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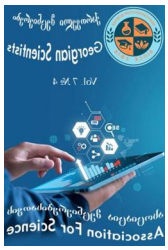

Fifth Generation (5g) Networks's Implementation State in Countries around the World

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Abstract

Existing cellular networks were originally designed for low data demands. They can no longer effectively handle today's large data volumes, especially high-bandwidth applications. Fifth generation (5G) wireless technology provides high data transfer speeds, ultra-low latency, greater reliability, scalable network capacity, increased availability and flexibility.

5G is the fifth generation of mobile networks. It is the new global wireless standard after 4G network. 5G wireless technology uses radio waves to transmit data, similar to 4G, but operates at higher frequencies, which increases network capacity, provides higher data transfer rates and lower latency. 5G also uses beamforming antenna's technology, which allows more devices to connect at the same time. 5G technology creates a dense network of small cell towers. The combination of these factors makes 5G an ideal option for data-intensive applications such as video streaming, enabling a new type of network designed to connect virtually everyone and everything, including cars, objects and devices.

In the article described the evolution of mobile communication development; given the differences between the current 4G and 5G, new capabilities of 5G and areas of industrial application; named the leading countries in the implementation of 5G, 5G service providers and device manufacturers; given information on the current status of the fifth generation implementation in various countries.

Key words: Mobile Network, Wireless connection, Fifth generation, 5G, mmWave, MIMO, IoT.

Introduction

Not so long ago, such broad technological possibilities that 5G now offers us were considered fantastic: the development of interaction between intelligent devices that will be included in the global network - the Internet, which will be able to collect, process data and exchange them with each other without human intervention. For example, a smart refrigerator that not only checks which products are lacking in it, but also orders them from the store and the product comes to the house with the help of an automatically controlled drone. 5G technology is the basis of future medicine, economics and social development. The spread of new generation networks will radically change many areas.

The evolution of mobile connectivity

Each generation of mobile connectivity, from 1G to 4G, offered improvements in data transfer speed, capacity and functionality and this evolutionary development of mobile connectivity opened the way for the transformative capabilities of 5G (Figure 1).

– **1G:** In the 1980s, 1G was introduced, which allowed for basic voice calls using analog technology.

– **2G:** In the 1990s, 2G appeared, which offered users digital voice communication and limited data services such as SMS (Short Message Service), MMS (Multimedia Messaging Service).

– **3G:** In the 2000s, 3G began the era of mobile broadband: wireless mobile Internet, video calls, mobile TV. It provided higher data transfer speeds for multimedia applications.

– **4G:** The current standard, 4G LTE, provides much higher transmission speeds, increased network capacity and also allows for improved quality of service for IP telephony, mobile TV, gaming services and 3D television [2,3].

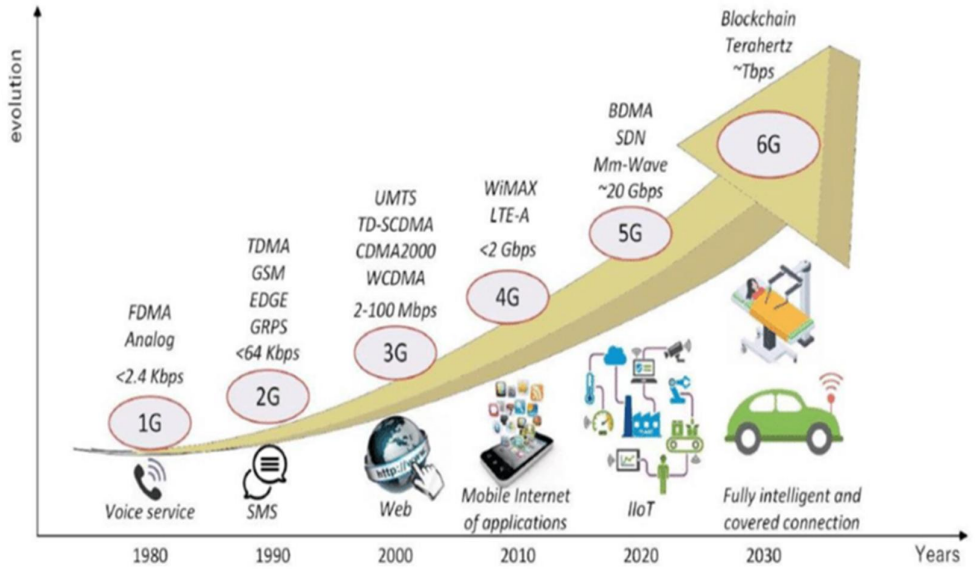

Figure 1. Evolution of mobile communication networks [3]

Several key technological advances have led to the increased capabilities of 5G:

– **Spectrum efficiency:** 5G uses a wider range of radio frequencies than previous generations, including higher-frequency bands called **millimeter waves (mmWave)**, which provide greater data throughput and capacity. There are **three frequency bands** allocated to 5G networks: **Low Bands (less than 1 GHz), Mid Bands (1 GHz to 6 GHz)** and **High Bands (24 GHz to 40 GHz),** which are defined as FR2/mmWave (Figure 2). Each band provides both outdoor and indoor coverage. **Low bands** have **greater coverage** but **lower speeds** and can penetrate buildings. **Medium bands** have a balance of **coverage** and **speed,** while **high bands** have **higher speeds** but **less coverage** and require direct vision when placing antennas [9,10].

