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A Review Of 5G Technology: Architecture, Security and wide Applications

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Abstract - *The eventual goal of the forthcoming 5G wireless networking is to have relatively fast data speeds, incredibly low latency, substantial rises in base station's efficiency and major changes in expected Quality of Service (QoS) for customers relative to the existing 4G LTE networks. In order to deal with state-of-the art technologies and connectivity in the form of smart cell phones, internet of things (IoT) devices, autonomous vehicles, virtual reality devices and smart homes connectivity, the broadband data use has risen at a fast rate. Further, to meet the latest applications, the bandwidth of the system needs to be increased widely. This development will be accomplished by using a modern spectrum with higher data levels. In particular, the fifth generation (5G) mobile network seeks to resolve the shortcomings of previous telecommunication technologies and to be a possible primary enabler for future IoT applications. This paper briefly discusses the architecture of 5G, following by the security associated with the 5G network, 5G as an energy efficient network, various types of efficient antennas developed for 5G and state-of-the-art specifications for IoT applications along with their related communication technologies. We have also outlined the broader usage of 5G and its future impacts on our lives. Furthermore, at the end of each subtopic, the necessary recommendations are given for the future work.*

Key Words: **Device to Device (D2D), Millimeter-wave (mm-Wave), Internet of Things (IoT), Massive MIMO, Long Term Evolution (LTE).**

1. INTRODUCTION

The phrase "5G" directs to the fifth generation of wireless telecommunication technology that will have an epoch-making impact on many facets of life. Mobile network traffic continues to grow in a very rapid manner due to new mobile technologies, like; virtual reality applications, high-resolution video streaming and cloud gaming [1]. In a few years, the 4G services would certainly not meet the speed of the rise in traffic, as well as the anticipated demands of new scientific technologies, such as Unmanned Aerial Vehicles (UAVs), virtual reality and autonomous vehicles. Therefore, academia and industrial researchers have made many efforts to make 5G systems a reality in the near future [1]. Academia and industry have reached a consensus that 5G systems will use rising prominent technologies like network function virtualization (NFV) and software-defined networking (SDN) to achieve their goals [2]. 5G is far superior to the current network in terms of transmission speed. 5G will provide data transmission rates of up to 10Gbps, which is 10 to 100 times higher than 4G and 4G-LTE. 5G is expected to surpass ultra-broadband networks and combine existing technologies such as the Internet of Things (IoT), cloud, big data, artificial intelligence, and blockchain to support the creation of innovative services. In addition to improving speed, another significant feature of 5G is its lower latency. As a matter of fact, in the 5G era, the delay time is less than one millisecond (ms), which is almost equal to the zero data response time in the real world. In addition, unlike current Internet of Things (IoT) services, 5G is expected to release a huge Internet of Things. Not only that, based on the super bandwidth of 5G per unit area, connectivity per unit, coverage (near to 100 percent) and the ability to connect devices, an ecosystem can be established, where "smart networks" can be used for large medical devices and provide real-time interactivity [4]. Recently, global companies have taken the lead in the competition for the upcoming 5th-generation (5G) cellular technology, which is thought to be the most important source of revenue in the future [5]. The 5G network will be broadly introduced as a simple framework for hyper-connected mobile devices and will ultimately evolve into a modern 5GaaP (5G platform) platform [6]. Future technology in the 5G environment would create an "intelligent virtual power plant" that will optimize resource usage and incorporate energy use, production and trading. In addition, it is expected that 5G technology will make tremendous changes in the energy industry [7]. 5G is a profound network which is expected to solve or shall bring ease in solving the most crucial social problems like; current social problems, such as climate change, disaster safety and traffic congestion, and ignite the awareness of concept of smart virtual power plants in the energy sectors [8][9]. South Korea's 5G technology can be applied to real-time energy transactions between production and consumption resources, demand management of factories and buildings, and distributed resource management across the country [10]. Therefore, it is possible to analyze and predict energy production and consumption patterns using artificial intelligence engines with present real-time big data. The combination of digital twin technology and 5G technology enables system operators to perform optimal operation and control of virtual power plants through visualized energy production and energy consumption simulation, thereby balancing energy production and energy consumption within virtual power plants. Furthermore, by adopting blockchain technology, real-time secured energy transformation between energy producers and consumers can also be accomplished [11]. Figure 1 shows the multilayer system of 5G.

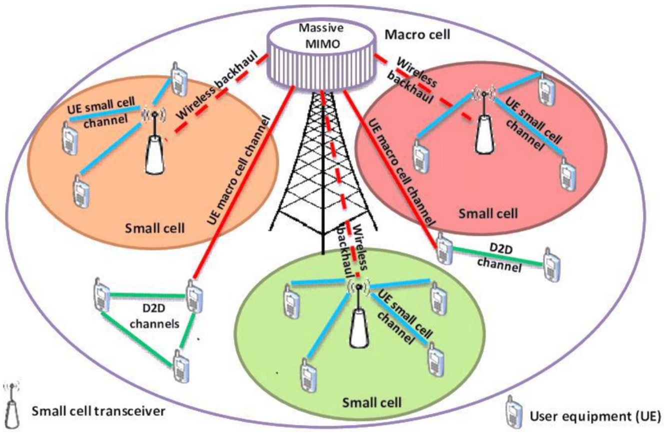


Figure 1. 5G multi-layer system engineering. The coming era of system development includes large cells (<3 GHz group).

Small cell (millimeter wave); femtocell and Wi-Fi; huge different information, mass production with shaft forming (M-MIMO); device to device (D2D) and machine to machine (M2M) correspondence relationship. Power bolts show remote (front pass) connections, while running bolts show return connections.

1.2 Use Cases of 5G

In the scope of 5G, three different types of usage cases are related like [12]:

- Enhanced-Mobile-Broadband (eMBB)
- Massive-Machine-type Connectivity (mMTC)
- Ultra-Reliable and Low-Latency Connectivity (URLLC)

- The eMBB refers to a much or less simple progression of the improved consumer experience in cell broadband, for example by encouraging still better customer efficiency.

- mMTC refers to facilities that are distinguished by a wide range of devices, such as remote controls, actuators and tracking of different systems. Main criteria for these systems involve extremely low system expense and relatively low computer energy usage, allowing for a very long battery life lasting at least a few years. Usually, each system absorbs and produces only a fairly limited volume of data, i.e. support for large data volumes is of less value. There may be other instances of usage that do not fall perfectly into either of these groups. As an instance, there could be programs that need massive reliability without the importance of latency requirements. Similarly, there may be cases of usage involving very low-cost equipment, but where the likelihood of a very long battery life might be less significant.
- URLLC (Ultra-reliable low-latency communication)

Systems for latency reactive tools for applications such as industrial automation, automated driving, and virtual surgery. Such systems need sub-millisecond latency with a response rate smaller than 1 packet loss in 10^5 packets.

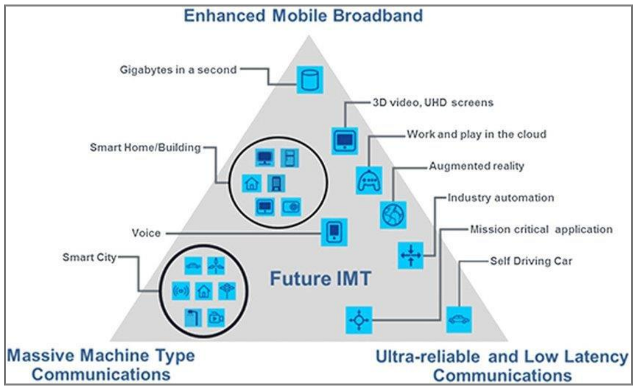


Figure 2. Use cases of 5G

2. ARCHITECTURE

2.1 5G E2E Network Architecture

Figure 3 shows the 5G E2E network architecture, which outlines the 5G E2E network, the same picture is shown in Figure 1, Figure 2 and Figure 3, but highlight dissimilar features. The base stations are mainly concentrated for the transition of 3G to 4G, due to bottlenecked wireless communication from base stations [13]. However, while transacting from 4G to 5G, the E2E architecture of 5G network has much more significance because in the 5G network the base station is not the main bottleneck. The figure 1 shown below describes the architecture of E2E developed by Huawei for 5G [14].

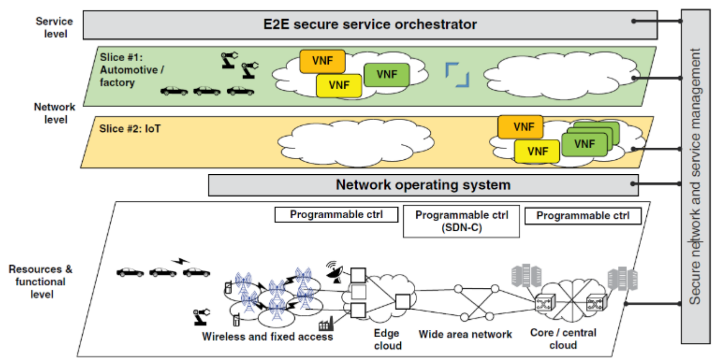


Figure 3. Architecture of E2E in 5G

2.2 Network Slicing Architecture

Several autonomous service level agreements are being offered by Network slicing architecture in order to meet the necessities. A network slice can be categorized into two categories: one for RAN network slice subnet instance (NSSI), and the other for CN NSSI. A slicing network can provide several various services at a time, and the network slicing network and service are independent. The figure 2 below shows the 3GPP diagram of slicing network. The 3GPP specifications of slicing network have been described in detailed in [16]-[18]. The 3GPP specifications are mentioned in the figure 4 below from [19].

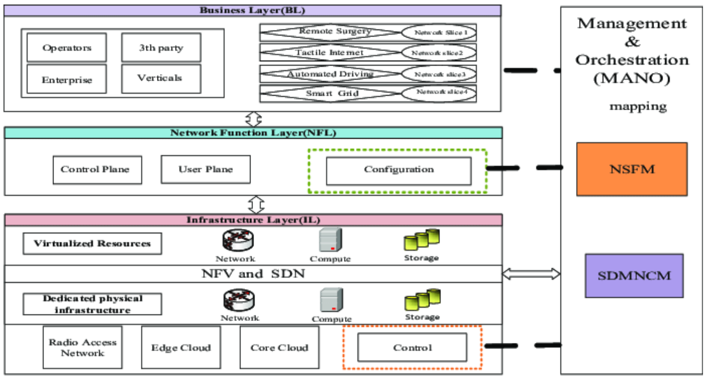


Figure 4. Network Slicing Architecture

2.3. vEPC Network Functions

vEPC is a network and stands for virtual evolved packet core. Virtual Evolved Packet Core (vEPC) is an outline for switching and processing data for mobile networks. Multiple virtual network functions (VNFs) virtualize the functions of LTE evolved packet core (EPC). The reductions in the construction cost and the ability to quickly deploy service environments are offered by virtualization. The functions of LTE evolved packet core (EPC) are compared with the components of evolved packet core vEPC in the Figure 5 below.

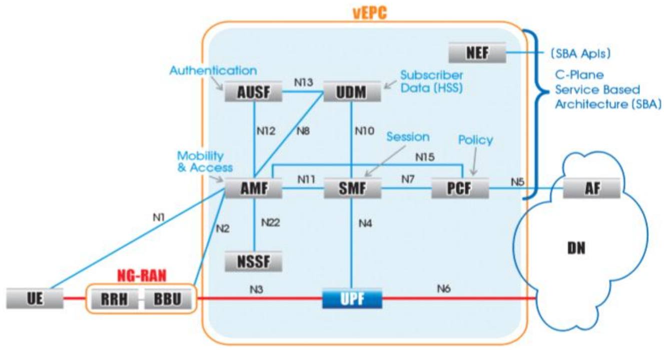


Figure 5. vPEC Achitectuure

2.4 NFV MANO (Management and Orchestration)

Management and Orchestration (MANO) are a significant component of the European Telecommunications Standards Institute ETSI network functions virtualization (NFV) architecture and they published the NFV system architecture framework [20]. Management and orchestration (MANO) coordinates network resources the lifecycle management of virtual network functions (VNFs) and for cloud-based applications and network services and it is an architectural framework. It is shown in Figure 6 from [21] based on the ETSI framework; many open source organizations have developed their own NFV MANO frameworks.

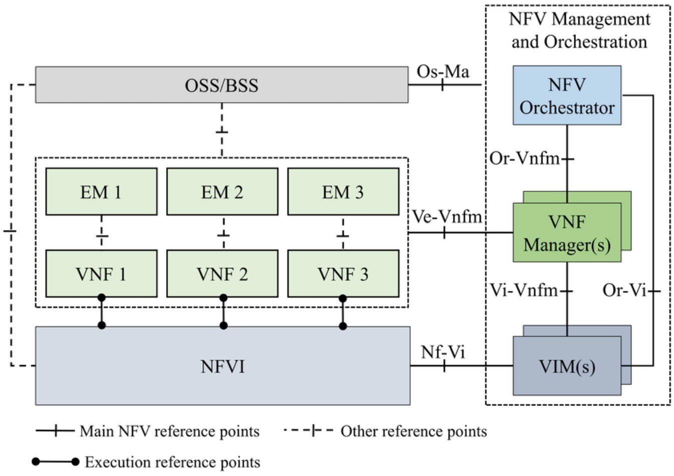


Figure 6. ESTI NFV Architecture

2.5 5G Mobile Network Architecture Design

Figure 7 demonstrates the system model that incorporates the design of the network infrastructure for 5G mobile networks, an all-IP model for wireless and cellular network interoperability. The architecture contains a computer terminal (which plays a crucial role in the current structure) and a number of independent, self-reliant radio system technologies. Any of the radio approach technologies is noticeable in each terminal due to an IP hyperlink to the outside environment of the internet. However, through Radio Access Technology (RAT) inside the mobile terminal must have a separate network interface. For e.g., if there is a need to reach four separate RATs, we need to provide four different approaches to similar interfaces inside the mobile terminal, and make all these interfaces active at the same time, so that the architecture can work properly [17].

