IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 2, February 2022

DOI: 10.17148/IARJSET.2022.9210

A Review Paper on 5G Wireless Technology

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Abstract: 5G Technology known as fifth generation technology. As day-by-day use of internet for various activities are increasing rapidly every individual demand for a high-speed internet. 5G is new globally invented wireless technology after 1G, 2G, 3G and 4G networks with various extended feature's like high speed, superior reliability, massive network capacity and negligible latency to enable next generation user experiences to users. Broadly the 5G is used across three main types of connected services, including enhanced mobile broadband, mission-critical communications, and the massive IoT. 5G is designed in a such a way that it is capable to fulfil all the ever-increasing demand of future that are unknown today. This paper provides a brief introduction to the latest 5G wireless technology, evolution from 1G to 5G its advantages and disadvantages.

Keywords: 5G, Wireless Technology, Evolution 1G-5G, Core Architecture, Advantages-Disadvantages

I. INTRODUCTION

Wireless communication has started in early 1970s. In next four decades, a mobile wireless technology has evolved from 1G to 5G generations [1]. 5G stands for Fifth generation wireless technology. It offers very high bandwidth that user never experienced before. The 5th generation technology offer various new advanced features which makes it most powerful and in huge demand in the future [1].

5G technology has changed to use cell phones within very high bandwidth [2]. 5G technologies use CDMA and BDMA and milli-meter wireless that enables seed is greater than 100Mbps at full mobility and higher than1Gbps at low mobility. The 5G technology provides the mobile phone users more features and efficiency. A user of mobile phone can easily hook their 5G technology gadget with laptops or tablets to acquire broadband internet connectivity. Up till now following features of the 5G technology have come to surface-High resolution is offered by 5G for extreme mobile users, it also offers bidirectional huge bandwidth, higher data rates and the finest Quality of Service (QoS) [2].

The NEXT GENERATION MOBILE NETWORK ALLIANCES define the following pre-requisite for 5G networks: [3]

- Increased Data rates
- 1 Gb per second simultaneously to many workers on the same office floor
- SPECTRAL efficiency more enhanced as compared to 4G
- Coverage speed
- Signal efficiency enhanced
- Legacy reduced significantly compared to LTE

II. PAGE EVOLUTION OF WIRELESS TECHNOLOGIES

Mobile communication has become more popular in last few years due to fast revolution in mobile technology. This revolution is due to very high increase in telecoms customers.

This revolution is from 1G- the first generation, 2G- the second generation, 3G- the third generation, and then the 4G- the fourth generation, 5G-the fifth second generation [1].

First Generation(1G):

1G emerged in 1980s. It contains Analog System and popularly known as cell phones. It introduces mobile technologies such as Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT).

It uses Analog radio signal which have frequency 150 MHz, voice call modulation is done using a technique called Frequency-Division Multiple Access (FDMA). It has low capacity, unreliable handoff, poor voice links, and no security at all since voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties [1].

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Second Generation(2G):

The 2nd generation was accomplished in later 1990's. The 2G mobile communication system is a digital system; this system is still mostly used in different parts of the world. This generation mainly used for voice communication also offered additional services such as SMS and e-mail.

In this generation two digital modulation schemes are used; one is time division multiple access (TDMA) and the 2nd is code division multiple access (CDMA) and frequency band is 850-1900 mhz. In 2G, GSM technology uses eight channels per carrier with a gross data rate of 22.8 kbps (a net rate of 13 kbps) in the full rate channel and a frame of 4.6 milliseconds duration. The Family of this generation includes of 2G, 2.5G and 2.75G [2].

Third Generation(3G):

Third generation (3G) services combine high speed mobile access with Internet Protocol (IP)-based Services [2].

The data are sent through the technology called Packet Switching. Voice calls are interpreted through Circuit Switching. Along with verbal communication it includes data services, access to television/video, new services like Global Roaming [1].

