Core Technologies and Harmful Effects of 5G Wireless Technology

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Abstract. 5G (fifth generation) technology is used to interconnect all terminals, networks, multiple wireless technologies, applications simultaneously which can also switch between them based on VOIP (Voice-over-IP), flat IP, and Internet Protocol Version 6 (IPv6), thus user experiences call volume services and high-level data transmission. 5G network is reliable and very fast with minimum delay, higher data rate, greater security, real-time data handling, less error rate, and few data losses. The core technologies used in 5G networks include cloud computing, Heterogeneous Network (Het Net), internet of things (IoT), Cognitive Radio (CR) network, software-defined networking (SDN), Multiple Input Multiple Output (MIMO), and massive MIMO. 5G produces different harmful effects such as human health issues, environmental issues, health issues on birds and animals, thermal effects, etc. Regulating agencies have to set a Specific Absorption Rate (SAR), its maximum levels for handset, and every mobile phone must have a SAR rating. 5G technology is used as intelligent technology in which 5G mobile phones can also be used as a tablet PC. This paper presents a general review on 5G along with its comparison with 4G, the general architecture of 5G, a detailed explanation about core technologies of 5G, and also harmful effects on different issues using 5G.

Keywords: 5G, Cloud computing, Harmful effects, IoT, SAR, SDN

1. Introduction

5G network systems deal with the 1000 times of traffic growth with zero latency and fiber-like access data rate by connecting 100 billion devices. 5G is IP-based, used for the wireless network, and mobile inter-operability. 5G is not just incremental development of 4G, but from many perspectives, it will be treated as new technology. The three main benefits of 5G wireless technology are faster speed higher than 4G allows transmitting images, videos at a faster rate, reduced latency with shorter delays, increase in connectivity which allows more devices and people can communicate with each other simultaneously by providing faster, reliable connections than 4G/LTE. At Airtel’s network Centre in Manesar, Gurugram in India, the first trial on 5G was conducted. 5G network implementation in research, industries, and companies is required. Gigabit transmission rate in 5G networks is achieved by using millimeter-wave communications, massive MIMO, and small cell technologies. 5G network is reliable and very fast with minimum delay, higher data rate, greater security, real-time data handling, less error rate, and few data losses. 5G mobile phones can also be used as a tablet PC. 5G is evolved as the integration of several techniques and will be expected to be used in around 2020. 5G technologies use higher bandwidth which allows many users to access mobiles and provides services such as e-payment, e-transaction, documentation, and production engineering.
The core technologies used in 5G networks include soft-ware defined networking (SDN), cloud computing, nanotechnology, machine-to-machine (M2M), network slicing, mobile edge computing, millimeter wave, full-duplex systems, Het Net along with D2D communication, wave networks function virtualization (NFV), massive MIMO and internet of things (IoT) based on flat IP, VOIP (Voice-over-IP) and IPv6. A smart grid that contains sensors, meters, and data management systems with proper monitoring is used to make electrical utilities more sustainable. So, the implementation of a smart grid and smart metering technologies is required. To achieve continuous demand in the present smart grid era for power storage and distributed generation, new wireless technologies with a grid should be incorporated. In smart grids, developing new communication infrastructure is more advantageous than the existing wireless technologies. 5G smart grid networks can be used to establish edge and fog computing with intelligent control and automation. 5G uses higher millimeter-wave frequencies in the microwave spectrum in the 0.6–3.7GHZ(LOW), 3.7GHZ–24GHZ(MID), 24GHZ, and higher frequencies for faster communications used for communications technology and the Internet. High frequencies do not travel for long distances which are blocked by buildings, and the network uses antennas every 300 meters indoors and outdoors as well which has formed as a dense network that creates and exposes microwave radiation continuously on people led to the development of long-term health effects. In millimeter Wave, everything is IoT connected which provides high data rates, but millimeter waves possess hazardous effects on wildlife and human health which is not negligible and has become life-threatening as well which makes 5G more disadvantageous. So, it is necessary to reduce the effects by considering the SAR value within the recommended limits to make 5G the most advantageous and useful future upcoming technology.

