

**6G – NETWORK OF THE FUTURE**Nehad Gaši<sup>1</sup>, Almira Salkić<sup>1</sup>, Bakir Čičak<sup>2</sup><sup>1</sup>International University Travnik in Travnik, Travnik, Bosnia and Herzegovina<sup>2</sup>University Vitez; Travnik, Bosnia and Herzegovina*Review article*<https://doi.org/10.58952/nit20231102152>**Abstract**

*6G stands for the sixth generation of mobile networks, which represents the future of wireless communication. While 5G networks are still being developed and expanded around the world, the industry is already thinking about the next generation to meet the needs of the accelerated digital transformation and the demands of modern society. 6G networks will be even faster, more reliable, with lower latency and higher capacity than their predecessors. It is expected to deliver incredible data transfer speeds of terabytes per second, enabling instant downloads of large files and supporting technologies such as virtual and augmented reality, artificial intelligence, autonomous vehicles, Internet of Things (IoT) devices and other advanced applications.. One key features of 6G networks will be greater connectivity between people, machines and things, creating an intelligent network that will enable highly sophisticated communication scenarios. 6G networks are expected to provide the possibility of continuous connectivity with high quality of service, even in difficult environments such as rural areas, inside buildings or in motion. 6G networks will use multiple frequency bands, including terahertz frequencies, which will allow for greater capacity and higher data transfer speeds. It will also require advanced use of antenna systems, such as massive multiplexed antennas (Massive MIMO), in order to achieve a high degree of wireless efficiency. However, it is important to note that the 6G network is still in the research and development phase. Standardization and commercial implementation are expected only after 2030. Industry,*

**Keywords:** 6G, networks, future, IoT, transfer, industry, standardization



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## 1 INTRODUCTION

Considering the development of 6G networks, there are several key features and technological innovations that are expected to be part of this advanced system:

- a) Extremely high data transfer rates: 6G networks will provide extremely fast data transfer rates of terabytes per second. It will enable instant downloads of large files, streaming of high-quality content and advanced applications such as virtual reality and augmented reality.
- b) Extremely low latency: 6G networks will have extremely low latency, which is the time from sending a request to receiving a response. This will be critical to support real-time applications such as autonomous vehicles, remote surgery and industrial automation.
- c) Greater connectivity: 6G networks will enable greater connectivity between people, machines and things. This will result in the introduction of advanced communication scenarios, such as mass communication of devices in IoT networks, interaction with smart cities and smart houses, as well as improved cooperation between humans and artificial intelligence.
- d) Multi-layer networks: 6G networks will likely rely on the concept of multi-layer networks, including the terahertz frequency range. The combination of different frequency bands will enable greater capacity and better network performance.
- e) Advanced antenna technologies: 6G networks will use advanced antenna technologies, including massive multiplexed antennas (Massive MIMO) and adaptive antennas. These technologies will enable better use of frequency bands, increased capacity and improved coverage.

- f) Artificial intelligence for network optimization: In 6G networks, artificial intelligence will play a key role in network optimization. AI will be used to efficiently manage resources, predict traffic, detect and debug errors, and improve network security.
- g) Security and privacy: 6G networks will place a strong focus on user security and privacy. Advanced technologies of encryption and protection of user data will be developed.

## 2 TECHNICAL CHARACTERISTICS OF THE 6G NETWORK

6G networks will be based on numerous technical features that will enable advanced wireless communication. Although technical specifications are still being developed, here are some of the key features expected in 6G networks. Extremely high data rates where 6G networks are expected to deliver data rates of terabytes per second (Tbps), which is several times faster than current 5G networks. It will enable incredibly fast downloads of large files, streaming of 8K/16K video content and support for advanced applications such as virtual and augmented reality. Also extremely low latency 6G networks will have extremely low latency, which will be crucial for supporting real-time applications. Latency is expected to be less than 1 millisecond (ms), enabling rapid response and interaction with advanced technologies such as autonomous vehicles, remote surgical procedures and industrial automation. The higher capacities and spectral efficiency of the 6G network will use more frequency bands, including the terahertz (THz) band, to provide more data capacity. This expanded frequency band will enable greater bandwidth and speed up data flow. Advanced multiplexing and modulation techniques will also be implemented to increase spectral efficiency. Also, 6G networks are likely to rely on the

concept of multi-layer networks to exploit the potential of different frequency bands. This will include a combination of microwave, millimeter wave and terahertz frequency bands, which will provide greater capacity, better coverage and greater signal reliability. 6G networks will also have advanced antenna technologies such as massive multiplex antennas (Massive MIMO) and adaptive antennas, to improve coverage and increase the efficiency of wireless communication. These technologies will enable better signal management, reduce interference and provide greater signal reliability.

