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"Exploring the Future of IoT in Next-Gen Smart Systems: 5G Integration, Challenges, and Opportunities"

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ABSTRACT

Augmented reality, high-resolution video streaming, self-driving cars, smart environments, e-health care, and other ideas that are based on the Internet of Things (IoT) are now everywhere. For these products to work, you need better data rates, more capability, less delay, and a high flow. Because of these new ideas, IoT has changed the world by making it easy for different types of networks (HetNets) to join to each other. The ultimate goal of IoT is to create plug-and-play technology that makes things easy to use and gives users access to control and configuration from afar. The IoT technology is looked at from a high level in this study. It talks about its statistics and design trends, use cases, problems, and possible futures. The paper also gives a thorough and in-depth look at the new 5G-IoT situation. Fifth Generation (5G) wireless networks are one of the most important technologies that make it possible for IoT to be used everywhere. These include centralised radio access network (CRAN), software-defined wireless sensor networks (SD-WSN), network function virtualisation (NFV), coordinated multipoint processing (CoMP), device-to-device (D2D) communications, coordinated multipoint processing (CoMP), cognitive radios (CRs), and carrier aggregation. This paper gives a full analysis of these important technologies that make 5G possible. It also talks about the new 5G-IoT use cases that are coming up because of progress in AI, machine learning, and deep learning, as well as ongoing 5G projects, quality of service (QoS) requirements in 5G, and issues with standardisation. Lastly, the paper talks about problems that come up when trying to set up 5G-IoT because of the high data rates that need both cloud-based systems and edge computing on IoT devices.

INDEX TERMS: Internet of Things (IoT), 5G, carrier aggregation, CoMP, CRAN, CRs, HetNets, MIMO, M-MIMO, NFV, SD-WSN, QoS.

I. INTRODUCTION

A lot of progress has been made in portable sensor networks, telecommunications, and computers, which has made widespread intelligence [1, 2] possible and envisioned the future Internet of Things (IoT). In the 1980s, someone came up with the idea of "ubiquitous computing," which meant putting technology into every part of daily life [3]. At this point, the IoT is thought to be useful for both individuals and businesses. For a person, IoT is a key part of improving living standards through e-health, smart homes, and smart schools. For a business, IoT can be used for automation, smart transportation and supply chains, distant tracking, and services. Ericsson reports [4] say that by 2021, the world's 28 billion smart gadgets will all be linked together. Machine-to-machine (M2M) communication is also used by more than 15 billion gadgets [4]. More study showed that by 2020, each person will likely have between 6 and 7 gadgets with them [5]. It is said that the all-communications world will have a system that increases the amount of data sent per area by 1000 times, as well as the number of devices linked and the user data rate by 10 to 100 times. Also, the longer battery life of up to 10 times for large machine communication devices and a 5 times reduction in end-to-end delay [6]. So, experts are now very interested in combining different technologies, like putting together sensors and integrated systems with cyber-physical systems (CPS), device-to-device connections (D2D), and 5G wireless systems that use the Internet of Things (IoT) as their core. At the moment, new business models for IoT implementation need a lot of connections, high privacy and security, full coverage, very high dependability, and very low delay. The popular 5G-enabled IoT includes faster data rates, better coverage, and high speed, which helps businesses and makes IoT possible for robots, controllers, and drones [7].

So, in this study, the authors do a comparison analysis and take a close look at the Internet of Things (IoT) technology, looking at its use cases, obstacles, and possible futures. The paper also gives a thorough and in-depth look at new 5G-IoT scenarios, current 5G projects around the world, Quality of Service (QoS) standards in 5G and its standardisation problems, as

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well as the effects of combining 5G with IoT and artificial intelligence (AI).

Here's how the rest of the piece is put together: In Section II, we go over the history and main ideas of the Internet of Things (IoT), including its goals and design trends, as well as its chances and opportunities, projects, and research trends. In Section III, we talk in depth about 5G-enabled IoT, including its features, architectural trends, quality of service problems, and issues with standardisation. The new idea of 5G Intelligent IoT is talked about in Section IV, which is about AI-based systems. In Section V, the topic of difficulties that 5G-IoT may face is summed up, and Section VI ends the study.

