Service Models Importance in Mobile Cloud Computing: A Survey

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***Abstract*—Mobile Cloud Computing (MCC) which combines mobile computing and cloud computing, 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 cloud computing and mobile cloud computing services models and differences issues.**

***Keywords*—Cloud computing, cloudlet, mobile cloud computing, service models.**

I. INTRODUCTION

Mobile Cloud Computing is a new paradigm for mobile applications whereby most of the processing and data storage associated with the applications is moved off the mobile device to powerful, centralized computing platforms located in the Cloud. These centralized applications are then accessed over the mobile Internet, using either a thin native client or web browser on the device. However, this model for Mobile Cloud Computing still does not fully leverage the powerful communications, context and commercialization capabilities of the mobile network itself. Mobile Cloud Computing builds on the principles of cloud computing, bringing attributes such as on demand access, no on premise software and "XaaS" (Everything as a Service) to the mobile domain, adding Network as a Service (NaaS) and Payment as a Service to the maximum of on demand capabilities and allowing applications to leverage the full power of mobile networking and billing without the need for specialist application servers. The phrase "Mobile Cloud Computing" was introduced after the concept of "Cloud Computing" was launched in mid 2007. It has been attracting the attention of entrepreneurs as a profitable business option that reduces the development and running cost of mobile applications and 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 core IT [7].
The Mobile Cloud Computing Forum [8] 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".

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II. ARCHITECTURE

An overview of basic Mobile Cloud Computing was presented in the previous section. A general architecture in a broader sense was as depicted in Fig 1. A more detailed representation will be presented in this section.

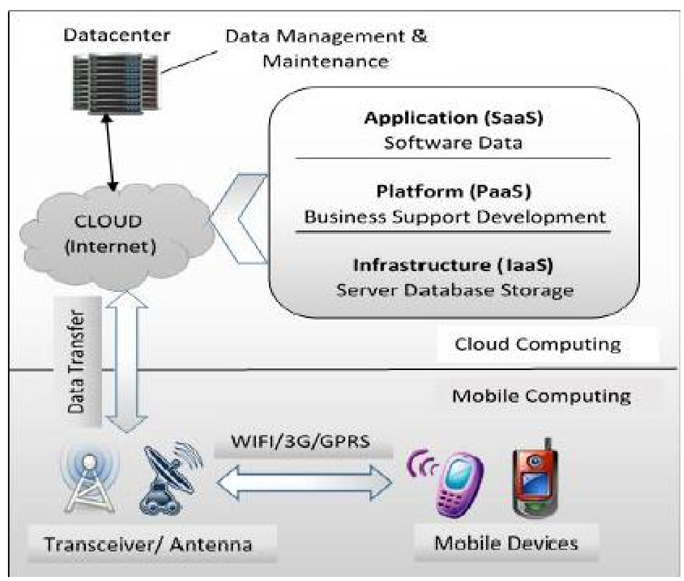

Fig 1: Mobile Cloud Computing

The general architecture of MCC proposed by [20] can be shown in Fig. 1. 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).

III. SERVICE MODELS

The following concept describes the cloud computing and mobile cloud computing services models.

A. Cloud Computing Service Models

"Cloud computing isn't so much a technology as it is the combination of many pre-existing technologies. These technologies have matured at different rates and in different contexts, and were not designed as a coherent whole; however, they have come together to create a technical ecosystem for cloud computing" (Matheret al., 2009) The cloud computing concept is also divided into three different service models (Mell&Grance, 2009), also referred to as infrastructure models (Reese, 2009) or services delivery models (Mather et al., 2009). The service models are generally categorized as Software as a Service (SaaS), Platform as a Service (PaaS) and cloud Infrastructure as a Service (IaaS).