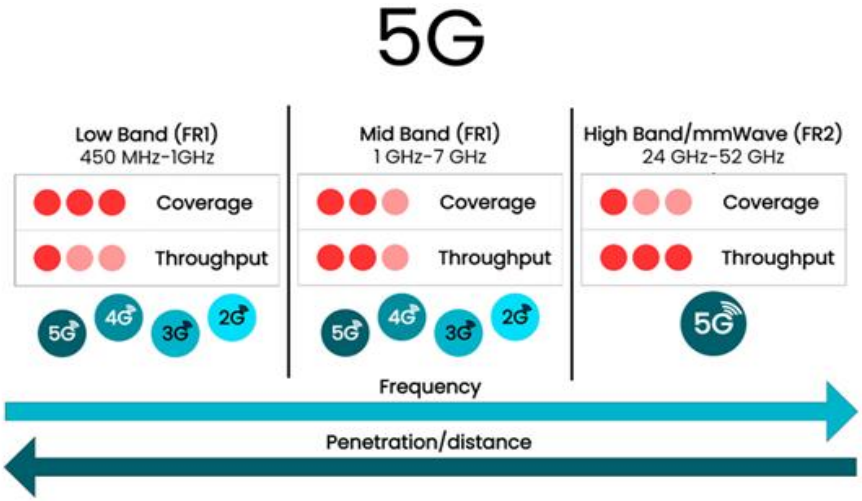

Figure 2. 5G radio frequency spectrum [9]

– **Advanced Network Architecture:** 5G uses a flexible, software-defined network architecture that allows resources to be efficiently allocated and the network to be partitioned to accommodate a variety of use cases with different requirements.

– **Massive MIMO:** Multiple-Input Multiple-Output (MIMO) technology that uses multiple transmitters and receivers to transmit more data simultaneously. Antennas allow 5G to handle multiple simultaneous connections and improve spectral efficiency, which is better for efficient network operation in crowded areas.

– **Beamforming:** Traditional antennas transmit signals in all directions. Beamforming technology allows the signal to be directed and amplified towards a specific receiving device, delivering high data rates to specific users, improving 5G network efficiency, reducing power consumption and supporting more reliable connections (Figure 3). Beamforming is useful in densely populated urban environments where many devices are connected simultaneously [1,4].

Figure 3. Massive MIMO antenna

There are significant **differences** between 5G and the current 4G (Figure 4), including:

- **Frequency range**: Current 4G (LTE) technology only uses the low-frequency range up to 6 GHz. 5G's radio range is from **30 GHz to 300 GHz.** This higher frequency allows 5G to significantly increase speed, transmit large amounts of data and increase network throughput.
- **Significant speed**: The main difference between 5G and 4G is the significant speed offered by 5G networks. 4G networks peak at around 1 GB per second, while 5G can increase this by 20 times. This means much faster mobile downloads without having to connect to Wi-Fi.
- **Reduced latency**: 5G can have four to five times less latency than 4G. This reduction in latency is due to 5G's improved radio technology.
- **Greater throughput**: 4G networks have trouble handling data from multiple devices connected to the same location, but 5G solves this problem by providing high-fidelity transmission to each device, allowing it to serve up to 1 million devices per square kilometer. This network feature is crucial as the use of mobile devices is growing exponentially.
- **Connectivity:** 5G can serve 100 times more devices and endpoints than 4G.
- **Innovative mobile traffic usage:** According to Ericsson's Mobility 2025 report, data traffic is expected to grow by 60% annually. While 4G networks can only carry a limited amount of data, 5G will allow more users to use the networks: with increased demand for social media, online gaming and video streaming.
- **Energy efficiency:** 5G is more energy efficient, allowing operators to reduce power consumption. Importantly, mobile devices running 5G also consume less power, which can extend battery life.
- **Mobile data capacity:** 5G can deliver up to 1000 times the data capacity of 4G. The increased data capacity allows users to use network resources more efficiently in crowded areas, such as airports, when using public networks [7,8].

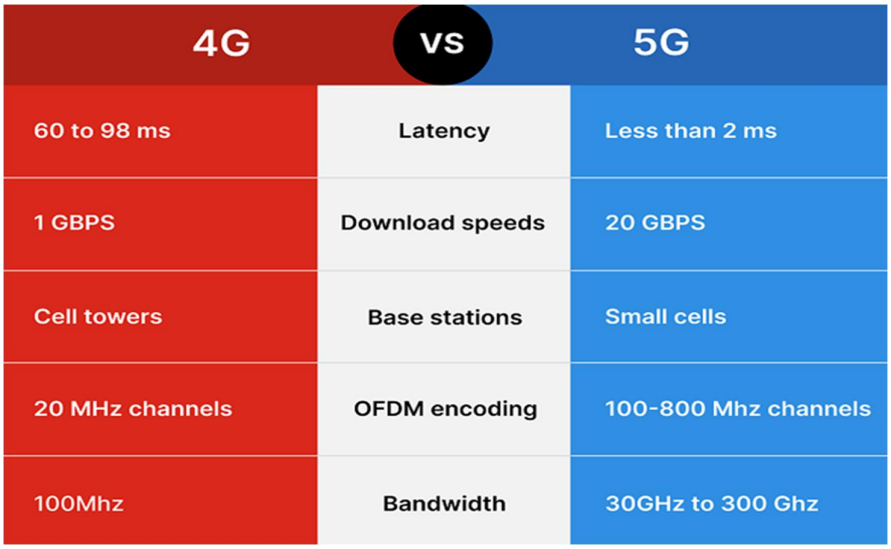

Figure 4. Difference between 4G and 5G [2]

