and XAMP(X-cross platform) limited to J2EE, and Ruby etc. Google App Engine, Salesforce.com, etc. are some of the popular PaaS examples.

iii) Infrastructure as a Service (IaaS): It delivers computer infrastructure (typically a platform virtualization environment) as a service. The end users are provided with processing, storage, networks, can deploy and run arbitrary software, which may include operating systems and applications. The user does not manage or control the underlying cloud infrastructure but it has control over operating systems, storage, deployed applications, and possibly limited control of select networking components. Some of the common examples are Amazon, GoGrid, 3tera, etc.

iv) Monitoring-as-a-Service (MaaS): It is the outsourced provisioning of security, primarily on business platforms that leverages the Internet to conduct business. Security monitoring involves protecting an enterprise or government client from cyber threats. A security team plays a crucial role in securing and maintaining the confidentiality, integrity, and availability of IT assets. The major functionality of MaaS is to monitor the working of all the three layers SaaS, PaaS and IaaS.

2) Cloud Computing Features:

i) Scalability and On-Demand Services: Cloud computing provides resources and services for users elastically in an on demand manner. The resources are largely scalable over several data centers [13].
ii) Quality of Service (QoS): The QoS can be guaranteed to users in terms of hardware or CPU performance, bandwidth, and memory capacity [13].
iii) User-Centric Interface: Cloud interfaces are location independent and they can be accessed by well-established interfaces such as Web services and Web browsers [13].
iv) Autonomy: Cloud computing systems are autonomous systems managed transparently to users. However, software and data inside clouds can be automatically reconfigured and consolidated to a simple platform depending on user's needs [13].
v) Pricing: Cloud computing does not require any upfront investment or capital expenditure. Users may pay and use or pay for services and capacity as they need them [13].

3) Cloud Computing Challenges:

The number of challenges addressed by researchers, academicians and practitioners in the field are:

i) Performance: Since users at long distance from cloud providers may experience high latency and delays, the performance will be degraded for data-intensive applications [13].
ii) Security and Privacy: Companies are still concerned about security when using cloud computing because when information and critical IT resources are outside the firewall, chances for attacks [13].
iii) Control: A quantity of IT wings or departments are concerned because cloud computing providers have a full control of the platforms. Cloud computing providers typically do not design platforms for specific companies and their business practices [13].
iv) Bandwidth Costs: Though companies can save money on hardware and software; but incur higher network bandwidth charges. Bandwidth cost significantly grow for data-intensive applications [13].
v) Reliability: Cloud computing still does not always offer round the clock reliability since its services may suffer few hours' outages [13].

III. MOBILE CLOUD COMPUTING

The Mobile Cloud Computing can be divided into Cloud Computing and Mobile Computing. The mobile devices can be laptops, PDA, smartphones which connects with a hotspot or base station by LTE, 3G, WIFI or GPRS. Since the mobile devices are limited to resource constraint, the device intensive computing, data storage and mass information processing have been transferred to "Cloud "for processing.

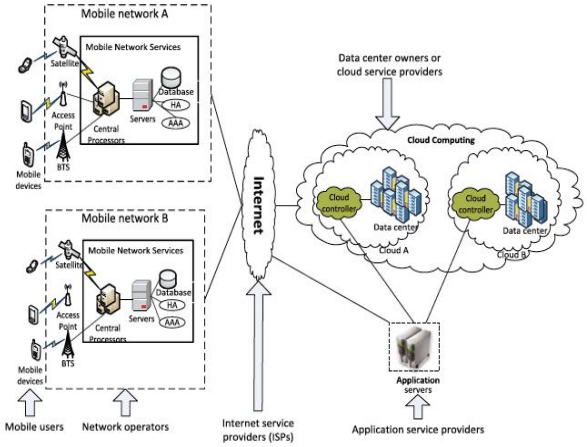

Figure 3: Architecture of Mobile Cloud Computing

Mobile devices are connected to the mobile networks via base stations that establish and control the connections and functional interfaces between the networks and mobile devices. Mobile users' requests and information are transmitted to the central processors that are connected to servers providing mobile network services. 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.

A. MCC Advantages

- Extending battery lifetime
- Improving data storage capacity and processing power
- Improving reliability and availability
- Dynamic provisioning
- Scalability
- Multi-tenancy
- Ease of Integration

B. MCC Challenges and Issues

In mobile cloud computing environment, the limitations of mobile devices, such as limited computing capability and energy resource, quality of wireless communication, to deploy complicated application, storage capacity, network bandwidth and support from cloud computing to mobile are all important factors that affect assessing from cloud computing. The following are the challenges and some solutions about mobile cloud computing:

1) Limitations of Mobile devices:

The processing capacity, storage, battery time, and communication of those smartphones will be limited when compared to desktop systems. Computation offloading techniques migrate the large computations and complex processing from resource limited devices to resourceful devices, thus avoiding mobile devices to take a large execution time.

