Cloud and Mobile Computing – Issues and Developments

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***Abstract*— Cloud computing can be seen as a classical model that offers computing in a dimension that benefits both the providers and the consumers. The cloud providers have their infrastructure spread within or across several geographical locations, while the user is able to utilize services on-demand over the Internet. The cloud also offers storage and computing resources to the user. Mobile cloud computing is the grouping of mobile, Internet and the cloud to allow access to information at any place and any time. It reduces the issues of performance, environment and security associated with mobile computing. Applications run on the mobile phones or on servers. Real time information is available as long as there is sufficient data and bandwidth. This study was executed by means of review of some literature available on cloud and mobile computing. This paper examined present-day trends in cloud and mobile computing and also provides a guide for further research. Papers published in journals, conferences, white papers and those published in respectable magazines were analyzed. The results show that secure channel transmission on mobile cloud needs more focus, because only 5% of the papers examined discussed this topic. The outcome of this review will be useful in research on trends in cloud and mobile computing.**

***Index Terms* - Cloud computing, mobile cloud computing, Internet**

I. INTRODUCTION

"CLOUD computing represents a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [1]. Cloud services can be categorized in three primary ways. Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS). SaaS offers the cloud user customized applications for use.

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Cloud service providers (CSP) ensure the availability of applications over the Internet for use by cloud consumer. Cloud users need not bother about installing software or even software licenses. In PaaS, the CSP provides a platform for each user to develop and deploy applications. Each user exercises control over his applications and some resources, while the CSP maintains total control over the platform [2]. In IaaS, the CSP provides CPU, memory, storage, bandwidth and other resources that allows an enterprises to outsource, store and utilize compute resources [3]. Enterprises can migrate some application and activities to the cloud. The user has control over storage, operating system and the deployed applications. The various cloud services are provided on a pay-as-you-use-the-service basis, utilizing the concept of virtualization and multi-tenancy.

Cloud computing also has four deployment types; private, public, community and hybrid. Private cloud is operation by a firm and controlled by in-house staff only. It is sometimes considered an extension of an organization's datacenter. The private cloud infrastructure can be installed on-premises or operated by a third party. Private cloud are presumed to be more secure. Public clouds are hosted by major cloud service providers who have huge infrastructure and technologies at their disposal. Their datacenters are sometimes spread across several geographical locations. Hybrid cloud computing combines either private, public or community cloud. Hybrid cloud takes advantage of the benefits available in the different cloud deployment types. The mobile cloud computing forum [2] states that mobile cloud computing basically denotes an infrastructure where the storing of data and processing of data takes place external to the mobile device.

Cloud mobile computing combines cloud computing, the mobile computing and the Internet [4]. In mobile cloud computing (MCC) majority of the processing and data associated with the applications are relocated from the mobile device to strong computing platforms positioned centrally in the cloud [2] [5]. However, using MCC for today's purpose is restricted to two configurations: applications that can operate on phone or on servers which are remotely accessible by the phone [6]. MCC is seen as a viable option that lessens the increase in the expenses of managing mobile software and mobile infrastructure. This novel technology is being used to attain lots of know-how through various types of mobile services which costs very little to the users [2]. Mobile cloud computing involves running applications on a remote resource, usually an enriched server, while the mobile device act as thin client

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that connects into the remote server [5]. Although technology is continually refining the quality of mobile devices, certain expectations are still lacking. In MCC, mobile capacity is offloaded or migrated to the compute cloud [6]. The remaining part of the paper is as follows: Section 2 reviews related work. Section 3 examines various aspects of MCC. Section 4 presents industry developments in MCC. Section 5 concludes the paper and recommends further work.

