

A Review on 5G Technology: A Heterogeneous Architecture, OSI protocol model & Future Challenges

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Abstract—In today's era of mobile communication different mobile generation plays very important role that is from 1G to as now 5G (1G,2G,3G,4G,5G).5G provides various features such as High speed, accessibility, low latency, flexibility, spectrum efficiency, higher bandwidth and Quality of service(QoS).The development of worldwide wireless web (WWW),Dynamic Ad-hoc wireless network(DAWN),design of wireless network using millimeter wave (mm),cognitive radio these are few main consideration of researcher point of view under 5G.This paper is based on the study of architecture of 5G technology with various radio access technology(RAT),advanced features of 5G and the future challenges that 5G possess while working with the advancement of mobile technology.

Index Terms—5G; WWW; RAT; QoS;HET-NET.

I. INTRODUCTION

In recent few years the communication through our landline and later through our mobile phone is became very easier or very handy to each and every user. Now this means of communication not only able to communicate through voice but they also provide communication through data, mobile broadband. In few seconds we are able to link our mobile with our laptops to create portable internet connections. Today's internet serving is not a very big deal. We can communicate our near and dear one easily, we are able to do our office work easily, and entertainment through internet also became easier that we no longer bother on dish connection at our home. There are approximately over 1.1 billion mobile subscribers in India and approx 5 billion mobile subscribers today worldwide by 2020, which is going to be increased in next few years [2]. Today in a single family each and every person has mobile phone and sometimes the number may be increased as compared to members. Facebook, Youtube, Instagram, twitter are few social networking sites which have billions of subscribers today's. Internet becomes necessity of today's life that we can't even move a single step without it. Now how all such necessity can fulfill, how each subscriber has good service in hand is main consideration. So the answer is to have better internet connection, with great speed, no time delay, no any interrupt to download any file or movies and all. By combining all such aspects the result is 5G.5G is the fifth generation of wireless mobile communication which provides highest data transfer speed, higher energy efficiency, reduced latency, better connectivity, good flexibility, and mobility of user, which is

the main constraint of mobile user. Different mobile companies also providing all these mentioned facilities to their users. Prior 5G, 4G that is the 4 generation of mobile communication fulfilling the requirements of users. If services of 3G and 2G standards are combined or we can say that services of 4G provides offspring towards that of 3G and 2G. 3rd Generation Partnership Project (3GPP) is standard Long Term Evolution (LTE) is presently work as Advanced 4G standard along with Mobile Worldwide Interoperability for Microwave Access (WiMAX). A 4G system improves the prevailing communication networks by imparting a complete and reliable solution based on IP. As compare to the previous generation from 4G that is 2G, 3G 4G provides higher data rates that the people can send data whether it is voice messages, video, image file and other large file within few seconds. Messaging Service (SMS), Digital Video Broadcasting (DVB), and video chat, High Definition TV content and mobile TV are such few applications which are supported by 4G. Apart from all these facilities provided by 4G there are few challenges of this generation too. In 4G if single user terminal operates in different wireless networks then that terminal possesses various design related issues like power consumption, size and cost so this problem can be eliminated by using software radio approaches (RAT) [2]. Another issues occurs in 4G such as Jamming and spoofing which includes fake data transmission, can easily access by criminals, data loss by creating easy link between transmitter and receiver that can be easily access or break by third party so data encryption required and the hurdle to maintain different consumers data charge and billing. All such challenges will going to overcome in 5G. 5G offers common network platform towards various wireless networks [4]. This scheme is radio access technology (RAT). So this paper provides the comprehensive study of architecture of 5G with different protocols and different RAT technology and future challenges which possesses by 5G.

II. RADIO ACCESS TECHNOLOGY (RAT)

Before going to the architecture of 5G Network necessary to describe what is radio access technology. As today different radio or wireless technologies is employed such as 3G mobile networks (UMTS, CDMA 2000), LTE (Long Term Evolution), WiFi (IEEE 802.11 wireless networks), WiMAX (IEEE 802.16 wireless and mobile networks), as well as accompanying networks, such as sensor networks, or personal area networks (e.g., Bluetooth, ZigBee [1]). Now to interact with these technologies it is necessary to create some interface from mobile terminal just like GSM. But GSM in 3G is based on circuit switching which is not so popular now a days. So the better solution of today's connectivity is Internet Protocol that is IP. In 5G advance LTE will going to give such kind of connectivity through IP. That means all the data and messages will be transform through IPs on the network layer [1]. In wireless mobile or radio communication network a Radio Access Technology or (RAT) is the core physical connection method between one end devices to other. As discussed earlier the example of all RATs are Bluetooth, Wi-Fi, GSM, UMTS, LTE. The network which is formed by this Radio Access Technology is known as Radio Access Network (RAN). Basically it exists among a end device for example a cell phone, a computer, or any machine which controlled by remote to provides the connection with its core network (CN). End devices such as mobile phone and computers are also known as user equipments (UE) as given in below Fig.1.

