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Survey: Approaches to solve heterogeneity issue in MCC

KEYWORDS: CPMTC, Middleware, Mobile cloud apps, Seamless Connectivity.

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ABSTRACT Together with an explosive growth of the mobile applications and rising of cloud computing concept, mobile cloud computing (MCC) has been initiated to be a potential technology for mobile services. Different mobile devices by leveraging heterogeneous cloud resources have created a new research area that is Mobile Cloud Computing (MCC). In the core of such a non-uniform environment facilitating interoperability, portability, and integration among heterogeneous platforms is nontrivial. Building such facilitators in MCC requires research to understand heterogeneity and its challenges. In this paper, we define MCC, explain its major issues, and discuss heterogeneity in MCC & different approaches to deal with heterogeneity issue.

I. INTRODUCTION

Mobile devices (e.g., smartphone and tablet PC) are increasingly becoming an essential part of human life; it is a most effective and convenient communication tools not restricted by time and place. Mobile users accumulates rich experience of various services from mobile applications (e.g., iPhone apps and Google apps), which run on the devices and/or on remote servers via wireless networks. 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)[1].

Cloud computing provides services by allowing users to use infrastructure(e.g,storages, servers, and networks), platforms (e.g., middleware services and operating systems), and softwares (e.g., application programs) provided by cloud providers (e.g., Google cloud, Amazon, and Salesforce) at low cost. In addition, Cloud computing enables users to elastically consume resources in an on-demand approach. MCC brings new types of services and facilities mobile users to take full advantages of cloud computing [1].

II. OVERVIEW OF MOBILE CLOUD COMPUTING

1. What is mobile cloud computing?

Mobile Cloud Computing refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. It serves a large number of mobile devices anywhere anytime through the channel of Ethernet or internet regardless of heterogeneous environment and platform based on the pay-as-you-use principle. [8].

2. Architecture of MCC

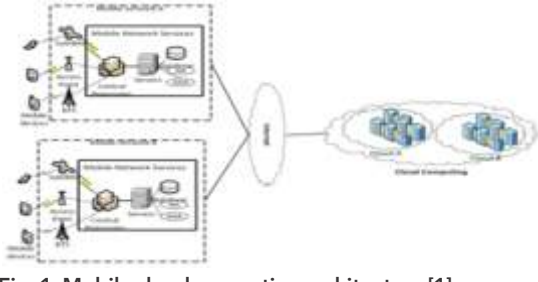

Fig. 1. Mobile cloud computing architecture [1]

From the concept of MCC, the general architecture of MCC can be shown in Fig. 1. In this 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 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. 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 [1].

3. Applications of MCC

Mobile applications gain increasing in a global mobile market. Currently various mobile applications have taken the advantages of MCC to increase efficiency and provide wide range of services.Today MCC become useful in Mobile commerce, Mobile learning, Mobile healthcare, Mobile gaming and other practical applications.

III. ISSUES

As discussed in the previous section, MCC has many advantages for mobile users and service providers. However, because of the integration of two different fields, that is, Cloud computing and mobile networks, MCC has to face many technical challenges [10].

1. Issues in mobile communication side

Bandwidth: It's one of the big issues in MCC because the radio resource for wireless networks is much scarce as compared with the traditional wired networks.

Availability: Heterogeneity: Different mobile nodes access to the cloud through different radio access technologies such as GPRS, WCDMA, WiMAX, CDMA2000, and WLAN.

2. Issues in computing side

Offloading: Offloading is a technique to migrate the large computations and complex processing from resource-limited devices (i.e., mobile devices) to resourceful machines (i.e., servers in clouds) [10].Offloading is one of the main features of MCC to improve the battery lifetime for the

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mobile devices and to increase the performance of applications.

Security: Protecting user privacy and data/application confidentiality from intruder is a key to establish and maintain consumers' trust in the mobile platform.

Seamless Connectivity: Wireless networks have low-bandwidth, intermittent, and less-reliable transmission grounds compared with the wired networks. Interruption of constant connectivity, exploitation of limited resources on a large scale and frequent application execution delays are some of the most important problems that cause quality of service degradation[2].

To overcome some of these limitations, Satyanarayana proposes cyber foraging approach.

MCC is a convergent technology combination of three keystone heterogeneous technologies, namely mobile computing, cloud computing, and networking. Such heterogeneity aggregation complicates MCC and slowdowns its success. Vendor lock-in problem is the state when code and data cannot (easily) be moved from one cloud to another because of dissimilarities among underlying architectures and programming languages. Though the problem might be attractive in business competition, it causes several challenges particularly data integrity, interoperability, and portability [2].

