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Edge Computing: Needs, Concerns and Challenges

Vaishali Sharma[1]
Sagitech Solution
California, USA
vaishali.sharma@sjsu.edu

Vipul Pratap Rai[2]
San Jose University
California, USA
vipul.rai@sjsu.edu

Dr. K K Sharma[3]
Lingaya's University
Faridabad, Haryana
kksharma@lingayasuniversity.edu.in

Abstract— In **numerous parts of computing, there has been a continuous issue between the centralization and decentralization aspect which prompted to move from mainframes to PCs and local networks in the past, and union of services and applications in clouds and data centers. The expansion of technological advances such as high capacity mobile end-user devices, powerful dedicated connection boxes deployed in most homes, powerful wireless networks, and IoT (Internet of Things) devices along with developing client worries about protection, trust and independence calls for handling the information at the edge of the network. This requires taking the control of computing applications, information and services away from the core to the other the edge of the Internet. Relevance of cloud computing to mobile networks is on an upward spiral. Edge computing can possibly address the concerns of response time requirement, bandwidth cost saving, elastic scalability, battery life constraint, QoS, etc. MEC additionally offers, high bandwidth environment, ultra-low latency that gives real-time access to radio networks at the edge of the mobile network. Currently, it is being used for enabling on-demand elastic access to, or an interaction with a shared pool of reconfigurable computing resources such as servers, peer devices, storage, applications, and at the edge of the wireless network in close proximity to mobile users. It overcomes obstacles of traditional central clouds by offering wireless network information and local context awareness as well as low latency and bandwidth conservation. In this paper, we introduce edge computing and edge cloud, followed by why do we need edge computing, its classifications, various frameworks, applications and several case studies. Finally, we will present several challenges, concerns and future scope in the field of edge computing.**

Index Terms— Mobile Edge Computing (MEC), Internet of Things (IoT)

1 Introduction

A. Understanding of Edge Computing?

Emergence: Back in the early days, when Mainframe computers were used, the end devices or clients were completely dumb. They were meant for only taking the input and giving output to the screen. The entire load of computation was on the server. Later on, in the eighteenth century, client server architecture was introduced. During those day's clients comparatively had better intelligence still most of the processing was done on server side. Recently, in 2015, the concept of Internet of things came up which transformed the end devices into smart devices. Now when millions of end users send terabytes of data to the server, the computation power of a standalone centralized server is not enough to process huge data. Also there is not enough bandwidth to allow all these devices to communicate constantly with the server. This led to the concept of edge computing i.e. pushing intelligence to the edge of the network.

B. Why do we need Edge Computing?

Edge computing is required as the computation power of a single server is not enough to handle terabytes of data coming from the end users. Also there is not enough bandwidth to allow all these devices to communicate constantly with the server. Secondly, cloud computing is not always efficient when it comes to computation of data generated at an edge device. In addition to requesting service and content from the cloud, edge devices also perform the computing tasks from the cloud. Edge can take the responsibility of processing, storing and caching data and offload both requests and responses from the cloud to the end user. Given those responsibilities to be handled by the edge device, it is to be equipped well to perform efficiently as well as for maintaining security, reliability, privacy etc. Recent studies show that the results of data analysis that were retrieved from edge computing were in near real time. It reduced the maintenance as well as the operational costs as the number of data center's that were needed to be maintained were reduced. In addition to that, it reduced the network traffic as well and also improved latency.

Use Cases: Usually, Digital surveillance cameras used to send continuous data, earlier to the back end server 24 hours a day 7 days a week and keeping a note of the notion but now the entire statistics is stored on client side and goes to the server only when there is a notion. Envision has a large network of 20,000 wind turbines. There are 3 million sensors which are set up on these turbines and they produce up to 20 terabytes of data at a time. By implementing, edge computing, envision has reduced its analysis of data from minutes to few seconds, which increased the efficiency of wind turbines' production by 15 percent. Besides that, there are many other real world im-

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plementations of edge computing as well. Palo Alto city in California, is working towards making the parking spaces smart.

C. Needs, Challenges and concerns

Needs: In many scenarios, it makes sense to compute and store data on the edge devices rather than pushing everything to cloud. For example, considering the case
of important matters related for human survival like health and safety concerns, due to restricted access in cloud, these crucial information is not shared which could have benefitted many individuals. By allowing computation and storage of data locally, edge computing can implement collaboration across stakeholders. Not only that, with the help of sensors and controllers, homes can be made smart. But terabytes of data regarding the whereabouts of home if uploaded to the server outweighs the computation power and bandwidth required for processing it. But this problem can be outwitted if this huge amount of information can be executed and stored locally. In a similar way the idea of building smart cities for the favorable and safe existence requires involvement of cutting edge technology, human coordination and connection between smart cities.

Challenges: There needs to be efficient discovery mechanisms to search appropriate edge nodes to decentralize computation tasks. In this case, manual search won't make much difference as there will are thousands of end devices. Along with the distribution of computation and storage of information, there should be a mechanism to keep the system up and running even if one of the edge node fails. This needs technologies such as high availability where for every edge node, there will be a replica (either in active or passive mode so that if the main edge node fails, it can immediately take over without causing any disruption in the system. Also, each device needs to be confined once, it fails to avoid failure of the entire system.

Concerns: Offloading of tasks among the end users is a challenge as, when the end devices are selected for task offloading, it is done in a random manner without considering the capabilities or location of the edge nodes. Also, it's needed to be ensured that the edge devices achieve intended throughput and perform efficiently even if they are handling extra load. Other concerns include how to use edge nodes securely and reliably etc.

D. Understanding of Edge Cloud Computing.

What is an Edge Cloud? (Definitions): When, a service implementing edge computing is deployed in cloud, it is known as Edge Cloud. Edge cloud is mostly beneficial over traditional approaches where the data center is geographically far away from the user.

Why do we need Edge Cloud? (Motivations and needs):

We need Edge cloud so that we can implement edge computing and combine it with cloud so as to reap the benefits of both as distributing the computation across multiple edge devices and at the same time the user pays how much resources he uses on the cloud, has the flexibility to access the servers for which he has subscribed for from anywhere from any device at any point of time.

