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A SURVEY ON MOBILE CLOUD COMPUTING APPLICATIONS, OPPORTUNITIES AND ISSUES

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ABSTRACT

Mobile Cloud Computing is an emerging technology. All the statistics have listed that MCC is the future of cloud. The increasing number of cloud vendors, the job openings for the mobile application developers, the number of mobile applications, and the technologies that rushes to diminish the drawbacks in MCC is a proof that, it is one of the future trends. In this paper, types of mobile applications, few statistics about mobile applications, growth of smart phones, few MCC applications, some issues in MCC from various papers and listed some of the solutions that are proposed by researchers. Some of the proposed solutions are partially implemented.

Keywords: Mobile Cloud Computing, Cloud, Google Drive,SaaS, PaaS, IaaS, Mobile Apps.

1. INTRODUCTION

The invention of Cloud Computing enables the users to share and access the applications and services from the cloud. There is no need to install these applications in our devices. The user needs an internet connection to avail these cloud services..The cloud services are classified as

- Saas(Software as a Service)
  Ex: Gmail, Calendar, Maps, CRM systems such as Salesforce, Facebook , Dropbox etc

- PaaS(Platform as a Service)
  Ex: It provides programming environments (IDE) and runtime environments. It targets the developers, not users. Django framework and Sun

  Caroline are some sample programming environments.

- Iaas (Infrastructure as a Service)
  Ex: It provides resources like servers, storage, networks and operating system. Sometimes referred as Hardware as a Service.

Some free cloud services are available, but most of the services are “pay as you use” services and these services are provided as “on demand” basis. These cloud services are available in mobile ecosystems such as Laptops, Smart phones, PDA’s etc. The combination of cloud computing and mobile devices leads to a new technology called Mobile Cloud Computing. This paper gives a brief survey about, issues and challenges faced by Mobile Cloud Computing (MCC) and the related works going on trying to solve the issues. The term mobile devices used in this paper means smart phones. Both the terms are used interchangeably.

2. MOBILE DEVICES

A mobile device is a small handheld computing device having a touch or non-touch screen with a miniature keyboard. They made for portability and they are compact and lightweight. From 1990s mobile devices

started getting its popularity. Handheld computing device has an operating system and can run various types of applications known as apps. These devices are equipped with Wi-Fi, Bluetooth, GPS and they can be connected to the internet [1].The mobile devices are powered by rechargeable batteries. Lithium-Ion, Lithium Polymer are the mostly used rechargeable batteries in mobile devices. Most of the mobile devices have camera or video player to play audio and video files. PDAs, Smartphones, Tablet Computer, Ultra mobile PC and wearable computers are the well known mobile devices. Symbian, Windows, Palm OS, BlackBerry, iOS, Android and Bada are some popular mobile operating systems [2].

A recent survey conducted by scmagazine listed out the mobile devices by its popularity [3]. The following figure 1 shows the several devices and their popularity in detail.