II. RELATED WORKS

In [2], the analysis of mobile cloud computing: its architecture, applications, and approaches are proposed focusing on providing general understanding of the emerging concept of mobile cloud computing. In [4], mobile cloud computing: implications and challenges is presented. This paper discusses various aspects of mobile cloud computing including legal issues. In [5], Mobile storage expansion in mobile cloud computing taxonomy, methods, and concerns is presented. It was noted that data generation impacts on storage and life span of battery in mobile cloud computing. The paper focuses on mitigating this situation. In [6], context-aware computation offloading for the mobile cloud computing which is the study of requirements, review and guide for design is proposed. Computational offloading helps to address the issues of performance and security. The dynamic nature in the development of mobile cloud computing was discussed in this paper in relation to designs. In [8], review of mobile cloud computing is presented. In [9], Mobile cloud computing: A survey is proposed. The challenges and likely solutions to the effective utilization of mobile cloud computing was also discussed. In [10], mobile cloud computing is examined. Various issues were surveyed in relations to mobile cloud computing and application areas were also discussed. In [11], cloud computing for mobile world is presented. In [12], a security structure for mobile cloud applications is proposed. The paper briefly examines mobile cloud computing models and discussed security concerns. Thereafter, a security structure is proposed for mobile cloud computing. In [13], an assessment of mobile cloud computing application model is proposed. Smart phones have limits of power, storage and mobile energy that can be mitigated by cloud computing. The focus of the paper is on how constraints relating to mobile cloud application models can be resolved. In [14], mobile cloud computing: the forthcoming of cloud is proposed. The paper examined mobile cloud computing architecture and also discussed some challenges and proffered solutions. In [15], Resource usage optimizing in Mobile Cloud Computing is proposed. The main focus is on resource usage for virtual machine in relation to mobile cloud computing. Various architectures were designed and implemented to enhance optimum utilization of resources on the cloud. In [16], towards securing mobile cloud computing: a survey is presented. Mobile cloud computing is anticipated to grow quickly, but this is being hindered by security concerns. Mobile cloud computing architecture and application

A. Mobile Cloud Computing Architecture [2] [3] [4]

The proposed common architecture of MCC can be found in [2]. Base stations are used to connect mobile devices to the networks such as base transceiver stations point of access that establishes and controls activities and which interfaces between the networks and the mobile devices. ID and location information based on user request are communicated to centralized processors that are connected to servers that provides mobile network services to the mobile users. Services such as authentication, authorization and accounting (AAA) as established on the home agent (HA) and subscribers' data storage in the database. Services like these are designed with the concept of virtualization, utility computing and service oriented architecture including web application and data base services. Another diagram for cloud computing architecture can be found in [14].

Mobile clients interrelate with service providers for cloud using built-in mobile software or browser software that are programmed using standard web development languages [14]. There are two types of cloud servers: the cloud portal server and the cloud back-end server [14]. The cloud portal server accepts and processes the mobile client's request for the usage of the cloud service.

Virtualization is a core concept in cloud computing. There are, the single user for single VM, many users per single VM and many users that are on Queue architectures as shown in [6]. The pathway for communicating with the user is indicated with bold lines and communication in relation with auto-scaling is marked with the dashed dot line in [6]. The pathway of communication with the user is indicated with bold lines and the communicating in relation to balancing the load is indicated alongside the dashed-dot line in [6] for "Single User – Queue Architecture. The various VM architectures are discussed in subsequent paragraphs [6]:

1) Single User – Single Virtual Machine

In the single user VM architecture, when an assignment comes from a mobile device, this is sent through a load balancer which performs in accelerative mode to an application instance that is idle. As the request is being sent, the instance is immediately tagged as being occupied, if there is no node application existing, the load balancer immediately gives a feedback error to the user.

2) Many users – single VM

For one user – one VM, users' request is directed to an instance of an application through the load balancer, using a simple joint idle queue (JIQ) algorithmic for choosing the destination node. This method shares the same user-single VM code, though designed in a dissimilar way. In this architecture, selection of any chosen node is allowed if instances are not idle, and more than one concurrent client can be served by each virtual machine

3) Many users – Queue

When a remote call is summoned in the many user–Queue architecture, the request moves to the Queue proxy that is responsible for getting and sending feedback to the user. When the Queue proxy obtains all node requests, it puts the details about the request on an inline wait. The queue transmitter collects the sent information from the queue, copies the applicable data from store service and delivers the sent demand to an application instance where computation happens.

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Usage of resources in each architecture can be refer to by using the following formulas [6].