What are the differences between an edge cloud and conventional cloud?

In conventional cloud technology, when a device attempts to communicate with any other device, the communication happens through the cloud for example if someone sends a text message to another person, it first goes to the cloud, gets stored there and then reaches the other person whereas in edge cloud, the text message directly reaches the receiver without having to pass through the cloud. Another difference between edge cloud and conventional cloud is that cloud is used when the location where the application is deployed is known whereas edge cloud is used when the application is deployed all over the world. So, in general the cloud where any service which is deployed in cloud and the end users do not participate in processing of any data is conventional cloud whereas a cloud hosted service from any of the vendors such as AWS, Azure or Open shift with the computation distributed across edge devices is called as edge cloud.

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F. Needs, Challenges and Concerns

When it comes to edge cloud, the major challenge for programmers is to write codes in different programming languages to suit to the platform and environment of various end

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devices for example the language to choose, the frameworks to select etc. In addition to that an efficient naming convention needs to be maintained as there are multiple applications running in the edge nodes and for a vendor to provide a service to these nodes, there has to be standardization in programming, frameworks, data transfer etc. Overall there needs to be differentiation of services, flexible design for extension to other devices when needed, isolation of a node when it fails and maintaining reliability throughout the lifecycle of the system.

2 Edge Cloud and Services classification

2.1 *Edge Cloud classifications*

Edge computing is pushing the computing, storage, analytics, data, applications and services towards the edge rather than having a centralized structure where everything is done by the central unit. There are many ways to implement the edge computing paradigm. Edge computing cloud networks can take many shapes and form i.e. infrastructures and frameworks. The way an edge computing infrastructure is laid out depends on the application it is going to serve and the edge clouds purpose. Therefore, when classifying the edge computing cloud, it is best to classify different edge architectures with relation to the use cases. This way of classifying the edge cloud and its services helps to bring a clear view about different architectures used while implementing edge cloud computing.

1. *Edge clouds at mobile towers:*

Many mobile applications rely upon the data provided by the remote servers, data centers. To provide data to the mobile applications and services mobile networks work to transfer the data from the mobile phone to datacenter and vice versa. This leads to huge amount of data transferred back and forth from the datacenters. It is estimated that bandwidth requirements will continue to double each year [mec1] and the advent of 5G networks only partially solve the problem of bandwidth constraints. To mitigate the bandwidth problem mobile edge clouds are being proposed. The mobile Edge clouds are located at the cellular network base stations. These mobile edge clouds change the cellular network base stations from forwarding points to computational edge cloud locations." Mobile edge computing eco-system has four main stakeholders: 1) Mobile end user Equipment (UE) 2) Network operators maintaining the base station 3) Internet Infrastructure providers 4) Application services provider" [11].

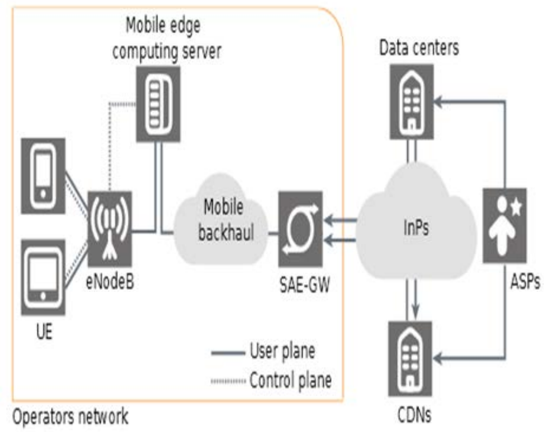

Figure 1 Mobile edge computing [11]

Introducing a mobile edge platform at the cellular network allows the application to execute their need for computation directly at the cellular tower. This reduces the amount the data to be carried to the remote data center. These Mobile Edge clouds can be hosted with commodity hardware i.e. with regular CPU's, memory hardware and network interfaces. Mobile operators define the type of the traffic that should be forwarded to the cloud and the type of the traffic that should be processed at the Mobile Edge clouds. This decision can be taken by considering of privacy and the application provider's demands. The application developer demands can be specified by sending the additional information at the header of a HTTP Request by the mobile application which are requesting data and processing. Also, the traffic originating from the devices can be marked as transparent and blocked to make sure only the transparent data would be processed at the edge location. If the packets are marked for processing at the Mobile Edge cloud and the application VM is not present at the Mobile Edge server those packets are routed to mobile networks core handling the requests. As the packets are rerouted transparently developers can use the same URL to access the Mobile Edge Computing infrastructure or backend server if needed.

2. *Edge computing as IOT devices aggregator:*

Many of the IOT devices are sensors and data collection units which send lot of data to the cloud for process. "CISCO estimated that there will be 50 billion devices which will be connected to the internet and produces data touching zettabytes" [14]. So, the regular centralized cloud based solution is not a feasible idea. To help reduce the bandwidth load produced by IOT devices edge computing at the IOT level is proposed.

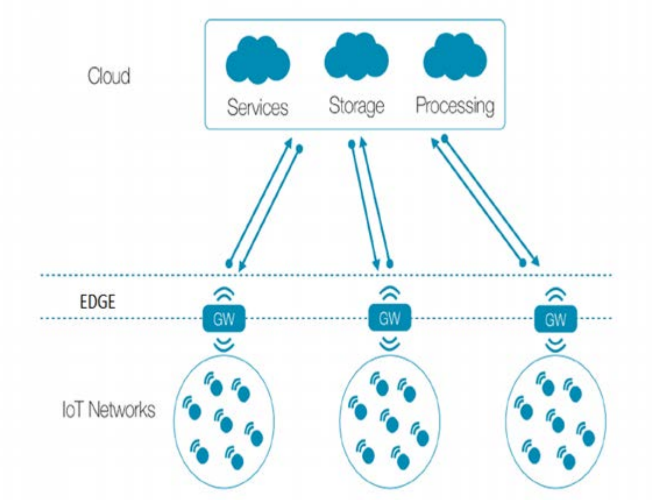

Figure 2 Edge computing for IOT [15]