III. HETEROGENEOUS NETWORK

A heterogeneous network and Radio access technology both are interconnected to each other. For 5G technology it is essential to give brief about these two terminologies. By using heterogeneous Network in mobile networks capacity of networks can be enhance in high traffic dense areas [RAT]. Heterogeneous Network is a network which is formed by connection of end devices to the different operating system and protocols. The end devices are computers and mobiles. The example of Heterogeneous Network (Het Nets) is the connection formed by local area networks (LANs) to one's windows and Linux operated personal computer with the Apple computers. Not only in computer is the heterogeneous network also deals with mobile or radio communication with different Radio Access Technologies as well. Example of wireless heterogeneous network is connection between wireless LAN and cellular network. Heterogeneous Networks are formed by disparate Radio Access Network (RAN), as already discussed in above paragraph the RAN is nothing but is the network builds up off different Radio access Technologies [9]. Now what is the requirement of this heterogeneous network in the 5G architecture? The answer is for better transmission solution, that means Heterogeneous Networks are used to providing best connections and best quality of service (QoS) at client terminals. Base stations of varying power capacity. HetNets are deals with the all-IP

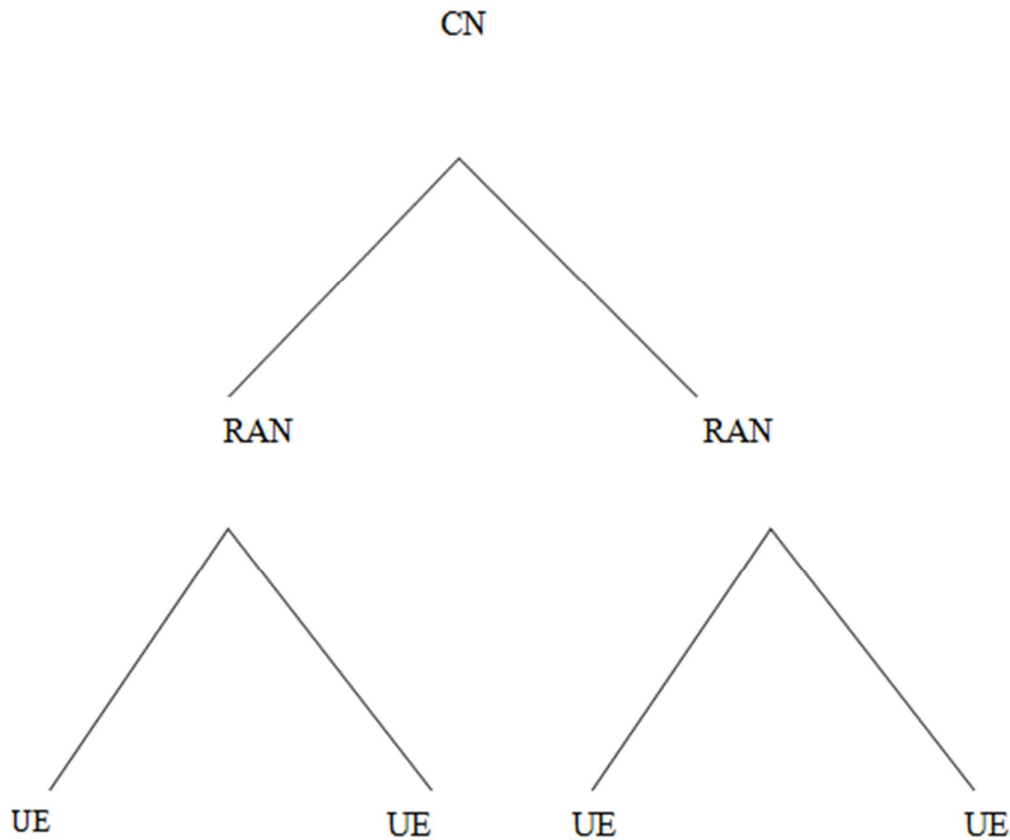


Figure 1. Radio Access Network (RAN)

concept that means internet protocol is used for every connection between CN to RAN. Hence it is useful in providing intelligent IP traffic routing system and management.[1].