Smartphones	-	85%
Laptop	-	65%
Tablet	-	48%
MP3 Player	-	40%
E-Reader	-	29%

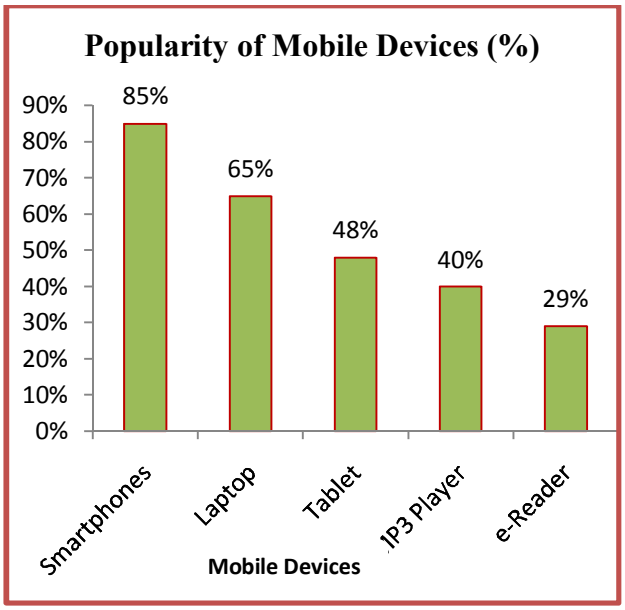

Figure 1: Various Devices with their popularity

Gartner Incorporation survey states that the mobile phone shipment increases 4.9% than the previous year. In 2014, the survey forecasts the tablet market will grow 38.6% [4]. According to Salesforce's exact target marketing cloud's statistics, 85% of people say that mobile devices are a central part of day to day life [5].

3. APPLICATIONS OF MOBILE DEVICES

Consumers normally relate the term "mobile" with mobile phones. But Tablets, e-Readers, Laptops, MP3 Players are also known to be as mobile devices. Mobile devices are inevitable from human life. In day to day life, people use mobile devices for searching local information (searching services, places &etc.). The common applications of mobile devices are surfing information(about news, sports and weather), emailing, accessing social media, using maps to locate places, banking , payment, marketing, instant messaging, using sensor data applications, searching multimedia contents and downloading, learning and playing games[6]. Apart from these, many organizations allow their employees to use their personally owned devices at work. This is known as BYOD (Bring Your Own Device) that improves productivity of enterprises when security is not a concern.

4. MOBILE APPS

A software application that runs in a smartphone, tablet or other portable device is called as mobile application. There are different types of mobile applications.

They are

- Native applications
- Web applications
- Hybrid applications

Native applications are smartphone applications that are coded using a specific language such as Objective C for iOS and Java for Android operating systems. Native applications are platform dependent; For example, Android apps can't run on iOS, Blackberry apps can't run on Android, iOS apps can't run on Windows, and so on. Native apps are distributed through their respective platform's marketplace/app store and installed on the device itself. A native application makes use of the available mobile resources like camera, microphone, GPS, gyroscope, accelerometer, file upload and contact list. Most video games are native mobile applications.

Web applications are coded using HTML5, CSS and Javascript. They can run on any mobile devices using mobile web browsers. Web applications need internet connection to run. They are platform independent. Mobile web applications can't use mobile phone's resources. It's important to note the differences between a mobile web page and a mobile web app. While often confused, mobile web apps and mobile web pages are

quite different. A mobile web page is a static HTML/CSS/Javascript page formatted for use on a mobile device. A mobile web app connects to a back-end database and requires underlying business logic. YouTube, Gmail are good examples for mobile web applications.

Hybrid applications are a cross between native apps and mobile web apps. A hybrid app is a mobile web app wrapped in a platform-specific shell. This platform-specific shell gives the application native qualities, such as full device integration, native installation, and app store/market distribution. Google goggles are an example for hybrid mobile application [7].

5. STATISTICS ABOUT MOBILE APPS

When talking about mobile applications, the statistics about mobile applications download puts us into surprise. As of June 2014, more than 75 billion mobile applications had been downloaded from the Apple App store. In 2009, world wide mobile app downloads amounted to approximately 2.53 billion and are expected to reach 268.69 billion in 2017. About paid mobile apps, by 2016, paid mobile apps are projected to reach 13.49 billion [8].

The statistics about the revenues generated by apps could be $20-25 billion in 2013; this could be triple by 2017. ABI research forecasts, in 2018, app revenues will be worth $92 billion. Portion research forecasted $63.5 billion in 2017. But, app users are increasingly reluctant to pay for apps and the revenues are not equally distributed among app publishers [10]. The app category market share for all mobile devices are games, entertainment, social apps, utilities, education and productivity [9]. Games dominate top apps. Games account for 145/300 of top paid apps on Apple App store and 116/300 on Google Play store. Games account for 94/300 of top free apps on Apple App store and 110/300 on Google Play store. 50% of app revenues are shared between just 25 developers. They are game developers including Zynga, Disney, Electronic Arts, Kabam, Rovio, Glu, Gameloft and Storm8's Team Lava [10].