1. Software as a Service (SaaS)

Software as a Service or SaaS refers to: "The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure." (Mell & Grance,2009). The traditional method of purchasing software requires the customer to locally install an application on their computer and use licenses to authorize the usage. With SaaS the customer pays for the software on a subscription level and does not need to install any software on their computers. The software, application, is instead accessed via the Internet, through a web browser (Mather et al., 2009).An example of this is Google Docs which is a word processing application offered online. The user can access the application through a web browser, create documents and use all the features of the application (Google Docs, 2012). What differs SaaS from PaaS and IaaS is that the user will not alter the application itself, nor the hardware that the application runs on, or the network configuration. What Google offers with Google Docs is an application that the user can use but not directly alter. It is like a traditional computer program but used through the Internet. According to Reese (2009), Rittinghouse&Ransome (2010) SaaS applications areaccessed through a web browser, and there is no need to install the application to use it(Reese, 2009; Rittinghouse&Ransome, 2010). Other characteristics of cloud computing does also apply, that the application always should be accessible and that no specific platform should be needed.

2. Platform as a Service (PaaS)

"In a platform-as-a-service (PaaS) model, the vendor offers a development environment to application developers, who develop applications and offer those services through the provider's platform" (Mather et al., 2009). In comparison to SaaS where the application already exists, and is usually owned by the cloud provider, PaaS offers the possibility to create and modify applications. It is an outgrowth of the SaaS application delivery model (Rittinghouse&Ransome, 2010). To aid the developer, different tools are provided like programming languages and Application Programming Interfaces (API). In comparison to cloud Infrastructure as a Service, IaaS, the user does not control the virtualization instance or network configuration of the cloud server (Mell&Grance, 2009). An example of PaaS is Google App Engine that offers the possibility to create Java, Python and Go applications on servers hosted by Google (Google App Engine, 2012; Reese, 2009).

3. Cloud Infrastructure as a Service (IaaS)

"Infrastructure as a Service (IaaS) is the delivery of computer hardware (servers, networking technology, storage, and data center space) as a service. It may also include the delivery of operating systems and virtualization technology to manage the resources." (Hurwitz et al., 2010). The actual network infrastructure of the cloud servers does not lay in the hands of the user, but rather network options like firewalls, storage, operating systems etcetera (Mell&Grance, 2009).An example of IaaS is Amazon EC2, where virtual servers can be set up and configuredover a web based interface within minutes (Amazon EC2, 2012; Hurwitz et al., 2010). The customer can choose operating system, database and application development environment which gives the customer greater control over the hardware in comparison to PaaS. The customer has the possibility to configure the servers based on their needs, which generally includes more maintenance in comparison to PaaS but also more options.

These three service models constitutes the general model of cloud computing. It is a very broad concept and there are many different definitions, and new ones are coined frequently.SaaS, PaaS and IaaS are the most encountered in cloud computing literature and are basically divided by hardware abstraction level. Youseff&Dilma Da Silva illustrates this in Fig. 2. where two additional lower layers were added, the Firmware/Hardware and the Software Kernel (Youseff&Dilma Da Silva, 2009), it illustrates how interconnected the different layers are

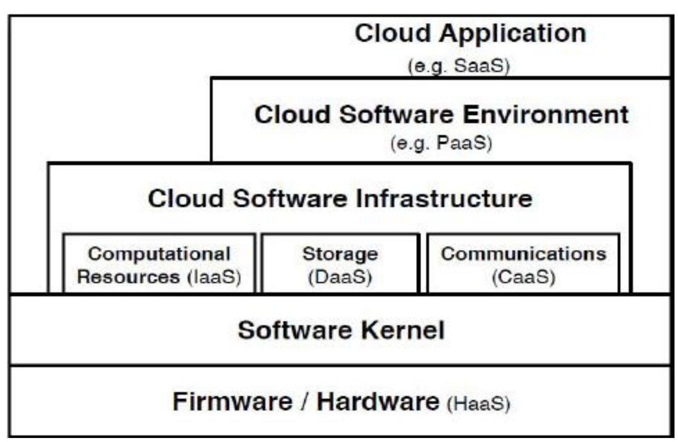

Fig 2: Cloud ontology (Youseff&Dilma Da Silva, 2009).

