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A review on Edge computing and 5G in IOT: Architecture & Applications

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Abstract— **Edge computing simply refers to an emerged technology for processing collected data. The use of an edge-computing version enables the computations to carry out within the nodes in the edge network systems. With the quick evolution of the Internet of Everything (IoE), the quantity of smart gadgets associated with the Internet is expanding, bringing about huge scope information, which has caused issues, for example, poor security and protection in the existing computing models. Specifically, edge computing has been extended to reduce privacy and security risks and enhance network performance in data transmission. Edge computing tasks communicates between IOT applications; thus basic tasks include the data sources, which is a place in which the data are kept and recorded from other data sources or clients, data processing steps, where the collected data are accessed and used to reveal insight patterns-based machine learning mechanisms and demonstrating the result from the previous phase in visualization tools the newest developments around technologies in edge computing that are driving social and business growth and innovation. Therefore, educational and industrial researchers have put many efforts to study the advancements of edge computing technology. The main purpose of this review paper is to explore the deployment of the 5G network in this faster and localized edge infrastructure, The architecture of edge computing along with the some of the popular application of Edge computing and limitation of the edge computing in 5g are explained.**

Keywords— Edge computing, 5G, IoT, Architecture, smart grid, latency, Artifical Intelligence.

I. BACKGROUND

Before digging into the detailed concept of edge computing, it is important to know the evaluation of edge computing. There is a research paper discussed about the origin of edge computing. Due to the past record of transmission and distributed systems, edge computing is not a new-born idea. It can be dated back to the 1990s when Akamai initiated Content Delivery Network (CDN) [1].The purpose of CDN is also to improve system performance, availability, and accuracy by bringing web content to storage servers as near as possible to users [2]. The centralized cloud computing systems have emerged as a standard IT communication platform for more than a decade. The concept of cloud computing is that all information content is distributed to a central storage center where most computing processes are executed and then the results from computing require to be responded back to the devices and sensors, causing intense pressure on data transmission and attacking the network performance [2]. Although cloud computing is widespread, extended workplace demands and requirements start exposing its restrictions. To cope with evolving demands and address the limitations of cloud architecture, different kinds of delivery platforms needed to be introduced. A research paper contributed by Alrowaily and Lu stated that Edge computing becomes an essential approach as the generated data from IOT devices are hosted and performed at the nodes within the edge network. With edge computing infrastructure, data processing workload at the centralized data center and personal data privacy concerns can be eliminated [3]. Another similar study stated that real-time data processing without latency becomes necessary as there is a dramatic increase in the number of Internet of things. A vast amount of data can be executed at or around the data source, therefore, effective data processing goals can be achieved by the capabilities of edge computing, which make it easy to reduce the usage of internet bandwidth.

II. INTRODUCTION

The amount of data created every day is growing remarkably. Approximately 2.5 quintillion bytes of data are produced every single day. Sources of data that are being driven by social media websites, business online transactions, location-based sensors and mobile applications become complex and prevalent. In the future, higher interactive smart applications connected to the Internet are expected to generate large-scale data. In addition, International Data Corporation (IDC) [4 estimated that global data will be up to 180 zettabytes (ZB) and edge devices will produce 70% of the data in 2025. To put things into perspective, it is important to keep up with the advanced technologies to access, manage and process the data which will be used in the real-world workflows. It is witnessed that there are improving trends in database technologies and storage systems including SQL, NoSQL, and many data processing frameworks like Hadoop. Likewise, cloud-based services over the Internet have rapidly developed. Based on the growth of massive data, data processing requirements, latency, security and privacy concerns in data transmission, edge computing technology is adopted to handle computational tasks and storage issues.

Similarly, edge computing is preferred to combine with wireless mobile communication technologies in order to support the requirements of the latest IT applications. Thus, this is because edge-computing matters with 5G tends to raise interest in the research environment. The fifth generation "5G" network [5] means a new wireless telecommunication technology, which is being developed to deliver higher performance and faster speed to new mobiles technologies and services. The speed of 5G networks is 10 times faster than 4G-network speed while the computational delays inside the network can be reduced with mobile edge computing. In fact, both edge computing and 5G are inseparably connected technologies and they are designed to considerably enhance the performance of IOT devices and to process massive amounts of data at the same time. In addition, two reasons that edge computing works with 5G are as follows. First of all, 5G standards are essential to meet the latency goals which have been achieved. Only radio interface developments will not accomplish these capabilities. Secondly, operators are trying different approaches to 5G so that the ecosystem of new devices will be sufficiently cultivated by the coverage of full 5G. Nevertheless, edge industries could spend millions of dollars in 5G before its coverage becomes widespread [6]. The competitions in technologies to develop 5G become popular and some organizations like central administrations are taking actions to support 5G utilization. In the same way, this paper studies two proposed edge computing infrastructures with 5G network and then it highlights some applications of edge computing and finally discusses the open concerns of edge computing in the latest AI and other sectors.

