Development of xG Active Mobile Networks

Matija Varga

North University, Trg Žarka Dolinara 1, 43000 Koprivnica, Republic of Croatia

Abstract **– The first part of the research aims to: describe theoretical concepts of 5G connection, list the advantages and disadvantages, give examples of 5G connection in science and technology. The second part of the paper identifies the key aspects of the survey: what cellphone respondents use, what active network they use, whether they know what the Air Flash 5G Microwave Enterprise Solution is, whether they know that they will perform authentication on the 5G network because of the new architecture between third parties, whether storing configuration secrets in plain, unencrypted text can cause system vulnerability, agree with the statement that a 5G connection will increase the possibility of accelerated attack on mobile devices, whether the 6G network will soon be implemented and when it could be used for commercial purposes, which is the opinion of the respondents about the possibilities of implementing the latest generation of 7G network.**

Key Words **- active networks, mobile devices, stack 5G network, 6G, 7G.**

1. Introduction

The first part of the paper explains the basic concepts of xG networks (the scientific method of content analysis) and gives examples of the application of 5G connection in science and technology as well as layers of the 5G network compared to the layers of the OSI model (Figure 1) where the scientific method of modelling was applied. The main advantage of a 5G connection is: (1) faster data transfer, (2) reduced delay time, (3) enables better quality services.

DOI: 10.18421/TEM91-21
https://dx.doi.org/10.18421/TEM91-21

Corresponding author: Matija Varga,
North University, Trg Žarka Dolinara 1, 43000 Koprivnica, Republic of Croatia.
Email: maavarga@gmail.com

Received: 03 January 2020.
Revised: 08 February 2020.
Accepted: 13 February 2020.
Published: 28 February 2020.

The aim of the paper is also to obtain feedback from the respondents: (1) what type of cell phone respondents use, (2) what connection speed or active network they use on their mobile device, (3) whether respondents know what "AirFlash 5G Microwave Enterprise Solution" is i.e., whether respondents heard of the most advanced 5G connection option, (4) whether respondents knew that due to the new architecture, authentication on the 5G network would have to be performed between third parties such as service providers, (5) whether respondents know that it is simple to send IP packets with a fake source IP address, (6) whether respondents knew that storing configuration secrets in plain, unencrypted text could cause system vulnerability and threat to mobile applications, (7) agree that respondents would agree with 5G increase the possibility of rapid attack on mobile devices, i.e. the software part of mobile devices and that the security of mobile networks will be endangered, (8) the level of usefulness of evaluation threats using the list of threats that at the top of the list have threats against the application layer of the highest-risk computer network, (9) whether a 6G network will be deployed and used in the near future, and in what time period (deadline) it may be used (6G network) in commercial purposes (in the opinion of the respondents), (10) what is the opinion of the respondents (since the 6G network research has already begun) about the possibilities of existence and implementation of the latest generation of standards for mobile communication of the 7G network (will there actually be one day and 7G networks) based on the collected survey data (using the scientific survey method).

Now awaiting future will experience 6G. In present time cell phones have everything and they are compact, with high memory and high speed with low power consumption. Today Bluetooth technology and other technologies are just like a child's play. 6G wireless cell phone communication network will meet world class standard covering the whole world under its communication just like Global covering system has been devised by some companies. This individual system creates difficulty in space roaming. 7G mobile phone communication system is developed to integrate these in one unit communication system [1].

In the research on "**Development of xG Active Mobile Networks**", hypotheses (scientific

assumptions) have been put forward that seek to prove or disprove:

***H_{11}**: 5G connection will increase the possibility of faster attacks on mobile devices, i.e. the software part of mobile devices, and will endanger the security of mobile networks, according to the respondents working in the ICT sector.*

***H_{12}**: 5G connection will not increase the possibility of faster attack on mobile devices, i.e. the software part of mobile devices and will not endanger the security of mobile networks according to the respondents working in the ICT sector.*

***H_{21}**: Within 5 to 10 years a 6G network for commercial purposes will be implemented and used according to the opinion of respondents working in the ICT sector.*

***H_{22}**: 6G networks for commercial purposes will not be implemented or used within 5 to 10 years according to the opinion of respondents working in the ICT sector.*

***H_{31}**: as research into the 6G network has already begun, it is possible to implement the latest generation of standards for mobile communication of the 7G network, according to respondents working in the ICT sector.*

***H_{32}**: As research into the 6G network has already begun, there is no possibility of implementing the latest generation of standards for mobile communication of the 7G network, according to respondents working in the ICT sector.*

2. 5G Mobile Communication Standard and Innovative Application in Science and Technology

It is widely known that 5G is a mobile network, the fifth generation network that brings in more channels and aims to enable multiple devices to connect, since 5G technology relies heavily on IoT (Internet of Things).