II. BACKGROUND, MOTIVATION AND OVERVIEW

The number of devices linked to the internet is expected to grow [8]. This is because internet nodes may live in every item by 2025. Cisco says that by 2030, 500 billion things will be online. Additionally, Telefonica said in 2013 that by 2020, 90% of cars will be linked to the internet [9]. But a study from 2015 says that by 2020, more than 250 million cars around the world will be online, which is 67% more than now [10]. The Internet of Things (IoT) is one of the new trends of this decade. Gartner's IT Hype Cycle [11] also says that IoT will not be widely used for 5 to 10 years. This prediction was made in 2011. To that end, the International Data Corporation (IDC) says that the IoT will cost $1.7 trillion by 2020 [9].

A. IoT VISION: Everything, everywhere, at any time

Kevin Ashton was the first person to use the term "IoT" in 1999 to talk about stock chain management [12]. IoT is based on the word "smartness," which means "the ability to independently obtain and apply knowledge" [13]. So, IoT refers to "smart things" like "devices and sensors" that can be uniquely addressed based on their communication protocols, are flexible and self-sufficient, and have built-in security [14]. Atzori et al. [3] have come up with three ways to describe IoT. The visions are Internet-oriented, which means they focus on how objects can connect with each other, Things-oriented, which means they focus on general objects, and Knowledge-oriented, which means they focus on how to describe, store, and organise knowledge. The International Telecommunication Union (ITU) describes the Internet of Things (IoT) as "from anytime, anywhere connectivity for anyone; we will now have the connectivity for anything." [15]. To put it simply, the end goal is "to plug and play smart objects."

A. ARCHITECTURAL TRENDS AND OBJECTIVES

There are three components that form the basis of IoT archi- tecture:

(1) Hardware: It comprises of sensor nodes, its embedded communication and interfacing circuitry.
(2) Middleware: It comprises of data storage, analysis and handling resources.
(3) Presentation layer: It comprises of efficient visual- ization tools that are compatible with various platforms for different applications and present the data to end-user in an understandable form.

The parameters affecting the architecture of IoT are man- ifold. Hence, current research efforts have been made to devise the most optimized architecture that handles network issues such as scalability, security, addressability, and effi- cient energy utilization.

As for the future, the number of devices connected to the network will rise. Hence, the architecture of IoT must cater to it. Scalability, energy consumption, and addressing issues are all considered as challenges for successful deployment of IoT. Research is carried out in solving the scalability issues by developing various multi-hop routing protocols covering a larger area and are self-adapting. These fall into three domains: 1) Data-centric, 2) Location-based and 3) hierar- chical [16].

Energy harvesting methods [17, 18], as well as energy-efficient MAC protocols [19] and cross-layer protocols [20], are used to solve the energy use problems. People who wrote [3] say that low-power wireless personal area networks (6LoWPAN) and internet protocol (IPv6) should be used together on a big scale [21]. The goal of 6LoWPAN technology is to connect low-power sensor units that work with the IEEE 802.15.4 protocol to IPv6 networks with 10128 addresses. In [22], the idea of Mobile IP was put forward as an alternative to the home location register (HLR) and guest location register

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(VLR), since it doesn't need a central computer. In a smaller way The goal of the European Coordinated Action was to change the RFID standards so that they could be used for IoT [23].

It's a pain to deal with a lot of big IoT data from all the nodes in a network. It is also important to think about how energy-efficient the data hubs are. Because of this, to solve these problems, we need to use AI, new fusion algorithms, cutting-edge temporal machine learning techniques, and neural networks to make decisions automatically and save energy [16].

Security and privacy are two of the biggest problems that still need to be solved in IoT design. End-user data needs to be kept safe from people listening in or messing with it. Data should be checked for authenticity, and at the user end, it should be kept whole. Several cryptographic methods have been suggested for data security, but they use a lot of energy and bandwidth. Because of this, key cypher methods are put forward and discussed [24, 25]. An IoT network's security and privacy are also put to the test when a node joins or when the apps that run on nodes need to be added or updated. A direct wireless reprograming technique is suggested for this situation [3]. The node can use this protocol to check each code for errors and look for any signs of a hostile attack during installation. These are mostly based on a common method known as Deluge [26].

The lack of a uniform base, interface, and computer language is another problem that needs to be solved before IoT can be widely used. All gadgets that are linked today use a different set of systems and standards. It's important for gadgets that are connected to work together these days. Big companies like LG, Samsung, Philips, and others should work together to create a group that will create a universal code language and platform. A big part of the problems with IoT connectivity can be fixed with the suggested method [13].