IV. HETEROGENEITY IN MCC

As discussed earlier heterogeneity in MCC occurs because of its combination of three heterogeneous technologies: Mobile computing, Wireless Network and Cloud computing. The major issues related to heterogeneity are interoperability between fragmented systems with varied APIs, data integrity within/across heterogeneous data warehouses, and migrating data from one cloud to another and from mobile devices to the cloud or in reverse [2]. Heterogeneity in MCC is the existence of differentiated hardware, architectures, infrastructure, and technologies of mobile devices, clouds, and wireless networks [9].

Heterogeneity in Mobile Devices: The increasing popularity of smartphones creates a dynamic and demanding market that break up them to different dimensions.

Heterogeneity in Clouds: Many cloud vendors provide different services with custom-built policies, infrastructures, platforms, and APIs that make the cloud landscape heterogeneous.

Heterogeneity in Wireless Networks:Variations in wireless networks and their related technologies impact the delivery of cloud services and influence mobility, augmentation, and usability of smartphones.

IV. TAXONOMY OF HETEROGENEITY IN MCC

Hardware Heterogeneity: Variety of hardware with different inward architecture between mobile devices, cloud servers, and network infrastructures (e.g. access points, radio transceivers, and routers) generate hardware heterogeneity in MCC.

Platform Heterogeneity: Platform heterogeneity is the availability of various OSs, programming languages, and data structures in MCC.

Feature Heterogeneity: Feature heterogeneity occurs due to variation in native features like multimedia, sensing, and interaction tools, visualization area, and networking technologies in smartphones. For example, HTC Sensation possesses an 8MP camera while BlackBerr Curve 8520 provides 2MP camera.

API Heterogeneity: Application Programming Interface (API) is an interface supplied by OS vendors or service providers that allows an application written in a high-level language to access specific data or functions from the API distributor. PIs play an important role in delivering a rich experience to mobile users. Mobile platforms such as Android, BlackBerry, and iOS offer a gigantic number of APIs to assist programmers with developing rich mobile applications without direct access to the kernel.

Network Heterogeneity: Wireless Network is composition of various wireless technologies such as Wi-Fi, 3G, and WiMAX which makes MCC more complicated compared to cloud computing.

Heterogeneity dimensions: we can divide heterogeneity dimensions in MCC into two categories of vertical and horizontal. The following Fig. 6. shows how three underlying MCC components are influenced by two dimensions of heterogeneity. Vertical Heterogeneity: Differentiation within a single type of mobile OS, cloud service, or wireless network it is named vertical heterogeneity. Horizontal Heterogeneity: Differentiation across different types of mobile OSs, cloud services, or wireless networks it is named horizontal heterogeneity.

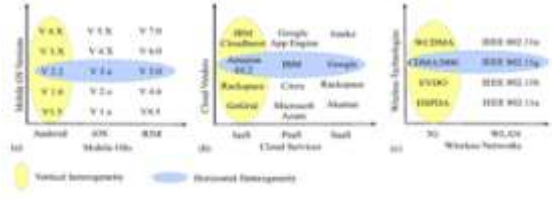

Fig. 2. Vertical and Horizontal Heterogeneity in 3 Aspects within MCC [9].

VI. APPROACHES TO HANDLE HETEROGENEITY

1. Cross Platform Computing Method

Cross-platform mobile transparent computing (CPMTC): With the rapid development of Mobile computing, mobile device becomes the essential tool in people's daily life. However there are several issues when designing a cross-platform solution on mobile device and it is well known that mobile software is tightly coupled with OS and the OS is highly dependent on hardware in mobile computing. In fact, it is quite hard to run two kinds of heterogeneous operating system on a single device.

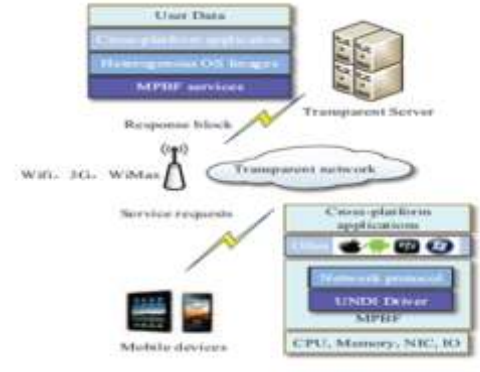

Fig. 3. CPMTC Architecture [11]

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CPMTC mainly works in mobile devices, and the client always communicates with server via wireless network (e.g. Wi-Fi, 3G, WiMax). In this mode, mobile OS is not necessarily to be installed previously on mobile devices (tablet, PDA, smart phone, embedded appliances, etc.), for they can load and launch heterogeneous mobile OSes (Android, iOS, Blackberry, Windows mobile, etc.) through network according to users requirement. On the process of the mobile clients booting, the application binary code is loaded to memory on demand from the server, which makes full use of mobile devices computing capability and reduces the pressure of its limited storage[11].

