Mobile Edge Computing: Review and Analysis

Komal Kharbanda[1]*, Kiranbir Kaur[2]

[1,2]Department of Computer Engineering & Technology, Guru Nanak Dev University, Amritsar, India

*Corresponding Author: kkharbanda76@gmail.com, Tel.: +91-7652937079

Abstract— These days with intense use of mobile applications and cloud computing, mobile cloud computing has been acquainted. The cloud computing deals with high latency, limited flexibility, platform dependency. The mobile edge computing(MEC) combines cloud computing and wireless communication to overpower the obstacles of delay, scalability and mobility. MEC helps to bring the various resources and cloud computing services nearer and accessible anywhere by the user with the use of mobile edge clouds(MEC). In this paper we provide an extensive survey of mobile edge computing research, while highlighting the specific concerns in mobile cloud computing. We present a taxonomy based on the key issues in this area, and discuss the different approaches taken to tackle these issues.

Keywords—Mobile Cloud Computing, Mobile Edge Clouds, Mobility, Internet of Things

I. INTRODUCTION

The cloud computing provides pool of resources and services such as infrastructure, platform, storage, software and many more[1]. One of the major concerned issue is to deliver the services and resources on time and with less downtime. But currently structure of cloud computing paradigm is the far distance between the customer and cloud server that leads to edge to edge more downtime and more latency. The major cause of this drawback is one cloud server is accessed on the basis of multiple to single.[2]

These problems are resolved by offloading the infrastructure or applications at each network hope. As the services can be accessed by using various mobile applications. Different mobile applications are becoming abundant in different categories like social networks(Gmail, Facebook), news and games, entertainment (music, videos, and pictures)[3]. These applications get popular by the use of play store in android mobiles or app store in IOS mobiles. Different portable gadgets like smart phones, IPad are able to support location independence, portability irrespective of movement of naive user. To support scalability, flexibility, position independence, mobility mobile edge computing has been introduced.

This concept is possible with the help of mobile edge clouds(MEC) with the combination of similar technologies like fog computing[4], wireless communication[5], cloud computing[6] and mobile computing[7]. These technologies are too different from each other but the motive of these technologies is similar, to make the cloud services closer. Mobile edge clouds are placed only few network edges (in form of application server) apart from the smart phone user therefore the latency become very low.

This paper presents a survey on mobile edge computing in which Section II describes overview of mobile edge computing and mobile edge clouds. Section III discusses the related terms to mobile edge computing. Section IV discusses the comparison of mobile edge clouds with cloud computing and mobile edge computing. Section V discusses the motivation to use mobile edge clouds. Section VI discusses the review of papers based on energy and latency. Section VII describes some challenges of mobile edge computing. Section VIII summarize the conclusion of the review paper.

II. MOBILE EDGE COMPUTING

Through recent research, The cloud infrastructure and platform located at mobile hops and accessed by mobile user rather than to store on data-centres'. This facilities in mobile edge computing is provided by adopting resources of edge hops, these facilities provide some real time applications like video traffic optimization, Big data Analytics. In white paper, Aepona describes[8] mobile edge computing is tool for mobile applications, where the storage and platform is provided by centralized platform by the mobile edge clouds. These clouds are accessed by wireless connection based on naive user. Mobile edge computing provide smart phone users with data processing and memory services on mobile edge clouds. It is an extension of cloud computing with new infrastructure based on some portable devices that is business oriented. Mobile cloud computing can be defined as combination of mobile applications and cloud computing(CC). MCC is best to access mobile applications and services by the mobile users.

