The Impact of 5G Technology on Life in the 21st Century

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Abstract: ***This paper presents the concept of 5G technology. First, we will review the evolution of 5G technology and then find out how the 5G networks works. Currently, 5G technology is in testing phase in many countries, with researchers facing the problem of the security issues. Next, we explain how 5G network impacts modern technologies such as the artificial intelligence (AI), Internet of Things (IoT) and self-driving cars. And finally, if all current problems with 5G networks are resolved, it could become the keystone of the Smart City concept, which is expected to solve many running problems associated with infrastructure, public transport, environment, etc.***

Index Terms: ***5G*, *Artificial Intelligence* (*AI*), *Internet of Things* (*IoT*), *Self-driving cars*, *Smart City***

1. INTRODUCTION

AT the end of 2018, the industry association 3GPP[(1)] defines any system that uses "5G NR" (5G New Radio) software as "5G", which is the fifth generation of cellular network technology.

This paper covers following topics:

- The evolution of 5G shown in Figure 1,
- Functioning of the 5G,
- 5G safety,
- Artificial intelligence (AI),
- IoT (Internet of Things) devices,
- Smart Cities
- Self-driving cars.

2. CONCEPT OF 5G

2.1 The Evolution of 5G

1G is the analog mobile network introduced in 1979. The phones did not use SIM cards, while phone numbers were encoded into phones themselves. The phones were extremely expensive.

2G technologies like CDMA[(2)], GSM[(3)], and TDMA[(4)] were the first generation of the digital mobile technology. It is interesting that only in this time the 1Generation got its name. When it was launched in Finland in 1991, it had its derivates: 2.5 (GPRS[(5)]) two and a half generation referred to the 2G network with an implemented package data transfer. There was also a 2.75 network in which GPRS evolved into EDGE[(6)].

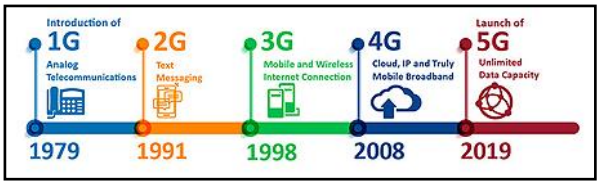

Figure 1: The Evolution of 5G

3G brought higher Internet connection speed, which increased from 200 kbps to couple of Mbps. Introduced in 1998, it was essential for the development of the wireless voice communication over the Internet, video calls, and mobile television.

4G technologies such as WiMAX[(7)] and LTE[(8)], were officially introduced in 2008. They were the next step in mobile network technology which brought higher Internet connection speeds of

[(1)] The **3rd Generation Partnership Project** (**3GPP**) is a standards organization which develops protocols for mobile telephony [1].

[(2)] **Code-Division Multiple Access** (**CDMA**) refers to any of several protocols used in second-generation (2G) and third generation (3G) wireless communications. CDMA is a channel access method used by various radio communication technologies [1].

[(3)] The **Global System for Mobile Communications** (**GSM**) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile devices such as mobile phones and tablets. It was first deployed in Finland in December 1991. By the mid-2010s, it became a global standard for mobile communications achieving over 90% market share and operating in over 193 countries and territories [1].

[(4)] **Time-division multiple access** (**TDMA**) is a channel access method for shared-medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots [1].

[(5)] **General Packet Radio Service** (**GPRS**) is a packet oriented mobile data standard on the 2G and 3G cellular communication network's global system for mobile communications (GSM). GPRS was established by European Telecommunications Standards Institute (ETSI) in response to the earlier CDPD and i-mode packet-switched cellular technologies. It is now maintained by the 3rd Generation Partnership Project (3GPP) [1].

[(6)] **Microsoft Edge** is a web browser developed by Microsoft. It was first released for Windows 10 and Xbox One in 2015, then for Android and iOS in 2017, and macOS in 2019 [1].

[(7)] **WiMAX** (**Worldwide Interoperability for Microwave Access**) is a family of wireless broadband communication standards based on the IEEE 802.16 set of standards, which provide multiple physical layer (PHY) and Media Access Control (MAC) options [1].

[(8)] In telecommunication, **Long-Term Evolution** (**LTE**) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies. It increases the capacity and speed using a different radio interface together with core network improvements [1].

