

# The 5th Generation Mobile Wireless Networks- Key Concepts, Network Architecture and Challenges

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**Abstract** The process of learning, our way of working, thinking and interaction has all changed due to the internet supported by world wide mobile revolution. Currently the 4G's concept is marching towards the standardization phase. So time has come to introduce a new technology in which we can connect to multiple wireless technologies, networks, terminals and applications, all simultaneously and can also switch between them. This latest technology is named as 5G. 5G (5th generation mobile networks or 5th generation wireless systems) is a term used in some research papers and projects to denote the next major phase of mobile telecommunications standards beyond the current 4G/IMT- Advanced standards. 5G is considered as beyond 2020 mobile communications technologies. This upcoming technology will support IPv6 and flat IP. This paper addresses an overall description of the 5G systems and its architecture, standard, benefits, challenges in deployment, Security issues and scope of 5G technologies. This paper will also focus the researches being made on worldwide wireless web (WWW), Dynamic Adhoc Wireless Network (DAWN) and real wireless world.

**Keywords:** 5G, 4G/IMT advanced, WWW, DAWN, Flat IP, real wireless world Introduction

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## 1. Introduction

Mobile is a radio terminal that can be moved during operation or it may be attached to a fast moving vehicle or portable hand set. We can say a mobile is a radio, because it also radiates electromagnetic waves or radio waves just like a radio. In the process of communication, man has seen a number of changes. The technology creation, revolution and evolution of the wireless mobile had started since the early of 1970s. In the modern world of communication system, cellular telephone began as a simple concept. The increased demand for cellular services has caused cellular telephone systems to evolve in to complicated networks and internet comprised of several types of cellular communication systems. The cellular concept is used in some full-duplex systems like standard cellular telephone services (CTS), personal communications systems (PCS), and personal communication satellite system (PCSS).

Technologies like frequency modulation (FM) and frequency shift keying (FSK) were used previously in cellular communication system. FM was used for voice and FSK was used for transporting controlling and signaling information. Now days some advanced digital communication techniques like Quadrature phase shift keying (QPSK), Minimum shift keying (MSK) are used in

wireless cellular communication system and also some new frequency bands has been assigned by Federal Communication Commission (FCC). Presently, the use of landline has come to an end. We are now actually living in the era of convergence. The word convergence denotes merging of technologies, domain and discrete IT systems. The basic part of convergence is digitization which is accomplished through Analog-to-Digital Converters (ADC).

Digitization has created a more ambience in the natural process of communication. With each and every day passing the world of telecommunication has seen a lot of changes starting from 1G to 2.5G and from 3G to 5G. 5G technology is on its way to reform the way by which most of the users access their handsets. 5G allows users to use their handsets with a very high band width such that broadband is always supported. This advanced feature is going to make it the most powerful and in near future it is going to be in a huge demand. So the day is not too far when the entire system surrounding us will communicate with each other automatically with our need to feel connected with anyone, anywhere and at any time across the entire world. This is called as Ubiquitous Computing Paradigm.

Mobile telephone services (MTS) was started in the 1940s and frequency modulation technique was used in this system [2]. They were assigned a single carrier frequency in the 35MHz to 45 MHz and in 1964 improved

mobile telephone system (IMTS) was launched. In IMTS several carrier frequencies were used and also it could handle several simultaneous phone calls at the same time.

In [4], it is mentioned that wireless communication system is one of the most important element in the global information and telecommunication strategy and also it is one of the most fastest as well as dynamic growing sector in the world. Now day's people's ability has been increased dramatically by the development of wireless communication technology to communicate and live in both business operations as well as in social communication. The mobile communication sector had total revenue of €174 billion in 2010 and this had been reported by European Mobile Observatory (EMO) [16].

We are expecting that the 5<sup>th</sup> generation wireless technology will be launched around 2020. But we can't say anything about 5G with any kind of surety. One thing is very clear that as compare to 4G, 5G will give better response in various factors like energy efficiency, bandwidth, spectral efficiency etc [4].