Various researchers have focused on concept mobile edge computing and they have given classification of MEC as

shown in figure1. This classification is shown based on its characteristics, where it can be accessed, what are the main goals to focus on this technology and which platforms it exists.
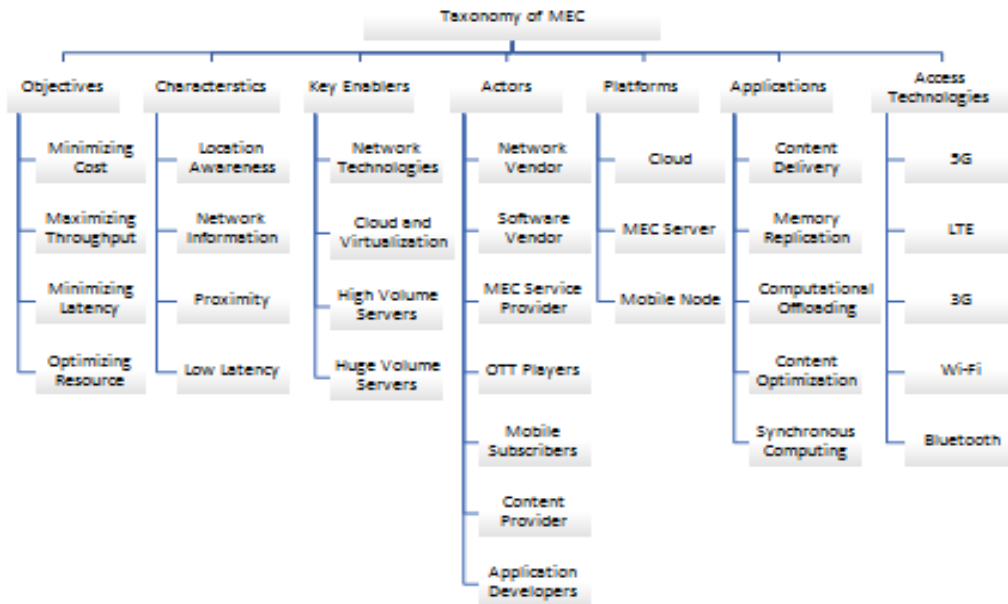

Figure1: Taxonomy of mobile edge computing.

A.　Mobile Edge Computing Architecture

Mobile edge computing is generally a architecture that brought cloud computing services to the end of mobile device. The motive of this architecture is to bring all the data processing tasks and computational tasks to RAN(radio access network) rather than cloud data centres'. This task will reduce network traffic, latency, downtime and give better throughput according to user experience. To get the high throughput, mainly mobile edge computing servers are deployed anywhere mainly near LTE nodeB, edge of core networks[9]. In figure 2 some of the elements require in mobile edge computing has been shown.

Mobile edge computing are not restricted to some kind of mobile devices but it is usable in all the portable gadgets. With mobile edge computing there is no worry about processing speed and storage of data. This concept make possible the processing and storage on the mobile view point only. The cloud computing is the only best solution for mobile cloud computing because cloud computing provides easy integration, scalability, mobility.
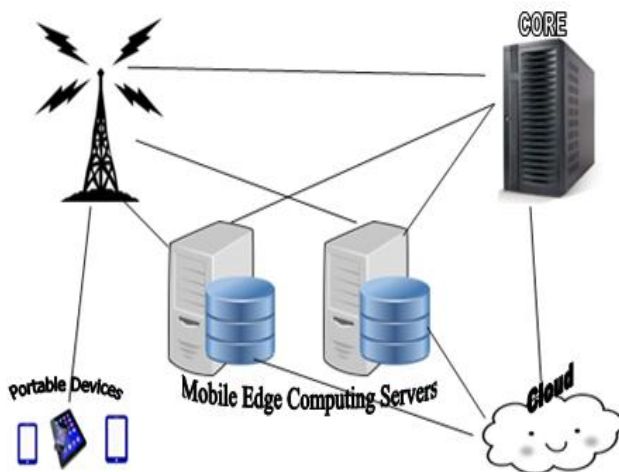
B.　Three Level Architecture

As shown in figure3, mobile edge computing is interface between cloud data centres and mobile devices. the architecture contains three layers[10]: cloud data centres, mobile edge computing servers and mobile devices. Mobile edge servers mainly depends on cloud to enhance performance. Mainly the social network platforms, big data or various internet devices are connected through the edge network. i.e. Radio access network and MEC(mobile edge clouds) as shown in figure4. As network generation is moving from fourth to fifth, then it is becoming more easy to deploy mobile edge clouds. This task is performed to bring cloud computing services near to the mobile users.

