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# AN EMERGENCE OF 5G COMPUTING WITH IOT: PROGRESS, CHALLENGE AND APPLICATION

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## ABSTRACT

*The objective of this paper is to show the impact of 5<sup>th</sup> generation (5G) on Internet of Things (IoT) and study about the benefits of 5G as compared to other technologies. This study also shows an evidence of Edge Computing with emerging 5G technology and IoT. As technology shaping, 5G is becoming a hope for an enhancement in trends of mobile communication. The paper not only focuses on the working and building architecture of 5G network but also shows that how 5G will rule the different platforms such as Internet of Things (IoT) and its applications in its use cases and also how edge computing became more evident with emerging 5G network and its contribution in IoT. The massive capacities of 5G network such as higher data speed, ultra-low latency has made it possible to stretch its wings and contribute in different platforms and to bring technology to virtual reality. The challenges in emergence have been also discussed in latter part of this article.*

**Key words:** Mobile Computing, Internet of things, Edge Computing, 5G, Future Technology

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## 1. INTRODUCTION

The creation, evolution and revolution in technology in the mobile wireless industry has started since 1970. The cellular communication industry has witnessed massive growth over the years through research and innovation [1-3]. Now the time has come when network is designed in such a way that connects everyone and everything virtually including objects,

devices and machines. This technology or network is named as 5G the fifth generation of wireless communication, a significant progression of change in today's 4G LTE networks. 5G has been designed to serve very large data growth and connectivity among the society with the help of billions of connected devices through IoT [4-7]. Initially 5G will function with the link of 4G networks before it gets evolved to fully standalone networks. In addition, to serve faster connections the most essential advantage of 5G network is the fast response time i.e., "latency" which helps to connect world virtually through various applications. Some research have been developed in china for 5G communications and its management with deployment [8,9]. The technology is upgrading day by day like green computing, smart technology etc. [10-14]. Edge computing also plays vital role in the deployment of 5<sup>th</sup> generation mobile communication with IoT. With the evolution in wireless communication, the deployment of 5G technology is in progress. People may have questions in their mind regarding the application of 5G and its impact on their regular life [15-18]. The answer to this question is the impact of 5G is going to change their lives drastically once it is released, people will enable ample amount of applications that are not possible today. In this paper, authors tried to show the progress of 5G in IoT with human applications using other technologies.



Figure 1 Showing connected connectivity

## 2. WORKING PRINCIPLE OF 5G COMMUNICATION

### 2.1. How 5G works

Like any other cellular system, 5G network will also divide areas into cells to transmit the data through radio waves. 5G network may also use the low frequencies as well as unlicensed frequencies that Wi-Fi is using currently to transmit the data without any conflict with the current Wi-Fi network. 5G technology is a new evolution in the history of cellular system, it is expected to provide the highest data speed of about 1Gbps and with extremely low latency anytime anywhere as compared to 4G LTE network. It will not only provide faster speed but will also provide ample amount of services for different applications like IoT. To meet the need, 5G technology mobile phone will have an IPv6 i.e., each user will have their own IP address. With Ipv6, everything in the world can be interconnected which means the growth of IoT platform will be accelerated.

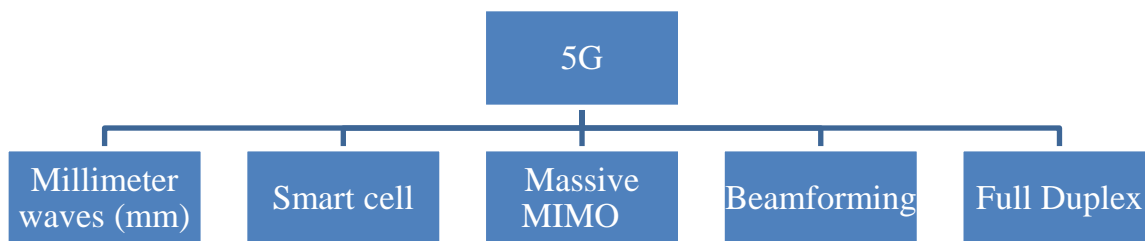
To meet world's expectation aforementioned are the technologies used by 5G technology:-

**Millimeter (mm) Wave:** Higher the frequencies narrower the wavelengths. 5G technology uses the wavelength in the range between 30GHz-300GHz that is measured in mm (millimeter). The very high frequency means that 5G technology is susceptible to astonishing

data bandwidth, i.e., massive amount of data can be sent and received among the users simultaneously and with the reduced rate of latency. For example: - An autonomous vehicle needs very high speed data to communicate in order to prevent any fatal accident.