B. Mobile Cloud Computing Service Models

Mobile Cloud Computing is a rich mobile computing technology that leverages unified elastic resources of varied clouds and network technologies toward unrestricted functionality, storage, and mobility to serve a multitude of mobile devices anywhere, anytime through the channel of Ethernet or Internet regardless of heterogeneous environments and platforms based on the pay-as-you-use principle.The cloud computing concept is also divided into three different service models..

Current Internet clouds have been broadly classified in three-type service models: Infrastructure-as-a-service(IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Mobile software-as-a-service (MSaaS), Mobile Data-as-a-Service (MDaaS), Mobile Platform-as-a-Service (MPaaS), Mobile Infrastructure-as-a-Service (MIaaS) , Mobile Network-as-a-Service (MNaaS), Mobile-based Testing-as-a-Service (MTaaS), Mobile multimedia services, and mobile social community services , Mobile clouds for e-commerce and local-based mobile applications.. They are classified according to the layers of virtualization. However, due to the involvement of both Cyber Physical System (CPS) and Cyber Virtual System (CVS), the MCC's service models are more appropriate to be classified according to the roles of computational entities within its service framework, where the classification of MCC service models can usethe roles and relations between mobile entities and their invoked cloud-based resource provisioning. Based on this view, existing MCC services can be classified in three major models: Mobile-as-a-Service-Consumer (MaaSC), Mobile-as-a-Service-Provider (MaaSP), and Mobile-as-a-Service-Broker (MaaSB). These MCC service models are illustrated in Fig. 3. in which arrows indicate service processing flows from service providers to service recipients.

MaaSC is originated from the traditional client-server model by introducing virtualization, fine-grained access control, and other cloud-based technologies at the initial stage. Mobile devices can outsource their computation and storage functions onto the cloud in order to achieve better performance and more application capabilities. In this architecture, the service is one-way from the cloud to mobile devices and mobile devices are service consumers. Most existing MCC services fall into thiscategory.

MaaSP is different from MaaSC in that the role of a mobile device is shifted from a service consumer to a service provider. For example, with on-board sensors, i.e., GPS module, camera, gyroscope, etc., mobile devices are able to sense data from the devices and their neighboring environment, and further provide sensing services to other mobile devices through the cloud. In Fig. 3. consumers receive services provided by both the cloud and mobile devices. The types of services provided by mobile devices are diverse based on their sensing and processing capabilities.

MaaSB can be considered as an extension of MaaSP, where MaaSB provides networking and data forwarding services for other mobile devices or sensing nodes. MaaSB is desired under some circumstances because mobile devices usually have limited sensing capability compared to sensors that are dedicated for specially designed functionalities and sensing locations. For example, mobile phones can be used to collect users' physical activities from Nike Fuelband [2]. MaaSB extends the cloud edges to mobile devices and wireless sensors. Thus, a mobile device can be configured as a gateway or a proxy providing networking services through various communication approaches such as 3/4G, Bluetooth, WiFi, etc. Moreover, the proxy mobile device can also provide security and privacy protections to their interfaced sensors.

