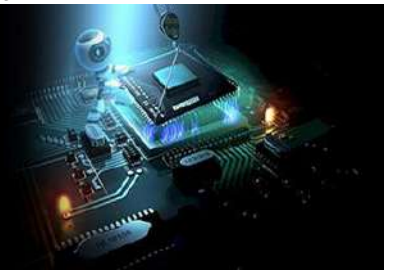


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5G Wireless systems: Is it the future?

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Abstract

With the 5G technology so close to its launch we will discuss is this technology really the future of the tech industry. It is supposed to be launched in the market by the end of 2020 and people are still unaware of what this actually is and how will it affect their lives and the industry of almost every sector. It basically is a wireless network architecture which is anticipated to replace an already present wireless network architecture which supposedly will have lower energy consumption, less maintenance cost and offers very high quality services. In this paper we will discuss what 5G technology is and how will it affect different aspects of life once it is released. How does this technology affect the life of a common man and how will it change the world for the good or worse? Is the world willing to accept such a massive change in its ways of working and is 5G a reliable replacement? All these questions are discussed in this paper on the base of detailed reviews, surveys and interviews carried out with notable spokespersons of different industries.

Keywords: Wireless network architecture, 5G technology

1. Introduction

One of the most important factor and characteristic of 5G which is promised by its makers is that the whole network will be wireless. The administrators of 5G which include transmission equipment makers, telecommunications service providers, server manufacturers and antenna manufacturers state that once all the components of 5G are deployed and are operational there will be no need of any sort of wire or cable to operate but all the communication will be done over wireless channels resulting in saving the cost of transmission of data. This will result in solving the 'last mile' which has been a transmission problem in the 4G network system. This means that in order to provide connectivity between the service provider and the consumer there will be no need of any wires but the whole process would be wireless saving up the cost of wires^[1].

The story behind all the "G's" is that it was introduced to differentiate between all the systems and technologies of mobile communications. It was made to make the transition process from one network system to another network system easy and differentiable. The transition between each network system has never been easy and it has had a lot of problems. Some of these problems are explained as:

- **Unified carrier offering converged services**

In most of the developed countries such as US an internet provider also provides the services of TV to its consumers. This relationship between the internet provider and TV is under the protection of municipally-regulated authorities that sometimes do not provide fair advantages to the cable and TV service providers. With the introduction of 5G the playing field will be levelled for all the competitors which will result in a healthy competition and as a result of that healthy competition we will get better quality of services.

- **Small cell sites**

The current 4G network consists of cell areas that take up a lot of space. A usual network cell consists of a BTS and a tower. The usual size of the cell of 4G networks range from 400 meters to 2 km and compared to that the area taken up by a 5G network cell is 400 times smaller. This means that the cell of 5G network will take up very small space as compared to the cell of a 4G network. This will result in saving a lot of resources. Another benefit will be that it will be easy to deploy such equipment in urban areas making communication with far stretched areas possible.

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• Global technology shift

Right now Scandinavian countries such as Finland and Sweden are considered to be the hub of the telecommunications. They have headquarters of companies such as Ericsson and Nokia there. Right now China has the most valuable technology and advancements in the field of 5G. Huawei is a leading vendor of China and it has made substantial advancements and is likely to be introduce 5G services first. This will result in a shift of technology from Scandinavian countries to China ^[2].

The completion of 5G will result in major changes in the telecom industry. It would be safe to compare this change to the example that if in the 19th century people would discuss shifting from telegraph to fax. One of the reasons why this shift from 4G to 5G is becoming necessary is that the 4G technology is approaching unsustainability at a faster rate than the industry experts predicted. Meaning that 5G is not a commodity or luxury but it is becoming the need of time.

According to some experts there are four generations and according to some there are seven generation of mobile networks and there are three sets of global standards. "1G" was never an official term whereas in the case of "2G" there was the introduction of GSM technology as well as CDMA technology so there was not a well-defined or set system that represented 2G. The case of 4G was pretty much similar with the case of 2G there were two major standards or system that both represent 4G. These systems are known as WiMAX and LTE. Both of them have been fighting for supremacy but this battle seems to have been a lost cause as they both need to be replaced by 5G sooner or later. Engineers have been having same views about 5G and this has been a great factor in the steady improvement of 5G as they all have same goal in mind ^[3].