Enterprises are struggling hard to maintain their market presence by trying out various and unique marketing methodologies. However, all businesses that are targeting web to be the main platform for selling and marketing their products cannot ignore the massive growth of the mobile industry. Websites are being optimized by various app and software development companies for hand-held devices such as smartphones and tablets [11].App based, mobile searches, advertisements, SMS and QR codes are few mobile marketing techniques. Smartphones impact a lot in shopping by products, price comparison and reading product reviews. Smartphone owners in the U.S. are the most likely to use their device for in-store price comparison, online coupons and purchasing products [12].

6. GROWTH OF SMARTPHONES

Today mobile use is expanding. The number of smartphones in use in 2013 is 1.4 billion. That is 1 in 7 people worldwide. The worldwide smartphone market is having shipped one billion units in a single year for the first time. According to the International Data Corporation Worldwide Quarterly Mobile phone tracker, vendors shipped a total of 1,004.2 million smartphones as worldwide. "Among the top trends driving smartphone growth are large screen devices and low cost" said Ryan Reith, Program Director with International Data Corporation Worldwide Quarterly Mobile phone tracker [13]. Gartner survey expedited that mobile devices shipments have been increased to 7.6% in 2014 and out of all the mobile devices, smartphones dominate all others. 29% of internet connected devices today are PC's, while smartphones and tablets makeup 66%.

7. MCC

In the era of mobile devices, many resource intensive mobile apps that need high computing power and storage could not be implemented in mobile devices. Because mobile devices lack in storage and processing power. Though the mobile devices have improved a lot, they lack when their improvements are compared with PCs. Cloud computing is resource rich and it helps to overcome the drawbacks in mobile devices. Cloud services in mobile devices are known as Mobile Cloud Computing where both data storage and data processing happens outside of the mobile devices.

Pragya Gupta and Sudha Gupta [14] states, 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).

Mobile Cloud Computing is referred as availing cloud services in mobile devices. MCC gains its popularity by supporting variety of applications, growth in smartphone usage, capacity and BYOD (Bring Your Own Device) strategy. MCC is a gaining stream. According to the latest study from Juniper Research, the number of

mobile cloud computing subscribers is expected to grow rapidly in the next five years [5].

8. EVOLUTION OF MCC

The growth of mobile devices throws a new requirement. They need to access the data anywhere and anytime. This requirement accelerates and changes the mobile apps into mobile cloud apps. Accessibility via multiple devices expediting business speed and reduced cost pushes the mobile apps into the cloud.

Juniper Research [15] states in their new research as by 2014, the usage of mobile cloud-based enterprise applications tops 130 million. Annual revenues from cloud based mobile applications will reach $9.5 billion and cloud based mobile applications revenue will top more than 25% than others by 2014.

A survey says, between 2009 and 2014, cloud-based mobile apps is projected to increase by nearly 90%. Many companies like Netflix, Instagram, Pinterest, Foursquare, Yelp, Groupon, Newsweek, Zynga, Sega, LinkedIn and Etsy are already running their mobile apps in cloud [16].

From the mobile app developers point of view, they started to develop their apps in cloud using the noticeable cloud service PaaS (Platform as a Service). 52% of developers already adopted a Paas. SAP HANA, a cloud platform from SAP helps companies to speed up their mobile development efforts without capital investment.

Nearly 50% of the 400 developers surveyed for the “Evans Data Cloud Development Survey” they state that app development and testing in cloud saves their time. Because resources are available 24 X 7, so that no need to wait for the resources and it simplifies the development of cloud based mobile applications.