**Small Cells:** Small cells are nearly spaced base stations which are smaller as compared to any other precedent cell towers and require less power to transmit the data. Small cells are portable and can be placed over buildings and a lamppost to provide uninterrupted connection and the fastest data speed to the user even in far-off and remote areas with reduced latency. No doubt 5G technology will surpass the other networks with this we may expect to see 5G antennas in our own homes in near future.

**Massive MIMO:** MIMO stands for multiple input multiple output, it has played the crucial role in 4G and now it will play a significant role in 5G technology by providing “massive” number of antennas at the base station to provide the user to experience better connectivity, throughput and highest data speed and better efficiency.



**Figure 2** Technologies used by 5G

**Beamforming:** Beamforming are the focused signals that direct the signal into specific directions to send and receive data without any connection interruption. Beamforming technique plays a significant role in the deployment of 5G technology by resulting in more higher and reliable transmission of data among the users irrespective of any obstacles (buildings or trees).

**Full Duplex:** Full duplex in 5G technology is used to double the rate of transmission of data in same frequency. In full duplex transmission of data is done using one channel instead of two. Full duplex is a capable contender of 5G technology in near future.

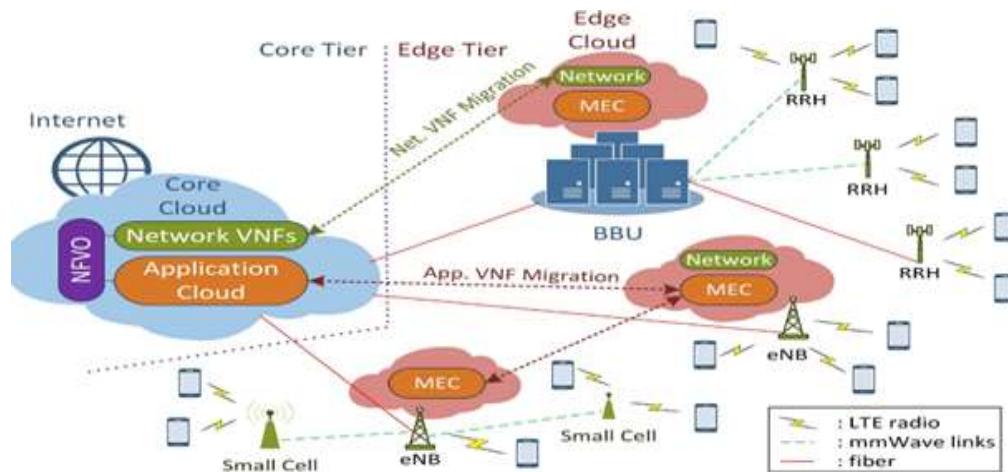
## 2.2. Core Network of 5G Architecture

GSM stands for Global System for Mobile communication in cellular wireless technology. It was developed to provide voice services, for this it used circuit-switched system. Later it provided data services also by using circuit-switched modem but the data rates were too low. The Internet Protocol (IP) based packet switched system was then first adopted and the technology was evolved from GSM to General Packet Radio Service (GPRS), using the same air interface and access technique. A new technology named as Wideband Code Division Multiple Access (WCDMA) was developed to meet higher data rates in Universal Mobile Terrestrial System (UMTS). In UMTS, the access network used circuit-switched system for voice services and packet switched system for data services. But UMTS had to still depend upon the circuit-switched system for incoming data services. To prevail this problem, fully IP based technology was developed, named as Evolved Packet System (EPS). EPS technology carries both voice and data services by Internet Protocol (IP).

Later a new access network was developed named as Long Term Evolution (LTE). It is based on Orthogonal Frequency Division Multiple Access (OFDMA). The main objective of

LTE is to provide high data rates and low latency. It is designed in such a way that it also supports packet-switched congestion. Later LTE was evolved to Voice over Long Term Evolution (VoLTE) where we can use voice as well as data at a time without hampering the quality of call services.

From the above explanation it is very clear that the primary objective of all the mobile networks are to provide fast and reliable data services to the users. The 5G network is newly evolved technology that will provide high range of services to its user across various platforms and through multi-layer networks. To support various platforms, it doesn't only need the upgradation of current networks rather it requires some higher changes in its core network.