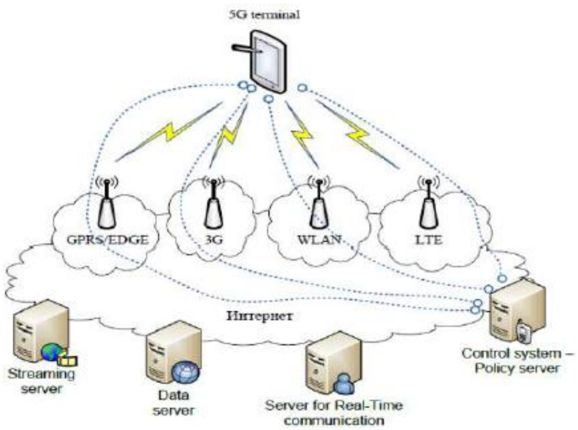


Figure 7. Functional Architectre of 5G

2.6 5G Architecture based on NGMN Envision

Based on the envisions of NGMN the architecture of 5G is presented in figure 8 which leverages constructional separation between software and hardware. APIs are given to support multi use scenario and business model. The architecture is demonstrated in figure below from [185].

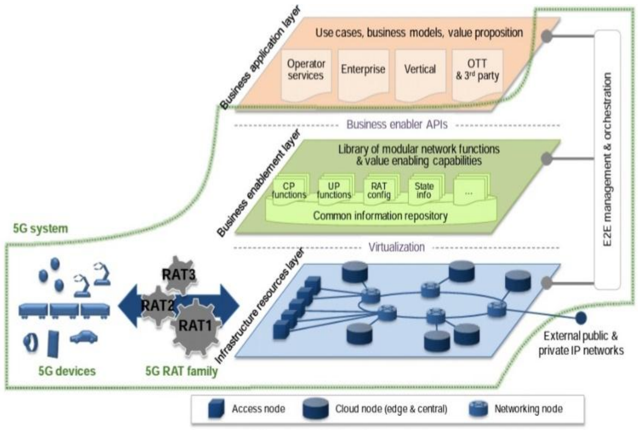


Figure 8. Architecture of 5G

RECOMMENDATIONS

In this section we recommend the following areas to be worked on for the architecture development for 5G.

a. Data Forwarding Efficiency

The benefit of a virtualized network focused on NFV technologies and common equipment is the simplicity needed by the service scenarios. For single machines, the price of basic hardware is smaller than the price of specialized hardware dedicated technology, though, typically utilizes technology acceleration techniques that can increase forwarding performance. In order to achieve the same data forwarding efficiency, more standard hardware than specialized hardware is required at the current technology stage. That often implies more space and more energy use. As a consequence, virtualization systems may be used first in the control plane.

b. Fixed and mobile convergence after SDN

Since all fixed and mobile networks have implemented SDN technologies, to know if the communication systems of the two networks are incompatible and what are the differences? How to obtain efficient control and optimal routing is to be discussed in increasing potential user-plane forwarding process and delivery scenario. How to obtain efficient control and optimal routing is to be discussed in increasing potential user-plane forwarding process and delivery scenario.

c. Network capability exposure

This is not originally intended for 5G. However, in the 5G period, the exposure of the network capacity would be broader and greater, coupled with the centralization of the network control functions. For simple network connectivity, usable APIs and interfaces between the network visibility module and the required network features need to be further specified.

3. 5G-ENERGY EFFICIENCY

The current 5G structure indicates that energy utilization can be decreased to 10 percent contrasted with the present 4G systems. It includes the reduction in the power requirements of wireless base station antenna and client devices (such as smartphones, tablets, and Internet of Things (IoT) devices) to broaden battery life [22]. Nowadays, the key component for designing communication network is energy consumption, based on this factor the networks are being developed. [23] On account of the transformation of technology, the data traffic in today's era is increasing every day, due to this the round-trip time delay of the data packets raises higher in the network [24] which is turning into a more noteworthy issue for the energy costs on 5G systems. The cell systems are the fundamental source of increment in energy utilization in the telecommunications sector [25] The rapid energy consumption is the major challenge in meeting the green environment targets and reduction in the cost of system. Heterogeneous network is a new trend which is increasing day by day in order to enhance coverage, capacity and power savings in the upcoming 5G network [26]. The necessity for energy consumption goal and operation will be significantly much more urgent with the advent of the fifth age of wireless systems with hundreds of thousands progressively base stations and multi millions of linked gadgets [27][28]. It is expected that before the end of 2020, mobile access systems will encounter critical difficulties when compared with the today's circumstances. Traffic volumes are expected to be much higher than the current rate and number of associated gadgets will be 10-100 times higher than today in the network. One of the enormous difficulties is to give 1000-fold increase in capacity for billions of gadgets in a moderate and economical manner [29]. Energy use of the network is a crucial consideration to reduce the total cost of ownership (TCO), including the environmental impact of networks. This capability is the core design concept of 5G [22].

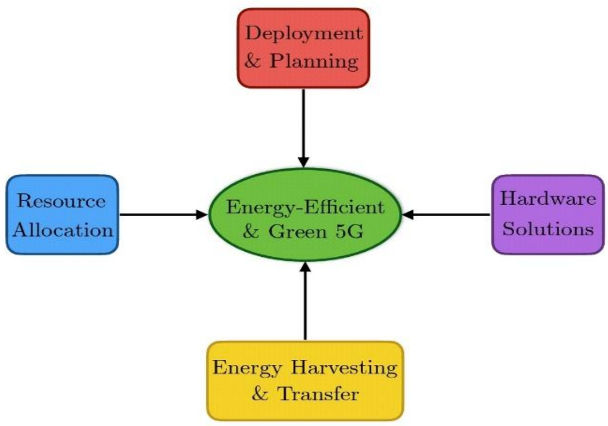


Figure 9. 5G Energy efficient

Energy efficiency is defined as the number of bits that can be transmitted per Joule of energy, where energy is measured across the whole network. The 5G network will accommodate a 1,000-fold rise in traffic in the next 10 years, although the energy usage of the whole infrastructure is just half of the existing system's consumption [29]. This drives the need for an improvement in energy efficiency of x2000 in the next 10 years. Every practicable effort must be made to gain energy without debasing efficiency, but the technology should allow native flexibility for the operator to configure trade-off between the performance and vs the energy [30]. There are different facets which make 5G network as an energy efficient network for the future [31] [32]. We have illustrated some of the parameters below.

- Sleep mode
- High network data rate
- Dense small cell deployment.
- Full Duplex
- Massive MIMO Antennas
- Millimeter-wave frequency band

3.1. Sleep-Modes

The base station adjusts itself in to sleep during the gap in activities on network, thus reduces power consumption [33]. As the base station uses for even in high mobile networks doesn't surpass 20 percent so the gadgets in new base station enter into the sleep mode [34]. Most of the base stations remain idle for throughout the period of 24 hours and almost 80% of the power in any versatile mobile system is utilized by the base station in 24 hours, they can go into sleep mode rapidly and remain for as long as possible [35][36]. A technique to execute an advanced sleep mode is discussed in [37], the idea of advanced sleep modes compares to a continuous deactivation of the base station's parts so as to diminish the utilization of energy. The [38] author proposed a methodology to execute the advance sleep modes and to oversee clients whose administration demands happen while the base station is in drowsy mode. As the base station needs to wake up occasionally to send flagging blasts [39], the author introduced a procedure to build the periodicity so as to augment the energy gains [40]. The paper [41] demonstrates system level simulation findings for hypothetical base station energy savings using a time-triggered sleep pattern. Millimeter power-saving modes of differing power consumption and deactivation/activation periods, in these modes base station does not transmit or receive something else that reacts to approaching DL user traffic by waking up [42]. When the base station awakens, the procedure is switched, subsystems and segments are in effect step by step activated. Numerous types of energy maintenance strategies based on the macrocells level have been investigated in [42], among various strategies, the sleep mode is one of them. Sleep mode is the desirable type of small cell due to its low expenses in the femtocells [42]. It is a lower power middle range state where it is switched off for only partial degree [33] presenting energy storage while not being required and activate a rapid turn back to full service. This ensures improved effectiveness for either the individual data rate or the total collection capacity and power savings. Components of the femtocell turn off separately in [42] [43] from the ones required for sensing user activity and the backhaul network connection in order to turn ON the femtocell. Sniffer is used for detecting, it detects rises in received power on the uplink, demonstrating a user-macrocells connection. The sniffer must wake up the femtocell by setting a threshold value for desirable range so, whenever the proposed range is reached, it should be triggered. Likewise, the extra number of signals because of rest mode incorporation and the handover is more than accommodated by the decrease of functionalities of femtocells in the rest mode [43]. This technique permits segments to be triggered off as found in Table 1 [42], for example, segment of the field programmable door cluster (FPGA) related memory and the radio recurrence (RF) transmitter. The "sniffer" is determined to have a yield of 0.3W. Savings among the two modes is derived as:

$$P_{savings} = P_{micro} + P_{FPGA} + P_{receiver} + P_{transmitter} + P_{amplifier} - P_{sniffer} = 4.2W \quad (1)$$

This suggests the power consumption of 40%. The subsequent arrangement is centered around a controlled rest mode [42]. In Long Term Evolution Advanced (LTEA) the central network finds links and searches through the mobility for the suggestive femtocells that are used for wakeup sign connected by the user. It has the vantage of swapping any part of femtocell from the backhaul circuitry and microchip by saving up to 70 percent of power. For proficiency markers, the author agreed to LTE-A, utilizing the Orthogonal Frequency-Division Multi-Access (OFDMA) for versatile sharing of spectrum, and follow the LTE-A criteria for urban zone parameters, for instance, the route loss [44], the author considered its area for the femtocell's power. In co-channel, the efficient scope of femtocells depends upon the femtocell-macrocells. Therefore, the power of femtocells towards coverage radius is constant [45]:

$$P_f = min(P_m + G - PL_m(d) + PL_f(r), Pmax) \quad (2)$$

Where $PL_f(r)$ is the way misfortune at the objective separation r, Pm is the influence of the nearest macrocells and G is the reception apparatus gain. $PL_m(d)$ is a macrocells heading consumption of maximal quality at the femtocell hole d and Pmax. The sign to-obstruction in addition to commotion proportion (SINR) of the client u is then gotten from subcarrier k:

$$SINR_{u,k} = \frac{P_{B,k} G_{u,B,k}}{N_0 \Delta f + \sum_{B'} P_{B',k} G_{u,B',k}} \quad (3)$$

Where PB, k is the user base station B transmission limit on subcarrier k, and Gu, B, k is the channel gain between user u and its control cell B on subcarrier k. In a similar way, PB, k and Gu, B, k represent respectively the base station's gain and power. N0 is a light issue otherworldly level, at that point a characteristic issue ghastly power. what's more, Δf the sub-bearer separating. We at that point compute the client's ability on that subcarrier [46]:

$$C_{u,k} = \Delta f \cdot log_2(1 + \alpha SINR_{u,k}) \qquad (4)$$

Here alpha α is defined by α = −1.5/ln(5BER).

By setting βu, k = 1, when the k (sub-carrier) is assigned to user u and βu,k = 0. Based on subcarrier allotment, the overall output is [47]:

$$T_B = \sum_u \sum_k \beta_{u,k} C_{u,k} \qquad (5)$$

Table 1. Femtocell consumption

Hardware component	Consumption (Watts)
Microprocessor-associated memory	1.7 (0.5*)
FPGA-associated memory	2.0 (0.5*)
Other circuitry	2.0
RF transmitter and receiver	1.5*
RF power amplifier	2.0*

*Parts that are switched off during sleep mode

The table shown above displays the consumption of power in watt by various components. It is drawn by collecting data from [48].

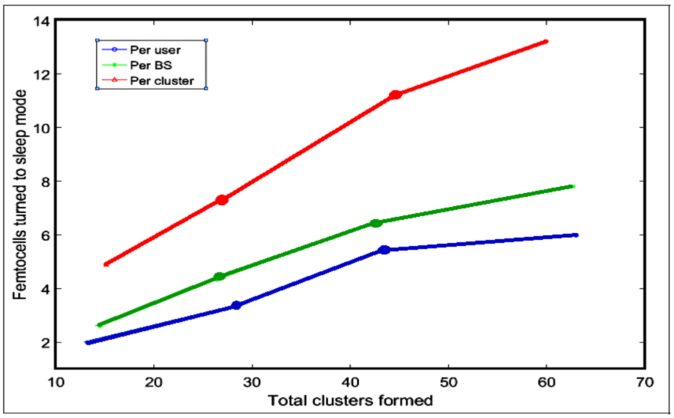


Figure 10. Graph of deployment density versus the no: of femtocells triggered to sleep mode

An advanced sleep mode has been structured in [49] which is extended form of sleep mode. The advanced sleep modes implementation consists of closing down the base station components gradually into segments starting from the lowest level requiring a short activation delay until the deepest one. An advanced sleep mode was initially tended to by IMEC and currently is being considered for the standard so as to characterize the New Radio for 5G systems. Furthermore, the idea of advanced sleep mode is discussed in [36], the idea is similar to save the energy consumption by turning the base station off into segments. The authors in [37][48] this propose a methodology to actualize the ASMs and to oversee clients whose administration demands happen while the BS is resting. The outcomes show that ASMs can extensively diminish the energy utilization (up to around 90% for low loads).

3.2. Higher Network Data Rates

5G services have a larger data output and a decreased packet latency [50]. A higher data rate denotes that due to 5G networks data transmission will be in a shorter time [51]. It would make the network link between the client and the base station idle for a longer period of time. These idle times allow longer sleeping modes. Millimeter wave telecommunication is a favorable technology for 5G wireless networks in the future because extremely high data speeds (several gigabits per second) can be provided for cellular devices [52]. The usage of millimeter wave telecommunication technology for device-to-device (D2D) communication over the network has been introduced by the authors in [53]-[55] and [56]. Multiple Gbps speeds for 5G network is supported by reviewed different technologies and Device to Device communication are highlighted by another author clearly in [57]. A space division multiplexing technology which will increase bandwidth capacity and reduce energy utilization for higher data rates is proposed in [58].

