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An Overview of the Technological Highlights of 5G Network Technology and Research Challenges

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ABSTRACT:
Every major telecom in the globe is attempting to make it even faster because everyone loves speed and more specifically fast internet. More and more devices, including smartphones, watches, homes, and cars, need reliable internet connectivity. The fifth generation of technology or 5G is coming to help us survive in a world where pace is changing every second and where we need more and more technology. Some of the most important goals that must be achieved in the future or in a world beyond 4G are higher capacity, improved data rate, lower latency, and quality service. Large-scale improvements in the 5G cellular architecture are necessary to meet these expectations. The 5G cellular network architecture and some of the key new technologies that can help the architecture become more human and better meet user demands are primarily the focus of this study. The primary focus of this paper's coverage of 5G details is device-to-device communication and huge multiple input multiple output technologies (D2D). A general, believable 5G cellular network architecture is put out using guidelines from online sources and thorough research on the subject.

Keywords: 5G Communication Network, Multiple Input Multiple Output Ports, Smart Devices.

I. Introduction

The cellular system was developed to offer mobile devices ubiquitous services. Nowadays, both industry and academia are working to create better substitutes for supplying mobile devices with high-speed bandwidth and real-time services. With the help of 5G, the next-generation wireless network can deliver greater End-to-End (E2E) connectivity as needed. According to CISCO's analysis, mobile data traffic might expand to 4.8 Zettabytes (ZB) [1] each year or 396 Exabytes (EB)/month by 2022 up from about 1.5 ZB/year or 122 EB/month in 2017. According to a different CISCO research, there will be almost 50 billion connected smart devices by the year 2020 [1] [2].

The term "5G" merely designates the most recent and up-to-date mobile wireless standard, which is based on the IEEE 802.11ac broadband technology standard. Instead than focusing on faster Internet connection speeds 5G aspires to be more capable than current 4G LTE supporting more mobile broadband users per area unit and data consumption in gigabytes per second [2] [3]. This would make it possible for a significant section of the population to watch high-quality streaming video on their mobile devices for several hours each day, even when they are not near wifi hotspots. The Internet of Things also known as machine-to-machine connectivity, is supported better by 5G research and development, with the goal of lowering costs, battery usage, and latency.

IoT has transformed pervasive computing during the past ten years as a result of its many applications in areas like smart cities, smart agriculture, smart health, etc. A collection of smart devices and sensor nodes are included in the IoT paradigm. Sensor nodes keep an eye on the predetermined parameters and share information online. By the year 2020, there will be billions of devices, with each person having an average of six to seven devices.

The reach of 5G extends beyond radio technology and includes services for fixed host communication, cloud infrastructure, and other things [4]. The 5G mobile network's extension services enhance the ecosystem of the telecommunications network and offer services to the healthcare, agricultural, and smart city projects in an energy-efficient way. From personal communication to societal connectedness 5G technology creates the framework for digitalization.

Section I predicts the Introduction of work. Division II mentions the Architecture of 5G Network. Sector III states the Radio Spectrum for 5G Generation. Portion IV depicts the Theory Framework of 5G Technology. Sector V intimates the 5G Manufacturing Concepts. Division VI predicts the 5G Technologies Evolution. Portion VII initates the Issues and Problems with 5G Network Development. Section VIII scopes the Applications of 5G Comunication. Finally Conclusion is stated in Portion IX.

II. Architecture of 5G

In comparison to present technologies, 5G networks will require a shift in architecture. It must be built to handle increased demands for video transmission, faster data transfer rates, greater connectivity, low latency, low power consumption and greater mobility for communications, as well as it supports all smart devices that will connect to the network, including those that use the Internet of Things (IoT). Since present technologies have created a resource bottleneck in the current spectrum, making it challenging to improve capacities with limited bandwidth available, the current paradigm of communications networks must be modified in order to meet these requirements. For this new network, a number of technological adjustments are necessary [17] [18] [19]. According to network reports, current technology like OFDMA should last for at least the next 50 years. Additionally, there is no need to update technology. From the Fig.1 it depicts the 5G architecture network, A survey of low latency towards 5G decribes the network system. As an alternative, once 4G is operationally established commercially, the inclusion of an application or we can say improvement made at the basic network from 1G and it is prompting the package providers to shift a 5G network. However, there was broad consensus that the 5G network should accomplish the following compared to the 4G network.

