A Comprehensive Survey on Internet of Things (IoT) Towards 5G Wireless Systems

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Abstract-
Recently wireless technologies are growing actively from all parts of globe. In context of wireless technology, 5G technology has become a most challenging and interesting topic in wireless research. This article provides an overview of internet of things in 5G wireless systems. IoT in 5G system will be a game changer in future generation. It will open a door for new wireless architecture and smart services. Recent cellular network LTE (4G) will not be sufficient and efficient to meet the demands of multiple device connectivity and high data rate, more bandwidth, low latency Quality of service (QoS) and low interference. To address these challenges, we consider 5G as the most promising technology. We make a depth overview on challenges and vision of various communication industries in 5G IoT systems. The different layers in 5G IoT systems are discussed in detail. This paper provides a comprehensive review on emerging and enabling technologies related to 5G system that enables internet of things. We consider the technology drivers for 5G wireless technology such 5G new radio (NR), MIMO antenna with beamformation technology, mm wave commutation technology, heterogeneous networks (HetNets), role of augmented reality in IoT are discussed in detail. We also make a review on low power wide area networks (LPWAN), security challenges and its control measure in 5G IoT scenario. This article introduces the role of augmented reality in 5G IoT scenario. The article also discusses the research gaps and future directions. The focus in this paper is also on application areas of IoT in 5G systems. We therefore outline some of the important research direction in 5G internet of things.

Index Terms—Internet of Things (IoT), MTC, MIMO, beam forming, LPWAN, mm wave, cloud, New Radio (NR), Numerology, NOMA, Heterogeneous Networks, Dual Connectivity. Dual connectivity

I. INTRODUCTION

Nowadays, wireless communications with high speed internet connectivity and higher data rates have a significant demand on the society and are important factor in smart economic development and digitization of society and the world. Existing wireless technology such as 3G, 4G cannot meet the demand of 5G wireless requirements and it cannot be used for low power wide area (LPWA) technology and long distance communication. 5G wireless technologies in IoT are expected to use the unlicensed or unused spectrum band and it can only be easily accessed through low power wide area networks (LPWAN) such as SigFox, LoRa, WiFi, ZigBee, and NB-IoT [12]. NB-IoT is used in three modes, standalone, in band and Guard band with their respective applications. The technology related to NR are cognitive where standalone mode is used for spectrum reuse, in band for proper spectrum utilization and guard band for utilization of unused resource block [4][5][6]. Today, current mobile users are in millions with annual growth rate of around 25% and are expected to reach 80 billion by 2030. As we know, wireless communication has been one of the major trends in building smart world [13]. 5G new radio technologies feature in enhanced mobile broadband (eMBB), enhanced machine type communication (eMTC) and critical communications (URLLC). These technologies will enable machine to machine (M2M), device to device (D2D) and device to everything (D2E) communication, internet of things (IoT) and internet of vehicles (IoV) [14]. Such communication systems must make sure that it is low CSWAP (Cost, Size, Weight, and Power) enabled. While many IoT communication has been deployed so far, but it has not been considered for massive connectivity and better energy efficiency. The Massive MTC, from the name implies more connected objects for example, e-health services, City/village, e-Farm, intelligent transportation system (ITS), whose end-to-end cost must be sufficiently low to make cost effective ensuring secured communication [15]. These kind of smart technology provides enormous demand in future communication system which will be fast and more connected devices which are normally supported in combined networks called a “heterogeneous network”(HetNets). It uses small base stations comprising of Femto cells, Pico cells, mm wave technologies and MIMO antenna. It provides a significant impact on human’s daily life. To design and deploy 5G Internet of Things, the concept of 5G requirements and its feasible technologies should be clearly investigated. To have generalized 5G infrastructure, the development with respect to architecture, enabling technologies and its challenges and security measures should be known first. 5G IoT deployment will generate diverse form of traffic, reliability, bit rates, energy consumption and security and privacy. The key motivation for developing IoT over 5G cellular networks is predicted and massive number of devices are expected to be deployed which requires significant data rates.

The major contribution of this review article is listed below:

- Challenges and vision of IoT in 5G is presented.
- Presentation of the architecture of IoT in 5G scenario.
- Enabling technologies in each layer is presented in detail.

- Security threats and is preventive measures in 5G IoT is presented.
- Presentation of area of application in 5G IoT.
- Research direction in 5G IoT is provided.

II: CHALLENGES AND VISION OF 5G IOT

We have been witnessing the growth of cellular technology within the decades. Evolution from 1G to 4G technologies has shown many challenges in both physical and network layers design and their fields of applications. Considering all these challenges in existing network, 5G has come up with huge revolution in wireless technology. As per the review the research challenges on 5G technology mainly focus on following issues.

1. 1~10 GBPS data rate in real time networks: the data transfer must be 10X more than that of existing technologies [9].
2. Low latency > 10ms: latency must be 10X smaller as compared to LTE networks [19].
3. High bandwidth and spectrum efficiency: 5G technologies require high bandwidth and it can be achieved through the use of MIMO antenna and mm wave technologies and spectrum efficiency can be achieved by cognitive radio which allows the user to utilize both the licensed and unlicensed spectrum bands [14].
4. Low cost: IoT should feature with low cost sensors, devices and their deployment cost should be low [37].
5. More number of connected devices: As we are dealing with IoT system and is expected around 80 billion IoT devices are connected over a network [26].
6. Longer battery life: As the devices are expected to be smart and it requires more power consumption and the charge storage and battery backup should me more [39].
7. Reduce energy consumption by almost 90 percent: reduction of energy in 5G technologies can be achieved by deployment of green technologies and it can be efficient in massive connectivity and high data rates.

From the above mentioned 7 major challenges in 5G IoT, wireless communication industries and research institutes are collaborating and started research activities in different aspects of 5G IoT. Table I [48] [52] [90] [91] [92] [97] shows the vision of 5G IoT and its present research activities by different network providers and operators. Some of the leading cellular, semiconductor companies and service providers with excellent research facilities are conducting research and field trials to provide the accessibility of 5G wireless technology by 2030. Some research institution with world class laboratory facilities are engaged in 5G research and experiments. The latest advancement and up gradation in cellular technology promises to meet the demand of faster internet speeds, better spectrum efficiency, long distance communication, better battery life and communicating billions of devices. IoT in 5G framework can be the most revolutionary technology in field of information technology. According to research, 5G wireless technology will be accessible in many countries within 2030.

TABLE I
Vision of 5G IoT: Industrial and Research Perspective

Research Industries	5G IoT Key Vision
Samsung	Samsung has considered IoT as a platform in making things more convenient in human lives. As per samsung, there are four key approaches in IoT era: human centric, openness, connectivity and security. The vision of samsung is to connect all things that exist on earth. The expectation of Samsung is that, all the devices from IoT platform are connected to each other [52]. The active cooperation is key requirements in realizing 5G IoT areas such as smart homes, smart cities, smart factories, smart healthcare, smart agriculture, logistics etc [94]. Samsung is providing extensive contribution in IoT open cloud platform that enables users to control over home appliances. Samsung electronics gadgets like AC, Washing machine, Refrigerator can be controlled by remote. Some of the recent development by Samsung in IoT are as follows: ✓ Development of 'SIMBAND', a modular sensor that can be used in e –wearable. ✓ 'SAMI', an open cloud server platform that stores and secures the data provided by the users. ✓ Samsung is coming up with 'ARTIK' which is a comprehensive IoT platform comprising of both software and hardware development kits. ✓ Samsung has introduced I T100 which is usable in secure and reliable IoT devices for short range communications.
Intel	Intel has been the global pioneering in deployment of sub 6 GHz and mm wave communication, so that industry ecosystem across the world can develop 5G service solutions. Intel is developing a new critical technology that enables 5G HetNets and maximizing efficient use of spectrum resources. Intel is working on recent technologies such as licensed accessed access (LAA) that can boost speed performance. Some of the key contribution of Intel in context off 5G are: ✓ Intel has played a major role in standardization of NB-IoT, core technology necessary for low cost, longer battery life and better coverage. ✓ In consideration to industry 4.0, Intel is working on IoT products and technology in robots and robotic

	internet and factory automation with Honeywell. ✓ They are driving the industrial IoT by enabling machine operation like, M2M automation, low latency connectivity and Intel powered 5G networks. ✓ They are working on 5G end to end solution like fabric of smart cities, smart car and deployment of wireless connectivity replacing fibers with cognitive radio.