The advent of 4G mobile networks like LTE supports a large scale mobile cloud deployment. In Visiongain’s latest management research named “Mobile Cloud Computing Industry Outlook Report 2011-2016”, they expect, Mobile Cloud services to reach $45 billion in 2016 as their revenue contributions cloud powered mobile apps[17].

According to CNET, 30% of world population, which is 2.1 billion internet users, is in the world today. Thus the evolution of MCC proves that MCC is the future of the cloud.

9. MOBILE CLOUD APPS

Mobile cloud apps run on external server using a browser. They need not to be downloaded or installed in the mobile devices. All they need is an uninterrupted internet connection [18].

Today’s Mobile Cloud Applications include:

Mobile Commerce – Tasks such as transactions, payments, messaging and ticketing are the apps that are related with commerce. Mobile transaction apps started moving to the cloud. This trasactions or billing is known as POS (Point Of Sale). Leaf, NCR Silver, Shopkeep, Revel Systems, QuickBooks Point Of Sale, BreadCrump and Square are few mobile cloud POS systems [19]. Issues relating to this are low network bandwidth, complexity of mobile device configuration and security.

Mobile Learning – Expandable cloud storage capacity enables mobile learning apps to access the large data stores necessary for today’s data intensive requirements. Examples are Cornucopia, a collaborative tool for genetics students, and Plantation Pathfinder.

Mobile Health Care – Monitoring, emergency medical services, patient record access and seamless connection to cloud storage are part of the Mobile Health Care suite of tools. Mobile health care apps started gaining its revenues. The mobile health care apps have increased 150% on Android and 140% on BlackBerry. Apple has 4200+ health care apps. AirStrip, MyPlace History, Sana[20] are some mobile cloud health care apps.

Other Applications – These include tag based searching, semantic based services, voice based services and mobile gaming [8]. There are many cloud storage apps are available for mobile devices. Dropbox, GoogleDrive, OneDrive, box, iCloud are some famous cloud storage mobile apps. Facebook and Twitter are cloud based social apps and Skype is a cloud based app for chatting.

Real Player, YouTube are cloud based video player apps. Likewise, MyCloudPlayer, Pandora, Amazon MP3 and SoundCloud are some popular cloud based audio players for mobile phones. For mailing, Gmail and Yahoomail are there. Maxthon and Puffin are high speed cloud browsers for mobile devices.

Apart from this, many cloud based mobile games started gaining popularity. Toggle-Time tracking app, Moo-Design and Printing service for business cards, postcards, Quickbooks-Online accounting service app are

few other mobile cloud apps. CloudPrint, Cloud Printer is few cloud based mobile apps for printing documents.

10. ADVANTAGES OF MCC

Utilizing the cloud services in mobile devices saves energy and battery life of the mobile devices by accessing the apps in the server. Unlike native apps, there is no need for installing apps in the mobile devices [21]. Mobile cloud apps are platform independent and the storage and processing is done outside of the mobile devices. Flexibility is a major advantage of MCC that is the users can access their data from anywhere in the world. Real time data availability helps the users for many applications like ticket reservation etc. These are few noticeable advantages of MCC.

11. ISSUES IN MCC

MCC avails the cloud services in mobile devices. [22] This combines three technologies in to one. i.e. Mobile Computing + Cloud Computing + Networking = Mobile Cloud Computing. The issues and challenges of these three technologies became the challenges of MCC shown in Figure 2. MCC challenges include hardware and software heterogeneity, security issues, limitations of mobile devices, network latency delay and bandwidth issues. The solutions proposed for heterogeneity is Hypervisors and cross platform development tools. For network problems the suggested solutions are HTML5, cloudlets, Ad Hoc networks. For resource shortage, the new technologies are New chip, offloading and for security issues, encryption, decryption, PKI (Public Key Infrastructure) and homomorphic encryption are proposed by researchers. The solutions are listed in Figure 3.

