Research Article

Study on 5G Technology and Logical Review

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ABSTRACT

In wireless communications, fifth generation (5G) technology is a new generation of cellular networks. This article presents evaluations in the field of mobile radio technology. Several challenges have been addressed in each development, which have been overcome with the help of next-generation cellular networks. Among all previously existing cellular networks, 5G offers high-speed Internet facility anytime, anywhere and for everyone. 5G is slightly different due to its novel capabilities such as connecting people, controlling devices, objects and machines. The 5G cellular system will bring different power and performance levels that will serve as new user experiences and connect new businesses. Therefore, it is important to know where the company can take advantage of 5G.

In this research article, it has been observed that extensive research and analysis unfolds various aspects, namely, millimeter wave (mmWave), massive multiple-input and multiple-output (massive-MIMO), small cell, mobile edge computing (MEC), beamforming, various antenna technologies, etc.

The main objective of this article is to highlight some of the recent improvements in the 5G cellular system and to discuss its future research goals.

Key words: 5G, millimeter wave (mmW), massive multiple input and multiple output (MIMO), small cell, mobile edge computing (MEC), beamforming, machine learning

INTRODUCTION

In the last three decades, the wireless communications field has seen rapid growth in terms of the transition from 1G to 4G [1,2]. The main motto behind this research was the requirement for high bandwidth and very low latency. 5G offers high data rate, improved quality of service (QoS), low latency, high coverage, high reliability and economically affordable services. 5G offers services classified into three categories:

(1) Extreme Mobile Broadband (eMBB). It is a non-standalone architecture that offers high-speed Internet connections, increased bandwidth, moderate latency, Ultra HD streaming videos, virtual reality and augmented reality (AR/VR) media, and much more.

(2) Massive Machine Type Communication (eMTC), 3GPP publishes it in its 13th specification. It provides long-distance and broadband machine communications at a very cost-effective price with less power consumption. eMTC provides a service with high data rate, low power consumption and extended coverage through less device complexity by mobile operators for IoT applications.

(3) Ultra-Reliable Low Latency Communication (URLLC) provides low latency and ultra-high reliability and comprehensive Quality of Service (QoS) not possible with traditional cellular network architecture. URLLC is designed for on-demand real-time interactions such as remote surgery, vehicle-to-vehicle (V2V) communications, Industry 4.0, smart grids, intelligent transportation systems, etc. [3].

<div align="center">MATERIELS AND METHODS</div>

Evolution from 1G to 5G

We used survey to get information based on each generation for methodology.

First generation (1G): 1G cell phone was launched between the 1970s and 80s, based on analog technology, which works just like a landline phone. It suffers in various ways, such as poor battery life, voice quality, and dropped calls. In 1G, the maximum achievable speed was 2.4 Kbps.

Second Generation (2G): In 2G, the first digital system was offered in 1991, providing improved mobile voice communication over 1G. In addition, Code-Division Multiple Access (CDMA) and Global System for Mobile (GSM) concepts were also discussed. In 2G, the maximum achievable speed was 1 Mpbs.

Third Generation (3G): When technology ventured from 2G GSM frameworks into 3G universal mobile telecommunication system (UMTS) framework, users encountered higher system speed and quicker download speed making constant video calls. 3G was the first mobile broadband system that was formed to provide the voice with some multimedia. The technology behind 3G was high-speed packet access (HSPA/HSPA+). 3G used MIMO for multiplying the power of the wireless network, and it also used packet switching for fast data transmission.

Fourth Generation (4G): It is purely mobile broadband standard. In digital mobile communication, it was observed information rate that upgraded from 20 to 60 Mbps in 4G [4]. It works on LTE and WiMAX technologies, as well as provides wider bandwidth up to 100 MHz. It was launched in 2010.

Fourth Generation LTE-A (4.5G): It is an advanced version of standard 4G LTE. LTE-A uses MIMO technology to combine multiple antennas for both transmitters as well as a receiver. Using MIMO, multiple signals and multiple antennas can work simultaneously, making LTE-A three times faster than standard 4G. LTE-A offered an improved system limit, decreased deferral in the application server, access triple traffic (Data, Voice, and Video) wirelessly at any time anywhere in the world. LTE-A delivers speeds of over 42 Mbps and up to 90 Mbps.