So it is clear while include heterogeneity concept in 5G wireless mobile systems will leads to improves different radio interfaces in the new terminals. Hence RATs are so designed to get maximum utilization of available data resources which is not providing in the previous mobile generations. So this is how heterogeneous network useful in 5G.

IV. 5G ARCHITECTURE

The functional architecture of 5G is based on the all IP concept for wireless network interoperability. The architecture consisting of a user terminal and various autonomous radio access technologies such as GPRS, 3G, WLAN and LTE. Each these RATs is operate on the IP link to outer world and form a RAN. To interconnection among different Radio Technologies there should be individual's radio interfaces within each mobile terminal. For an example, suppose if someone wants to access to four different RATs, then it is required to have four different access interfaces in the mobile terminal which all are active at the same time. This concept thus how helpful in architecture of 5G.[1].

According to the architecture as shown in Fig. 2, the first two layers of OSI models that is data-link and physical layers are defined by these different radio access technologies which generates the access to the internet with good QoS. After these two layers of the OSI model the next network layer incorporates with the IP (Internet Protocol) which is very important for today's communication generally used either IPv4 or IPv6. The main focus of IP is how to control transmission between client as well as in servers.[1]. Proper connection between client and server through internetwork is accomplished via some electronics sockets. These sockets are nothing but the end device or end points that allow data to flow for communication. Now to determine which path is suitable for data flow is also very important ,so for that purpose these sockets get

combined with IP address and targeted communication port along with transport protocol. Considering that, For synchronization between client and server or in other words for one to one communication between client and server it is required to defined an unique IP address at both side so that chances of mismatching of

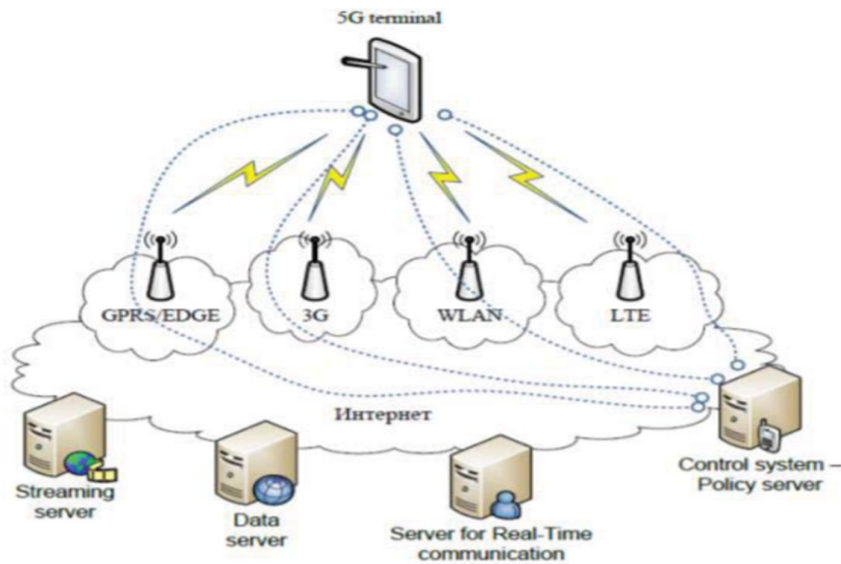


Figure 2. The functional Architecture of 5G[1]

IP can be avoid. By doing so heterogeneous network interoperability and for vertical handover between different RAT, the source IP address as well as destination IP address get fixed. Here term vertical handover is used so Vertical handover (VHO) is changing of different RAT by a mobile terminal according to requirement in Heterogeneous wireless network. As mentioned above that source and destination IP address is unchanged which ensures transparent vertical handover, to end to end internet connection. Also to prevent packet losses routing is done in such a way that from source to destination and from destination to source by following same Path. In this way the path between sender to receiver is dedicated. So this mechanism is followed by 5G architecture due to its flexibility to access different RAT. As this facility is not provided in the recent generations of mobile communication because handover between access technology means changing IP address again and again which enable to changes in sockets that is closed the current sockets and on the new one. So this is not so flexible process, that's why 5G is becoming best in recent mobile generations.