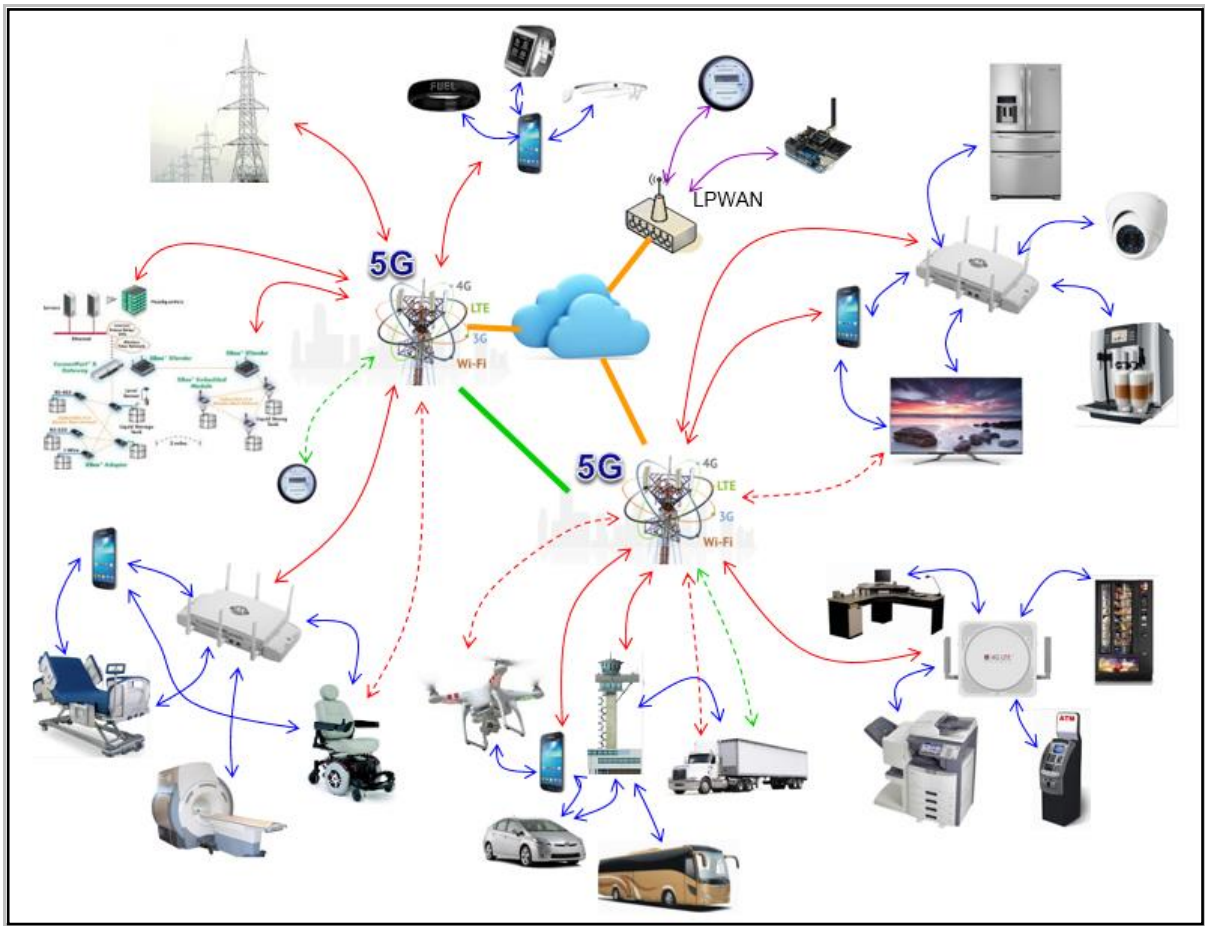

Figure 2: 5G and Internet of Things

several hundred Mbps and even Gb levels.

5G has brought three new aspects – higher speed, lower latency, and connection of multiple devices both as sensors and IoT devices.

5G system is a non-stand-alone network because it still needs active 4G support for the initial connection. It still needs a several years of development to become stand-alone system.

2.2 5G functioning

Like other networks, 5G uses the cells system which separates territories into sectors and sends encoded signals between the hotspots using radio waves. Each cell must be connected to the network spine, whether wirelessly or through landlines. 5G works on higher frequencies than 4G, generally on two types of frequencies: bellow and above 6 GHz.

Nowadays, there are 5G networks being developed in the USA (Chicago, Minneapolis), they are being tested in Argentina and Columbia, but Asia is the leader in developing and implementing 5G technologies. South Korea, Japan and China went the furthest, while UAE, Turkey, and Singapore have already implemented the pilot projects. Many European countries have announced that they plan to test the 5G signal – Norway, Germany, Great Britain, Italy, Switzerland, Spain, Austria, Russia, and Finland.

2.3 5G safety

There are a lot of concerns regarding the public and health safety in connection to the 5G.

There is a need for specific standard which takes into account all the threats and benefits of 5G.

3. ARTIFICIAL INTELLIGENCE

Artificial Intelligence is important for 5G network because it provides new concepts and possibilities for communication in industry, as well as within academy researches [8].