IOT data filtering and aggregation can be used to in industrial mining and oil rigs, where the individual sensors produce high quality, bandwidth consuming data constantly. But not all the data produced by those sensors are necessary to maintain and manage the industrial process running. There is a good need of filtering and aggregating the data before sending it to remote datacenter for processing, Edge computing here help to weed out the unwanted data from the streams of data provided by the sensors and aggregate them to a format best suited for processing and utilization

3. *On-premise Edge computing:*

The need to keep up or increment accessibility of IT and its systems is quite often a top of mind concern. Cloud computing has dependably been a centralized design. Edge computing changes cloud computing into a more circulated computing cloud engineering. The primary preferred standpoint is that any sort of disturbance is restricted to just a single point in the system rather than the whole system. A Distributed Denial of Service DDoS assault or a dependable power blackout for instance would be constrained to the edge computing device and the neighborhood applications on that device instead of all applications running on a centralized cloud server farm. Organizations that have moved to off-premise cloud computing can exploit edge computing for expanded redundancy and accessibility. Business basic applications or applications expected to work the center elements of the business can be duplicated nearby. “An approach to think about this is a residential area utilizing an extensive shared water supply as principle source as represented in Figure. Ought to this water supply be hindered because of an interruption created in the primary supply or dispersion organize, there is a crisis water tank situated in the town” [16].

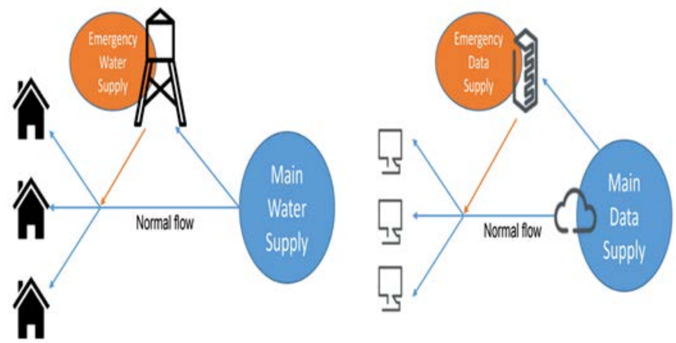

Figure 3 In premise Edge [15]

Thus, this kind of on premise edge computing server acts as a backup in case of outages and failures. These on premise edge computing servers can also use as the extension of the cloud where you can process and store the sensitive material for a public cloud.

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2.2 Edge Cloud Services classification

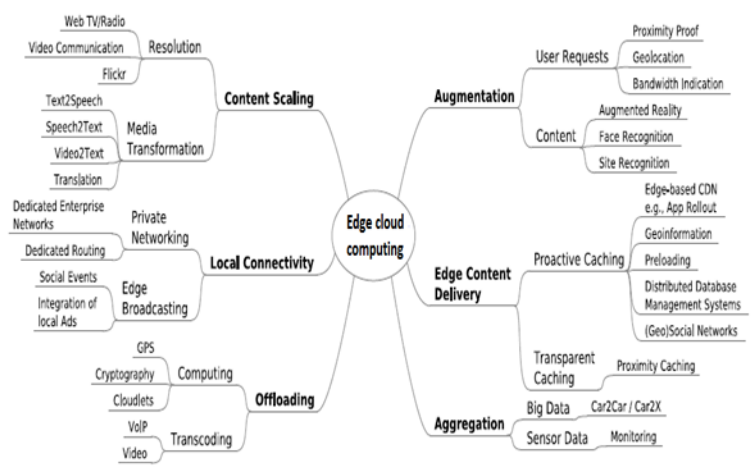

Figure 4 Edge service classification [11]

1) *Augmentation:*

Edge computing clouds are very ideally placed to identify the location of the user since the requests they receive are mostly local. When a request is received by an edge server the very fact that this edge server received the request narrows down the geographical location from which such a request may originate. Using this information as a base the edge server can further identify the exactly location of the device by reply to the device from where the request originated or can define a protocol to identify the exact location of the device. This can be done with very less bandwidth usage compared with the using a centralized server. This ability of the edge cloud can be used to verify the proximity and location of the service requesting device. The location data which is identified by the local edge cloud can be passed along to the main core server.

2) Offloading:

Even today many mobile and desktop applications are limited by the hardware which is available to them locally at their machines. This had presented itself as a bottleneck for designing applications which are processor and memory intensive. This situation has resulted in making tradeoffs between the performance of the applications and having low latency when delegating the workloads to remote servers.

This kind of the situation where you should choose to have a low performing application or high latency can be eliminated by using the edge cloud computing.

Offloading essentially means transferring the processing and the memory intensive task to remote servers. But by using edge cloud servers to offload we can use the required computational capacity with very low latency compared to offloading to remote server. This will increase the computational, storage, bandwidth and battery capacities of the mobile and desktop computational devices. Rules can be set at the user devices when to offload the workloads. These rules may include situations like offloading when there are not enough computational resources available at the local machine to perform the task on time. To reduce or improve the battery consumption. New form of pay to use offloading edge cloud computing servers can take form.

3) Content scaling

Edge computing empowers downscaling of user created traffic before it is directed through the portable core network. Content scaling can likewise be connected to traffic sent by Internet servers. Scaling user equipment created content before it is conveyed to far away data centers diminishes transfer speed requests of core network. For instance, picture sharing locales like flickr and facebook downscale user produced content keeping in mind the end goal to diminish stockpiling requests. Downscaling user equipment content straightforwardly at the edge likewise decreases Internet service providers core network usage. Moreover, Edge mists additionally empowers ongoing scaling of Internet infrastructure – if traffic clog happens at data centers of website, Edge cloud computing servers can downscale traffic with a specific end goal to both decrease worry of Internet service providers core network and increment network speed.