**Energy efficiency:** 6G networks will focus on improving energy efficiency to reduce environmental impact. New techniques will be implemented to manage energy and reduce energy consumption, both at the network level and at the device level. Artificial intelligence will play an important role in 6G networks. AI will be used for resource optimization, traffic prediction, network management, error detection and threat protection. The integration of artificial intelligence into 6G networks will enable a more intelligent, autonomous and efficient functioning of the network. It is important to note that these technical characteristics are currently the subject of research and development, and may change in accordance with technological progress and industrial requirements.

### **3 6G NETWORK IN INDUSTRY**

The term "gray economy" in the broadest The 6G network will have a significant impact on the industry, providing new opportunities for connecting, automating and optimizing business processes. Here are a few areas in the industry that could benefit from 6G networks:

**Industrial automation:** 6G networks will enable advanced industrial automation and optimization of production processes. High data transfer speed, low latency and higher

signal reliability will enable the connection of a large number of IoT devices, sensors and machines in real time. This will improve efficiency, flexibility and accuracy in industrial environments.

**Smart factories:** 6G networks will support the concept of smart factories, where machines, robots, devices and people will be able to connect in an advanced way. With fast data transfer rates and low latency, smart factories will be able to optimize production processes, perform real-time monitoring and diagnostics, and reduce downtime and maintenance costs.

**Wireless automation in industry:** 6G networks will enable wireless automation in industry, eliminating the need for wired infrastructure and allowing flexibility in the placement of sensors, actuators and control systems. This will facilitate the rapid and scalable implementation of industrial systems in different environments.

**Advanced supply chain management technologies:** 6G networks will support advanced supply chain management technologies, such as real-time inventory tracking and management, logistics optimization, shipment tracking, and the application of artificial intelligence in data analysis. This will result in more efficient supply chains, cost reductions and improved service quality.

**Virtual and Augmented Reality:** 6G networks will support advanced Virtual Reality (VR) and Augmented Reality (AR) applications in industry. With fast data transfer and low latency, virtual training, simulations and visually guided procedures can be used for workforce training, maintenance and repair, design and process planning.

**Robotics and autonomous vehicles:** 6G networks will enable advanced communication between autonomous vehicles, robots and machines. It will be crucial for coordination, management and security in industrial environments. Real-

time communication between autonomous systems and rapid decision-making can increase efficiency, productivity and safety in industry. 6G networks will provide the foundation for advanced digital transformation in industry, improving efficiency, productivity, reliability and security in a wide range of industrial applications.

#### 4 6G NETWORKS IN TRAFFIC

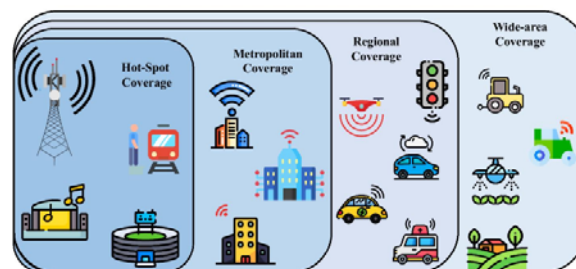
6G networks will have a significant impact on the transport sector, providing advanced opportunities to improve safety, efficiency and user experience. Here are a few areas where 6G networks can be used in traffic:

**V2X communication:** 6G networks will enable advanced communication of vehicles with other vehicles (V2V), infrastructure (V2I) and pedestrians (V2P), known as V2X communication. This real-time, low-latency, high-reliability communication will enable more efficient information exchange between road users, improving safety, traffic management and reducing congestion.

**Autonomous vehicles:** 6G networks will be key to supporting autonomous vehicles. High data transfer speed and low latency will enable fast and accurate data exchange between autonomous vehicles and their environment, including information about traffic, obstacles, roads and road conditions. This will improve the performance of autonomous vehicles, increase safety and optimize traffic efficiency.

**Smart cities and traffic management:** 6G networks will be key to the development of smart cities and advanced traffic management systems. With fast data transfer, a large number of connected devices and low latency, the networks will enable efficient traffic management, traffic light optimization, parking monitoring and management, as well as rapid information

exchange between different aspects of the traffic system.