The main, improved, new capabilities and industrial applications of 5G are as follows:

- **Enhanced Mobile Broadband (eMBB),** which provides speeds of up to Gbps. Video streaming, AR/VR, interactive experiences, using higher bandwidth and capacity.
- **Massive Machine-to-Machine Communication (mMMC),** which supports high density (up to 1 million devices per square kilometer) and unique IoT (Internet of Things) requirements.
- **Fixed Wireless Access (FWA):** Offering broadband internet via 5G where wired infrastructure is weak or non-existent.
- **Internet of Things-IoT and mMTC:** Massive connectivity of devices (sensors, smart meters) in cities, agriculture and logistics.
- **Ultra-Reliable Low Latency Communications (URLLC):** Provides high reliability and very low latency, which is critical for many industrial applications. Remote surgery, autonomous vehicles, real-time industrial control.
- **Smart cities and infrastructure, smart manufacturing:** Traffic management, environmental sensors, video surveillance, real-time production control using 5G networks.
- **Augmented reality, cloud gaming, immersive media:** Due to low latency and high throughput.

Leading countries in terms of 5G implementation

Countries with successful and large-scale 5G network implemented:

- **China** - A leader in 5G innovation and deployment. The country has made significant deployments to support the growth of 5G. As of 2022, the country had approximately **961 000** 5G base stations and **365 terminal connections** for the network. China has deployed 5G services in more than **356 cities**. 5G coverage will increase to approximately 85% by 2030.

- South Korea - was one of the first countries to introduce 5G technology in 2018. In 2020, the number of 5G subscribers in South Korea exceeded **9 million.** The country predicts that this number will increase further and exceed **40 million** by the end of 2025.

- United States - Along with China, the United States is one of the largest players in the implementation of 5G networks. According to a report published by Ericsson, it is expected that there will be approximately **195 million** 5G subscribers in the United States by the end of 2026. This report also states that by 2029, 5G will account for **71%** of the total US mobile market. The United States has launched 5G services in more than **296 cities.** In **North America**, 5G usage is expected to reach **314 million connections** by the first quarter of 2025, **covering** approximately **83%** of the population. In 2018, the US launched **4425 satellites** to support 5G. It is planned to launch **20000 satellites** to fully implement 5G technology, covering the entire Earth, directing microwave beams to mobile phones, thus creating a global microwave grid around us in the millimeter wave range. **20000 satellites** in orbit around the Earth, which will surround the Earth with powerful, focused, controlled beams, each satellite will emit millimeter waves. The principle of operation of millimeter waves is that radio waves fall into the spectrum of non-ionizing radiation, which cannot damage DNA or cause cancer, unlike ionizing radiation.

- Spain - Spain has invested billions of dollars in digitalization initiatives in the country. About **80%** of the Spanish population has access to 5G services.

- Saudi Arabia - One of the leaders in the 5G industry. The country expects to deploy **45 million** 5G-enabled internet devices by the end of 2030. As of today, the country already has optimal 5G telecommunications service coverage.

- India has surpassed many developed countries in 5G network deployment, recording the fastest deployment, with over **1000** 5G BTS deployed in 50 cities and towns across the country. With the introduction of 5G technology, India is expected to improve internet speed, latency and connectivity. The deployment of 5G BTS has been initiated by leading telecom operators such as **Airtel** and **JIO**, who are spearheading the 5G revolution in India. According to recent reports, Airtel and JIO have already launched 5G services in 50 cities and towns in India. This makes India one of the first countries in the world to deploy 5G technology on such a large scale.

- The countries with the highest 5G network penetration in the second quarter of 2025 are disproportionately represented in **northern** and **southern European** countries, such as **Denmark (83.9%), Sweden (77.8%)** and **Greece (76.4%),** with coverage rates that are twice as high as those in **western** and **eastern** countries, such as the **United Kingdom (45.2%), Hungary (29.9%)** and **Belgium (11.9%). Finland, Sweden** and **Norway** lead the way in innovation. 24 of the 27 EU countries support 5G **bands,** from **700 MHz to 3.8 GHz.** 5G deployment in Europe lags behind **North America** in terms of mid-range coverage.

- European superpowers - **Germany, Great Britain, France** continue to invest heavily in deployment.

- Many developing regions are lagging behind in the process of implementing 5G networks [12,13].

