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Connecting the World: A Guide to 3G, 4G, 5G Technologies

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ABSTRACT
Internet gadgets such as smart phones, hotspots, and Wi-Fi zones are essential players in the rapid development of data usage in the wireless era. Internet connection devices are creating new hurdles for internet service providers, such as increased bandwidth and an ever-increasing user base. This article provides an overview of existing wireless communication technologies, as well as anticipated enhancements to wireless services. Throughout the past ten years, various methods have been developed to handle next-generation methods for ISPs. We compared many generations, including 3G, 4G, and 5G, and we focused on the 6G and 7G next-generation communication technologies. The next generation of communication technologies and 5G are the subject of current research. For enhanced mobile broadband experiences, internet infrastructure expansion is crucial.

Keywords – Mobile communication, Wireless network, 3G, 4G, 5G, Interfacing.

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I. INTRODUCTION

The wireless sector has advanced astronomically in recent years, both in terms of subscribers and mobile technology. Known as NMT (Nordic Mobile Telephone), the analogue (or semi-analogue) systems were the first generation of mobile systems, introduced in the early 1980s. Their services, which were basically speech and linked, were very incompatible with one another. The 1980s saw the introduction of analog cellular technologies, or 1G. Second-generation digital networks, or 2G, included features like short-messaging and slower data speeds [1]. In recent years, a significant amount of research has been conducted to increase wireless capacity by deploying greater intelligence in wireless networks. Developing cutting-edge receiver signal processing techniques and inventive signal transmission strategies that enable significant gains in wireless capability without corresponding increases in bandwidth or power needs has been a crucial component of this drive [2]. Any kind of network without any kind of cable connecting devices is referred to as a wireless network. It's a way to avoid the expensive procedure of installing cables inside buildings or connecting different locations of equipment for households, telecommunications networks, and enterprise (business) installations. Even now, many years after wireless technology was developed, there are still obstacles to efficient communication is still observed. Nowadays, a large number of individuals use wireless communication, which has caused network congestion, slow connectivity, and limited capacity. It would be impossible to browse the internet or use cell phones, which are a common component of wireless networking and enable simple personal conversations, with no wireless networks. Wireless networking finds application in both transcontinental network systems and global radio satellite communication. With the use of this technology, there is no longer a need to establish costly physical network mediums like fibre-optic and coaxial lines. Devices connected to a network can become mobile thanks to wireless networking, which significantly reduces the time and expense of physical installation [2].

II. 3G NETWORKS

2.1 INTRODUCTION

3G stands for third generation mobile telecommunications technology. A minimum of 200 kbit/s of data transmission speed is offered by the

3G network-supported services. Using 3G systems, we may access mobile broadband on our smart phones handheld modems. The International Telecommunication Union (ITU) was established in the early 1980s. They conducted the research and development that led to the creation of 3G technology. It is took almost fifteen years to establish the 3G network specs and standards. The 3G technical specifications are known as IMT-2000. Next, the distribution of the 400 MHz–3 GHz communication spectrum for 3G was completed[3]. Three G following that, the government and communications businesses ratified the standard. At least 200 kbit/s of information transfer speed is supported by 3G telecommunication networks. Several Mbit/s of mobile broadband connection are also available to smartphones and mobile modems in laptop computers with later 3G releases, typically referred to as 3.5G and 3.75G. This guarantees that it can be used for mobile TV technologies, video calls, fixed wireless Internet access, wireless voice telephony, and mobile Internet access.

2.2 *HISTORY AND EVOLUTION*

Third-generation wireless networks, or 3G, went live for the first time in 2001. They were able to enable mobile internet access and other data-intensive applications because they provided a noticeable speed and capacity increase over earlier 2G networks. Wide band code division multiple access was one of the primary technologies that made 3G possible (WCDMA). WCDMA gave each user a unique code, allowing them to share the same frequency band. As a result, the maximum number of users that could be accommodated on a single cell site was greatly increased. High-speed data packet protocols like HSPA (High Speed Packet Access) were developed, which was another important technological advancement that helped make 3G[7] a success. With the help of HSPA, 3G networks were able to reach 14.4 Mbps, a major speed increase over 2G networks.