Picture: Transition technologies towards 6G networks

Source: [https://media.springernature.com/lw685/springerstatic/image/art%3A10.1186%2Fs13638-021-01973-9/MediaObjects/13638\\_2021\\_1973\\_Fig1\\_HTML.png](https://media.springernature.com/lw685/springerstatic/image/art%3A10.1186%2Fs13638-021-01973-9/MediaObjects/13638_2021_1973_Fig1_HTML.png)

**Advanced navigation and driver assistance:** 6G networks will provide improved navigation and driver assistance services. Fast data transfer will enable real-time information about traffic, route, road conditions and alternative routes. It will also be possible to provide personalized recommendations and instructions based on data about the driver's preferences and road conditions.

**Traffic safety:** 6G networks will improve traffic safety through the rapid exchange of information between vehicles, infrastructure and pedestrians. This will provide warnings about hazards, collisions, pedestrians and other risks, which will allow drivers to react more quickly and reduce the risk of accidents.

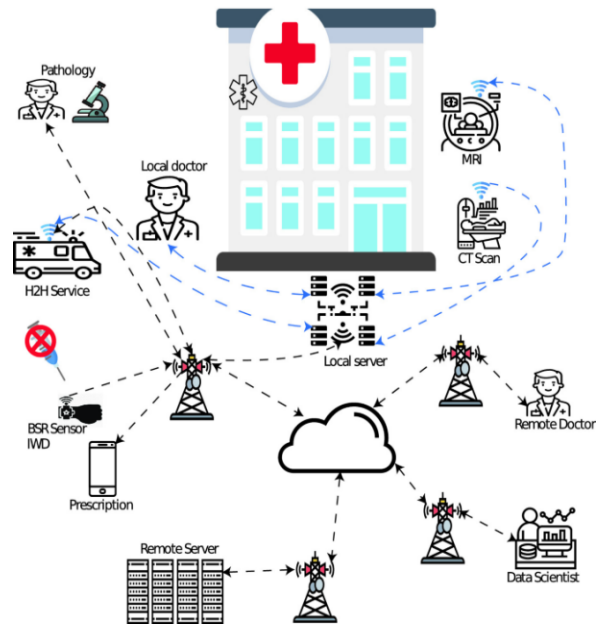
We can say that 6G networks will transform the transport sector, improving safety, efficiency and user experience. With real-time connectivity of vehicles, infrastructure and pedestrians, traffic will become more intelligent, safer and more sustainable.

## 5 6G NETWORK IN MEDICINE

6G networks will have a significant impact on the medical sector, bringing numerous innovations and improvements in healthcare delivery. Here are a few areas where 6G networks are expected to be used in medicine:

**Telemedicine and remote monitoring of patients:** 6G networks will enable advanced telemedicine, which will enable the provision of medical diagnostics, consultations and treatments at a distance. High data transfer speed, low latency and the connection of a large number of devices will enable the real-time transfer of medical data, images and videos between doctors and patients. It will also enable remote patient monitoring, enabling continuous monitoring of vital signs, chronic disease management and reducing the need for unnecessary hospital visits.

**Remote surgical procedures:** 6G networks will enable advanced remote surgical procedures, known as telesurgery. Low latency and high data transfer rates will allow surgeons to precisely control robots and instruments far from them, providing the ability to perform complex surgical procedures even in remote locations. This will provide access to specialists in different parts of the world and improve the availability of high-quality medical care.



Picture: A Vision on Intelligent Healthcare

Source: [https://media.springernature.com/lw685/springerstatic/image/chp%3A10.1007%2F978-981-15-9735-0\\_1/MediaObjects/494934\\_1\\_En\\_1\\_Fig1\\_HTML.png](https://media.springernature.com/lw685/springerstatic/image/chp%3A10.1007%2F978-981-15-9735-0_1/MediaObjects/494934_1_En_1_Fig1_HTML.png)

**Medical research and data analytics:** 6G networks will enable rapid exchange and analysis of large amounts of medical data. It will support medical research, data analytics and the application of artificial intelligence in diagnostics, prediction and personalized medicine. High-speed data transfer will enable faster sharing of medical information, including genetic sequences, medical images and electronic medical records, which will advance research and improve medical treatments.

**Internet of Things in Healthcare:** 6G networks will enable more connected medical devices and sensors, creating an Internet of Things (IoT) ecosystem in healthcare. It will enable patient monitoring, medical device inventory management, temperature and drug storage conditions monitoring, as well as process automation in hospitals and health centers. IoT will improve the efficiency, safety and quality of healthcare.