4) Local connectivity

With traffic being routed through Edge distributed computing servers, servers are fit for isolating traffic streams and diverting traffic to different goals. A use of this class is interfacing enterprise users straightforwardly by means of edge stations sent on enterprises housetops to the enterprise network. For instance, this applies on games/music occasions where cameras getting extra perspectives communicate their substance among users in the cell. Moreover, Local Breaking considers nearby redistribution of data bolstered into the cell, for instance, notices and data identified with the land area of the base edge station. In this manner, Edge computing servers communicate privately produced and locally important substance inside the phone. Traffic is routed by going around Internet switches, prompting to lower correspondence delay for User Equipment and Internet service providers. Besides, network transfer speed usage and power utilization is decreased, since traffic is not routed through the core network. Decreased network usage has a positive contact concerning core network correspondence delay.

5) Edge content delivery

Edge cloud servers offer assets for the organization of extra content delivery services at the network edge. Content generally facilitated by Internet services/Content delivery networks is currently moved more to the network edge. Edge cloud servers work as nearby content delivery hubs and serve reserved substance. Storing methods, not just with regards to Mobile Edge Computing, can be delegated being either responsive/transparent or proactive. Transparent Caching: Caching is transparent if neither the user equipment nor the Internet service provider know about the storing Edge cloud server. Proactive Caching: Content is non-transparently reserved before it was asked for, since it is relied upon to produce high network use later. Both methodologies can be utilized either isolated or shared. In the isolated situation, each cache works autonomously of other caches: Content as of now stored by other Edge cloud servers is not shared. In the common situation, Edge cloud servers collaborate and get content from other Edge cloud servers.

In fact, edge computing decreases content delivery network usage furthermore. Like distributed database management frameworks (DDBMS), edge content delivery points at putting away data near where they are often asked. This sort of data limitation prompts to a lessening of computational complexity, contrasted with incorporated database frameworks. Also, it likewise diminishes access delays with deference to inactivity, since correspondence ways are kept short

6) Aggregation

Rather than routing all User equipment data to core routers independently, Edge cloud computing servers are fit for totaling comparable or related traffic and, in this manner, lessen network traffic. For instance, numerous Big Data applications like Car2Car arrangements create a considerable measure of a comparative and locale related occasion notices which can be aggregated. This likewise applies in the setting of checking applications where numerous gadgets measure comparable data that can be aggregated at the edge. Because of the way that the amount of data got by Internet service providers would diminish, aggregation has a beneficial outcome as far as Internet service provider's transmission capacity usage, control utilization, and versatility. Nonetheless, postpone increments since data should be prepared by Edge cloud computing servers. Since core network traffic diminishes, the same applies for data transfer capacity usage, control utilization. Working Edge cloud computing servers comes with extra power utilization cost, in any case, add up to control utilization is relied upon to diminish therefore of lower core use.

3 Edge Cloud Infrastructures and Frameworks

A. Edge Cloud Infrastructure

Edge Cloud Generic Architecture

Mobile edge computing provides access to IT services and cloud computing services to the mobile subscribers in the close range of Radio Access Network (RAN). Its motive is to reduce the latency by bringing the storage capacity and computation to the edge network from the core WAN. It can also be defined as "Mobile Edge Computing is a model for enabling business oriented, cloud computing platform within the radio access network at the close proximity of mobile subscribers to serve delay sensitive, context aware applications." [17]

Versatile Edge Computing offers constant RAN data (like system load, client's area) to the application designers and substance engineers. These constant system data are utilized to give setting mindful administrations to the portable supporters, in this way advancing client's fulfillment and enhancing Quality-of-Experience (QoE). Versatile Edge Computing stage builds the edge obligation and permits calculation and administrations to be facilitated at the edge, which lessens the system idleness and transfer speed utilization of the endorsers. Arrange administrators can permit the radio system edge to be taken care of by outsider accomplices, this will permit to quickly convey new applications and edge administrations to the versatile endorsers, undertakings.

Figure 5: Mobile edge Computing Architecture [17]

There are three essential segments in the architecture:
1) Edge gadgets incorporate all sort of gadgets (both cell phones and IoT gadgets) associated with the system.
2) Edge cloud is the less ingenious cloud sent in each of the versatile base station. Edge Cloud have the duty of customary system movement control (both sending and separating) and facilitating different portable edge applications (edge medicinal services, savvy following and so on.)
3) open cloud is the cloud foundation facilitated in the Internet.

B. Edge Cloud (Swarm Architecture)

Figure 6: Swarm Architecture of Edge Cloud [18]

The original sensor nets were application-specific and limited in scope and reach, the swarm represents a much broader vision, potentially connecting trillions of sensory and actuating devices worldwide into a single platform abstraction. This enables the true emergence of concepts such as cyber-physical and cyber- biological systems, immersive computing, and augmented reality, and will have a tremendous impact in domains such as advanced healthcare, improved energy efficiency, environment-friendly living, mobility management, enhanced security, and many others.

Unleashing the full force of the swarm however requires leaps forward at all levels of the reflection chain, from the gadget level through universal remote availability up to the application levels.

The "vanishing" part of the swarm – requiring that hubs are incorporated with and are a necessary piece of their condition – be it dividers, protests, garments or even the human body requests execution systems that go a long way past the customary silicon hardware. It might incorporate "More than Moore" (silicon consolidated with different advancements) or "Past Moore" (natural, organic, mechanical) systems.

One property that is normal between most swarm hubs is that they give "detecting modalities" improving the hyper-world

with a rich arrangement of channels to interface with the physical world. Giving these capacities in a smaller than normal and ultra-low vitality design requires inventive detecting approaches, utilizing nanoscale NEMS, natural and bio-compound innovations.
The independent and self-managing nature of the hubs obliging them to work for their lifetime of vitality put away or reaped consolidated with their size imperatives requires hardware for calculation and correspondence whose vitality utilization is request of greatness beneath the cutting edge of today. While inventive gadgets can in part help to address the hole, creative correspondence and calculation models are essential. What's more, vitality conveyance and capacity textures must be considered.
One of the essential parts of the "swarm" is that future scaling is not in the "quantity of transistors on a chip", however in the "quantity of segments associated in the frameworks", that is "Moore's law meets Metcalfe's law". The origination, investigation, plan, sending and administration of swarm frameworks require procedures that contrast significantly from our present understandings. All the more definitely, swarm frameworks are non-direct, non-deterministic, versatile and complex.
Additionally, the troublesome applications that are sent on the dispersed swarm/versatile/cloud stage should be considered in light of the attributes of the stage prompting to various utility measurements and algorithmic methodologies. The meaning of the reflection layers that consider a compelling mapping of capacity on stage while guaranteeing that utility measurements are met is a to a great extent open issue.