Fifth Generation (5G): 5G is a pillar of digital transformation; it is a real improvement on all the previous mobile generation networks. 5G brings three different services for end user like Extreme mobile broadband (eMBB). It offers high-speed internet connectivity, greater bandwidth, moderate latency, Ultra HD streaming videos, virtual reality and augmented reality (AR/VR) media, and many more. Massive machine type communication (eMTC), it provides long-range and broadband machine-type communication at a very cost-effective price with less power consumption. eMTC brings a high data rate service, low power, extended coverage via less device complexity through mobile carriers for IoT applications. Ultra-reliable low latency communication (URLLC) offers low-latency and ultra-high reliability, rich quality of service (QoS), which is not possible with traditional mobile network architecture. URLLC is designed for on-demand real-time interaction such as remote surgery, vehicle to vehicle (V2V) communication, industry 4.0, smart grids, intelligent transport system, etc.

5G faster than 4G and offers remote-controlled operation over a reliable network with zero delays. It provides down-link maximum throughput of up to 20 Gbps. In addition, 5G also supports 4G WWWW (4th Generation World Wide Wireless Web) and is based on Internet protocol version 6 (IPv6) protocol. 5G provides unlimited internet connection at your convenience, anytime, anywhere with extremely high speed, high throughput, low-latency, higher reliability and scalability, and energy-efficient mobile communication technology [6]. 5G mainly divided in two parts 6 GHz 5G and Millimeter wave (mmWave) 5G.

6 GHz is a mid-frequency band which works as a midpoint between capacity and coverage to offer perfect environment for 5G connectivity. 6 GHz spectrum will provide high bandwidth with improved network performance. It offers continuous channels that will reduce the need for network densification when mid-band spectrum is not available and it makes 5G connectivity affordable at anytime, anywhere for everyone.

mmWave is an essential technology of 5G network which build high performance network.

5G mmWave offer diverse services that is why all network providers should add on this technology in their 5G deployment planning.

There are lots of service providers who deployed 5G mmWave, and their simulation result shows that 5G mmwave is a far less used spectrum. It provides very high speed wireless communication and it also offers ultra-wide bandwidth for next generation mobile network.

The evolution of wireless mobile technologies is presented in Table 1. The abbreviations used in this paper are mentioned in Table 2.

Table -1 Summary of Mobile Technology

Generations	Access Techniques	Transmission Techniques	Error Correction Mechanism	Data Rate	Frequency Band	Bandwidth	Application	Description
1G	FDMA, AMPS	Circuit Switching	NA	2.4 kbps	800 MHz	Analog	Voice	Let us talk to each other
2G	GSM, TDMA, CDMA	Circuit Switching	NA	10 kbps	800 MHz, 900 MHz, 1800 MHz, 1900 MHz	25 MHz	Voice and Data	Let us send messages and travel with improved data services
3G	WCDMA, UMTS, CDMA 2000, HSUPA/HSDPA	Circuit and Packet Switching	Turbo Codes	384 kbps to 5 Mbps	800 MHz, 850 MHz, 900 MHz, 1800 MHz, 1900 MHz, 2100 MHz	25 MHz	Voice, Data, and Video Calling	Let us experience surfing internet and unleashing mobile applications
4G	LTEA, OFDMA, SCFDMA, WIMAX	Packet switching	Turbo Codes	100 Mbps to 200 Mbps	2.3 GHz, 2.5 GHz and 3.5 GHz initially	100 MHz	Voice, Data, Video Calling, HD Television, and Online Gaming.	Let's share voice and data over fast broadband internet based on unified networks architectures and IP protocols
5G	BDMA, NOMA, FBMC	Packet Switching	LDPC	10 Gbps to 50 Gbps	1.8 GHz, 2.6 GHz and 30–300 GHz	30–300 GHz	Voice, Data, Video Calling, Ultra HD video,	Expanded the broadband wireless services beyond mobile