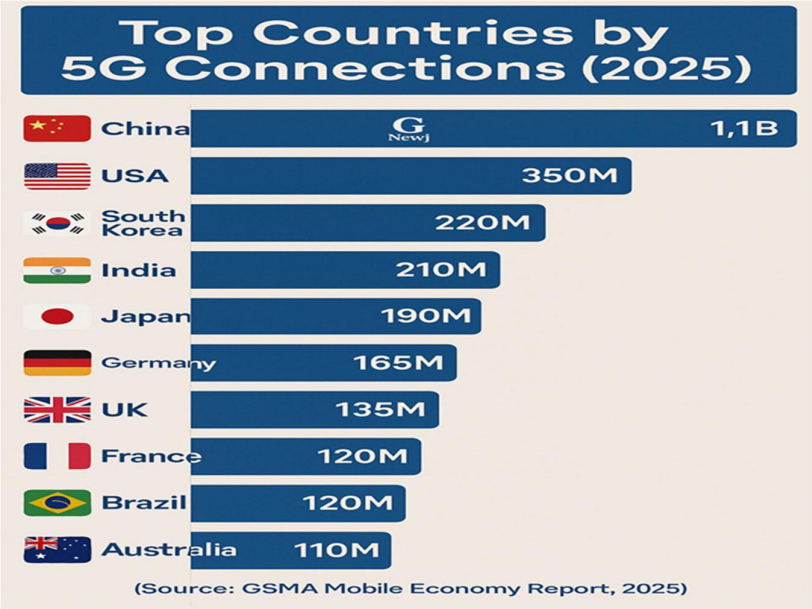

Figure 5. Top countries by 5G connectivity
(Source: GSMA Mobile Economy Report, 2025)

The number of global 5G connections reached 2.**4 billion** in the first quarter of 2025. This number is forecast to reach **2.9 billion** by the end of 2025. The number of 5G subscribers, according to the Ericsson Mobility Report, November 2025, is forecast to reach **6.4 billion** by the end of 2031 [14].

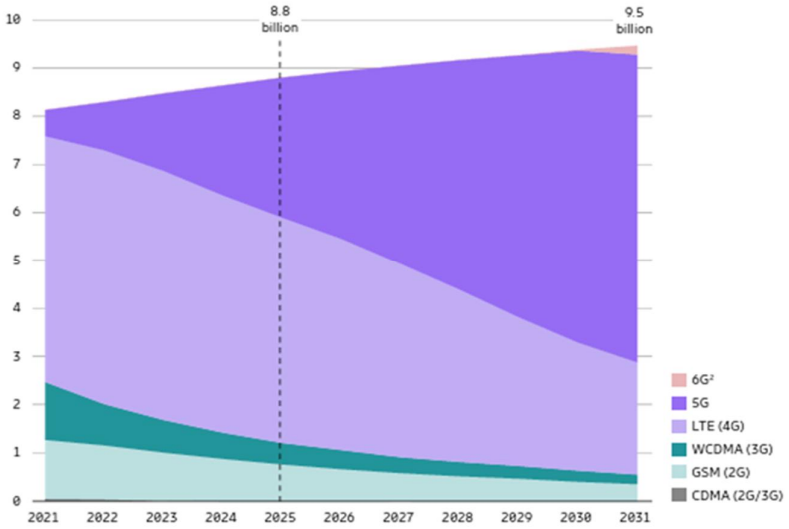

Figure 6. Number of mobile technologies
(Source: Ericsson Mobility Report, November 2025)

Data traffic provided by 5G is expected to exceed **1.2 trillion exabits** by 2025. Mobile data traffic is expected to **double** over the forecast period to 2030. According to forecasts, by 2030, more than **80%** of mobile traffic will be carried on 5G networks. By the end of 2025, **5G** networks will **cover one third** of the world's population. By 2029, there will be **8 billion** 5G connections worldwide.

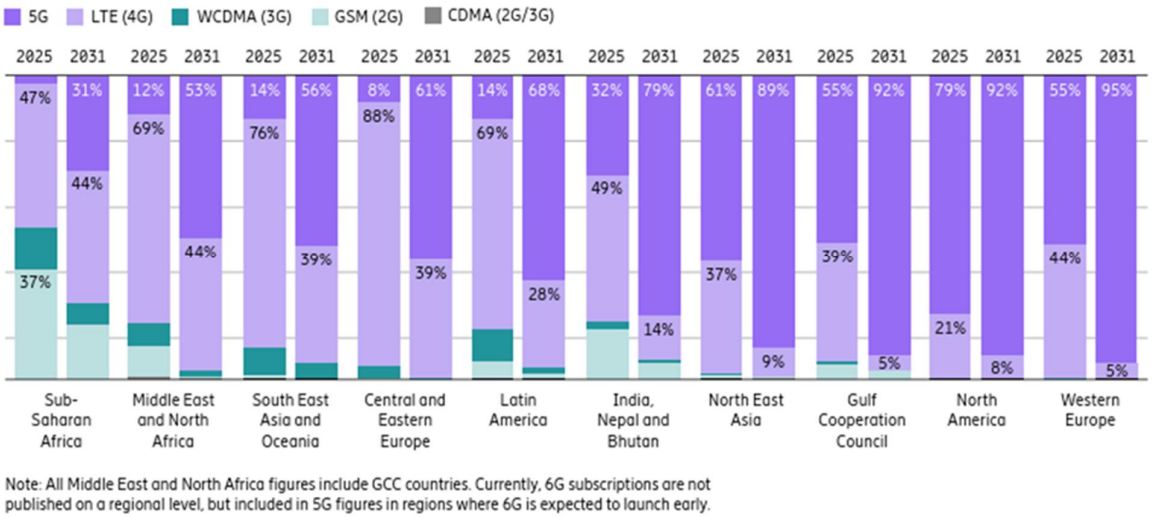

Figure 7. Regions and Technology in % of Mobile Users [5,15]
(Source: Ericsson Mobility Report, November 2025)