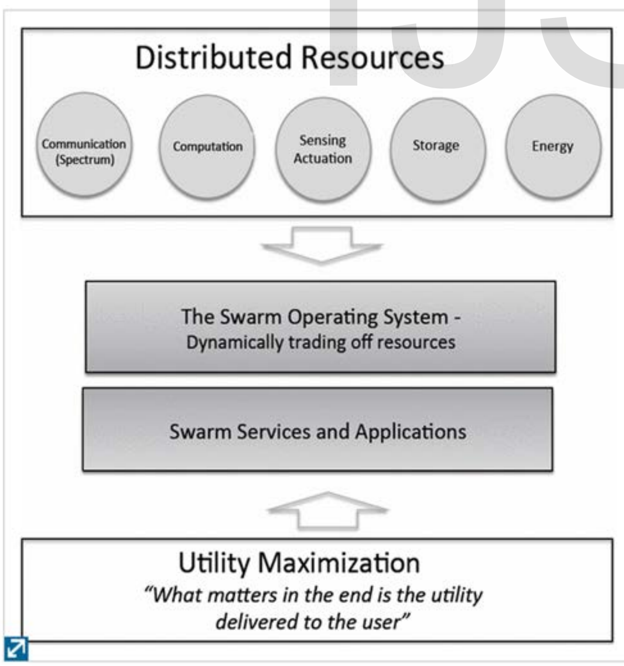

Figure 7: Swarm OS creates virtualized platform abstraction [18]

It is fundamental for the worldwide framework to be "gigantically adaptable", which means being fit for performing proficiently over an expansive execution run. Acknowledging such a "vitality relative" framework [19] with current day advancements and designs is hard, as most systems administration or figuring abilities are enhanced for a constrained operational range. For instance, most remote connections perform just well as far as vitality per bit for a settled and very much characterized information rate. The production of vitality relative advancements, segments and frameworks is of quintessence to the acknowledgment of viable swarm stages.

C. Heterogeneous Network for Mobile Edge Cloud Computing:

In MECC (Mobile Edge Cloud Computing), MDs associate with the Internet and afterward to the cloud through the remote associations. So, the remote wireless system is a critical segment of the MECC engineering. With SMDs turning out to be progressively universal and portable application economy keeping on demonstrating amazing development, future remote wireless systems need to bolster detonating versatile information activity and ought to be advanced for versatile broadband movement. The presentation of MECC puts additionally strain on remote systems since extra information related with cloud benefits between the MDs and the cloud must be transported by means of the remote systems with potential QoS as well as power imperatives.
HetNets (Heterogeneous Network) offer promising answers for these difficulties. We discuss about the structure of HetNet for MECC, distinguishing the principle blocks. We particularly concentrate on the conventional unified cloud, of which the figuring asset pool is put in the remote cloud and MDs can get to the assets by associating with the current remote system. As represented by Fig. 2.4, the HetNet for the most part comprises of two segments, i.e., macrocells and little cells, where the previous give versatility while the last lift scope and limit.

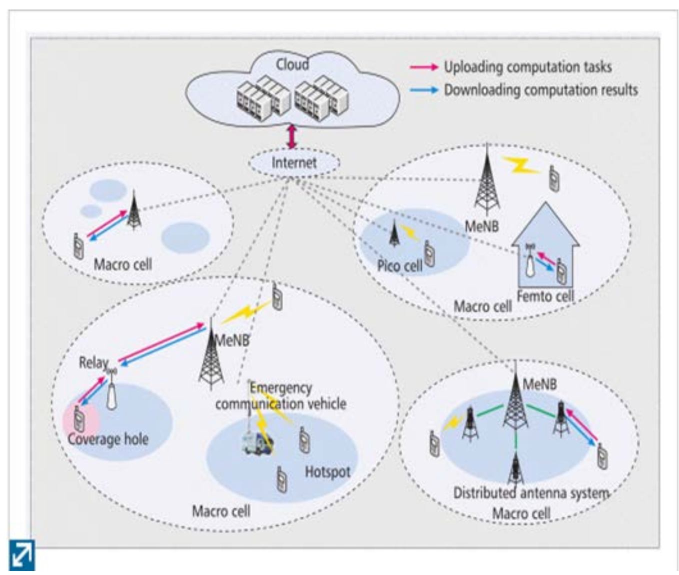

Figure 8: Access Nodes in Heterogeneous Network for Mobile Edge Cloud Computing [20]

1. Small Cells

Since SMDs and cloud applications are eager for a rapid and stable availability to the cloud, the little cells improve as a decision.

2. Pico Cells
The low-fueled radio gets to hubs, which have a scope of around 200 meters or less, are sent in Pico cells. Their get to is interested in every cell Md. Generally, the pico cells are utilized to give hotspot scope in shopping centers, air terminals or stadiums.

3. Femto Cells
A femto cell has a little, low power base station, normally intended for MDs in a home or private company, whose get to hub is alluded to as Home eNB in LTE. Like Wi-Fi, the scope extend for a femto cell is under 100 meters. The entrance to a femto cell can be either controlled to a constrained arrangement of MDs in the femto cell's get to control list (shut get to mode), or open to every single cell Md (open get to mode).

4. Distributed Antenna System
A distributed radio wire framework is a system of spatially isolated receiving wire hubs associated with a typical source by means of a vehicle medium that gives remote administration inside a geographic region or structure. It can make little virtual cells by circulating radio wires of large scale eNBs crosswise over whole cell. The receiving wires are associated with a typical handling unit by means of fiber.