ZTE	ZTE has come up with latest technology and successfully demonstrated 5G Multiple Input Multiple Output (MIMO) antenna and won several awards in different international platforms. Orthogonal Frequency Division Multiple Access (OFDMA), 5G New radio and software defined radio (SDR) are the major contribution of ZTE in IoT industry. ZTE has made outstanding achievement with its quality cloud based networks. . ZTE has found patents on some new technologies such as FBMC, Wireless security and low power consumption. ZTE has research collaboration with leading service provider like Korea Telecom, China Telecom and China mobile. ZTE is actively driving standards and discovering novel technologies like ultra-dense networks (UDN), multi user shared access (MUSA) AND NB-IoT.
Huawei	Recently, Huawei has successfully conducted test of 5G NR at 2.6GHz spectrum band. IMT 2020 has supported the company for their test trials and they have proved that 2.6 GHz is suitable spectrum range for operators to deploy 5G in both SA and NSA mode. Huawei is also conducting R&D trial which supports VoNR (Voice over New Radio). The company has tremendous contribution in IoV and IoT research and their use cases. More Recently, Huawei has launched 5G smartphone (MATE X) with flexible display. Some of revolutionary contribution of Huawei in 5G and IoT [91] are: ✓ They have developed a network slicing as service (NaaS) on IoT cloud computing in 5G networks as best telecom services. ✓ Huawei has signed a MoU with Middle East electrical product manufactures to explore how IoT and 5G technologies can be implemented in the upcoming electrical products for home/building automation. ✓ They have successfully complemented an integration of NB-IoT chips, such as smart energy monitoring via NB-IoT devices. ✓ It is also a pioneer company in delivering innovation in cloud services and launched some products which support both new radio (NR) and ling term evolution (LTE).
Ericsson	Ericsson is the largest contributor of 3GPP release 16 standardization. It has huge contribution in 5G IoT cloud infrastructure. Ericsson is driving IoT industry by providing tremendous contribution in remote application where real time network performance is critical such as remote control of heavy machineries in hazardous environment. Some research dedicated by Ericsson towards 5G IoT [48] [49] are: ✓ Ericsson has main contribution in 5G smart factories and smart healthcare by developing smart device and sensors. ✓ They have successfully developed and showcased 5G technology like spectrum sharing, intelligent management services and communicating smart devices. ✓ They have contribution on important technologies like network architecture and cloud computing. ✓ Ericsson has successfully installed 5G base station of radio frequency systems which will be able to support 3GPP release 15 application. The installed base station supports remote software operation and satisfies all 3GPP cellular technologies.
Nokia	Nokia has expected their 5G trail in mid-2019 and is currently working in 5G domain with airtel and BSNL. Nokia is also working on 3GPP release 16 since 2017. They have provided immense contribution in RAN and MIMO antenna technology such as adaptive array and beam formation. Nokia has launched cross domain architecture to support 5G technology. Some of the major technical revolution by nokia in 5G are presented below: ✓ Nokia is working on modernizing networks which helps to kept total power consumption flat by minimizing the use of energy not directly related to data transmission [97]. ✓ They are working on several major opportunities for increasing energy efficiency of base station: some of them are as follows. • Reduce the energy consumption when the base station has no data to be sent. • Reduce the energy due to auxiliary equipment. • Increase hardware efficiency, particularly when operating below maximum power. ✓ According to Nokia, small cell energy efficiency can be admired by small cell on/off switching, where macro cell provides full coverage and small cell can be switched off when there are no users or low number of connected users. ✓ Nokia is working on MIMO and mm wave technologies and demonstrated 5G deployment below

	6GHz, resulting in ubiquitous coverage, especially for massive IoT and critical communications. ✓ They are also working on reducing latency in 5G communication by successful NR numerology selection and mini slots.
NTT-Docomo	It is world's first wireless industry to successfully design and conducted the field trials to developed 28 GHz wireless communication for 5G, aiming to launch their commercial services in 2020, [16] NTT Docomo is in full focus on 5G R&D activities. Company is engaged in providing super high data rate communication of over 10 GBPS, low latency which enables wide range of MTC and IoT applications. They have scheduled to launch their pre commercial services on 5G in September 2019. Some of NTT- Docomo towards 5G deployment is discussed under. ✓ NTT docomo incorporates non orthogonal multiple access (NOMA) technology that that improves system capacity in existing frequency bands and radio access technology (RATs) [92]. ✓ Recently NTT –Docomo is studying on smart new devices, sensors, and services towards 5G commercial services. ✓ Their commercial devices are expected to contribute in safe, secure, rich life style and highly effective society through IoT platform.
Qualcomm	mm wave antenna technology is prime focus of Qualcomm R&D activities. Qualcomm is working on delivering URLLC service in IoT with sub ms latency and 99.99 % reliability [90]. Qualcomm also has contribution in 3GPP release 16 standardization and are presented below. ✓ Time sensitive networks: It is capable of handling ethernet switch functions, enhanced quality of service (QoS) and microsecond time congestion. ✓ Qualcomm has sincere effort in 5G NR in utilization of unlicensed or shared spectrum. ✓ They also have contribution in cloud services such as cloud analytics virtualized core network functions. QTM 052, mm wave antenna module is the world's first mm wave RF solution for 5G smartphone and other devices. This module is capable of supporting 5G NR integrated chip and RF front end services. They have research collaboration with Bosch for developing 5G enabled IoT.

The use of IoT services and number of connecting devices within a network and device connected per person is shown in fig1. and is expected around 80 billion devices will be connected within in a network and 20.5 billion devices will be connected per person by 2030 as shown in fig. 1 [9] [19] [26]. The technology of IoT and 5G is transforming and bringing industrial revolution 4.0 in every aspects of technological era. The IoT can be developed with the concepts like machine to machine (M2M), device to device (D2D), vehicle to vehicle (V2V), and vehicle to anything (V2A), where every convenience is taken by the interconnected devices, sensors and communication networks. IoT may be used in different field of life changing applications such as smart factories, smart hospitals, smart transportation, smart agriculture, smart homes and cities etc.

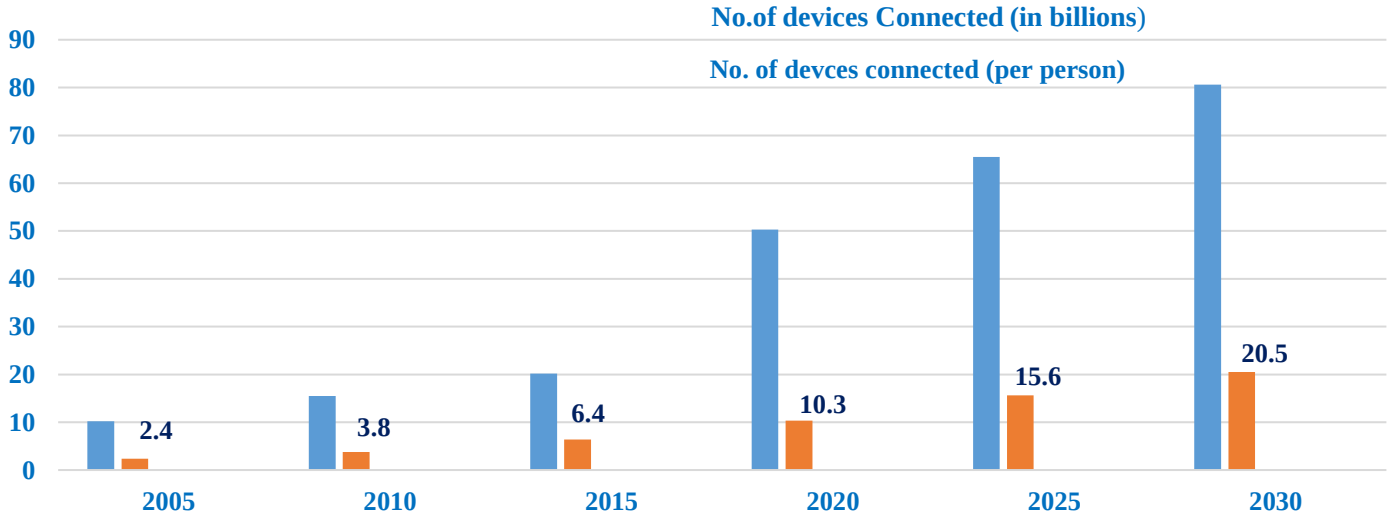

Fig 1: 5G IoT Vision from 2005 (3G) to 2030 (5G)

It can also be used in logistics, retail management and different online service providers. IoT in vehicular communication can be used in collision and accident prone situations by the transmission of information between cars, street lights through radars and sensors. Smart Bulbs, smart energy monitoring, communication between different electronic devices are used in making smart homes. IoT can also be used in public safety, agriculture. Robotics Internet can be realized for smart factories in industrial IoT. Overall smart architecture can be realized using IoT in 5G.