3.3. Dense small cell deployment

Small cells are controlled by operators, operating in licensed spectrum and are a collective term for low power consumption and low-cost base stations, high data rates can be provided by densely deploying them so as to significantly reduce the cell coverage to reach high spatial spectrum efficiency [59]. A large number of small cells must be deployed to achieve seamless coverage in urban areas and form a 5G ultra-dense cellular network [60]. Small cells may be of different sizes depending upon which they are classified as:

1. Femtocells 2. Picocells 3. Microcells

Small cells can have a central base station or a remote radio header, which can be wired or wirelessly connected to the core of network. This decreases the gap between the user and the base station and thus therefore decreases the transmitting power needed to resolve the no-path, particularly in the indoor environment, thereby enhancing the energy efficiency of uplink and downlink communications. To increase signal power and offload macrocells, it is necessary to deploy dense small cell [61]. Moreover, uncontrolled deployment of small cells may lead to uncontrolled cell shapes, in such case network operators have little control over the location of small cells [62]. We can provide a simple, cost-effective solution to the network capacity problem caused by the massive increase in mobile traffic, by using small cells for indoors and outdoors. Small cell with limited radius deployment is necessary for the improvement of spectrum and efficiency of the network [63].

3.4 Full Duplex

The fourth generation (4G) mobile communications network extensively uses Orthogonal Frequency Division Multiplexing (OFDM) as a physical layer technology [64], due to its higher band consumption, strong anti-interference ability and strong fading ability [65]. However, the physical layer of the fifth-generation (5G) mobile communication proposed to be having higher requirements for flexibility, reliability, spectrum efficiency, robustness and scalability [66]. Now Full-duplex network communications at the same frequency are being supported by advanced in signal processing electronics [67]. The early technologies required different frequencies to send and receive data simultaneously. To transmit and receive on the same frequency band at the same time of radio are enabled by full-duplex wireless technology, and it is considered to be one of the candidate technologies beyond the fifth generation (5G) and wireless communication networks for the following reasons. The benefits include the prospect of increasing bandwidth and enhancing spectrum efficiency. Nonetheless, the prevention of heavy self-interference is one of the key challenges of full duplex technology [68]. In [69] the author suggested a combination of massive MIMO (mMIMO) and in-band full-duplex (IBFD) as a possible 5G and higher technology, IBFD mMIMO can accommodate multiple uplink and downlink users with the same time-frequency tools, significantly improving the system energy [66]. Moreover, the author proposes that, by taking advantage of the new degrees of freedom given by IBFD's transmission. IBFD mMIMO can reduce the complexity of the base station design, due to a large increase in the number of antennas [71]. The high space target of the huge range of antenna array eliminates the trouble of SI drop required for IBFD transmission. Because of these favorable conditions, authors proposed the IBFD mMIMO framework as a key innovation to support simple development towards future 5G and higher networks [72][65]. The ongoing advances in system and antenna structure, the actual implementation of full-duplex communication has become rapidly feasible in the network [73].

3.5 Massive MIMO Antennas

For the mobile network operators, the energy efficiency of cellular networks is becoming more and more important [74] because it has a significant economic and ecological impact on future generation wireless networks, i.e. the fifth-age (5G) network [75]. As per the general assessment, 5G system will stretch the traffic quantity of multi Exabytes (10006 Bytes) in every month. Thus, it requires a lot of space for the system in contrast to the current system [76]. As the 5G system is likely to be 100 times faster than the current 4G system. Attempting to accomplish this eager objective depending on the ideal models and structures of present systems can't be supportable, so it shall probably prompt an energy crash with real environmental and financial concerns. Massive MIMO can enhance the efficiency of spectrum of wireless communication systems by more than 10 times [77]. To improve the energy productivity of MIMO communication some digital and hybrid precoding plans have been concentrated in [78]. Multi-input multi-output technique has an important role in present mobile telecommunications and will play significant role in 5G network. These technologies are necessary to meet the requirements for expanding data rates through increasing the utilization of the space domain. Massive MIMO is an advancing innovation upgraded from the current MIMO technology. The fundamental goal of enormous latest technology is to separate the advantages of MIMO for a bigger scope by expanding the throughput, spectrum effectiveness, and energy proficiency and diminishing the multifaceted nature into precoder/identifier [79]. The authors in [80] proposed an energy effectiveness improvement issue in detailed for 5G remote utilizing massive MIMO receiving wires and millimeter wave innovation. The massive multi-input multi-output (MIMO) is an evolving technology that is extended from the current MIMO technique [81][82]. The authors [83] introduced simultaneous wireless information and power transmission (SWIPT) technique and the goal is to boost the energy productivity.

3.6 Millimeter-wave frequency band

Due to the useful characteristics of the microwave spectrum, a huge number of communication systems are working on it below 03 Gigahertz [84]. Thus, it makes microwave spectrum excessively rare. 5G can handles such spectrum shortage as below.

Extra amount of spectrum is mandatory for higher network connectivity and capacity. Furthermore, mobile networks have enhanced or heighten the quality of service (QoS) by using supplementary amount of spectrum with wider width and higher frequencies. Hence, 5G shall also consume high amount of spectrum, for instance utilizing the millimeter-wave spectrum owing to its actual bandwidth available [85][86]. In accordance to the U.S. Governmental Exchange Commission (FCC), many groups in the millimeter wave band seem to be encouraging and may be the possibility of upcoming 5G portable frames [87], including 28-30 GHz, and 71-76 Gigahertz in the E-band , 81-86 Gigahertz and 92-95 Gigahertz free licensed bands of 60 Gigahertz and 12.9 Gigahertz. Therefore, due to access to a large amount of unused data transmission it relies on the 5G framework to utilize the 20-90 Gigahertz millimeter wave group [88][89].

Millimeter wave has completely different production conditions, environmental retention and equipment limitations, so this progress is gradual. These difficulties can be compensated by using beamforming and a larger cluster of receiving equipment. It is widely recognized that the millimeter wave band must be used with constrained cell scanning (<100 m) to limit the high path loss [90]. Fortunately, this activity is very suitable for a thin cell deployment model. Compared with microwave groups below 3 Gigahertz, high path loss is an important issue in millimeter wave 5G architecture. In general, the path loss is mentioned below in the equation 1.

$$L_{FS} = 32.4 + 20 \log_{10} f + 20 \log_{10} R \quad \text{------------------- (1)}$$

Here the LFS is known as the free space path loss and is given in decibels (dB) and carrier frequency is represented as f in Gigahertz and R is the distance in meters among the receiver and transmitter. This implies that there will be approximately extra path loss of 23 and 31 decibels which actuate the operating frequency from 2 Gigahertz to 28 Gigahertz and 70 Gigahertz, respectively. Along these lines, millimeter-wave could be utilized with profoundly directional radio wires in line-of-site (LOS) transmissions. A challenge in mm-wave at high frequency bands is the signal attenuation, this is a significant problem, since it limits strength of signal [91]. The water vapors and oxygen consume mm-wave energy [92]. The oxygen particle absorbs electromagnetic energy at around 60 Gigahertz; along these lines, the free licensed band from 57–64 GHz has high oxygen ingestion with around less than 15 dB/km [93].

4. SECURITY IN 5G

Higher coverage, and significantly batten the quality of service (QoS) and extremely lower latency and very high data rates shall be provided by upcoming 5G wireless networks [94] A large number of new devices related to Internet of Things (IoT), ubiquitous, machine-to-machine communication (M2M), ultra-reliable and affordable broadband access for cellular handheld devices and cyber physical system will also be provided by 5G [95]. These qualities indicate that 5G is not just an incremental upgrade of 4G that people naturally think of, but 5G is the amalgamation of new disruptive technologies that are cable to meet user traffic, emerging services, and the continuous growth of existing and future IoT devices Demand [96]. Because of the expected role of 5G and its influence on our lives, the security of 5G is even more important. Hence, huge efforts are required to ensure the security of the 5G network system, the users of the network system and the 5G network itself [97]. The important part 5G is evolution of LTE. However, progression of all parts of the network, like core and management systems, and all protocol layers from radio to applications will be included in 5G [98]. As a result, security may be affected anywhere.

4.1 Related Work

The authors in [99] proposes general mechanisms for strengthening 5G security. By reviewing the security requirements of LTE, the author outlined the security requirements for 5G in [99]. A good analysis has been presented on the security of current 4G network and future 5G network in [100]. The privacy protection solutions and the existing authentication for 4G and 5G networks is focused in the article. Paper [101] proposes possible mitigation techniques for the security challenges as well as standardization work for 4G and previous generations. The security threats and attacks on mobile networks have been investigated in [102]. Thorough analysis on security threats m, challenges in mobile access and core networks are focused in the article [103], however, the main challenge is related to the 4G network architecture. The paper [103] also considers various wireless access technologies, such as Bluetooth, Wi-Fi, WiMAX, and LTE, and discusses the inherent security restrictions and future trend for enhancing the security of each technology. Literature [104] investigates the security technology of 5G wireless networks for physical layer, the key area of this paper is the physical layer security coding, massive MIMO, non-orthogonal multiple access technology (NOMA), millimeter wave (mmWave) communication, heterogeneous networks (HetNets) and full-duplex technologies. In [105], a 5G security study compared to current or traditional cellular networks was conducted, here the security of 5G is investigated in terms of usability, confidentiality, key management and privacy identity verification. In [106], interesting work on future mobile network security research is presented, this work aims to deliver a comprehensive understanding of the security of mobile networks and to present some research challenges. However, because of the integration of large-scale Internet of Things and the collection of new technology concepts, the security challenges in 5G will be more diverse. The extended concepts of SDN, NFV, and cloud computing like multi-access edge computing (MEC) have many advantages in terms of their performance and total cost of efficiency, but these technologies all have their own security weaknesses [107]-[19]. The articles mentioned in the related work focus on particular areas. For example, [106] and [105] focus on authentication, [104] and [103] respectively address the security of the physical layer and air interface, [102] proposes access and core network security, and proposes LTE security. The security requirements of 5G [100] cover the privacy issues in future networks.

The table 2 shown below demonstrate the progression of security from 1G to 4G. It is modified from data collected from [126].

Table 2. Security from 1G to 4G

Network	Security Mechanisms	Security Challenges
1G	No explicit security and privacy measures.	Eavesdropping, call interception, and no privacy mechanisms.
2G	Authentication, anonymity and encryption-based protection.	Fake base station, radio link security, one way authentication, and spamming.
3G	Adopted the 2G security, secure access to network, introduced Authentication and Key Agreement (AKA) and two way authentication.	IP traffic security vulnerabilities, encryption keys security, roaming security.
4G	Introduced new encryption (EPS-AKA) and trust mechanisms, encryption keys security, non-3G Partnership Project (3GPP) access security, and integrity protection.	Increased IP traffic induced security, e.g. DoS attacks, data integrity, Base Transceiver Stations (BTS) security, and eavesdroping on long term keys. Not suitable for security of new services and devices, e.g. massive IoT, foreseen in 5G.

4.2 Overview of 5G design principles

The need for new design principles for 5G emerges with different kind of networks and hardware devices and new consumer criteria in terms of lower latency, higher capacity and global coverage [110]. Networks other than radio have different requirements, and these requirements are more about incorporating new technologies. For instance, th3e generic compostable core will use NFV and SDN to disintegrate the user plane and control plane and allow dynamic network function positioning [111]. The purpose of this is to minimize traditional networks and introduce new interfaces between the core and the radio access technology (RAT). The deployment of security mechanisms and functions (such as virtual security firewalls) when required on the periphery of any network must be supported by the network architecture of 5G. The most outstanding technology to simplify network management is SDN [112]. SDN separates the network control from the data forwarding plane and the control plane is logically centrally controlled to monitor the entire network below and control network resources by using a programmable Application programming Interface (API). However, in network device loop holes for security vulnerabilities can also be opened by centralized network control and the introduction of programmable APIs. Therefore, the security challenges associated with SDN are needed to be analyzed. Similarly, NFV and network slicing also face security challenges, such as joint conflicts and resource hijacking. Hence, the challenges of security related to all technologies used by 5G must be properly investigated. In the following subsection we briefly define 5G security architecture focusing on the security domains which is defined by 3GPP.

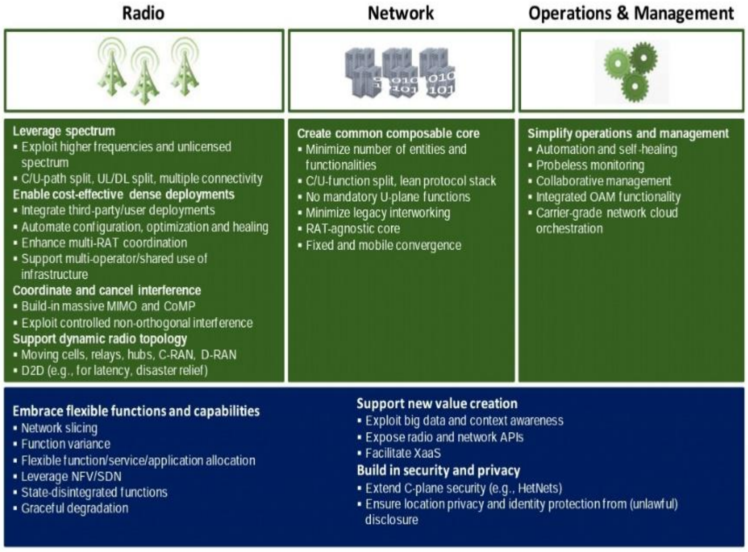


Figure 11. 5G design principles from [31]

4.3. 5G Security Architecture

The security features are logically divided by a security architecture into separate architectural components, according to The International Telecommunication Union (ITU-T) [113]. This allows a systematic methodology to end-to-end security of services, which helps to plan to assess the security of current networks and enable new security solutions. The 5G security architecture has been explained in the newest 3GPP technical specification release shows the security architecture and has the following key domains

4.3.1 Network access security

Comprises a series of protection parameters that enable the user-equipment to safely authenticate and access network resources. Service security requires the monitoring of 3GPP and non-3GPP communication systems and the transfer of security contexts from SN to the user-equipment.