## 2. Evolution of Mobile Radio

After a brief introduction to 5th generation wireless systems, this section briefly outlines the evolution of mobile communication technology from 1G to 5G.

In [3], the authors have described that, the First generation cellular system (1G) were analog telecommunications standards introduced in the 1970s. Here the voice channel used frequency modulation, and they used frequency division multiple access (FDMA) techniques. The major disadvantages of 1st generation wireless systems are poor voice quality, poor battery quality and large phone size. 2G was introduced in 1980s. The 2G systems were digital and were oriented to voice with low speed data services. 2G used GSM technology and GSM stands for global system for mobile communication. It is a circuit switched, connection based technology, where the end systems are devoted for the entire call period. Therefore, it causes low efficiency in usage of bandwidth and resources. Generally GSM enabled systems don't support high data rates and they are generally unable to handle complex data like video. Next comes 2.5G. 2.5G is not an officially defined term rather it was invented for marketing purpose.

3G stands for 3rd generation wireless system. It has the capability to handle complex data like video and also it supports high data rates. Generally 3G wireless systems use Code Division Multiple Access Technique (CDMA). The 3G technology adds multimedia facilities to 2G phones by allowing video, audio, and graphics applications. Apart from that, 3G promises increased bandwidth, 384 kbps when the device holder is walking, 128 kbps in a car and 2 Mbps in a fixed application.

4G stands for 4th generation wireless system. It has been launched in many countries. In 2009 ITT-A specified the requirements for 4G standards. A 4G system is expected to provide a comprehensive and secure based solution to laptop and mobile devices. Such as internet access, gaming services and streamed multimedia may be provided to users. The technologies like Coded Orthogonal Frequency Division Multiplexing (COFDM),

Multiple Input Multiple Output (MIMO) and link adaptation are used in 4th generation wireless system.

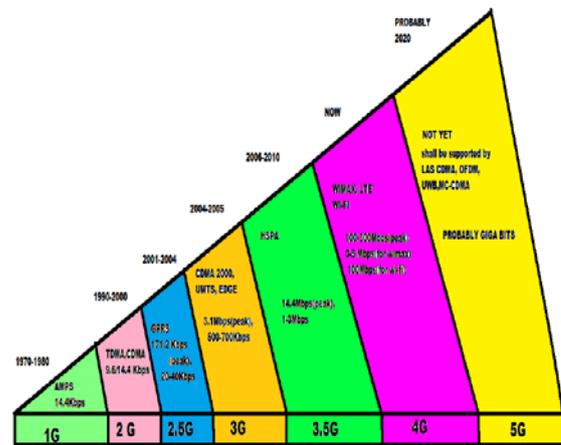


Figure 1. Comparing Various Technologies

Now research is going on 5th generation wireless system (5G). It is expected that, it will fulfill the entire requirement that has not been fulfilled by 4G. 5G technology has changed the means to use cell phones within very high bandwidth. User never encountered ever before such a high value technology. All kind of advanced features which makes 5G technology most powerful and in huge demand in near future. 5th generation technologies which are on hand held telephone offering more power and features than at least 1000 lunar modules. A user can also attach their 5G technology cell phone with their Laptop to get broadband internet access [14].

## 3. What 5G Technology Offers??

5G is going to be a new mobile revolution in mobile tele-telephone market. 5G technologies now we can use worldwide cellular phones and this technology also strike the china mobile market and a user being competent to get access to USA phone as a local phone. Because of 5G technology the customers can be offered approximately priceless handset to its customers. In future also 5G will take over the world market. One of the biggest advantages of 5G is, it has excellent capability to support both software and consultancy. 5G network will provide high connectivity because of switch and router technology.

## 4. Need of 5G Wireless System

If we will compare 5G with other generation mobile phones, it is obvious that 5G has some extraordinary features and advantages.