3G systems offer high data rates up to 2 Mbps, over 5 MHz channel carrier width, depending on mobility/velocity, and high spectrum efficiency. The data rate supported by 3G networks depends also on the environment the call is being made in; 144 kbps in satellite and rural outdoor, 384 kbps in urban outdoor and 2Mbps in indoor and low range outdoor. The frequency band is 1.8 - 2.5 GHz [2].

Fourth Generation(4G):

4G offers a downloading speed of 100Mbps. 4G provides same feature as 3G and additional services like Multi-Media Newspapers, to watch T.V programs with more clarity and send Data much faster than previous generations. LTE (Long Term Evolution) is considered as 4G technology [1].

A 4G system may upgrade existing communication networks and is expected to provide a comprehensive and secure IP based solution where facilities such as voice, streamed multimedia and data will be provided to users on an "Anytime Anywhere" basis and at much higher data rates compared to previous generations [2].

4G is being developed to accommodate the QoS and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB), minimal services like voice and data, and other services that utilize bandwidth [1].

III. COMPARISON OF 1G TO 5G

Technologies / Features	*1G*	*2G/2.5G*	*3G*	*4G*	*5G*
Evolution	1970	1980	1990	2000	2010
Deployment	1984	1999	2002	2010	2015
Data Rate	2 kbps	14.4-64 kbps	2 Mbps	200 Mbps to 1 Gbps for low mobility	10 Gbps to 100 Gbps
Famous Standards	AMPS	2G: GSM,C]DMA 2.5G: GPRS, EDGE, 1xRTT	WCDMA, CDMA-2000	LTA, WiMAX	Not yet defined
Technology behind	Analog cellular technology	Digital cellular technology	Broad bandwidth CDMA, IP technology	Undefined IP and seamless combination of broadband. LAN/WAN/PAN/ WLAN	Undefined IP and seamless combination of broadband. LAN/WAN/ PAN/WLAN
Service	Voice	2G: Digital Voice, SMS 2.5G: Voice+Data	Integrated high quality audio, video and data	Dynamic information access, wearable devices	Dynamic information access, wearable devices with AI capabilities
Multiplexing	FDMA	TDMA,CDMA	CDMA	CDMA	CDMA
Type of Switching	Circuit	2G: Circuit 2.5G: Circuit and packet	Packet	Packet	Packet
Handoff	Horizontal	Horizontal	Horizontal	Horizontal and Vertical	Horizontal and Vertical
Core Network	PSTN	PSTN	Packet network	Internet	Internet

[4]

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IV. 5G TECHNOLOGY

What is 5G technology?

5G Technology stands for 5th Generation Mobile technology. 5G technology has changed the means to use cell phones within very high bandwidth. User never experienced ever before such a high value technology. Nowadays mobile users have much awareness of the cell phone (mobile) technology. The 5G technologies include all type of advanced features which makes 5G technology most powerful and in huge demand in near future.

The gigantic array of innovative technology being built into new cell phones is stunning. 5G technologies which are on hand held phone offering more power and features than at least 1000 lunar modules. A user can also hook their 5G technology cell phone with their Laptop to get broadband internet access. 5G technology including camera, MP3 recording, video player, large phone memory, dialling speed, audio player and much more you never imagine. For children rocking fun Bluetooth technology and Pico nets has become in market [5].

5G Core Architecture:

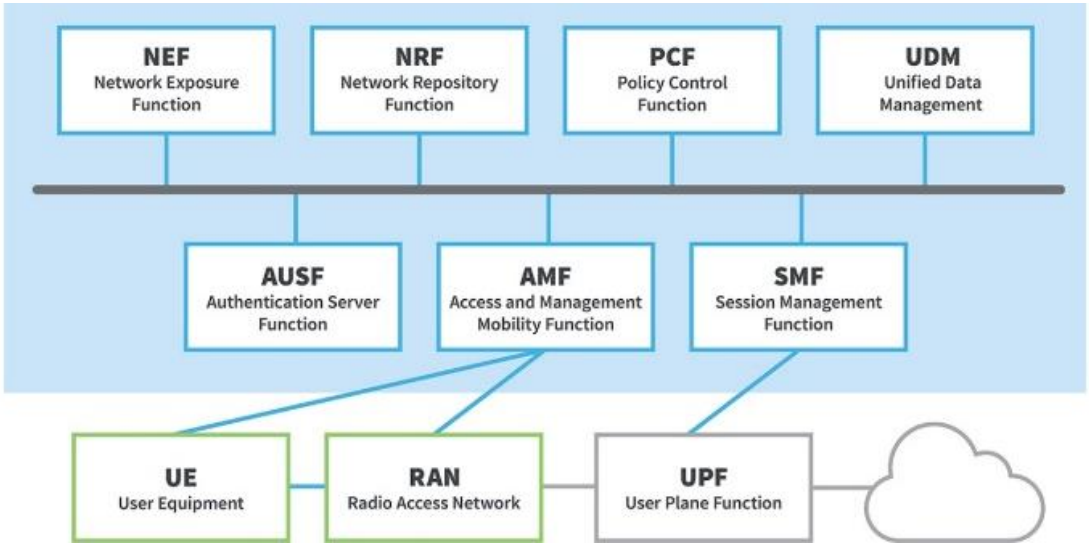
The 5G core network, which enables the advanced functionality of 5G networks, is one of three primary components of the 5G System, also known as 5GS (source). The other two components are 5G Access network (5G-AN) and User Equipment (UE).

The 5G core uses a cloud-aligned service-based architecture (SBA) to support authentication, security, session management and aggregation of traffic from connected devices, all of which requires the complex interconnection of network functions, as shown in the 5G core diagram.

The components of the 5G core architecture include:

- User plane Function (UPF)
- Data network (DN), e.g. operator services, Internet access or 3rd party services
- Core Access and Mobility Management Function (AMF)
- Authentication Server Function (AUSF)
- Session Management Function (SMF)
- Network Slice Selection Function (NSSF)
- Network Exposure Function (NEF)
- NF Repository Function (NRF)
- Policy Control function (PCF)
- Unified Data Management (UDM)
- Application Function (AF)

5G was designed from the ground up, and network functions are split up by service. That is why this architecture is also called 5G core Service-Based Architecture (SBA). The following 5G network topology diagram shows the key components of a 5G core network [7]:



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How it works:

- User Equipment (UE) like 5G smartphones or 5G cellular devices connect over the 5G New Radio Access Network to the 5G core and further to Data Networks (DN), like the Internet.
- The Access and Mobility Management Function (AMF) acts as a single-entry point for the UE connection.
- Based on the service requested by the UE, the AMF selects the respective Session Management Function (SMF) for managing the user session.
- The User Plane Function (UPF) transports the IP data traffic (user plane) between the User Equipment (UE) and the external networks.
- The Authentication Server Function (AUSF) allows the AMF to authenticate the UE and access services of the 5G core.
- Other functions like the Session Management Function (SMF), the Policy Control Function (PCF), the Application Function (AF) and the Unified Data Management (UDM) function provide the policy control framework, applying policy decisions and accessing subscription information, to govern the network behaviour.

As you can see, the 5G network architecture is more complex behind the scenes, but this complexity is needed to provide better service that can be tailored to the broad range of 5G use cases [7].

Key Enabling Technologies used in 5G:

The development of 5G will not be from scratch but will gradually build on 4G LTE.

Major technologies enabling 5G include [6]:

- **D2D Communication:**

Direct connectively is achieved through device-to-device (D2D) technology. 5G cellular network will implement D2D mm wave communication technology to provide high speed data rate, improve coverage, and offer peer-to-peer services. Much research effort has been invested of characterizing D2D connections as part of LTE.

- **M2M Communication:**

While D3D communication targets mobile radios, machine-to-machine (M2M) expands the scope and facilitates ubiquitous connectivity among mobile devices. It is estimated that there will be over 100 billion connected devices using M2M communications in 5G backbone.