AI is able to address three main technical problems of 5G: optimization (allocation problem), detection (minimized error rate), and estimation (channel estimation problem).

This kind of technology will open new possibilities in robotics, allowing intelligent robots to operate within a broader ‘smart’ environment. While there are concerns that this can be used for military purposes and population monitoring, the benefits it will bring to the health technology cannot be ignored.

5G connectivity allows different automated solutions to access more real-time data, while using much less power, using IoT sensors with a lifespan of several years.

4. SMART CITIES

With a new wave of smart applications impacting the way we approach to everyday activities, personal assistants like Amazon's Alexa and Google Home creating opportunities for more comfortable living, now the same idea was expanded to Smart Cities, which are viewed as a future of urbanism. These cities should connect infrastructure and technology on a yet unseen level, improving both the quality of life for the citizens and the way they interact with their environment [1], [5]. There are nine major characteristics that are used to determine the level of smartness in a city:

- infrastructure based on technology
- eco-friendly initiatives
- seamless public transportation system
- responsible urban planning
- smart government
- intelligent grid and energy utilities
- machine learning
- telemedicine and smart healthcare
- personal data privacy.

As an enabling technology for IoT, 5G is essential for the smart city concept. It will play an important role in information gathering through sensors, which is then transmitted to central monitoring location in real time.

Multi-access edge computing (MEC) is another 5G-based technology that will impact smart city developments. MEC is an architecture that enables computing and storage capabilities for applications at the edge of is internal network, whereas in traditional centralized network architectures, latencies were caused by traffic having to go through the entire network to a central point and then back to the end user hardware.

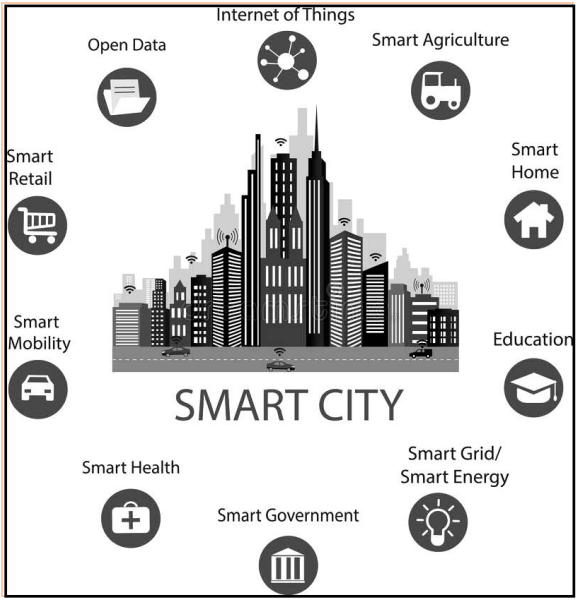

Figure 3: Smart City

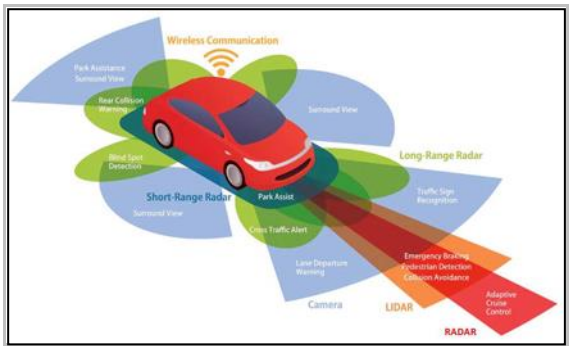

Figure 4: Self-driving car technology

5. SELF-DRIVING CARS

5G network will have a major impact on the self-driving cars' development making them faster, smarter, and safer.

Tesla and Toyota have already tested autonomous vehicles, however there are still some concerns whether driverless cars will ever be safe enough for the occupants, other drivers, and pedestrians.

Due to their fast sensors (Figure 4), the idea is that their reaction time frame will be minimal so they can be considered much safer than human-controlled vehicles [4].

In addition, autonomous cars are expected to solve problems with parking, improve the safety of traffic, making it faster, controlled, and more efficient [3]. These changes are expected to impact the rest of the economy.

Intel and Qualcomm are developing microchips that turn self-driving cars into mobile data centers that make complex decision in the real time [6].

Potential communication will be realized between vehicles and infrastructure, vehicles and network, vehicles and pedestrians, vehicles, and vehicles [7].

Self-driving vehicles employ a wide range of technologies like radar, cameras, ultrasound, and radio antennas to navigate safely on our roads. All the communication will be performed through cloud data transfer [2].