In December 2001, Telenor opened for business with no commercial handsets and no paying customers. This was the first European pre-commercial network, a UMTS network operated by Manx Telecom, which was then owned by British Telecom. The first European commercial network was also UMTS based W-CDMA. In January 2002, SK Telecom in South Korea became the first company to launch a commercial network using the CDMA-based 1xEV-DO technology. South Koreans saw competition among 3G carriers as early as May 2002, when KT launched the country's second 3G network on EV-DO.

Using CDMA2000 1x EV-DO technology, Monet Mobile Networks operated the[7] first commercial 3G network in the United States before ceasing operations. In July 2002, Verizon Wireless became the second 3G network provider in the United States, using CDMA2000 1x EV-DO technology. After completing the 3G network's upgrade to HSUPA, AT&T Mobility is also a real 3G UMTS network[3].

For mobile internet access and other data-intensive uses like gaming and streaming video, 3G networks gained popularity very quickly. Globally, there were more than 1 billion 3G users by 2012.

The first 4G networks went live in 2009. 4G provided a notable enhancement in speed and capacity compared to 3G, enabling it to accommodate increasingly sophisticated applications like augmented reality and high-definition video streaming. Even with the introduction of 4G, 3G networks are still in operation. In many developing nations, 3G remains the predominant mobile network technology. The following is a synopsis of the major occasions in the development of 3G networks: 2001: South Korea and Japan roll out their first 3G networks. 2003 saw the introduction of 3G networks in North America and Europe. 2004 saw the launch of HSPA, which provides
14.4 Mbps of speed. 2006 saw the debut of 3G networks in South America and Africa. 2009 saw the deployment of 4G networks. 2012: The global 3G subscriber count exceeds 1 billion. 2023: The majority of the world's developing nations continue to use 3G networks. The growth of the mobile internet has been greatly aided by 3G networks. They have enabled users to stay in touch and have mobile access to entertainment and information.

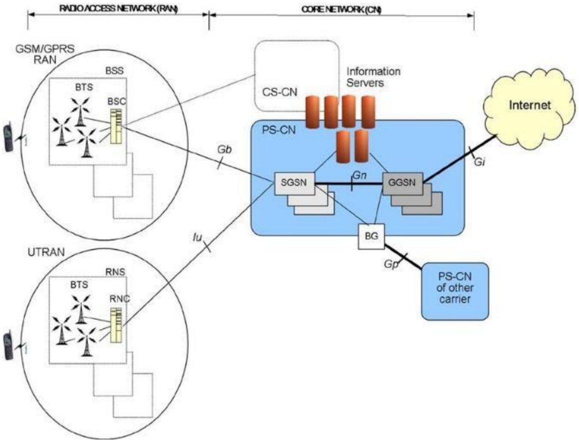


Fig1. Architecture to 3G network

2.3 *PROS AND CONS OF 3G*

2.3.1 Pros of 3G Network:-

- Data transmissions with 3G are significantlyquicker, reaching up to 2Mbps.
- This network allows developers to make

location services and maps that the younger generation frequently uses.

- Additionally, this network provides strong multimedia services that you can use to create apps like online payment portals, video conferencing, and other similar ones.
- Those wishing to develop visual voicemail apps will do very well to work on the 3G network.
- Advanced developers can also develop apps for mobile TV, IM and video chatting, as 3G supports all these and much more.

2.3.2 Cons of 3G Network:-

- Even though 3G is already accessible in most

countries, some still need to adopt it. Users in these areas have the option to use other networks.

- The battery life of the device will decrease more quickly while utilizing 3G networks since they consume more power than 2G or4G networks.
- It's possible that you won't be able to receive a signal everywhere because 3G coverage is less extensive than 4G or 5G.

2.4 APPLICATIONS OF 3G

- Mobile broadband
- Location based services
- Video Conferencing
- Global Roaming

III. 4G NETWORKS

3.1 INTRODUCTION

Fourth generation wireless systems, or 4G wireless systems, are high throughput, wide area coverage packet switched wireless systems. It is made to be both highly spectrum efficient and reasonably priced. Ultra-Wide Radio Band (UWB), millimeter wireless, and orthogonal frequency division multiplexing (OFDM) are used in 4G wireless. A 20 Mbps data rate is used. The maximum mobile speed will be 200 km/h. Long-term channel prediction, in both time and frequency, user scheduling, smart antennas in conjunction with adaptive modulation and power control, all contribute to the excellent performance. The 2–8 GHz frequency spectrum allows for global roaming, enabling mobile access from any location.