- **MIMO:**

Multiple-input-multiple-output (MIMO) technology plays a crucial role in 4G and is expected to play an important function in 5G. Massive MIMO extracts the benefits of MIMO on a large scale by increasing the throughput and spectrum efficiency.
Other enabling technologies of 5G include mm Wave communication, ultra-dense network (UDN), all-spectrum access (ASA), OFDM (orthogonal frequency division multiplexing), and Internet of things [6].

Why 5G?

As a user point of view, the major difference between current generations and expected 5G techniques must be something else than increased maximum throughput; other requirements include [2]:

1. It could make better revenue for current global operators as well as interoperability will become more feasible.
2. Improved and innovative data coding and modulation techniques, which includes filter bank multi carrier way in schemes.
3. For wireless access and back haul use of milli-meter wave frequencies is very useful.
4. With the support of different conduction points with related coverage and surrounding the option of a supple usage of resources for up-link and down-link transmission in each cell is achieved by superior intrusion and mobility management.
5. To make 5G practical for all sorts of radio access technologies there should be a common platform unique for all the technologies.
6. Lower battery consumption and outage probability.
7. Better coverage and high data rates available at cell edge.
8. Multiple concurrent data transfer paths.

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9. Possible to1Gbps and higher data rate in mobility.
10. More secure; better cognitive radio/SDR Security.
11. Higher system level spectral efficiency.
12. World Wide Wireless Web (WWWW), wireless-based web applications that include full multimedia capability beyond 4G speeds.
13. More applications combined with Artificial Intelligent (AI) as human life will be surrounded by artificial sensors which could be communicating with mobile phones.
14. Not harmful to human health.
15. Cheaper traffic fees due to low infrastructure deployment costs.
16. Smart beam antenna systems.

How to experience 5G?

Even though carriers have implemented 5G infrastructure which nearly took almost a decade of time, the users are required to upgrade their handsets to enjoy the 5G network.

Smartphones powered by the Snapdragon X55 or Snapdragon X60 Modem-RF System are 5G compatible.

Samsung Galaxy S20 launched on March 6, 2020, became the first-ever all-5G smartphone [11]. Followed by many other devices supporting 5G are launching.

Advantages of 5G:

Fifth generation objective is at providing countless of utility to the consumer at high speed. The applications developed to use these utilities are highly customer companionable; curtail the intercommunication among the application and the customer.
For example, unification of speech recognition technology in the user interfaces would ease the use of the applications for each user [9].

1. 5G targets at providing a unified global standard which will facilitate global mobility and service portability.
2. 5G stations and networks will provide common services independent of their capabilities. This is also called as service personalization.
3. It is expected to provide wireless download speeds of above 1Gbps in local area network (LAN) and 500 Mbps in wide area network (WAN), about 40 times greater than the 4G wireless networks.
4. Its focus at lower power consumption.
5. It would provide users access to large repository of data and services where he would have flexibility to filter these data and services as per his preferences by configuring the operational mode of their devices.
6. Better Network Convergence
7. Provide Higher Bandwidth
8. More effective and efficient
9. Most likely, will provide a huge broadcasting data (in Gigabit), which will support more than 60,000 connections.
10. You can control your PCs by handsets.

Disadvantages of 5G:

The fifth generation (5G) of mobile technology is emerging as a superior communication network, delivering increased speeds, coverage and reliability. This innovative network is bringing about the reality of Internet of Things (IoT) as it is able-to handle significantly more devices.

However, as with any new technology, there are some disadvantages to be considered as follows [10].

1. OBSTRUCTIONS CAN IMPACT CONNECTIVITY: The range of 5G connectivity is not great as the frequency waves are only able to travel a short distance. Added to this setback is the fact that 5G frequency is interrupted by physical obstructions such as trees, towers, walls and buildings. The obtrusions will either block, disrupt or absorb the high-frequency signals. To counter this setback, the telecom industry is extending existing cell towers to increase the broadcast distance.