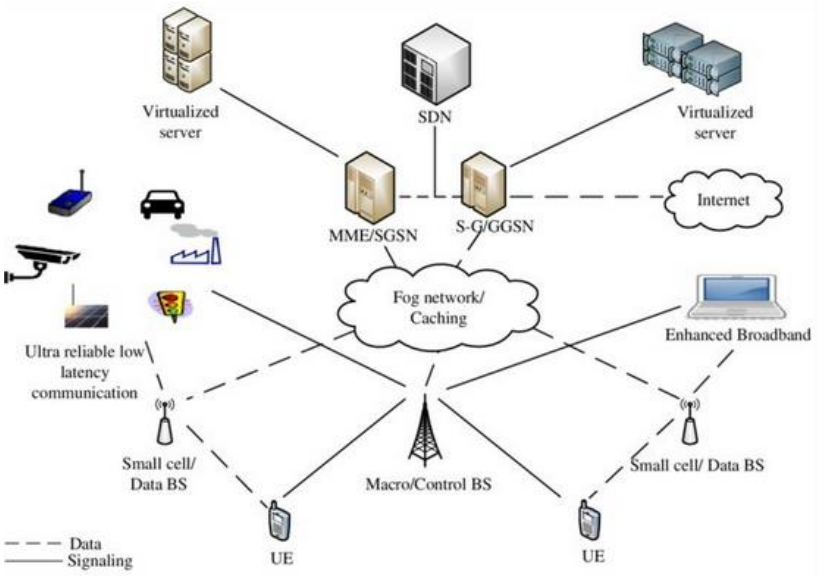

Fig.1 5G Architecture

To satisfy the needs of the user and overcome the difficulties presented by the 5G system, significant modifications in the design philosophy of the 5G wireless cellular architecture are required. With wireless cellular architecture, an outside base station is constantly present in the centre of a cell, aiding communication, allowing mobile users to connect or interact whether inside or outside. Wireless communications will incur costs due to reduced spectrum effectiveness, data rate and energy efficiency as a result of the signals having to pass through the walls of the interior to provide communication between inside and outside base stations. The loss caused by the building's walls being penetrated will be somewhat lessened with the aid of this designing strategy [3] [4]. This strategy will be backed by the use of massive MIMO technology, which deploys a scattered array of antennas geographically and is made up of tens or hundreds of antenna units. Since MIMO systems now only use two or four antennas, the concept of massive MIMO systems, which has been introduced, focuses primarily on harnessing the benefits of large array antenna elements in terms of significant performance gains.