V. PROTOCOL DESIGN FOR 5G

The OSI model for 5G is given in this section. Which plays an important role in All-IP based system functioning which includes mobile health, mobile banking, mobile commerce and all other facilities supported by mobile phone. The OSI model for 5G is given in Table I below:

A. Physical and Data link layer (MAC)-OWA

The model has seven layers in which first two layers Physical and data link layer combined form open wireless architecture (OWA). The OWA architecture first incorporates with the 4G mobile communication. The model has seven layers in which first two layers Physical and data link layer combined form open wireless architecture (OWA). The OWA architecture first incorporates with the 4G mobile communication. OWA is basically an open interfaces in wireless networks which consisting of base band signal, RF parts, Networking parts, OS and Application parts to supports various wireless networks and different industrial standards on the basis of open access platform. Example of OWA is a single user can automatically connect to the local high speed wireless networks, in any location whether it is in office, mall, railway station and airport etc. [5].

B. Network layer

The main functioning of Internet Protocol (IP) is from Network Layer. Basically two version of IP that is IPv4 and IPv6 is commonly used. The version 4 and 6 is nothing but the IP address. First IPv4 was throughout the world which is routing efficient, provide reliable Routing. But Version 4 of IP protocol has some issues such as limited address space and there is no any possibility for QoS per data flow.[3].These

TABLE I. 5G OSI PROTOCOL MODEL

Application Layer	Application (Services)
Presentation Layer	
Session Layer	Open Transport Protocol (OTP)
Transport Layer	
Network layer	Upper network layer
	Lower network layer
Data link Layer(MAC)	Open Wireless Architecture (OWA)
Physical Layer	

problems are resolved in the next version that is in IPv6, protocol. IPv6 has big size of header packet due to which mobility is the main problematic concern. As from the OSI model of 5G it can be shown that the network layer is divided into two parts that is Upper Network layer and Lower network layer. The main reason of this separation is that all mobile networks will have one Mobile IP in 5G, and each mobile terminal will be FA (Foreign Agent). As a single mobile phone user can be direct connected to different wireless network at the same time. So it is required to have different IP address for different radio interfaces. For that mapping is also very crucial. That's why FA is used to map the IP address between fixed IPv6 of mobile to care of address (COA) of current network. The task to maintain constant IPv6 protocol in a mobile phone is done by 5G phone manufactures. Thus how the 5G mobile phone possesses the multi wireless network connectivity.

C Session and transport -Open Transport Protocol (OTP) layer

The Session and Transport layer together work as open transport protocol layer for 5G mobile communication system. As the communication is two types wired and wireless. This transport layer is responsible to differentiate the duo wire as well as the wireless communication. The protocol used in the transport layer is TCP protocol. According to TCP protocol it is assumed that the lost data segment is only due to network traffic in mobile communication whereas in wireless communication losses depend on the higher bit error rate. So TCP modifications are planned for the mobile and wireless networks, so that the lost and corrupted TCP segments can be retransmit through wireless link. In the 5G mobile phones there is a facility provided to download all version of TCP protocol such as TCP,RCP etc. which is useful to wireless technology at the base station. This protocol is now known as Open Transport Protocol which has the facility Open Transport layer Protocol (OTP) to getting downloaded by any user equipment when needed.[3].

D Application layer

The Application layer in 5G which is formed by combining Application and Presentation layer of OSI model. This application layer provides proper formatting of the data for the further transmission to the outer world. It encrypt as well as decrypt of the data for the security purpose. Now the main concern of 5G system is to provide the best wireless connection for existing mobile service. In other words Application layer works to provide best QoS over many wireless networks for 5G mobile terminal. This makes 5G more efficient as compare to previous generation. Generally mobile user manually selects the wireless network for the particular internet service he/she is using without having the freedom to choose best QoS. But 5G phone has this facility to test QoS and storage of measurement information in database of mobile terminal. There are several of QoS parameter to be test and stored in database such as jitter, delay bandwidth, losses and reliability. The testing is done on the basis of intelligent algorithms running in mobile phones the results of such algorithms is the best connectivity for better QoS.[3].

VI. SPECIAL FEATURES IN 5G TECHNOLOGY

Following are few functions provided by the 5G technology:

1. 5G is a wireless communication without limitation; that is no limitation of speed ,and the connectivity, people can access this service without any limitation, perhaps on this regard 5G is the REAL wireless world.
2. 5G provides High Definition Facility that people can watch Programs, movie and many more with so fine clarity just likes as in HDT.V.
3. Till now we have using WWW to address any website in 5G the new web address will going to be WWWW that is World Wide Wireless Web means no any zone or area issue with this service.
4. 5G provide an advanced billing interface which makes it more efficient as compare to previous one.
5. With the high quality services of 5G technology there is less chances of error.
6. From 5G, user has all the control to access application and networks according to their requirement at any location.