There are more challenges faced by MCC, this figure 2 shows some important issues need to be solved quickly.

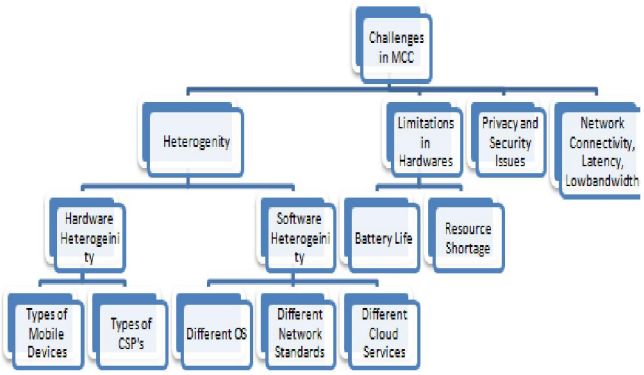

Figure 2: Challenges in Mobile Cloud Computing

The following figure 3, lists out some solutions proposed for the issues.

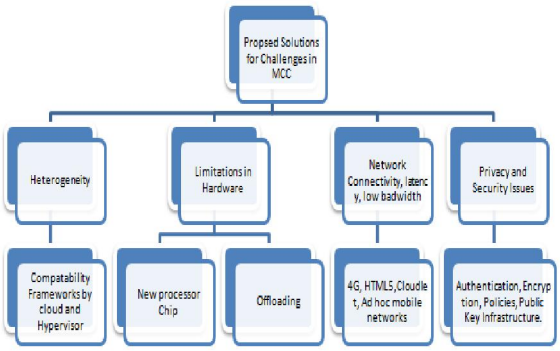

Figure 3: Proposed Solutions for the Challenges in MCC

11.1 Heterogeneity

Heterogeneity in MCC is the existence of differentiated mobile devices, architectures, clouds, cloud services and mobile Operating Systems. To provide interoperability in these heterogeneous hardware and software environments is a big challenge in MCC.

11.1.1. Hardware Heterogeneity

Hardware heterogeneity reflects the presence of different devices with different capabilities, as well as different network technologies and architectures, integrating those devices. Heterogeneity aspects are concentrated to achieve collaboration among different devices and systems [23].

Heterogeneity in mobile devices (with various configurations)

The increasing popularity of smart phones creates a dynamic and demanding market that disperse them to different dimensions.[24]. "Crittercism" the leading mobile application performance solution (mAPM) says in their recent survey that, there are 2582 mobile device manufacturer models, 106 OS versions and 691 carriers. This large number of permutations creates complex ecosystem [25]. Some of the popular smart phones in trend are [26]

- Samsung Galaxy S5
- Sony Xperia Z2
- LG G3
- Nokia Lumia 630
- Apple iPhone 6.

These enormous numbers of varieties in mobile devices throw a hardware challenge when MCC needs for interoperability.

Heterogeneity in CSP's (Cloud Service Providers)

According to ABI Research, the number of MCC subscriber is expected to reach 998 million by 2014.This leads to increasing number of cloud vendors. There are many cloud providers with many services [27].

For e.g.

- Amazon
- VMware
- Google
- Salesforce
- Rackspace
- IBM
- Microsoft Azure.

The wide number of cloud providers provides different services with different policies to their customers. Without any standard policies, non uniformity of API's and heterogeneous frameworks makes the heterogeneity issue even more challenging. These bounds the MCC customers with data lock in problem [24]. i.e. If a mobile cloud user uses Apple's iCloud as an automatic cloud storage which is meant for Apple products, the user cannot fetch his own data from iCloud with a non Apple mobile. This issue is sometimes mentioned as Vendor lock in. This issue must be dealt with both mobile and cloud sides. The interoperability and data integrity among different cloud vendors will be accomplished, only if different mobile devices can communicate with different cloud providers. This is an extremely challenging issue in MCC.