The IoT needs to work for all kinds of uses with both flexible and rigid flows [16]. The first type, called "elastic traffic," is for applications that can handle delays. These include tracking apps, network scheduling apps, and so on. The second type, called "inelastic," needs a quick answer from the network, like when video streaming. So, IoT needs to be able to handle both types of traffic, each with its own set of KPIs, while still providing high quality of service. Taking into account the above open questions, the IoT design reference model (ARM) [3] gives some basic steps to take.

In the same way, different IoT designs have been suggested to solve different problems. The energy problem was solved by Kaur and Sood [27], who came up with a hierarchical design with three layers: the sensing and control layer (SCL), the information processing layer (IPL), and the application layer (AL). This not only sets the energy economy, but it also makes better use of the hardware resources in both the SCL and IPL stages. The main idea behind the design is for the SCL and the IPL to share knowledge about energy so that controlling how long the sensing nodes sleep for. There are sensor nodes (SNs) in the SCL. These are controlled by gateway nodes (eGNs), which are controlled by a base station (eNode). The SNs have two modes of operation: periodic mode and trigger mode, which are each good for different types of events.

On the other hand, the eGNs decide how long the SNs sleep between sessions based on how they were used in the past and the quality of the information at the nodes. The conflict factor is another important factor in this case. It is a measure of how much information is being sent by different sensors twice, the battery level, and the coefficient of variation. The coefficient of variation shows how different the current value is from values that have already been felt. If the information received in the past and present doesn't change, the sensors' sleep gap gets longer. If there are changes, it gets shorter. The eNodes set up the way for the SNs to talk to the cloud resources, which will then be assigned based on need. The eNodes also send the SNs to the generator nodes based on how far away they are and how full their batteries are. The information processing layer uses a cloud-computing platform and an energy-efficient resource scheduler to store, process, and analyse the extracted data. The resource scheduler divides up the hardware resources based on the needs of the information analyser and the Sensing and Control Layer so that data can be processed quickly. The information analyser figures out how much information can be taken from the data and chooses how long the SNs should sleep between tasks. The application-dependent information converter then turns the data into a form that humans can understand and stores it on the storage medium. Visualisation tools are used by the AL to provide services to end users. So, the eGNs and BS in the sense and control layer are used to control the SNs' sleep time intervals, which saves energy. The energy-efficient resource scheduler in the IPL can be used to make this happen by allocating the hardware resources correctly. It is also compared to other structures, like the self-organised things (SoT) [28], the energy-efficient index tree (EGF-tree) [29], the energy-efficient hierarchical clustering index tree (ECH-tree) [30], and the object group localisation (OGL) [31]. It can be said that the suggested design is more useful than the others after a careful comparison.

Gubbi et al. [16] and Zhou et al. [32] both talk about a cloud-based design that makes it easier to handle data.

To solve the problem of scale, [33] shows a new design that combines third-generation (3G) networks with power line communications (PLC). This design is called 3G-PLC. In the same way, self-configuring peer-to-peer infrastructure is already set up for big networks [34].

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B. IoT OPPORTUNITIES AND PROSPECTS

IoT offers many business opportunities, which allow compa- nies to build new business strategies and models to implement

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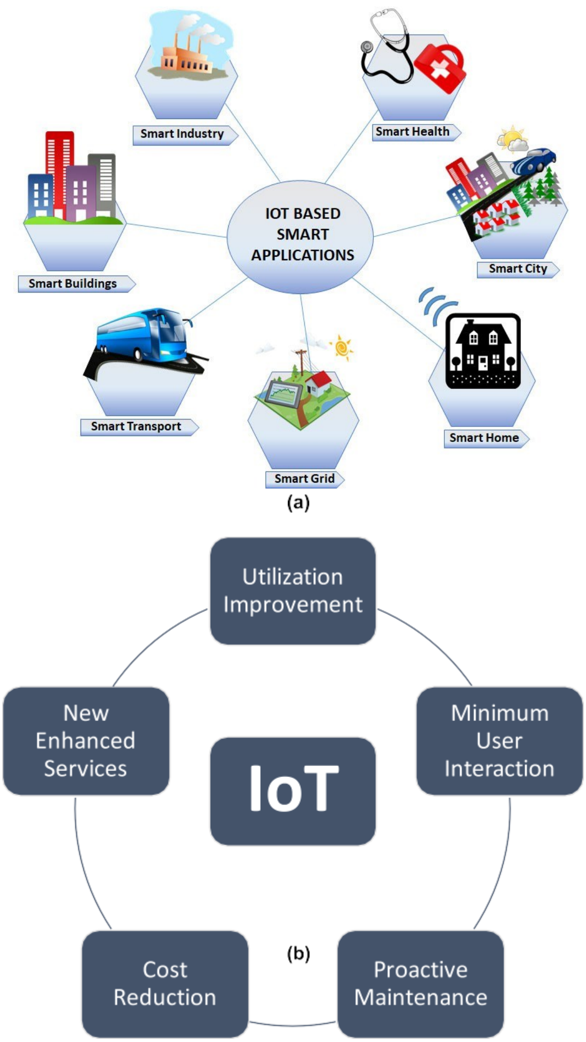

