5G: Consequences for (I)IoT

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***Abstract*—"The Internet of Things (IoT) is very part of Industry 4.0.The number of mobile hosts that will be used in 2020 will be exceeding 50 billion hosts" [1]. So today in this world with so many mobile devices present and needs to be connected with the Internet of things (IoT) devices. We have LTE (4G) present which is unable to fulfill the needs for the higher data rate , more bandwidth ,higher capacity and there is also less use of energy .It also needs to provide higher efficiency .With increasing demands of customers the current IoT architecture is quite fragile and not flexible for next generation Iot applications and upcoming future .We need to overcome these problems. So,We use Fifth Generation (5G) mobile network having potential with IoT.In this paper, we have discussed the role of 5G cellular networks in the growth of IoT.Also this paper compare the other wireless networks with 5G as a role for IoT Furthermore, we have discussed the challengesS,applications ,and the future of IOT devices with 5G.**

***Index Terms*—Internet of Things, IoT, 5G, cellular networks, wireless software defined network,, 5G-IoT,IoT Architecture**

I. Introduction

A. Motivation of the Paper

Momentous developments in wireless sensor networks, telecommunications, and informatics have paved the realization of pervasive intelligence [2], [3] which envisions the future Internet of things (IoT). "The genesis of IoT goes back to the 1980s with the idea of ubiquitous computing whose objective was to embed technology in everyday life" [4]. Today IoT can be visualized in every scenario whether we take the example of smart home hubs, Smart appliances, and Smart assistants for individual purposes. For the professional level, we have IoT Tracking and Monitoring System, Smart Supply Chain Management and Smart Grids. One of the most important technologies needed to run IoT devices is cellular technology. There are wide range of cellular networks with which IoT device can be connected and 5G technology is latest with its own unique advantages.The whole world is planning and promoting the use of 5G in IoT between different industries and areas of development because of 5G technology's high data rate .Today 5G stands at a rate of at least 1Gb/s .But it will definitely grow upto 10Gb/s in coming 5 years and more so on [5].We should also realize that 5G is not only a improvement its predecessor 4G over data rate only. It has also been opening gates for so many new application domains which are linked to IoT .This paper describes the challenges,applications ,and the future of IOT devices with 5G.

II. Challenges and vision of IoT in 5G

Internet of things (IoT) can be defined according to [6] as a dynamic global network infrastructure with ability of self-configuration.As we are looking into the evolution of cellular technologies from 1G to 4G over the years and faced many challenges in both physical and network layer designs and their fields of applications.In this section,we will look into the challenges faced by IoT and how to resolve them

1) Zero-Entropy systems

Energy is going to be a major technological problem in next 5-10 years.Today researches are conducted how we can save energy and develop thats systems that are able to collect energy from environment and in the process do not waste energy.The maximum consumption of IoT device depends on the device is continuous , processing, sensing and transmitting / receiving necessary information.The more the samples or data from the sensor we can have better data exploration and the irony is it increase power consumption. Most of the energy consumption in IoT is related to connected devices which usually operate on batteries or some energy harvesting source.The main issue comes with devices that require recharging and replacement of energy systems.IoT achieves the energy efficiency or consumption by the mean of direct communication between connected devices, which allows sort of local connectivity among devices that is usually provided by wireless technologies [7].5g requires less energy and have no synchronizations.The application can come in Micro-robots could perform inspection of sensors and share information in real-time for fault prevention, helping to reduce costs.

2) Scalablity

Today billions of devices are connected and many more billions devices are need to be connected.This means that IoT applications must have the ability to support an increasing number of connected devices, users, application features, and analytics capabilities, without any degradation in the quality of service. "Scalable IoT applications are also essential to monitoring, securing, and managing an increasing number of devices through a proportionate increase in the resources" [8].This increase in devices always result in potential fail-

ure.So industries should have a reliable infrastructure so that failures can be reduced the handover between cellular cells is smooth. Serving and handling that number of devices need an efficient scalable network which is provided by 5G. Providing high scalability for cellular networks require enough frequency spectrum resources and efficient media control.[10]