Table -2 Notation and abbreviation

Abbreviation	Full Form	Abbreviation	Full Form
AMF	Access and Mobility Management Function	M2M	Machine-to-Machine
AT&T	American Telephone and Telegraph	mmWave	millimeter wave
BS	Base Station	NGMN	Next Generation Mobile Networks
CDMA	Code-Division Multiple Access	NOMA	Non-Orthogonal Multiple Access
CSI	Channel State Information	NFV	Network Functions Virtualization
D2D	Device to Device	OFDM	Orthogonal Frequency Division Multiplexing
EE	Energy Efficiency	OMA	Orthogonal Multiple Access
EMBB	Enhanced mobile broadband:	QoS	Quality of Service
ETSI	European Telecommunications Standards Institute	RNN	Recurrent Neural Network

eMTC	Massive Machine Type Communication	SDN	Software-Defined Networking
FDMA	Frequency Division Multiple Access	SC	Superposition Coding
FDD	Frequency Division Duplex	SIC	Successive Interference Cancellation
GSM	Global System for Mobile	TDMA	Time Division Multiple Access
HSPA	High Speed Packet Access	TDD	Time Division Duplex
IoT	Internet of Things	UE	User Equipment
IETF	Internet Engineering Task Force	URLLC	Ultra Reliable Low Latency Communication
LTE	Long-Term Evolution	UMTC	Universal Mobile Telecommunications System
ML	Machine Learning	V2V	Vehicle to Vehicle
MIMO	Multiple Input Multiple Output	V2X	Vehicle to Everything

RESULTS & DISCUSSION

Key Contributions

The objective of this work is to provide a detailed guide of 5G key technologies, methods to researchers, and to help with understanding how the recent works addressed 5G problems and developed solutions to tackle the 5G challenges;
• This survey focused on the recent trends and development in the era of 5G and novel contributions by the researcher community and discussed technical details on essential aspects of the 5G advancement.
In this paper, the evolution of the mobile network from 1G to 5G is presented. In addition, the growth of mobile communication under different attributes is also discussed.
• This paper covers the emerging applications and research groups working on 5G & different research areas in 5G wireless communication network with a descriptive taxonomy.
This survey discusses the current vision of the 5G networks, advantages, applications, key technologies, and key features. Furthermore, machine learning prospects are also explored with the emerging requirements in the 5G era. The article also focused on technical aspects of 5G IoT Based approaches and optimization techniques for 5G.
• We provide an extensive overview and recent advancement of emerging technologies of 5G mobile network, namely, MIMO, Non-Orthogonal Multiple Access (NOMA), mmWave, Internet of Things (IoT), Machine Learning (ML), and optimization. Also, a technical summary is discussed by highlighting the context of current approaches and corresponding challenges.
• Security challenges and considerations while developing 5G technology are discussed.
•Finally, the paper concludes with the future directives.

The existing survey focused on architecture, key concepts, and implementation challenges and issues. In contrast, this survey covers the state-of-the-art techniques as well as corresponding recent novel developments by researchers. Various recent significant papers are discussed with the key technologies accelerating the development and production of 5G products.

Limitations of existing Surveys

The existing survey focused on architecture, key concepts, and implementation challenges and issues. The numerous recent surveys focused on various 5G technologies with different parameters. Few authors have worked on MIMO (Non-Orthogonal Multiple Access) NOMA, MEC and small cell technologies.

In contrast, some others worked on beamforming, millimeter waves (mmWave).

However, the present survey did not cover all technologies of the 5G network from a research and further development perspective.

No detailed survey covering all 5G network technologies and currently published research trade-offs is available in the market. So, our main goal is to give a detailed study of all the technologies that work in the 5G network.

In contrast, this overview covers the state of the art as well as corresponding recent developments by researchers. Various recent significant papers are discussed with the key technologies that accelerate the development and production of 5G products.

This review article collected important information about 5G technology and recent advances and can be a kind of guide for the reader.