Besides Technological challenges there are other aspects of challenges like government regulations, security and privacy, spectrum allocation. These challenges made IoT a little more critical. Since, 5G IoT operates on licensed and unlicensed spectrum bands by proper spectrum sensing and allocation. So proper spectrum sensing is most needed in realizing 5G IoT.

A. 5G IoT: Motivation and Objectives

Considering the above-mentioned challenges in 5G and IoT, we are deeply motivated to provide a comprehensive review on 5G wireless technology which enables internet of things (IoT). Since large number of communication and network industries including different research institution are involved in research activities in 5G IoT and it provides us encouragement to provide a research perspective towards 5G. To provide efficient directions on 5G IoT, the communication and network technology is deeply investigated and presented. In particular this article provides a comprehensive survey on driving technology, its security issue. Nowadays, cyber-crime has been a serious issue in IoT and we provide a cyber-crime issues, its and its security measures. So, IoT can be considered vast area of research and it should cover all relevant technologies on 5G governing IoT. 5G IoT is propped in 5 layered architecture and discussed in detail. The generalized form of network architecture is to be designed for IoT in 5G which results in intercommunication between the devices and share resource more effectively. The generalized form of networks can reduce complexity and cost.

In present technological era internet plays a major role in connecting different multiple devices and machines which we use in day to day life without human interruption. The objective of this review article is to provide analytical knowledge and research directions in 5G. Key technology drivers in 5G IoT are discussed in detail. Since, 5G IoT is a vast technology which involves massive critical communication and network technology. mmwave technology, MIMO, 5G NR are some important technologies are reviewed and discussed in detail. Since 5G operates in much faster speed as compared to existing technology and it can provide reliable communication and large number of devices are connected within a single network. The network used in 5G is HetNets and its architecture is discussed. Collectively, this review article provides a deep learning on 5G and IoT, its vision and technical specification.

III. ARCHITECTURE OF 5G IOT

IoT in a 5G framework mainly comprises of five layered architecture as shown in fig. 2 [8] [18] [69] [129] and involves the operation of collecting data, processing, analyzing and sharing the information between the devices and communication network.

(a) IoT Sensor Layer: This layer consists of physical layer system such as smart sensors, devices and communicates to the network layer.

(b) Network Layer: Network layer in IoT comprises of low power wide area network (LPWAN) such as Sigfox, LoRa, ZigBee, NB-IoT.

(c) Communication Layer: This layer can be considered as the backbone of IoT architecture because it transfers the whole information within the layers.

(d) Architecture Layer: It is the framework of IoT, where architecture likes cloud computing, Big Data Analytics are considered.

(e) Application Layer: IoT applications like, smart factories, smart homes, smart agriculture, smart transportation etc can be realized. This layer integrates all the devices sensors and information over wireless connectivity using internet. The pictorial representation of 5G IoT architecture in shown in figure 2.

In this architecture, smart IoT sensors for different application are connected to IoT gateway through low power networks such as SigFox, LoRa or NB-IoT which are used for long distance communications [3][12]. This efficient gateway collects all the information from IoT devices and it transmits the collected data to 5G base stations via 5G communication link. 5G communication links can be designed using 5G new radio technologies with efficient numerology selection and mm wave communication technology. Further, IoT signals are processed through 5G cellular base station which has multiple inputs multiple output (MIMO) antenna with additional capability of beam formation and spatial multiplexing[7][13]. 5G mm wave communication technologies help to transfer radio signals in higher frequencies greater than 6 GHz. This millimeter wave communication is preferred which allows larger frequency operation up to 80 GHz [1] [9]. It can also support maximum number of connected utilities with micro and macro base stations called heterogeneous network for new CRATs. Various application of IoT can be realized using 5G Radio technologies.

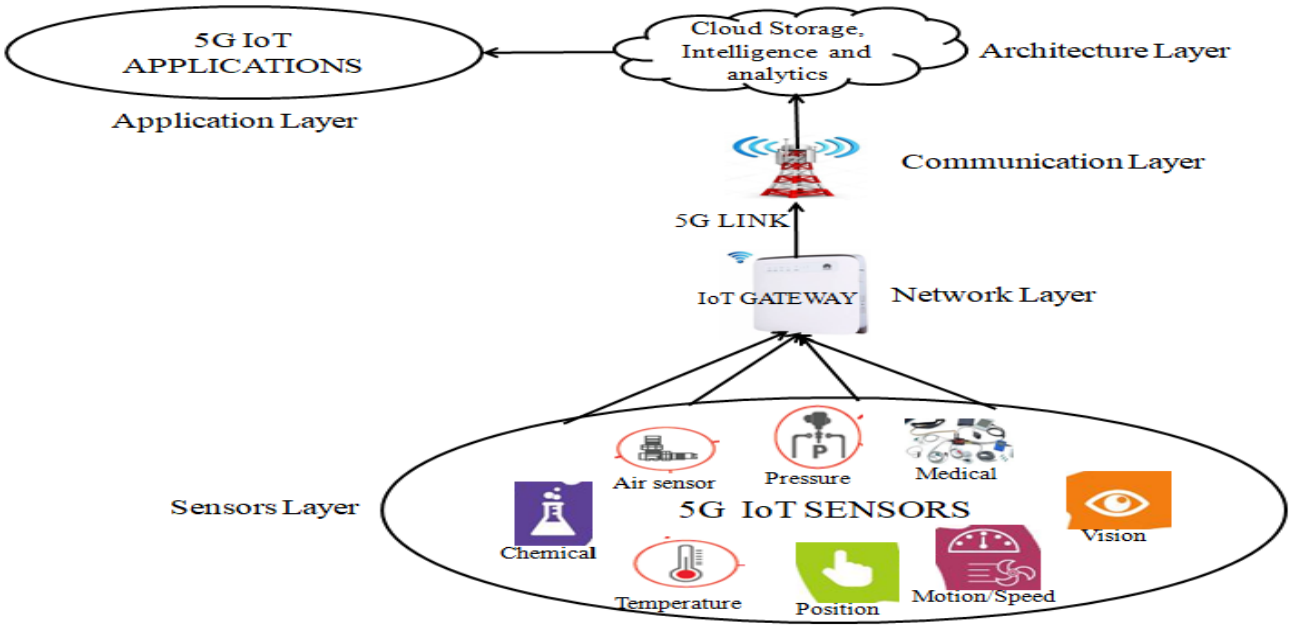

Fig 2: Architectural Overview of 5G IoT

IV. ENABLING TECHNOLOGY DRIVERS IN DIFFERENT LAYERS OF 5G IoT

Based on the architecture shown in fig 2, IoT can be realized with several 5G enabling technologies. In this section, the five layered architecture are discussed with challenges and their promising technical technologies in each layer.

A: Sensors Layer

Everywhere we look, technological evolution is surrounding us. Advancement in semiconductor industries, electronic device and automation solutions are driving the growth in smart sensors. The smart sensors are the combination of sensors and interfacing unit. The smart sensors are capable of two way communication between the sensors and network layers and make their communication and make the decisions. The sensors layer in IoT performs a machine type communication (MTC) and communicates with the network layer. Smart sensors have numerous advantages over conventional sensor such as:

- Smart Communication between Devices, Sensors, and Network Protocols
- Lesser Cable communication.
- Installation and maintenance are easy.
- Flexible Connection.
- Low Cost and Power.
- High Reliability band efficient performance.