CloneCloud is introduced by B. Chun in 2011. The Virtual machine migration technology to offload execution blocks of applications from mobile devices to CloneCloud either fully or partly extending the smartphone-based execution to a distributed environment. In CloneCloud system, the smartphone is cloned (virtualized) as an image in distributed computing environment. Then it is passes computing or energy-intensive blocks to cloud for processing. Once execution completed, the output will be passed back to the smartphone. Though it reduces battery consumption, it fails in handover delay and bandwidth limitation.

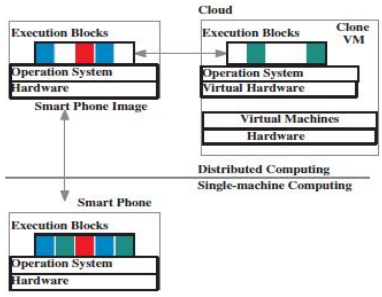

Figure 4: CloneCloud System Architecture

2) Quality of Communications:

The dynamic changing of application throughput, mobility of users, and even weather will lead to changes in bandwidth and network overlay. Thus, the handover delay in mobile network is higher than in wired network. Network bandwidth performance can be improved by regional data centers or other means to bring content closer to mobile broadband. Network latency can be reduced by moving Application processor to the edge of mobile broadband.

Cloudlet is presented by M. Satyanarayanan from Carnegie Mellon University, which provides rapidly instantaneous customized service to mobile devices using virtual machine (VM) technology for solving bandwidth-induced delay between devices and cloud, and so on. Cloudlet is deployed as a 'Micro Cloud' to be accessed by mobile devices with high bandwidth low delay. Fig. 5 shows that mobile devices use WIFI or WLAN to access Cloudlet which is located in a coffee shop, and then rapidly provides customized service using VM technology.

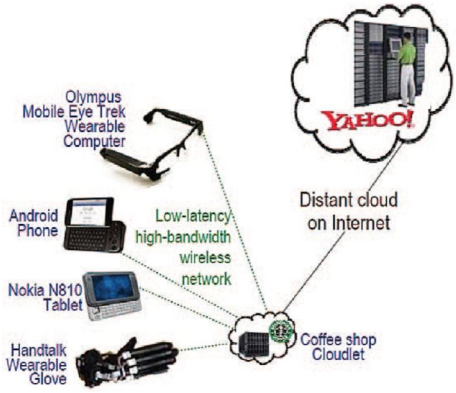

Figure 5: Concept and Infrastructure of Cloudlet

3) Division of application services:

The mobile devices have inherently limited resources. Thus the applications have to be divided in order to achieve a particular performance target (low latency, minimization of data transfer, fast response time etc.)

Considering the demands of MCC, the essential factors for delivering 'good' cloud services have been enumerated below:

- Optimal partition of application services across cloud and mobile devices
- Low network latency in order to meet application and code offload interactivity
- High network bandwidth for faster data transfer between cloud and mobile devices
- Adaptive monitoring of network conditions to optimize network and device costs against user perceived performance of the Cloud application

Samsung introduces a novel elastic application model which enables a partition to a single application into multiple components called Weblet, and dynamically deploys these Weblets in execution according to a configuration strategy at cloud and mobile terminals. Some overhead will be generated in the communication among Weblets, between the Internet and Weblets, and the implementing Weblets during the model processing. To avoid overhead, a cost model is used, which collects sensor data (such as battery life, loads of devices and cloud, network conditions and so on.) from both mobile devices and cloud as input, and implements the optimal algorithm to dynamically output an execution configuration for the applications, such as deployment of Weblet, resource allocating of cloud, selecting of different network connection, and so on.

C. Open Research Issues

1) Security: The absence of standards poses a serious issue specifically with respect to security and privacy of data being delivered to and from the mobile devices to the cloud [4].
2) Better service: The original motivation behind MCC was to provide PC-like services to mobile devices. However, owing to the varied differences in features between fixed and mobile devices, transformation of services from one to the other may not be as direct [4].
3) Task division: Researchers are always on the lookout for strategies and algorithms to offload computation tasks from mobile devices to cloud. However, due to differences in computational requirement of numerous applications available to the users and the variety of handsets available in the market, an optimal strategy is an area to be explored [4].
4) Pricing: MCC involves with both mobile service provider (MSP) and cloud service provider (CSP) with different services management, customers management, methods of payment and prices. This will lead to many issues. The business model including pricing and revenue sharing has to be carefully developed for MCC [14].
5) Service Convergence: Services will be differentiated according to the types, cost, availability and quality. A single cloud may not be enough to meet mobile user's demands. New scheme is needed in which the mobile users can utilize multiple cloud in a unified fashion. The scheme should be able to automatically discover and compose services for user [5].

IV. CONCLUSIONS

In this paper we have given an overview of Mobile Cloud Computing that includes architecture, benefits, key challenges, present research and open issues. Mobile cloud computing will equip many benefits to the mobile device users and applications enterprises. The mobile industry has broad range rapidly and tracks constantly. The number of mobile users has been boosted swiftly and also smart phones and different sophisticated mobile devices are in the domain of almost every individual. The internet usage and mobility concern have leaped and reached to obsession, so we predict mobile cloud computing application with its new innovation will invade the future.

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