5. Transfer Nodes
The transfer hubs are low power base stations that can give scope and limit improvement to large scale cells at the cell edge. A transfer hub is associated with its Donor eNB (DeNB) by means of a radio interface. Because of the insecurity of DeNB scope, MDs in a few areas of the large scale cell may have a disappointment in access to the DeNB. The arrangement of transfer hubs can take care of this issue successfully.
The HetNet offers to the offloading choice capacity a scope of remote transmission administrations with various service classes and financial costs, and the offloading choice is made considering both the offloading pick up and the cost of utilizing the Het-Net when a Service Level Agreement (SLA) is built up with it. In particular, the SLAs depend on the assessed normal values or most pessimistic scenario values with a given infringement likelihood of two qualities, i.e., control utilization and remote transmission delay.

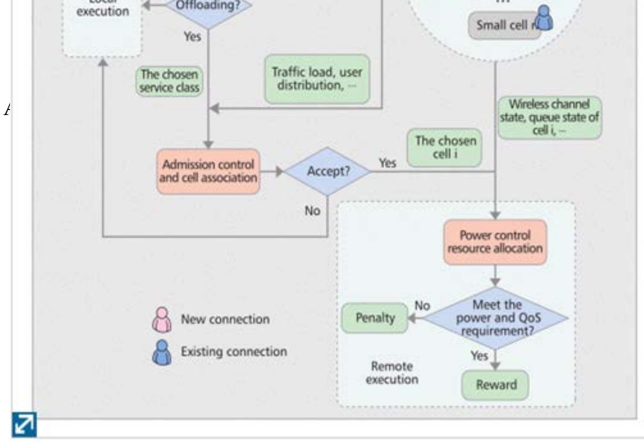

Figure 9: Framework of heterogeneous network for MECC [20]

The previous is the aggregate power devoured in the MD and the last is the aggregate postponement by means of the HetNet for transmitting the calculation assignments to the cloud and getting the calculation comes about because of the cloud. Despite the fact that there is some current research on the QoS system for MCC we concentrate on the communications between the offloading choice capacity of MCC and the radio asset administration capacity of HetNet, which haven't been tended to in earlier work to the best of our insight

4. Edge Cloud Applications and Services

A. Geo Targeting

Users are distributed to the different region of the world and each of those regions has their own preferences, business, products and user requirement. So, to provide the region/user specific data Edge cloud computing is proving to be an important. Edge computing customizes the experience for each user like a different version of the homepage, serve different content and change the language preference, etc., based on the geographical location of each user. This can be done by maintaining the IP-to-Geo databases for all the locations to provide low latency in lookup and response time.

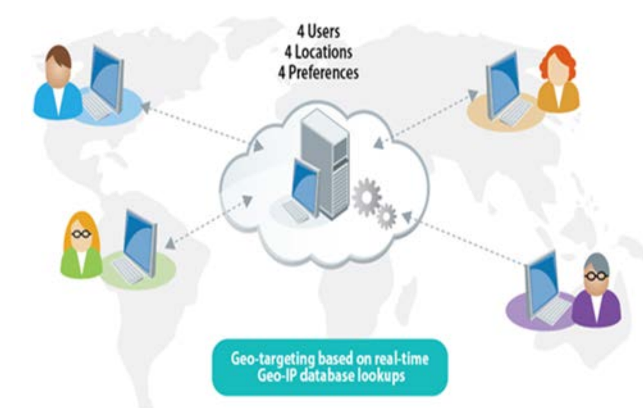

Figure 10: Geo Tagging Based in Real-time Ge-IP database lookups [26]

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B. Geo-Blocking

This is another application of Edge computing, which works similar to the Geo Targeting. It blocks or prevent the certain content to accessed at a certain location. Such traffic filtering requires to be taken care at the edge itself to provide better filtering of traffic to comply with the rules, licensing restrictions etc.

Figure 11: Geo Blocking Based in Real-time Ge-IP database lookups and Custom rules [26]

C. Augmented Reality

Augmented Reality is becoming possible because of the mobile network support for low latency computing and high data rates. Augmented Reality is nothing but the combination of real-world and supplementary computationally produced tactile information, for example, video, Graphics, GPS or sound information. Augmented reality enhances the user experiences to an individual point of interest. For example, consider a person visited to an exhibition hall, museum or city landmark holding their cell phone towards a specific purpose of enthusiasm with the application identified with their visit enacted. The camera captures the image of the user interest and based on the analysis algorithm the application shows extra data identified with what the person is viewing.

Augmented Reality Service requires an application to examine the output from the camera, and the location in-order to enhance the user's experience by giving extra details/information to the user more than what a user will receive without it.

To provide accurate information the application need to know the precise location of users, the direction in which they face. This is accomplished by either by location positioning sensor or/and by camera view. And after the analysis of data, the application can give extra real time data to the user. Also, in the event of that the User moves, the data will be refreshed. So, hosting augmented reality services on the mobile edge will be advantageous as supplementary data relating to a point of intrigue are profoundly local and is frequently irrelevant beyond the point of interest. The figure below shows how a MEC platform can be used to provide an Augmented Reality

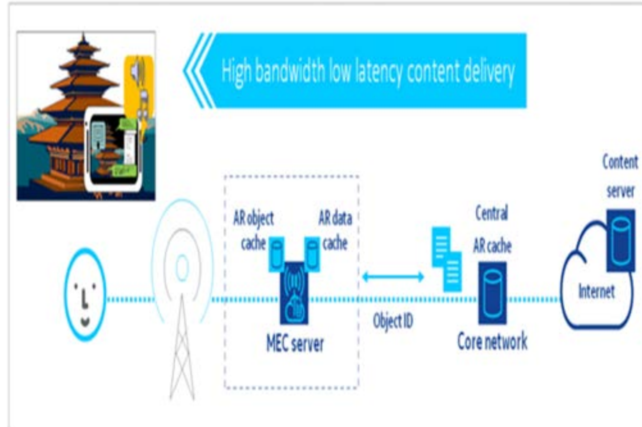

Figure 12: Augmented Reality Service [25]