**Figure 3** Monitoring cells and network

**3GPP:** 3GPP stands for 3<sup>rd</sup> Generation Partnership Project. It is associated with two core networks of 5G architecture- (1) Point-to-Point based architecture (P2P) and (2) Service Based architecture (SBA). The P2P architecture has huge amount of unique interfaces and operational elements as it has been used for 2G, 3G, and 4G. Whenever a new system is upgraded or transformed or new elements are introduced in the system it is hard for it to change according to the deployed system because these system requires the set up for new functions. SBA enables functional as well as quick service to the end-user by providing service using common framework with the basic network functions that are allowed to use the services without any interruption. 3GPP hence provides all the complete requirements of 5G core network architecture which is more focused on the service than all the precedent generations.

**Network Function Virtualization (NFV):** NFV is all about the virtualization of network functions. It decouples software and hardware. So the functions of network is no longer dependent on the standard hardware and can simply use the virtual resources to meet their needs and services. This reduces the expenses of hardware elements and also speed up the time of installation. Hence, it results in providing faster services to the user. The adoption of network from reality to virtual like “cloud” concede better support and give variety to the 5G network. This includes the key technology that is “Network Slicing” that allow various network to run simultaneously. The main function of NFV is to realize that the network and resources are virtualized but the performance is same. NFV can also deal with the various 5G network challenges through virtualized network, memory and can also give the services to different platforms such as IOT which will rise under the deployment of 5G network.

**5G RAN Architecture:** The mobile networks keep evolving to meet user’s expectations and provide them a network which has low latency rate, higher data rates, less data traffic,

security and reliability. To meet these requirements NFV is extended to Radio Access Network (RAN). The main concept of 5G RAN is that it provides a connection to its core network as well as the user equipment.

*Distributed RAN (DRAN):* To meet the best performance 5G network uses DRAN architecture. It has the same design as small cells which is responsible to provide uninterrupted connectivity to the user. With the deployment of 5G network, DRAN will provide high quality and flexible and IP based connectivity.

*Centralized RAN (CRAN):* Since the mobile network is heading towards 5G, the traffic of data will also increase in future to deal with such situation and manage those data, network is providing the CRAN architecture that will provide a centralized storage or cloud to the user. The benefit of CRAN is that it will reduce the cost of ownership, improve the performance of network and the most important is the low latency rate.

*Virtualized RAN (VRAN):* VRAN is the most important move for the future of 5G network. The VRAN has its strong source with NFV that unlink software from hardware resulting in providing agility and flexibility to the user. The VRAN also moves the traditional base station functions to the centralized server that is closer to the user and can also adjust the radio network according to the network traffic. VRAN can be applied on both CRAN as well as DRAN networks. The rapid growth of the use cases of IOT and machine-to-machine (M2M) data require smart network resources at the granular level of smart control. Under VRAN environment the services will be more flexible and smoother.

**Network Slicing:** In network slicing, the physical network is divided into multiple virtual network in the form of slices. Network slicing is the key technology in 5G core network. NFV and SDN plays the major role in implementing Network Slicing. NFV provides virtual functions to the virtual networks to establish in order to meet the user services and SDN is Software Defined Network that separates network control traffic(control plane) and user data traffic(user plane) and it also supports the cloud and edge locations. Network Slicing provides separate network to the user for different tasks or services and since the network is separated in slices, an error in one slice will not affect the operations of other slices that brings much more flexibility, reliability and robustness and thus allow several networks to run simultaneously. 5G has all the capabilities such as higher connections, low latency rate, data congestion control so it is now the role of network to support the changing needs in business and different platforms which is accessed by network.

**Enhanced CPRI (eCPRI):** Common Public Radio Interface (CPRI) has been used so far but now it is extended to Enhanced CPRI (eCPRI) to support 5G technology and it has become important for the 5G network. CPRI is an interface that transfers the data from Remote Radio Unit (RRU) to the Baseband Units (BBU). RRU is spread to some miles in the cities and the outskirts of the cities that consists of antennas and computational functionalities. Baseband Units are spread to 10 miles in the populated areas for good coverage. Fiber runs from a bunch of RRU and connect to centralize BBU. It is a serial interface which has very high connectivity speed and can easily change any radio signals to computational function but when it comes to 5G, then it will be difficult for it to carry large amount of data traffic. Enhanced CPRI reduces the burden of fiber by dividing the baseband functions and providing some of its functionality to RRU. It will have more bandwidth with less fibers. It also demands low latency and gives best performance.