3) Network Performance and Data Rate

Today the IoT success depends on very reliable IP-based networks.So we should use tried and tested devices which provide productive and effective network.If we look into tough environments conditions like oil ,marine , power and railways the device reliability is most important.we make a IoT system with the most user friendly interface but that app has no benefits if that system backend is not reliable.So the industries need rugged enough devices as they rely more and more on remote access.Devices that cannot bear these situations , defective so they are a failure in IoT.It can be a danger to people life , costly and plus inaccurate information. The high data rate will help the video-oriented applications that require streams ranging up to Ultra-High Definition resolution are emerging (e.g., surveillance, physical security). Also Millimeter wave solutions impose a requirement for small cells will also be solved by 5G high speed.

4) Latency

Today the main challenge with IoT devices is they run on batteries otherwise no one wants a device to be connected by a power chord. The important thing is to preserve the lifespan of batteries . The devices wake up from sleep mode to retrieve new information. As longer the device sleep , the less power is consumed. This means there are few opportunities for information to be exchanged. It impacts the performance and will run slower . Example of where low latency is important for the potential of an IoT device is a surveillance camera with PTZ control (PTZ is Pan-Tilt-Zoom, the ability to move and zoom the camera). Low latency makes the PTZ controlling much smoother and easier to control the position of the camera. If the latency is above 100ms, the camera movements start to be out of sync with the user's control and the user will start to "overshoot" the target being late with the stopping movement commands [9]. Lower latency means near real time communications, which can be a big boost when it comes to real-time control of devices, automation, autonomous vehicles, industrial robotics, and security systems. 4G latency is actually quite around 30-40 milli-seconds but with 5G that number is reduced to 1-2 milliseconds, which again, makes 5G a major game changer when it comes to IoT.[10].So latency is relatable to mainly end-to-end communication where uplink consists of one fraction of communication followed Downlink.It is helpful in Industrial automation,Intelligent transport systems (ITS), and Real-time professional audio.

III. Architecture of 5G IoT

In the following section , we have described an architecture that is needed for 5g and Iot services and applications. This

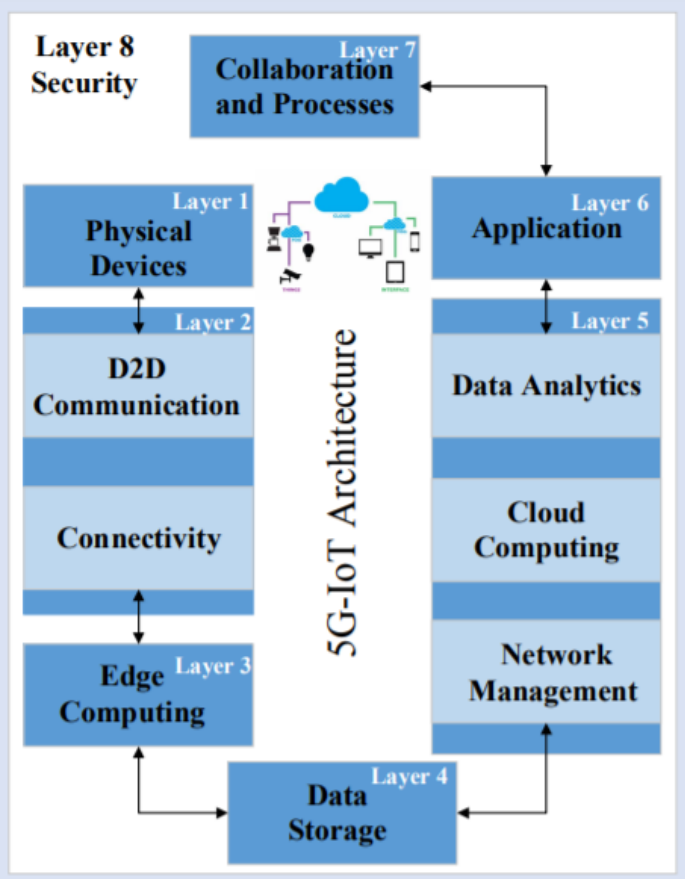

Fig. 1. Architecture of 5G IoT [12]

architecture will help us solve the problem as discussed in above section.This architecture has eight interconnected layers with two-way data-exchange capability as shown in Fig.1.[12] The second layer and fifth layer consist of two and three sub-layers, respectively, and the security layer covers all other layers.These layers are selected to provide the best performance and maintain the modularity of the architecture simultaneously.[12]

