Mobile Cloud Computing

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Abstract – **Mobile cloud computing is a new platform combining the mobile devices and cloud computing to create a new infrastructure, whereby cloud performs the heavy lifting of computing-intensive tasks and storing massive amounts of data. Mobile cloud computing bring benefits for mobile users, network operators, as well as cloud computing providers. MCC 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). This paper presents characteristics, some challenges and solutions, applications and architecture of MCC.**

Keywords- Mobile cloud computing (MCC), Cloud Computing, Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS).

I. INTRODUCTION

Mobile devices (e.g., Smartphone, Tablet PCs, etc.) are increasingly becoming an essential part of human life as the most effective and convenient communication tools not bounded by time and place. Dream of "**Information at your fingertips anywhere anytime",** Mobile users accumulate rich experience of various services from mobile applications (e.g., iPhone apps, Google apps, etc), which run on the devices and/or on remote servers via wireless networks. The rapid progress of mobile computing (MC) becomes a powerful trend in the development of IT technology as well as commerce and industry fields. Mobile devices still lack in resources (e.g., battery life, storage, and bandwidth) compared to a conventional information processing device such as PCs and laptops.

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 since 2007.Commonly, cloud computing is described as a range of services which are provided by an Internet-based cluster system. Such cluster systems consist of a group of low-cost servers or Personal Computers (PCs), organizing the various resources of the computers according to a certain management strategy, and offering safe, reliable, fast, convenient and transparent services such as data storage, accessing and computing to
Clients. In addition, CC enables users to elastically utilize resources in an on-demand fashion. As a result, mobile applications can be rapidly provisioned and released with the minimal management efforts or service provider's interactions. With the explosion of mobile applications and the support of CC for a variety of services for mobile users, mobile cloud computing (MCC) is introduced as an integration of cloud computing into the mobile environment. Mobile cloud computing brings new types of services and facilities for mobile users to take full advantages of cloud computing.

II. MOBILE COMPUTING

Mobile Cloud Computing (MCC) 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" Mobile computing is based on a collection of three major concepts: hardware, software and communication. The concepts of hardware can be considered as mobile devices, such as Smartphone and laptop, or their mobile components. Software of mobile computing is the numerous mobile applications in the devices, such as the mobile browser, anti-virus software and games. The communication issue includes the infrastructure of mobile networks, protocols and data delivery in their use. They must be transparent to end users.

1) Features: the features of mobile computing are as follows:

I) mobility: mobile nodes in mobile computing network can establish connection with others, even fixed nodes in wired network through Mobile Support Station (MSS) during their Moving

II) Diversity of network conditions: normally the networks using by mobile nodes 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: as 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: due to signals is 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.

2) Challenges: Compared with the traditional wired network, 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. Due to the wireless environment and numerous mobile nodes. In addition, the Quality of Service (QoS) in mobile computing network is much easier to be affected by the landforms, weather and buildings.

III. CLOUD COMPUTING

"A model for enabling 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" Cloud computing is a style of computing in which dynamically scalable and often virtualized resources are provided as a serve over the Internet.

Cloud Computing has become a popular phrase since 2007. However, there is no consensual definition on what a Cloud Computing or Cloud Computing System is, due to dozens of developers and organizations described it from different perspectives. C. Hewitt introduces that the major function of a cloud computing system is storing data on the cloud servers, and uses of cache memory technology in the client to fetch the data. Those clients can be PCs, laptops, smart phones and so on. R. Buy ya give a definition from the perspective of marking that cloud computing is a parallel and distributed computing system, which is combined by a group of virtual machines with internal links. Such systems dynamically offer
computing resources from service providers to customers according to their Service level Agreement (SLA). However, some authors mentioned that cloud computing was not a completely new concept. L. Yourself from UCSB argue that cloud computing is just combined by many existent and few new concepts in many research fields, such as distributed and grid computing, Service-Oriented Architectures (SOA) and in
Virtualization. In this paper, we consider the cloud computing is a large-scale economic and business computing paradigm with virtualization as its core technology. The cloud computing system is the development of parallel processing, distributed and grid computing on the Internet, which provides various QoS guaranteed services such as hardware, infrastructure, platform, software and storage to different Internet applications and users.

1) Framework: cloud computing systems actually can be considered as a collection of different services, thus the framework of cloud computing is divided into three layers, which are infrastructure layer, platform layer, and application layer (see Fig. 2).