- 1). 5G has better coverage area and high data rate at the edge of the cell.
- 2). It has low battery consumption.
- 3). Availability of multiple data transfer path.
- 4). Around 1 Gbps data rate is easily possible.
- 5). Security is more.
- 6). Energy efficiency and spectral efficiency are good.

Due to the above advantages, 5<sup>th</sup> generation wireless system is very much essential.

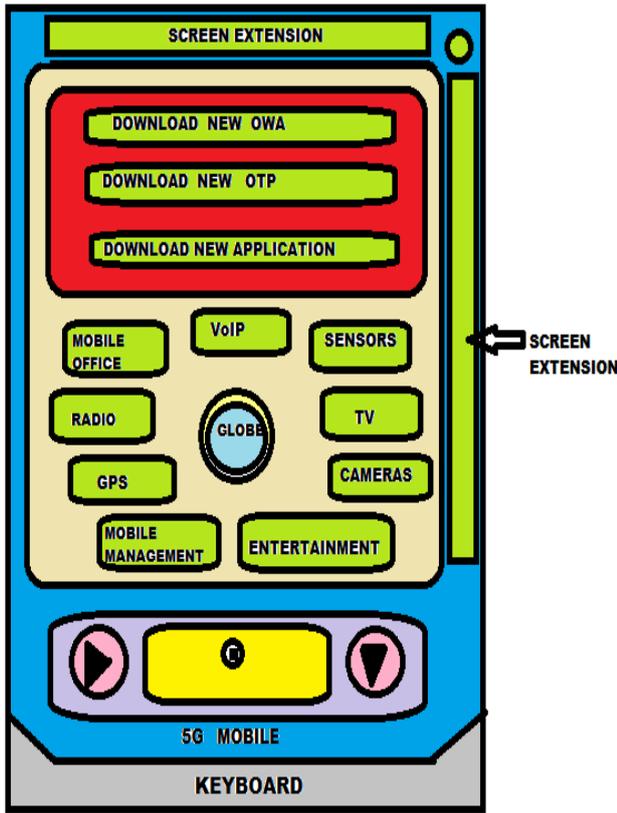


Figure 2. 5G Mobile Phone[6]

### 5. 5G Wireless Cellular Architecture

The proposed 5<sup>th</sup> generation cellular architecture is shown in Figure 3 below. The architecture shows that it is an IP based model for wireless and mobile networks interoperability. According to the authors [6], the 5G wireless system consists of a user terminal and number of independent radio access technologies. User terminal plays a very important role in this system.

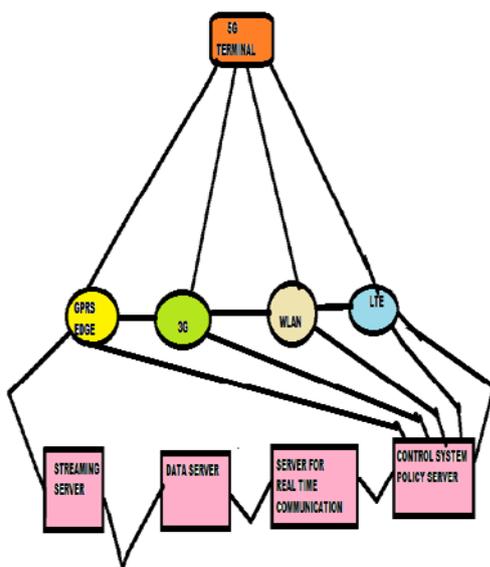


Figure 3. Functional Architecture for 5G- Network [6]

Radio access technology (RAT) means a physical connection method for a radio based communication network. It is shown in the figure that, with in each of the

terminals each RATs are the IP link to the outside world and also in mobile terminal there should be different radio interface for each RATs. If someone wants to access four different radio access technologies than four different accesses specific interfaces should be there in the mobile terminal and all of them should be activated at the same time in order to function the architecture.