With remarkable user applications like complex graphical user interfaces, top-tier gaming, high- definition video, and high-performance images, 4G enhancements promise to take wireless technology to whole new heights. The level of sophistication in consumer expectations for mobile phones and related items is rising. Customers are more sophisticated and practical apps on more ergonomic devices, combined with an improved user experience. While the present 3G devices are good, they will need to advance in areas like as processing power and imaging in order to enable 4G applications in the future[3], such as holographic and three-dimensional (3D) games, 16 mega pixel smart cameras, and high-definition (HD) camcorders. These kinds of apps will need more processing power than the 3G phones available today, necessitating the development of more effective application processors.

Users join 4G networks by adding mobile routers to the infrastructure of the network.

Dynamically adjusted network coverage and capacity are made to adapt to shifting user patterns. More routes are made wherever there is a higher concentration of people, which allows for more access to network capacity in terms of quality of service. This enables the network to optimize capacity and boost network usage in a dynamic and autonomous manner. Social networking is now being employed on the network. The paper's next section discusses social networking and related technological challenges.

3.2 HISTORY AND EVOLUTION

The term "generation designations" distinguishes wireless mobile communications systems. The first generation (1G) systems were introduced in the early 1980s and were mostly used for voice communications. They were distinguished by analogue frequency modulation. Second-generation (2G) wireless communications technologies, which debuted in the late

1980s, were primarily utilized for speech transmission and receiving. The current wireless technology is commonly referred to as 2.5G--an "in between" service that acts as a stepping stone to 3G. Whereas 2G communications are commonly linked with Global System for Mobile (GSM) service, 2.5G communications are commonly described as being "fueled" by General Packet Radio Services (GPRS) in addition to GSM. 3G systems, which debuted in late 2002 and early 2003, are intended for voice and paging services, as well as interactive media applications such as teleconferencing, internet access, and other services. The issue with 3G wireless networks is that they only give WAN coverage ranging from 144 kbps (for vehicle mobility applications) to 2 Mbps (for interior static applications). Then we'll go on to 4G, the "next dimension" of wireless communication. Orthogonal Frequency Division Multiplexing (OFDM), Ultra-Wide Radio Band (UWB), Millimeter wireless, and smart antenna are all used in 4g wireless[3-6]. A data rate of 20mbps is used. Mobile speeds will reach 200km/hr. The frequency range is 2 to 8 GHz.

It enables global roaming and mobile connectivity from anywhere in the world.

The strategy plan for 4G, which the ITU classified as IMT-Advanced, was outlined in 2002. A contender for the HSOPA downlink, which was eventually dubbed 3GPP Long Term Evolution (LTE) air interface E-UTRA, was selected in 2005 using OFDMA transmission technology. KT held a mobile WiMAX service demonstration in Busan, South Korea, in November 2005. In Seoul, South Korea, KT launched the first commercial mobile WiMAX service in the world in April 2006. Sprint declared in the middle of 2006 that it will devote around US$5 billion ($5.85 billion in actual terms) on the WiMAX technology rollout over the ensuing few years. Sprint has seen several failures since then, which have led to sharp quarterly losses. Sprint combined its Xohm WiMAX subsidiary with Clearwire to establish a firm that would adopt the name "Clear"; on May 7, 2008, Sprint, Imagine, Google, Intel, Comcast, Bright House, and Time Warner announced the pooling of an average of 120 MHz of spectrum[9]. A 4G communication system prototype named VSF-OFCDM, using 4x4 MIMO, was tested in February 2007 at 100 Mbit/s when moving and 1 Gbit/s while stationary by the Japanese business NTT DoCoMo. In an experiment, NTT DoCoMo used 12×12 MIMO with a 100 MHz frequency bandwidth and 10 km/h to attain a maximum packet transmission rate of about 5 Gbit/s in the downlink. The company plans to launch the first commercial network in 2010. NTT Docomo conducted a test in September 2007 and was able to achieve 200 Mbit/s e-UTRA data speeds with less than 100 mW of power usage. A spectrum auction was held by the Federal Communications Commission (FCC) of the United States in January 2008 for the 700[4] MHz old analog TV frequencies. As a consequence, Verizon Wireless received the largest portion of the spectrum, followed by AT&T. These two businesses have both declared their desire to support LTE.