4.3.2 Network domain security

Contains a series of security features that allow network nodes to securely share signaling and user-level data.

4.3.3 User domain security

Incorporates protection measures that enable users to safely access the user-equipment.

4.3.4 Application domain security

Contains security tools to allow applications (user and provider domains) to safely share messages.

4.3.5 Service Based Architecture (SBA) domain security

Including security functions for network element registration, discovery and authorization, and security of service-based interfaces.

4.3.6 Visibility and configurability of security

This includes notifying the user whether the safety function is running.

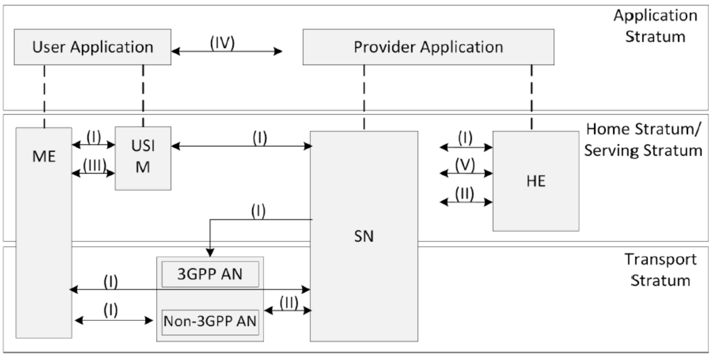


Figure 12. Overview of the security architecture.

The 5G security system in figure 12 itself does not recognize specific security risks and solutions to those threats [114]. Indeed, there are a range of current security solutions either come from past generations with enhancements or freshly developed in the 5G domain. The LTE security requirements are the starting points and are considered to be the safety guidelines for the potential wireless network. [115]. In any scenario, the high-level vision of 5G protection is focused on (i) Supreme built-in encryption, (ii) Versatile security systems, and (iii) Automation as specified by Nokia [116].

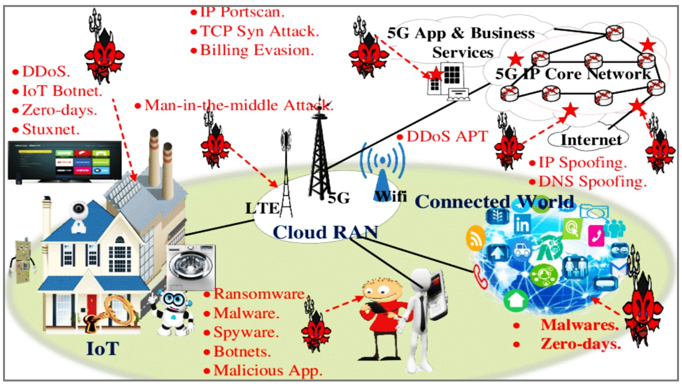


Figure 13. Security threats in 5G network

4.4. Security Recommendations by ITU-T

The Security Recommendations of the International Telecommunications Union (ITU) Agency for the Standardization of Telecommunications Sector (ITU-T) include a range of protection considerations to defend against all global security threats [113]. I The eight protection dimensions are not restricted to the network alone, but also include programs and end-user detail in fact, the security aspect applies to companies that provide services or service providers. Such security measurements are set out in Table. III with a brief summary. The following addresses how to protect the protection aspect of 5G. ITU-T Research Group 17 (SG17) was allocated to function and future health recommendations. ITU-T has established security standards for numerous relevant areas of telecommunications and internet infrastructure, such as Next Generation Networks (NGN), Internet of Things (IoT), and cloud computing [117][118]. ITU-T SG20 is dedicated to establishing guidelines and guidance for IoT technology, smart cities and communities [119]. In terms of protection, it partners with SG17 to establish health criteria and standards [120][121]. The key goal of ITU-T is to identify the possible threats to the protection of IoT-enabled networks and to include reasonable recommendations for coping with these protection attacks [122]. Further, ITU-T also makes recommendations on security concerns between consumers and cloud service suppliers [123].

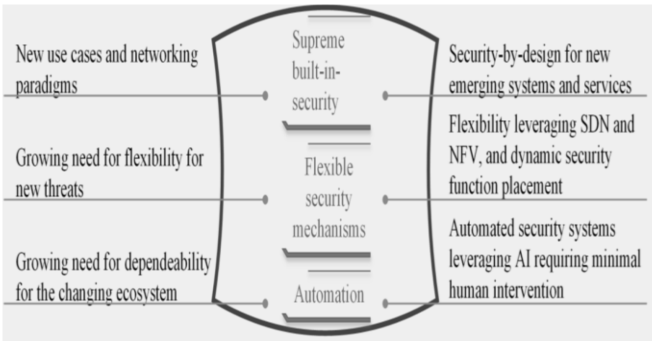


Figure 14. Objectives of 5G Security

4.5. Security Standardization

On the arrival of 5G network, all the walks of life, even companies outside the telecommunications industry such as automobiles are influenced with evaluating the security impacts of 5G. Therefore, various crucial organizations have made significant addition in to the fast development of security measures [124]. However, standardization is still in the drafting stage. The following are the most common standards.

- Next Generation Mobile Networks (NGMN)
- 3G Partnership Project 3GPP
- 5G Public-Private Partnership (5GPPP)
- Internet Engineering Task Force (IETF)
- National Institute of Standards and Technology (NIST)
- European Telecommunications Standards Institute (ESTI)

4.6. Security in Key 5G Technologies

The security and privacy issues in 5G may be easily highlighted when recognizing the key supporting technology in 5G. As defined in Section IV, large MIMO antennas, SDN, NFV and cloud networking principles such as Multi-Access Edge Networking (MEC) are the key facilitation and transformative developments concerned to previous generations. SDN, NFV and cloud infrastructure have rich literature in terms of security and these have been used in wired networks [125]. In this section, we only highlight the key technologies in terms of security for 5G.

- Security in massive MIMO
- Security in SDN
- Security in NFV
- Security in Cloud Applications

RECOMMENDATIONS

Since it is expected that the huge number of devices shall be connected with upcoming 5G network which includes massive number of Internet of Things (IoT) devices so these shall introduce new security issues and challenges for the 5G network. Currently three communication protocols are widely used which are based on cryptographic algorithms, like the Elliptic Curve Cryptosystems (ECCs). The communication protocols are; IEEE 802.15.4, standard IPv6 over low-power Wireless Personal Area Networks (6LoWPAN) Standard, and Constrained Application Protocol (CoAP). With the introduction of quantum computing and massive capacity of the network these protocols shall not be secured for communication. Following are the briefly defined recommended techniques for the strong security of the 5G network.

a. Security using software

Security functions implemented in software being able to be deployed in any network perimeter based on necessity, shall provide many opportunities to strengthen the network security. A number of firewall applications such as FLOW GUARD and OpenFlow firewall software can be Considered as the basic step towards softwarized security for Softwarized and virtualized networks.

b. AI-based Security

The monitoring and analysis of massive devices on network shall require self-adaptive intelligence system and such type of systems shall employ innovative algorithms and techniques of artificial intelligence, consequently, cyber-security may become one of the best application areas for AI. Security services such as authentication and access control need to be proactively carried out within the time constraints in order to meet the main service requirements such as service migration from one edge node to another. In doing so, AI shall play a critical role to timely identify the terminal actions and requirements to avoid service interruptions. Apart from this we can also use security automation and Blockchain security perspective techniques in order to further enhance the security.

5. ANTENNAS FOR 5G

5G mobile communications technology shall contribute higher data rate, higher security, lower latency and latest experience in to the environment and industry. The 5G shall make a notable change in our lives, despite of latest massive research on the antennas for 5G, there are still many challenges which require more efficient solutions [127]. The current antennas used in the existing wireless telecommunication systems uses capacitors, conductors and metal rods and therefore known as passive antennas [128]. Whereas latest antennas proposed for 5G network are known as active antennas and that is crucial technology which differentiate 5G network from the previous generations in terms of speed, latencies and security [129]. 5G network requires more complex antenna deployment and design accomplishments for the faster speeds and low latency [130]. After thorough literature survey following some of the efficient antennas for the upcoming 5G network are discussed along with their performance characteristics and efficiencies.

5.1 Three Notch Circular Patch Antenna

A three-notch circular patch antenna with millimeter-wave (Mm-wave) pin fed has been designed and analyzed by authors in [131]. The antenna work in the spectrum of 58.5-60.5 Gigahertz. It is compatible with the mobile station and has size of 5x5x0.1 mm3. The developed antenna has a radiation efficiency higher than 88% (percent) at the reverberance band and produces a reasonable returning loss of lower than-10 dB, three notch circular patch antenna has highest gain value of 7.839 decibels at 60 GHz frequency, it has form factor of 5x5 mm2 [132].

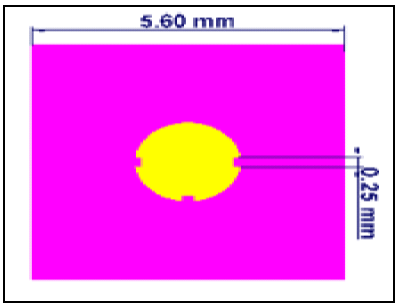


Figure 15. Circular Patch Antenna with millimeter wave Pin-fed

TABLE 4: Mm Wave pin-fed three notch antenna parameters

Parameters	Values (mm)
Substrate Height	0.100
Ground Plane Width	5.601
Ground Plane Length	5.601
Notch Width	0.25
Notch Length	0.125
Feed Pin Offset	0.305
Feed Pin Diameter	0.050
Coax Diameter	0.115

The S11 parameter of three notch circular patch antenna with millimeter-wave fed [131] is given below in figure 16.

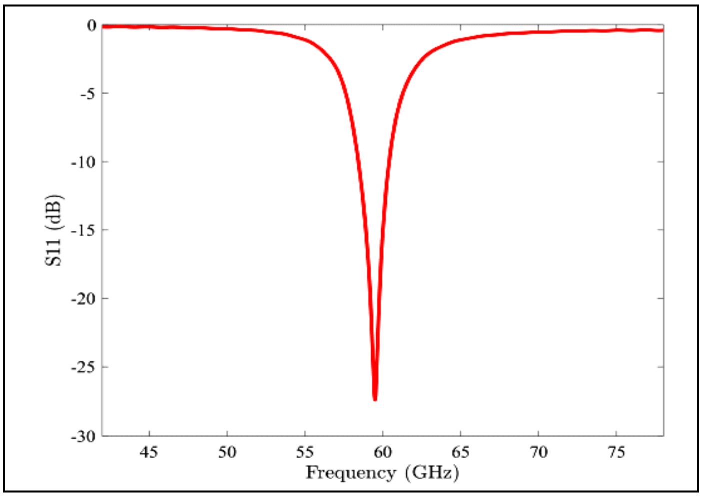


Figure 16. S11 parameter of millimeter wave pin-fed three notch circular patch antenna

- **Total Efficiency**

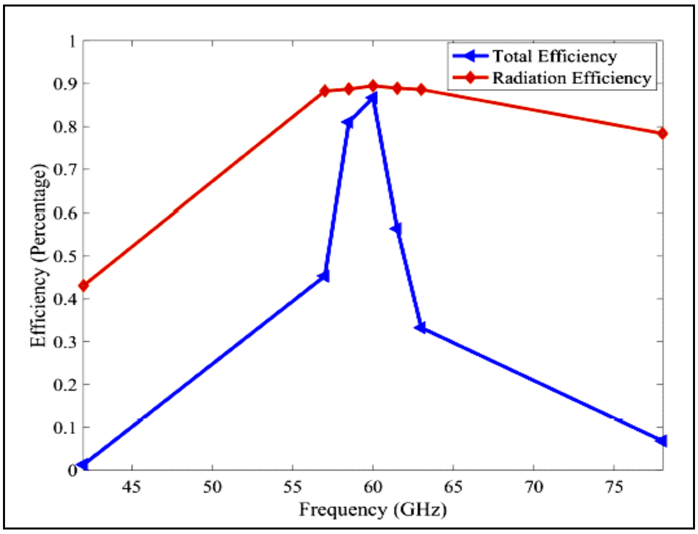


Figure 17. Radiation performance and overall output of three pin-fed circular patch antennas with a millimeter wave

5.2 Dual-Band Eight-Antenna Array Design for MIMO

This type of antenna technology consists of four pair of L-shaped slots and is based on SIRs. The dual band eight antenna array with multiple-input-multiple-output (MIMO) has been discussed and implemented in [133] for the future 5G mobile networks. The impedance ratio of SIR is the responsible for the dual resonance and gain of the antenna, so by adjusting impedance we can gain. The simulated design shows, the inter element insulation of higher than 11 decibels and return loss of higher than 10 decibels were gained. Over the long-term evolution (LTE) spectrum 42 (ranges from 3400 to 3600 MHz) and LTE spectrum 46 (ranges from 5150 to 5925 MHz), the total efficiency of the designed antenna was almost 51%. The suggested MIMO antenna array performed a simulated channel efficiency of more than 36.9 bps/Hz in both operating bands [134]. Furthermore, the calculated envelope correlation coefficient (ECC) is found to be less than 0.1 between arbitrary two antenna elements [134] [135].