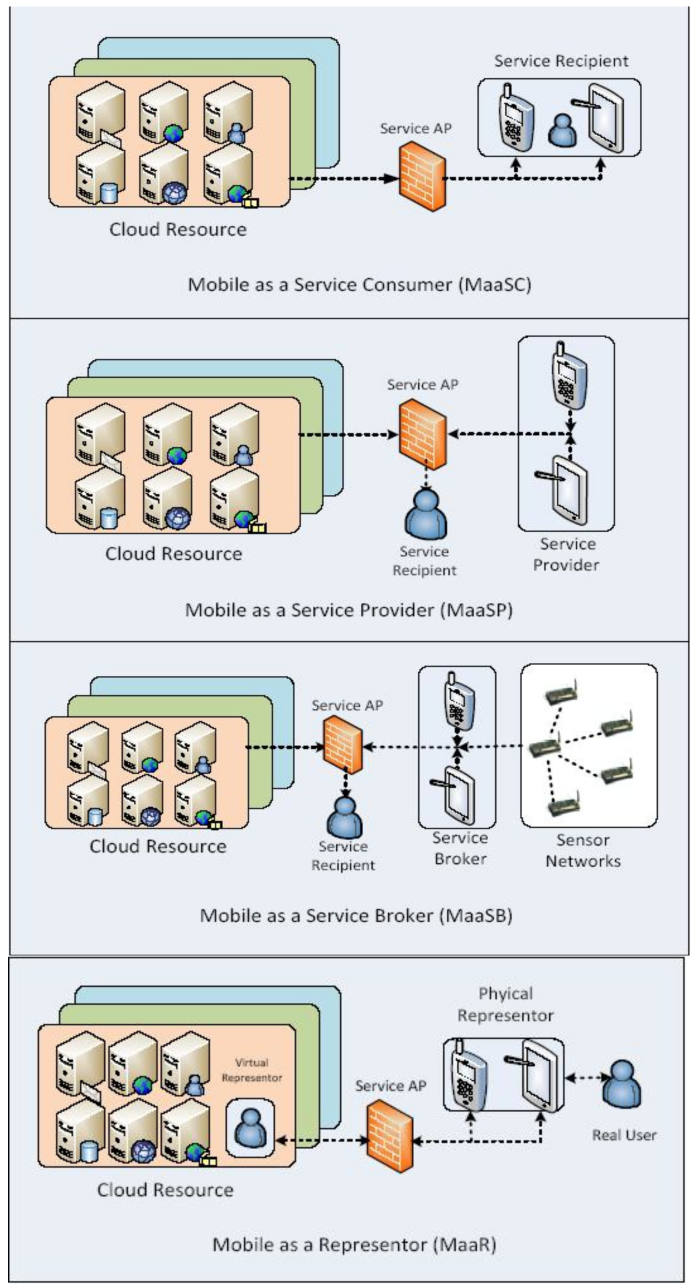

Fig. 3: Current Service Models of MCC.

IV. LITERATURE SURVEY

The survey describes the characteristics, advantages, disadvantages and challenges of cloud computing and mobile cloud computing as a new phrase, has been devised since 2009. in order to help us grasping better understanding of mobile cloud computing.

A. Characteristics:

Cloud Computing: On demand access, Pay per use, Resource Planning.

Mobile Cloud Computing: Scalability, agility, Reliability, security, reduced cost.

B. Advantages

Cloud Computing: Cost Efficient, Almost Unlimited Storage, Backup and Recovery, Easy Access to Information, Quick Deployment.

Mobile Cloud Computing: Multi-tenancy, Reliability and availability, Dynamic provisioning, Scalability, Ease of Integration.

C. Disadvantages:

Cloud computing: Technical Issues, Security in the Cloud, and Prone to Attack.

Mobile Cloud Computing: Security of data on cloud, Security of data on mobile.

D. Challenges:

Cloud computing: The new paradigm of cloud computing provides an array of benefits and advantages over the previous computing paradigms and many organizations are migrating and adopting it. However, there are still a number of challenges, which are currently addressed by researchers, academicians and practitioners in the field.

Performance, Security and Privacy, Control, Bandwidth Costs Reliability.

Mobile Cloud Computing: In the MCC landscape, an amalgam of mobile computing, cloud computing, and communication networks (to augment smartphones) creates several complex challenges such as Mobile Computation Offloading, Seamless Connectivity, Long WAN Latency, Mobility Management, Context-Processing, Energy Constraint, Vendor/data Lock-in, Security and Privacy, Elasticity that hinder MCC success and adoption.