EU commissioner Viviane Reding proposed repurchasing 500–800 MHz spectrum in January 2008 to support WiMAX and other wireless technologies. Skyworks Solutions developed a front-end module for e-UTRAN on February 15, 2008. By releasing a Circular Letter in November 2008, ITU-R laid out the specific performance standards for IMT-Advanced and invited potential Radio Access Technologies (RATs). Following the ITU-R agenda, it was determined that LTE Advanced, a development of the present LTE standard, will satisfy or even surpass IMT-Advanced standards during the IMT-Advanced workshop held in April 2008, shortly after the 3GPP received the circular letter. Traveling at 110 km/h, LG and Nortel showed 50 Mbit/s e-UTRA data speeds in April 2008. The first mobile phone with WiMAX support, the Max 4G, was unveiled by HTC on November 12, 2008. The largest food and beverage company in Southeast Asia, San Miguel Corporation, and Qatar Telecom QSC (Qtel) signed a memorandum of agreement on December 15, 2008, to develop mobile communications and wireless broadband projects[6-7] in the Philippines. Wi-tribe Philippines, a joint venture, provides 4G service across the country. Globe Telecom launched the first WiMAX service in the Philippines at about the same time.

Lithuania's LRTC announced on March 3, 2009, that the Baltic nations' first "4G" mobile WiMAX network was now live. Sprint started promoting "4G" service in December 2009, even though typical download speeds were only 3-6 Mbit/s and peak speeds were 10 Mbit/s (not accessible in all areas). The first commercial LTE rollout took place on December 14, 2009, in the Scandinavian cities of Stockholm and Oslo. TeliaSonera, a Swedish-Finnish network operator, and NetCom (Norway), its Norwegian brand[5], were responsible for this deployment. The network was dubbed "4G" by TeliaSonera. Huawei (based in Oslo) and Ericsson (based in Stockholm) developed the network infrastructure, while Samsung (dongle GT- B3710) produced the modem devices that were available. TeliaSonera intends to introduce LTE nationally in Finland, Sweden, and Norway. Single-in- single-out and a 10 MHz spectral bandwidth were employed by TeliaSonera, which could result in physical layer net bitrates of up to 50 Mbit/s in the downlink and 25 Mbit/s in the uplink. In Stockholm, preliminary testing revealed a TCP throughput of 5.3 Mbit/s uplink and 42.8 Mbit/s downlink. Estonia's EMT launched its LTE "4G" network on February 25, 2010, albeit it was still in test mode. Sprint unveiled the HTC Evo 4G, the country's first WiMAX smartphone, on June 4, 2010. MTS of Uzbekistan installed LTE in Tashkent in July 2010. Latvia's LMT launched its LTE "4G" network on August 25, 2010, covering 50% of the country in test mode. The first LTE smartphone to be sold commercially was the Samsung Galaxy Craft, which MetroPCS began offering on November 4, 2010. At the 2010 ITU World Radiocommunication Seminar on December 6, the ITU said that "4G" might refer to "evolved 3G technologies" including Wi-Max, LTE, and other related technologies. With a live demonstration held in Yerevan, VivaCell- MTS launches a 4G/LTE commercial test network in Armenia on December 12, 2010.

With permission from NBTC, Thailand's AIS and its subsidiaries DPC, along with CAT

Telecom for the 1800 MHz frequency band and TOT for the 2300 MHz frequency band, launched the country's first field testing LTE on January 31, 2012. Ericsson showcased mobile-TV via LTE in February 2012, making use of the recently introduced eMBMS (enhanced Multimedia Broadcast Multicast Service). India's first 4G LTE service was introduced by Bharti Airtel in Kolkata on April 10, 2012. Azercell, the largest mobile provider in Azerbaijan, introduced 4G LTE on May 20, 2012. Vodacom, also known as Vodafone South Africa, introduced a commercial LTE service on October 10, 2012, making it the country's first operator to do so. In nine major Mexican cities, Telcel introduces a 4G LTE network in December 2012. On December 26, 2012, 4G LTE was introduced throughout Kazakhstan, covering all of the country's territory in the frequency bands 1865– 1885/1760–1780 MHz for urban populations and 794– 799/835–840 MHz for less inhabited areas[8-9].