The earliest paper in 5G Wireless Technology is reported in [1]. In their work, the authors described the growth of 1G-5G with 5G network architecture and its services. Arun Agarwal et al., [2] had concluded the role of 5G and its functional concept. Rupendra Nath Mitra et al., [3] indicated the research direction and the development of 5G technologies along with the salient features. Guangyi Liu et al., [4] focuses on the application of mobile communication and also a demonstration of the efficiency requirements and the capabilities of 5G. Nam Tuan Le et al., [5] described the usage of core technology methods for 5G and also explained its functionalities. Raksh Kumar Singh et al., [6] explained all generations of mobile technologies along with basic concepts and architecture including its features and offered services to them. David Soldani [7] has defined usage and the technological requirements of 5G and its enabling technologies. Siddhika Arunachalam et al., [8] explained the introduction, evolution, requirements of hardware, and software along with specifications with the architecture of 5G. Uvika Kujur et al., [9] presented a detailed description of the different mobile generation technologies of 5G including its enabling technologies. Swati Yada et al., [10] described the differences between 1G to 5G with its advantages and disadvantages of each and also explained as 5G as Intelligent Technology.

Udit Narayana Kar et al., [11] had given the introduction of 5G and explore about 5G technology. Kelechi G. Eze et al., [12] explained the features of 5G and also presented a brief introduction to 5G technology. Opeoluwa Tosin Eluwole et al., [13] explained about 1G to 5G technologies with its characteristics of each and also enabling technologies of 5G with current technological trends. Damanpal Singh et al., [14] define the communication technology with present and future impact, usage of technologies, and the introduction to 5G along with technical details. Naveen Chhaganlal Rajput [15] explained the requirements of 5G and services provided by 5G. Subhash Chander Verma et al., [16] described the human and environmental effects caused by using 5G technology. And also discussed the harmful effects of 5G radiations on various physical and mental health perspectives including environmental issues. Sofana Reka et al., [17] exhibited the 5G architecture analysis and also focused on the smart grid with grid perspectives. Amit Kr. Jain et al., [18] presented the Overview of 5G, radio spectrum, the architecture of Cognitive Radio (CR), Ultra-dense radio access networks (UDRAN), Software-defined networking (SDN), Software-defined radio (SDR), mixed infrastructure, and also impact of 5G network on the Society. Tian Qin et al., [19] enable the history of 5G, working, enhanced capabilities, 5G Impact, Equipment Providers in 5G technology, and its health effects. Pekka Pirinen [20] explained the basic building blocks of the 5G core system and its main challenges and tackling methods along with its capacity boosting technologies.
In this paper, Section 2 deals with a general view on 5G wireless technology along with its comparison with 4G and the general architecture of 5G. The discussions about key enabling core technologies are presented in section 3. Harmful effects on different issues using 5G are explained with the role of specific absorption rate are described in section 4. Finally, the last section presents conclusions about 5G wireless technologies.

2. A General Review on 5G

2.1. Comparison of 4G and 5G Wireless Mobile Technology

|                  | Fourth Generation (4G) | Fifth Generation (5G) |
|------------------|------------------------|-----------------------|
| **Specification**| Start/Deployment       | By 2020               |
|                  | 2010-2020              |                       |
| **Data rate**    | Up to 100 Mbps         | >1Gbps                |
| **Technologies used** | Unified IP, integration of broadband, LAN/WAN/PAN/WLAN | 4G, OFDM based technologies and IPv6 |
| **Multiplexing technique** | CDMA | CDMA, BDMA, FBMC |
| **Switching technique** | Packet Switching | Packet Switching |
| **Core network** | IP Networks            | Flatter IP network, 5G network interfacing |
| **Frequency**    | 2-8GHz                 | 3-300GHz              |
| **Standard technique** | IP based on LAN/WAN/PAN | IP based on LAN/WAN/PAN+WWWW |
| **Antenna**      | Sub Wavelength Antenna | Array Antenna         |
| **Radiation pattern** | Omni-directional | Fan-beam Directional |
| **Diversity &MIMO** | Present               | Present               |
| **Services**     | HD streaming, global roaming, wearable devices | HD streaming, Devices with AI, wearable devices |