"The first generation of mobile systems that were launched around 1991 -- popularly known as 2G/GSM -- was really focused on massive mobile device communication," said Sree Koratala works for Ericsson as the head of strategy and technology in North America for 5G Wireless while talking with *ZDNet*.

"All these networks primarily catered towards consumers," Koratala continued. "Now when you look at this next generation of mobile networks, 5G, it is very unlike the previous generation of network. It's truly an inflection point from the consumer to the industry."

The technology in 5G is been specified by 3GPP which includes "Release 15" "Release 16" and "Release 17". The work on Release 15 and Release 16 has been completed but the work on Release 17 has just started. 3GPP is basically an organization that has all the standard bodies of the telecommunication industry and they all have agreed to share the definition of 3G and to improve on it. Right now 3GPP consists of all technology that is specific to 5G wireless. 5G wireless standard has to be global and achieving that is a very tough task. The participating countries would want to retain their own rights and would like to have their own definition of 5G. In November 2018, the US Federal Communications Commission started a closeout for selective sections of range in the 28 GHz band, destined to be trailed by offers in the 24 GHz band, for elite use by the triumphant bidders. The next month, the FCC

collectively endorsed an arrangement to make more range in the 37 GHz, 39 GHz, and 47 GHz groups accessible for the most astounding velocity interchanges level for 5G remote, called millimeter-wave (mmWave). In any case, a great piece of the 5G plan includes numerous, synchronous reception apparatuses, some of which use range that telcos consent to impart to each other (for example, the 3.5 GHz band in the US) just as unlicensed range that controllers, for example, the FCC keep open for everybody consistently (regions between 5 GHz and 7 GHz, and 57 GHz to 71 GHz). Among the advances inside the 5G umbrella are frameworks empowering transmitters and recipients to mediate access to unused directs in the unlicensed range, much the way 802.11ac Wi-Fi gadgets do now ^[4].

2. How does 5G work?

Like the previous cellular networks 5G network uses a system based on cell sites that helps map large territory into small sectors and then send encoded data with the help of radio waves. These cell sites are interconnected and each cell site should be connected to the backbone of the network. This connection can either be wired or wireless. The encoding used by 5G networks is known as OFDM and it is sort of similar to the techniques that were used in 4G networks. The difference will be in the air interference, meaning that it will have low latency and more flexibility than LTE systems. One of the major differences of 5G from 4G is that 5G has a system that is designed to work on larger channels having more bandwidth so that they can maintain high speeds. In 4G 20MHz channels are bonded together into up to 160 MHz, whereas in 5G the channels can have 100MHz with up to 800MHz at a time. This means that 5G will have bigger transition channels as compared to that of 4G ^[5].

5G networks are considered to be very smart networks as compared to 4G because they have to take care of many more calls as compared to 4G. They have to cater for many calls and they have to be much smarter than previous systems as they have to juggle many more calls and the size of their cell is also substantially smaller as compared to previous networks. The existing macro cell technology is not able to handle the load of running a 5G network. They need to boost their capacity to about 4 times to meet the requirements of 5G networks. They can achieve this task by leveraging wider bandwidths and using advanced antenna technologies. The aim is to achieve higher speeds of data processing and very high capacity per sector and doing all this at a way less latency as compared to 4G ^[6]. The standard bodies and experts are trying to achieve 20Gbps of speed and 1ms latency. 5G basically runs on two types of airwaves: above and below 6GHz. Low frequency 5G networks i.e. below 6GHz are used by existing Wi-Fi and cellular bands. This gives them the advantage of flexible encoding and massive channel sizes which provide 25 to 50 percent better and faster results than LTE. Those networks can cover the same distances as existing cellular networks and generally won't need additional cell sites. Sprint, for example, is setting up all of its new 4G cell sites as 5G-ready, and it'll just flip the switch when the rest of its network is prepared.