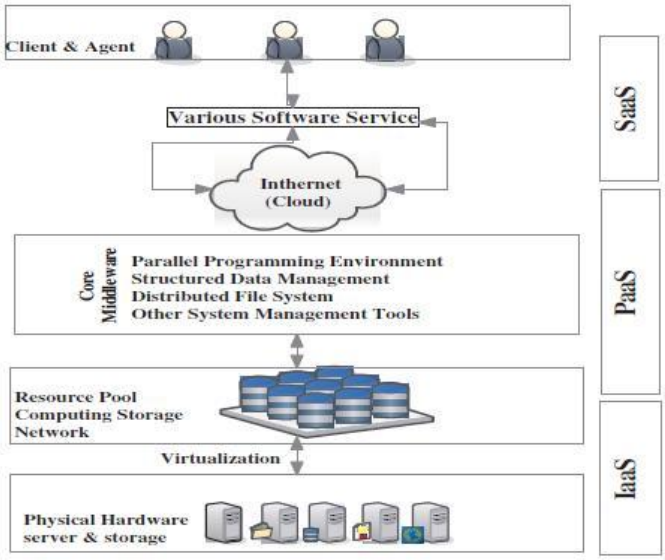

Fig. 1 the Framework of Cloud Computing

I) Infrastructure layer: it includes resources of computing and storage. In the bottom layer of the framework, physical devices and hardware, such as servers and storages are virtualized as a resource pool to provide computing storage and network services users, in order to install operation system (OS) and operate software application. Thus it is denoted as Infrastructure as a Service (IaaS). Typically services in this layer such as Elastic Computing Cloud of Amazon .

II) Platform layer: this layer is considered as a core layer in the cloud computing system, which includes the environment of parallel programming design, distributed storage and management system for structured mass data, distributed file system for mass data, and other system management tools for cloud computing. Program developers are the major clients of the platform layer. All platform resources such as program testing, running and maintaining are provided by the platform
directly but not to end users. Thus, this type of services in a platform layer is called Platform as a Service (PaaS). The typical services are Google App Engine and Azure from Microsoft.

III) Application layer: this layer provides some simple software and applications, as well as costumer interfaces to end users. Thus we name this type of services in the application layer as Software as a Service (SaaS). Users use client software or a browser to call services from providers through the Internet, and pay costs according to the utility business model (like water or electricity). The earliest SaaS is the Customer Relationship Management (CRM) from Sales force, which was developed based on the force.com (a PaaS in Sales force). Some other services provided by Google on-line office such as documents, spreadsheets, presentations are all SaaS.

2) Features: the features of Cloud Computing are as follows:

I) Virtualization: the 'Cloud' can be considered as a virtual resource pool where all bottom layer hardware devices is virtualized. End users access desired resources through a browser and get data from cloud computing providers without maintaining their own data centres. Furthermore, some virtual machines (VMs) are often installed in a server in order to improve the efficiency to use resources; and such VMs support load migration when there is a server over-load.

II) Reliability, usability and extensibility: cloud computing provides a safe mode to store user's data while users do not worry about the issues such as software updating, leak patching, virus attacks and data loss. If failure happens on a server or VM, the cloud computing systems transfer and backup those data to other machines, and then delete those failure nodes from the systems automatically in order to make-
sure the whole system has normal operation. Meanwhile, cloud can be extended from horizontal and vertical in a large-scale network, to process numerous requests from thousands of nodes and hosts.

III) Large-scale: in order to possess the capability of supercomputing and mass storage, a cloud computing system normally consists of thousands of servers and PCs. Google Cloud Computing, for example, has already controlled 2% of all servers or about 1 million servers located in two hundred different places in the world, and will move upward to 10 million servers in the next decade.

IV) Autonomy: a cloud system is an autonomic system, which automatically configures and allocates the resources of hardware, software and storage to client's on-demand and the management is transparent to end users.
3) Challenges: first of all, cloud computing needs an improved mechanism to provide a safe and high efficiency service as the numerous invoked third-party software and infrastructures are implementing in computing. In addition, due to data centres of resource using a mass of electricity, efficient resource scheduling strategy and methods are required in order to save energy. Furthermore, as a Service Level Agreement (SLA) is established between users and service providers in cloud computing, so the performance and analysis of services are necessary to be monitored. Last but not least, simple and convenient application interfaces are indispensable for service providers in cloud computing, thus a uniform standard is required eagerly.