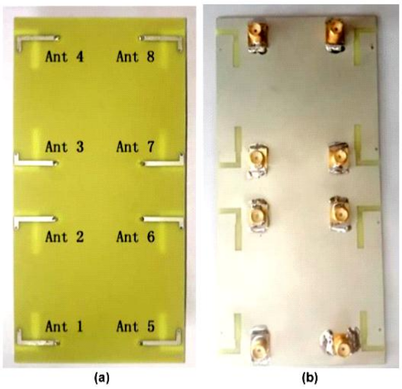


Figure 18. Dual-band 8 antenna prototype

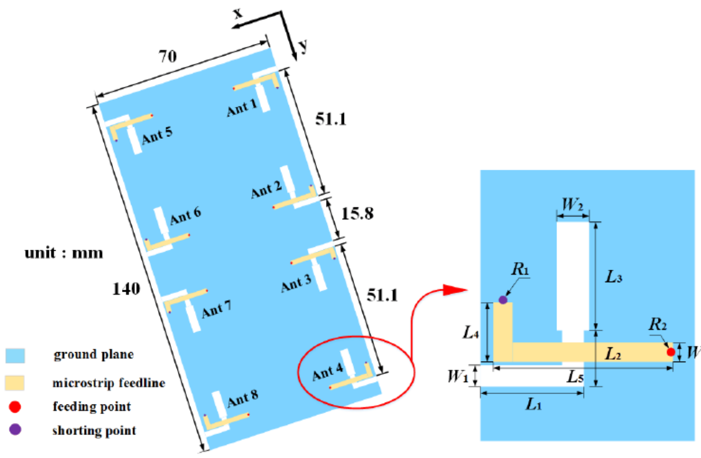


Figure 19. Configuration of dual-band MIMO antenna array

TABLE 5. Optimal Physical Dimensions of Each Antenna Element

Parameters	*L1* (mm)	*L2* (mm)	*L3* (mm)	*L4* (mm)	*L5* (mm)	*W1* (mm)	*W2* (mm)	*W3* (mm)	*R1* (mm)	*R2* (mm)
Ant 1/Ant 4/Ant 5/Ant 8	9.6	5.2	10.0	5.5	15.0	1.5	2.7	1.8	0.6	0.4
Ant 2/Ant 3/Ant 6/ Ant 7	10.0	6.3	10.0	4.3	15.0	1.5	2.7	1.8	0.5	0.4

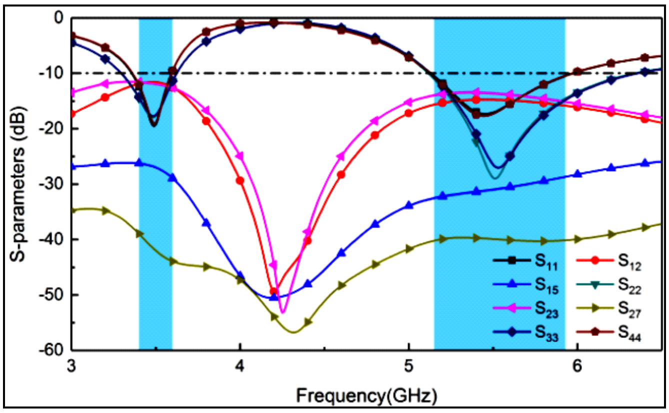


Figure 20. Simulated *S*-parameters of the MIMO antenna array.

It is necessary to remember that due to the symmetry of the design, only the simulated effects of Ant 1 to Ant 4 are seen. It is quite obvious that the return loss of the planned 8-port MIMO antenna system is greater than 10 dB in all frequency groups. The predicted subsequent surface current distributions of Ant 1 at 3500 MHz and 5500 MHz can be seen in Figure 21 to clearly show the two resonant modes of the SIR-based slot antenna feature.

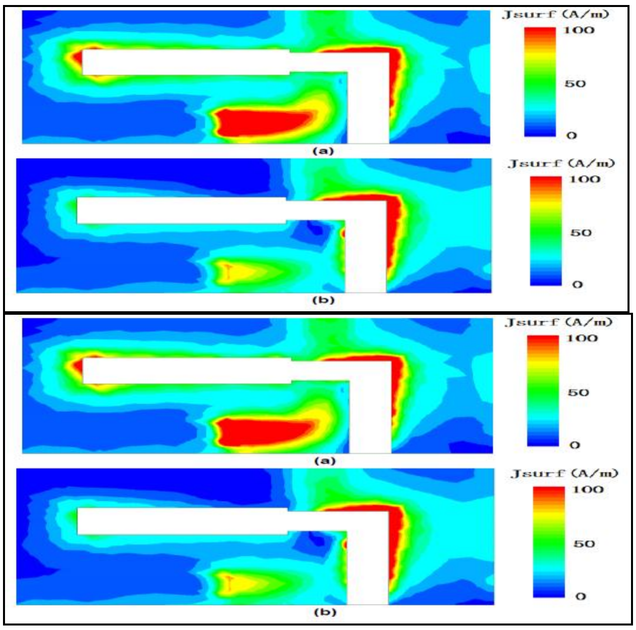
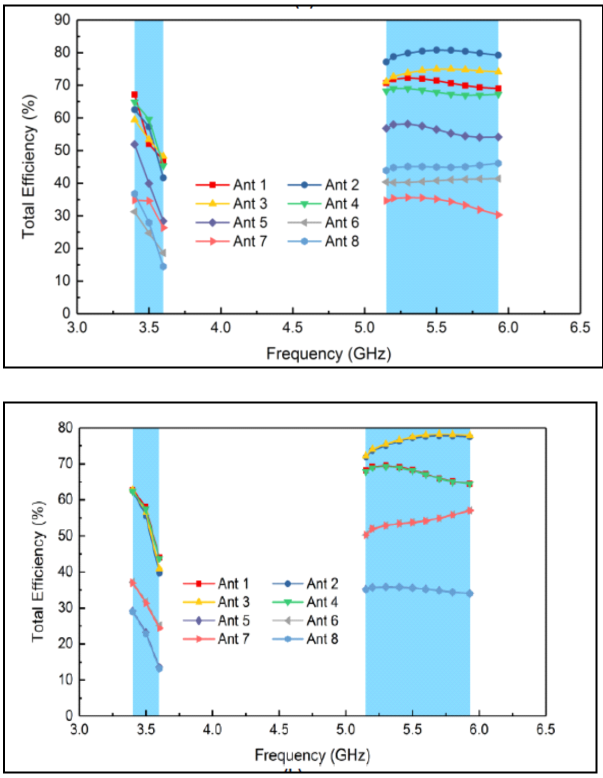


Figure 21. Simulated equivalent surface current distributions of Ant 1. (a) 3500 MHz (b) 5500 MHz



B

A

Figure 22. Simulated results of the proposed MIMO antenna array total efficiency with;(a) one hand, (b) two hands and Total efficiency

5.3 Leaky-Wave Antenna

The author in [136] proposed an efficient antenna for the 5G mobile communication network. In order to keep the characteristics of high-gain, planar structure, and simple-feeding, the leaky-wave antennas (LWAs) ultimately present a stimulating resolution for low-cost scanning and high-gain. The designed antenna functions in the mm-Wave band from 37- 43 Gigahertz. The design of leaky wave topology is well discussed in [137]. The final results of this antenna suggest that the efficiency of antenna is about 85%.

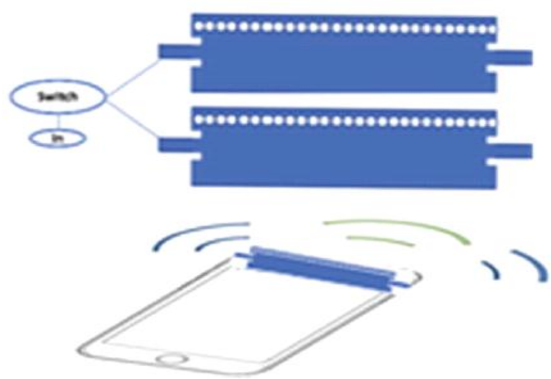


Figure 23. Leaky-wave Antenna Design

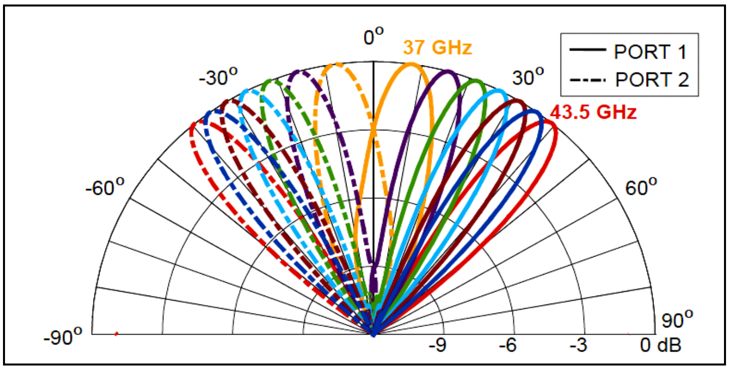


Figure 24. Scanned frequency radiation

5.4 Circularly Polarized Magneto- Electric Dipole Antenna

The author in [138] proposed a circularly polarized magneto-electric (ME) dipole antenna based on printed ridge gap waveguide (PRGW) technology which has high efficiency. The final results suggested the gain of antenna was more than 10 dBi on a frequency range of 31-35 Gigahertz, on 34 Gigahertz the total efficiency of about 94% was observed. For the optimal gain of antenna, a wideband lens was used. The lens used here consists of 3 layers with 3x4 mu-near zero (MNZ) unit cell on individual layer. The printed ridge gap waveguide (PRGW) is prominent technology for millimeter wave (mm-Wave) electromagnetic band. Mm-Wave band from 30-300 Gigahertz is the candidate of 5G radio cellular networks. Several designs of magneto-electric antenna in [139][140] are the base of the circular polarized magneto electric dipole antenna. The printed ridge gap waveguide (PRGW) based waveguide from [138][141] is shown in figure 25 below from [138].

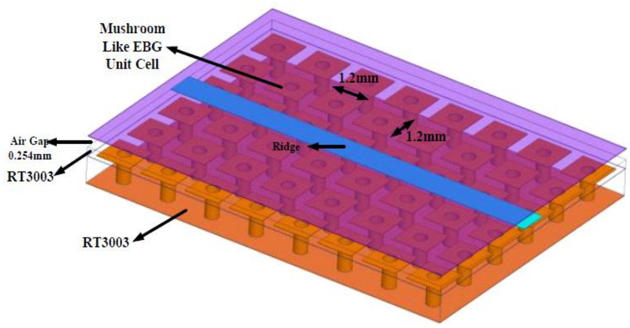


Figure 25. The printed ridge gap waveguide (PRGW) based waveguide

A 3-Dimensional figure of a dual polarized Split-ring resonator (SRR) enabled magneto-electric dipole antenna is shown in figure 26 from [138].

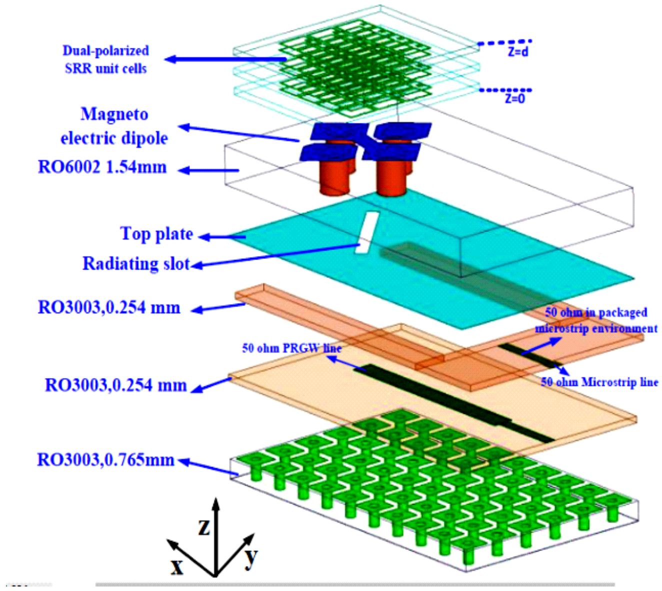


Figure 26. Magneto-electric dipole antenna loaded with a dual-polarized Split-ring resonator

The radiation schematic of the magneto-electric dipole antenna consisting of four parallel patches connected to the ground plane as seen in Figure 27. The bridge across the slot consists of 2 patches aligned with the written ridge gap waveguide while all 4 patches with the Y axis are rotated at 45 degrees. It is obvious from the waveform that the antenna gain exceeded 8 dBi at 32 Gigahertz range.

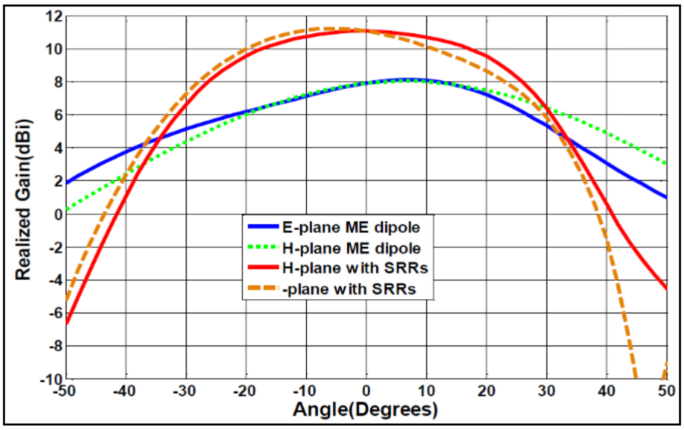


Figure 27. Circularly polarized magnet magnetic dipole antenna design with and without Split-ring resonator in the E(xz)-and H(yz)-plane at 32 GHz.

The Magnitude of S11 of the three-layer magnetoelectric dipole antenna with 3 by 4 dual-polarized mu-near zero (MNZ) cells as seen in Figure 28. The findings reveal that the antenna gain is increased when the mu-near zero is connected to the antenna. Second, the spectrum of 29-37 Gigahertz is given by the Circularly Polarized Magnet Electric Dipole Antenna.