Also, it's better to analyze and process the location, camera information on a mobile edge cloud rather than centralized cloud as because there might be need to refresh and update the information at a faster rate, depending upon a user moves and in context of AR service. "In other words, augmented reality data requires low latency and a high rate of data processing in-order to provide the correct information to the user's device depending on the location and orientation of the user. Performing such data processing on the MEC platform also has the advantage of collecting metrics, anonymized meta-data, etc., in-order to analyze the service usage and help to improve the service in order to provide a better user experience." [25]

D. Intelligent Video Acceleration

End client Quality of Experience (QoE) and use of radio system assets can be enhanced through intelligent video acceleration. In general Hypertext Transmission Protocol over the TCP protocol is used for media, file streaming or downloading. Accessible limit can differ depends the size of the requested data. TCP might not able to adjust sufficiently quickly to rapidly changing conditions in the radio access network (RAN). This may prompt to under-use of valuable radio resources and to a user experience.

The figure below shows an example of the intelligent video acceleration service.

In this, a radio examination application, which lives in a MEC server, furnishes the video server with a sign on the throughput assessed to be accessible at the radio downlink interface. This data can be utilized to help in deciding the TCP congestion control, "for example, in selecting the initial window size, setting the value of the congestion window during the congestion and avoidance phase, and adjusting the size of the congestion window when the conditions on the 'radio link' deteriorate" [25].

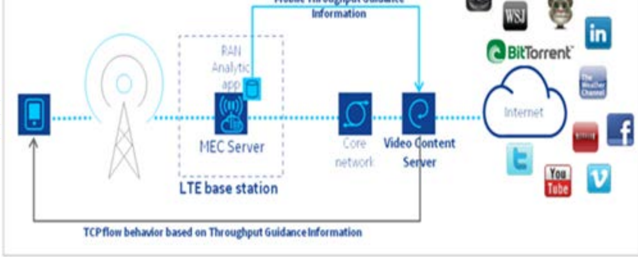

Figure 13: Intelligent Video Acceleration Service [25]

The video server may utilize this data to help TCP Congestion control choices. The content's time-to-start as well as video-stall occurrences can be reduced and additionally video-slow down events can be diminished, enhancing enhanced video quality and throughput.

E. Connected Cars

Recently there have been huge developments in the vehicular network, which involves communication between vehicles and RSU (road side units) which intends to increase safety, efficiency, and convenience of the transportation system. Such communication can also be utilized to offer some incentive included services, for example car finder, parking location etc.
So, with the increasing number of vehicles the amount of data flow will also increase, which cause latency in data delivery, analysis and further delay in services.
For such scenarios, Mobile edge cloud computing can be proven advantageous.
"Mobile Edge Computing can be used to extend the connected car cloud into the highly distributed mobile base station environment, and enable data and applications to be housed close to the vehicles" [25]. Such effort minimizes the round-trip time of data. It additionally gives a layer of abstraction from both the core network and internet applications. MEC Applications and servers can be deployed on base stations to provide RSU (road side unit) functionality so that it can receive the communication messages for vehicles, sensor and can analyze and can further propagate received hazard warnings and other latency-sensitive messages to other vehicles in the area. Such information can help other vehicles to react immediately reducing the large-scale hazards. Figure below shows scenario of connected car. Here the MEC application on the base station receives the information from the car in the hazard region and thus propagate the warning to the cars that are nearby in the affected area. Also, RSU will further send the information to the centralized cloud server for further processing and reporting.

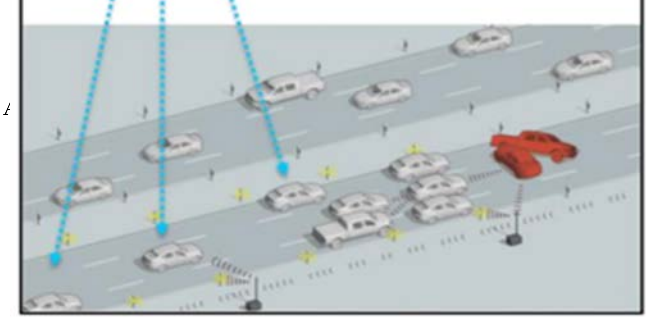

Figure 14: Connected Vehicles Service [25]

F. Internet of Things Gateway

In the IOT world, device interact with each other and with the internet to provide the efficient service. In-order to do so, it sends messages over the network and aggregate the message to ensure low latency. Also for IOT applications real time capability is required.

IOT device generally has very limited storage and processing capabilities. Thus, there is always a requirement of another system which can store and process the messages and give desirable instruction to other IOT devices. Such system should have high processing capabilities and high storage.

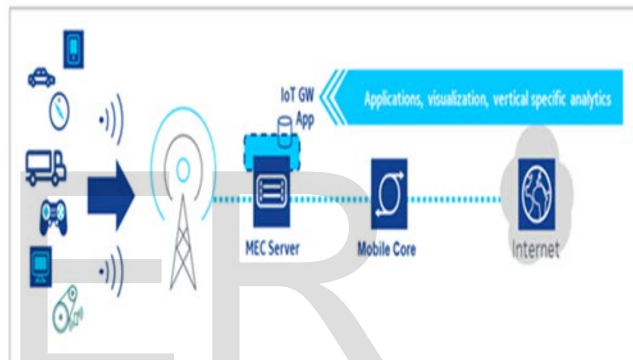

Figure 15: IoT Gateway Service [25]

Different gadgets are associated over various types of network, for example, 3G, LTE, Wi-Fi or other radio advancements. There is a need for a low latency aggregation point to manage the various protocols, dispersion of messages and for the processing and analytics. For such scenarios, mobile edge cloud can prove to beneficial.

Mobile Edge computing can be utilized to associate and control gadgets remotely, analysis of data and provide real time provisioning and analytics. MEC provides collection and dissemination of IoT service into the exceptionally conveyed Edge base station, which allows applications to react immediately. This reduces the RTT of the data, thus providing high speed service and improving efficiency.

G. Big Data at the Mobile Edge

Geographically Distributed Database as a Service (DBaaS) provides replication, storage and access of data sets globally to enable faster performance.