2.2. 5G Network Architecture

Figure 1. Schematic diagram of 5G Architecture
Network architecture for 5G mobile systems is shown in figure 1. Different RANs (Radio Access Networks) supported by 5G is LTE, GSM, Wi-Fi, Wi-Fi-MAX, etc. can use the same single Nano core for communication because it uses the flat IP concept. 5G aggregator aggregates all RAN traffics and routes to a gateway which is located at BSC/RNC. IP network reduces network elements in a data path that reduce cost. 5G nano core consists of cloud computing nanotechnology and All IP network (AIPN), 5G network includes Flat IP architecture as an important part. All-IP Network (AIPN) is used for a competitive edge for both cost and performance. AIPN Nanotechnology is the application of nanoscience for process control on a nanometre scale from 0.1-100 nm. With the nano equipment in the 5G nano core features such as self-cleaning, self-powered, sensible to the environment are loaded. Cloud Computing is a technology that uses the internet and central remote server for maintaining applications and data divided into three segments as applications based on software services, deployment of internet, and infrastructure which is the backbone of the entire concept. 5G architecture contains a user terminal with many radio access technologies (RATs) which provides different services namely commerce, banking, government, health care in mobile applications and mobile portals, etc. via Cloud Computing Resources. Cloud computing is used for network access to configurable computing resources such as servers, network storage, services, applications and allows consumers to use applications with internet access without installation. Dealing with increasing different RATs is the main challenge and the convergence of nanotechnology, radio, and cloud computing is the Core that changes communication functions depends on user demands. Physical connection used for a radio communication network is known as Radio access technology (RAT). Each RAT within each terminal has an IP link and different radio interface in the mobile terminal for each RAT.

2.3. Used Technologies for achieving the required parameters in 5G

| Parameter                  | Used Technology                                      |
|----------------------------|------------------------------------------------------|
| Low Latency                | D2D, Het Net                                         |
| High Data Rate             | mm Wave, Full Duplex Communication, Het Net, massive MIMO |
| Low Cost                   | SON Architecture, Green Communication, Het Net        |
| High Connection Density    | Het Net, M2M                                          |
| High Energy Efficiency     | Green Communication, Het Net massive MIMO,            |
| High Spectrum Efficiency   | Full-Duplex Communication, massive MIMO              |

3. Core Technologies of 5G

3.1. Multiple Input and Multiple Output (MIMO)
MIMO plays an important function in 5G. By increasing the throughput and spectrum efficiency in a large-scale massive MIMO extracts the benefits of MIMO. MIMO combines multiple transceivers or antennas on both sides of networks and MIMO arrays of antenna have only a few antennas, this array contains multiple antennas used to beam shape and for transmitting signals directly to a particular direction. Reducing latency thereby increasing data rate directly meet goals of 5G and indirectly meet goals by allowing millimeter waves with low diffraction and high attenuation. Communicating using multiple antennas between two devices with each other are known as point-to-point MIMO. In wireless communication, MIMO is used for increasing the channel capacity of a radio link with multiple transceiver antennas and has WI-MAX and IEEE 802.11a standards, etc. MIMO is used to add more data to wireless channels, which can be used for increased reliability, energy, and spectral efficiency using antenna arrays or a large number of transceiver antennas. MIMO uses multipath propagation to transmit and receive data signals during the same time on the same channel. In this method, transmitting antennas are distributed for different applications whereas receiving antennas are
distributed for many devices. This method can be used to minimize noise and intracell interference. Due to these advantages, MIMO is an important concept used in wireless communication.