11.1.2. Software Heterogeneity

Software heterogeneity in MCC means the presence of different applications, operating systems and different network standards [23].

Heterogeneity in mobile Operating Systems

The MCC technology is supposed to deal with various mobile operating systems. Some of the popular mobile operating systems are

- Android OS from Google
- Apple iOS from Apple Corporation
- Symbian OS from Nokia
- Windows OS from Microsoft
- Bada OS from Samsung
- BlackBerry OS from BlackBerry [28].

These platforms provide different applications and supports different programming languages. For eg. Android OS supports Java, Apple iOS supports Objective-C, and Windows OS supports languages such as .NET, Ruby, Python, Java and PHP. This heterogeneity in operating systems affects both mobile users and application developers. When the mobile users use multiple clouds, they are heavily billed and it is a time consuming, risky process. The mobile application developers should have a deep knowledge of various mobile and cloud computing languages to provide interoperability among mobile OS. Even though the cloud-ready solution, such as Marmalade and PhoneGap, automatically generates compatible codes for various platforms, integrity with various mobile OS s is a big challenge [24].

Different Cloud Services

The cloud provides various services such as software, platforms, data storage, operating systems, networks, IDE's so on. For e.g.

- Amazon cloud drive
- Dropbox
- Google drive
- SugarSync

Are some cloud provided storage services [29]. Other than these,

- Appery.io
- Conduit
- Knack

Are some cloud based platforms which are used to build mobile apps.

- Amazon Elastic Compute Cloud[EC2] provides virtual server as PaaS
- 10gen provides MongoDB i.e. cloud database
- Adobe photoshop Express
- Google Docs- online office application
- Google Maps API
- Salesforce's CRM

are some cloud based services[30]. As stated earlier, an application developed for an Operating system, won't work with other OS which makes the cross-platform

compatibility as a challenge [11]. A recent survey states, the average application depends on six cloud services (5 is the median). E.g. Facebook for logins, Amazon web services for storage and Flurry for analytics. 57% of apps depend on 5 average number of cloud services, 43% of apps depend on over 5 cloud services and connecting to 6+ cloud services increases the complexity of MCC [25].

11.1.3. Network Heterogeneity

The mobile devices are connected to the cloud using different wireless technologies such as Wi-Fi, 3G, WiMAX that makes MCC even more complicated than cloud computing. The mobility of the client from one wireless technology to another is a challenging task because of different protocols, topologies and different architectures involved. The MCC billing for these rapid changes must include additional parameters such as interception latency, jitter, and bandwidth capacity. The mobility of a client with these heterogeneous networks gives a tough challenge for MCC to overcome [24].

Related work in Heterogeneity

To solve this heterogeneity in both hardware and software, Hypervisor is proposed as a solution. A hypervisor is a hardware virtualization technique that allows multiple guest operating systems (OS) to run on a single host system at the same time [18]. Motorola Atrix has an embedded hypervisor which allows wider range of application run in a mobile device not developed for the particular device [19].

11.2 Limitations of Hardware

11.2.1. Resource Shortage (Limitations of the Handheld Devices) and related work

Mobile devices with cloud, directly deals with resource constrain. Though the smart phones have improved processing capacity, memory, sensing technology, wireless communication, operating system and increased screen size, they lack when their improvements are compared with PC's and Laptops. The iPhone5 or Android or Windows based mobile phones, all of them are 3 times less in processing capacity, 8 times less in memory, 5 to 10 times less in storage capacity and 10 times less in network bandwidth when compared with PC's and laptops[20]. Processors found in smart phones are slower still and far behind the best from AMD and Intel. The ARM company's (the company behind almost all mobile processors)ARM Cortex A15 core has proven in Samsung Chromebook that it is faster, but it uses 4 watts at idle and up to 11 watts at load. This is not a big issue in laptops, but, mobile phones stagger. These disparities pose a limitation to Mobile Cloud Computing.