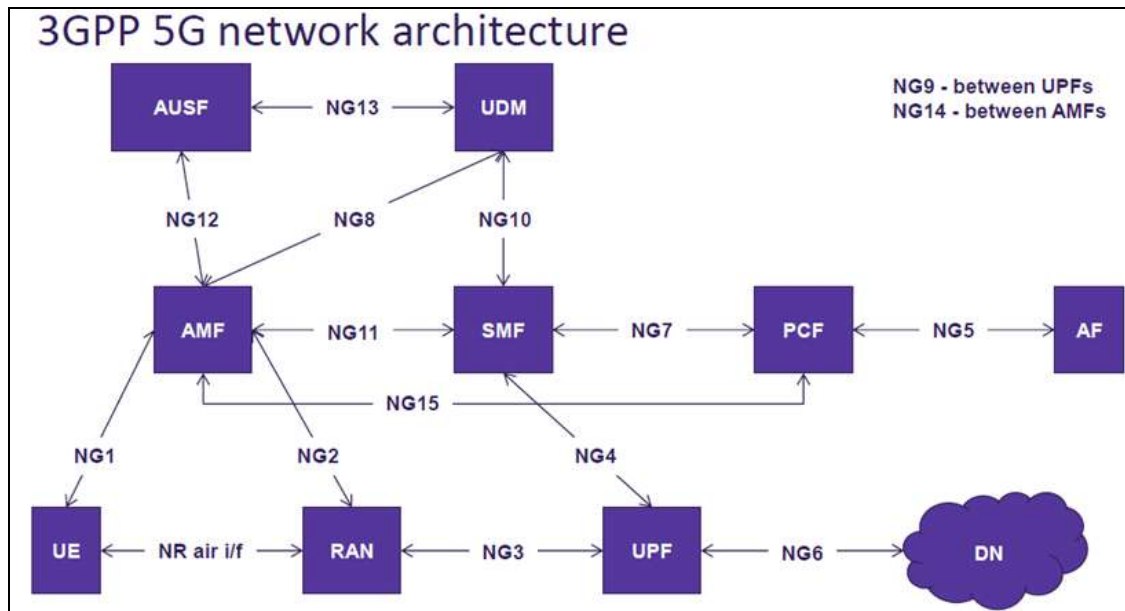


Fig 1: 5G network architecture

Low-band 5G networks have great range from towers so it is best to use them for rural networks as there are less number of users in a wide spread area. In order to achieve high multi-gigabit speed carriers are using a much higher frequencies known as millimeter wave. In the existing cellular bands the spectrum is heavily used as it has a lot of traffic. Having said all that the spectrum between 28GHz and 39GHz there is a potential to create bands that can cater for big channels and very high speed transmissions. These bands have been used previously in the case of a backhaul in which their job was to connect base stations to remote internet links, but they have never been used for consumer's devices as the previous antennas and handheld processing power of the devices wasn't enough. Millimeter wave signals also drop off faster with distance than lower-frequency signals do, and the massive amount of data they transfer will require more connections to landline internet. The base stations required by the cellular providers will be small and use less power as compared to using powerful macro-cells so that they are able to offer multi-gigabit speeds that have been promised to the customers. Usually the macro-cells use about 20-40W but these small stations will use 2-10W [7]. During the 4G era, these small cells that are required for rapid communication and transmission were already installed to increase the capacity of the cells. This is a fortunate thing as there will be needed to deploy new cells, which will save the deployment cost. In order to make that site a 5G compatible site they just have to add a radio. In suburban areas the carriers are having difficulty convincing the towns to add these small sites that are essential for the working of 5G. These towns caused similar problems at the times of implementation of 2G and 4G. It is easier to explain to them that this network uses sites that use less power as compared to the macro-cells that have already been working there. 2 W compared to 20W is very less. There is another type of band that is currently being used by some countries. It is known as the mid-band and it lies between the frequencies of 3.5GHz to 7GHz. This is marginally above the current band used for cellular services. This band is also being used by the satellite companies and the Navy so it is not easy to use or utilize this bandwidth but some efforts are made to use this band. The benefit of using

mid-band is that it does not require as many cell sites as other bands do [8].