Smart sensors used in different IoT applications are shown in table II [2] [22] [26] [37] [49] [128].

TABLE II
5G IoT Sensors Used in Different Applications

IoT Applications	5G IoT Sensors
Smart Homes	▪ Light(IR, Visible) ▪ Temperature ▪ Chemical(Co2) ▪ Energy Consumption
Smart Transportation	▪ Radars Laser Beam ▪ Ultrasonic sensor ▪ Traffic Sensor ▪ Position Sensor ▪ Ultrasonic Sensor ▪ Proximity
E-Healthcare	▪ Temperature ▪ Pressure ▪ SpO2 ▪ X-Ray, e-wearable
	▪ Gyroscope ▪ Hall effect ▪ Temperature ▪ Pressure

Smart Factories	▪ Proximity sensor ▪ Air Quality Senor ▪ Fibre Optic sensor ▪ Smoke sensor
Environment	▪ Humidity ▪ Temperature ▪ Light (IR, Visible) ▪ Chemical
Security and public safety	▪ Gyroscope ▪ Light (IR,Visible) ▪ Temperature ▪ Chemical ▪ Location Sensors Radars

B: Network Layer

In 5G, the requirement in network layer is to provide low power and long range connectivity in IoT applications. Multiple connections are possible to achieve massive IoT and critical IoT connectivity through low power wide area networks (LPWAN). LPWA technology are mainly used in IoT applications because of their unique features such as wide area coverage, low power consumption, better energy efficiency and high data rates. Some of the important LPWA technologies which can be used in 5G IoT are discussed below and summarized in table III [7] [8] [15] [18] [68] [119] [128].

1. SigFox

SigFox is a French based low power network and is turning out to be the first global IoT networks dedicated to massive machine type communications [4][5][12] to communicate huge range of devices and broadcasting data without the help of established and maintained network connection. SigFox offers a software based communication solution which reduces energy consumption and cost of connected devices. It operates in a frequency band of 915 MHz to 928 MHz with a channel bandwidth of 100 MHz It is a radio access network which uses the unlicensed spectrum bands and it varies with the nation regulations. SigFox supports ultra-narrowband technology and operates in an un-licensed spectrum band. It provides a cellular type of network communication that determines a proper solution for low throughput in IoT. The small cells in this network are installed on an average range of 30-50 km in rural areas and it reduces to 7-10 km in urban areas due to network interferences and more internet users within the range. Overall, SigFox provides high capacity network with low power consumption.

2. LoRa

LoRa is the other technology in 5G low power networks. When processing with the LoRa gateway, additional processing gain is achieved due to its ability to filter on the constant ramp chirp signal [12]. This is how high sensitivity is achieved. This technology offers a very compelling mix of long range, low power consumption and secured data transmission. Public and private networks using this technology can provide coverage that is greater in range as compared to other existing cellular technologies. It operates within a frequency band of 868 MHz to 915 MHz with a channel bandwidth of 125, 250 or 500 MHz; it is also easy to plug into the existing infrastructure and offers a solution to serve networks with low power battery operated IoT applications. The preamble can be set as a variable number of symbols which are just the number of chirps. If there is a constant chirp at the right frequency and chirp rate at LoRa demodulator will listen to it and data transmission begins with a series of symbols that functions with M-ARY-PSK symbols.

3 Wi-Fi

Wi-Fi is a local area network device which is based on IEEE 802.11standards. It is used in machine type communications for transmitting IoT sensors information to the gateways within a range of 100m. Wi-Fi in machine type communications can be used possibly in short range Communication which is called local area network (LAN). It operates in a frequency band of 2.4-5 GHz. Wi-Fi is feasible in short range communications.

4. ZigBee

It is a low power wide area network used for IoT communication. It is an extended version of IEEE.802.15.4 with all OSI layers. The use of ZigBee in IoT technology has various advantages over other networks because it is simpler and less expensive. The transmission distance of ZigBee is 100m. ZigBee networks are used in home automation, healthcare and industrial IoT.

5. Narrowband Internet of Things (NB-IoT)

NB-IoT is a new and promising technology in LPWAN. It is introduced by 3GPP release 13 standardization. It is used to deploy massive IoT within the available spectrum. It operates in a system bandwidth of 180 KHz in both uplink and downlink. It supports single tone and multitone transmission. NB-IoT can be deployed in three modes of operation.

- In band operation: It utilizes resources within a LTE carrier.
- Guard band mode, which makes use of the unused frequency band of 180 KHz within a LTE carrier guard band.
- Standalone mode, it is based on reframing of channel or reusing of GSM carrier frequency.

Finally, the NB-IoT is a pioneering technology in developing b5G New Radio (NR), which can be used in new application in IoT. It will also provide a tremendous contribution in building future generation wireless communication technology using low power applications and it can be used in MTC application such as smart homes, security system, autonomous lightning system etc.

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TABLE III:
Summary of LPWAN Used in 5G IoT

Technology	Frequency Band	Range	Maximum Data Rate	Channel Bandwidth	Modulation	Standardization	Reference
SigFox	868 and 915-928 MHz	20+km	100 kbps	250 or 500 KHz	BPSK	Collaboration of ETSI	[4] [5] [75]
LoRa	915- 928 MHz	15 km	50 kbps	100 Hz	CSS	LoRa alliance	[12]
ZigBee	902-928 MHz, 2.4 GHz	Less than 1 km	250 kbps	2 MHz	BPSK (902-928 MHz), QPSK (2,4 GHz)	ZigBee alliance	[15]
Wi-Fi	2.4-60 GHz	100m	10 mbps	20 or 40 MHz	DSSC	IEEE 802.11	[12]
NB-IoT	700,800,900 MHz	1 km (urban),10 km (rural)	200 kbps	200 KHz	QPSK	3GPP	[23]

C: Communication Layer

In communication layer, 5G uses Radio access technology (RAT) in IoT applications. 5G new radio (NR) is an effort of 3GPP to develop the standard for next generation wireless communication technology [23].5G NR is specified as per 3GPP release 15 and release 16 standardization. 5G new radio technology is a part of radio access technology (RAT) which is composed of LTE and 5G NR. 5G NR technology are operational in sub 6 GHz and 20-100 GHz (mm wave range. A variety of complex technologies like NR supported IoT including massive MIMO, waveforms and frame structure; coding and mm wave radio frequencies are to be considered. Radio access provides both opportunities and complexity in RAN structure particularly in IoT platform such as, smart factories, critical services and other applications. 5G NR access technology will facilitate market opportunities for small base station, small cells like pico cells and femto cells and smart sensors for different IoT applications.

5G NR has two major technologies i.e.

(i) Waveform Design, numerology and frame structure

(ii) MIMO and mm wave radio frequency technology

The technology related to 5G NR is discussed below.

1: Waveform, Numerology and Frame Structure

As per 3GPP, the waveform that has been introduced in 5G is based on OFDM technology with some updates to that of LTE. Different waveform candidates such as FBMC, GFDM, and UFMC were investigated with reference to 5G. After successful investigation, scalable and multiplexing numerology are considered the best suitable waveform candidates for 5G NR. Numerology is an important context in new radio, the major advantage of numerology is more efficient use of OFDM. It uses CP-OFDM in downlink waveform and both CP-OFDM and DFTs-OFDM in uplink waveform. NOMA is the most appropriate multiple access technology in 5G NR. NOMA allows the use of same transmission power for multiple users which results in low latency and better efficiency. NR uses scalable numerology and mixed numerology [1] where carrier spacing is given by

