

University of Primorska
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Scientific work

on topic

“The fifth generation of mobile networks”



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1. Introduction

Today, in the time we live, the internet plays an important role in our lives. It contains thousands of web pages that we can visit and access from anywhere in the world - without any problems.

Every day, new technologies and methods for operation are being developed, such as unmanned vehicles, and so on. In order for all of these to function "flawlessly" remotely (wirelessly), a high degree of precision is required. This precision is made possible by the fifth generation of mobile networks - 5G. What is characteristic of this new generation of mobile internet network is that it operates at high frequencies in the radio spectrum, which allows a large amount of data to be shared in a very short amount of time. It was precisely this that impressed me to work on this current topic for my graduation project - "The fifth generation of mobile networks."

This is the beginning of a change towards a better world. A large number of concepts are based on the new generation of mobile networks, due to the high speed of data transfer.



Picture 1. Example of a wireless mobile network in a city

2. What is 5G?

5G is the term for the fifth generation of mobile networks. It is a new standard of wireless mobile network, after 1G, 2G, 3G, and 4G, whose concept is to provide a higher speed of communication than current technologies, extremely low latency and reliable communication, as well as support for massive device connectivity.

5G enables us to virtually connect anywhere in the world (developing virtual reality), including machines, objects, and devices, fully autonomous vehicles and factories, smart environments (such as smart homes, etc.), new interactive gaming models, new surgical methods, and many other things.



Picture 2. How 5G works

3. A brief history of wireless networks

Wireless networks have been evolving for 40 years now (starting from 1980 until now). From analog phones and walkie-talkies to a virtual network supporting the transfer of gigabytes of data per second for just one user. An interesting story with many interesting details.

3.1 First generation mobile networks - 1G

1G was the first step towards commercial mobile technology. It was an analog technology, similar to regular radio or walkie-talkies. Unlike them, the radio waves of 1G were transmitted through stations or antennas. This technology enabled telephone calls for the first

time in 1980.

Analog phones were huge, like big boxes, and the only thing they achieved was transmitting voice messages. For a start, this was a revolutionary discovery when it comes to the future.



Picture 3.1. Devices that worked with 1G technology

3.2 Second generation mobile networks – 2G

2G was introduced in 1990 and represented a transition from analog to digital voice. The audio quality was improved, and more users could use the same part of the radio spectrum, which was determined by the operators. With this technology, texting or sending messages in real-time between two users was also enabled. This was a significant achievement for the last century.



Picture 3.2. A mobile phone that uses 2G technology

3.3 Third generation mobile networks – 3G

5G enables virtual connection everywhere around the world (developing virtual reality), including machines, objects, and devices, fully autonomous vehicles and factories, smart environments (e.g. smart homes, etc.), new interactive gaming models, new methods of surgical intervention, and much more.



Picture 3.3. A mobile device that uses 3G technology and connects to the internet

3.4 Fourth generation mobile networks – 4G

The features that were not possible with 4G were achieved with 5G. It enabled much faster internet connectivity and opened up more opportunities for the future.



Picture 3.4. Tablet that uses 4G technology

3.5 Fifth generation mobile networks – 5G

At the end of the list, we have 5G. It offers huge internet connections and many opportunities for the future, on which many concepts are based. Some of these concepts are autonomous vehicles, smart cities, new surgical procedures, the development of virtual reality, and many more. The new generation of wireless network is the beginning of something new.



Picture 3.5. A person who is in virtual reality enabled by 5G

4. How 5G works?

5G works with a new type of technology, using higher frequency radio waves than its predecessors. This requires new antennas, unlike the ones used for 4G. Without a 5G antenna, we don't have a 5G network.

The 5G antenna is different from the 4G antenna both physically and functionally. They are smaller and more of them are needed to cover the same area, but they transmit much more data on a completely different part of the radio spectrum. A 5G antenna is not functional without a small cell, which provides high speeds and low latency.

4.1 What are small cells?

Small cells are the basic building blocks of 5G networks and play a significant role in the overall network. They are called "small" because they are relatively smaller than the macro cells in 4G antennas.



Picture 4.1. Types of small cells

Because they do not require a lot of energy, they can be very small. It is important not only for the aesthetics of the antennas but also for the space they occupy. However, even though they support high frequencies, they have a shorter range.

Although small, they are not weak. Their technology enables 5G to be super-fast and connect more devices to the internet. In small cells, there is radio equipment that emits data to connected devices. They can adapt the energy they use, so when they are not in use, they will switch to a low-energy phase in just a few milliseconds and reactivate when more energy is needed.

The design of small cells is simple and they can be installed in just a few hours (sometimes even less), unlike 4G antennas that required several days. Small cells are recommended for outdoor use as they have a range of 200 to 2000 meters, while for indoor use, femto-cells are recommended, with a range of less than 10 meters.

4.2 Location of 5G antennas

Due to the short range of the small cells, 5G antennas must be placed close to each other in order to cover a larger area. Since the antennas are small (like a box), they can be installed in ordinary places such as streetlights, building rooftops, traffic lights, and so on. This promises a different look from previous 4G (standard) antennas.