Cloud computing is a large-scale distributed network system implemented based on a number of servers in data centers. The cloud services are generally classified based on a layer concept (Fig.).In the upper layers of this paradigm, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are stacked.

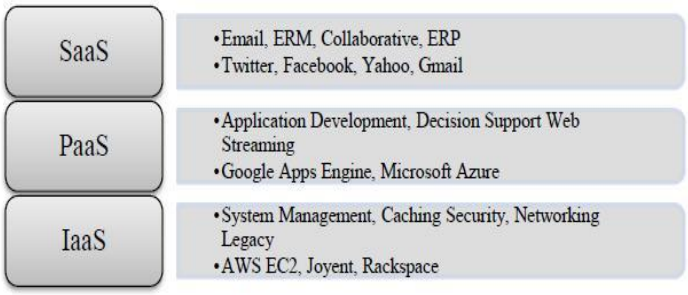

Fig 2 Cloud Services

Software as a Service (SaaS): SaaS supports a software distribution with specific requirements. In this layer, the users can access an application and information remotely via the Internet and pay only for that they use. Sales force is one of the pioneers in providing this service model. Microsoft's Live Mesh also allows sharing files and folders across multiple devices simultaneously.

Platform as a Service (PaaS): PaaS offers an advanced integrated environment for building, testing and deploying custom applications. The examples of PaaS are Google App Engine, Microsoft Azure, and Amazon Map Reduce/Simple Storage Service.

Infrastructure as a Service (IaaS): IaaS is built on top of the data center layer. IaaS enables the provision of storage, hardware, servers and networking components. The client typically pays on a per-use basis. Thus, clients can save cost as the payment is only based on how much resource they really use. Infrastructure can be expanded or shrunk dynamically as needed. The examples of IaaS are Amazon EC2 (Elastic Cloud Computing) and S3 (Simple Storage Service).

IV. MOBILE CLOUD COMPUTING

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. Alternatively, MCC can be defined as a combination of mobile web and cloud computing which is the most popular tool for mobile users to access applications and services on the Internet. Briefly, MCC provides mobile users with the data processing and storage services in clouds. The mobile devices do not need a powerful configuration (e.g., CPU speed and memory capacity) since all the complicated computing modules can be processed in the clouds.

HOW MOBILE CLOUD COMPUTING WORKS?

Typical services needed by mobile cloud client:

I) Sync
Sync service auto- synchronizes all state changes to App data back with Cloud server It supports various synchronization modes such as both way sync, one way server sync, one way device sync, slow sync, and boot sync.

II) Push
Push service the service that manages state updates being sent as notifications from the Cloud Server. This improves the mobile user's experience as they do not have to pro-actively check for the new information. When relevant

III) OfflineApp
OfflineApp service provided is designed to be an App Developer's best friend. Its carries the management capabilities to create smart coordination between the low-level services like Sync and Push. Because of the OfflineApp service, the programmer never has to write any code to actually to perform any synchronization. Synchronization is something that is managed by the OfflineApp service and it decides which mode of synchronization is the best for the current runtime state of App. The App developer is never exposed to low level synchronization details like both way sync, one way device sync, etc. It coordinates managing the Push service. It carries the smartness to track the type of data being pushed along with which it is installed App on the device needs the notification. The App developer does not have to write any special code to receive the notifications. The moment the data channel for the App is established, all synchronizations and push notifications are automatically handled by OfflineApp service.

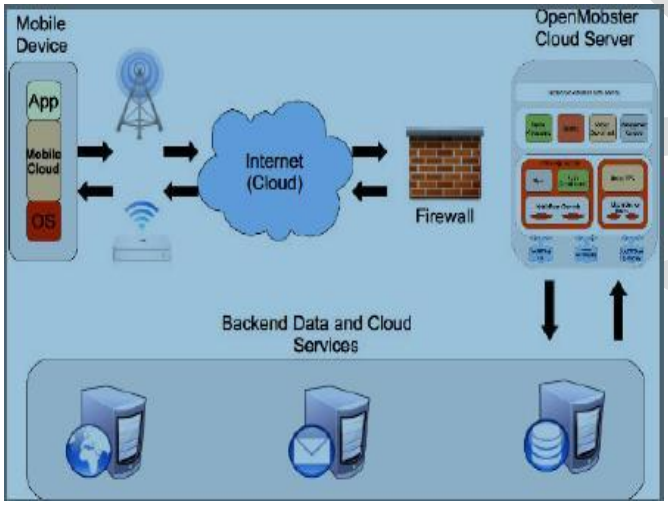

Fig 3 Architecture for Mobile Applications in Cloud Environment

IV) Mobile RPC
Mobile RPC facilitates making synchronous RPC (Remote Procedure Call) invocations from the device to server side 'Mobile Service Bean' components.