III. ARCHITECTURE OF EDGE COMPUTING

Due to the fact that the volume of data being generated by devices connected to the Internet and business services is growing quickly, business organizations are reacting to big data challenges through the utilization of edge computing architecture. Generally, edge computing is based on distributed computing architecture in which components of data processing are used as near to the data generation sources to perform computing and data storage processes in the distributed computing paradigm. A recent study conducted by Bumgardner and Hickey [7] stated the breakdown layers of basic components in edge computing systems.

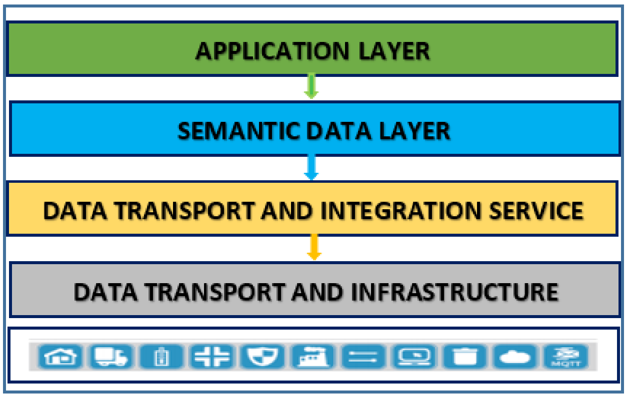

Figure 1: Components of edge computing

Distributed data and infrastructure: in the bottom layer applications and data sources are allocated in hierarchical structure to operate with above layers and this layer also handles the required operations such as establishing new delivery channels and running an application.

Data transport and Integration service bus: facilitates direct routing paths to hosts, especially operating framework supervised messages in the service bus alliance and passing data information in the data transport path.

Semantic data layer: allows functions to make data requests based on their types instead of tracking down the actual location of requested objects.

Application layer: computing tasks and multiple functions are distributed over edge computing framework in order to be executed by using arriving data and the results are delivered to other functions.

The architectures of edge computing may vary depending on implantation processes because some components are added and some are removed. In addition to this, there are a lot of edge computing systems designed for a variety of application frameworks and as well as many existing proposed architectures of Edge Computing such as the Industrial Internet Consortium Reference Architecture aimed at Industry 4.0, a three-tier edge computing architecture for IOT devices and the architecture of EdgeX Foundry for various sensors and devices. It is obvious that the innovation of edge computing is ongoing. Since several types of edge systems operate in the network environment, integrated edge infrastructure with 5G helps make the edge devices and systems more efficient and upgraded to perform complex operations and on-demand services. The network speed of 5G is 200 times as fast as 4G LTE network so that 5G edge computing can bring computation capabilities with the highest speed rate to end devices. Therefore, the next section describes a review of the architecture of mobile edge computing in 5G and the existing hybrid infrastructure for 5G edge computing.

IV. MOBILE EDGE COMPUTING ARCHITECTURE WITH 5G NETWORK

Coordinating 5G with emerging technologies for management of spectrum is one of the objectives in smart solutions. Communication technologies of Emerging 5G against the developing number of clients and organization traffic. Further organization limits rely upon the future 5G designs as well as effective methods of taking care of the network. Again, needs and dynamic wise administration happen to further develop network limits when really needed [8]. The articulation of systematic Mobile Edge Computing (MEC) was introduced by the European Telecommunication Standards Institute (ETSI). This innovative technology helps the operators to run their wireless communication edge on the authorized third agents [9]. As discussed earlier, 5G network systems can support high speed internet access and provide massive amounts of device communication. 5G uses its technology enablers called Network Function Virtualization (NFV) and Software Defined Networking (SDN) in order to set up virtualized network resources for building a complete optimized system for computation and storage services. Nevertheless, 5G functions bear elevated latency, which could not fulfill the latest IOT devices requirements. This problem can be solved by allocation of 5G NB in Mobile Edge Computing (MEC).