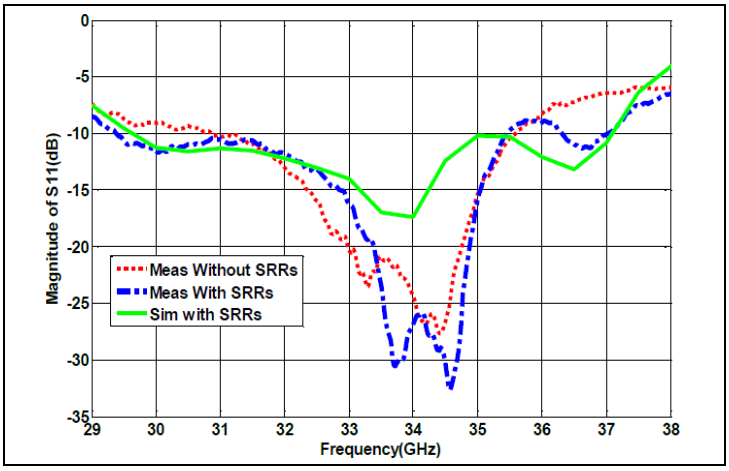


Figure 28. Physical layout of the Circularly Polarized Magneto- Electric Dipole Antenna from [138]

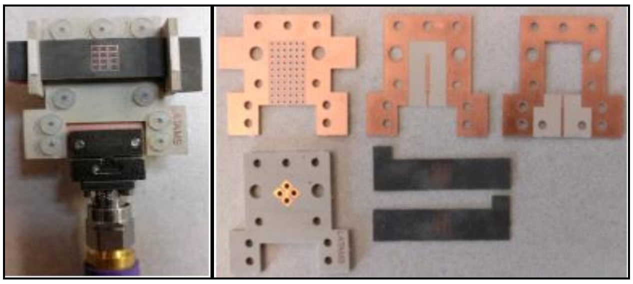


Figure 29. (a) Physical layout of the antenna fragments and the assembled Circularly Polarized Magneto- Electric Dipole Antenna.

5.5 MM-Wave Phased Array Quasi-Yagi Antenna

It is the goal of this manuscript to propose a new phased array antenna model for the 5G mobile platform [142]. The eight components of the Quasi-Yagi compact antenna are mounted on the upper part of the smartphone's printed circuit board (PCB) to form a beam-proof phased array configuration. Several papers have been published on this, and the results show that the recommended -10dB impedance bandwidth of the 5G smartphone antenna is 25 GHz to 27 GHz, which can provide 2 GHz bandwidth and the shared coupling efficiency is less than -16 dB. The via crown on the coaxial cable from the coaxial cable to the microstrip line has been shortened and has been used as a feeding mechanism for each radiation feature. As the antenna substrate [142], Arlon Ad 350 with characteristics of ш = 3.5, Δ = 0.003, h = 0.8 mm was selected. The proposed phased array antenna offers a wide-angle scan of 0-pop~75-pop with a gain level of more than 10 dB realized. The antenna array offers more than 90 percent (−0.5dB) of radiation and overall efficiencies for the scanning angle of 0 to 60. Additionally, the basic absorption rate (SAR) and radiation efficiency of the device when the user's hand / user's hand is present are studied [142]. These findings confirm the feasibility of the new system for handheld 5G applications. In addition, using the proposed quasi-Yagi materials, the radiation characteristics of 2 × 2, 4 × 4 and 8 × 8 planar arrays have been studied, and beyond 8.3, the planned planar arrays have reached 13.5 and 19.3 dBi directions. The results show that the constructed arrays (linear and planar) meet the general standards for 5G platforms [142][143]. The schematic diagram of Quasi-Yagi antenna is outlined below.

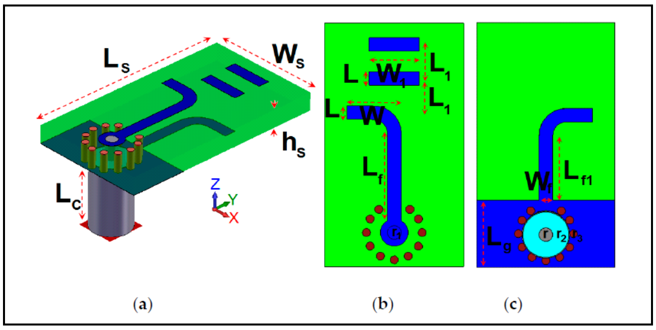


Figure 30. Schematic diagram of quasi-Yagi antenna; transparent view (a), top layer (b) and bottom layer (c).

The antenna in the above figure is fed by microstrip line to coax. The cylindrical metal was used to sound the coaxial cable. The external connector is attached to the ground plane, while the internal connector of the probe is the Yagi feed line. The linear array parameters and the concluding dimensions of the Quasi-Yagi antenna and its parameters are specified in Table 6 by collecting data from [143].

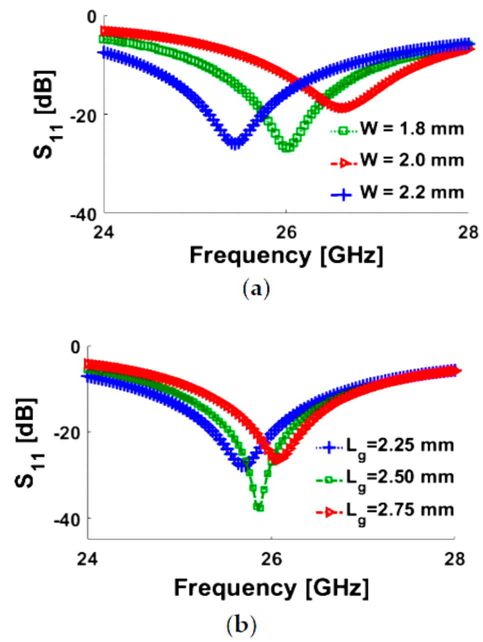


Figure 31. S11 results [142] of the Quasi-Yagi antenna for different values of (a) W (width of the antenna arm), (b) Lg (length of the ground plane)

Table 6: Parameter values of the Quasi-Yagi antenna and its array design.

Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)
W_{sub}	60	L_{sub}	120	h_S	0.8
W_S	4.5	L_g	2.5	W_f	0.5
L_f	3.15	L_C	3	W	1.95
L	0.1	W_a	40	$L_S = L_a$	9
W_1	1.8	L_1	1.25	r_1	0.5
r_2	0.87	r_3	0.15	R	0.25

- **Efficiency**

The simulated efficiency is above 90% of the Quasi-Yagi Antenna.

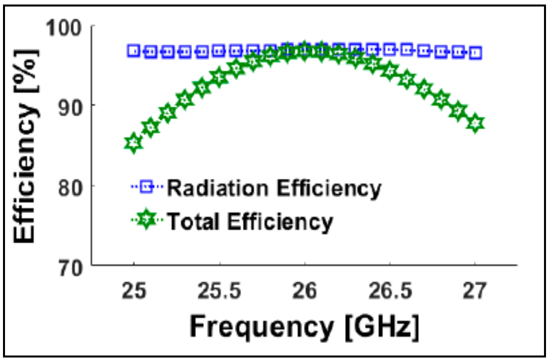


Figure 32. Efficiency of Quasi-Yagi Antenna

5.6 Flexibly Extensible Planar Self-Isolated Wideband MIMO Antenna

In [144], an extensive self-isolated planar broadband MIMO antenna array is proposed and studied. Eight-element MIMO antenna arrays have been assembled and tested for test examples. The designed kit shows 65% wide bandwidth (IBW) at 3.82–7.5 GHz. Because the inverted L-shaped strip load is on the ground, in the proposed design, any two components can also achieve good isolation (> 18 dB) [144]. The smaller the ECC between any two components, it indicates that the proposed eight-element MIMO antenna system has a strong diversity of output [145]. The distinctive characteristics of scalability and self-isolation render the 8-antenna system a possible candidate for future 5G applications. The front and bottom view of the 8-element MIMO antenna system from [144] is seen in figure 33, displaying the arrangement of antenna elements.

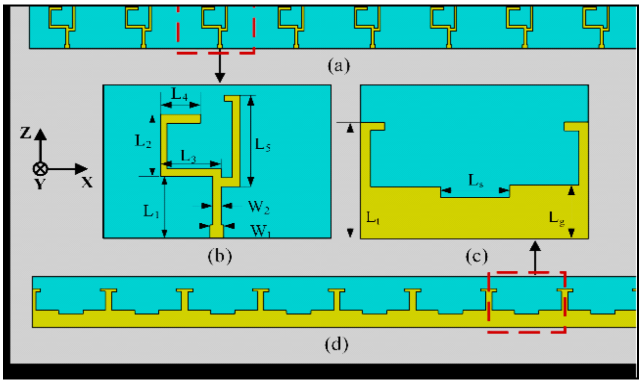


Figure 33. (a) Front view of an eight-element MIMO antenna; (b) Front view of an element antenna; (c) Bottom of the element antenna; (d) Bottom view of the planner's self-isolated broadband eight-MIMO antenna.

The authors conducted a current distribution analysis on the 4.5 GHz eight-element MIMO antenna array to verify the isolation effect of elements 1 and 2 being excited. When port 1 (one) is energized, a large part of the surface current is limited to the reverse L-shape, while the other ports are connected to the corresponding loads. Similarly, when port 2 (two) is energized, most of the surface current is confined in the inverted L-shaped bar. Therefore, determining the inverted L-shaped strip can significantly improve the isolation between the components. The figure 34 below from [144] shows the simulation results.

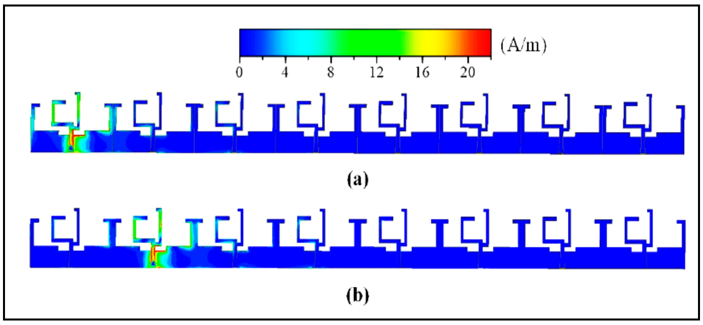


Figure 34. Simulation results at 4.5 GHz current distribution: (a) Excitation port one (1); (b) Port two (2) is excited

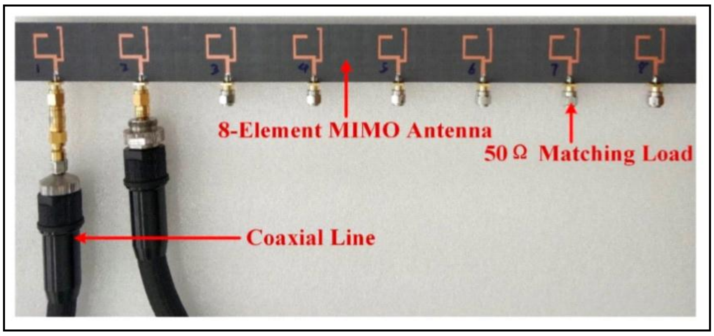


Figure 35. Photograph of the 8-element MIMO antenna.

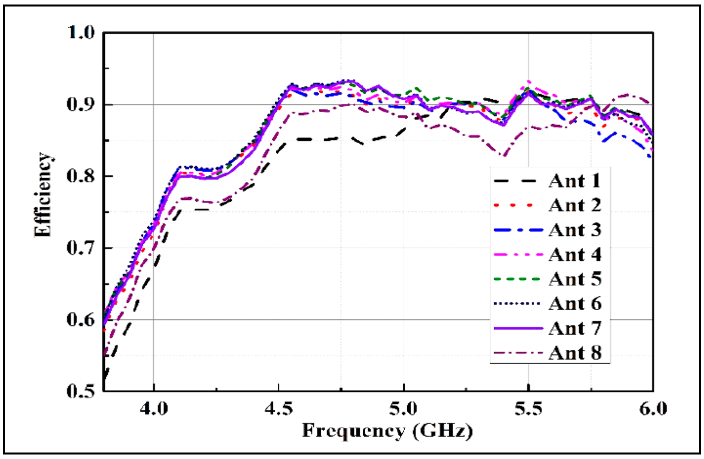


Figure 36. Measured performance of the 8-element MIMO antenna

Table 7. Output relation between the current design and the previous MIMO multi-element antenna **designs**

Designs	Decoupling Method	Adjacent Space	Isolation	Extensibility	Structure Complexity
Ref. [146]	Polarization orthogonality	>12.5 mm	>12.5 dB	No	Simple
Ref. [147]	Polarization diversity	>19 mm	>17.5 dB	No	Medium
Ref. [148]	Polarization orthogonality	>6 mm	>12.5 dB	No	Medium
Ref. [149]	Neutralization line	>8 mm	10 dB	No	Simple
Ref. [150]	Neutralization line and ground slot	17 mm	>15 dB	No	Medium
Ref. [151]	Pattern diversity	>9 mm	15 dB	No	Medium
Ref. [152]	Pattern diversity	>14 mm	<15 dB	No	Simple
Ref. [153]	Decoupling structures	>4 mm	>15 dB	No	Complex

5.7 An Advanced Antenna System

The new technical advances have made the integrated antenna system a flexible alternative for positioning in the existing and upcoming 4G and 5G networks. Advanced antenna system (AAS) allows beam shaping and multi-input multi-out (MIMO) strategies. Beamforming and MIMO strategies are effective tools to boost performance, coverage and user experience. As a result, the integrated antenna system significantly increases network efficiency in both upward and downward connections. In order to achieve cost efficiency and quality improvements to network implementation, it is important to have a rich awareness of the features in order to identify the most appropriate integrated antenna system [154]. The advanced antenna system is described as the "summing up of advanced antenna system features of the advanced antenna system." The improvement in end-user efficiency has made the radio access network (RAN) more successful in terms of capacity, coverage and output. Mobile network operators (MNOs) will also develop the Radio Access Network (RAN) in such a manner as to require a decreased cost per bit thus fulfilling modern expectations for the performance of end-users [155]. It is now time for infrastructure to switch to an advanced integrated antenna network in order to increase performance both in uplink and downlink [156]. Shifting to an advanced antenna system involves a decrease in the manufacturing costs of MIMO and beam formation and an improvement of the baseband, antenna and device. The advanced antenna system is similar to the current infrastructure so that it is easy for mobile network operators to introduce it on existing network sites rather than constructing costly sites. The advanced radio / wireless antenna system is made up of an antenna arrangement that is closely combined with the software and hardware for transmitting and receiving wireless signals and signal processing techniques to facilitate the implementation of advanced antenna system functionality. This method is very successful in adjusting the antenna emission patterns to increasingly changing traffic and multi-path wireless environments compared to the current method [157]. Often, with various types of radiation, several signals may be sent and obtained simultaneously.