- Single user – Single VM

$$\text{Instance hours} = R * (T_r + T_h + T_s + T_u) \quad \textbf{(1)}$$

- Multiple User – One VM

$$\text{Instance hours} = R/S * (T_r + T_h + T_s) \quad \textbf{(2)}$$

- Multiple User – Queue

$$\text{Instance hours} = R/S * (T_d + T_h + T_u) \quad \textbf{(3)}$$

Here:

R – is the ratio request that is expected.
T_r – is the time data is transmitted from the mobile device to the VM.
T_h – is the time virtual machine serves what is demanded inside the VM.
T_s – is the time data is transferred from the mobile device to the VM.
T_u – is the awaiting time for user action.
T_d – is the time storage server receives request download.
T_u – time of upload response to the storage server.
S – is the sum of demands a virtual machine can be served on a concurrent basis.

B. Benefits of Mobile Cloud Computing.

Mobile cloud computing can be viewed as a provision that enables resources required by mobile users to be adaptive to a modifying process and storage capabilities by subdividing and offloading the computationally demanding and storage intensive jobs on native cloud resources through provision of ubiquities wireless access [14]. MCC has the following advantages and benefits [5] [9].

1) Prolonging Battery life

Battery life is of major concern in the use of mobile devices. Some resolutions have been projected to boost the use of CPU and to enhance the disk and screen with a view to reducing power. Computational offloading techniques are proposed with a view to migrating big processes and multifaceted computations from the limited resources on mobile devices to the cloud. This avoids prolong performance time on mobile devices, which leads to less amount of power consumed.

2) Improved Data Storage and Processing Power

Mobile devices have constraints in its storage capacity. MCC enables its users to save and have access to enormous data on the cloud over the Internet. MCC also helps in reduction of the operating cost for computation–demanding applications that takes lengthy time and great amount of energy when done on a mobile device.

3) Improved Reliability

Keeping and running applications on the cloud is an integrative method that enhances reliability because the data and applications are shared and stored on some servers on the cloud. This decreases the possibility of losing mobile device data. The cloud usage may be used to safeguard copyrighted digitals contents and also provide security services to mobile users.

4) Operating systems Fragmentation

MCC is a prospective solution for the disjointed provisions of mobile operating system. There are presently around eight main mobile operating system and it is expected that this can be streamlined through mobile cloud computing.

5) Online Shopping

MCC can become a shopping choice for mobile devices users. Mobile cloud operators act as operators of virtual network that provides electronic payment services, software, data and services for storage.

III. Application and Challenges of Mobile Cloud Computing

A. Applications of Mobile Cloud Computing [13]

1) Mobile Commerce

Mobile commerce is a method of business that uses mobile devices. Mobile commerce applications are having challenges of little network bandwidth and security. Applications such as M-commerce are being brought into the cloud to resolve these concerns. This combines the advantage of fourth generation network and the cloud to increase speed and security levels in data processing. In [13], a fourth party logistics advanced video coding (4PL-AVC) trading platform uses the cloud to enhance user's security, customer satisfaction and competiveness.

2) Mobile Learning

Mobile learning is built on e-learning and agility. Traditional m-learning and applications are limited in device cost and network, slow network transmission rate and narrow educational processes [13]. Cloud e-learning applications have been presented to mitigate these limitations. Utilization of the huge storage capability, and powerful processing capacity, the e-learning apps provide learners with better services. 'Cornucopia' is an example of MCC applied for researchers purposes by undergraduate genetic students aimed to make available information and the provision of collaborating space. In [13], an education instrument is designed based on cloud computing for creation of courses on image and video processing.

3) Mobile Healthcare

The reason for using MCC in medical is to bring to minimum the barriers of medical treatment in terms of storage, security and privacy. In [13] an e-health cloud is proposed which is an application of mobile healthcare information system centered on cloud computing.

4) Mobile Gaming.

Mobile gaming can fully offload game engines needing huge computing resources such as graphic transcription to the servers in the cloud and gamers are only to relate with the user interface on mobile devices. It has been demonstrated that offloading multimedia codes to the cloud does conserve energy for mobile devices, thus increasing time for playing game on mobile devices.

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5) Mobile Banking

Mobile banking is a term used for execution of balance checking, different transactions and various payments through mobile devices. Presently, mobile banking is usually done using SMS, though it can equally use specialized programs known as clients, downloaded to the mobile device based on the concept of MCC.

B. Challenges of Mobile Cloud Computing [9]

1) Absence of Standards

There is no openly established protocol for mobile cloud computing. A possible solution is the mobile agent based on the open cloud computing federation mechanism. Since compatibility is of high concern in terms of migration of user applications and data between CSPs, this technique uses mobile agents to execute computation.