3. Uses of 5G

5G as a whole has a lot of advantages both in communication and data center architecture. All these advantages ultimately benefit the telecom industry and their consumers. The majority of the technical advancements made in this field are related to these three categories:

- **Spectral efficiency:** Using frequencies more efficiently such that greater bandwidths are achieved which can travel across larger distances from base stations which is the main goal of all the generations.
- **Energy efficiency:** To reduce the costs of cooling and achieving that by designing efficient technology for transmitters and servers.
- **Utilization:** In order to finance this massive change in the infrastructure for implementation of 5G the telecom industry has to come up with more ways to generate revenue and provide services such as edge computing, hosting mobile apps and add them on public cloud providers for competition [9].

During the implementation of 4G the telecom industry realized that they need to have different classes of services that are according to the needs of their customers. This option was included in the 5G network. It offers three types of services which are according to the business model of the clients:

1. Enhanced mobile broadband (eMBB)

This service is mostly used in densely populated areas. Metropolitans and populated areas are provided this service in which indoors the speed is 1Gbps and outdoors the speed is 300Mbps. This can be achieved by installing high-frequency antennas that cater for millimeter-wave (mmWave). These antennas are the size of a baseball so in order to cover a densely populated area we would need hundreds and thousands of them. So to cater for this they would be placed on lamp posts, towers, top of buildings and even on public busses. EMBB will act as a replacement for

current LTE systems that belong to 4G. It will provide omnidirectional antennas which use less power and provide us with a downlink speed of 50Mbps ^[10].

2. Massive machine type communications (MMTC)

This service caters for machine-to-machine (M2M) and internet of things (IoT) related services. Experts in the M2M and logistics fields state that the 2G generation was best for narrow service bands and other advancements have actually made this service worse. MMTC would help cater for this problem and will do this by adding a compartmentalized service tier that will cater for downlink bandwidth which can be as low as 100kbps and the latency will be almost 10

milliseconds.

3. Ultra reliable and low latency communications (URLLC)

This service is for consumers that demand more speed and do not care much about the bandwidth especially end-to-end latency of 1ms or less. This service is mostly used by the industry that deals with autonomous vehicles where they need high speeds and ability to take decisions in no time. URLLC could also be used by the satellite industry as they can also be an application of 5G and they would most likely work on geolocation which is a replacement of GPS ^[11].