**Augmented Reality in Medical Education:** 6G networks will support the application of

Augmented Reality (AR) in medical education. Fast transmission speed and low latency will allow students and doctors to access real-time educational content, virtual demonstrations and interactive training. This will improve education, simulations and understanding of medical procedures. From all appearances, 6G networks will enable advanced medical applications and transform the way healthcare is provided. Telemedicine, remote surgical procedures, medical research and IoT applications in healthcare are just some of the ways in which 6G will improve the quality, availability and efficiency of medical care.

## 6 6G NETWORK AND IMPACT ON HEALTH

The 6G network has not yet been widely implemented and has not been thoroughly investigated in terms of its impact on human health. However, there are some questions and assumptions related to the potential impact of the 6G network on health. Here are some important points:

**Electromagnetic fields (EM fields):** Like previous generations of mobile networks, 6G will use electromagnetic fields to transmit signals. While previous research has shown that EM fields from mobile networks do not pose a significant health hazard at current exposure levels, further research should be conducted to assess the impact of EM fields that may be present in the 6G network.

**Data security and privacy:** As the 6G network will be ubiquitous and support a large data exchange, it is important to ensure adequate data privacy and security measures. This is important to prevent unauthorized use of personal medical information and to maintain the confidentiality of health information<sup>1</sup>.

<sup>1</sup> [Kako će 6G mreža dovesti do revolucije u komunikacijama - IT mixer \(it-mixer.com\)](#)

<sup>2</sup> [Šesto čulo: Kako će 6G mreža promijeniti svijet - BIGportal.ba](#)

**Implementation of health regulations:** As the 6G network will be used in health institutions and for the provision of medical services, it is necessary to comply with relevant health regulations and standards. This includes protecting patient privacy, regulating medical devices, and ensuring the quality and safety of healthcare services delivered over the 6G network.<sup>2</sup>

It is important to note that further research and evaluation of the impact of the 6G network on human health is needed to ensure the safe and reliable use of this technology. Organizations such as the World Health Organization (WHO) and other regulatory agencies will monitor and evaluate the health impact of the 6G network to ensure user protection.

## 7 IMPORTANT DIFFERENCES BETWEEN 4G, 5G AND 6G NETWORKS

4G, 5G and 6G networks differ in several key features. Here are some important differences between these generations of mobile networks:

**Data transfer speed:** 4G networks provide data transfer speeds of up to several tens of megabits per second (Mbps), while 5G networks enable speeds of several gigabits per second (Gbps). On the other hand, 6G networks are expected to enable even faster data transfers from tens to hundreds of Gbps.<sup>3</sup>

**Latency:** Latency refers to the time it takes for data to transfer between the device and the network. 4G networks have latency between 20 and 50 milliseconds (ms), while 5G networks provide a much lower latency of 1 to 10 ms. 6G networks are expected to further reduce latency to less than 1ms.

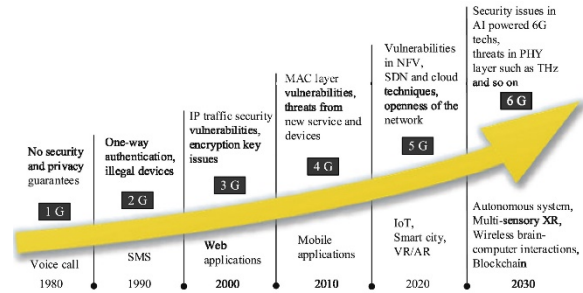
<sup>3</sup> [Brzina, kapacitet... Razlike između 4G i 5G mreže - Elta-Kabel](#)

Number of connected devices: 4G networks can support up to several thousand devices per square kilometer, while 5G networks enable a much larger number of connected devices - from several tens of thousands to several million devices per square kilometer. 6G networks are expected to support an even greater number of connected devices, ranging from tens of millions to hundreds of millions of devices per square kilometer.

Network capacity: Network capacity refers to the amount of data that the network can transfer in a unit of time. 4G networks have limited capacity, while 5G networks provide more capacity and can transfer much more data. 6G networks are expected to have even greater capacity, enabling the transfer of huge amounts of data in real time.

Advanced Technologies: Each new generation of network introduces new technologies and features. For example, 5G networks bring greater support for a large number of devices, greater reliability, improved security, greater energy efficiency, and support for a new generation of applications such as virtual and augmented reality. 6G networks are expected to bring even more advanced technologies such as quantum communication, holographic communication and even more advanced artificial intelligence.