Massive MIMO: massive MIMO used for increasing data rate by increasing 10 to 20 times spectrum efficiency in the same frequency range. High energy, spectrum efficiency are the two advantages of massive MIMO. MIMO systems are used to multiplex multiple signal streams and these are decoded at the receiver accurately. The channel characteristics are known to the sender and are estimated by using pilot sequences or reference signals. Each user equipment sends a pilot sequence to the base station periodically to know the wireless channel between user and base station in massive MIMO systems. Within the same cell and adjacent cell, the same pilot sequence should not be used by other user equipment since they may cause interference at the base station which results in inaccurate channel estimation.

3.2. Cloud Computing

![Service Layers of Cloud Computing](image)

SaaS: Software-as-a-Service; PaaS: Platform-as-a-Service; IaaS: Infrastructure-as-a-Service

For accessing four various RATs there should be four various accessing interface techniques in a mobile terminal, to function the architecture and all of them should be activated at the same. For enabling network access, convenient, ubiquitous to resources namely storage, servers, applications, services and networks with minimum service provider interaction or minimal management effort, Cloud Computing model is used central remote server i.e., content provider and internet for maintaining applications and data which also allows business, consumers can use applications with internet access without installation. Similarly, cloud computing allows the user for accessing a private account from a global content provider in multi-core technology using computing resource sharing. 5G is an enhanced technology mobile services and applications with full on-demand with the highest capacity also with high accessibility which also gains from different services like cloud computing, IoT, social networks, wearable devices, etc. A QoS model is dynamically configured with three models such as series, parallel, hybrid, and architecture are divided into three types namely PaaS, IaaS, and SaaS as shown in the figure. Google Compute Engine, Rack space cloud, and Amazon cloud Formation are the applications of IaaS and Salesforce, Microsoft Office 365, and Google Apps are the applications of SaaS. To define service for users of storage and servers, this service model is used. Microsoft Azure, Amazon Elastic Beanstalk, and Google App Engine are the applications of PaaS.

3.3. Internet of Things (IoT)

IoT is used for connecting various devices and also with people any place, any time, anyone, and with anything as a dynamic network crossing boundary of a traditional network. For enabling advanced services by interconnecting existing and evolving technologies for interoperable information, IoT is used as a global infrastructure. IoT architecture has evolved and provides communication between
many computers using computer networks, and to connect all computers worldwide as World Wide Web (WWW). Interconnecting different electronic device users with computers are established by connecting to cloud network are further technological advancements. Three layers of IoT contain the perception, network, and application layer. Middleware layer, coordinate layers with a large number of layers are formed as middleware-based IoT architecture and the perception layer is formed by combining the access layer and the edge technology. Unlike, middleware-based architecture, Service-oriented architecture (SOA) consists of five layers such as objects layer, object abstraction, service management, service composition, the application layer. However, architecture for common IoT networks consists of layers such as objects, object abstraction, service management, application, management layer. The objects layer is the first layer similar to the perception layer and IoT architecture contains heterogeneous devices in the network. The second layer is the object abstraction layer used to convey data generated by devices. 5G network uses different technologies for data transfer such as Bluetooth, RFID, Zig Bee, Wi-Fi, and UWB, and cloud computing is also used in this layer. The service management layer is used for application programmer management for processing generated data using any hardware. The application layer is used to provide services as requested by the customers and also provides different smart services like home, vehicle, wearable device, city, industrial automation, and health care. This layer also integrates the entire system for services like healthcare, traffic care management, and so on. In the network layer, the IMS server is connected to the M2M layer, gateway, and GPRS server are the main components. Using the Internet, the network and application layer are interconnected while using some protocol or a gateway network layer and infrastructure layer are interconnected. M2M server is updated by M2M devices using a network layer with information of M2M devices i.e., smart devices, body sensors, etc. Computation, security, large scale storage, ubiquitous protocol design, privacy, performance, and reliability are the main key challenges of IoT in 5G.