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2. INITIAL COSTS FOR ROLLOUT ARE HIGH: The costs related to the development of 5G infrastructure or adaptations to existing cellular infrastructure will be high. This amount will be further compounded by the ongoing maintenance costs needed to ensure the high-speed connectivity, and it's likely the customers will bare the brunt of these big price tags. Cellular operators are looking to minimise these costs by exploring alternative options in the form of network sharing.

3. LIMITATIONS OF RURAL ACCESS: While 5G might bring about real connectivity for the predominantly urban areas, those living in the rural settings will not necessarily benefit from the connection. As it stands, many remote areas countrywide are not able to access any form of cellular connectivity. The 5G carriers are going to target big cities with larger populations, eventually working their way into the outer areas, but it's not likely this will be happening any time soon. As a result, only some of the population will benefit from 5G communication.

4. BATTERY DRAIN ON DEVICES: When it comes to cellular devices connected to 5G, it seems the batteries are not able to operate for a significant period-of time. The battery technology needs to advance to allow for this enhanced connectivity, where a single charge will power a cell-phone for a full day. Alongside depleted batteries, users are reporting that cell-phones are getting increasingly hot when operating on 5G.

5. UPLOAD SPEEDS DON'T MATCH DOWNLOAD SPEEDS: The download speeds of 5G technology are incredibly high, in some cases up to 1.9Gbps. However, the upload speeds are rarely more than 100Mbps, which is not quite as incredible as initially touted. In relation to existing mobile connectivity, however, the upload speeds are higher than being seen with 4G LTE.

6. DETRACTING FROM THE AESTHETICS: The erection of more cell-phone towers, or extension of existing cell-phone towers, is not welcomed by most communities because they are seen to diminish the overall look and feel of an area. With 5G, there is going to be a need for increased infrastructure development, which won't necessarily see as a good thing for local resident.

Where is 5G being used?

5G is meant to bring revolutions in many fields. Some of the areas where 5G is being used are [11]:

- Internet of Thongs – IoT
- Health care
- Public safety and infrastructure
- Autonomous vehicles
- Manufacturing
- Entertainment/Gaming
- Supply-chain management
- Energy

5G Impact on Society:

It has a great impact on people as working speed has increased with increasing speed of network. All official as well as unofficial works are getting faster which help to save time.

From the social view, fifth generation networks have the capability to ameliorate the cell-phone broadband connections in rustic regions. The expenditure of wealth for installing a huge number of BS & the less ARPU (average revenue per user) has deferred the wide-ranging coverage of rustic environments.

By utilizing TV White Space & offloading of traffic elucidations, the placement of 5G networks in rustic regions will be feasible at a lesser budget thanks to 1871 further favourable propagation situations in the very high-frequency/ultrahigh-frequency gamut that unswervingly transform into littler base stations [8].

V. CONCLUSION

1. The development of the mobile and wireless networks is going towards higher data rates and all-IP principle. Mobile terminals are obtaining each year more processing power, more memory on board, and longer battery life for the same applications [1].

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2. 5G Wireless Technology is more intelligent technology, which will interconnect the entire world without limits. It is designed to provide unbelievable and extraordinary data capabilities, unhindered call volumes, and vast data broadcast. Our world would have universal and uninterrupted access to information, communication, and entertainment that will open a new dimension to our lives and will change our lifestyle meaningfully. Moreover, governments and regulators can use this technology as an opportunity for good governance and can create healthier environments, which will definitely- encourage continuing investment in 5G, the next-generation technology [11].

3. 5G technology has various advantages which a user can used in a positive way also along with all the advantages it has some disadvantages which every user should keep in mind and work with 5G keeping all the points.

4. Many tests and trials need to be conducted before implementing 5G. 5G technology is still in development stage. It has a bright future and will be a revolution in the mobile market [6].

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