3.3 4G ARCHITECTURE

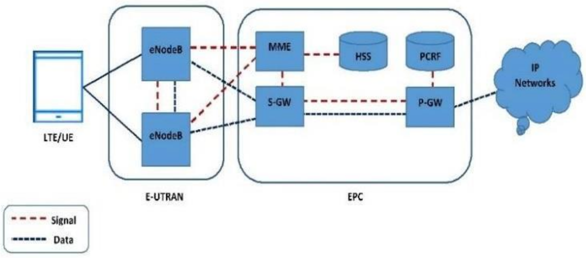


Fig2. Architecture of 4G Networks

3.3 FEATURES OF 4G

- Interactive multimedia, voice, streaming video, Internet, and other broadband services are all supported.
- Voice over LTE (VoLTE) technology is used in 4G, and it delivers high-quality voice conversations with better audio and reduced background noise. This is an enormous improvement over 3G, which frequently had choppy and confused audio conversations.
- High speed, high capacity, and low cost per bit
- 4G has lower latency than 3G, which means it takes less time to submit a request and receive a response. This is critical for real-time responsive applications such as online gaming, video conferencing, and virtual reality.
- Due to 4G's widespread adoption, you may use your phone without changing SIM cards in the majority of nations. This is a significant benefit for travellers who wish[4-6] to keep connected while on the road.
- Smooth transitions and an assortment of offerings focused on quality of service

3.4 PROS AND CONS OF 4G

Pros of 4G:

- Compared to 3G, 4G delivers noticeably higher internet rates. This makes it possible to download and publish data more quickly, watch videos of greater quality, and play better online games.
- 4G offers significantly faster internet speeds than 3G. This allows for faster data downloads and publishing, higher-quality video viewing, and improved online gaming.
- 4G networks have far more coverage than other networks, including Wi-Fi, which requires users to rely on hotspots in every location they visit. With 4G, customers may be guaranteed constant connectivity throughout overlapping network regions and coverage up to 30 miles in all directions.
- Internet security is one of the main issues with Wi-Fi networks. This particularly applies to mobile devices. Complete privacy, security, and safety are provided by 4G networks. Businesses and executives, who often have critical data on their mobile devices, will particularly benefit from this.
- Nowadays, 4G networks are reasonably priced due to significantly reduced pricing plans that cater to customers' budgets. Of course, this kind of connectivity costs more than conventional WiFi networks, but customers may benefit from many other benefits as well.

Cons of 4G:

- While the idea of 4G mobile networks is becoming more and more popular, connection is still restricted to a few designated carriers and geographical areas. Naturally, more and more cities are getting 4G coverage every day. But it would take some time before this network could be accessed in all of the world's main cities[5].
- Since 4G mobile technology is still in its infancy, users may experience some initial annoyances due to malfunctions and problems. It goes without saying that these teething problems, along with increased network coverage, will be resolved eventually.
- Because 4G mobile networks employ several antennas and transmitters, users' mobile devices' battery life will be significantly reduced while connected to this network. This would imply that in order to be able to stay online for longer periods of time, users would need to use larger mobile devices with better battery life[6].
- In places without 4G mobile network coverage, users would have to settle with 3G or Wi-Fi access. Even while this is a concern, the bigger

difficulty is that they would still be required to pay the 4G network plan's stated fee. This loophole has already led to a great deal of unhappy clients. Only when cell carriers reach more areas with their 4G networks will this issuebe rectified.

3.5 APPLICATIONS OF 4G

- Mobile gaming
- Cloud-based services
- Fieldwork and remote operations
- Remote work
- E-commerce

IV. 5G NETWORKS

4.1 INTRODUCTION

The designation "G" in 5G signifies "generation," with 5 representing progression by numerical value.

Wireless phone technology commenced with 1G, evolving to 2G in the early 1990s, enabling text messaging between cellular devices, which captivated global attention.

Subsequently, the shift to 3G liberated users to engage in phone calls, send texts, and browse the internet at remarkable speeds. Building upon the capabilities of the third generation, 4G significantly enhanced browsing speeds, text messaging, and call functionality, enabling seamless downloading and uploading of large video files without delays[8-9].