Server side GUID database make use of user cookie information to identify visitor and stores their information. Generally, cookie size is limited. "While a server side GUID database can support vastly larger data sets than cookies, it often results in performance problems when the local data center processing a request must reach 'off-box' to a distant data center housing the visitor data needed to process the request" [26]. In such cases, Mobile edge cloud can be used as Geographically Distributed Database as a Service (DBaaS) which can provide the highest end-to-end performance irrespective of each User's geographical area and ensuring a reliable end-user experience across all data centers at all times.

Figure 16: Big Data Service at Mobile Edge [26]

H. Dynamic Creative Optimization for Ad Tech

Generating dynamically customize ad creative templates in real time is one of the Mobile edge cloud services. This provides highly personalized messages without the need to create and store a large set of data.

5 Conclusion

These days, an ever-increasing number of administrations are pushed from the cloud to the edge of the system since preparing information at the edge can guarantee shorter reaction time and better unwavering quality. Besides, transmission capacity could likewise be spared if a bigger segment of information could be taken care of at the edge as opposed to transferred to the cloud. The thriving of IoT and the universalized cell phones changed the part of edge in the processing worldview from information customer to information producer/consumer. It would be more productive to process or back rub information at the edge of the system. In this paper, we thought of our comprehension of edge figuring, with the reason that registering ought to occur at the nearness of information sources. At that point we list a few cases whereby edge registering could prosper from cloud offloading to a keen domain, for example, home and city. We additionally present collective edge, since edge can interface end client and cloud both physically and consistently so not exclusively is the traditional distributed computing worldview still upheld, additionally it can associate long separation arranges together for information sharing and cooperation because the closeness of information. Finally, we set forward the difficulties and openings that merit chipping away at, including programmability, naming, information reflection, benefit administration, protection and security, and in addition streamlining measurements. edge processing is here, and we trust this paper will convey this to the consideration of the group.

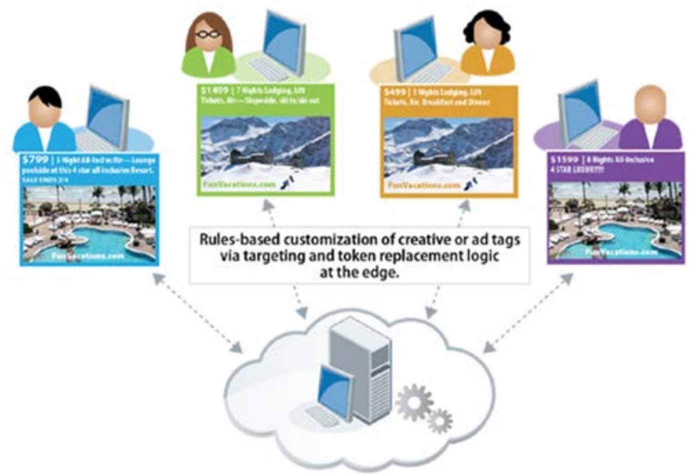

Figure 17: Dynamic AD Service [26]

6 CHALLANGES

6.1 Privacy and Security

Edge-driven Computing goes past endeavors on utilizing E2E (End-to-End) encryption and client driven privacy frameworks that attempt to ensure clients data in the cloud. Edge-driven models will challenge analysts in new ways. Past encryption to ensure private information, more secure intermediaries will be required for meet, correspondence, and get to control utilizing different procedures like re-encryption or quality based encryption among others. Besides, novel secure middleware for privacy mindful data sharing must be made to lift edge-driven frameworks. Many existing takes a shot at cloud security, for example, scrambled information stores, inquiries over encoded information, homomorphic systems could add to the making of novel edge-driven administrations. An essential difference with customary cloud security research is that Edge-driven Computing may accept the presence of trusted or most confided in, stable assets playing out some correspondence, diligence, inquiries, and indeed, an even calculation for applications sent and controlled in the edges. Edge-driven computing may likewise consider the conjunction of put stock in hubs with pernicious ones in distributed edge-based overlays. This will again require secure directing, repetitive steering put stock in topologies and past P2P examine connected to this novel setting. Another key difference is that Edge-driven Computing keeps the convergence of data when contrasted with centralized computing. Past cloud security inquiries about on fracture of data consolidated with encryption may unite with decentralized overlay advances to guarantee fitting data assurance for sensitive data. Besides, secure cloud queries and calculation over divided data and lists in overlay systems may make totally new models regarding the privacy of sensitive data.

6.3 Scalability

Scalability is a repeating research challenge both in distributed and distributed computing settings. The design of architectures that scale to many clients must consider issues like adaptation to internal failure, churn, flexibility and numerous others. In P2P, beat and dynamism entangle the possibility of these models and their general administration accessibility. In distributed computing, scaling and flexibility are repetitive points, what's more, even real cloud suppliers might be overcome by the huge dissent of administration assaults. Edge-driven Computing, in any case, changes totally the versatility challenges introduced some time recently. Stir is not such a constraining variable any longer, because of the utilization of stable cloud assets. A noteworthy test is a right trade between computing and correspondence duties between edge devices, trusted servers, and untrusted administrations. Given that the control is at the edges, scaling issues are still exceptionally significant. Building gigantic overlays joining cell phones with constrained batteries with stable cloud resources require unique consideration for correspondence conventions among hubs. Besides, cloud edge administrations should likewise be efficient and consider the heterogeneous hubs they should serve. Another research test is the mix of scalability with security in huge overlays. Edge models requiring security will force non-insignificant overheads due to encryption, that must be managed to give adaptability.

7 FUTURE WORK

In future edge computing would unravel large portions of the most troublesome issues confronting robotics and computing infrastructure. A swarm of air-and land-based drones inspecting a remote forest fire, a collapsed building or a limitless tract of farmland is today tested by a powerlessness to associate and transmit extensive quantities of information over wireless systems or to get directions from a central controller in a timely manner. These issues are exacerbated by the befuddling territory of debacle environments however; edge computing dodges these impediments.

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