To overcome resource constraints on mobile devices, a general idea is to offload the resource-intensive tasks to cloud and extend the capabilities of mobile devices. There are many offloading models which offloads the computation part from mobile devices. The offloading unit can be a method or thread or component. Some of the computation offloading methods are MAUI, CloneCloud, COMET, ThinkAir, and mCloud, Weblet, SAMI and MAMCC. It is proven that, these offloading models saves battery life and improves performance. Likewise, cloud computing extends the capabilities of mobile devices by providing storage, computation and networking to compensate the resource constrains in mobile devices. Silk, Puffin are cloud browsers which does the computation in cloud, and it is proven that the loading speed of web pages are improved. Dropbox, SkyDrive are other cloud services which provides storage capacity [21].Dr.Atul Gonsai [22] mentioned Rudenkoet and Smailagic and Ettus's evaluation as the offloading techniques save energy of mobile devices. For example, offloading a compiler optimization for image processing can reduce 41% for energy consumption of a mobile device. Also, using memory arithmetic unit and interface (MAUI) to migrate mobile game components to servers in the cloud can save 27% of energy consumption for computer games and 45% for the chess games.

11.2.2. Low Battery Life and related work

Many applications are computation intensive. They need lot of battery and data transmission between mobile devices and cloud. So, Battery life is a major issue in Mobile Cloud Computing [36].It is proven that, in PC's, cloud based applications consume more power than non cloud applications. In Mobile devices, if a cloud application runs, obviously it consumes more battery power and the researchers have to focus on prolonging battery life of a mobile device or moving the computation part of an application to cloud. Mobile devices have very limited battery life and this issue needs emergency focus on Mobile Cloud Computing.

To solve the battery life issue in devices that run on batteries, the mobile-chip makers are developing low-power designs which reduce energy consumption [24]. The ARM Company designed a new eight-core processor which is more efficient than its predecessor. ARM's leading mobile strategist James Bruce [38] told that, new octa-core design features both "little cores and big cores". This technology is called BIGlittle. Rather than having eight regular cores in a single processor, the new BIGlittle design is two processors. One with four little core and another with four big cores. BIGlittle system

designs, which core would be better to use for applications.

Big core handles big tasks like opening feature-rich webpage and small core deals with little things like checking mails in smart phones. It ensures, Smartphone doesn't waste power and battery life when handling low demand activities. According to Bruce, an octa-core ARM processor should get 50-70 percent better battery life.

Many apps are available to optimize the battery life of the mobiles. The snapdragon BatteryGuru [39] app is designed to intelligently learn the user's usage patterns on the majority of snapdragon powered smart phones. It then uses that data to optimize the battery life without disabling all the connectivity.

11.2.3. Network connectivity, latency low bandwidth and related work

The mobile devices are connected to the mobile network using Wi-Fi, 3G, GPRS and recent days with 4G technologies. These wireless technologies are frequently affected by weather, signal disturbance, land forms etc [40]. The mobility of the users is frequently leaded to connectivity issues of services [35]. Energy consumption and bandwidth cost, both are higher in 3G/4G networks than WiFi [41].

It is proven that, latency delay in mobile network may be 200 milliseconds and in wired network, it is 50 milliseconds [42]. This latency delay leads to hand off delay. Rich internet mobile applications such as online gaming, speech recognition, requires high processing capacity and minimum latency delay. Low bandwidth issue is a big challenge for these types of applications [41].

The numbers of clients accessing social media sites (Facebook, Twitter, YouTube) through smart phones are increasing day by day. These sites require more bandwidth than traditional sites. If the number of users increases, then low bandwidth will become a big challenge to MCC [41]. Each day, the mobile network's size keeps on expanding and this increasing number of devices in mobile network is the root cause for limited bandwidth. So, the lack of speed in mobile internet access is a challenge in MCC [43].