### 2.3. 5G- Interconnecting Devices (IoT)

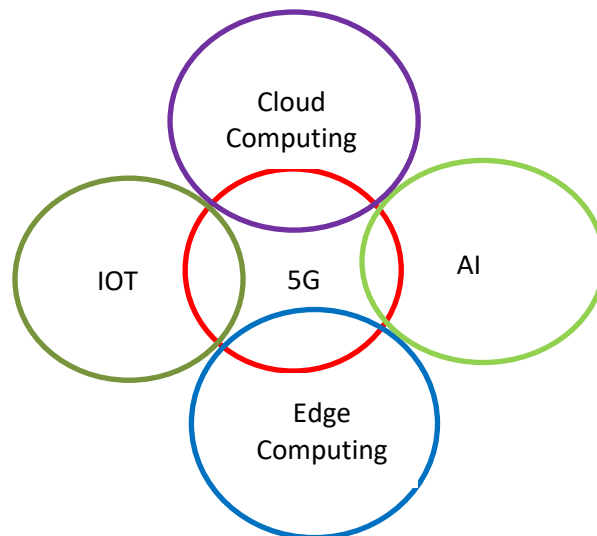
One of the major applications is “Internet of Things”(IOT) i.e., the billions of people throughout the world will be connected virtually through various wireless devices because of the fastest connectivity and extremely low latency provided by the 5G technology. The

Internet of Things (IOT) is a giant network which connects physical devices like mobile phones, tablets, vehicles, electronic appliances and almost everything which we use in our daily life using sensors which is embedded into the physical devices. IOT helps devices to communicate with each other via sending data or information which requires very strong connectivity and less response time in order to prevent any kind of delay. This platform requires an availability of internet connection anytime anywhere to meet user's expectations. With an emerging 5G technology the scope of rise in the internet of things (IOT) platform will reach to its peak.

The internet of things (IOT) emerged with 5G network will be the game changer not only for the business but multi purposes. The hype of this platform will help to make greater profit than usual by promoting smart work through the giant network globally. With such network the productivity and sale of the manufactures will be improved in IOT industries and will also help people with improved lifestyle and help them to enjoy the real world implications of 5G IOT such as smart cities, smart homes, smart vehicles etc., with unstoppable internet connectivity in their devices. The studies and reports till now have shown that it is not limited it may stretch their field in near future.

#### 2.4. Edge Computing- Fundamental of 5G Network in Connection with IoT

5G network is a new revolution in the era of technology which can be proved to be a game changer in comparison to all the precedent networks. With its massive capability of connectivity, high speed internet anytime anywhere and extremely low latency it will make the use of other platforms such as IOT, AI, etc., to meet the user's expectations in near future.