5.7.1 Multi Antenna techniques

The beamforming and MIMO from multi antenna techniques referred as an advanced antenna system feature. These features have already been implemented in the current LTE network systems so, by applying an advanced antenna system features to an advanced antenna system radio/wireless would result in greater performance gains.

5.7.2 MIMO (Multiple Input, Multiple Output) Techniques

Multiple Input, Multi Output (MIMO) is a multiplexing strategy that has the capacity to communicate multiple data beams at a time. The aim of MIMO is to increase the throughput. MIMO works in both uplink and downlink, although the concept below stresses downlink for ease of usage. The MIMO may be a single user and several SU-MIMO and MU-MIMO users respectively. The single-user MIMO (SU-MIMO) is used to transfer data to multiple users from one source, it improves the capacity of the network and the output of the customer [158]. SU-MIMO can also be used in a multi-path environment where there are many radio broadcasts paths of equal strength between the EU and the AAS; by sending various layers to separate transmission routes as shown in Figure 37(a) from [154].

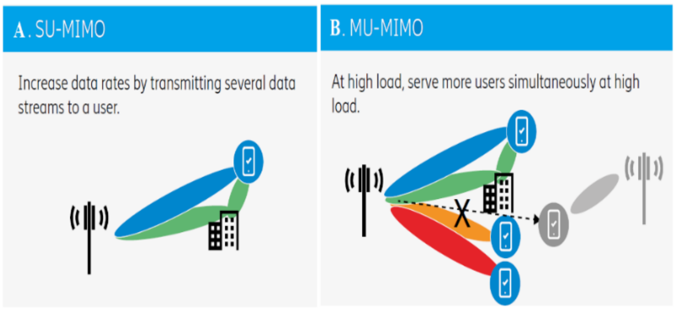


Figure 37: Single user and Multi user MIMO, with the different colors of the filled beams representing streams.

A multi-user MIMO (MU-MIMO) as can be seen in Figure 37(b), the advanced antenna network simultaneously transfers multiple layers in separate beams to various users utilizing a common time and frequency tool, thereby increasing the network bandwidth. In order to utilize multi-user (MU)-MIMO and connection b, the system will accept two or three users that wish to transmit or retrieve data at the same time.

5.7.3 Beamforming

Beam formation is the ability to guide wireless energy over a wireless channel to a specific receiver, as shown in Figure 38(a). Useful addition of the appropriate signals to the EU receiver can be accomplished by changing the amplification and phase of the transmitting signals, resulting in a higher reception signal intensity and also a higher end-user efficiency. Similarly, beam shaping is the ability to absorb signal energy from the transmitter when it is transmitted. In order to achieve high efficiency in uplink and downlink, the beams emitted by the advanced antenna system are continuously adjusted to the surroundings.

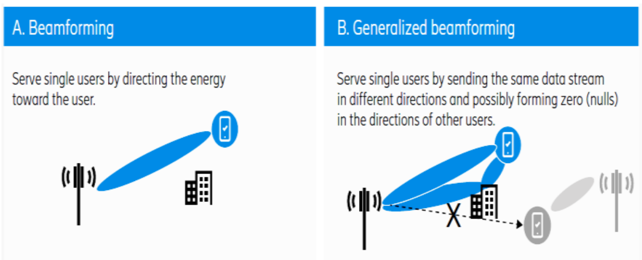


Figure 38: Beamforming representing streams from [154]

In multi-track scenarios where the wireless channel comprises of multiple transmission tracks from sender to receiver by diffraction around angles and reflections against artifacts, it is desirable to transmit the same data beam in a variety of different phase and amplitude paths regulated in such a way as to contribute constructively to the receiver. This is referred to as generalized beam formation, as shown in Figure 38(b).

5.7.4 Antenna array structure

In order to permit excessive-advantage beams and make it achievable to reveal beams at quite a number of angles, as proven in Figure 39(A) from [154]. The use of the square antenna array is considered. By multiplying the antenna signal range from multiple antenna components, benefits can be obtained in the uplink and downlink. The more factors of the antenna, the higher the advantage. It is performed by way of independently controlling the phase and amplitude of the smaller elements of the antenna array. It is finished by way of splitting the antenna array into subarrays (companies of non-overlapping elements) as shown in figure. 39(C) and by means of adding two constant radio chains per sub-array to allow power, as shown in figure 39(D). The route and other houses of the generated antenna array beam may be modified on this technique.

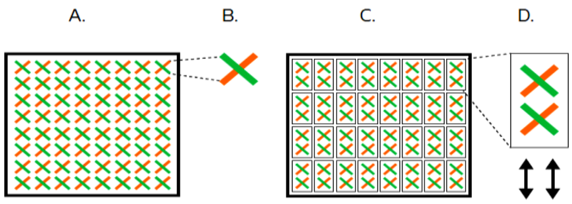


Figure 39: The normal antenna configuration (A) consisting of rows and columns of dual-polarized antenna variables (B) Antenna arrays may be separated into sub-arrays (C), with each sub-array (D) attached to two radio chains, normally one in the polarization process.

The benefit of the array is defined as the benefit executed while all sub-array alerts are constructively brought (in segment). The size of the benefit array, relative to the advantage of a sub-array, relies upon on the wide variety of sub-arrays. By altering the phases of the sub-array signals in a specific manner, this benefit can be obtained in any manner as proven in Figure 40(A). Growing sub-array has a particular sample of radiation that defines the benefit in distinctive directions. The width of the beam relies upon the size of the sub-array and the traits of the man or woman antenna components. There is a trade-off between the gain sub-array and the width of the projector. The wider the sub-array, and the narrower the width of the beam, the higher the gain, as noticeable in figure 40(B). The total range of factors determines the overall gain, and the sub-array splitting enables high-advantage beams to be directed across the variety of angles. In addition, the sub-array pattern of radiation is used to evaluate the boundary of the slender beams (dashed outline in Figure 40 (C).

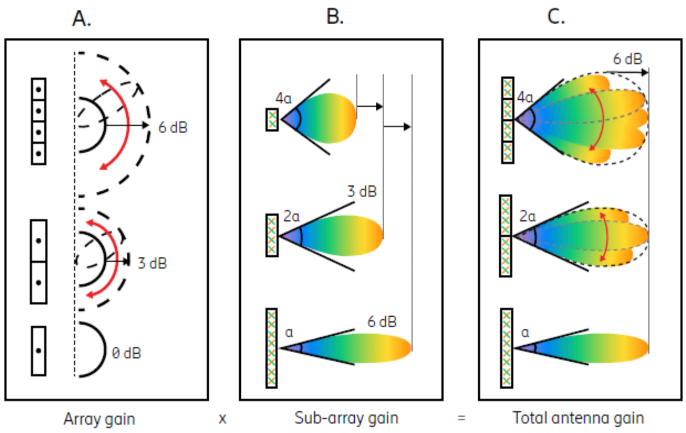


Figure 40: A set of sub-arrays that endorse an unsustainable overall antenna benefit and steerability

5.7.5 Deployment Situations

Delineating which type of advanced antenna system (AAS) configuration is the most suitable and cost-effective for a given deployment situation, this requires a combination of expertise in various situations, functional website boundaries and convenient AAS functions, especially for vertical beams the demand for steering, the effectiveness of equivalent beamforming and the advantages of MU-MIMO. We selected three common usage scenarios that revealed various factors for installing AAS: dense city higher rise, city low rise, and rural / suburban conditions, including related functions, correct advance antenna system settings and output capacity, as shown in Figure 41 from [154]. Reference [157] provides a more complete overall performance test that can be achieved through AAS.

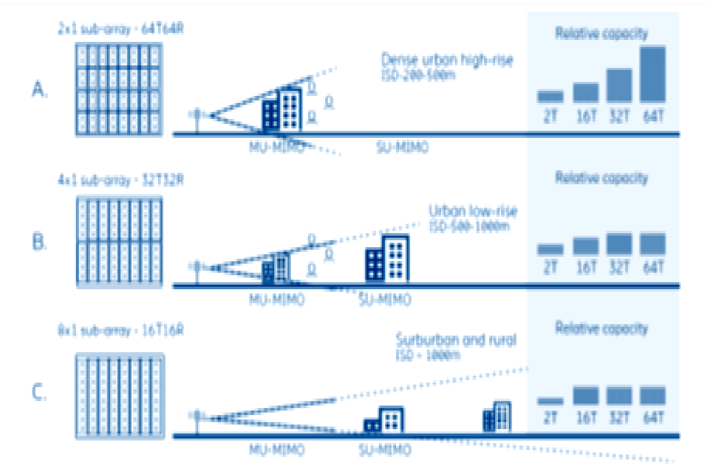


Figure 41: Appropriate AAS configuration in special deployment situations, schematic MU-MIMO and SU-MIMO usage range and typical capacity profit

1. Deployment Situation #1: Suburban/Rural

As shown in Part C of Figure 4, the macro situation in the suburbs or rural areas is defined by the base stations installed on the roof or the top of the tower. The distance ranges from one kilometer to several kilometers. The population density ranges from medium to low. This situation includes an AAS with a huge antenna nearby and the ability to help form a horizontal beam. However, due to the small size of vertical buyers, vertical beamforming has not brought any of the most important benefits. As a result, large-scale vertical sub-arrays with limited vertical coverage are sufficient. Compared with other cases, full beamforming based on reciprocity can help fewer users, and MU-MIMO gain is more limited. AAS with 8 to 16 radio links achieves pleasing stability between failure and efficiency.

2. Deployment Situation #2: Dense urban higher rise

As shown in stage A of Figure 5, a compact higher rise urban scene is described by higher rise buildings, a small inter-site distance (ISD) of 200-500 m, huge traffic flow and huge population density, and a strong vertical space to describe customer distribution. For the described traffic, the key element of community development is improved functionality or equivalent end-user performance. For conventional non-beamform networks used with 2T2R, the vertical distribution of customers and thin ISD can lead to a situation where many customers exceed the vertical base beam of the closest base station. Coupled with the large number of websites, this creates an environment in which the indicators from the outage base station are effective and serious outage problems may occur. In the case of over-emergence of densely populated cities, the antenna position required by the required AAS function should be wide enough to ensure adequate exposure (UL cell edge fact occurrence rate). Furthermore, the vertical exposure category is expected to be large enough to accommodate the vertical distribution of customer. It allows small sub-arrays with huge beams in the vertical plane. Dividing the antenna into small sub-arrays will produce a high-precision beam, which can be controlled through a large number of angles, thereby effectively solving the problem of interference with conventional systems. AAS requires a sufficient number of radio channels to accommodate a considerable number of sub-arrays. Better insurance and a wide range of customers mean that the capacity of reciprocal beamforming and MU-MIMO with a relatively large multiplexing user range is too large, and these technologies will be guided by AAS. By managing 64 radio links of a small sub-array, many complex and high-quality tasks can be completed.

3. Deployment Situation #3: Urban lower rise

The lower rise buildings in the city mentioned in Part B of Figure 4 reflect the world's largest towns and the edges of many high-rise cities. The base station is usually installed on the top of the mountain, and the length between the sites is some kilometers. Compared with the crowded high-rise city, the public transport that fits the location of the unit is smaller. Generally, a set of multi-process distributed construction styles will be generated between AAS and UE. Enhancing the antenna position is crucial for enhancing the throughput of UL cells, especially for higher frequency bands using TDD. Due to the expansion of ISD and the reduction of the vertical distribution of users (decrease of buildings), compared with densely populated high-rise urban areas, the scope of vertical publicity can be reduced; therefore, a wider vertical sub-array can be used, and the advantages of vertical beamforming are less. Using a wider sub-array for the described antenna area means that fewer radio links are required. Horizontal beam shaping is a completely powerful function that produces the main gain. Reciprocating beamforming strategies will be suitable for the largest plans, but packages with limited insurance will have to rely on strategies including feedback-based beamforming. Due to the multi-route propagation environment, precise connection, and UE pairing capabilities, MU-MIMO is also suitable for heavy loads. The perfect solution between the problem and the performance is AAS with 16 to 32 radio hyperlinks.

RECOMMENDATION

In this paper we would recommend a geometrical adjustment of the geometry parameters of the antennas, in order to obtain a multiband response with a fair gain and to obtain the frequency tuning of the resonant bands. The efficient antennas for the 5G network produce a higher gain in millimeter-wave (mmWave) spectrum. The frequency spectrum from 20 GHz to 80 GHz is typically referred to as the mmWave band. The network in this band has 10 times greater capacity range than 4 G channels, meaning that this system can have faster download speeds and a far broader spectrum to enable future wireless connectivity. Furthermore, Multiple Input Multiple Output (MIMO) based antennas are recommended for the fastest network operation for 5G. So, all the efficient antennas should be MIMO based developed for the mmWave spectrum for the future 5G network. The common issue with this mmWave spectrum is that, the signal may experience loss due to rainfall, fog or snowfall, so necessary steps should be taken to protect the signal loss in this band for the future 5G network.