FIGURE 1. Block diagram showing (a) IoT based smart applications and (b) IoT benefits as the cutting edge technology.

the thought. Not only business chances, but also study opportunities that are useful and efficient for researchers and students from many different areas. In this way, it brings together business studies, technical skills, science, and the arts. The Internet of Things also makes the world smarter, where everything is easy to get to with less work and time, as shown in Fig. 1(a) and (b). Companies will usually decide whether to spend right away or wait and see, depending on how mature the IoT technologies are [35]. It's important to leave some room for change during the initial rollout phase. Open software and hardware-based IoT solutions should be put forward to do this [12]. When it comes to this, one way to save money is to use smartphones as IoT hubs [16].

C. IoT PROJECTS

Due to the extensive research and interest in the IoT domain since the concept was first introduced in the 1980s, various countries such as Canada, China, Brazil and UAE have implemented the concept of the smart-cities, smart cranes, smart flood warning system and smart-grid, respectively [12]. These projects are successfully implemented and are running at the Rio Operations Centre, SK Solution, Yellow River Conservancy Commission and BC Hydro, respectively [12]. China had also invested $100 million in studying the IoT industrial standards and technologies in Shanghai as a part of its 12th 5-year plan [16], [35]. Substantial efforts are underway to merge cross-domain research activities span- ning machine-to-machine (M2M) communication, wireless sensor network (WSN) and RFID into unified IoT frame- work [16]. The European Research Cluster on IoT [3], [16], [36], an organization of the European Union, is currently funding 33 IoT projects [36]. The focus of the organization is to develop IoT architectures, technological and knowledge interoperability with security, reliability and scalability [3], [16], [36], [37]. The reason behind the interest of the first world countries in IoT trends and developments is its pre- vailed benefits, as shown in Fig. 1(b). The outlined benefits hence proved advantageous for the country's economic sus- tainability, growth, urbanization, infrastructure, employment rate, citizens' health and services.

D. IoT - A CORPORATE SECTOR VISION

The IoT deployments also enabled the enterprises to meet their business needs [9]. Microsoft proposed a cloud-based architecture in which the nodes send their data to the cloud gateway for processing. Similarly, the IoT based video solu- tion is implemented by Banco de Cordoba [9]. With this implementation, the trainers are not required to visit fields; hence, increased their productivity level. The designed solu- tion also enables security and marketing efficiency. Also, Daimler employed IoT architecture and used IBM services to launch their smart cars concept, which is popularly referred to as Car2go [38].

E. IoT - RECENT TRENDS

Weiser [26] and weiser *et al.* [39], introduced the concept of ubiquitous computing, which later evolved the vision of the smart environment. In the current decade, the 'smart environment' concept has become a booming technology.

The concept is diverse as it covers transportation/logistics, healthcare, utilities, personal home/offices and much more. During this decade, concepts like augmented maps, autonomous car, mobile ticketing, and passenger count- ing in transportation/logistics domain have been success- fully implemented. The continuous improvement in these technologies is also currently in practice. The concept of IoT enabled Robot taxi, which is underway as a futuristic application [40], [41]. Similarly, remote patient monitoring, smart biosensors, smart ambulances, wearable devices, tele- medicines in IoT-enabled healthcare domain benefitted the society manifold [42], [43]. Public utility infrastructure has been improved to a large extent, with the concept of smart metering and smart-grid systems [44].

TABLE 1. IoT enabled smart environment.