E. Open Research Issues

Cloud computing: Threats and opportunities of the cloud, Privacy, Privacy solutions, Compliance, Legal, Vendor lock-in, Open source, Open standards, Security, Sustainability, Abuse, IT governance, Consumer end storage, Ambiguity of terminology, Performance interference and noisy neighbors and Monopolies and privatization of cyberspace.

Mobile Cloud Computing: Although significant research and development in MCC is available in the literature, still efforts in the following domains lacking: Architectural issues, Energy efficiency, Security, Better service, Task division, Energy-efficient transmission, Context-awareness issues, Live VM migration issues, Mobile communication congestion issues, Trust, security, and privacy issues.

V. CLOUD COMPUTING VS. MOBILE CLOUD COMPUTING

A. Cloud computing

‘‘Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services’’ [6].

A cluster of computer hardware and software that offer the services to the general public (probably for a price) makes up a‘public cloud’. Computing is therefore offered as a utility much like electricity, water, gas etc. where you only pay per use. For example, Amazon’s Elastic cloud, Microsoft’s Azure platform, Google’s App Engine and Sales force are some public clouds that are available today. However, cloud computing does not include ‘private clouds’ which refer to data centers internal to an organization. Therefore, cloud computing can be defined as the aggregation of computing as a utility and software as a service. Virtualization of resources is a key requirement for a cloud provider—for it is needed by statistical multiplexing that is required for scalability of the cloud, and also to create the illusion of infinite resources to the cloud user. Ambrust et al. [5] holds the view that ‘‘different utility computing offerings will be distinguished based on the level of abstraction presented to the programmer and the level of management of the resources’’. Totake an example from the existing cloud providers, an instanceof Amazon’s EC2 is very much like a physical machine and gives the cloud user almost full control of the software stack with a thin API. This gives the user a lot of flexibility in coding; however it also means that Amazon has little automatic scalability and fail over features. In contrast, Google’s App Engine enforces an API on the user but offers impressive automatic scalability and fail over options. Microsoft’s Azure platform is something in between therefore mentioned providers by giving the user some choice in the language and offers somewhat automatic scaling and fail over functions. Each of the aforementioned providers has different options for virtualizing computation, storage and communication.

B. Mobile Cloud computing

There are several existing definitions of mobile cloud computing, and different research alludes to different concepts of the ‘mobile cloud’:

1. Commonly, the term mobile cloud computing means to run an application such as Google’s Gmail for Mobile6 on a remote resource rich server (in this case, Google servers) as displayed in Fig. 4, while the mobile device acts like a thin client connecting over to the remote server through 3G. Some other examples of this type are Facebook’s location aware services, Twitter formobile, mobile weather widgets etc.

2. Another approach is to consider other mobile devices themselves too as resource providers of the cloud making up a mobile peer-to-peer network as in [14]. Thus, the collective resources of the various mobile devices in the local vicinity, and other stationary devices too if available, will be utilized as shown in Fig. 5. This approach supports user mobility, and recognizes the potential of mobile clouds to do collective sensing as well. Peer-to-Peer systems such as SATIN [26] for mobile self-organizing exist, but these are based on component model systems representing systems made up of interoperable

local components rather than offloading jobs to local mobile resources. This paper focuses primarily on this latter type of work.

3. The cloudlet concept proposed by Satyanarayanan [23] is another approach to mobile cloud computing. Fig. 6 illustrates this approach where the mobile device offloads its workload to a local 'cloudlet' comprised of several multi-core computers with connectivity to the remote cloud servers. Plug Computers 8 can be considered good candidates for cloudlet servers because of their form factor, diversity and low power consumption. They have the same general architecture as a normal computer, but are less powerful, smaller, and less expensive, making them ideal for role small scale servers installed in the public infrastructure. These cloudlets would be situated in common areas such as coffee shops so that mobile devices can connect and function as a thin client to the cloudlet as opposed to a remote cloud server which would present latency and bandwidth issues.