$$\Delta f = 2^{\mu} \times 15\ kHz$$

Here 'μ' is the numerology. It is an integer that depends upon the type of service requirements. Numerology value ranges from -2 to 4.In scalable numerology, inter sub carrier spacing interference in highly reduced due to the use of single numerology value at a time where as in mixed numerology the problem arises with the sub carrier spacing due to multiple numerology usage. Mixed numerology is specified by 3GPP release 15 and the users are not mandated to support simultaneous DL reception or UL transmission of multiple frequency division multiplexing physicals channels. In 5G NR, OFDM symbol duration, cyclic prefix duration and OFDM symbol including CP decreases with higher numerology values. Sub carrier spacing 15, 30 and 60 kHz are used in frequency less than 6 GHz and 120, 240 and 480 kHz is used in frequency greater than 6 GHz (mm wave communication). For a machine type application the value of sub carrier spacing should be small as possible. Small numerology value of -2 with sub carrier spacing of 3.75 kHz can be easily implemented in narrowband IoT (NB-IoT). The lower carrier spacing is used for IoT applications and higher sub carrier spacing values are used in eMBB and critical communications. The major difference in 4G as compared to 5G is that, the value of Δf is fixed in 4G but in 5G it changes with the IoT service requirements. Here different subcarrier spacing values are used in different bandwidth parts (BWPs). The cyclic prefix used in lower sub carrier spacing is normal and extended in higher subcarrier spacing. Numerology of 0 and 1 with sub carrier spacing of 15 kHz and 30 kHz can be used in machine type applications. The modulation scheme used in 5G will be the key factor responsible for the performance of 5G system. PAPR, spectral efficiency and interference are the major factor to be considered in 5G NR. PAPR plays a major impact on system performance, Higher the PAPR lesser will be the Performance efficiency. 5G system must ensure low PAPR to gain better system performance. Spectral efficiency will be achieved by using mm wave communication and cognitive radio. The interference in 5G system can be reduced by using MIMO antenna. To overcome the difficulties in 5G APSK (Amplitude Phase Shift Keying) is adopted as a suitable modulation technique in 5G NR communication technologies.

In slot-based scheduling, 5G NR uses 14 symbols per slot. The sub frame reference period decreases with the increase in numerology values. The slot length can be calculated by

$$\text{Slot Length} = 1\text{ms}/2^{\mu}$$

Mini slot is used to support very low latency use case i.e. part of URRLC. Mini slot enables supports of linear TDM

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granularity of scheduling from same or different users within a slot especially if transmit power beam sweeping above 6GHz. The mini slot can be suitable in unlicensed spectrum operation. The slot format indicates the user whether an OFDM symbol is downlink, uplink and flexible. In 5G NR numerology resource elements are grouped into physical resource block (PRB) where each PRB consist of 12 subcarriers achieved for 120 KHz. 5G NR consist of PSS and SSS as specified for LTE.

2. MIMO and mm wave radio frequency technology for future 5G heterogeneous networks

MIMO antenna is defined as smart system where the entire antenna array configuration is made in digital domain. 5G wireless technology uses MIMO antenna in the form of smart antennas which has the capability of hybrid beam formation, beam tracking, tracing and spatial multiplexing [7]. In multiple antenna technology, both transmitter and receiver are equipped with MIMO antenna because it has the tendency of interference cancellation and better spectral efficiency. With the use of MIMO antenna, the delay spread can be greatly reduced. It is a promising technology which offers considerable bandwidth with less power consumption on transmission. Transmission of large information without any interference, better efficiency and secured communication is the major requirements in 5G IoT and it can be achieved by increasing the number of antenna arrays in MIMO configuration. Generally, smart antenna is cognitive radio which senses the spectrum and location. The main goal of the cognitive radio is to sense the underutilized spectrum by the secondary user. In 5G communication system, the devices can search an unoccupied spectrum in the form of base station downlink signals and takes the instruction from the cellular system. Cellular system is quite sophisticated and achieves high spectral efficiency. 5G systems will be based on dynamic spectrum sharing such as detect and avoid (DAA) and the dynamic frequency selection. The smart MIMO antennas have the ability of beam formation and beam tracking. MIMO antenna posse's two unique properties switched beam pattern and adaptive array [15]. In switched beam antenna pattern, the desired user is peaked and the interference are traced and tracked by switching the antenna beam. This unique property of smart antennas has the tendency to reduce interference and increase spectral efficiency. In switched adaptive array the desired user is peaked and the interference is null.

The main reason for using mm wave radio frequency in 5G is that they offer a huge opportunity in using unutilized spectrum bands by efficient sensing as compared to lower frequencies. Higher frequency in wireless communication results in better spectrum sensing and allocations. This technology allows hybrid beamformation and produces beam with the size of laser torch and also gives multiple and reconfigurable polarization and its mostly suitable multi user connectivity. Most promising bands in mm wave technology are sub 6GHz, 28-30 GHz, 38-40 GHz, unlicensed band of 60 GHz and E band 71-76 GHz and 81-86 GHz and supports up to frequency range of 300 GHz. The major concern in mm Wave technology is propagation and results in higher path loss because of greater carrier frequency. In addition, the effect of noise power is more due to the use of higher bandwidths. The path loss is highly dependent on carrier frequency f_c, increasing in carrier frequency will reduce antenna size by a factor of $\frac{\lambda^2}{4\pi}$, while free space path loss is increased by fc^2. Hence, there will be greater power loss of 20 dB in frequency less than 30 GHz, without concern in transmitter-receiver distance. Therefore, it is recommended to use higher frequency range in mm wave communication technology in 5G NR. The blockage is another challenge in mm technology and propagation mostly tends to be in 'Line of Sight' (LOS), and this problem can be mitigated by MIMO beam forming which provides additional gain to compensate propagation loss. To provide sufficient gain, MIMO should be implemented in much larger scale. 5G NR technology must adapt quickly to a rapidly changing channel conditions. Channel interference due to small variation in environment can change the performance of entire system. mm wave technology in 5G environment requires dense network called heterogeneous networks (HetNets). 5G NR is capable of licensed assisted access (LAA) and small cell deployments. The Heterogeneous networks using mm wave and MIMO base station is shown in fig 3 [4] [33] [60] [64] [73] [85] [88] [102] [124].

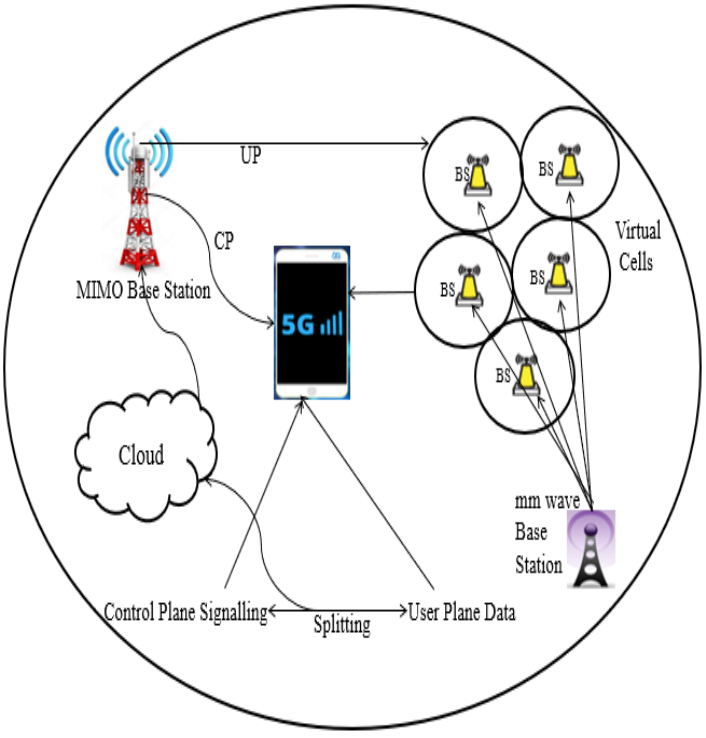

Fig 3: 5G Heterogeneous Networks incorporating MIMO and mm wave communication Technology