2) Access Schemes

MCC is usually installed in a heterogenous access setup with a widespread variety of dissimilar radio technologies such as GPRS, LTE and WLAN. MCC needs an all time–on wireless connection for small data rate cloud control signaling channel and one with a flexible link bandwidth.

3) Security

Most mobile phones have almost all the functionalities of a standard PC. This implies that the same security threats will feature on mobile devices. To overcome threats to security, mobile devices run threat services on the devices itself. To reduce vulnerabilities on mobile devices, regular software updates of such devices are imperative. Unfortunately, most mobile manufacturers do not provide updates beyond 3 years in most cases, making such mobile devices susceptible to attacks. A better resolution is to migrate the detection services to the cloud for better detection of threats and reduction of resource consumption.

4) Need for Elastic Mobile Application

Cloud computing services are scalable through changing provision of resources which is elastic and on–demand. This requirements are not yet completely manifested in MMC due to limitations of mobile devices.

TABLE I
COMPARATIVE ANALYSIS ON CLOUD AND MOBILE COMPUTING AREAS

References	Cloud Computing Migration	MCC Latency and Bandwidth	MCC Security Issues	MCC Latest Trends	Secure Channel Transmission on MCC	Computation Capability of MCC
Sajid Umair, et al. (2015).	x					
Preston A. Cox (2011)		x				
Yaser Jararweh, et al. (2014)		x		x		
Flavio Bonomi, et al. (2015)		x		x		
Shanhe Yi, et al. (2015)				x		
Saeid Abolfazli, et al. (2015)	x					
Mohammad Goudarzi, et al. (2017)	x					x
Riyadh Nuiaa (2016)			x		x	
Amit Sinhal (2012)	x	x				
SM Shamim, et al. (2015)		x	x			
Christos Stergiou & Kostas E. Psannis (2016)		x	x			
Deepak G. I., & Dr. Pradeep B. S. (2012)		x	x			
Anureet Kaur (2016)				x		
Tianhui Meng, et al. (2018)			x			
Hui Lin, et al. (2017)			x	x		
Mehdi Boukhechba, et al. (2016)				x		x
Khadija Akherfi, et al. (2018)			x			x
Nur Idawati Md Enzai, & Maolin Tang (2016)						x

IV. ANALYSIS AND DISCUSSION

There are numerous reliable and credible authors and researchers that have done a lot of work in the area of MCC. Major topics in the area of MCC were extracted from the papers of some of these key authors. The findings from reviewing such papers are outlined Table 1 and discussed below.

A. Cloud Computing Migration

Data migration is a major problem on the cloud platform especially when the users want to change their cloud provider [17]. Migrating cloud and mobile computing components from one smartphone to other smartphones, across heterogeneous clouds with little/no modification or configuration is very difficult to achieve, and it poses challenging risks especially when there are no standards, technologies, and solutions to handle heterogeneity in mobile cloud computing [22][25]. Latency rests on several elements which are: loaded code size, size of input data, where data is located, off-loading scheme and granularity, network bandwidth, postponement in computing, and consequential size of data [27]. However, only 22% of the papers reviewed discussed the issue of migration in MCC.

B. Cloud and Mobile Computing Latency and Bandwidth

Bandwidth affects mobile cloud computing as Wi-Fi does make latency inevitable, there is a reduction in bandwidth when there are several mobile devices being utilized [18]. In [19], the authors' practical experimental results with the use of multimedia applications have shown that usage of the projected method will reduce power ingestion of the mobile devices and also reduce the communicating latency when the mobile devices demand for a task to be done remotely as it enhances the value of services required [20] [28]. Due to device storage limitations to store software, data, multimedia and operating system, transferring huge size of data needs to

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be optimized in a single transfer; that is chunking the size comparative to setup bandwidth, considering that bandwidth is very important in mobile applications [25]. Presently, there is very little support for mobile cross-platform implementation and relocation in mobile cloud computing. Peer-to-Peer Media Streaming is used for distributing little bandwidth among the subscribers located in a locality for the related content like video [26]. Only 38% of the papers examined considered the issue of bandwidth latency in MCC.