III. Radio Spectrum for 5G Generation

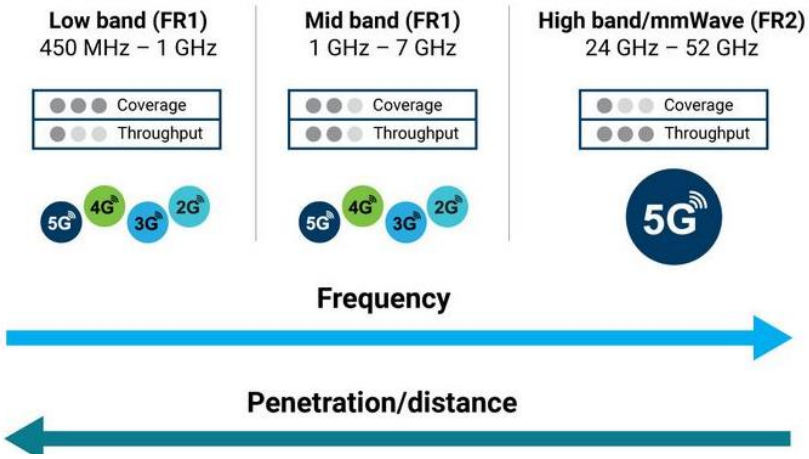

Fig 2. Radio Spectrum for 5G Generation

Through the electromagnetic spectrum, specifically the radio frequency, 5G transmits data wirelessly. Fig.2 depicts the radio spectrum for 5G. Different degrees of frequency bands exist within the radio spectrum, some of which are utilised for this next-generation technology. You may have heard of the 5G bandwidth spectrum, spectrum auctions, mmWave 5G, etc. as 5G is still in its early phases of implementation and is not yet available in every region. The speed of the connection and the range it may traverse are impacted by choosing one portion of the spectrum over another [5].

IV. Theory Framework of 5G Technology

The term "5G Technology" is used in a number of research papers and initiatives to denote the greatest significant advancement in mobile communication standards following the 4G standards. Currently, there are no official specifications that utilise the term "5G." Beyond 4G and LTE, the 3GPP standard was released. Around the year 2020, specifications under the 5G umbrella would likely be implemented [6] [7].

5G technology buzzwords:

1. 5G is a wireless communication standard that has nearly no limitations; some people have dubbed it the "REAL Wireless world."
2. Additional features include multimedia newspapers and the ability to watch TV shows with HD-quality clarity.
3. Compared to earlier generations, we are able to convey data considerably more quickly.
4. The real wireless world without access and zone restrictions.
5. AI-capable wearable technology.
6. Internet protocol version 6, which assigns a visitor's care-of mobile IP address based on location and the connected network.
7. A single international standard.
8. Pervasive networks that enable ubiquitous computing allow the user to connect to multiple wireless access technologies at once.

V. 5G Manufacturing Concepts

The 5G will be able to guarantee coverage in factories and offer innovation for the manufacturing sector by installing indoor radio systems. A high-quality product that can effectively support the systems is created by the ultra-low network latency, extremely high capacity and dependability, high bandwidth and connection density, and extremely low device cost and energy consumption [7] [8]. Only fixed-line wired systems can now function within such confines; mobile technologies are not compatible with the aforementioned requirements, hence manufacturers rely on wired technologies. The usage of 5G in production could be advantageous and helpful because it will provide greater flexibility, reduced costs and practically zero round trip time. Starting with integrating previously disconnected systems and equipment to gather data and information, the introduction of 5G is anticipated to accelerate the digitalization phase. Other alternatives for possible industrial usage will emerge as 5G spreads, bringing with it Smart Factories and maintenance assistance from augmented

reality. By 2020, it's anticipated that over 50 billion sensors will be worldwide connected to the internet, using low-cost hardware designs, and that the volume of data to be collected, sensed, and communicated would expand at an unprecedented rate. The goal of earlier mobile technologies was to boost spectral efficiency and enable high bandwidth applications for human users. In contrast, the 5G network will be driven by a variety of recently developed use cases. This cellular system will fulfil the need for human-type traffic as well as function as a new paradigm for MTC. MTC will cover a wide range of ideas, including Industry 4.0, the Internet of Things, smart features, etc. Every concept has its own specifications, from low energy consumption to smart cities operating with millions of sensors to the Smart Factories that will be served by wireless systems with predetermined requirements regarding latency and reliability [8] [9]. All of these factors must be taken into account for the 5G to be used broadly by future industries.