This survey provides an overarching approach to bring together multiple solutions and latest improvements in a single place to accelerate 5G research with the latest key solutions and assessments. A systematic layout represented below:
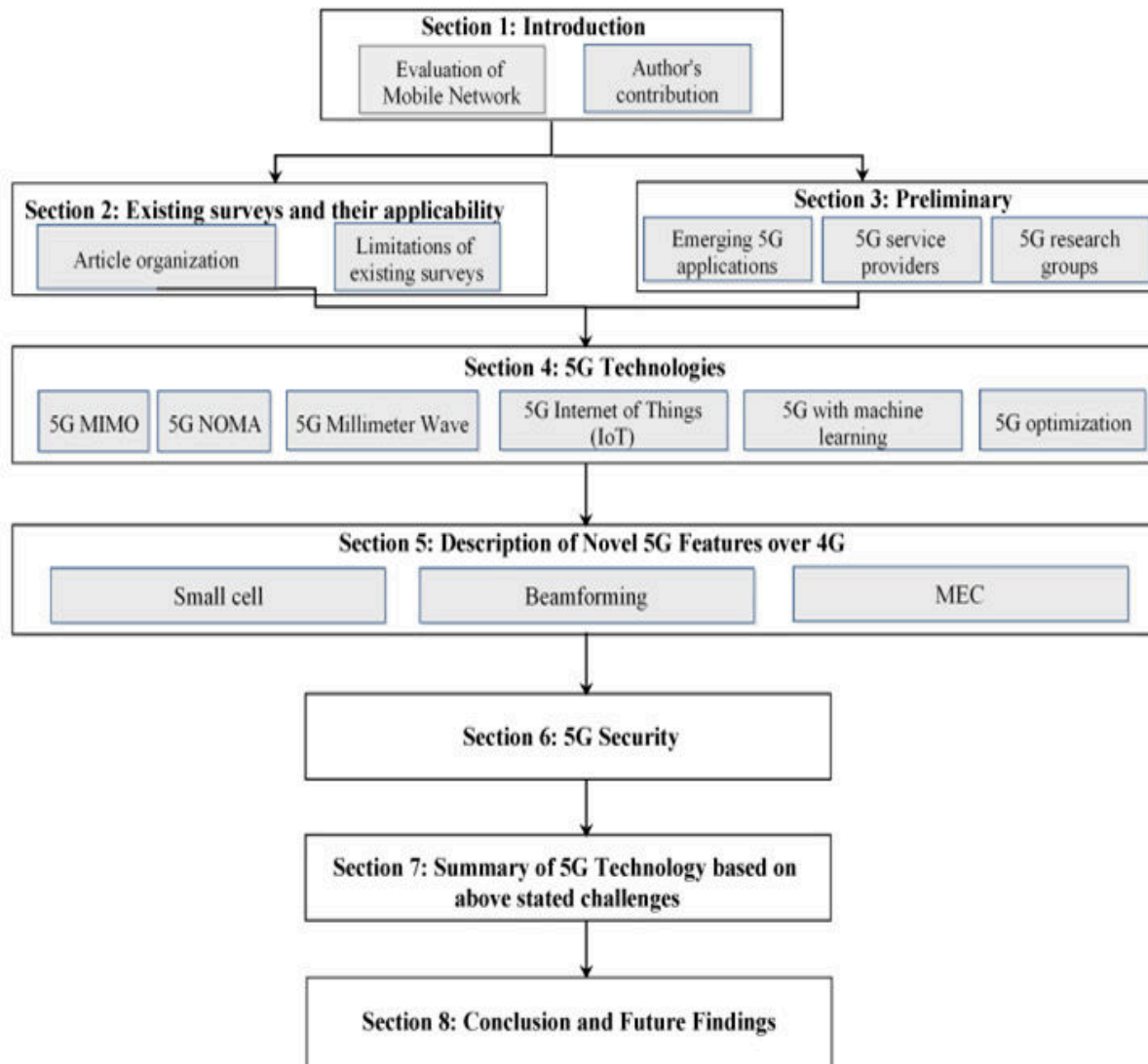
Systematic layout representation of survey

Commercial service providers of 5G

5G provides high-speed internet browsing, streaming, and downloading with very high reliability and low latency. 5G network will change your working style, and it will increase new business opportunities and provide innovations that we cannot imagine. This section covers top service providers of 5G network.

Ericsson: Ericsson is a Swedish multinational networking and telecommunications company, investing around 25.62 billion USD in 5G network, which makes it the biggest telecommunication company. It claims that it is the only company working on all the continents to make the 5G network a global standard for the next generation

wireless communication. Ericsson developed the first 5G radio prototype that enables the operators to set up the live field trials in their network, which helps operators understand how 5G reacts. It plays a vital role in the development of 5G hardware. It currently provides 5G services in over 27 countries with content providers like China Mobile, GCI, LGU+, AT&T, Rogers, and many more. It has 100 commercial agreements with different operators as of 2020.

Verizon: It is American multinational telecommunication which was founded in 1983. Verizon started offering 5G services in April 2020, and by December 2020, it has actively provided 5G services in 30 cities of the USA. They planned that by the end of 2021, they would deploy 5G in 30 more new cities. Verizon deployed a 5G network on mmWave, a very high band spectrum between 30 to 300 GHz. As it is a significantly less used spectrum, it provides very high-speed wireless communication. MmWave offers ultra-wide bandwidth for next-generation mobile networks. MmWave is a faster and high-band spectrum that has a limited range. Verizon planned to increase its number of 5G cells by 500% by 2020. Verizon also has an ultra wide-band flagship 5G service which is the best 5G service that increases the market price of Verizon.