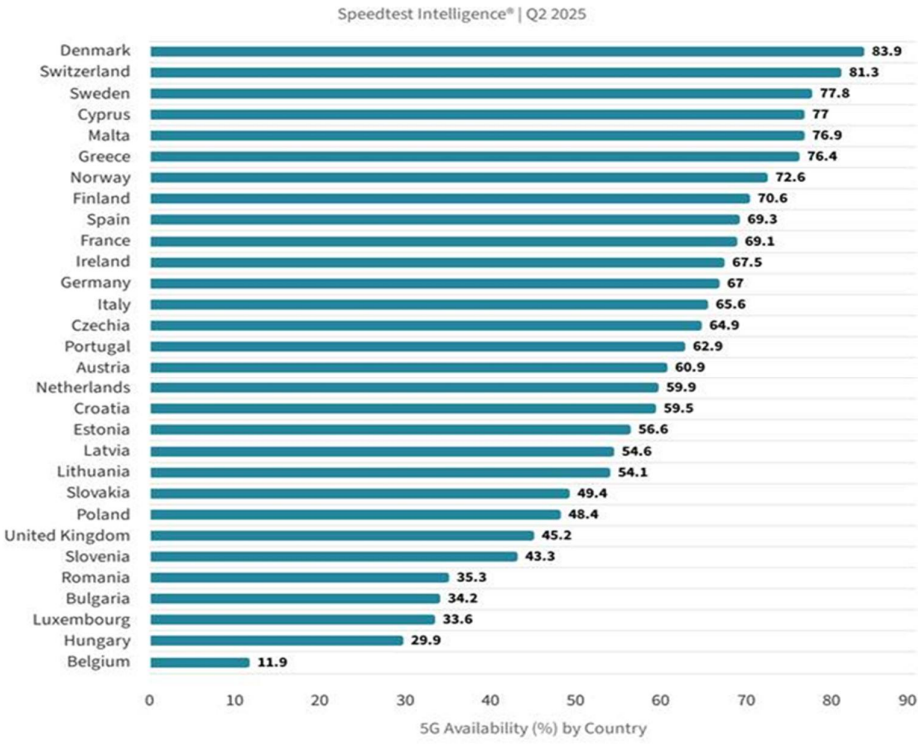

Figure 8. 5G availability (%) by country
(Source: The UK Future Connectivity Forum)

Some analysts estimate that the number of 5G connections could reach **9 billion** by 2030 [11,17].

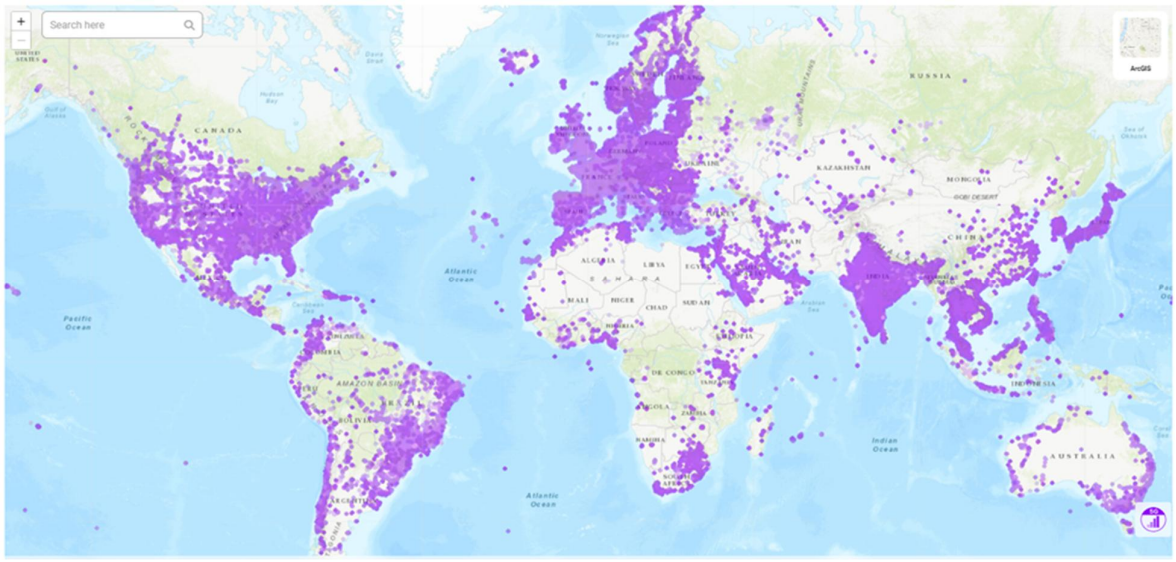

Figure 9. World map of 5G coverage as of 2025 (Source: nPerf)

Georgia is also not lagging behind modern technological progress, and in 2020 the Communications Commission began active work to implement 5G technology. The Communications Commission determined the parameters and conditions necessary for the implementation of 5G, considering the decisions of the European Commission and the experience of fellow European regulators. In August 2023, the Communications Commission announced an auction for the implementation of the 5th generation mobile Internet, offering frequency bands in the 700, 3400-3700, 2600 MHz ranges, as well as the 800 and 1800 MHz bands. The winner of the auction was the company "Selfie Mobile". The operator is obliged to gradually cover Georgia's densely populated areas, tourist zones, ports, airports, railways and main roads with the 5G network over the next 3-7 years (Figure 10).