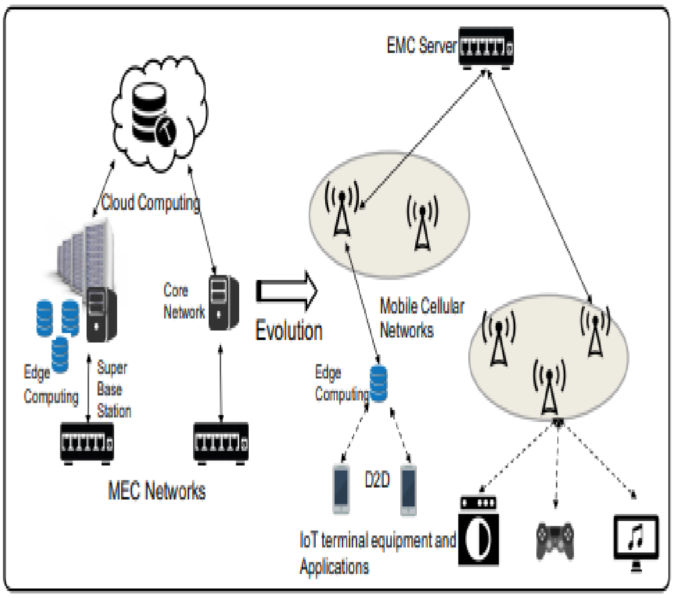

Figure 2: Evaluation of integrated 5G and MEC architecture.

This integrated framework can support both edge and cloud computing activities. Inside the architecture, MEC computing assets are assigned to LTE eNodeB, 5G gNodeB, super 5G Base Station (BS), the edge of backbone networks for computing and storage service provisioning. This contributes to system performance and capabilities improvements [10].
The rapid advancement of the internet of things, as well as 5th generation technologies, necessitates the selection of the most appropriate conveyance frequency. "However, while using fifth generation networks in the high frequency band, it is vital to avoid issues such as signal attenuation, faster and easier obstruction, and coverage distance. [11].

V. APPLICATIONS OF EDGE COMPUTING

Depending on technology advancement, there are many more new and upcoming devices, which are connected to the Internet. In many instances, the IT service environment allows the applications to be integrated with edge computing technologies for improving quality of services, reducing operational cost and decreasing the energy consumption. Therefore, many applications and services which use full advantage of edge computing technology includes healthcare systems, entertainment and interactive media devices, virtual, augmented and mixed reality technologies, Tactile network communications, Ultra Reliable Low Latency Communications (URLLC), Internet of Things (IOT) applications, Intelligent Transportation Systems (ITS) and smart systems [12]. Additionally, today's deep learning technologies have been progressing rapidly integrated with edge computing technology, which enhances real time data management processes through the edge terminal. Collected information can be classified as either private or public, as well as permissioned or unpermitted. There are numerous smart applications for this interface layer, including smart health, smart home, and smart transportation, smart parking systems that work together to make good decisions [13].

<u>Autonomous driving technology:</u> allows the vehicles to move safely without involving a human driver. As this technology is applied with AI capabilities based on the accurate collected data, it would be incredibly beneficial to analyze and manage big data. Edge computing is the right model for achieving rapid computing processes to handle exactly the vehicle. Figure 3. depicts how an autonomous driving system is working with edge computing. Data collected from each sensor connected to a self-driving vehicle are used to handle the different types of incidents experienced in driving a car. This sensor records data by studying the ground environment, traffic and road conditions. Processing such kinds of real time tasks and intermediate responses are handled by the edge computing system instead of reaching to the cloud server [14].