It is called as the IP based model and the main purpose is to ensure control data for proper routing of IP packets belonging to a certain application connections. Routing of packets is carried out by the users with some specific policies and rules. Application connections are established between clients and servers in the internet i.e. via sockets. These Internet sockets are end points for data communication flows and each socket of the web is an unique combination of local IP address and appropriate local transport communications port, target IP address and target suitable communication port, and type of transport protocol.

In case of interoperability between heterogeneous networks and for the vertical handover between the respective radio technologies, the local Internet Protocol address and destination Internet Protocol address should be fixed and unchanged. Fixing of these two parameters should certain handover transparency to the Internet connection end-to-end, when there is a mobile telephone user at least on one end of such connection. In order to preserve the proper design of the packets and to reduce or prevent packets losses, drive off to the target destination and vice versa should be unique and it should be using the same path.

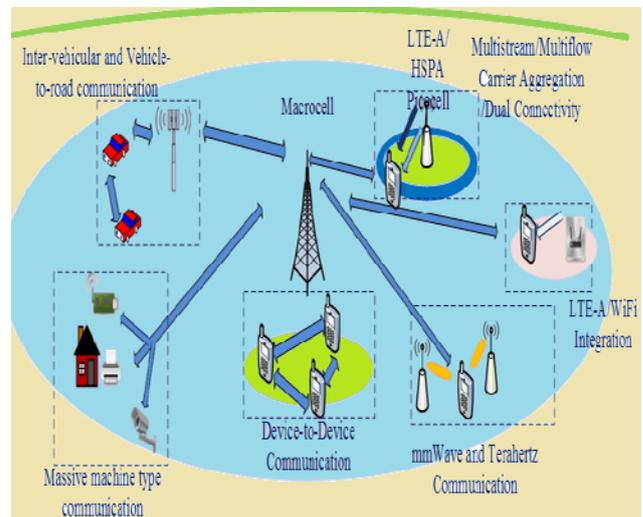


Figure 4. Deployment Scenario Envisioned For 5G Cellular System [26]

Each radio access technology that is available to the user in achieving connectivity with the relevant radio access is presented with appropriate Internet Protocol interface or medium. Each Internet Protocol (IP) medium or interface in the terminal is characterized by its IP address and net mask and parameters associated with the routing of IP packets across the network. In uniform inter-system handover the modification of access technology (i.e., vertical handover) would mean changing the local Internet Protocol address. Then, change in some parameters of the socket means change of the socket that is, closing and opening of a new socket. This approach is not adjustable, and it is based on today's wireless

communication. In order to solve this insufficiency we propose a new level that will take care of the abstraction levels of network access technologies to higher layers of the protocol stack. This layer is very critical in the new architecture. From the authors [6], to enable the functions of the applied transparency and control or direct routing of packets through the most appropriate radio access technology, in the suggested architecture we introduce a control system in the functional architecture of the networks, which works in complete coordination or works together effectively with the user terminal and provides a network abstraction functions and routing of packets based on defined rules or policies. At the same time this control system is an essential element through which it can determine the quality of service for each transmission technology. Protocol system of the new levels within the occurring protocol stack, which form the suggested design and architecture, is given in Figure (Protocol Layout for the Elements of the Proposed Architecture). The network concept or idea would be provided by creating IP tunnels over IP interfaces obtained by connection to the terminal via the access technologies available to the terminal (i.e., mobile user). In fact, the tunnels would be established between the user terminal and control system named here as Policy Router or blueprint router, which performs routing based on given policies or some strategies. In this way the client side will generate an appropriate number of tunnels connected to the number of radio access technologies, and the client will put a local Internet Protocol address which will be formed with sockets Internet communication of client applications with Internet servers. The way Internet Protocol packets are choosing the right tunnel, would be worked by policies or strategies whose rules will be exchanged via the virtual network layer protocol. This way we achieve the necessary idea of the network to the client applications at the mobile terminal. The process of initiating a tunnel to the Policy Route or strategy router, for routing based on the given strategies, are took out immediately after the initiation of IP connectivity across the radio access technology, and it is started off from the mobile terminal Virtual Network-level Protocol. Initiating tunnel links as well as maintaining them represents basic functionality of the virtual network level [6].