2. Mobile Cloud Middleware

Middleware is used to connect several machines in order to provide a smooth interaction between them and it is often used in applications or distributed systems, which can be defined as "a collection of autonomous computers that are connected through a network which enables computers to share the resources of the system, so that users perceive the system as a single, integrated computing facility"[4].

Here architecture of middleware is proposed in order to describe how it works and provide communication between mobile user and cloud. It is based on the middleware technology which is used for supporting the mobile clients in accessing the services of cloud platform. The middleware should provide an infrastructure for a transparent execution of elastic applications and a flexibility of adjusting the requirements for mobile clients to Cloud Services. The middleware is software that provides a runtime environment the necessary support and organization of multiple applications [4].

The used architecture breaks down the system into independent elements where each one of them does specific functionalities in order to contribute to the achievement of our middleware's objectives [4].

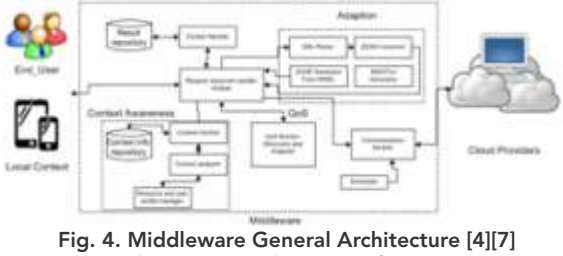

Fig. 4. Middleware General Architecture [4][7]

Fig.4. shows the generic architecture of MCM system. It is composed of several modules in addition to two different repositories. The objective of the architecture of this middleware is to allow the mobile clients to connect to cloud services.

3. Mobile cloud apps

There is currently much controversy over which mobile apps are better - native applications or mobile cloud applications. It is essential to look at the differences between developing mobile cloud apps and native apps.

Differences between mobile cloud apps and native apps:

	Native Apps	Mobile Cloud Apps
The mobile app environment	Application Server or mobile device.	Mobile cloud server or mobile device.
Look and feel	Provide for notifications, such as the iOS notifications.	Do not natively support notifications.
Access to on-device features	It have direct access to on-device features such as GPS, camera, locomotion and sound.	It may have access to some of these features through (APIs) that reach down to the device itself.
UI speed	Faster (A native app interface runs on the mobile device & access app server)	Slower (It runs on mobile cloud and views the UI through a mobile device browser.)

Native apps: mobile application developed for platform such as iOS and Android, uses its own development process and has its own native programming language: Java (Android), Objective-C (iOS) and Visual C++(Windows Mobile). Native apps developed using app development tools such as Apple's iOS SDK, Google's Android development tools and Microsoft's .NET Compact Framework.

Mobile cloud apps are written in HTML5, CSS3 and JavaScript and server-side languages such as C++ or Web application frameworks of the developer's choice such as PHP, Rails and Python [3]. For both native apps and mobile cloud apps, tools and frameworks are available to help in developing software for deployment on multiple OS platforms and Web browsers.

Fig. 5. PhoneGap- An easy way to build cross platform hybrid mobile applications[5]

There are a number of questions to rises before creating a mobile app. They include [3]:

How many mobile device platforms do you intend to support? If cross-platform compatibility is a concern as it will certainly be in corporations implementing bring your own device (BYOD) strategies.

How important is security? Security is the biggest weakness of mobile devices.Mobile cloud apps' data are stored on the mobile cloud, not on the mobile device. Therefore, a lost or stolen mobile cloud app device poses less of a security risk.
What is the purpose of the app? If you are building mobile business apps for internal use or customer use and you have many mobile devices to support, mobile cloud apps are a good choice.

How important is data integration with the rest of the system? When mobile business apps access databases -- and most do -- you will need to integrate the apps with your current system.

VII. CONCLUSION

With the advancement of technology, everyone demands for optimum service with minimum usage of resources so, mobile cloud computing (MCC) is one of them. This survey paper portrays issue rises during implementation of mobile cloud computing environment, how heterogeneity becomes an obstacle in MCC implementation and in which part of

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MCC it may occurs. This provides different three approaches to solve heterogeneity issue these are: Cross platform computing method, Mobile cloud middleware and Mobile cloud applications. These approaches will help to reduce heterogeneity in MCC.

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