Applications	Communication Enablers	Network Types	Wireless local area network (WLAN) standards	Modules	References
Smart-Cities	Wi-Fi, 3G, 4G, Satellite	MAN, WRANs	802.11	Architectures, protocols, and enabling technologies for urban IoT. Integrated information centre for the smart-city	[46], [57]
Smart Homes	Wi-Fi	WLAN	802.11	Cloud-based home solution for detection of faulty location using software-defined networks (SDNs)	[58]
Smart-Grid	3G, 4G, Satellite	WLAN, WANs	802.11	Real-time monitoring system for powering transmission-lines to avoid disasters. Smart-grid control	[59]-[60]
Smart	Wi-Fi	WLAN	802.11	Access control for services inside a	[13]

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Buildings				typical smart building	
Smart Transport	Wi-Fi, Satellite	WAN, WRANs, MANs	802.11	Smart-ticketing, smart passenger counting	[61]
Smart Health	Wi-Fi, 3G, 4G, Satellite	WLAN, WPANs, WANs	802.15.4	Remote health care	[62]
Smart Industry	Wi-Fi, Satellite	WLAN, WPANs, WANs	802.11	Energy-efficient remote monitoring and optimized decision-making.	[63]

TABLE 2. Comparison of previous wireless technologies from 1G - 4G.

Wireless Technology	Data-Rate	Services	Bandwidth	Reference
1G	2.4Kbps	Voice	30KHz	[63]
2G	10Kbps	Voice, Data	200KHz	[63]-[64]
2.5G	50Kbps/200Kbps	Voice, Data	200KHz	[63]-[64]
3G	384Kbps	Voice, Data, Video Calling	5 MHz	[63]-[64]
3.5G	5-30Mbps	Voice, Data, Video Calling	5MHz	[63]-[64]
3.75G	100-200Mbps	HD video, peer to peer file sharing, composite Web services, online gaming	1.4MHz-20MHz	[63]-[65]
4G	DL 3Gbps UL 1.5Gbps	HD video, multimedia, data services at much higher data-rate	1.4MHz-20MHz	[65]-[66]

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Not only the country's infrastructure has been improved, but also the end-users are also benefitted at a personal level with the concept of smart homes [45] and smart-cities [46], [47], which prove cost-effective and convenient. Smart health-care manages the health of the consumer efficiently. The concept of the smart gym [48] allows the end-user to monitor his exercise schedule regularly. Since today's human beings are also socially active; there is a need of time to automatically update their social activities on social media. This concept has already been introduced by Tweetbot [49]. A digital diary application that records personal data and updates it on the Google calendar [3]. Hence, IoT also proved beneficial at the end-user level with the challenges of security and privacy.

In a nutshell, the technical specifications currently become part of published literature on IoT enable smart environment is summarised in Table 1.

F. WIRELESS TECHNOLOGY AND IoT

IoT is a heterogeneous network that will be connecting around 7 billion devices by 2025 using different wireless technologies and standards such as 2G, 3G, 4G, Blue- tooth and Wi-Fi etc. as predicted in 2015 by Machina Research [50]. The mobile devices subscriptions as per 2G/3G/4G technologies are shown in Fig. 2 [51], [52]. The specifications of previously used wireless technologies are listed in Table 2 [53]. Currently used IoT networks use these technologies as listed in Table 3 [51].

It is important to realize that the above discussed tech- nologies are not fully optimized for IoT business models and devices which requires low power and less data-rate [51], [54]. Therefore, adrift from various wireless technolo- gies such as 1G, 2G, 2.5G, 3G, 3.5G and 4G towards 5G can be observed. The 5G technology is highlighted as it addresses the major challenges of a cellular network more effectively as