In [7], the authors have mentioned that, the wireless users stay indoors generally for 80% of the total time and stay outdoors for 20% only. The outdoor base stations are used in the current cellular architecture to communicate with the mobile users. That doesn't matter, whether they stay indoor or outdoor. When the indoor users communicate with the outdoor base station, the signals penetrate the building walls. Due to this, penetration loss occurs and apart from that data rate, spectral efficiency and energy efficiency are also damaged. In order to avoid these deficiencies, some new technologies are used now days and they are such as- Distributed antenna system (DAS), and MIMO technology [8].

Cognitive radio technology is one of the key concepts of 5G. Cognitive radio technology, also known as smart-radio: allowing different radio technologies to share the same spectrum efficiently by adaptively finding unused spectrum and adapting the transmission scheme to the requirements of the technologies currently sharing the spectrum. This powerful radio resource management is

achieved in a distributed fashion, and relies on software defined radio.

## 6. MIMO Concept for 5G

MIMO stands for Multiple Input and Multiple Output. In wireless communication system this method is used to increase the capacity of channel in radio link by using multiple transmit and receive antennas [9]. MIMO has become an important element of wireless communication system standards including IEEE 802.11ac (WI-FI), WI-MAX (4G) etc.

In [4], it has been mentioned that MIMO system consist multiple antennas at both the transmitter and receiver. One of the big advantage of this system is more data can be added to the wireless channels. So by using this method the energy efficiency, spectral efficiency and reliability can be improved. In MIMO system the transmitter and receiver part contained large number of antennas or we can say array of antennas. At one time in wireless the term "MIMO" referred to the mainly theoretical use of multiple antennas at both the transmitter and the receiver. In modern technical world, "MIMO" refers to a practical technique for sending and receiving more than one data signal on the same radio channel at the same time via multipath propagation. MIMO is conceptually different from smart antenna techniques developed to enhance the performance of a single data signal.

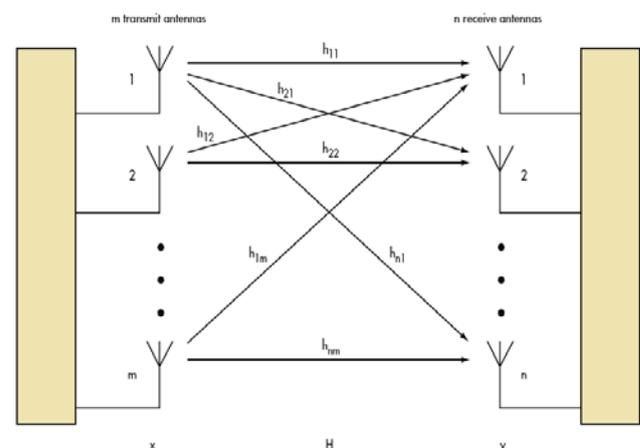


Figure 5. MIMO System [24]

In [10,11], the authors mentioned that recently, MIMO is applied to Power line communication for 3-wire installations as part of ITU G.hn standard and Home Plug AV2 specification. In MIMO system the transmit antennas are distributed to in various applications and also the receive antennas are distributed to many devices. In [8], it is clearly mentioned that by using this massive MIMO system, the energy efficiency and spectral efficiency can be increased dramatically. One of the biggest advantages of MIMO technology is, here in this method intracell interference and noise can be minimized.

So due to these advantages, MIMO system is one of the key concept of wireless communication system.