Following this, companies integrated LTE (long term evolution) into 4G connectivity, marking it as the

fastest and most consistent type of 4G, competing with technologies like WiMax. While both offered similar outcomes, establishing a universal standard was imperative. LTE accomplished this by augmenting 4G speed, laying the groundwork for 5G. 5G promises easier access to Ultra HD and 3D video downloads and uploads, signifying a speed advancement in daily life, akin to upgrading from a garden hose to a fire hose for data connectivity—a noticeable and appreciable difference.

A new iteration of mobile technology has emerged approximately every decade since the advent of the initial 1G system, the Nordic mobile telephone in 1982. The first commercially operational '2G' system emerged in 1992, followed by the introduction of the 3G system in 2001. 4G systems, fully compliant with IMT Advanced, became standardized in 2012. The development of the 2G (GSM) and 3G (IMT-2000 and UMTS) standards took around a decade from the inception of official R&D projects, setting the stage for the commencement of 4G system development around 2001 or 2002.

Fig. 3 illustrates the evolutionary trajectory of wireless generations concerning data rate, mobility, network coverage, and spectral efficiency. As wireless technologies continue to emerge, there are marked enhancements in data rate, mobility, coverage, and spectral efficiency. Notably, 1G and 2G technologies employed circuit switching, while 2.5G and 3G utilized a combination of circuit and packet switching.
Subsequent generations, from 3.5G to the present 5G,predominantly[8] rely on packet switching.
Additionally, the diagram delineates the contrast between licensed and unlicensed spectrum usage. Emerging generations leverage licensed spectrum, while Wi-Fi, Bluetooth, and Wi-Max utilize the unlicensed spectrum.

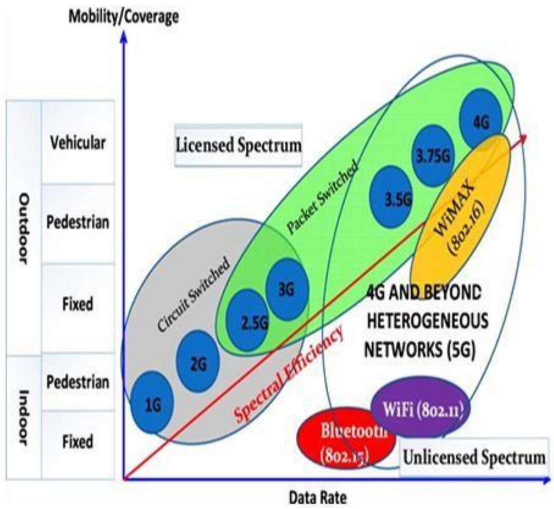


Fig.3

4.2 ARCHITECTURE OF 5G NETWORK

There are numerous hurdles confronting 5G designers. Among the most crucial challenges is the scarcity of available radio frequency (RF) spectrums allocated for cellular communications. Furthermore, these frequency bands have been extensively utilized, leaving no additional room in the current cellular bands. Another challenge is the high energy consumption associated with operating advanced wireless technologies. Adding to environmental concerns, cellular operators have observed and reported that the energy consumed by base stations accounts for over 70% of their electricity bills.

An assessment of the 5G network currently in the market reveals that the multiple access techniques within the network are nearly stagnant and urgently require upgrades. Existing technologies like OFDMA are projected to remain functional for at least the next 50 years, rendering a technology change unnecessary. The progression from 1G to 4G in wireless setups has been more about enhancements and applications to meet user demands, prompting service providers to transition to a 5G network soon after establishing 4G commercially.

Nevertheless, there was widespread agreement that the 5Gnetwork should surpass the following benefits compared to 4G:

- A system capacity increase of 1000 times.
- 10 times the spectral efficiency.
- Improved energy efficiency.
- Enhanced data rates.
- A 25-fold increase in average cell throughput.

Significant alterations in the approach to designing the 5G wireless cellular architecture are necessary to address user challenges and overcome the obstacles present in the 5G system. In the current wireless cellular architecture, an exterior base station typically exists at the center of a cell to facilitate communication for mobile users, whether indoors or outdoors[10].

However, the transmission of signals through indoor wallsfor communication between the indoor and outdoor base stations results in substantial penetration loss, leading to increased costs and reduced effectiveness in spectrum usage, data rates, and energy efficiency in wireless communications.