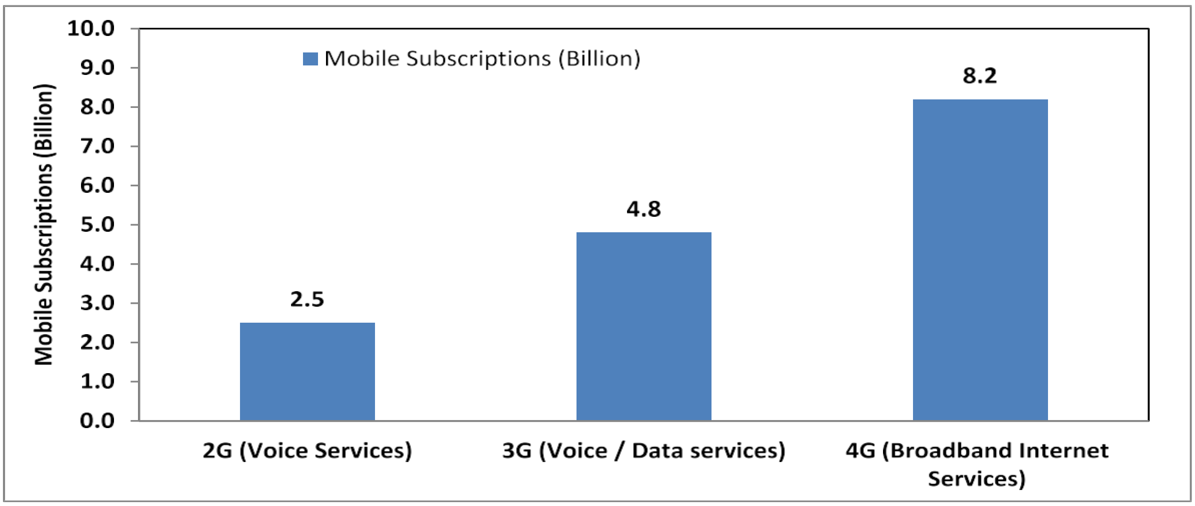

FIGURE 2. Mobile devices subscriptions with respect to different wireless technologies.

TABLE 3. Wireless technology currently employed for IoT.

Type of Technology	Wireless Technology
Personal area network (PAN)	Bluetooth Low Energy, Zigbee
Wireless local area network (WLAN)	Wi-Fi
	3GPP, 4G (LTE)

TABLE 4. 5G initiatives in different countries.

Country	Initiative
United States	4G America
China	IMT-2020 (5G)
Japan	2020 and beyond
Korea	5G forum
Europe	5G Private Public Partnership (5GPPP)
UK	5G Innovation Centre (5GIC)

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compared to its predecessors [55], [56]. These challenges are appended below:

- Large bandwidth
- Higher data-rate
- Massive connectivity
- Low end to end latency
- Cost-effective
- Consistent Quality of Service
- Device computational capabilities
- Device intelligence services

III. VISION AND DEVELOPMENT OF 5G-ENABLED IoT FROM 5G CELLULAR TECHNOLOGIES

A. *5G ENABLED IoT – GLOBAL INITIATIVES*

Table 4 [67] shows the different steps that are being taken around the world to accept and standardise 5G-enabled IoT. From 4G to other European projects, you can find them in [68]. In the same way, International Mobile Telecommunications (IMT) started working on study and technology in 2013 and standardised it in 2016 [67]. The Third Generation Partnership Project (3GPP) chose in 2015 to create a group called the technical standard group (TSG). This group will be in charge of setting up 5G RAN [69].

During the same era, International Telecommunication Union-Radio Communication (ITU-R) has taken the respon- sibility of defining and specifying 5G technology by 2020 [70].

B. *SPECTRUM REQUIREMENTS OF 5G-IoT*

Innovation in wireless domains, next-generation technologies and development of 5G enable IoT requires cutting-edge services and solutions together with the need of broadband spectrum to meet the demands of rapidly growing traffic. Therefore, a combination of low-band, mid-band and high- band spectrum is desirable to manage the use cases of 5G enable IoT successfully as suggested by 5G Americas [71]. Using a combination of different bands help to address certain use cases better than others. The comparison of each band with respect to different use cases presented in Table 5 [71]. Apart from the generalized spectrum requirements, a new air interface called New Radio (NR) is defined by 3GPP for 5G [72]. Its specification falls into two categories. Firstly, FR1, which refers to spectrum below 6GHz [72]. Here, FCC has provided two licensed spectrums for 5G deployment.

TABLE 5. Comparison of the spectrum with respect to different 5G use cases.

Spectrum Type	Characteristics	Use Cases
Low-frequency band (below 2GHz)	• Higher Coverage and Mobility • Wider channels availability	1. Massive Machine-Type Communications 2. Indoor applications
Higher frequency millimetre waves (mmWave) bands	• Short-range with low latency. • High capacity due to wider channelization	1. Enhanced mobile broadband Communications 2. Urban and sub-urban applications
Mid-frequency bands	• Short-range with low latency and high capacity transmission for few macro-based stations	1. 5G implementation in uncrowded/open areas 2. Urban deployment.

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predecessor (LTE) [71]. Secondly, FR2, which is a higher frequency mmWave band [72] has significant unused spec- trum having large bandwidths which is suitable for 5G deployments. Therefore, 24GHz, 28GHz, 37GHz, 39GHz, and 47GHz are also identified for 5G deployment by FCC, and their auction is expected nearly [71]. For instance, in Nov 2018, 28GHz band auction has begun. Other bands to be auctioned in 2019. In addition, bands such as 32 GHz, 42 GHz and 50 GHz are also under consideration [71]. The details of the spectrum allocation of each NRs can be viewed in [72].