These differences point to the gradual improvement of mobile networks to enable faster data transfers, lower latency and greater support for connecting a large number of devices. Each new generation of network brings new opportunities and potential for different industries and applications.<sup>4</sup>



Picture: Differences between 4G, 5G And 6G Networks

Source: [https://www.drishtiiias.com/images/uploads/1634034986\\_image4.jpg](https://www.drishtiiias.com/images/uploads/1634034986_image4.jpg)

## 8 12 CHALLENGES FOR 6G NETWORK

As of last knowledge update in September 2021, 6G networks were still in the early research and development phase. However, based on the challenges faced by previous generations of wireless networks and some potential future considerations, here are 12 challenges that 6G networks might encounter:

1. **Spectrum availability:** As the demand for wireless communication continues to grow, finding and allocating sufficient spectrum for 6G networks will be a significant challenge.
2. **Higher frequency bands:** 6G networks may need to operate in higher frequency bands, which present technical hurdles such as shorter propagation distances and increased signal attenuation.
3. **Massive connectivity:** 6G is expected to support an exponentially larger number of connected devices, requiring new approaches to handle massive connectivity and device management efficiently.
4. **Energy efficiency:** With the proliferation of connected devices, ensuring energy-efficient network

<sup>4</sup> <https://root-nation.com/hr/ua/articles-ua/tech-ua/ua-what-is-6g-networks/>

operations will be crucial to minimize environmental impact and support sustainable practices.

5. Network densification: To cater to the increasing demand for high-capacity connections, 6G networks will require denser deployments of base stations and infrastructure, posing challenges related to power consumption, interference, and infrastructure availability.
6. Security and privacy: As networks become more pervasive and interconnected, ensuring robust security and privacy mechanisms will be essential to protect sensitive data and prevent cyberattacks.
7. Network slicing and virtualization: 6G networks are expected to support network slicing and virtualization to enable tailored services for different use cases, but achieving seamless management and resource allocation across virtualized networks will be a complex task.
8. Edge computing and distributed intelligence: 6G networks may heavily rely on edge computing and distributed intelligence to support low-latency applications. Overcoming the challenges of managing distributed resources and optimizing computing capabilities will be critical.
9. Heterogeneous access technologies: 6G networks will likely integrate multiple access technologies, including traditional cellular networks, Wi-Fi, and beyond. Coordinating and managing these technologies to provide a seamless user experience will be a significant challenge.
10. Ethical and societal considerations: As with any emerging technology, 6G networks will raise ethical and societal questions. Addressing concerns related to privacy, data ownership, equity of

access, and potential social impacts will be crucial.

11. International standards and collaboration: Establishing global standards and promoting international collaboration will be essential for the successful deployment and interoperability of 6G networks.
12. Regulatory and policy framework: Developing appropriate regulatory and policy frameworks that encourage innovation, investment, and fair competition while safeguarding public interests and addressing societal concerns will be vital for 6G networks.



Picture: 12 Challenges for 6G networks

Source: <https://assets.telecomtv.com/assets/telecomtv/softbank-6g-challenges-12321.jpeg?w=1200>

## CONCLUSION

In conclusion, 6G networks represent the future of telecommunications and promise to revolutionize the way we connect and use digital services. 6G networks are expected to bring data transfer speeds from tens to hundreds of gigabits per second, very low latency of less than 1 ms, support for a huge number of connected devices, and large network capacity. These features will enable advanced technologies such as augmented and virtual reality, holographic communication, autonomous vehicles, industry 4.0, medical innovation and many other applications that will improve our daily lives. Also, 6G networks will be key to connecting all aspects of our environment, including people, devices, vehicles, infrastructure and sensors, creating intelligent, connected and



sustainable ecosystems. However, while 6G networks promise many benefits, it is also important to consider potential challenges and issues related to health, privacy, data security and regulation.

Further research and development is needed to ensure the safe and ethical implementation of 6G networks. In total, 6G networks will enable an even more advanced digital experience, improve the efficiency of industries, transform the way we live, work and communicate, and open the door to innovations that we may not currently be able to imagine. With proper development, implementation and management, 6G networks will shape the future of the information society and affect all aspects of our lives. 6G networks will enable an even more advanced digital experience, improve the efficiency of industries, transform the way we live, work and communicate, and open the door to innovations that we may not even be able to imagine right now. With proper development, implementation and management, 6G networks will shape the future of the information society and affect all aspects of our lives.

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