VI. 5G Technologies Evolution

The mobile sector is about to undergo a new mobile revolution thanks to 5G technology. You may now use mobile phones anywhere in the world thanks to 5G technology. Your entire office is now at your fingertips or in your phone thanks to the development of cell phones that are similar to PDAs. The most recent mobile operating system can connect unlimited call volumes with endless data broadcast thanks to 5G technologies exceptional data capabilities. Because it can handle the latest technologies and provide clients with priceless handsets, 5G technology has a promising future. It's possible that 5G technology could soon rule the global market. The ability of 5G technologies to enable software and consulting is amazing. High connectivity is provided by the router and switch technology used in 5G networks. The 5G technology can be used to deploy a combination of wired and wireless network connections, and it distributes internet access to nodes within the building [10] [11]. Future prospects are bright for the present technology trend of 5G. The key component of 5G technology can be summed up as follows:

i. For crazed smartphone users, 5G technology will provide high resolution and bidirectional huge bandwidth shaping.
ii. The sophisticated billing interfaces of 5G technology will increase its use and appeal.
iii. Tools for quick action in subscriber oversight will be provided by 5G technology.
iv. Using policy to prevent error, 5G technology provides high-quality services.
v. With nearly 65,000 connections, gigabit transmission of data will be made possible by 5G technology.
vi. With unmatched consistency, 5G technology will deliver transporter-class gateways.
vii. It will become more accurate thanks to 5G technology's traffic statistics.
viii. A user can receive a better and faster solution through remote management made possible by 5G technology.
ix. The remote diagnostics capability of 5G technology will be fantastic.
x. Up to 25 Mbps of connectivity will be available thanks to 5G technology.

VII. Issues and Problems with 5G Network Development

Challenges are a natural component of new developments. In contrast to 3G or 4G networks, 5G aims to offer ultra-low latency, high reliability, and security in addition to high-speed mobile broadband and better throughput [12] [13].

A. High Data Rates, Expanded Network Capacity, and Energy Efficiency

A complicated infrastructure supports 5G. It calls for the installation of a significant number of Base Stations (BS) within a constrained geographic area. Although it will increase network costs, it will increase high data transmission rates and decrease energy consumption. Massive Multiple Input and Multiple Output (mMIMO) and Cognitive Radio Networks (CRN) design will be used to achieve high-speed. In compared to communication devices, mMIMO uses a lot of antenna to boost efficiency. The mMIMO employs a wavelength of 1-10 mm and a frequency range of 30-300 GHz.

B. Increased network capacity, high data rates, and energy efficiency

Channel for Full Duplex Communication. Half-duplex communication is used by the 4G network, meaning that there are two distinct channels—one for uploading and another for downloading. However, 5G is built for full duplex transmission, which means it will use the same channel for both access and backhaul. Although it will improve link capacity, conserve the frequency spectrum, and be more cost-effective, interference makes it very challenging to put into practice. As a result, a mechanism to reduce the effects of interference is also needed.

C. Environmentally Responsible

Approximately 4G Radio Network (RN) consumes 70.0–80% of the total power. This results in a CO2 emission in a significant amount and has a detrimental effect on the environment. For the same, numerous 5G options are put up. It contains, CRN for Cloud Radio, VLC for Visual Light Communication (VLC), mmWave (communication over millimetre waves) and D2D Massive Multiple Input and Multiple Output in communication 5G will be environmentally benign thanks to (mMIMO) architectures.

D. Device-to-Device Communication (D2D)

The majority of D2D [18] conversations take place beyond the current cellular networks' coverage area. These direct links speak to one another directly, cutting away the base station from the conversation. The walkie-talkie is an example of this, however in order to communicate, a narrow spectrum is available, and as a result, a communication bandwidth is available. Multi-RAT (Radio Access Technologies) systems are made possible by the 5G network for seamless communication. Single-hop or multi-hop D2D communications are both possible. D2D communication utilising LTE-Advanced and LTE Advanced Pro is possible with 5G. A 5G high-speed D2D communication model is shown in Fig. 3.