Figure 10. Selfie Mobile 5G network coverage map (Source: nperf) [16]

In October 2024, MagtiCom became the winner of additional separate lots in the auction announced by the Communications Commission for the implementation of the fifth generation mobile Internet. In particular, the company obtained licenses to use the 2600 MHz frequency band for a period of 15 years. MagtiCom has been offering its customers the latest, fifth generation (5G) network since 2024, which creates completely new opportunities for mobile Internet. The network is built according to the best international standards and uses the full spectrum of frequency resources allocated for 5G technology. MagtiCom is traditionally outstanding by its most extensive coverage. Magti's latest generation 5G network is available almost throughout Georgia (Figure 11) [19,20].

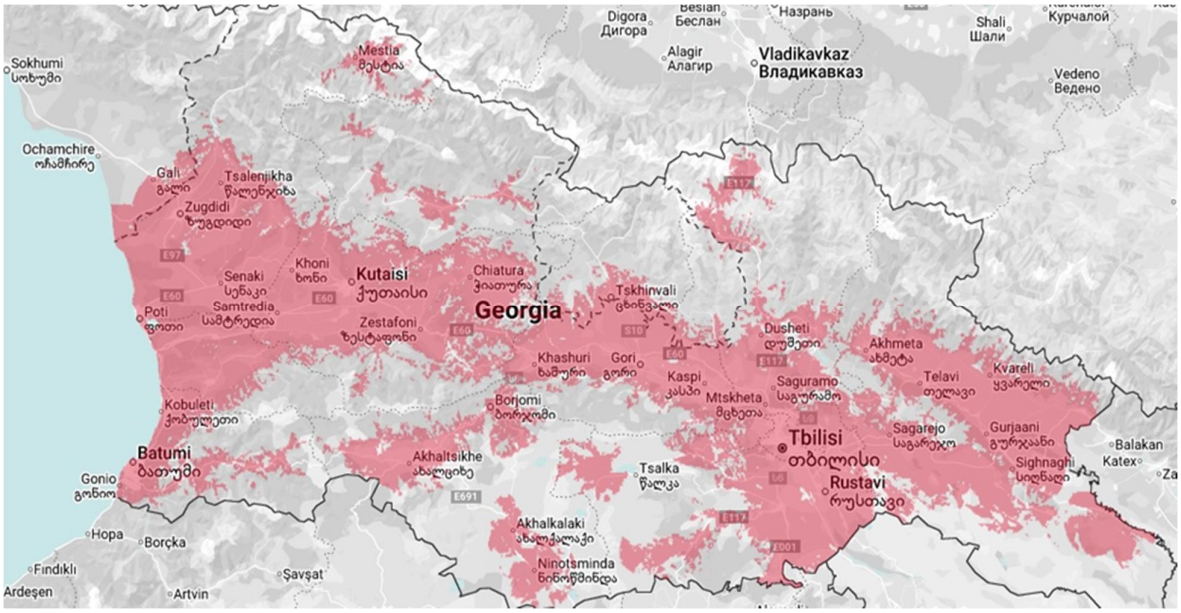

Figure 11. Magticom 5G network coverage map (Source: magticom.ge) [18]

Silknet has made 5G technology available since 2023. Since December 14, 2023, subscribers in the central districts of Tbilisi - from Freedom Square to Bagebi - have received fifth-generation Internet service. Silknet continues the process of implementing 5G throughout Georgia (Figure 12).