After looking at the above-mentioned spectrum char- acteristics/requirements of 5G technology, there is still a gap between the actual implementation of a 5G technol- ogy and the promises made by the next-generation wireless network.

Hence certain technologies must be involved in the imple- mentation of 5G deployment [73]. For instance, transmis- sion/reception at mmWaves have high path-loss, and their rate of absorption by the atmospheric parameters such as rain and greenery are very high. Hence, it is likely that a smaller cellular architecture is needed in a form micro- , pico- or femto-cell to improve the coverage and decrease the path-loss at mmWaves. This paved the way towards the new concept – small, low-power cellular base station (BS). These cells are low power, compact and portable BSs which are placed meters apart. Thousands of these small cells form a dense network acting as a relay and boosting a signal between the end-users and BSs. As these small cells are handling mmWaves, so the antennas attached to these BSs are smaller and lighter as compared to their traditional counterparts. Hence, these BSs can be easily fitted on poles or buildings top. Also, another benefit of using a small cell is spectrum re-usage. To further enhance the advantages of small cells and reduce the complexity of extensive cells and antennas running in an urban environment – a M-MIMO technology is also incorporated.

A 4G BS currently employs dozens of antenna ports to handle its traffic efficiently. However, in case of 5G traffic, these ports must be increased significantly from dozens to hundreds to enhance the capacity by a factor of at least 22. This is solved by incorporating M-MIMO technology, which targets at incorporating many antennas on a single BS. This creates another problem: Interference. To cater for it, a beam- forming technology is incorporated [53], [73]. As the 5G technology aimed at integrating various heterogeneous access technologies leading to the implementation of the vision of IoT. The 5G technology employs beam division multiple access (BDMA), an advanced technology in which BS allows an orthogonal beam to each mobile device and BDMA tech- nique will divide the beam as per the position of the mobile devices. This enables the multiple accesses to the devices hence increases the capacity manifold [53] with reduced interference.

Besides using mmWaves for enhanced data-rates, M-MIMO and beamforming for spectrum efficiency, 5G technology also requires high throughput with low latency. This necessity is fulfilled by integrating the full-duplex tech- nology, which targets at antennas' transceiving methodol- ogy [73].

A 5G transceiver must be capable of transmitting and receiving the data at the same time and on the same frequency – hence a transceiver must be full-duplex and operate in both Time Division Duplexing (TDD) and Frequency Divi- sion Duplexing (FDD) modes. This is achieved by using silicon transistors acting as fast switches allowing it to trans- mit/receive on the same frequency [73].

Nevertheless, the above mentioned technologies are still in their infancy and are under research to cater for their drawbacks and implement a successful 5G enable the system. Furthermore, other related technologies are also discussed in the later section.

C. FEATURES EMPLOYED IN 5G PHY LAYER TO SUPPORT 5G-IoT

MIMO, CoMP, and the HetNets, etc. are some of the features that have been standardized for LTE/LTE Advanced (LTE-A) technology. These technologies show encouraging results in providing massive connectivity and high data-rate. Therefore, 5G technology employs these concepts. These concepts are discussed at first to get their insight in the next sub-sections.

1) CARRIER AGGREGATION

Based on Release 10 of the 3GPP, carrier aggregation was added to 4G LTE–A. It brings together up to five LTE–A component carriers (CCs), each with 20 MHz of bandwidth. This makes the total capacity 100 MHz. When there is provider consolidation, the phone could get more than one CC request. In both the uplink and downlink, multiple CCs with different bandwidths can be combined. However, the number of combined CCs in the uplink cannot be greater than the number of combined CCs in the downlink. Inside-band carrier aggregation means that the CC can be in the same band, and inter-band carrier aggregation means that it can be in a different band. It is also possible to do both continuous and non-continuous component carrier aggregation in each type of carrier aggregation. It is necessary to choose one of the CC as a primary component carrier (PCC) and the other as a secondary component carrier (SCC) for both uplink and downstream. In different 3GPP versions, there are a lot more CCs than there used to be. In rel-10, there were only two CC in the downlink and none in the uplink. Adding two CC to the uplink made carrier aggregation much better in rel-11, and adding

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FDD/TDD made it even better in rel-12. The number of 20 MHz combined CCs has grown from 5 to 32 in rel-13. Even though carrier aggregation is a strong method, intermodulation products may mess up the signal because of inter- and intra-band carrier aggregation.