6. INTERNET OF THINGS

The fifth-generation wireless technology will connect everything around us with an ultra-fast, highly reliable and fully responsive network. IoT gadgets – devices specifically connected via mobile apps to the Internet give individuals more control over what is happening around them.

IoT includes baby monitor devices, smart security systems, smart thermostats, smart home devices, motion sensors, and many others, all of which can be controlled from anywhere in the

world using a smart phone [5].

These devices should make living easier and more comfortable, with people having more time for their families and friends, leisure, travels, etc. [9-11].

7. CONCLUSION

After the finalization of 5G standards, we could expect numerous benefits for our everyday life.

There will also be significant improvements in fields of AI (artificial intelligence), self-driving cars, IoT devices, as well as security.

The achievements mentioned in this paper will make life easier and more comfortable in many ways.

Smart cities are our future with their efficient traffic, less accidents, less pollution, less criminal opportunities, and safer living.

There are potential health concerns with 5G networks, which will hopefully be addressed thoroughly in the near future, so that all the benefits of the fifth-generation mobile technology can be implemented with minimum health risks.

Smart cities are already in our neighborhood – Budapest is one of one hundred smart cities around the world.

We hope that in the future smart city initiatives will meet more understanding Serbia as well.

REFERENCES

[1] https://en.wikipedia.org/wiki/3GPP
https://en.wikipedia.org/wiki/Code-division_multiple_access
https://en.wikipedia.org/wiki/GSM
https://en.wikipedia.org/wiki/Time-division_multiple_access
https://en.wikipedia.org/wiki/General_Packet_Radio_Service
https://en.wikipedia.org/wiki/Microsoft_Edge
https://en.wikipedia.org/wiki/WiMAX
https://en.wikipedia.org/wiki/LTE_(telecommunication),
accessed 1st December 2019

[2] Mester, G., Pletl, Sz., Pajor, G., Basic, Dj., "Adaptive Control of Rigid-Link Flexible-Joint Robots," *Proceedings of 3rd International Workshop of Advanced Motion Control*, 1994, pp. 593-602.

[3] Mester, G., Pletl, Sz., Nemes, A., Mester, T., "Structure Optimization of Fuzzy Control Systems by Multi-Population Genetic Algorithm," *Proceedings of the 6th European Congress on Intelligent Techniques and Soft Computing* (EUFIT'98), 1998, Vol. 1, pp. 450–456.

[4] Mester, G., "Obstacle Avoidance and Velocity Control of Mobile Robots," *Proceedings of the 6th International Symposium on Intelligent Systems and Informatics* (SISY 2008), 2008, pp. 97-101.

[5] Rodic, A., Jovanovic, M., Popic, S., Mester, G., "Scalable Experimental Platform for Research, Development and Testing of Networked Robotic Systems in Informationally Structured Environments," *Proceedings of the IEEE, Symposium Series on Computional Intelligence* (SSCI 2011), *Workshop on Robotic Intelligence in Informationally Structured Space*, 2011, pp. 136-143.

[6] Stepanic, J., Mester, G., Kasac, J., "Synthetic Inertial Navigation Systems: Case Study of Determining Direction," *Proceedings of 57th ETRAN Conference*, 2013, pp. RO 2.7.1-3.

[7] Mester, G., Rodic, A., "Simulation of Quad-rotor Flight Dynamics for the Analysis of Control, Spatial Navigation and Obstacle Avoidance," *Proceedings of the 3rd International Workshop on Advanced Computational Intelligence and Intelligent Informatics* (IWACIII 2013), 2013, ISSN: 2185-758X, pp. 1-4.

[8] Mester, G., "Rankings Scientists, Journals and Countries Using h-index," *Interdisciplinary Description of Complex Systems*, 2016, Vol. 14, No. 1, pp. 1-9., ISSN: 1334-4684, DOI: 10.7906/indecs.14.1.1

[9] Nemes, A., Mester, G., "Unconstrained Evolutionary and Gradient Descent-Based Tuning of Fuzzy-partitions for UAV Dynamic Modeling," *FME Transactions*, 2017, Vol. 45, No. 1, pp. 1-8., ISSN: 1451-2092, DOI: 10.5937/fmet1701001N

[10] Mester, G., "Cloud Robotics Model", Interdisciplinary Description of Complex Systems, Croatian Interdisciplinary Society, Vol. 13, No. 1, ISSN 1334-4684, DOI: 10.7906/indecs.13.1.1., 2015, pp.1-8.

[11] Mester, G., "Massive Open Online Courses in Education of Robotics", Interdisciplinary Description of Complex Systems, Vol. 14, No. 2, ISSN 1334-4684, DOI 10.7906/indecs.14.2.7, 2016, pp. 182-187.

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