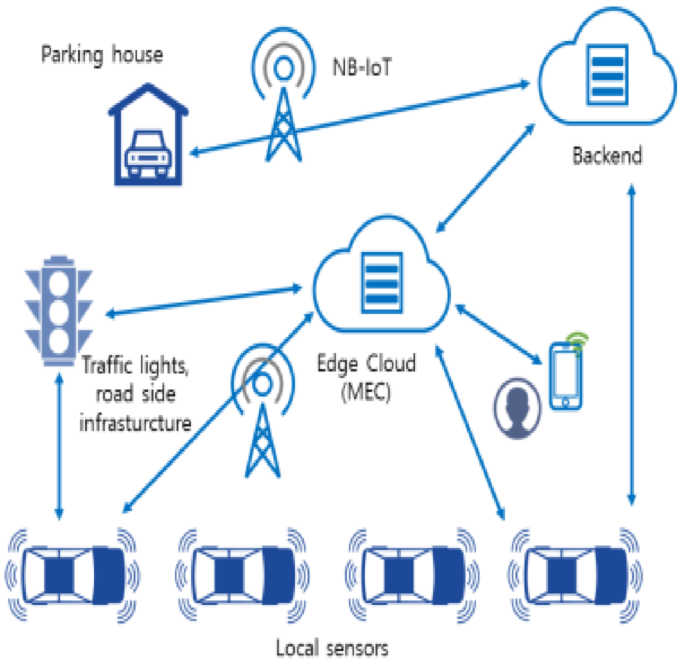

Figure 3 Self-driving vehicles working with edge computing

<u>Smart Grid</u> : is one more rich application of Internet of Things alongside edge computing. Here the architecture is multi-level and is dictated by sensors of the grid and gadgets. Some of the information may be time-sensitive and might require constant handling inside milliseconds to fractions of seconds. First layer, addressing connectivity between Machine-to-Machine can gather and process most sensitive data .The rest of the layers can resolve the issues of information analysis and long-term stockpiling [15]. There are an extensive set of objections that should be addressed before the perception of mobile edge computing can be completely imagined. This segment covers some of the most addressable and actual and quick ones.

<u>Smart home:</u> with the familiarity of the Internet of things application, home life has become increasingly keen and helpful. However, the act of interfacing brilliant lighting frameworks, smart TVs, smart gadgets, smart robots and other devices to the distributed computing center through the WiFi module is a long way from complete. *Addressing the* issues of smart homes in the smart home environment, a large number of wireless sensors and regulators are deployed in the rooms, pipes, floors and walls. For the thought of information of data transmission load and information protection. data privacy, the handling of delicate information should be completed inside the home

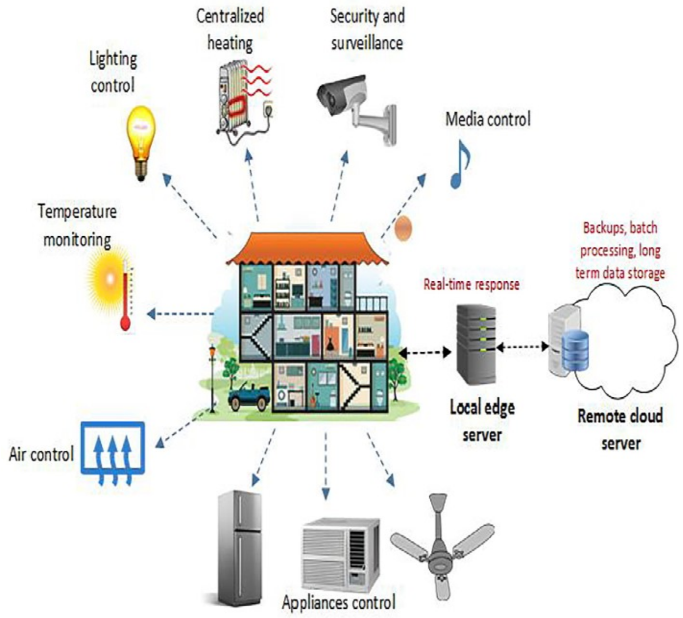

Figure 4: Smart home with edge computing

Traditional distributed computing models It is presently not completely no relevant to the applications of smart homes. So here the edge computing model makes it more convenient and easier to associate and supervise the devices of smart homes within the home environment and processes the data generated by these smart gadgets internally, decreasing the load of information transmission bandwidth.[16].

Medical Applications: High performance computing at the edge especially for the image mergers of medical area technology. In order to implement the exact medicine via the real time monitoring system and investigate the early pathologies of patient's medical data meantime reducing the risk of data providing privacy on site. Since there is massive amount of data is analyzing at the edge, altered and then only relevant data is assigned to the cloud so that would lead to the data privacy for the patient's information being compromised. Imaging in the medical sector at the Edge using High performance computing and discarding the latency on the resources of Cloud Computing along with that also decreases the digital footprint of patient's data by limiting access for particular numbers of systems. Usually artificial intelligence in medical imaging serves tools that provide better care to decrease the cost [17].