Nokia: Nokia is a Finnish multinational telecommunications company which was founded in 1865. Nokia is one of the companies which adopted 5G technology very early. It is developing, researching, and building partnerships with various 5G renders to offer 5G communication as soon as possible. Nokia collaborated with Deutsche Telekom and Hamburg Port Authority and provided them 8000-hectare site for their 5G MoNArch project. Nokia is the only company that supplies 5G technology to all the operators of different countries like AT&T, Sprint, T-Mobile US and Verizon in the USA, Korea Telecom, LG U+ and SK Telecom in South Korea and NTT DOCOMO, KDDI, and SoftBank in Japan. Presently, Nokia has around 150+ agreements and 29 live networks all over the world. Nokia is continuously working hard on 5G technology to expand 5G networks all over the globe.

AT&T: AT&T is an American multinational company that was the first to deploy a 5G network in reality in 2018. They built a gigabit 5G network connection in Waco, TX, Kalamazoo, MI, and South Bend to achieve this. It is the first company that archives 1–2 gigabit per second speed in 2019. AT&T claims that it provides a 5G network connection among 225 million people worldwide by using a 6 GHz spectrum band.

T-Mobile: T-Mobile US (TMUS) is an American wireless network operator which was the first service provider that offers a real 5G nationwide network. The company knew that high-band 5G was not feasible nationwide, so they used a 600 MHz spectrum to build a significant portion of its 5G network. TMUS is planning that by 2024 they will double the total capacity and triple the full 5G capacity of T-Mobile and Sprint combined. The sprint buyout is helping T-Mobile move forward the company's current market price to 129.98 USD.

Samsung: Samsung started their research in 5G technology in 2011. In 2013, Samsung successfully developed the world's first adaptive array transceiver technology operating in the millimeter-wave Ka bands for cellular communications. Samsung provides several hundred times faster data transmission than standard 4G for core 5G mobile communication systems. The company achieved a lot of success in the next generation of technology, and it is considered one of the leading companies in the 5G domain.

Qualcomm: Qualcomm is an American multinational corporation in San Diego, California. It is also one of the leading company which is working on 5G chip. Qualcomm's first 5G modem chip was announced in October 2016, and a prototype was demonstrated in October 2017. Qualcomm mainly focuses on building products while other companies talk about 5G; Qualcomm is building the technologies. According to one magazine, Qualcomm was working on three main areas of 5G networks. Firstly, radios that would use bandwidth from any network it has access to; secondly, creating more extensive ranges of spectrum by combining smaller pieces; and thirdly, a set of services for internet applications.

ZTE Corporation: ZTE Corporation was founded in 1985. It is a partially Chinese state-owned technology company that works in telecommunication. It was a leading company that worked on 4G LTE, and it is still maintaining its value and doing research and tests on 5G. It is the first company that proposed Pre5G technology with some series of solutions.

NEC Corporation: NEC Corporation is a Japanese multinational information technology and electronics corporation headquartered in Minato, Tokyo. ZTE also started their research on 5G, and they introduced a new business concept. NEC's main aim is to develop 5G NR for the global mobile system and create secure and intelligent technologies to realize 5G services.

Cisco: Cisco is a USA networking Hardware Company that also sleeves up for 5G network. Cisco's primary focus is to support 5G in three ways: Service—enable 5G services faster so all service providers can increase their business. Infrastructure—build 5G-oriented infrastructure to implement 5G more quickly. Automation—make a more scalable, flexible, and reliable 5G network. The companies know the importance of 5G, and they want to connect more than 30 billion devices in the next couple of years. Cisco intends to work on network hardening as it is a vital part of 5G networks. Cisco used AI with deep learning to develop a 5G Security Architecture, enabling Secure Network Transformation.

5G Research groups

Many research groups from all over the world are working on a 5G wireless mobile network. These groups are continuously working on various aspects of 5G. The list of those research groups are presented as follows: 5GNOW (5th Generation Non-Orthogonal Waveform for Asynchronous Signaling), NEWCOM (Network of Excellence in Wireless Communication), 5GIC (5G Innovation Center), NYU (New York University) Wireless, 5GPPP (5G Infrastructure Public-Private Partnership), EMPHATIC (Enhanced Multi-carrier Technology for Professional Adhoc and Cell-Based Communication), ETRI(Electronics and Telecommunication Research Institute), METIS (Mobile and wireless communication Enablers for the Twenty-twenty Information Society). The various research groups along with the research area are presented in Table 3.