## 7. Cognitive Radio Network

Cognitive Radio (CR) is an adaptive, smart radio and network technology that can automatically detect available channels in a wireless spectrum and also change transmission parameters making more communications to run at the same time and also to improve radio operating behavior. Technologies like adaptive radio and software defined radio (SDR) are used in cognitive radio network. Adaptive radio is a technology where the communication system operates and changes its own performance and in case of software defined radio (SDR), various hardware components like modulator, demodulator, amplifier and mixers are replaced by intelligent software system. Generally cognitive radio is used to improve or maximize the utilization of radio frequency spectrum. It is also observed that in some location or at some time, 70 percent of allocated spectrum are sitting ideal. The main feature of cognitive radio is their ability to recognize their communication environment and independently adapt the parameters of their communication scheme to maximize the quality of service for the secondary users [13].

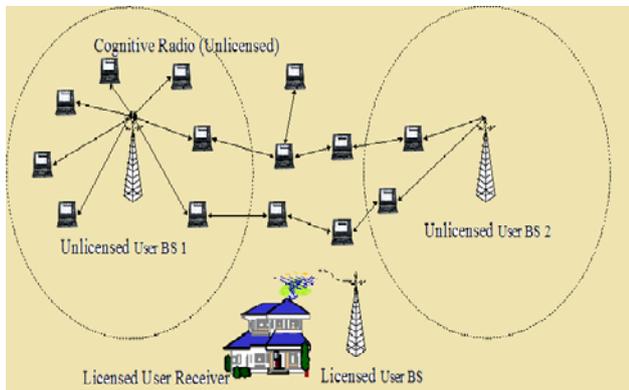


Figure 6. Cognitive Radio System [25]

In cognitive radio cycle a cognitive radio monitor's spectrum bands. It also catches their information and then detects the spectrum spaces. Apart from that the characteristics of the spectrum spaces that are detected through spectrum sensing. Then, a suitable spectrum band is chosen according to the characteristics and user requirements. Once the band of the operating spectrum is determined, the communication can be executed over this spectrum band.

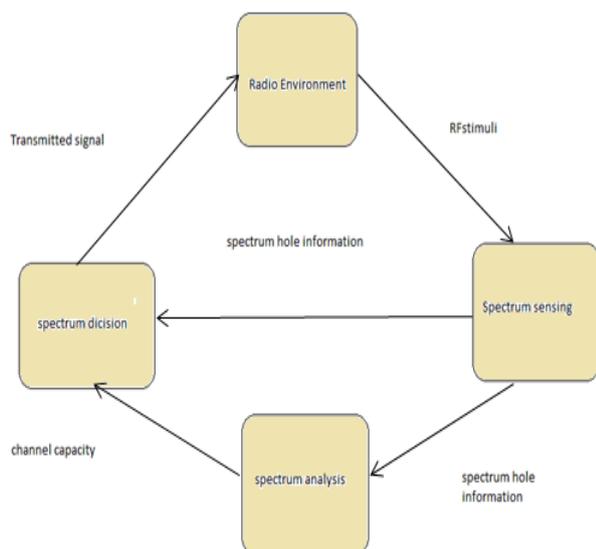


Figure 7. Cognitive Radio Cycle

Cognitive radio perceives the radio environment by empowering each user's receiver to sense the environment on a continuous time basis. Cognitive radio has some research challenges. They are such as spectrum sensing, advance spectrum management, and unlicensed spectrum usage etc. Cognitive radio is already being considered as the candidate for the 5th generation of wireless communications. The study of the cognitive radiowill be one of the most effective scientific ventures in the 21st century.

## 8. Applications of 5G Technology

From [6], we can summarize the applications.

1. One can be able to feel her kid's stroke when he/she is in her mother's womb.
2. One can be able to perceive his/her sugar level with his/her mobile.
3. One can be able to charge his/her mobile with his/her own heartbeat.
4. One can be able to view his/her residence in his/her mobile when someone enters.
5. The mobile will ring according to our mood.
6. One can be able to pay all bills in a single payment with his/her mobile.
7. One can get the live share value.
8. One can be able to navigate the train for which he/she might be waiting.
9. One can be able to vote from his/her mobile.
10. One can be able to know the exact time of his/her child birth that too in nanoseconds.
11. One can be able to sense tsunami/earthquake before it occurs.
12. Our mobile can share our work load.
13. One can get an alert in his/her mobile when someone opens his/ her intelligent car.
14. One can be able to lock his/her car or bike with his/her mobile when he/she forgets to do so.
15. We can be able to expand our coverage using our mobile phone.
16. Our mobile can perform radio resource management.