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5G wireless technology will give rise to the combined HetNets of cloud-based mm wave and microwave communication technology. The heterogeneous network will give new system architecture as shown in fig 4. The millimeter wave communication system uses small cell base station and transmits the data within short ranges. The small cell base stations will be installed in a size of lamp post within a radius of 1-2 km and transmits with a carrier frequency of 3.5 GHz. On other hand, macro base stations with massive MIMO will be installed within a distance of kilometers with carrier frequency of 28 GHz and above. These combined communication systems are termed as a dual connectivity [33]. The problem of splitting arises in dual connectivity and it can be solved by using baseband cloud technology. Cloud based RAN (CRAN) considers a split between user and control plane, thereby providing flexibility and efficiency in 5G cellular networks. Control and user signals are routed through nodes and consider both licensed and unlicensed spectrum bands to bring the diverse in the heterogeneous networks [49]. In cloud based HetNets technology both the CPs and UPs are send to the cloud and it is accessed in microwave base stations and further it is send to the individual processing unit. In dual connectivity HetNets, spectrum efficiency is achieved through the use of massive MIMO and advance receiver [37]. The spectrum can be extended by the use of mm wave communication and WAN [19]. Overall, this promising technology will give rise to the technology called computer communication. The research challenges related to mm wave communication systems is found to be signal generation and capturing. Selection of mm wave frequency bands, Ultra-broad bandwidth, Multi-channel, Data streaming & storage, Channel parameter estimation processing, Calibration and synchronization. And some of the advantages of mmWave communication is it can be easily used for measuring channel impulse response, path delay profile, AoA/AoD and Doppler shift. The use of small cells such as Pico cell, Femto cell and micro cell is a very key technology in enhancing network capacity, coverage and energy efficiency. Radio resource management plays a crucial role in adopting heterogeneous networks. The HetNets in 5G is used to increase bandwidth, transmission power and guaranteeing the quality of service (QoS) to the users. The mm wave and MIMO can solve various challenges in 5G HetNets. Installing of MIMO antenna in transmitter and receiver enhances network capacity. The mm wave frequency range (30-300 GHz) can offer utilization of underutilized spectrum by sensing and allocation. mm wave has an extremely short wavelength which can accommodate large number of antenna array in a small area which helps in realization of MIMO at base station and user terminal. It can act as an outdoor point to point backhaul which can support indoor high speed wireless application. Therefore, the mm wave communication technology is considered as the key technology in deployment of HetNets in 5G IoT. To determine operating frequency band in 5G HetNets, several factors should be considered such as regulatory issue, IoT application and characteristics of frequency band. These considerations lead to the deployment of microwave communication (MIMO base station). In mm wave bands (30-300 GHz), the selection of frequency depends upon factors such as application, absorption and blockages. Thus mm wave frequency band can be useful in backhaul links, indoor short range and line of sight (LOS) communication. The MIMO and mm wave HetNet architecture shown in fig 4 can also be designed as full duplex communication. The architecture also supports coordinated multipoint (CoMP) communication, where base stations are connected by optical fiber or wireless backhauls. In addition, 5G HetNets can be adopted with cell virtualization concept, where virtual cell can be defined as network centric or user centric that can be deployed as cloud radio access network (CRAN).

D. *Architecture Layer*

In 5G IoT, cloud based architecture is more preferred because Cloud technology is the most trending technology in IoT and is mainly associated to information technology (IT) services and can be extended to embedded system programming. The cloud architecture devices such as PCs, smartphone, laptops, and host machines are deployed into cloud. Cloud technology in IoT is architecture for ubiquitous services that can be delivered to the users with minimum service management with better efficiency. Since, IoT exist with big data and they are managed through cloud. It is an internet based computing where services like servers, data storage, login, registration user interface, Authentication, and application are delivered through cloud internet. Generally there are three basic models of cloud computing and are discussed below.

(a) Infrastructure as a Service (IaaS)

In this model, services include installation of physical gadgets like sensors, devices, servers, network and storage. This model requires fulfilling some important requirements like server installation, software installation, maintenance and secured privacy.

(b) Platform as a Service (Paas)

In this model, cloud consists of application infrastructure and enables to deploy application to the cloud. A service includes middleware, database, and development tools. Embedded systems with programming interfaces are executed in this model. The vendors manage the application platform and provide developers with tools for development and control the power consumption and its availability.

(c) Software as Service (SaaS)

This includes execution of user's demands. In this model configuration is done by consumers and manages user. It also includes browser initiated application software. This model is responsible for non-core functions like support in application infrastructure, reduce maintenance, and decrease in staff requirements. It is responsible in containing deployed application; configure settings for the host environment.

The cloud IoT can be deployed in three modes: Pubic Cloud, Private Cloud and Hybrid Cloud.

Public cloud is highly recommended and is easily accessible to general public. These services are owned and governed by an organization, cloud service providers and some combination of business companies. This mode operates in multitenant environment and user access resources through an abstraction layer on top of the digital layer. There are

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numerous advantages of public clouds and some of them are discussed below:

Utility Pricing: The users can pay for the resource consumed, scaling up and down as per the user requirement. There is no wastage of computation and there is no procurement of physical hardware except for the hardware to connect to the cloud.

Elasticity: The users can react to traffic spikes in real time. The users can also configure software solutions to dynamically increase or decrease resource to handle peak loads.

Core Competency: The data centre and infrastructure management is a major advantage of cloud.

Private Cloud is deployed and hosted within an organization firm wall and is managed by the organization itself. This cloud deployment in this mode are created, controlled and executed by the enterprise. It is deployed in single-tenant environment and not merged with other customers. It reduces regulatory issues. It is more costly than sharing in public cloud but has more efficient and control system as compared to public cloud.

Hybrid Cloud is the combination of both public and private cloud. The management responsibility is divided between both the models.

Some of the major challenges of using Cloud technology in IoT are:

(i) Chances of system failure while transmitting the information to the cloud.
(ii) Migrating application to the cloud.
(iii) Misinformation about cloud security and its planning.
(iv) Choosing favourite and appropriate vendors.
(v) Business opportunities in IoT market.
(vi) Understanding customer's requirement.
(vii) The deployment should be cost effective.

An IoT is ready with data analytic solution for optimizing efficient physical layer processing and communicating in IoT environment and is providing digital transformation with big data analytics. Information received from big data is used in different industrial IoT. Data analytics in big data has 4 major advantages in IoT framework and are discussed below.

(a) Descriptive Analytics: It is used in transforming complex information and sensors data visualization in reporting database.
(b) Diagnostic Analytics: It performs intensive data mining, data search, data processing and multi-level analysis.
(c) Predictive Analytics: It anticipates anomalies in equipment process or product to mitigate risk of failures or down time.
(d) Prescriptive Analytics: It optimizes processes through machine learning, capable of implementing solution without human intervention.

The other use case of data analytics in big data is 360^0 view of operation with proper assessment, manage and track assets at all location in real time environment. The automated real time monitoring is possible in big data analytics, with build in automated monitoring algorithm that incorporates SMS, Email or cellular applications. The big data analytics is used in advance analytics, which is capable of identifying and forecast future, equipment failures, improve asset utilization, and monitor energy consumption of the equipment. An advance use case of data analytics is operation; analysis, and advance process control, track and detect potential process and test analysis.

The web sensor hosts the data analytics application software. It must be capable to support massive data upload via streaming and bulk transfer. The data should be accessible in real time network, independent operating system and independent programming language, which means the users, can upload data via any data importing programming script such as Pythons, C#, C++ or java. The web server should use HTTPs for secure data transfer within IoT network and protect data from cyber attacks and corruption. This set up of big data analytics allows scalable, better performance and data security in IoT.

E. Application Layer

5G MTC provides a wide range of applications. In future generation wireless technology there will be communication between machines and devices without human interruption [25]. There are broad areas of application where technologies like higher data rates, latency, speed and multiple device connectivity are to be considered. [15] [23]. Some of the promising applications of 5G MTC are shown in fig. 4 [8] [9] [21] [31] [32] [33] [56] [76] [78] and discussed below.

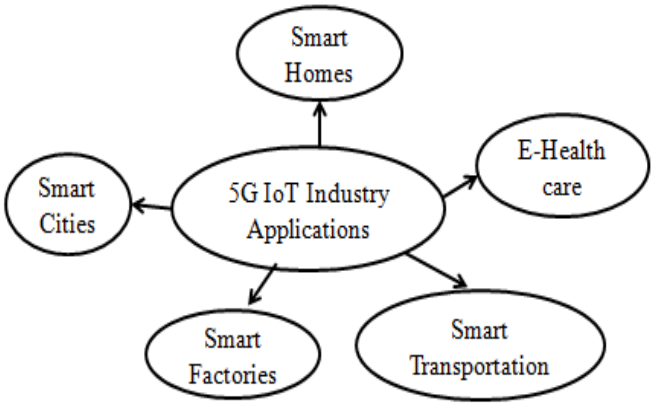

Fig 4: Applications of 5G IoT

1. Smart Cities

The world is looking for anything, anywhere and anytime connectivity to bring the world closer in only one roof of wireless technology. The future generation cellular technology will provide a higher data rate up to 2 GBPS which is 10X more than that of existing technology which enables smart communications between the devices and high speed internet connection. In future, a smart city uses public resources in more efficient way to provide quality of services (QoSs). Smart cities are the multi-tier applications of MTC including smart homes, smart grid, smart transportation, waste management, smart lightning etc and all these applications combine together to develop a smart cities [15][23]. All IoT applications must be supported in a single communication

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network called heterogeneous networks. The future generation smart city will see 24*7 wireless connectivity with more number of mobile and internet users with smart communications. In this context, Japan will be the first country which enables smart city by 2020 and is expected to be launched at Tokyo Olympics.