3.4. Heterogeneous Network (Het Net)

A network that establishes the connections between the operator’s network and application servers is called a heterogeneous network or a heterogeneous system and can be considered as a unified network. The increasing number of base stations in a region increases the number of cells that are used to support more mobile users. This network densification is used for the generation of several types of cells of base station transmit power and different coverage. The highest power is consumed by the macrocell base station, Pico cell and femtocell consumes less power. End-to-end latency is reduced with smaller cells which increases energy efficiency because its base station consumes less power than macrocells. Het Net combination of complex technologies used to find WLAN and cellular at the same time within the cell. For Internet access, the Wi-Fi access point connected to a cellular network can be used by a large number of Wi-Fi terminals. Cellular systems work in licensed bands and WLAN uses free, unlicensed frequency bands.
3.5. Cognitive Radio (CR) Network

This smart radio network can be used to change transmission parameters to establish multiple communications simultaneously and to detect available channels automatically for increasing radio operating behavior in a wireless spectrum. Cognitive radio network uses technologies such as software-defined radio (SDR) and adaptive radio. Different hardware components like mixers, amplifiers, modulators, and demodulators are replaced by intelligent software systems in Software-defined radio (SDR) whereas, in adaptive radio, the communication system changes its frequency and operates. To increase or maximize the utilization of the radio frequency spectrum Cognitive Radio is used. The ability to adapt parameters independently and recognizing the communication environment for maximizing QoS for second users is the main feature of cognitive radio.

Cognitive radio monitor’s spectrum bands which are formed as the cognitive radio cycle catches their information to detect spectrum spaces and characteristics of these spectrum spaces are detected using spectrum sensing. According to the user requirements and characteristics, a suitable spectrum band is selected, and using this spectrum band, communication is established after determining the operating spectrum band. Advance spectrum management, unlicensed spectrum usage, and spectrum sensing, etc. are some research challenges of cognitive radio.

3.6. Software Defined Networking (SDN)

![SDN Architecture for 5G Diagram](attachment:image.png)

Figure 4. SDN architecture for 5G
It is introduced for next-generation Internet and data networks which are defined in several ways. The clearest definition defined with Open Networking Function (ONF) deals with the development, commercialization, and standardization of SDN. SDN is defined as an architecture that is manageable, adaptable, low cost, dynamic in which control is decoupled and directly programmable for application and network services, and underlying infrastructure. SDN consists of a centralized controller and separated control and data plane which can be used to support multiple functionalities. The general functionalities of SDN are flexibility, granularity, centrally managed, programmability, open standard-based, dynamic control ability, protocol independence.

The architecture of SDN: SDN is divided into different layers such as control, an application, infrastructure layer are explained as below:

3.6.1. Control Layer. It is known as a Control plane that maintains a link between the infrastructure layer and application layer through open interfaces. For allowing the controller to interact with other layers three communication interfaces such as east/westbound interfaces are used for communicating with controller groups, for interacting with the application layer northbound interface is used, and interacting with the infrastructure layer southbound interface is used. Providing different service access points, importing packet forwarding rules and network status are the functionalities of the communication interfaces.

3.6.2. Application Layer. To fulfill user requirements, this layer is designed and contains end-user applications. SDN applications such as security, dynamic access control, migration, mobility, network visualization, load balancing, and cloud computing can access and control switching devices through control plane interfaces at the data layer.

3.6.3. Infrastructure Layer. This contains routers, wireless access points, physical, virtual switches which comprise the data plane and responsible for network collection, storing temporarily and to send stored data to network controllers and also to manage packets according to administrators or network controller provided rules that allow SDN to perform forwarding and packet switching through an open interface. For physical network communication SDN layers consists of switching devices that are interconnected using cloud networks, optical wires, and optical cables, etc., and maintains the connection through a south-bound interface with the controller. Open Flow is used as a south-bound interface in most SDNs and it is a flow-oriented protocol that has port abstraction, switches for flow control.

4. Harmful Effects Using 5G

4.1 Health issues on Human

Skin or human tissues are the basic effects of radiation, millimetre waves are absorbed within 1-2 mm of skin and on the surface of the cornea. Hence, mm-wave bio-effects are transmitted through the skin or nervous system. The high spectrum range of 5G leads to mutation of cells which creates tumors and results in cancer. The Effects of Radiation using 5G are shown in figure 5.