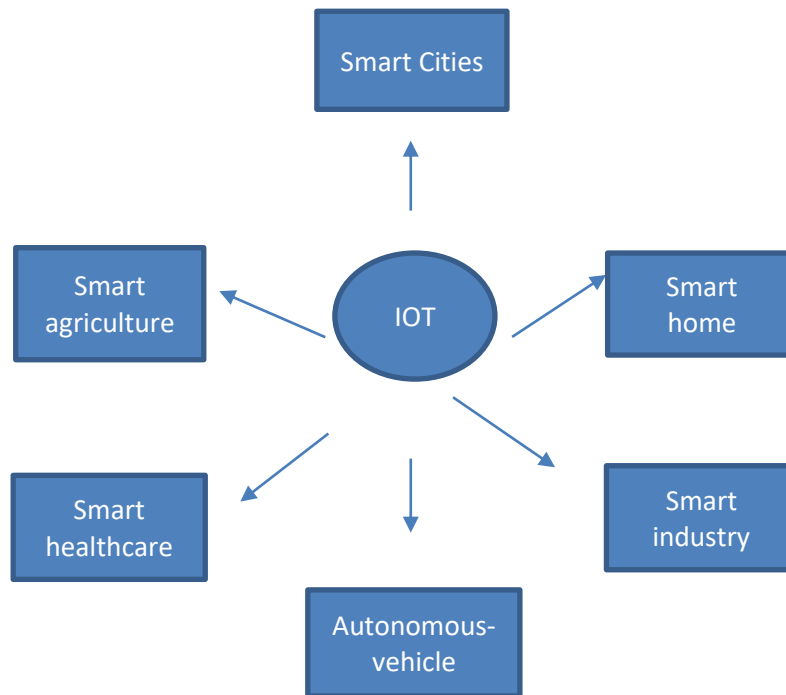


**Figure 4** Interconnection of 5G with other technologies

All the major platforms including IOT, AI etc., uses cloud computing to handle and process their massive data. Cloud computing provides several companies a cloud service i.e., a kind of rent for easy storage and access of their data which helps in sharing the workloads without any need of buying their own computing infrastructure. It is one of the brisk and an immanent part of any IT architecture. Later the constant question raised on the development of cloud computation due to its difficulty in handling and relocating some of the data and applications due to some of the physical distance between the user and data. With the growth of 5G network the market of other platforms will also increase abruptly resulting in rapid increase of data which requires high speed internet and low latency rate to provide user the data they need quickly. To handle such situations and reduce the distance between the user

and the data the cloud computation is being extended to a new version of technology and that is “Edge Computing.”

## 2.5. Application of use Cases with IoT



**Figure 5** Application and range of IoT

The aforementioned are some of the pioneer use cases of the IoT applications which will grow with the deployment of 5G technology.

**Smart Cities:** Imagine a city where you can easily get all the access in your hands by one touch such as the information about traffic, car Parking, water supply, electricity supply etc. You can get all the information and notification through your connected devices (IOT). With an emerging 5G network we can easily catch information without any delay of time and with continuous connectivity. This will help to save our time as well as energy.

**Smart Homes:** Smart home is a new trend in the advancement of technology where multiple devices at home communicate with each other using sensors. These sensors trace various activities and alert us on alarming situations such as gas leakage, commitment of theft etc., which is only possible with the deployment of 5G network because of its strong and fast internet connectivity and less response time. 5G will alienate our worries and anxieties from our daily lives as well as help in maintaining security managers in different aspects of living areas.

**Smart Industry:** An industry where workers are replaced with smart machineries that are connected to a single platform and can easily communicate with each other using sensors and keep a track of working of machines in order to make huge productivity and prevent damages. Earlier it was not viable because of low internet speed but 5G technology will bring a great revolutionary change in the escalating industrial developments due to its fast connectivity and quick response. This will enhance the productivity as well as diminish the extra expenditures by evolving automation and presumption of the functionary system.

**Autonomous-Vehicles:** Autonomous vehicles are self-driving vehicles that takes self-decisions and even response to an inappropriate situations such as an accident, traffic, snowfall etc., without any human intervention. The groundwork of an autonomous-vehicles

are fast internet connectivity and quick response so that an unforeseen circumstances can be avoided. With 5G network this will not be wrong to say that an autonomous vehicle can run smoothly and safely on roads and this will be no longer a dream.

**Smart Healthcare:** Earlier when we get sick the only option was to visit doctor or hospital but with an advancement of technology we can get quality treatment at our home through a single platform. Previously it was difficult due to poor internet connectivity. Now with the hype of 5G network it will be very easy to attend patients without any delay to provide fastest medication and treatment in order to avoid any long run problems. The symptoms of patient will be traced with immediate effect and this will assist to the medical workers and doctors to perform to prescribe the medicines and other results quickly and medical counsel be given to the victims from overseas also.

**Smart Agriculture:** Smart agriculture is a great evolution that adds up in the emerging technology. It works by using different equipment such as sensors, drones etc., to monitor the growth of crops and to fulfil its requirement for its healthy maturation. This whole process requires fast and reliable connectivity to benefit the crops according to their needs such as water supply, pesticides, fertilizers, optimal temperature etc. With 5G network it will be easy and simpler for the farmers to grow improved quality of crops in order to make large productivity and profit. 5G network will thus help to prevent wastage of water, time as well as energy.

### 3. CHALLENGES

#### 3.1. Challenges in Deployment of 5G

As we know that deployment of 5G will have a great impact on our day-to-day life and will change our lifestyle in every possible way. The massive speed and ultra-low latency will effectively replace the human effort by machines. Like IOT and its use cases such as smart homes, autonomous-vehicles etc., uses sensors and communicate with each other in order to perform any given tasks without any delay. It has brought technology to the virtual reality. Emerging of such technology comes with some challenges in its way. They are:-

**Higher Spectrum Deployment:** The 4G LTE already uses the frequency band under 6GHz but 5G technology uses the frequency of range up to 300GHz namely mm Waves that can carry huge capacity and has the ability to deliver larger files 20 times faster than 4G LTE. 5G network requires higher spectrum band to provide service without any delay and for this wireless carriers need to build such band to meet up the requirements of 5G networks. From the latest report, to put up only 28GHz spectrum the budget alone reached up to \$690 million in the U.S which means that it is very costly and we will have to invest more in order to take full services of different platforms such as IOT applications, virtual reality, AI etc.