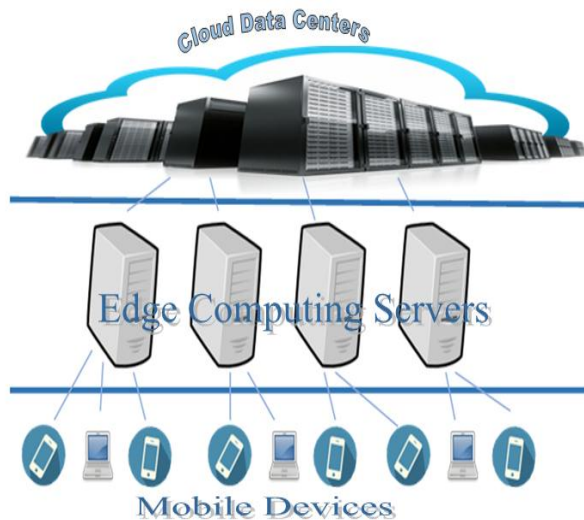Figure2: Mobile Edge Computing Elements

Figure3: Three Level Architecture of MEC

Figure4: RAN and MEC

III. RELATED TECHNOLOGIES TO MEC

C. Fog Computing

Fog computing is also known as edge computing. The fog computing is invented by CISCO to bring cloud services to the edge of the networks. fog computing offers low latency as compared to cloud computing. Fog computing and mobile edge computing are almost similar but different in some ways. In fog computing, work is used at LAN which is processed in internet of things. Mobile Edge computing environment, has capability and processing power. Mobile

edge computing is now becoming more popular in 4G and it will use in future 5G networks.

[11] has proposed a COT(cloud of things) architecture. This architecture contains a layer fog layer that is placed at hop edge. This layer is placed here to process the generated data by different portable devices. This architecture has sensor function, and this model is helpful to find combination of fog computing and cloud of things. The fog layer in this system will improve the flexibility of cloud of things.

D. Internet of Things

Some of the researchers relates the internet of things with mobile edge computing. Mobiles, portable devices are the tools or devices used as internet of things.

[12] has proposed a method to generate association of public or private clouds. This has given a paradigm named as mobile to IOT federation as a service, that combines properties of fog computing devices with public or private clouds to generate a federation. In this paper, performance of the system has been evaluated to provide flexibility and to reduce cost complexity.

[13] has proposed a approach to handle data at mobile devices. This paper presented a framework named as edgeIOT in which each portable device is linked with virtual machine that will collect, classify and analyze that data. And if any discrepancy happens on data, then offloading concept has been discussed.

[14]has discussed that mobile edge computing is rising day by day as mobile device applications and these applications demands for real time operations. This has discussed various applications of internet of things that enabled mobile edge computing like smart cities, mobility, maps and many more services.

[15]has presented a architecture that is given by ETSI. This paper has described advantages and some of the opportunities towards fifth generation. This paper has given a challenge to prove the existence of LTE as with the 5G.

E. Cloud Computing

Some of the researchers have related cloud computing and mobile edge computing.

[16] has provided recovery schemes to handle mobile edge computing failures. In this paper, the first recovery method is used in case of one failed mobile edge computing server. but the second method is suitable where no mobile edge computing server is available. He has evaluated the performance of these methods.

[17] has given error and fault detection based on mobile and cloud computing. It has given a framework that is based on RBAT(recovery blocks acceptance test). This method is to all the software faults, hardware faults, transient faults and any response time failures. This technique is applied to each computing edge of the cloud.

[18] has given a model for application storage on mobile cloud. In this paper, model contains different models user model, application model, data center model and many more. The main objective of this model is to deploy the applications in mobile cloud network. This model shows that the proposed model has given high performance and it minimizes the execution cost.

[19]has been focused on de-duplication concept to enhance the cloud storage on portable devices. This concept mainly use the technologies mobile edge computing and cloud computing. As to transfer data from mobile devices to and from the cloud   is costly because these gadgets have less

storage. To handle this, de-duplication concept discussed. This paper has discussed a method that will reduce de-duplication time. This paper discussed the reasons and advantages to use de-duplication.