V) Network
Network service manages establishing a network connection with the Cloud Server. It manages the communication channel needed to receive Push notifications from server. It carries smartness to track coverage and establishes proper connections automatically. This is a very low-level service and an App developer never has to deal with using directly. The App developer is shielded from any low level connection establishment, security, protocol details, etc by using higher level Mobile Data Frame work components.

VI) Database
Database service manages local data storage details for the Apps. Depending on the platform in question it uses corresponding storage facilities. It is designed to coordinate storage among the suite of the Apps installed on the device. It provides thread safe concurrent access to all Apps. Just like the Network service, it's a low-level service used by Mobile Data Framework components.

VII) Inter-App Bus
Inter-App Bus service provides low-level coordination/communication between the suite of Apps installed on device

V. CHALLENGES AND SOLUTIONS

I) How MCC Can Extend Battery Lifetime?

- **Challenges**
  Battery is one of the main concerns for mobile devices, traditional approaches need to changes the structure of mobile devices.
  The additional cost for the end mobile users is not appealing in wireless networks.

- **MCC's solution**
  Computation offloading technique:
  Immigrate 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.

II) How MCC Can Improve Storage Capacity?

- **Challenges**
  Users need more and more capacity for saving the essential information on mobile devices, Need to change the device, more capacity, and more weight.

- **MCC's solution:**
  MCC is developed to enable mobile users to store/access the large data on the cloud through wireless networks, Examples of existing services:
  Amazon Simple Storage Service (Amazon S3),
  Image Exchange, Flickr, ShoZu.

III) How MCC Can Improve Reliability?

- **Challenges**
  Users need reliable backup for their information, Lack of data security model for both service providers and users in existing mobile users.

- **MCC's solution:**
  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.

VI. APPLICATIONS

I. Image processing: Optical character recognition (OCR) program on a collection of mobile devices. In a real life scenario, this would be useful in a case of a foreign traveler who takes an image of a street sign, performs OCR to extract the words, and translates words into a known language. A similar scenario is given in where a foreign tourist is visiting a museum in particular country. He sees an interesting exhibit, but cannot understand the description since it is in language of that country. He takes a picture of the text, and starts an OCR app on his phone. Unfortunately his phone lacks the resources to process the Internet, that would mean he use roaming data which is too expensive. Instead, his device scans for nearby users/devices who are also interested in reading the description, and requests sharing their mobile resources for the task collaboratively. Those who are interested in this common processing task create an ad hoc network with main user and together, their mobile cloud is able to extract the text, and then translate it to English. This can be applied to many situations in which a group is involved in an activity together.

II. Crowd computing: Video recordings from multiple mobile devices can be spliced to construct a single video that covers the entire event from different angles, and perspectives. In, two scenarios of this nature are described in detail: 'Lost child' and 'Disaster relief'. The 'Lost child' scenario takes place at a parade in City. A five year old child who is attending the parade with his parents goes missing among all the people, and his parents only notice he is missing after some time. Fortunately, a police officer sends out an alert via text message to all mobile phones within a two mile radius, requesting them to upload all photographs they have taken in the parade during the past hour, to a server that only the police have access to. With boy's parents, the police officer searches through these photographs via an app on his phone. After looking through some pictures, they are able to spot John in one of the images, which they identify to be taken at a nearby location. Soon, the relieved parents are reunited with their child.

VII. CONCLUSION

Mobile computing offers significant benefits for organizations that choose to integrate the technology into their fixed organizational information system. Mobile computing is made possible by portable computer hardware, software, and communications systems that interact with a non-mobile organizational information system while away from the normal, fixed workplace. Mobile computing is a versatile and potentially strategic technology that improves information

Quality and accessibility, increases operational efficiency, and enhances management effectiveness. Here in this paper we have in term identified some of the challenges and solutions, applications of mobile computing along with few of the characteristics and architecture of Mobile computing.

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