Table -3 Research groups working on 5G mobile networks

Research Groups	Research Area	Description
METIS (Mobile and wireless communications Enablers for Twenty-twenty (2020) Information Society)	Working 5G Framework	METIS focused on RAN architecture and designed an air interface which evaluates data rates on peak hours, traffic load per region, traffic volume per user and actual client data rates. They have generate METIS published an article on February, 2015 in which they developed RAN architecture with simulation results. They design an air interface which evaluates data rates on peak hours, traffic load per region, traffic volume per user and actual client data rates.They have generate very less RAN latency under 1ms. They also introduced diverse RAN model and traffic flow in different situation like malls, offices, colleges and stadiums.
5G PPP (5G Infrastructure Public Private Partnership)	Next generation mobile network communication, high speed Connectivity.	Fifth generation infrastructure public partnership project is a joint startup by two groups (European Commission and European ICT industry). 5G-PPP will provide various standards architectures, solutions and technologies for next generation mobile network in coming decade. The main motto behind 5G-PPP is that, through this project, European Commission wants to give their contribution in smart cities, e-health, intelligent transport, education, entertainment, and media.
5GNOW (5th Generation Non-Orthogonal Waveforms for asynchronous signaling)	Non-orthogonal Multiple Access	5GNOW's is working on modulation and multiplexing techniques for next generation network. 5GNOW's offers ultra-high reliability and ultra-low latency communication with visible waveform for 5G. 5GNOW's also worked on acquiring time and frequency plane information of a signal using short term Fourier transform (STFT)
EMPhAtiC (Enhanced Multicarrier Technology for Professional Ad-Hoc and Cell-Based Communications)	MIMO Transmission	EMPhAtiC is working on MIMO transmission to develop a secure communication techniques with asynchronicity based on flexible filter bank and multihop. Recently they also launched MIMO based trans-receiver technique under frequency selective channels for Filter Bank Multi-Carrier (FBMC)
NEWCOM (Network of Excellence in Wireless	Advanced aspects of wireless communications	NEWCOM is working on energy efficiency, channel efficiency, multihop communication in wireless

Research Groups	Research Area	Description
Communications)		communication. Recently, they are working on cloud RAN, mobile broadband, local and distributed antenna techniques and multi-hop communication for 5G network. Finally, in their final research they give on result that QAM modulation schema, system bandwidth and resource block is used to process the base band.
NYU New York University Wireless	Millimeter Wave	NYU Wireless is research center working on wireless communication, sensors, networking and devices. In their recent research, NYU focuses on developing smaller and lighter antennas with directional beamforming to provide reliable wireless communication.
5GIC 5G Innovation Centre	Decreasing network costs, Preallocation of resources according to user's need, point-to-point communication, Highspeed connectivity.	5GIC, is a UK's research group, which is working on high-speed wireless communication. In their recent research they got 1Tbps speed in point-to-point wireless communication. Their main focus is on developing ultra-low latency app services.
ETRI (Electronics and Telecommunication Research Institute)	Device-to-device communication, MHN protocol stack	ETRI (Electronics and Telecommunication Research Institute), is a research group of Korea, which is focusing on improving the reliability of 5G network, device-to-device communication and MHN protocol stack.

5G Applications

5G is faster than 4G and offers remote-controlled operation over a reliable network with zero delays. It provides down-link maximum throughput of up to 20 Gbps. In addition, 5G also supports 4G WWWW (4th Generation World Wide Wireless Web) 5and is based on Internet protocol version 6 (IPv6) protocol. 5G provides unlimited internet connection at your convenience, anytime, anywhere with extremely high speed, high throughput, low-latency, higher reliability, greater scalability, and energy-efficient mobile communication.

There are lots of applications of 5G mobile network are as follows:

High-speed mobile network: 5G is an advancement on all the previous mobile network technologies, which offers very high speed downloading speeds 0 of up to 10 to 20 Gbps. The 5G wireless network works as a fiber optic internet connection. 5G is different from all the conventional mobile transmission technologies, and it offers both voice and high-speed data connectivity efficiently.   5G offers very low latency communication of less than a millisecond, useful for autonomous driving and mission-critical applications. 5G will use millimeter waves for data transmission, providing higher bandwidth and a massive data rate than lower LTE bands. As 5G is a fast mobile network technology, it will enable virtual access to high processing power and secure and safe access to cloud services and enterprise applications.