## 9. Features of 5<sup>TH</sup> Generation Wireless System

In [13,14], the authors have described some features of 5th generation wireless communication system.

Every mobile phone in a 5G wireless system will have an IP address. The technology is expected to support virtual private networks and advanced billing interfaces. The remote diagnostics also a great feature of 5G. The uploading and also downloading speed of 5G technology will be very high. The traffic statistics will be more accurate by using 5G technology. 5G technology provides large broadcasting of data in gigabits which supports almost 65000 connections.

## 10. 5G Super Core Concept

The 5G will have the following three main technologies:

- Nanotechnology.

- Cloud Computing.
- All Flat IP Platform.

The existing telecom networks are arranged in an ordered way, where subscriber traffic is aggregated at aggregation point (BSC/RNC) and then drives off to gateways. Flat Internet Protocol architecture will lessen burden on aggregation point and traffic will directly move from Base station to Media gateways. When transition from legacy (TDM, ATM) platforms to IP will be concluded, a common ALL IP platform will be appeared. All network operators (GSM, CDMA, Wi-max, Wire line) can be connected to one Super core with enormous capacity. The super core concept will roughly calculate all interconnecting charges, which is now days network operator is facing.

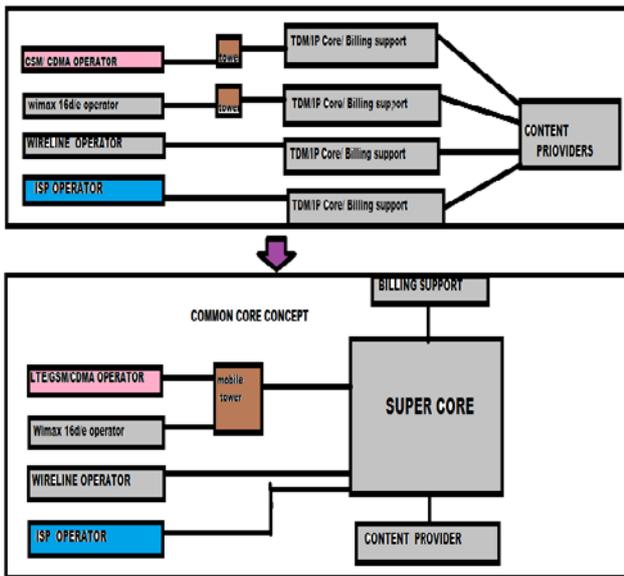


Figure 8. 5G Super Core Architecture [14]

## 11. Future Span of 5G

The future enhancement of Nano-core will be incredible as it combines with artificial intelligent (AI). One can be able to control his intelligent Robot using his mobile phone. Our Mobile can automatically type the message what our brain thinks.

The Google hot trends have rated the term 6G as the 17TH most searched word in the search engines. The iPod 6G comes in seven different colours and has an aluminium body which makes the body strong to with stand constant daily usage.

## 12. Conclusion

The future is becoming more and more difficult to predict with each passing year. So we should always expect an increasing pace of technological change. In this paper, the main importance is on 5G mobile phone concept and its architecture which is going to be a new mobile revolution in mobile market. This mobile technology will offer high data rate and reliable communication at an affordable rate. We conclude that it is a great time to invest in start-ups. Nowadays mobile users have much awareness of the cell phone technology.

The 5G technologies incorporate all type of advanced features which makes 5G mobile technology most powerful and in huge demand in near future. But the final success of 5G mobile communication systems will depend upon when it is fully implemented and the new services and contents made available to users.

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