[20] discussed an architecture helpful to deploy (M-FMC)mobile follow-me cloud and centric network. This paper has proposed a algorithm named as Multiple Attribute Decision Making Algorithm(MADMA), to configure the router. This algorithm is proposed for migration.

IV. COMPARISON OF MEC WITH CLOUD COMPUTING AND MOBILE CLOUD COMPUTING

Mobile Edge computing is combination of two technologies: cloud computing and mobile cloud computing. But still these technologies are differ from each other. Some of the parameters on basis of which these terminologies differ as shown in table1.

Table 1. Difference of cloud computing, mobile cloud computing and mobile edge computing based on various parameters:

Parameters	Different Computing		
	Cloud Computing	*Mobile Cloud Computing*	*Mobile Edge Computing*
Node Devices	Data Centre in a box	Large Scale Data centres	Server running in base stations
Node Location	Local/Outdoor Installation	Edge Network	Radio Network Controller/ Macro Base Station
Software Architecture	Cloud Agent Based	Cloud/ Mobile Based	Mobile Orchestrator Based
Context Awareness	Low	Moderate	High
Proximity	One Hop	One Hop	One Hop
Access Mechanisms	Wifi	Wifi and Mobile Networks	Mobile Networks
Internode Communication	Partial	Partial	Partial
Applications	Cloud computing provides various services like infrastructure, platform, storage and many more.	Online social networking and mobile commerce/health/learning	AR, automatic driving and interactive online gaming

V. MOTIVATION TO USE MOBILE EDGE CLOUDS

F. Edge Data Fetching
For accessing content from internet, mobile devices play important role. Mobile edge computing helps to enhance the performance of fetching data content by caching it on base stations. The edge data fetching improves naive users experience and is helps to reduce cost and delay of network.

G. Congestion Management
A situation of analysis of road traffic, and to search the other route without congestion to move plays a great in mobile edge computing. Because this task require computation in

real time circulation of information. The cloud data centers are sometimes infeasible due to more downtime and high latency in Wide area network. To solve this soft real time problem, mobile edge servers are used on roads to perform this sensitive task. The mobile edge clouds pass the information to the drivers to move towards the best route in real time.

H. Sea Monitoring
To handle with disastrous incidents like tsunami and many more the oceans and sea are monitored. For this task quick information computation and forecasting is required to take a quick action. Using mobile cloud computing, data and

information is fetched directly from deployed sensors to access able gadgets. With this way, it helps to handle additional latency delay of wide area network.

I. Security

Security is one of the most challenging task. In mobile edge computing, all the applications that are in execution are taken away from portable device on Mobile Edge Computing to cloud servers. The sharing of resources among different users arises security concerns. The transfer of applications securely is possible by encryption and decryption application code delay. But that can degrades the performance of application.

To handle with disastrous incidents like tsunami and many more the oceans and sea are monitored[21].

VI. LITERATURE REVIEW BASED ON ENERGY AND LATENCY

Mobile edge computing has given various opportunities and challenges including energy efficient system, offloading and many more. Below Table2 has discussed solution based on different parameters to form new objectives and problems. This table has discussed different methods those have been used by some researchers to get further challenges.

Table 2.

Parameters	References	Description
Energy	[22]	This paper has given solution for energy efficient systems by controlling the transmission rate of data from one hop network to other network.
	[23]	This paper proposed a framework for MEC systems. This paper has given a method of optimize offloading.
	[24]	This paper proposed various points to minimize energy consumption while migration of data from one hop to MEC server.
	[25]	This paper has given convex optimal decision for migration.
	[26]	This paper has discussed an algorithm for scheduling the optimal migration. This algorithm focused on maximum data transfer from one hop to other hop.
	[27]	This paper discussed an algorithm that works for parallel processing between mobile device and cloud computing.
Latency	[28]	This paper proposed an algorithm for portioning load balancing and minimize latency.
	[29]	This paper discuss the algorithm that is based on polynomial time for minimizing latency and energy.
	[30]	This paper proposes a method for computation on edge network. it discussed migration based on different parameters like clock speed, network based, task allocation.
Power And Energy	[31]	This paper discussed a Lyapunov optimization method to minimize the power consumption while migrating the data from one hop to other hop. This paper shows power and delay trade off with simulation.
	[32]	This paper discussed resource allocation criteria, according to that, with latency as a constraint energy consumption and power consumption is minimized.
Resource Utilization	[33]	This paper proposed a non covex optimized solution for minimizing resource utilization. The proposed framework contains distributed network implementation and parallel network implementation across hop points.
	[34]	This paper has given the solution to minimize energy and better way for resource allocation and utilization while migrating content from mobile network to servers.