1) Physical Layer

This layer converts analog signal into digital signal and vice versa.This layers act as common layer among all physical devices i.e. acts a bridge between the real and digital worlds.In this layer small size devices such as Nano-chips are to be used for power reduction and increase computational processing power.IoT things can be divided into the following groups.Sensors such as probes, gauges, meters, and others. They collect physical parameters like temperature or humidity, turn them into electrical signals, and send them to the IoT system. IoT sensors are typically small and consume little power."Actuators, translating electrical signals from the IoT system into physical actions".[13]

2) Communication Layer

This layer is also known as connectivity layers as it help in data transmission across devices , networks and cloud that make the IoT infrastructure. The connectivity between the

physical layer and the cloud is achieved via direct using TCP or UDP/IP.It can also be achieved using gateways.The communications between devices and cloud services or gateways involve different networking technologies for example ethernet which connects stationary or fixed IoT devices like security and video cameras , WiFi which is used in small areas, NFC sharing data over small distance in 10 cm and Cellular networks offer reliable data transfer and nearly global coverage.

3) Edge or fog computing layer

This layer help in reducing system latency .This level is essential for enabling IoT systems to meet the speed, security, and scale requirements of the 5th generation mobile network or 5G. The new wireless standard promises faster speeds, lower latency, and the ability to handle many more connected devices, than the current 4G standard [13]. The main idea behind the edge computing is to store and process information as close to it sources . I will allow for analyzing and transforming very high level of real-time time data. It also reduces system latency that lead to real-time responses and increased performance.

4) Data Storage Layer

Data Storage Layer: This layer helps in making data useful.It takes data from edge processing than store , accumulate and processes the information .This layer requires special protection in terms of security, and also should be conscious of the massive data volume and traffic of future applications. the entire goal is to arranged an outsized amount of diverse data and store it within the most effective way.The 2 stage takes place in this layer are Data abstraction stage and Data Accumulation stage

5) Management Service Layer

This layer is divided into 3 sub layers .the first one is Network Management Sub-Layer .Network management involves changing the type of communication between devices and data centers.The second one is cloud computing Sub layer. In this sub-layer, data and information from the edge computing are reprocessed in the cloud so that the final processed information can be derived. By implementation of 5G technology, the mobile devices are capable of performing this type of computing between devices and data centers.the third layer is Data Analytics Sub-Layer." In this sub-layer, new methods of data analytics are employed to produce value (manipulatable information) from raw data". [13]

6) Application layer

This layer helps in addressing business requirements.At this layer, information is observed by software and give answers to all important business questions.Application helps business people do the right thing with the right data .Some key examples are evice monitoring and control software,mobile apps for simple interactions, business intelligence services, and analytic solutions using machine learning.

7) Collaboration and Processes Layer

This layer helps in implementing data-driven solutions.It involves decision-making process with more than one person working with more than one software solution.The information

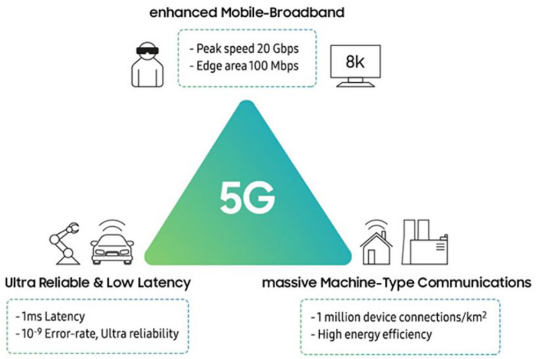

Fig. 2. 5G Applications and Use Cases[17]

generated at the previous layers brings value if only it results in problem-solving solution and achieving business goals.[14]

8) Security layer

It help in preventing data breaches.It goes without saying that there should be a security layer covering all the above-mentioned layers[14].This layer includes data encryption, user authentication and cloud security.It also prevents from dangers and cyberattacks , we can also learn and detect the type of attack.