Small cell is one of the best features of 5G, which brings lots of advantages like high coverage, high-speed data transfer, power saving, easy and fast cloud access, etc.

Entertainment and multimedia: In one analysis in 2015, it was found that more than 50 percent of mobile internet traffic was used for video downloading. This trend will surely increase in the future, which will make video streaming more common. 5G will offer High-speed streaming of 4K videos with crystal clear audio, and it will make a high definition virtual world on your mobile. 5G will benefit the entertainment industry as it offers 120 frames per second with high resolution and higher dynamic range video streaming, and HD TV channels can also be accessed on mobile devices without any interruptions. 5G provides low latency high definition communication so augmented reality (AR), and virtual reality (VR) will be very easily implemented in the future. Virtual reality games are trendy these days, and many companies are investing in HD virtual reality games. The 5G network will offer high-speed internet connectivity with a better gaming experience [41].

Internet of Things—connecting everything: the 5G mobile network plays a significant role in developing the Internet of Things (IoT).

IoT will connect many things with the internet like appliances, sensors, devices, objects, and applications. These applications will collect lots of data from different devices and sensors. 5G will provide very high-speed internet

connectivity for data collection, transmission, control, and processing. 5G is a flexible network with unused spectrum availability, and it offers very low-cost deployment that is why it is the most efficient technology for IoT [42]. In many areas, 5G provide benefit to IoT are as follows:

Smart homes: Smart home appliances and products are in demand these days. The 5G network makes smart homes more real as it offers high-speed connectivity and monitoring of smart appliances. Smart home appliances are easily accessed and configured from remote locations using the 5G network as it offers very high-speed low latency communication.

Smart cities: 5G wireless network also helps develop smart cities applications such as automatic traffic management, weather update, local area broadcasting, energy-saving, efficient power supply, smart lighting system, water resource management, crowd management, emergency control, etc.

Industrial IoT: 5G wireless technology will provide lots of features for future industries such as safety, process tracking, smart packing, shipping, energy efficiency, automation of equipment, predictive maintenance, and logistics. 5G smart sensor technology also offers smarter, safer, cost-effective, and energy-saving industrial IoT operations.

Smart Farming: 5G technology will play a crucial role in agriculture and smart farming. 5G sensors and GPS technology will help farmers track live attacks on crops and manage them quickly. These smart sensors can also be used for irrigation, pest, insect, and electricity control.

Autonomous Driving: The 5G wireless network offers very low latency high-speed communication, significant for autonomous driving. It means self-driving cars will come to real life soon with 5G wireless networks. Using 5G autonomous cars can easily communicate with smart traffic signs, objects, and other vehicles running on the road. 5G's low latency feature makes self-driving more real as every millisecond is essential for autonomous vehicles, decision-making is done in microseconds to avoid accidents.

Healthcare and mission-critical applications: 5G technology will bring modernization in medicine where doctors and practitioners can perform advanced medical procedures. The 5G network will provide connectivity between all classrooms, so attending seminars and lectures will be easier. Through 5G technology, patients can connect with doctors and take their advice. Scientists are building smart medical devices which can help people with chronic medical conditions. The 5G network will boost the healthcare industry with smart devices, the internet of medical things, smart sensors, HD medical imaging technologies, and smart analytics systems. 5G will help access cloud storage, so accessing healthcare data will be very easy from any location worldwide. Doctors and medical practitioners can easily store and share large files like MRI reports within seconds using the 5G network.

Satellite Internet: In many remote areas, ground base stations are not available, so 5G will play a crucial role in providing connectivity in such areas. The 5G network will provide connectivity using satellite systems, and the satellite system uses a constellation of multiple small satellites to provide connectivity in urban and rural areas across the world.