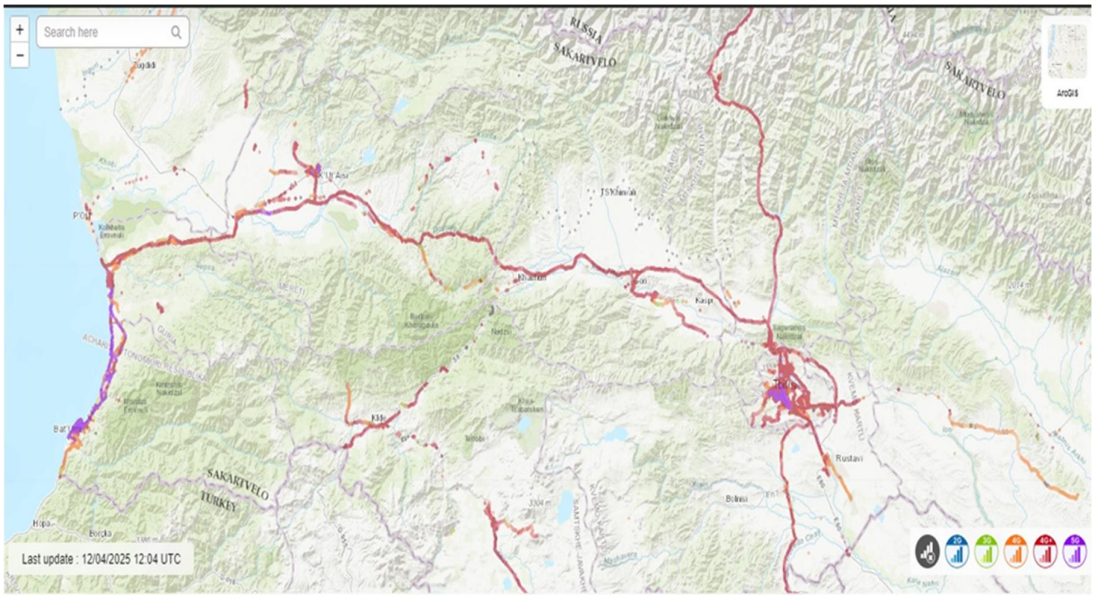

Figure 12. Silknet 5G network coverage map (Source: nperf) [16]

5G devices and infrastructure

The disadvantages of 5G include: the need to completely replace base station equipment and antennas, phones, limited coverage and incompatibility with older devices.

The main 5G service **providers** and **companies** are:

- **Huawei,** which predicts that 100 million 5G-Advanced phones will be on the market by the end of 2025, which indicates the development of new generation technologies in China.
- **Nokia,** which plans to deploy 5G equipment in India in large quantities from 2026.
- **Ericsson, Nokia** and **Huawei** are leading the global 5G infrastructure.
- US operators such as **Verizon, AT&T** and **T-Mobile** continue to implement large-scale deployments.
- **Samsung** creates 5G: chips, networking equipment and devices, including smartphones, smart TVs, appliances and automotive solutions - all with industry-leading security.
- In **China, China Mobile** and **ZTE** are leading.

Top 15 Global 5G Infrastructure Companies:

1. Huawei Technologies Co. Ltd - Guangdong, China;
2. Samsung Electronics Co. Ltd - Suwon-si, South Korea;
3. Nokia Corporation - Espoo, Finland;
4. Qualcomm Technologies, Inc. - California, United States;
5. LG Electronics Inc. - Seoul, South Korea;
6. ZTE Corporation - Shenzhen, China;
7. Intel Corporation - California, United States;
8. Ericsson - Stockholm, Sweden;
9. Oracle Corporation - Texas, United States;
10. Cisco Systems, Inc. - California, United States;
11. AT&T Inc. - Texas, United States;

12. NEC Corporation - Tokyo, Japan;
13. Dell Technologies - Texas, United States;
14. Microsoft Corporation - Washington, United States;
15. Mavenir Systems, Inc - Texas, United States. [21]

The 5G services market could grow from **$12536 billion** to more than **$2.2 trillion** by 2030:

- The 5G-Advanced market is expected to reach **$350 billion** by 2028.
- In 2025, global 5G smartphone sales are forecast to reach **153.3 million** units, representing a CAGR (Compound Annual Growth Rate) of about **35.6%.**
- Many new smartphones are equipped with multi-band 5G support (low, mid and sometimes mmWave).
- The 5G infrastructure market is estimated to be worth **$14 billion** by 2025 and is projected to grow to **$574.4 billion** by 2035 at a CAGR of **45%.**
- Some analysts estimate the 5G infrastructure market to be worth **$43.5 billion** by 2025.
- The private 5G market is expected to grow to **$3.86 billion** by 2025 and $**17.55 billion** by 2030.
- Many operators are investing in small cells, massive MIMO and Open Radio Access Network (Open RAN) architectures.

In the area of 5G **Fixed Wireless Access (FWA)** (Figure 13), it is expected that:

- 5G FWA will account for more than **35%** of new fixed broadband connections, with **98.55 million** FWA connections forecast for 5G.
- The FWA market is estimated to be worth approximately **$41.2** billion by 2025, growing to **$144.7 billion** by 2035.
- The average peak download speed published in the 5G FWA market is **≈768.6 Mbps**, significantly higher than LTE FWA's **≈150.8 Mbps.**