Picture 4.2. A 5G antenna installed on a street light

5. Why 5G?

Unlike its predecessor, 5G enables a complete transformation of everything we use. It brings us real and massive internet speeds, as well as incredibly low latency (up to 1 millisecond). That's why 5G is a step further than its predecessor.

5.1 Maximum speed

5G is ten times faster than 4G, reaching speeds of up to 10 gigabytes per second. This means that a 2-hour movie in 4K resolution could be downloaded onto our mobile phone in just a few minutes, whereas with 4G it would take hours.

Type of network	Average download speed	Maximum download speed	Theoretical maximum speed
3G	7.4Mbps	~20Mbps	42Mbps
4G	36.4Mbps	90+Mbps	300Mbps
5G	100Mbps-200Mbps	753Mbps+	10-50Gbps

Table 1. How fast is 5G??

6. Practical application

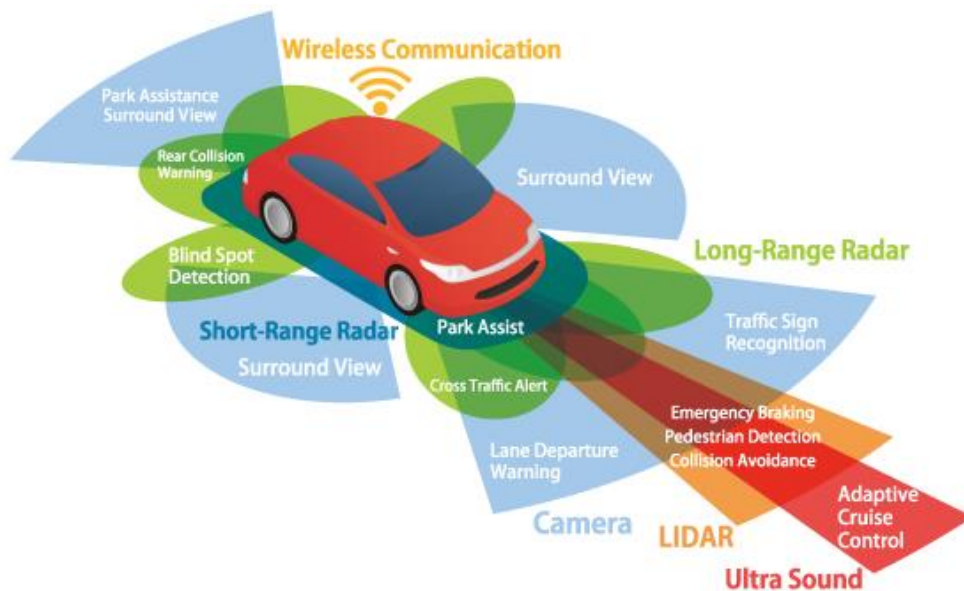
We can use 5G everywhere. It is the future. There are many possibilities. Some have already been fulfilled, while others are still only hypotheses and theories. But the future is close. Next, we will look at some of the goals of 5G technology.

Type of network	Milliseconds (ms)
4G	58.2ms (current)*
4G	36ms (current)*
5G	29ms (current)** / 1ms (theoretical)

Table 2. 5G latency

6.1 Autonomous cars

5G technology is essential for the future of autonomous vehicles. They will need to detect obstacles, moving obstacles, coordinate precisely on the map, as well as communicate with other vehicles on the road.



Picture 5.1. Model of autonomous cars

To achieve this, a large amount of data needs to be transmitted in a short period of time, and 5G is capable of doing that with very low latency. With this technology, electric cars would be used which would be cleaner for the environment, and it also reduces the factor of inconvenient accidents.

6.2 Smart cities

Smart cities would connect many smart devices together. A new type of public transportation would emerge, such as smart buses and flying drones-taxis, which would rely on the new 5G technology. Smart buildings would adapt to maximize energy usage, and areas where there is a shortage would be adapted to compensate for it. Smart billboards would play a crucial role by directly targeting buyers.



Picture 5.2. Model of a smart city (concept)

Smart cities would help authorities establish a comprehensive picture of resource use in the city, such as electric power and traffic congestion. This would uncover the shortcomings of the society we live in.

6.3 Virtual reality

Virtual reality is a computer-generated environment of real life as an alternative life. It is used for gaming and entertainment, training, education, and in scientific fields. What 5G would enable us in virtual reality is real-time movement from our homes. This means we could exercise in the gym with our friend from home. We would have no physical contact, but we would see and act together. Due to the low latency of the new technology, many opportunities are opening up. The video industry is also developing, generating computer games available in virtual reality that we can experience in great detail in first-person.



Picture 5.3. Model of how interaction would look like in virtual reality

We could also visit a virtual doctor without the need to go to hospitals and wait in lines for hours. Another example of how it would affect social obligations.