6. USES OF 5G

6.1. Fast data rate (Gigabytes in instants)

Fast broadband speeds and smart networks would define the 5G network. It takes around eight minutes to download a 4 G feature film; people will be able to do this in less than five seconds with 5G. Network speed can support technologies such as social networking sites, multimedia television, high resolution and 3D content, augmented reality, robots, driverless vehicles, advanced manufacturing, many others. For the billions of computers that would be connected, not all data has to be transferred concurrently. Some systems involve immediate communication, whereas others can be shared at off-peak hours. Getting networks that continuously manage data traffic and make split-second decisions is essential to the 5G world [159]. The 5G network is projected to serve 50 billion portable devices and 212 billion mobile sensors by the end of 2020 and to enable access to 44 zettabytes (ZB) of data [160]. It extends from smartphones and laptops to smartwatches, vehicles, computers, equipment and remote-control devices [161]. Almost all of this should produce a huge quantity of "useful data" that can be evaluated. Scientists predict that this linked world would make it possible to use a far higher proportion of digital data (35 per cent) than before (5 per cent) [162]. Wireless technology work is currently exploring a series of developments for a forthcoming wireless network. High-speed connectivity and low-latency specifications should be the focus for the upcoming 5G system. With 5G, the output is 40 times higher than 4 G, so you can stream 8 K or ultra-3-D videos in only a second [163][164].

6.2 4K STREAMING

Mobile network usage tends to increase at a very rapid rate due to emerging smartphone technologies such as high-resolution video sharing, online gaming and virtual reality apps [165]. In this sense, the EU 5G PPP SELFNET project [165][166] has introduced a QoE-aware Self-Optimization Use Case for UHD video streams utilizing the Scalable H.265 programming coding standard. Various forms of broadband devices that include a large amount of data traffic have been launched, such as 4 K extreme high resolution (UHD) video sharing, holograms, and virtual / augmented reality (VR / AR). Due to the developments in mobile connectivity networks, ITU-R has revealed the concept of the 5G (IMT-2020) mobile broadband linked business "Enhanced Mobile Broadband", "Low Latency", and "Massive Internet of Things" [167]. Through 5G vision, a maximum bandwidth of 20 Gb / s per device, a maximum throughput of 1 Gb / s per user and a low latency of less than 1 ms will be provided [168]. We have obtained findings that meet with the specific specifications of the IMT-2020 per-user throughput by achieving a data rate of more than 1 Gb / s in real-time. However, the real-time 4 K video delivery capability was effectively demonstrated by the 5G system and IFoF-based smartphone fronthaul [168]. AS 5G networks are slowly being phased out globally, it is anticipated that consumers will begin using enhanced Mobile Broad Band (eMBB) apps on their handheld devices. These technologies, e.g., 4 K and 8 K video sharing as well as virtual or augmented reality devices, provide far greater virtual environments though consuming much higher data rate to enable their seamless deployment to user devices. One of the main goals of 5G eMBB is therefore to maintain the consistency of service (QoE) of consumers of such apps in complex and demanding network scenarios. Satellite links have recently been integrated into 5G networks [169]. Since we have shown in the example use case, the measurement of 4 K material is actually restricted to virtual LTE networks. Although 4 K content offers the perfect catalyst for assessing 5G mm wave technologies, with regard to the number of users per cell and related transmission speeds needed to assess DASH streaming in real-time [169]. As 5G networks are slowly being phased out globally, it is anticipated that consumers will begin using improved Mobile Broad Band (eMBB) applications on their handheld devices. These technologies, e.g., 4 K and 8 K video sharing as well as virtual or augmented reality devices, provide far greater virtual environments though consuming much higher data rate to enable their seamless deployment to device. The aim of this work is to provide DASH dataset content to evaluate adaptive clients for higher speed networks [170]

6.3 Smart Mobility Using 5G

In the future, we are planning to merge the MIH paradigm with the DMM approaches in the sense of 5G heterogeneous networks, especially vehicle networks. In this type of network defined by a high agility environment, further parameters should be carefully considered, such as network size, vehicle speed, latency and likelihood of failure to produce [171]. Mobility technologies in 5G vary from conventional road / route preparation to new automated driving systems (connected vehicles) and expanded sharing of smart transport. Smart mobility advantages include road management, secure navigation, avoidance of incidents, fuel conservation, prices and emission reduction [172][173] We plan to analyze the advantages of utilizing existing / emerging mobile connectivity protocols (LTEX2 protocol and, most notably, 5G Device-to-Device — D2D) as suitable platforms for providing automotive technologies, with an emphasis on autonomous driving (AD)[174]. This paper addressed digital mobility technologies delivered in the framework of SCOs. As such, it also presented some of the core concepts in the smart city context, as well as some of the core obstacles that cities face while developing SCOs. This then concentrated on smart connectivity, which comes beyond the framework of SCOs, posing its key work accomplishments and challenges. In addition, it proposed a system focused on the utilization of 4G and, most notably, of 5G cell networking infrastructures, with a view to enhancing the quality of vehicle communications [174].

6.4 Smart Cities Using 5G

All through the immediate future, 5G technology will connect the planet from the biggest megacity to the smallest Internet of Things throughout ever-on-line fashion. Such a linked hierarchy will merge smart cities, smart homes and the Internet of Things into one big cohesive infrastructure [175]. So far, study on Smart Cities and self-organizing networking strategies for 5G wireless networks has been considered: the smart city depends on 5G to enable large M2 M communications, but the actual network is uncertain of the data streaming through it. However, stronger collaboration between the two will result in a shared partnership, as the information generated by the enormous volume of data obtained by the sensors can be used to enhance connectivity performance [176]. In addition, 5G is supposed to put together several various access systems, greatly improving the efficiency of the communication network and making it easier for transfers to take place to exchange information among heterogeneous systems and services [177]. The tactile internet would offer a forum for calculating, managing, tracking and scaling smart devices in actual or virtual reality in smart cities [178]. Ultra-low latency, stability and access quality are the key characteristics of the tactile internet that render it more advanced in 5G [179].

6.5 Augmented Reality on 5G

In recent years, augmented and virtual reality has started to take advantage of the high-speed capacities of video streaming technology and cellular networks. However, constraints such as bandwidth and latency also prohibit us from reaching high-fidelity telepresence and integrated interactive and augmented reality applications. Luckily, both developers and architects are conscious of these problems and have built up 5G networks to help us transition to the new phase of software interfaces [180]. Wireless Internet and IoT are the two major demand influences for the potential growth of wireless connectivity which should have a broad variety of opportunities for 5G. There will be a large range of usage cases in the 5G era, such as augmented reality, virtual reality, wireless computing, eHealth systems, car driving, and so on [181[182] Despite the network demands of new technological markets such as AR / VR, there is a lot of enthusiasm and expectation regarding the introduction of 5G network technologies. [183]-[186] 5G standards apply to anything from intense connectivity (e.g. large-speed trains) to significant improvements in energy consumption and network capacity, contributing to a hyper-connected world in which mobile devices can play an extremely essential part in our lives [187]. The primary driver of traffic on the network is the market for video streaming services. Asynchronous information reuse property is demonstrated by these live streaming demands of popular services by internet users that compensate for much of the data traffic. In fact, smartphone Augmented Reality and Virtual Reality (AR / VR) were anticipated to be among the first group of killer apps in 5G. According to ABI Research, the global AR industry is projected to hit $114 billion by 2021, while the global VR industry is expected to reach $65 billion during the same timeframe [181]. All Augmented Reality (AR) and Virtual Reality (VR) provide consumers with interactive content, but need an infrastructure capable of offering solid assurances of good quality 360° footage, low-latency two-way interactions and precise localization. Due to 5G, such activities will now be accessed, e.g. on consumer electronics, remote and handheld, thereby introducing a range of revolutionary educational scenarios [188]. 5G infrastructure aims to be able to help a variety of both conventional and new technologies, such as device-to-device connectivity and the Internet of Things (IoT). The aim of this research is on 5G features and functionality that can promote the deployment of advanced e-learning systems utilizing AR / VR. In this sense, the opportunity to promote the exchange of data via the creation of extemporary classrooms everywhere through user equipment is also important. To this purpose, an evaluation of recent – primarily European – 5G trials is provided in order to determine the viability of e-learning systems utilizing this technology [188].

7. MEDICAL IMPACT OF 5G TECHNOLOGY

We have divided the subject in two portions, one is good medical impacts we termed it as positive impacts similarly for bad impacts, we used the term negative impacts.

7.1. Positive Impacts

The 5G network allows new open doors for human services with imaging, diagnostics, information investigation, and treatment with its most remarkable availability, savvy supervision, and data/information abilities. It incorporates wearable and remote sensors which are associated with the system through the web of things (IoT) gadgets. The wearable gadgets and sensors screen clinical information, for example, vivacious signs, individual wellbeing, and physical movement and transmit the information electronically. These gadgets will convey at no other time seen tele medicine judgment and treatment administrations. Likewise give video conferencing of high goals, at the same time conveying greatness care at reasonable charges. These gadgets produce improved information and progressively precise examination for getting data. 5G will bring steady and dependable client experience and an improved clinical consideration and it will likewise help in some basic clinical capacities which require higher unwavering quality and lower idleness [189]. The utilization of computerized innovation is expanding quickly consistently, the utilization of PDAs, sensors and removed checking mechanical assembly going to develop and it will get gigantic headways patients accepting imaging, determination, and in the treatment. To ensure the sum of this transforms into a reality, be that as it may, the work ought to be done to urge an all the way structure. Contraptions must interface with frameworks and the cloud in habits that are interoperable and ensure about. That will engage prosperity providers and patients to get the benefits of cutting-edge improvement for wellbeing and human administrations. If we can vanquish these obstacles, both social protection clients and providers will see liberal advances in clinical treatment [189]. Despite concentrated endeavors, there are as yet gigantic difficulties that need to confront while giving social insurance offices to the quick expanding and old populace [2]. Despite the fact that the 5G for a great many people implies quicker web, the effects of 5G on social insurance will be duplicated. The computer-generated experience (VR) and expanded reality (AR) are bound to turn into the most straightforwardly profited territories and add to insight medication once 5G innovation develops [5]. The 5G will significantly advance the mix of virtual and reality, which is basic for far reaching recovery preparing, just as compact furthest point restoration and telemedicine because of its specialized qualities [190]. Also, we analyzed social insurance as for 4G and 5G advances and give a review of online interview, online wellbeing checking, remote finding, and versatile automated medical procedure. In view of the writing audit and basic investigation, we have reasoned that ramble correspondence for the arrangement and upkeep of basic foundations is the most testing situation that can be conveyed to the following period of our work [191]. Telemedicine or e-Health will permit scaling up of human services frameworks to meet a rising populace, particularly in remote, rustic and low-salary regions, by utilizing advances, for example, remote discussion and medical procedure. Specialists utilizing telemedicine will approach haptic input, which will take into consideration the sentiment of touch to be transmitted. Patients will have the option to quantify their own vitals at a small amount of the expense and with incredible accommodation. We accept that the 5G system will address individual correspondences, yet additionally make a completely advanced society where sensors might be installed in tissue (pacemaker), ingested (utilizing ingestible keen pills), imprinted on skin (utilizing epidermal sensors, for example, shrewd skin or computerized tattoo) and worn (utilizing wearable innovation, for example, savvy attire, brilliant gems or smartwatch) [192]. 5G empowered social insurance upset that will be driven by 5G remote innovation and completely bolstered by other related advances. We give a portrayal of every one of the different included advances and their potential for medicinal services, while giving pointers to existing writing and advances. We likewise introduced a contextual analysis on the monetary benefits that will be offered by 5G innovation empowered medicinal services. Further, we have featured the energizing examination and execution openings in building this eventual fate of 5G-empowered social insurance while likewise pinpointing the considerable difficulties included and the potential traps [192].

7.2 Negative Impacts

Alongside gigantic number of advantages remote innovation has additionally one of the most obliterating ecological and wellbeing dangers and dangers to individual freedom at any point made. It is turning out to be broadly realized that 4G and 5G innovations cause numerous damages to human wellbeing. Malignancy is just a single issue, and one that is effectively understood. 4G and 5G cause 720! (factorial) various illnesses in individuals, and can destroy everything that lives yet a few types of microorganisms. A few pathogens and certain parasites are made progressively harmful by chosen frequencies of RF [193]. Bugs and winged creatures are as of now being murdered by the RF communicates. There are different approaches to convey that do not require radio waves, nor wires, which cause no harm to any type of life [194]. The non-ionizing 5G RF-EMF can carry on like high LET ionizing radiations which have the most extreme vitality affidavit per unit separation [195]. Considering the low infiltration and high vitality statement per unit separation of 5G, this can prompt age of significant levels of free radicals in a short separation which thus expands the danger of skin malignancy [196]. It's important that Yakymenko et al. has mentioned that among 100 friends checked on examines with respect to the oxidative impacts of low-force radio frequency radiation that were accessible at the hour of their investigation, by and large, 93 affirmed that radio frequency radiation instigated oxidative impacts in organic frameworks [197]. Our point is not to reprimand 5G innovation but yet to be mindful of health repercussions and staggering clinical effects of upcoming innovation on the lives of users.

8. CONCLUSION

In this paper we have reviewed various aspects of the upcoming 5G network, we have discussed various segments that are necessary for the deployment of 5G network. 5G networks would be smarter and more effective to serve huge amount of radio spectrum, from a basic sensor to a complex self-driving vehicle, from embedded sensors in all sorts of hardware to automated cars, from aircraft to smart businesses and towns, 5G networks will link everything to one another, from a user to the web. 5G network is the next forthcoming technology and it has very high network capacity, lower latency and much higher bandwidth in comparison to the current network. In other words, 5G would contribute to one of the biggest technical revolutions in the human history, with infinite use cases. Not only can it will change human lives but it also aims to preserve them by improved emergency care and rising traffic accidents. Before the commercialization of 5G technology it is very important to keep improvement on the network capability and flexibility to cope with the various use cases and for business models. It is also important to keep eye on the efficiency of the 5G technology in terms of energy and cost. In this article we have presented the energy efficiency areas of 5G, various efficient antennas for 5G mobile network, architectures and wide uses of 5G technology in our lives.

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