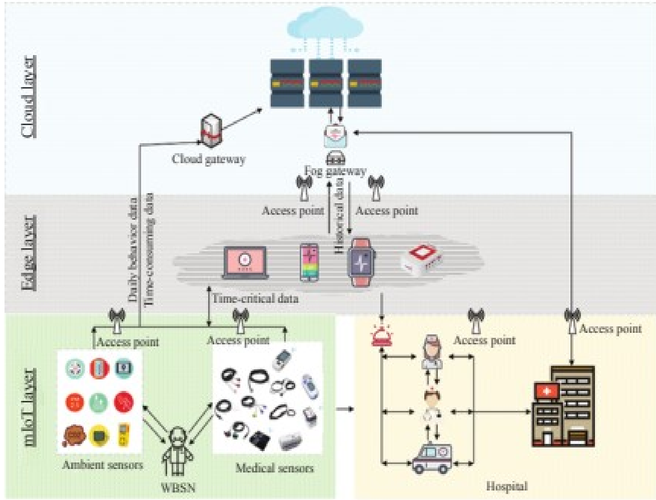

Figure5: Edge Computing is being used in healthcare

VI. LIMITATIONS

Edge computing in 5G is an excellent environment for processing and delivering data of IOT applications however there are limitations in edge computing which remain unsolved.

Limited storage space: is the limitation of edge computing technology that offers AI services for rapidly growing mobile end devices due to the fact that it can perform real-time data processing. However, some heavy machine learning algorithms, which consume a huge volume of storage, are not compatible well with edge devices. There is an experiment [18], which compares the memory consumption of different algorithms including VGG, SSD GoogleNet, SqueezeNet, MobileNet and L-CNN for object detection. It is verified that a huge memory consumption network is not suitable in edge applications.

Security issue: Although edge computing has obvious advantages to decrease processing time and boost the performance of the application, it will require new security considerations due to its infrastructure. The increasing number of devices which communicate with each other can lead to network vulnerability if higher security specifications are not offered. Processing and storing data on the edge devices can be easily exploited by threat attackers. From a data security perspective, encrypting the data over the network is safer than the data which is being processed. Therefore, centralized computing network, cloud computing are more reliable for dealing with sensitive data and special regulation requirements.

Data Loss: Due to the technological advancements in IOT and AI technologies, the amount of data flowing into the central server is obviously increasing. Multi access edge computing technology offers data computing to process at the edge node. However, there is a drawback that edge systems can utilize partial sets of data and the overlap data are rejected, resulting in the loss of valuable information. Hence, the industrial organizations should decide what types of information are not necessary before deploying Edge computing [19].

Inflexibility in quality of enhancement and Quality of service: QoE is related to measuring the level of customer satisfaction by service providers, whereas QoS is a measure of the quality of software and hardware capabilities. It is difficult to fully guarantee edge infrastructures for enhancement of the customer satisfactions and achieving in software and hardware characteristics when the localized edge nodes fail to accommodate the intended workloads receiving from data sources. Additional workloads at edge nodes can have negative impacts on the services provided to edge applications. Therefore, it is importantly required for the tasks to be partitioned and managed in flexible ways at the infrastructure [20].

VII. CONCLUSION

Processing the emerging technologies such as IOT applications, artificial intelligence and machine learning and the huge amount of data produced from them will need a large amount of computing power. For this reason, the deployment of edge computing in 5G becomes a key in this data-driven environment. There is a variety of edge computer architectures designed for various application processes. The existing architectures including mobile edge computing in 5G are proposed. Moreover, edge-computing technologies provide greater benefits to real world applications. It has been widely used in smart systems with the integration of deep learning techniques such as self-driving vehicles as well as object detections. Although edge computing and 5G provide numerous advantages, there are some concerns to edge computing. Therefore, this paper systematically presented the architectures of edge computing technology and applications of edge technology. In the future, the performance of edge computing technology running parallel with the new 5G network plays an important role in the development of Internet and human environments. Enables developers to share, monitor, or interact with the social network information of users. Developers can check and find any information about the online cosmetics industry, brand, and so on that is popular today as digital channels in what customers say, feedback, keywords, or topics. Therefore, the application's goal is to analyze feedback on specific product details through social sites using keywords. This analysis, which will be useful in getting a better idea of the product on the market for the students at Stamford. In this review paper, unique ideas for utilizing MECs in close proximity to end-users have been offered by many authors. It will be easier to manage the data created in a smart city as a result of all this, at the same time, it will help to reduce latency and give crucial information in a short period of time I n the future, would like to review on more frameworks as the scope of Edge computing is growing rapidly based on the real-life scenarios relying on implementation on the cities.

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