2) M-MIMO (very large MIMO)

Based on the idea of spatial combining, MIMO technology is seen as an important part of LTE-A. Data streams from several receivers are combined and sent over a number of lines that are spread out in space. M-MIMO, on the other hand, is an important part of the 5G infrastructure. At mmWave, you need a lot of antenna parts to make a narrow beam that is very focused and doesn't lose its direction. With this method, it's possible to use high-order multi-user MIMO (MU-MIMO) to make small cells more capable. "Macro-assisted small cells" are what the 5G radio access network (RAN) is built on. Control-plane traffic is sent in the macro cell using an omnidirectional antenna at lower band frequencies. User-data traffic, on the other hand, is sent at mmWave frequencies using a highly directed M-MIMO beam. M-MIMO lets distributed MIMO work, where multiple narrow beams are sent to the same mobile station at the same time from a base station in a different place. This increases speed and lowers the association between the antenna elements. A development on MIMO technology that aims to make the airwaves more efficient by using groups of a few hundred antennas, each with its own time and frequency slot, to serve tens of pieces of user equipment. In this way, MIMO technology is used on a bigger scale. M-MIMO is different from traditional MIMO technology because it doesn't use pilot waveforms to figure out the channel. Instead, it uses TDD mode and relies on the uplink and downlink channels working together [53]. It has been shown that M-MIMO can improve radiation efficiency by up to 100 times, increase capacity by an order of 10, protect against interference and intentional jamming, significantly lower latency, and be easy to set up and cost-effective [74].

3) MULTIPOINT PROCESSING THAT IS LINED UP

Coordinated Multipoint (CoMP) was first used in LTE-A and was first presented and standardised by 3GPP in Rel-10. CoMP transfer in the downlink and reception in the uplink is a great way to boost user throughput at the cell edge. CoMP uses distributed MIMO to send and receive signals from various stations that may not be in the same cell. This lowers spatial interference and improves the quality of the signals received. When used with MU-MIMO, CoMP is a very good way to improve cell edge coverage and lower the number of outages caused by blocking and channel conditions. Several tests were done by NTT Docomo and Ericsson in Stockholm, Sweden, using CoMP with MIMO to see how well spread MIMO coordinated and how the combination of the two technologies would improve user data rates at mmWave frequency bands. At mmWave, the study was done at 73GHz in a micro-cell setting in the city to look at BS variety in a CoMP-style way. The CoMP is a transmitter method that can help reduce disturbance. This is done by using channel state information to coordinate the sending and receiving between the BSs that are spread out in space. Coordinated timing and joint delivery are parts of the method [67].

Het Nets are short for heterogeneous networks.

A group of different RATs and kinds of cell layers, such as femto-cells, pico-cells, micro-cells, and macro-cells. Low-power hubs are what these networks need to offload data [75]. HetNets helps the "green" side of 5G by making the best use of bandwidth by reusing it tightly and sending data with low upload and downlink power [67]. This makes it both spectrum- and energy-efficient. An ultra-dense network (UDN) needs a smart way to reduce congestion because it shares the airwaves with a huge number of user devices. HetNets uses e-ICIC and feICIC, which are both better versions of ICIC, to deal with the interruption [67]. Because it has these features, it can handle a lot of data and a lot of nodes, which means it can meet the needs of service-driven 5G enabled IoT. The 5G-IoT options that are supported by HetNet can be found in [51].

IV. CONCLUSION

A full analysis of the 5G wireless technologies that have become important for the widespread use of IoT technology was given in this study. The poll looked at how cellular wireless technologies have changed over time and made the case for how 5G wireless technologies are better than their predecessors, which allows IoT to be used everywhere. The different building blocks of 5G networks are also talked about, with a focus on the main ways that the physical and network layers are better than those of previous networks. The study also goes into great detail about the difficulties of meeting QoS standards in

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current 5G-IoT, whose traffic patterns are very different from those of other 5G network applications, with most of the traffic going upstream instead of downstream. 5G-IoT nodes must be able to send and receive large amounts of data quickly and with little delay so that cloud-based application layer programs can run cutting edge AI, machine learning, and deep learning algorithms that can process and predict data in real time. Modern uses of 5G-IoT, like smart transport, smart healthcare, and more, are also talked about. Key performance indicators (KPIs), which measure how well something is working, are also shown. Another problem that is talked about in this study is the problem of standardisation, which comes up because the 5G-IoT network (HetNets) has a lot of different points. Industry and academia will be able to work together better to make 5G-IoT products better thanks to the in-depth study that is provided in this paper.

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