Mobile cloud computing would also be based under the basic cloud computing concepts. As discussed by Mei et al. in [10] there are certain requirements that need to be met in a cloud such as adaptability, scalability, availability and self-awareness. These are also valid requirements for mobile cloud computing. For example, a mobile computing cloud also needs to be aware of its availability and quality of service and enable diverse mobile computing entities to dynamically plug themselves in, depending on the requirements and workload. And in order for mobile users to efficiently take advantage of the cloud, a suitable method of self assuming one's own quality is needed—since the internal status and the external environment is subject to change. However, in addition to the similar requirements, a mobile cloud needs to consider other aspects such as mobility, low connectivity and finite source of power as well.

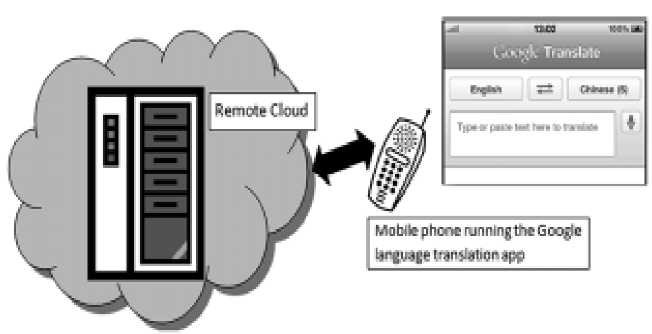

Fig. 4: A remote cloud server catering to mobile devices though the internet

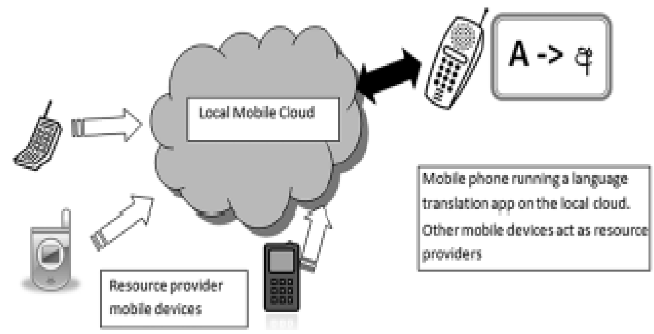

Fig. 5: A virtual resource cloud made up of mobile devices in the vicinity

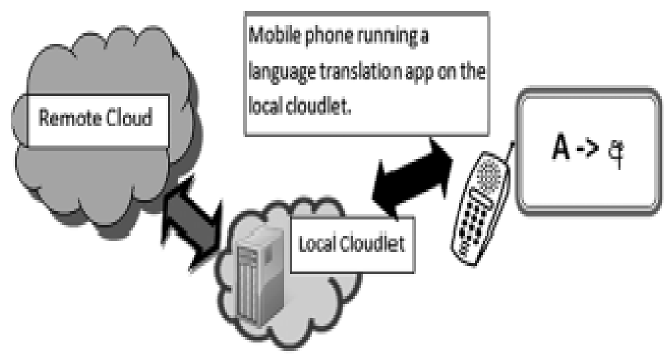

Fig. 6: A cloudlet enabling mobile devices to by pass latency and bandwidth issue while benefitting from it resources

VI. CONCLUSION

With the high increasing of data computation in commerce and science, the capacity of data processing has been considered as a strategic resource in many countries. Mobile cloud computing (MCC), as a development and extension of mobile computing (MC) and cloud computing (CC), has inherited the high mobility and scalability, and become a hot research topic in recent years. We conclude that there are certain main approaches in MCC, which are focusing on the cloud computing and mobile cloud computing service models. In this paper we have given an overview of Cloud computing and Mobile Cloud Computing that includes architecture, benefits, key challenges, service models and open issues.

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