5G Massive MIMO
Multiple-input-multiple-out (MIMO) is a very important technology for wireless systems. It is used for sending and receiving multiple signals simultaneously over the same radio channel. MIMO plays a very big role in WI-FI, 3G, 4G, and 4G LTE-A networks. MIMO is mainly used to achieve high spectral efficiency and energy efficiency but it was not up to the mark MIMO provides low throughput and very low reliable connectivity. To resolve this, lots of MIMO technology like single user MIMO (SU-MIMO), multiuser MIMO (MU-MIMO) and network MIMO were used. However, these new MIMO also did not still fulfill the demand of end users. Massive MIMO is an advancement of MIMO technology used in the 5G network in which hundreds and thousands of antennas are attached with base stations to increase throughput and spectral efficiency. Multiple transmit and receive antennas are used in massive MIMO to increase the transmission rate and spectral efficiency. When multiple UEs generate downlink traffic simultaneously, massive MIMO gains higher capacity. Massive MIMO uses extra antennas to move energy into smaller regions of space to increase spectral efficiency and throughput [43]. In traditional systems data collection from smart sensors is a complex task as it increases latency, reduced data rate and reduced reliability.
While massive MIMO with beamforming and huge multiplexing techniques can sense data from different sensors with low latency, high data rate and higher reliability. Massive MIMO will help in transmitting the data in real-time collected from different sensors to central monitoring locations for smart sensor applications like self-driving cars, healthcare centers, smart grids, smart cities, smart highways, smart homes, and smart enterprises.

Highlights of 5G Massive MIMO technology are as follows:

1. Data rate: Massive MIMO is advised as the one of the dominant technologies to provide wireless high speed and high data rate in the gigabits per seconds.

2. The relationship between wave frequency and antenna size: Both are inversely proportional to each other. It means lower frequency signals need a bigger antenna and vise versa.

3. Number of user: From 1G to 4G technology one cell consists of 10 antennas. But, in 5G technologies one cell consist of more than 100 antennas. Hence, one small cell at the same time can handle multiple users.
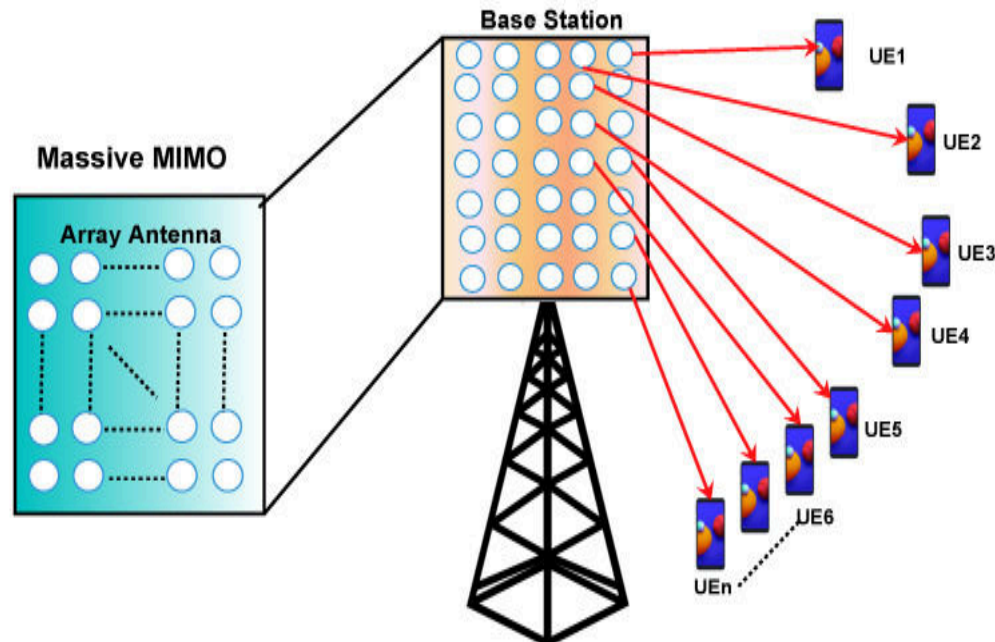
Figure of Pictorial representation of multi-input and multi-output (MIMO)

CONCLUSION

This overview article illustrates the emergence of 5G, its evolution from 1G to 5G mobile network, applications, different research groups, their work and the main features of 5G. It's not just a mobile broadband network, unlike any previous generation of cellular networks; It offers services such as IoT, V2X and Industry 4.0.

This whitepaper includes a detailed survey by several authors on various technologies in 5G, such as 5G. After each section, a tabular comparison covers the entire state of research on these technologies. This survey also shows the importance of these newly added technologies and building a flexible, scalable and reliable 5G network.

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