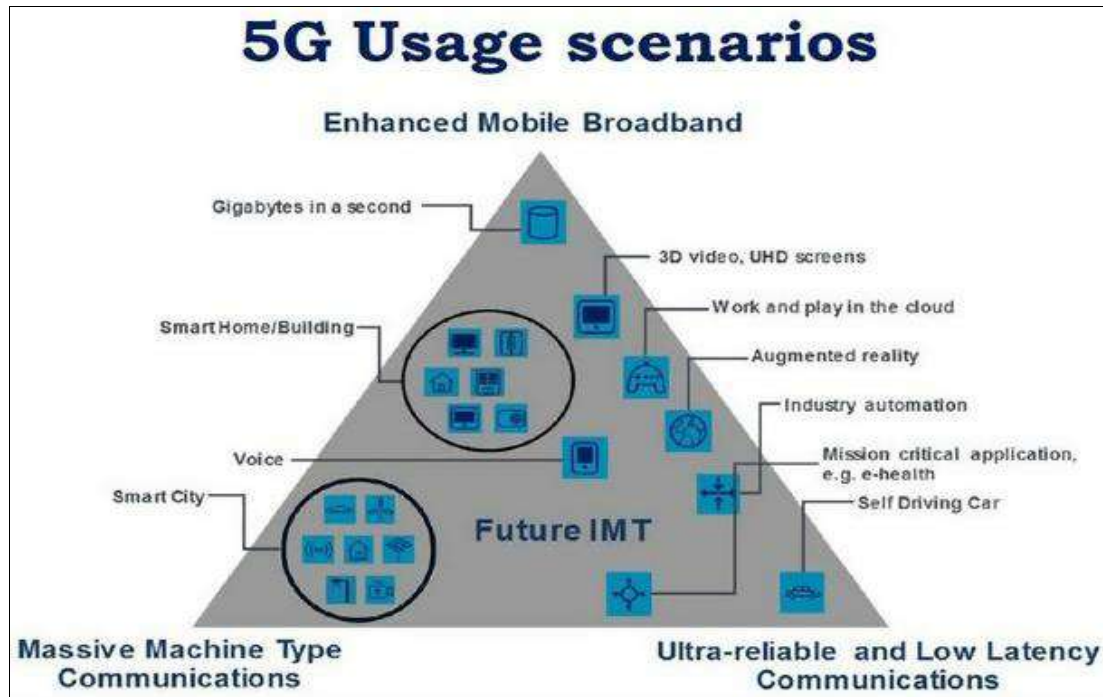


Fig 2: Uses of 5G

Up till now we have discussed in what fields can 5G work and the technical services that it can provide. Now we will discuss the application of 5G and how it assists different industries.

1. Autonomous cars

The industry of autonomous car depends upon 5G. Basically these vehicles are self-driving cars that follow precise maps, avoid obstacles, interact with smart signs and communicate with each other. In order for these cars to work properly we need to process huge amount of data in real time and only 5G has the capacity to provide such speed, low latency levels and security. The benefits of these cars is that they help in reducing pollution but also improve driver's security. Their introduction in the market has opened up an entirely new dimension in car industry. It also save up time of the drivers as they can do other tasks while the car drives itself. Intel predicts that this industry can be worth \$7 trillion by 2050.

2. Smart cities

In future the cities will be automated and to achieve that we have to use 5G. Various new ways of transport can emerge too such as smart busses and flying drone taxi's and they all will require next-generation advanced technology which can

be provided by 5G. The building will be smart meaning that they will be energy efficient and the businesses will be more automated such as smart billboards that can target the desired consumers. The data collected from smart cities can be used by the experts to see how resources are used and this can help them make decisions based on this data. 5G based cities will offer a lot of opportunities for improvement in the current systems and enable forward thinking in businesses ^[12].

3. IoT technology

The Internet of Things (or IoT) will benefit a lot from the introduction of 5G as it will allow it to get billions of more connections to the internet. This will result in increase in the number of IoT devices which is an opportunity for the hardware manufacturers but the real potential lies in industrial IoT. IoT will bring revolutionary changes in the field of manufacturing, agriculture and healthcare. With the help of 5G we can perform remote surgery with the help of a robot. We can also allot personalized medicine on the basis of vitals of the patient that can be tracked with the health of wearable trackers. This ability to monitor the vitals of the patient can also help the insurance industry and they can give insurances on the basis of their lifestyles ^[13].

4. Immersive entertainment

Thanks to the data capacity, speed and low latency offered by 5G we will be able to experience a new form of interactive entertainment. Such technology has also been used in sports recently such as VR which is helping making referees make the right decisions. They are also helping in improving the experience of the fans with games having Augmented Reality (AR) ^[14].

5. Communication and collaboration

The basic use of 5G was to provide a stable mobile network. So in addition with providing infrastructure to other businesses it will help provide streamline communication and improve data transmission speed. 5G will help support remote working and also makes working on cloud based platforms easy and in real-time ^[15].

4. Hazards of 5G

5G networks use radio waves to carry their signals and these radio waves are a part of the electromagnetic spectrum and are transmitted between the antenna and consumer's device. 5G devices use higher frequency as compared to the previous devices and this allows them to handle more devices and provide them internet along with higher speed

levels. The 5G network requires its transmitters to be placed close to the consumers meaning that they will be close to the ground level and this results the radiations being closer to the masses and this has lead a concern among the masses that it will increase the risk of certain types of illnesses including cancer.