To confront this challenge, a novel concept for designing the 5G cellular architecture has emerged: segregating the outside and inside setups. This design approach aims to mitigate the loss incurred due to signal penetration through building walls. This strategy involves the utilization of massive MIMO (Multiple Input Multiple Output) technology, employing distributed arrays of antennas geographically, comprised of numerous small units or tens to hundreds of antenna units. While current MIMO systems use two or four antennas, the concept of massive MIMO systems emphasizes leveraging the advantages of large arrays of antenna elements to achieve significant capacity gains.

Establishing a large-scale massive MIMO network requires outfitting exterior base stations with substantial antenna arrays, dispersing some around the hexagonal cell and connecting them to the base station via the fastest means, such as optical fiber cables, primarily leveraging massive MIMO technologies.

Mobile users outdoors typically have a specific number of antennas, but collaborating to form a large collective antenna array, along with the base station's antenna arrays, creates practical massive MIMO links[11-12]. Moreover, equipping every building with large antenna arrays from the outside establishes communication with outdoor base stations using line-of-sight components. Wireless access points inside the building connect to the extensive antenna arrays via cables to communicate with indoor users.

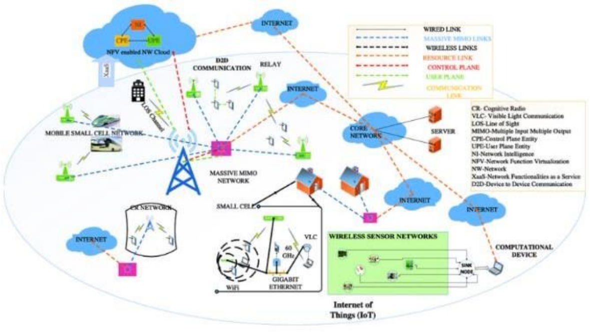
This approach significantly enhances energy efficiency, cell output, data rates, and spectral efficiency of the cellular system, albeit at the expense of amplified and leveled infrastructure costs. With this architecture, indoor users solely connect through wireless access points, while substantial erected antenna arrays remain installed outside the buildings.

For indoor communication, technologies like Wi-Fi, Small Cells, ultra-wideband, millimeter-wave communications, and visible light communication (VLC) prove beneficial for short-range communications with high data rates. However, technologies like millimeter-wave and visible light communication (VLC) use higher frequencies not typically employed in cellular communications. Utilizing these high-frequency waves for outdoor or long-distance applications is inefficient as they cannot efficiently penetrate dense materials and can be easily dissipated by rain, gases, and vegetation. Despite these limitations, millimeter waves and visible light communications technologies offer increased transmission data rates for indoor setupsdue to their large bandwidth.

As we're aware, the 5G wireless cellular network architecture predominantly consists of two primary logical layers: the radio network and the network cloud. The radio network comprises various components serving distinct functions. Typically, the User Plane Entity (UPE) and Control Plane Entity (CPE) execute advanced layer functionalities pertaining to the User and Control planes[12], respectively, and are part of the Network Function Virtualization (NFV) cloud. Within this context, one significant term is XaaS, which essentially denotes the linkage between a radio network and a network cloud.

This paper presents a proposed general architecture for the 5G cellular network. XaaS essentially represents the interconnectedness among emerging technologies such as Massive MIMO networks, Cognitive Radio networks, and both mobile and static small-cell networks. Additionally, this envisioned architecture aims to elucidate the role of Network Function Virtualization (NFV) cloud within the architecture of the 5th Generation cellular network.

The concept of Device-to-Device (D2D) communication, integration of small cell access points, and the Internet of Things (IoT) has also been incorporated into this proposed 5G cellular network architecture. Therefore, it can be inferred that this proposed architecture holds the potential to serve as a foundational framework for the standardization of future 5G networks. Considering the various intricacies involved, addressing these issues will be crucial in comprehending the wireless network architecture, particularly in the context of 5G networks overall.



A general 5G cellular network architecture.