**Coverage Deployment:** To meet user's expectation it is very important for 5G network to maintain connectivity with the devices of the user. Beam forming is one key technique that aims to specific directions with help of antennas and base stations. Sometimes it is difficult for antennas to aim at a specific target in crowded environment. Sometimes buildings, lampposts, trees in a street of a city can become obstacle for the antennas and 5G networks may fail to provide high speed data and lower latency. So the new antennas are designed and for 5G phone there will be many antennas and it will be very difficult to look after all those antennas and figure out the performance. Each antennas needs to be checked regularly and for this radio-testing rooms will be required to check that how mm Wave is travelling and it will in return demand for higher investment of money as well as the physical layer will get complicated due to increased antennas.



**Expensive Network Building:** Mobile carriers increases its cost to build any network and they do it by rising customer revenue. Building a network is very costly. Unlike LTE, 5G network plans will also incurred higher initial charge. Building a network means to start something new altogether from basic rather than just building a top layer of existing network. The foundation of a new network requires lots of money to provide user their best experience.

**Switching to new handset:** Evolving 5G network will provide best ever experience service to the user. To avail those services user will have to switch to a new handset that will provide all the brand new features of 5G technology but changing phones every time is not possible for all the individual in the country. Many companies have already upgraded their phones to the 5G network but is likely to be more costly as compared to the previous phones 4G/LTE.

**Security and Vulnerabilities:** 5G networks supports fully automated devices in massive number that includes IoT that plays the role of major component. Top 5G security challenges include IoT and spiked breaches in a network. The connected devices increases the rates of data and its value and with the deployment of various platforms with 5G data is being distributed to the different data centers (cloud & edge) and it demands for higher security in order to perform in an efficient manner. IoT use cases like autonomous- vehicles, smart homes and cities requires a lot more security because it consists of more personal data than ever and attackers may access those data and hence can threat the privacy of the user. 5G core networks architecture is so open and flexible in nature that comes with the security concern. For e.g.- SDN and NFV that provides the virtual hardware and have security threats, Network Slicing where each network is sliced into virtual networks and it demands for security for each of the slices based on their usage in different scenarios. 5G contributes a lot to the edge computing and it requires the real time detection at the edge to alleviate the threats. 5G is the most powerful technology and the breaches in network continue to rise in higher frequency and volumes. So its network must be built to evolve to the increasing security needs.

#### 4. CONCLUSION

The 5G wireless technology is a new evolution in telecommunication that has multipurpose wireless networks and various wireless applications. Before introducing 5G in the market an appropriate environment and encouraging aptitude needs to be prepared. So that consumers/buyers/users of the 5G technology enthusiastically feel that the benefit of 5G devices is comparatively much better than before existing devices and much more investment of money doesn't matter for them. This paper dealt with all types of advanced features of 5G technology that will make it more powerful and in huge demand in near future. In the wireless communication world, the joint infrastructure of 5G, Edge Computing and IoT accord a multi-dimensional progress and provide a new technique, speed and uninterrupted and regular services to its users. This has brought a new revolution in cellular technology. The user can experience the best ever performance and will take the advantage of fully automated devices that makes their life more faster, smarter, flexible, saves time, optimized and without much human efforts. The decentralized data also serves a lot to avoid any kind of delay and plays a crucial role in IoT use Cases Applications by bringing data more closely to the user. This helps user to avoid or prevent any kind of alarming situations and provide security and safety to the user much faster than before. With the implementations of 5G network the profits in business and industries will also reach to its peak. It provides a lot more new opportunities to the different operators and also supply different applications that help operators to perform more efficiently in order to give user its best service.

In the above context, it would be appropriate to mention that 5G will not only limit to its users/buyers/consumers but also plays a great role to enhance the all-round advancement of the country in several fields as also to meet the challenges of any growing situations

nationally and internationally. This will also help to explore new devices to overwhelm any unsolved problems. The way to new version is still going on.

With the deployment of 5G network and its demand among the other platforms the rate of need of data will also increase and the processing of data demands high speed internet and quick response time to serve user immediately with the data they require.

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