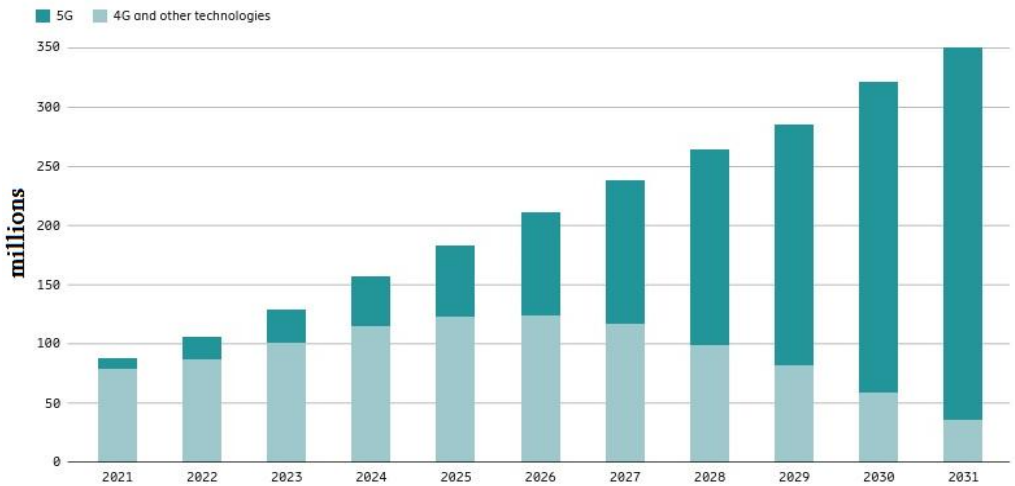

Figure 13. Fixed Wireless Access (FWA) forecast
(Source: Ericsson Mobility Report, November 2025)

According to ITU (International Telecommunication Union) data, more than **half of the world's** population is already covered by 5G networks, although there are still places in the world where there is either no network coverage at all or only 2G service is available [6].

Conclusion

The benefits of 5G network technology are numerous and significant. With higher speeds, lower latency, greater capacity and improved efficiency, 5G networks are playing a revolutionary role in various fields. As 5G networks expand and improve, we can expect even more technological developments. Future trends will be improved technologies of 5G. The implementation of 6G network is planned for 2030, which will be focused on integrated artificial intelligence and sensors. Soon the whole world will see the full potential of 5G in the technological world.

By the end of 2025, the total volume of world data is expected to reach 175 zettabytes. Data transmission in 4G networks has not exceeded 2 zettabytes. By 2025, global revenue from 5G networks should amount to approximately 225 billion euros. The use of 5G networks in 4 main industrial areas: automotive, healthcare, transport and energy, revenue can reach 114 billion euros per year. Soon we will have access to the full capabilities of 5G networks worldwide, operators are actively continuing to implement and develop 5G networks.

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მეხუთე თაობის (5G) ქსელების დანერგვის მდგომარეობა მსოფლიოს ქვეყნებში

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აბსტრაქტი

აქამდე მოქმედი ფიჭური ქსელები თავდაპირველად მონაცემთა დაბალი მოთხოვნებისთვის იყო შექმნილი. მათ აღარ შეუძლიათ ეფექტურად გაუმკლავდნენ დღევანდელი მონაცემების დიდ მოცულობას, განსაკუთრებით მაღალი გამტარუნარიანობის აპლიკაციებს. მეხუთე თაობის (Fifth Generation) 5G უსადენო ტექნოლოგია უზრუნველყოფს მონაცემთა გადაცემის მაღალ სიჩქარეს, ულტრადაბალ დაყოვნებას, მეტ საიმედოობას, ქსელის მასშტაბურ ტევადობას, გაზრდილ ხელმისაწვდომობასა და მოქნილობას.

5G მეხუთე თაობის მობილური ქსელია. ის არის ახალი გლობალური უსადენო სტანდარტი 4G ქსელების შემდეგ. 5G უსადენო ტექნოლოგია 4G-ს მსგავსად მონაცემების გადასაცემად რადიო ტალღებს იყენებს, ოღონდ მუშაობს

უფრო მაღალ სიხშირეებზე, რაც ქსელის გამტარუნარიანობის გაზრდას, მონაცემთა გადაცემის უფრო მაღალ სიჩქარესა და დაბალი დაყოვნებით გადაცემას უზრუნველყოფს. 5G ასევე იყენებს სხივის ფორმირების ანტენის ტექნოლოგიას, რაც საშუალებას აძლევს მეტ მოწყობილობას ერთდროულად ქონდეთ დაკავშირების შესაძლებლობა. 5G ტექნოლოგია ქმნის მცირე ზომის ფიჭური ანძების მკვრივ ქსელს. აღნიშნული ფაქტორების კომბინაცია 5G ქსელს იდეალურ ვარიანტს ხდის მონაცემთა ინტენსიური გამოყენების აპლიკაციებისთვის, როგორიცაა ვიდეო სტრიმინგი, საშუალებას იძლევა შეიქმნას ახალი ტიპის ქსელი, რომელიც შექმნილია პრაქტიკულად ყველასა და ყველაფრის ერთმანეთთან დასაკავშირებლად, მათ შორის მანქანების, ობიექტებისა და მოწყობილობების ჩათვლით.

სტატიაში აღწერილია მობილური კავშირის განვითარების ევოლუცია; მოცემულია მოქმედ 4G-სა და 5G-ს შორის განსხვავებები, 5G-ის ახალი შესაძლებლობები და ინდუსტრიული გამოყენების სფეროები; დასახელებულია 5G-ის დანერგვის მხრივ წამყვანი ქვეყნები, 5G-ის სერვისის მომწოდებელი და მოწყობილობების მწარმოებელი კომპანიები; მოცემულია ინფორმაცია სხვადასხვა ქვეყნებში მეხუთე თაობის დანერგვის მიმდინარე მდგომარეობის შესახებ.

საკვანძო სიტყვები: მობილური ქსელი, უსადენო კავშირი, მეხუთე თაობა, 5G, მილიმეტრული ტალღები, MIMO, IoT.