6.4 Surgical procedures

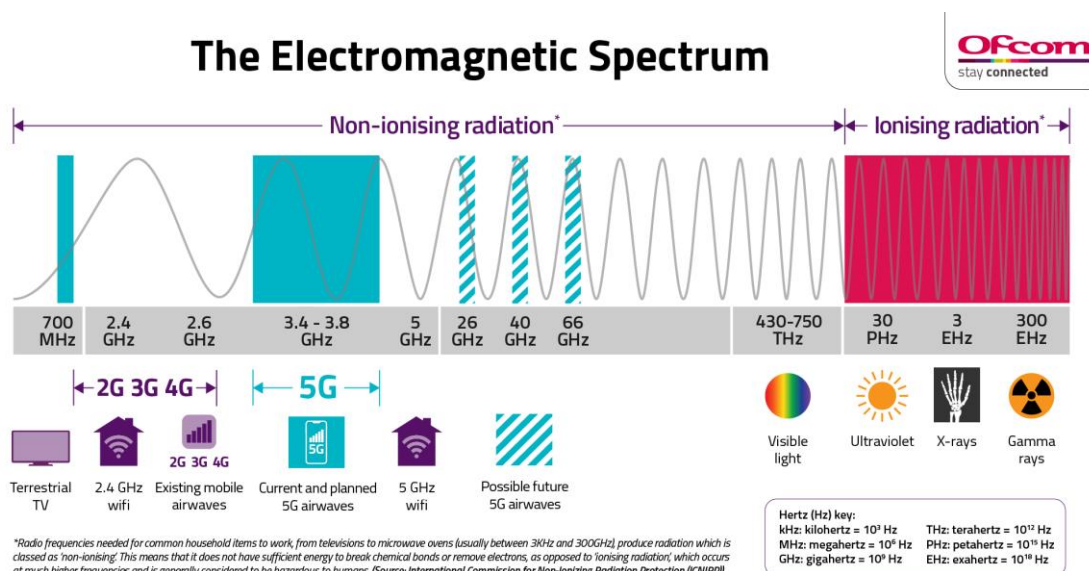
What is important in medicine is that surgical procedures can be performed over long distances, even thousands of kilometers away. On September 7, 2019, a surgical procedure on animals was performed in Haiti from a distance of 3000 kilometers. This requires special 5G robots capable of working without direct human interaction. At one end, the doctor can control the robotic arm to perform soft tissue surgery, while the robotic arm at the other end can precisely follow the doctor's instructions without causing any harm.



Picture 5.4. Performing remote surgery using a 5G robotic arm

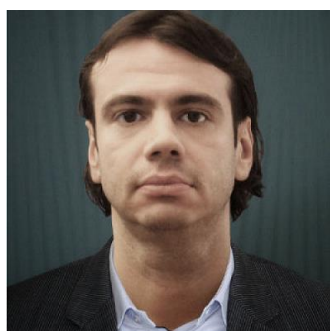
7. Is 5G dangerous?

The radio frequencies used by 5G are not harmful. However, despite this fact, there is a great deal of panic among people about them. Many believe that 5G frequencies cause brain tumors and dry out brain cells. All of these are conspiracy theories.



Picture 6.1. Radio spectrum and its parts

As Dr. Rakovic says, such reactions from people are normal. During the first industrial revolution, many opposed it, but over time it became a standard and continued to develop.



Picture 6.2. Doc. Dr. Valentin Raković



Picture 6.3. "Part of the equipment in the laboratory of the Faculty of Electrical Engineering and Information Technologies (FEIT)

During the past year, a large number of dead bird flocks have been reported around 5G antennas, but all of that is just a coincidence. There are many factors that affect nature and are part of it. The WHO and many institutions dedicated to 5G constantly monitor the situation and possible dangers of 5G to humans. The frequencies of 5G are not any more dangerous than those of 4G. The part of the radio spectrum that is dangerous to humans and causes brain cell tumors is used by the microwave ovens in our homes (with little, insignificant impact, and we are safe as long as we keep our heads out of them), as well as the X-rays in hospitals. Therefore, there are greater chances of getting a tumor from the microwave ovens in our homes than from 5G antennas.

8. Conclusion

With the modernization of the world and the daily effort to create new and better technology, striving for the best, we have reached the fifth generation of mobile networks, which is on the path to realizing the dream of humanity. Although new, this technology has great potential in the industry. A new industrial revolution is following, with the modernization of existing factories with modern, automated ones - without any human interaction.

In my opinion, the future is here. We just need to use it as we should. It's okay to be scared, but we shouldn't hinder its development. Many concepts, which would change the everyday life of every person, would be realized (and a large number of them will be realized during the time of the current 5G).

Of course, to use 5G on our mobile phone, we need a 5G antenna, which is not available on all models, at least for now. In a few months, it will be standard, and we will have a network with a speed of 10 gigabytes per second in our hands. When we can afford a 5G phone, a large part of the globe will be covered with 5G antennas, allowing us to use and enjoy its perfection without any obstacles.

And despite the great goals of 5G, this is not the end. Preparations are beginning for the development of 6G, which will be a much better network than the current one. It is believed that the last generation of mobile networks would be 7G, for which we still do not know how it would function and what it would be used for.

9. Used literature

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