IBM predicts that, by 2015, there will be 1 trillion cloud-ready devices. This prediction is taken to prove that MCC is the future of cloud. So, the challenges are faced in a rapid manner with proposed solutions. To solve this slow network connection, low bandwidth, and high latency delay challenges, there are number of solutions proposed such as 4G, HTML5, Cloudlets, and Ad Hoc mobile networks. The latency delay and bandwidth issues are going to be solved by enabling 4G technology. This technology has higher bandwidth and it increases the speed of mobile networks. E.g. Samsung introduced YesBuzz 4G cloud phone in Malaysia in January 2011. It has no SIM cards and all the contacts are saved in cloud.

HTML5 is also proposed to improve the speed of MCC. HTML5 allows offline storage in mobile devices (i.e. local cache) which helps with connectivity interruptions. Another advantage with HTML5 is, there is no need of plug-ins (Adobe Flash or Microsoft SilverLight) to watch videos. Some of the HTML5 features are implemented in Google Chrome, Apple Safari [32] browsers.

The normal MCC uses centralized cloud architecture, but, WAN delays create abnormality in the applications such as online games, which needs strict response time. So, Cloudlets and Ad Hoc Mobile networks are proposed as the new MCC architectures. Considering the internet connection as persistent, Cloudlet is a resource rich server that has internet access and is connected to mobile devices via a high speed LAN. Now, the distance is reduced and the latency delays are expected to diminish.

But, in MCC, mobility of devices is unavoidable, so, the mobile devices themselves are pooled together and act as a service provider. These two architectures try to solve the latency issues [34].

11.3. Privacy Issues and related work

In mobile devices, many applications are Location Based Services (LBS) provided by Global Positioning Systems (GPS) which creates a challenge for MCC user's privacy [44]. Some location-aware applications such as find out the nearby restaurant, needs frequent updates of user's location. This brings significant concerns on privacy. Many cloud service provides storage as service, and the client's data is stored in a remote place leads to data security, data ownership and privacy issues [45]. The attacks focuses the cloud providers and cloud applications. Cloud provider can be affected by a malicious cloud client and the cloud client can be affected by a cloud provider who can access the client's data. The security issues are consolidated as data loss, Denial of Services, privacy and data ownership. The cloud application is affected by the malicious programmers by modifying the original cloud service by acquiring many details about the user by making them to send messages from their mobile devices. This technique is called as

Repacking mostly affects Android based applications [46]. This leads security and privacy as a big challenge in MCC.

Security plays a vital role in MCC more than we predict. To protect data in a secured manner, many authentication schemes such as logins, passwords and PINS are employed. To keep and protect from misuse of the digital content such as eBooks, music, videos, encryption and decryption methods are applied [36]. Homomorphic encryption is a form of encryption which allows specific types of computations to be carried out on cipher text and generate an encrypted result which, when decrypted, matches the result of operations performed on the plaintext. This type of encryption is used to protect data. In MCC, the PKI (Primary Key Infrastructure) is the best for securing the data. But, mobile devices are resource constrain, and PKI is a overhead and it is not practical in mobile devices.MCC is highly dynamic and adaptive and the mobility of the users leads to insufficient resources to perform asymmetric key operations to transform heavy messages. So, a new PKI based protocol PKASSO is proposed. This protocol offloads the critical and computation intensive part of PKI to cloud [45].There are various policies (such as Fair Information Practice Principles (FIPP)) being proposed which protects the privacy of an individual in cloud. If the mobile devices are stolen, wiping the data from remote is also applied for security in MCC.

CONCLUSION AND FUTURE WORK

In this paper, the emerging technologies that have higher priorities are listed, and in future, I thought of focusing heterogeneity and offloading technologies that plays a vital role in MCC. The different types of mobile cloud applications and the usage of the mobile applications shows the importance of mobile applications in Ecommerce and the growth of smartphones clearly says Mobile Cloud Computing is the future.

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