2. Smart Homes

The other major application of 5G IoT is smart homes. The future generation wireless technology allows the household appliances to be connected between them. 5G technology allows the communication between machines and devices without human interruption. Home appliances such as refrigerator, AC, T.V, and every electronics gadget are connected to the internet for smooth and efficient functioning. Future houses will be constructed with smart windows and doors which operate with the internet connectivity and the electronics equipment such as smart sensors and remote control. Overall, 5G technology will provide high speed internet connectivity within the house and every appliance will communicate between them and we call it as a Smart Homes.

3. E-Healthcare

Health care is the other major sector where maximum priority has to be given. As there is a saying "Health is Wealth", considering this saying, telemedicine is the most trending technology to provide improvements in health sector. 5G wireless technology enables the health sector to be smarter with long distance communication through 5G link. In 5G telemedicine system, the efficient patient monitoring is provided to the remote areas. The patient vital sign such as ECG, SpO2, Temperature, and Pressure are transmitted from the remote hospitals to the major hospitals through 5G communication link. The major hospitals are equipped with modern electronics and wireless facilities which provides higher data transmission and better internet connectivity. After successful receiving of patient vital sign in major hospitals, the doctors will diagnose and send back the results via same communication link. Ultimately, 5G links has to be full duplex communication system and the treatment will be done in remote hospitals as per the diagnosis results send by the major hospitals. In future e-health services, the hospitals will be provided with high internet connectivity with communication between the hospitals, doctors, pharmacy and administration for smooth functioning and provide class health care services in every corner of the world.

4. Smart Transportation

Smart transportation, popularly termed as intelligent transportation systems (ITS) is one of the typical applications of 5G internet of things (IoT). Future intelligent transport management, control system and communications networks are integrated together to develop transportation systems more reliable, efficient and secured. In future transportation systems, each smart vehicle is deployed with smart sensors, electronic control unit to monitor and control the vehicle. The smart cars will give evolution to 5G radar which uses mm wave technology that propagates through fog and rain condition providing collision avoidance systems (CAS) and automatic brake system (ABS). With these communication interfaces, there will be communication between vehicle to vehicle (V2V) and vehicle to anything (V2X) with the help of radar communication. In this way, every vehicle in IoT networks are connected to the intelligent transportation systems to exchange information of traffic status and road conditions and prevents major accidents and provides more secured travels to the passengers. Thus, in order to deploy a smart transportation 5G technology comprising of HetNets with cloud based C-RAN should be deployed.

5. Smart Factories

Smart factory is the other important application of IoT. It is conceptualized as industrial revolution 4 and we see that all the activities are governed by digital technologies. Some of the requirements in making smart factories include smart manufacturing, smart buildings, smart transportation, smart machines and industrial robots. We can witness the smart factories with not just smart machines and manufacturing but complete architecture has advance technology that collaborates and communicates via advance low power network protocols, software algorithm and industrial process. Bringing industrial revolution 4.0 requires critical concern like collaboration between the companies, Government and research instructions. Cyber physical system (CPS) is the key in successful implementation of IoT industry. A smart factory is a cost effective initiatives as it reduces human resource like labors, technician and engineers. Smart factories require major technical trends as follows.

- Advance Sensor Technologies
- Artificial Intelligence.
- Cloud Robotics.
- Cognitive Robotic Internet.

V: CYBER SECURITY AND PRIVACY IN IOT ENVIRONMENT

The digital industry is constantly changing due to advance technology, resulting in more number of cyber threats and attacks. Cyber attack is done for personal benefits and destruction. Since IoT is prone to cyber threat environment, to overcome this issues security updates and network protection is necessary. Cyber attacks are existing since 1980s and the attacks were termed as 'General Attacks'. These attacks were less complex and less destructive. The attacks were limited to password guessing, cracking and domain name system (DNS) attack. To understand this attack, we must know how domain name system works. More recently, cyber attacks are flourishing because of advance wireless technology, trends in mobile and computer usage. Since, IoT depends all upon internet. Under this scenario, smart, dynamic and revolutionary approach should be adopted to restrict cyber attacks. At present direct attacks is practiced and are familiar with little complex and relatively sophisticated. These attacks involves advance scanning, Denial of Service (DoS), spooling and key loggers. Future attacks are more vulnerable and pre planned, complex and highly destructive. It involves bots, code hacking, morphing etc. Many strategic principles in

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cyber security, one has to analyze and implement in IoT service.

Some of important principles of cyber security measures are:

Confidentially and Integrity: it is the ability to hide important information between user and service provider who are unauthorized user. It is an important feature in 5th generation (5G) IoT environment. Some important information like private data, security keys, trades and military data, server data etc should be hidden properly and confidentially from hackers and attackers. Integrity ensures in providing reliable service to the users and IoT architecture must be capable of diverse integrity.

Availability: Availability is the access of information between the devices or device itself and the users. IoT resources should be timely available to meet demands and avoiding losses.

Authenticity: Only authorized user should be provided with information to perform the operation within the networks. Different authentication requires different solution.

Privacy: Privacy is a service provider rights to determine to which it will interact in IoT and to what extent the entity will be sharing the information.

In IoT environment, 100% solution regarding cyber attack is not possible but due to some preventive measures we can restrict the attack to some extent, some of them are:

- Do not allow direct connection between the devices and the networks on the internet.
- Remote access to a network using same protective methods like Visual Private Network (VPN). These can be strengthening by reducing IP address.
- PLCs and SCADA are the most promising technology in IoT for secured and preventive protection.
- Applying strong passwords, allows strengthening the security.

VI. ROLE OF AUGMENTED REALITY IN 5G IoT

Augmented reality (AR) is a popular technology since decades and it can also be vital in 5G IoT. AR in 5G can be used to obtain and manipulate the information towards another level by improving quality of perception of the real world with virtual information. For an extensive interaction, human needs to get invisible information's that are related to devices and networks as quickly as possible. Hence, AR has been considered as an innovative way of interaction for this purpose [159]. The main role of AR in 5G IoT is to enhance human perception about the system scenario and environment by additional computer generated information through PCs, Laptops, Smartphone's, Tablets, Projectors etc. The information which is generated through AR can be in the form of images, videos, texts, 3D models, Sounds etc. By these resources, the user is able to get the information about the communication within IoT environment. AR can be feasible in IoT applications such as smart offices, smart homes, smart factories, military, medical surgeries (telemedicine), logistics etc [160].

AR generally consists of four main hardware devices (i) Computer (ii) Display Device (iii) Tracking Device and (iv) Input Device. Computer is used for modeling augmentation and controlling all connected devices used in the system architecture. Additionally, it is also used in adjusting the positioning an augmentation in the real scene with respect to position of the user by the information through tracking device. The display device is used to display all the information collected and analyze the situation for proper investigation for securing efficient services. Very much widely used display technologies are "Head Mounted Display" (HMD) in which the devices are mounted on head of the users, "Hand Held Display" (HHD) which consists of hand gadgets such as smartphone, tablets and "Spatial Device" such as projectors. The tracking device is used to track the position of users and redirects augmentation to the desired position. The input devices in AR are used to interact with the system. Input device can be microphone, touchpad, wireless devices etc. Today, there are many software development kits to make AR application easier. Wikitude, ARToolKit, ARcore, metaio are some import software that are used in augmented reality for proper functioning and detail documentation which gives an opportunity for AR developer to design and implement AR application with less coding skills and experience.