![Diagram](image)

**Figure 5. Effects of Radiation using 5G**

Eyes receive more radiation and risk factors for cataract development include smoking, diabetes, age, UVB exposure which lead to blindness. Microwave radiation is another cause of cataracts in which eyes lack enough flow of blood to dissipate heat. More research is needed on repeated exposure to radiation that causes an effect on cataracts. 5G spectrums also induce electromagnetic sensitivity which has characteristics such as lack of concentration, headaches, depression, dizziness, insomnia,
nausea, and heart palpitations. If morphological, EMR, electrophysiological, and chemical changes occur, then the brain or nervous system is disturbed in which behavior changes occur. Short-term health issues such as aches and pains, headaches, burning sensations, anxiety, stress, irritability, and long-term issues such as cancers, brain tumors, fragmented DNA, mutated cells, neurological problems, and Electrical sensitivity problems such as sleeping, cognitive impairment, concentration, or memory loss, brain fog, etc. are caused due to radiation effects.

4.2. Issues on Environment
The horrible frequencies generating from devices are killing birds, other wildlife from areas saturated with 4G “non-ionizing” radiation. Next is mankind, for any amount of time, no life withstands using 5G. The damage in a plant because of radiation can be computed by the amount of radiation absorbed with time and results in reduced sperm germination.

4.3. Health Issues on birds and animals
Birds abandoning their nests and health problems such as locomotion, plumage deterioration, death, reduced survivorship since the implementation of 3G technology. This non-ionizing mm-Wave radiation affects bird species such as Rock Doves, House Sparrows, Collared Doves, Magpies, White Storks, and others. Not only are the birds, but the bee population also declined due to this non-ionizing EMF radiation. In November 2018, there has been an incident in the Netherlands that 287 birds were killed because of experimenting with the 5G implementation.

4.4. Thermal Effects using 5G
EM radiation is converted into heat, causing the effect of radiation is tissue heating i.e., thermal effect. Biological systems alter their functions with temperature changes. The charged particles oscillate and gain energy, when electromagnetic radiation incidents on a matter which is immediately re-radiates and appears as scattered, reflected, or transmitted radiation. Intense radio waves can cook food and can thermally burn living tissue.

4.5. Specific Absorption Rate (SAR)
SAR is defined as the rate at which radiation is absorbed by the human body and is measured in watts per kg(W/kg). If the temperature about 1 to 2 °C exceeds this capacity causes tissue damage. Regulating agencies must define SAR level values for handsets and every mobile phone must have a SAR rating. Organizations developed safety measures for RF exposure and radiations which depend on the antenna, its design, how it is held and used. The SAR values for various mobile handsets are tabulated in table3.

Table 3: SAR Values for Various Mobile Handsets

| Manufacturer/Brand | Model/Series | SAR Value (W/Kg) |
|--------------------|--------------|-----------------|
| LG                 | Phoenix4, Risio3, X Power3 | 1               |
|                    | Xpression Plus           | 1.04            |
|                    | Aristo2 Plus             | 1.05            |
| Tambo              | TA-1                     | 1.019           |
| Vivo               | BLU XL4                  | 1.03            |
|                    | BLU XL3                  | 1.04            |
| Mobistar           | C1 Shine                 | 1.037           |
| Samsung            | GS10+                    | 1.04            |
| Xiaomi             | Mi9                      | 1.04            |
5. Conclusion

This paper discusses a general review on 5G wireless technology along with its comparison with 4G, general architecture of 5G, detailed explanation about core technologies, and also harmful effects on different issues using 5G and concluded that 5G technology is used to interconnect all terminals, networks, multiple wireless technologies, applications simultaneously and used as intelligent technology. 5G wireless technology also creates harmful effects on different issues such as human health issues, environmental issues, health issues on birds and animals, and also thermal effects. So, there is a need for regulating agencies to define SAR values for handsets and every mobile phone must have a SAR rating.

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