VII. CHALLENGES OF MOBILE EDGE COMPUTING

Mobile Edge computing has given various opportunities and research areas.

J. Transport Navigation of Applications

One of the most challenging task of mobile edge computing is migration of applications from one mobile devices to mobile edge computing server should be transparent. For the

execution of different applications of mobile devices, data of the devices are migrated to the edge computing servers from mobile devices.[35]

This major issue is known as offloading of power and other resources. Thus, the mobile applications are competent to offload resources to mobile edge cloud servers. These applications use the services of MEC servers.

K. Flexibility

As in the above point migration has been discussed as a challenging task. Thus next most important challenge is flexibility of applications based on mobile edge computing environment. While doing migration, the developers have to separate the application into two parts like delay sensitive and delay tolerant part to improve the flexibility[36].

L. New Opportunities For Service Provider

To improve the mobiles, tablets service providers got the opportunities with mobile edge computing. The service providers can provide new services to the device users to improve performance of the system. These services will improve the application performance and it give better turnover and output based on their opportunity.

M. New Opportunities For Network Vendor

Mobile edge computing provide new opportunities for network vendors. network vendors will have to change the working faulty stations and hardware parts. Mobile edge computing generate the challenge for developers as well as for network vendors. The new features of base stations and access points will generate opportunity for vendors.

N. Generate Connectivity With Networks

Mobile edge computing employ the base place of mobile hop to provide mobile users with storage as service. That stations can be used for communication between two networks and for computation services. These services further provide networks to use computation convergence to perform different types of classification methods on the generated data from various portable devices.

O. Open Challenges

As the world is moving from fourth generation to fifth generation, all of the applications and their data are preferring to store on cloud, which brings the new technologies like connected systems, internet of things, real time applications, smart homes and many more in front. Mostly these technologies are based on portable devices like mobiles, iPads and new technologies like mobile cloud computing and cloud computing. As these technologies access the mobile infrastructure and store data on cloud. Hence these are providing new opportunities for mobile operators and some of the application vendors. The challenge is to handle the unlimited growth of mobile data with good throughput and high resource utilization[37]. Thus the major challenge is to make mobile edge computing cost effective with better user experience.

This is major challenge of mobile edge computing. As in cloud computing resource utilization is more as compared to mobile edge computing.[38] On mobile edge cloud servers, the resource availability is less. The proper utilization of resources is require to get better performance. [39]

VIII. CONCLUSION

The mobile edge computing is the most challenging technology these days. This technology enables all the mobile operators and application vendors to provide better services directly to the hop of the network. So that the most usable services can accessed by the edge of the network by offloading task from busy data centers. This only technology provide a chance to collaborate mobile operators, application developers and internet players. Using mobile edge computing user can enjoy services according to their needs and preference.

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Authors Profile

Komal Kharbanda pursuing Master's of technology in Computer Science & Engineering from Guru Nanak Dev University Amritsar. She pursued Bachelor's of Technology in Computer Science & Engineering from Guru Nanak Dev University Sathiala in year 2016. Her research interest are Cloud Computing and Web Development.

Kiranbir Kaur pursed Bachelor of Technology and Master of Technology in Computer Science from Guru Nanak Dev University, Amritsar, India in year 2008. She is currently pursuing Ph. D. and currently working as Assistant Professor in Department of Computer Science, Guru Nanak Dev University, Amritsar. She has published more than 12 research papers in Ugc Approved Journals. Her main research area focuses on Cloud Computing Interoperability and Portability, Cloud Security and Privacy. She has 7 years of teaching experience.