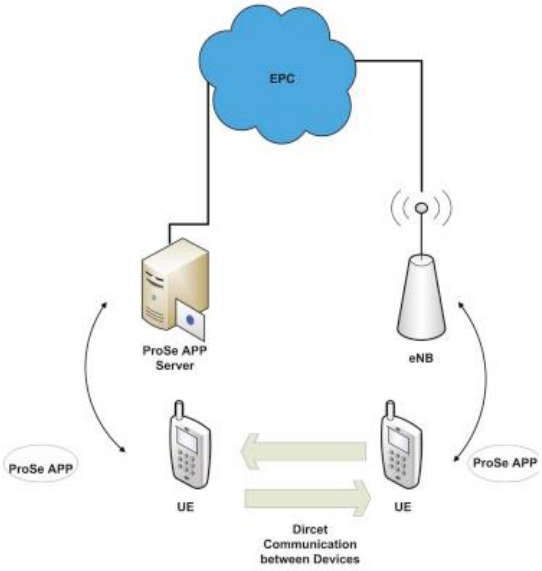

Fig.3 Device to Device Communication Networks

VIII. Applications of 5G Comunication

According to predictions, 5G will have the lowest latency and best service quality while being up to 100 times quicker than the current cellular infrastructure [14] [17]. The potential future applications include

Environmental Surveillance

One of the world's most important challenges is keeping track of environmental changes. Living things experience abrupt changes in the climate as a result of unforeseen natural and environmental calamities, such as storms, flooding, droughts, and tsunamis, among others. Sensor nodes are installed at remote locations to track the environment [21], and the 5G network instantly sends the data. We can preserve life by doing this.

Effective Agriculture

Indian agriculture relies on ancient methods. The goal of smart agriculture is to raise the quantity and quality of agricultural products by automating and monitoring the agricultural system. A smart agricultural system uses sensor nodes placed in the field to collect crop data in real time. A sensor node's most recent data can be shared thanks to 5G. To get the information to the individual person for whom it is valuable, it may first be evaluated using fog computing.

Good Health

People's living standards and health have substantially improved as a result of recent breakthroughs and advancements in medical technology. However, healthcare services are still the worst in rural areas due to a lack of doctors, medical resources, and healthcare providers. Healthcare is therefore a crucial concern in both urban and rural regions. With

the use of robotics, artificial intelligence, and 5G, people can receive healthcare services from anywhere [15]. The patient's health can be tracked using virtual visits, in which small sensor nodes can be implanted or attached to wearable clothing to track vital signs like blood pressure, sugar levels, heart rate, and anxiety in real time and send the information to caregivers and hospitals.

Vehicle Innovation

Today's civilization faces several challenges, one of which is traffic congestion. It impairs societal quality of life, negatively impacts the productivity of industries, and pollutes the environment. With the help of 5G technology, a significant amount of real-time data may be gathered from cars, drivers, and cameras and roadside sensors. The management of traffic flow will be aided. For instance, it can control traffic signals lights based on usage and traffic density and prevent vehicles from entering congested areas.

Smart House

A smart home is a residence where the majority of the home's appliances, including lights, refrigerators, televisions, air conditioners, and security systems, are tracked and managed via the Internet, or more specifically, a smartphone-connected node. These appliances are outfitted with Internet of Things sensor nodes, and the mobile LoWPAN protocol is used to control them.

IX. Conclusion

While current fourth generation wireless networks present a number of key improvements, there is still much space for advancement in the direction of upcoming fifth generation technology. Unfortunately, most current deployments do not offer the technological means to take advantage of context-related data, which is essential to significantly raising the quality of user experience. Intelligent networks with limitless capacity should offer users the potential for End-to-End performance in addition to their locations and other data. In addition, the 5G network should be able to store all data from connected devices that will help to enhance network quality and change network performance to best meet those standards. It has been established that the 5G network's development is focused on making it faster and using less energy. Exploration of the 5G network's path must continue. Unified communication standards would substantially aid the growth of international communication in the field of communication, thus the early identification of 5G network's essential technologies will be crucial to that network's development.

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