IV. 5G and IoT applications

5G is the fifth generation of mobile communication technology and the first that is specifically designed for various vertical IoT use cases with demanding requirements, including gigabit data rates, millisecond latencies, ultra-high network reliability and massive connection density can be seen in figure 2. [15].

The 5G IoT different examples are taken from [15]

1) Vehicle Telematics

Automotive and Transportation (AT) is sector which will adopt 5G technologies in IoT Applications. Today, millions of cars uses telematics applications tracking of location , diagnosis and even user-based insurance. Today the problem exist with the current cellular network, we cannot collect real-time data , so 5G we can satisfy the current communication needs. We can collect more data in real-time for health and driver behavior and even about how the vehicle performed. While LTE will likely remain the leading connectivity technology for these applications in the near future, especially with the planned switch off 2G and 3G networks in many areas of the world, in the next few years IoT Analytics expects many vehicle telematics implementations to support both 4G and 5G connectivity[15]. "Example: Harman announces the first 5G-ready car telematics solution".[15]

2) Video Surveillance

Over the years the crime rate has increased , so now many governments around the world are installing video cameras for surveillance and security This trend will get a great boost

with 5G connectivity .The majority of surveillance system today rely on wired connectivity but slowly with the advent of technology we are switching towards Wi-Fi or cellular networks. LTE was in trend and most preferred choice for temporary static installation , for example in festivals, concerts or even public rallies .It is also used by police car s ,buses .But LTE provides has its own limitation, and performance issues .With 5G we can have increase in performance we can stream live content at a fast pace. "Example: Samsung and KDDI demonstrate real-time transmission of UHD surveillance video via 5G".[15]

3) Smart Grid Automation

5G's has the capability that can make the smart grid the best work for the real-time and automation scenarios. This will help This will help in finding and correcting faults quickly. It will also help in meeting the increasingly stringent demand on their grid, driven by trends such as the integration of Distributed Energy Resources (DER) like renewables into the power grid, tighter regulations and evolving cybersecurity threats [15]. Most requirements such as latency and network reliability are fulfilled via wired communication technologies. So 5G is going to be opted which is likely to give same level of performance but with lost cost , and a high flexibility. "Example: Nokia, ABB and Kalmar successfully demonstrate 5G-based URLLC for smart electricity grids".[15]

4) Mobile and Collaborative Robots

We are really closing on robots in industries .So 5G seems to provide relevant reliability for connecting industrial robots with various degrees of mobility from static collaborative robots to fully mobile robots such as autonomous guided vehicles (AGVs)[15].These robots autonomous do tasks such as carrying or moving things .Therefore , they need to process fairly large amount of data.As it its a very expensive task accommodating them with such capabilities to do certain task .In that place 5G comes into the picture with its low latency and very high reliability."5G will make it easier to offload part (if not all) of this processing need to edge or cloud-based servers and thus minimize the hardware complexity (and cost) of the robots" [16].

"Example: 5G Transformer project demonstrates a 5G connected cloud-based mobile robot performing warehouse operations".[15]

5) Cooperative Intelligent Mobility

On the mid-long term, 5G is going to benefit the sharing of live feeds regarding traffic and road conditions among cars .This new assistance is gonna be for both private and public vehicles where 5G plays a crucial role warning drivers about the traffic jams , difficult road condition , and any emergency situations .It will increase road safety also. Currently, cellular-based V2X communications are supported on LTE networks as the part of the 3GPP Rel-14 15, while 5G-based V2X will be introduced as the part of 3GPP Rel-16 set to be released in 2020." Example: SK Telecom is building a 5G-enabled intelligent transportation system in Seoul".[15]

V. Conclusion

IoT is the technology which is going to change our lives for good.It will automate many things by the help of 5G technology.To use 5G with IoT several problems will be resolved as discussed in this paper which are issue in LTE and 4G.The advantages and features of 5G is going to help IoT in a big way. Few application has been discussed in this paper and there are many more places 5G plays a major role.

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