C. Cloud and Mobile Computing Security Issues

The fact that cloud solutions are bare on the public internet, privacy and security are easy to target by hackers and other malicious users [26]. Security is a common issue in Mobile Cloud Computing technology as a company's delicate information will be available to third-party cloud service [27]. There is usually inadequate bandwidth where mobile Internet access is commonly very slow compared to the use of direct cable connections, using technologies like GPRS and EDGE, including the 3rd generation networks. Using high speed wireless LANs are low-cost though they have less range to cover [28]. The utilization of bandwidth could be better by logging (big operations against small requests) and by compression of generated data in advance of the transmission. Security is the main issue for the mobile computing standards on the fleet. Security issues such as: confidentiality, integrity, availability, legitimacy, accountability, and encryption mechanisms are implemented into the network infrastructure. In [30] is a proposal combining security tactics and the addition of random delays in the encryption implementation flow and considering quantitative treatment of security problem. For quantifiable treatment of the trade-off issue, a hybrid Continuous-time Markov chain and queuing method is used for modelling the MCC system that handles security and performance attributes [24] [31] [33]. Security issues is a major focus of discussion in cloud computing. Such security issues indirectly affects MCC too, but from the short survey conducted in this paper, only 38% of the papers reviewed focus on MCC security.

D. Mobile Cloud Computing Latest Trends/Technology

Cloudlet-based mobile cloud computing system is aimed at minimizing the control ingestion and the delays of multimedia applications network when mobile cloud computing is used [19]. Fog Computing, is a virtualized platform which makes provision for computation, storage, and networking services between end devices and traditional cloud computing data centers positioned at the edge of the network, providing location awareness, and little latency in applications requirements [20]. Cloudlet is a cloud computing paradigm that depends on large capacity servers and emphases more on providing services to delay-sensitive, bandwidth restricted applications within locality [21]. MobiCloud is a proposed architecture that provides security seclusions to protect mobile users' information; it monitors the status for evaluating risk, detection intrusion and responding to intrusions [24]. From [29], mobile cloud computing and big data big data are emerging technologies that are complementary, that have a core common focus in terms of scalability, agility, and on-demand availability [31]. Clearly, a lot of grounds is being covered in the area of latest trends in MCC. Again the focus on the latest trend in MCC was by only 38% of the papers examined.

E. Secure Channel Transmission on Mobile Cloud Computing

Cloud computing security risks are not limited to security loop holes in the cloud infrastructure, but insecure application interfaces, wrong use of the cloud, Virtual Machine level attacks, lack of browser security, issues with extended markup language signatures, user access privileges, malicious insiders, service hijacking, flooding attack, internet protocol vulnerabilities, misconfiguration of network security, network attacks, and lack of safety standards all constitute security challenges [24]. Only one author out of the papers considered discussed the issue of secure channel transmission, constituting 5% of the papers reviewed.

F. Computation Capability of Mobile Computing

A quick hybrid multi-site computation offloading is the way out for mobile cloud computing as proposed together with a measured cost model for performance time and energy consumption for multi-site environment in order to attain a trade-off among them for offloading [23]. Optimized multi-site branch-and-bound algorithm with an elevated particle swarm optimization (PSO) algorithm called optimized multi-site particle swarm optimization (OMPSO) are engaged to achieve the paramount offloading partitioning in a practical time. In [32], is a proposal for a new battery-saving technique for mining semantically and incrementally significant geographical locations from users' by detecting outdoor activities. Mobile offloading depends largely on the mobile cellular and Wi-Fi network technologies which determine the viability of mobile offloading [33]. Present Wi-Fi technology provides high bandwidth connections, and computation offloading and it is worthwhile only when mobile device utilizes a lot of time and energy rather the offloading overhead. It is possible to allocate the flow of computation tasks to services delivered by mobile devices and cloud, and program them while reducing all mobile users energy requirements, completing time and price [34]. This is a very core issue in MCC and 22% of the papers examined discussed this topic.

V. CONCLUSION

The Cloud is a scalable, on-demand and elastic method of providing services to users. It also has huge infrastructure that provides compute resources and storage for customers. On the other hand, MCC aims at engaging cloud concepts and computing methods for the utilization of mobile devices data thus minimizing the limitations of processing power and energy usage. MCC has various advantages and applications in several areas of human endeavour, however there is no open accepted standard yet for MCC.

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