7. User can access the network, at the speed upto 25 Mbps using 5G.
8. With the IPv6 protocol the traffic problem can be resolved due to which connection is free of any congestion.
9. The uploading and downloading becomes easier with 5G. For user no any need to wait for proper network.
10. Internet protocol version 6 (IPv6), where a care-of address (CoA) IP address is assigned according to location and the connected network

VII. FUTURE CHALLENGES Possess By 5G

With the above mentioned features 5G possess following few future challenges:

1. *Spectrum harmonization: Millimeter wave Technology*

5G will work on the low ($f < 1$ GHz), as well as high ($1 \text{ GHz} < f < 6$ GHz) frequency and on very high frequencies which is known as Millimeter wave (MW) frequencies ($f > 6$ GHz). According to latest World Radio communications Conference (WRC-15 in Geneva), which is a conference under the aegis of ITU aimed to changes in frequency band for future mobile uses and future 5G studies for millimeter wave frequencies, on a specific number of bands situated between 24 GHz and 86 GHz (33.25 GHz in total): that is from 24.25 - 27.5 GHz, 31.8 - 33.4 GHz, 37 - 43.5 GHz, 45.5 - 50.2 GHz, 50.4 - 52.6 GHz, 66 - 76 GHz, to 81 - 86 GHz. These bands are also known as '5G bands'. So among such large bands there is no any information to know that whether these bands are employ to the development of 5G new mobile generations. Research results will only make sure that the uses of such bands is successful or not for new generation. At the Frequency bands below 6 GHz that is from 3.4-3.8 GHz band It won't be feasible for 5G to run entirely on millimeter wave frequencies: reason is the propagation issues of these bands found it tough to attain widespread coverage, mainly in populated areas. Consequently a "core" band below 6 GHz is required to provide sufficient large channels to facilitate future 5G subscriber for innovative services at very high quality as compared to 4G. Other challenges for mm Wave communications comprise a large path loss specially non-line-of-sight propagation, signal absorption by different objects presents in the environment.[6].

2. *Massive MIMO Systems*

Massive MIMO is a multiuser MIMO in which the large amount of antennas at the BS is uses as compare to the number of end devices per signalling resource. This concept employed in communication in order to improve the magnitude of spectral and energy efficiency by using linear processing. conventional cellular system uses an outdoor BS communicating with mobile terminals in the middle of a cell, without figuring out about the location of BS. For an example if the indoor users communicating with the outdoor BS, then the signals undergo to high penetration loss, resulting considerably decrease in data rate, spectral and energy efficiency. So the better solution is to split outdoor and indoor scenarios, by doing so the propagation loss can be avoid at some instant. This concept is followed by distributed antenna system (DAS) and massive (large-scale) multiple-input multiple-output (MIMO) system. Beside of all these features, certain research work and experiment will required to incorporate this massive MIMO technology for 5G mobile system. For

beam forming large amount of channel will needed and the information given by these channels is not so adequate for downlink. That is why massive MIMO is not practically feasible for frequency division duplexing, but it can be employed in time division duplexing. Massive MIMO also suffers from pilot contamination and thermal noise generated by neighbouring cells.[6]

3. Network Densification

The key mechanism to provide higher data rate by different mobile companies is to reduce the cell size. This mechanism of reduced cell size is also applicable for raise in spectral efficiency over higher frequency reuse. It has been observed that smaller the cell size will result more dense network, and known as Network densification. These macro cell base stations provide the guarantee to cover a relatively Wide Area Network, also provide good quality of service (QoS). Due to smaller size, these cell can be placed anywhere throughout network. The small cells are basically divided into two types low powered femtocells which is used in urban area or the higher power picocells used to cover gaps in macrocell. As the cell size is reduced results in dense network will arise the chances of inter cell interference. The inter cell interference is occur in channel due to sharing of common licensed frequency band by BSs of different coverage area, different access technology, and transmission powers.[10].

VIII. CONCLUSION

In this paper broad survey has to be done about 5G technology. The survey includes brief introduction followed by requirement of heterogeneous wireless network. The concept of different RAT has also be discuss so that different access technology can be access by a mobile terminal at the same time without failure of connection. The role of IP address for different radio technologies also be explained here. The detailed functional architecture with all the OSI layers supported by 5G has given in to this survey. This survey also include some special features of 5G followed by few future challenges possess by 5G. In future Artificial Intelligence (AI) is going to merge with 5G technology will make it more and more smarter than the conventional generations. With the merger of AI any idea that come into human mind can be executed more smartly than a human can do.

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