In 2014 the World Health Organization (WHO) said that "no adverse health effects have been established as being caused by mobile phone use" ^[16]. However, the WHO together with the International Agency for Research on Cancer (IARC) has classified all radio frequency radiation (of which mobile signals are a part) as "possibly carcinogenic". It has been put in this category because "there is evidence that falls short of being conclusive that exposure may cause cancer in humans". A report made by the US department of health stated that when rats were exposed to high dosage of radio radiations they developed some sort of cancerous tumor in their hearts. The rats were exposed to mobile phones for 9 hours every day for two years continuously. A similar study was done on mice but no tumors appeared. A respected scientist remarked that these studies cannot be compared to humans as the exposures are different ^[17].

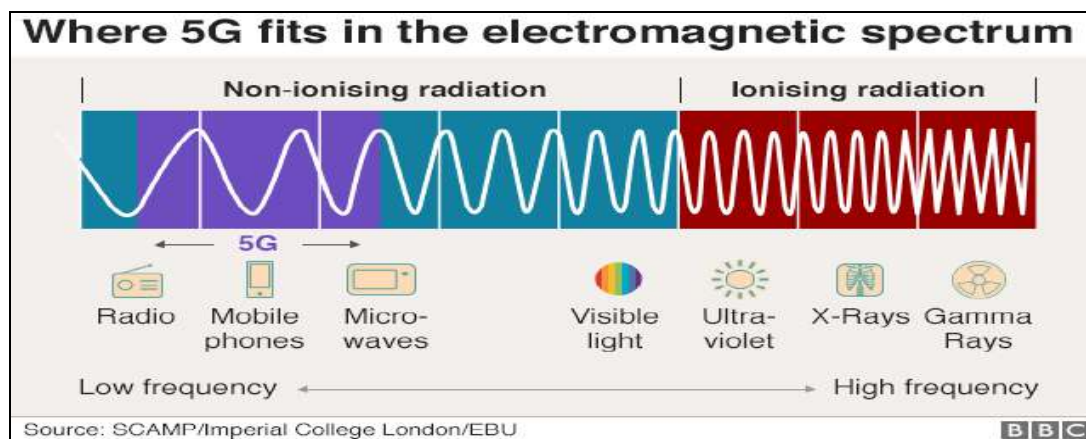


Fig 3: Electromagnetic spectrum

Dr. Frank De Vocht, who helps advice the government on mobile phone safety says "although some of the research suggests a statistical possibility of increased cancer risks for heavy users, the evidence to date for a causal relation is not sufficiently convincing to suggest the need for precautionary action".

The radio waves that are being used in 5G are non-ionizing meaning that they do not have sufficient energy to break the DNA which means that they cannot cause nay cellular damage. This research was done by David Robert Grimes, physicist and cancer researcher.

According to Dr. Grimes people consider the waves of sun to be a cause of cancer, but they should know that the radio waves used by the 5G network are far less energetic as compared to the light and radiations that come from the sun. He also says that there is no evidence that mobile phones and their radiations are the cause of cancer or other health problems in humans. As we know that the 5G network antennas work on lower power levels as compared of that of 4G network so it means that they will be an improvement from the current networks. The radio frequency levels of

base station are many times less than the guideline levels set by the UK government making it safe to deploy base stations ^[18].

5. Conclusion

5G technology is a very fast and efficient technology that cannot be considered as a luxury, but it is becoming the need of the hour as the currently existing 4G network system is failing to do its job at a very alarming rate. The future sure does belong to the 5G technology because of its high speed data transmission rates and its ability to cater for the huge amount of data in one go. This makes this system suitable for today's world as the users on the networks are increasing day by day and we need greater bandwidths and processing speed to provide them with the services that have been promised to them. 5G can also be used to set up new industries such as autonomous cars which, according to many experts is the next big thing. It also provides the option of smart cities that use integrated networks to make life easier. The introduction of IoT also signifies the importance of 5G and its need.

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