Some of the important applications of AR in 5G IoT are, Maintenance, collaborative operation of the system devices and user, and providing training to the employees working in the IoT industry.

VII. RESEARCH GAPS AND FUTURE DIRECTION

The current demand of 5G is to provide massive connectivity and new area of application for both industrial and social needs to satisfy the present need in IoT. It is important to address the technical challenges and their driving technology to support IoT devices ensuring quality of service (QoS) is achieved. In this section, we try to present some of the key challenges based on 5G IoT requirements and direction for future research consideration.

1. Big Data Aided Network Framework

The current architecture of wireless network is mainly designed to facilitate for transmission of information and communicating within the network. In order to access potential benefit from big data in 5G IoT, a new framework incorporating big data should be designed. This framework has the potential to accommodate large amount of data and integrates those big data chain efficiently into the network by collecting, storing, processing and analysing data to enhance network operation. In this new framework, the unused data are expected to ignore and process the desired resources at appropriate location. The other aspect of research in big data is customized networking for big data analysis. In this approach Service Function Chain (SFC) or network slicing can support multiple big data services by creating service-oriented networking over the physical network infrastructure. The end to end network slicing can be further customized as per the service requirements. To make best use of networking resources, multiple slices or service function chain (SFC) should be tuned. In support of 5G the SFC should be capable

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of adapting to determine changes in status of network and service requirements.

2. New Waveform design consideration for 5G New Radio (NR)

Waveform selection is one of the most challenging tasks in designing 5G new radio (NR). OFDM was the first choice in designing LTE but it cannot be suitable in 5G waveform because of its high inter channel interference (ICI), high inter symbol interference (ISI) and high PAPR. These limitations of OFDM based waveform are considered as the research challenge for 5G waveforms. The first aspect of new waveform should be shorter latency of less than 1ms to enable new services and application. The low latency is used in IoT and ultra-low latency is used in enhanced mobile broadband (eMBB) and Critical communication like autonomous driving and internet of vehicles. The other aspect of new waveform is to make cyclic prefix operational. The cyclic prefix can be used in two modes normal and extended. The use of cyclic prefix option makes framework with short symbol duration. The numerology selection is considered in designing 5G waveform and it uses different numerical value. All these aspects of 5G waveform leads to different waveform like filter bank multi carrier (FBMC), generalized frequency division multiplexing (GFDM), CP-OFDM.

3. Energy Efficiency

As per intense review energy consumption has become a key pillar in designing 5G wireless communication network. With the evolution of 5G, billions of devices are expected to connect in single network architecture with more base station as compared to existing LTE network. Hence, to accommodate such huge devices need for energy efficient system design and operation is an important need. The one aspect to overcome with energy efficiency problem is the use of small cell base station. The purpose of small cell base station is to increase the capacity in the high-density user areas. It also improves the coverage; increase data rate and extend the battery life by reduced power consumption. The small cells that can be studied further are pigo cell, Femto cell and micro cells. The energy efficiency can be increased by deploying following network framework. Energy efficiency can be achieved by following framework.

- Deployment- Energy-Trade-off: It is used to achieve low cost and less energy consumption in the network.
- Spectrum-Energy-Trade-off: It is used to balance the energy consumption.
- Bandwidth-Power-Trade-off: It is used to balance the bandwidth utilization.
- Delay Power Trade-off: It is used to balance end to end delay.

4. Trade-off among communication, catching and computing

5G wireless network is coming up with a heterogeneous communication. In context of 5G IoT, catching and computational resources should be used intelligently to support big data application in heterogeneous networks. Therefore, trade-off is necessary in communication, catching and computing resources. All these properties are used to reduce the communication link. The final result of computation should be stored temporarily which reduces the storage cost. The trade-off in 5G network among the HetNets resources is therefore required for optimum resource provisioning. Since 5G IoT is evolving with huge amount of data and these data are collected from different resources which leads to non-uniform data load distribution. Hence, co-operative edge catching is the solution to the storage, retrieval and processing of such huge amount of data. The edge computing capabilities required for data processing.

5. Design of concurrent multiband and high-power efficiency Amplifier

The multiband power amplifier is necessary to design in 5G IoT to reduce cost and physical size of the base station. Multiband power amplifier can support signals of multiband frequency simultaneously; this enables all wireless functions to perform all at a time. The most promising amplifier is parallel single band power amplifier and concurrent power amplifier. Radio frequency is used in 5G new radio (NR) which uses MIMO and mmwave communication in base station and linear radio frequency power amplifier plays a major role in energy consumption at the base station. The use of power amplifier at the base station also helps in reducing heat dissipation. The efficient power amplifier in base station plays a major in evolution of mobile systems. Reducing the energy consumed by radio base station will also reduce the environment input of the radio access network (RAT).

VIII. CONCLUSION AND FUTURE RESEARCH SCOPE

The vision and mission of 5G IoT is to connect multiple numbers of devices within the same network architecture. Many advance applications in 5G wireless application like smart cities, internet of vehicle (IoV), smart factories, smart agriculture and smart healthcare leads to IoT revolution. Such huge ranges of smart applications are expected to be supported with high speed massive connectivity under the same roof of 5G wireless communication. The new architecture in 5G IoT is proposed that includes New Radio (NR), MIMO, mm wave communication and cloud computing. We made a complete review on 5G revolution and highlighted some of the key technologies in IoT context. Finally, we provided some research challenges and research direction on this revolutionary technology. We also made some reviews on how and what kind of researches are conducting by industries in 5G domain. In future, 5G and beyond activities will be most interesting topic of research in academic institutions and telecommunication industry. Research in 5G and IoT can be a better social service in developing nation and the world. Research domain in 5G can be security, Data traffic management, development of cloud algorithm, networks and many 5G physical layer research including MIMO and mm wave communication technology. In our review, we have

provided with promising technologies like 5G NR, low power wide area networks (LPWAN) networks and advance sensors capable of supporting 5G networks for better understanding to the readers. Additionally, physical layer specification of 5G NR is also provided with individual numerology values. We have also highlighted how cloud computing and augmented reality is implemented in 5G networks and their inferences in 5G IoT are discussed. Subsequently, we provided detail description of 5G NR physical layers such as waveform and frame structure of 5G NR, beamformation technology in MIMO and HetNets using both mmwave and μWave technologies. Cyber security and privacy is a major concern in 5G networks. We took a detail survey on evolution of cyber attacks and preventive measures in cyber security and privacy.

In our review, we have highlighted how 5G paradigm promises to deploy an efficient networking through 5G HetNets. Since, LPWAN are the vital communication technology that is expected to support wide range applications in 5G. Moreover, it is worth mentioning that ZigBee, SigFox, LoRa and NB-IoT are the most trending solution in massive IoT deployment. We also provided a detail review on challenges and vision of 5G IoT and concluded that around 80 billion of IoT sensors and devices are expected to connect within a 5G infrastructure. The requirements in fulfilling such huge challenges are inspected and broadly conceptualized. In consideration to handling such massive data we make a review on how data analytics can be revolutionary measures in handling big data in 5G IoT. The architecture of cloud for 5G IoT has been discussed with additional services called Network Slicing as Service (NSaaS) This service is usable in creating virtual network segment. We have also highlighted some advance technology in realizing smart cities, IoV and many other critical communications. Robotic internet and robotics clouds are some of the new technologies in realizing smart factories which results in fewer requirements of human resources and less prone to human injuries.

However, still there are numerous challenges in efficient controlling and management of scalability and introducing new 5G sensors in IoT networks. In order to safeguard and provide massive connectivity, networks and architecture which are deployed in IoT environment should be optimized ensuring large number of connected devices as possible [54]. Since IoT is a multilayered functionality and it is to be re engineered for specific functionality such as unique security, control, and maintenance. Other technologies such as network mobility, latency, connectivity and traffic management remain an open challenge in deployment of IoT [59]. Mobility management should be re investigated and efficiency and management mechanism is to be re framed and proposed. Since, smart connectivity in advance sensors and devices plays a major role in gearing up signaling head and the major change in IoT is to accommodate huge traffic that creates congestion problems in networks. Finally, we have reviewed on how and what king of researches are contributed in 5G by different industrial spectrum, and we assure our readers, that this review will serve as a research guideline for future in IoT and 5G wireless communication technology.

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