Fig4. Architecture of 5G[11]

4.3 EMERGING TECHNOLOGIES FOR 5G WIRELESS NETWORKS

In the upcoming decade, there's an anticipated thousand-fold surge in mobile and wireless traffic volume, driven by a projected 50 billion or more connected devices expected to link to the cloud by 2020. Coping with the challenges arising from this rapid increase in connected devices involves enhancing energy efficiency, expanding capacity, optimizing costs and spectrum usage, and ensuring greater stability and scalability. Presently, our world is swiftly advancing, heavily reliant on technology for faster communication. The overarching technical objective is to establish a system capable of:

- Boosting data volume per area by a factor of 1000
- Increasing connected devices by 10 to 100 times
- Elevating typical user data rates by 10 to 100 times
- Prolonging battery life up to 10 times for low-power Massive Machine Communication (MMC) devices
- Reducing End-to-End (E2E) latency by 5 times

This section of 5G endeavors to cover the evolutionary stages of the internet and thoroughly explores emerging technologies, including their associated technical challenges stemming from diversity.

4.4 FEATURES OF 5G NETWORK

Characteristics of 5G Technology:

- 5G technology presents high-resolution capabilities catering to heavy mobile phone users and provides bidirectional large bandwidth.
- Shaping is a key aspect.
- Advanced billing interfaces in 5G technology enhance its attractiveness and effectiveness.
- Subscriber supervision tools are offered for swift action.
- High-quality services in 5G technology rely onPolicy to prevent errors.
- It supports large data broadcasting in Gigabit,accommodating nearly 65,000 connections.
- 5G technology includes a transporter class gateway known for its unparalleled reliability.
- Traffic statistics provided by 5G technologyensure greater accuracy.
- Remote management capabilities in 5G technology enable users to access quicker and better solutions.
- Remote diagnostics is another notable featureof 5G technology.
- It provides connectivity speeds of up to 25 Mbps.
- 5G technology supports virtual private networks.
- The new 5G technology will transform all delivery service business prospects.
- The uploading and downloading speeds achievable with 5G technology reach their peak.

Overall, 5G technology offers an array of features beneficial for diverse groups, including students, professionals (such as doctors, engineers, teachers, governing and administrative bodies), and the general public.

4.5 ADVANTAGES OF 5G NETWORK

- High resolution and bi-directional large bandwidth shaping.
- Technology to gather all the networks on one platform.
- More efficient and effective.
- Technology to facilitate subscriber supervision tools for quick action.
- Most likely, will provide huge broadcasting data (in Gb), which will support more than 60,000 connections.
- Easily manageable with the previous generation.
- Technological sound to support heterogenous services (including private network).
- Possible to provide uniform, uninterrupted and constant connectivity across the world.

4.6 APPLICATIONS

- Internet of Things (IoT)
- Autonomous Vehicles and Transportation
- Virtual and Augmented Reality (VR/AR)

- Smart Infrastructure and Cities

TECHNOLOGY	3G NETWORK	4G NETWORK	5G NETWORK
Evolution	2002	2010	2015-2020
Data rate and Speed	2Mbps	200Mbps to 1Gbps	More than 1 Gbps
Frequency band	850/900/2100 MHz	2-8 GHz	3-300 GHz
Standard	IMT-2000 3.5G-HSDPA 3.75G-HSUPA	Single Unified Standard LTE/LTE Advance Wi-Max, Wi-fi	Single Unified Standard
Hand-off	Horizontal	Horizontal and Vertical	Horizontal and Verticle
Switching	Packet except circuitfor interface	All Packet	All Packet
Core Network	Packet network	Internet	Internet
Multiple Access	CDMA	CDMA	CDMA & BDMA
Network Architecture	Wide area Cell-based	Hybrid: Integration of wireless LAN and wide area	Open wireless architecture

Fig5. Overall comparison of networks

VI. CONCLUSION

This paper delves into the progression of 3G, 4G, and 5G mobile technologies, examining and comparing various aspects such as network architecture, core network, switching, web standards, frequency bands, and data rates. Our analysis underscores the necessity for the development of distinct protocols and standards to ensure error-free services and superior connectivity. The evolution from 1G to 5G wireless technology manifests numerous enhancements. 5G, the most recent wireless technology, akin to advancements in nanotechnology, cloud computing, an All-IP framework, and high data rates, promises exceptional connectivity for forthcoming mobile networks. The concept of simplifying wireless networks while augmenting functionalities for end terminals is poised to materialize in the future generations of wireless mobile network technology.

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