With the increase of the demand for mobile phones and networks, the new Internet of things (IoT) for consumers and vertical industries has developed rapidly. The mobile Internet and the IoT tend to be the main forces to drive the development of mobile communication in the future network [2].

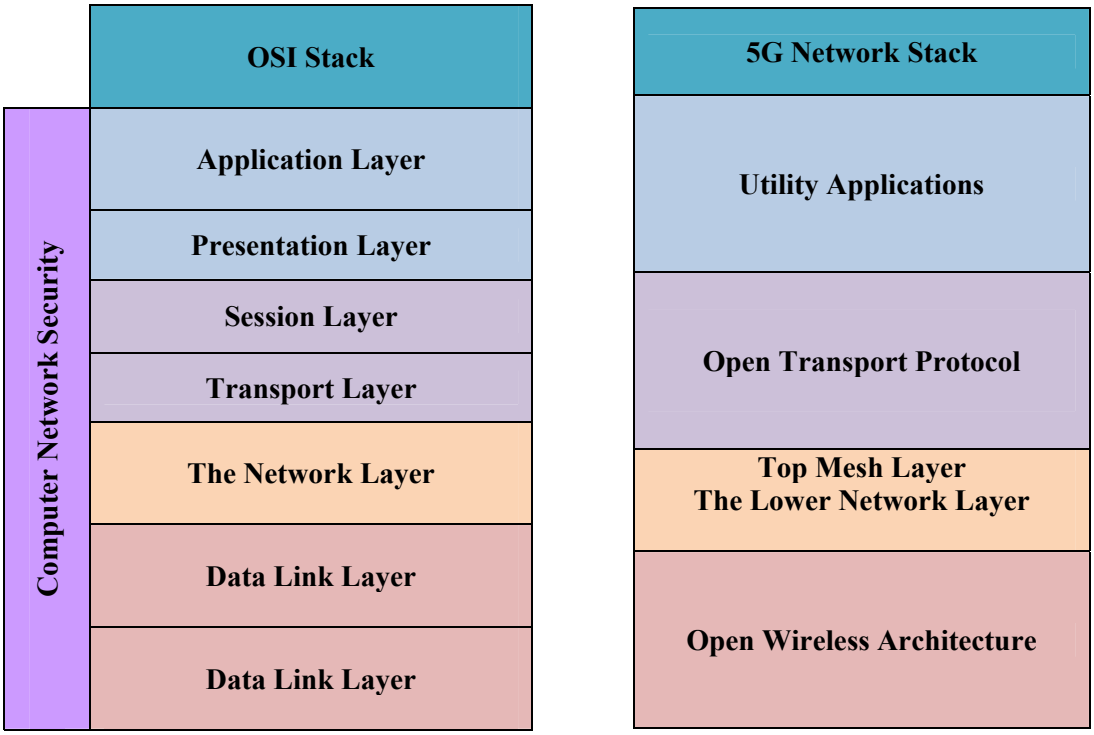
Internet of things (IoT) facilitates billions of devices to be enabled with network connectivity in order to collect and exchange real-time information for providing intelligent services. Thus, IoT allows connected devices to be controlled and accessed remotely in the presence of adequate network infrastructure.

Unfortunately, traditional network technologies such as enterprise networks and classic timeout-based transport protocols are not capable of handling such requirements of IoT in an efficient, scalable, seamless, and cost-effective manner. Besides, the advent of software-defined networking (SDN) introduces features that allow the network operators and users to control and access the network devices remotely, while leveraging the global view of the network in these areas, the utility of SDN-based technologies is discussed, while presenting different challenges and requirements of the same in the context of IoT applications [3].

The number of wireless network users is increasing day by day due to the world-wide web, Internet of Things (IoT), device to device (D2D) and machine to machine (M2M) communication, cloud based applications and services. People always want to have more uplink-downlink data rates, improved quality of services (QoS), better internet and mobile experience (QoE), better video streaming. As a result, these demands bring out extremely high data traffic on mobile networks. Therefore, new mobile system is required to provide these demands. Researchers and developers predict that 5G can be a suitable candidate to answer these demands [4]. This chapter (2) is about the introduction of 5G technology by a "stronger" telecommunications company. The fifth generation should introduce new standards that will gradually evolve and adapt and provide an even better and more stable network. The 5G network as a standard for mobile communication should bring the following benefits:

- better data transfer rate (from source to
- destination (decrease latency)),
- reduction of delay time (reduction of latency),
- higher quality services.

The advantage of the 5th Generation Network is: certainly 5x lower latency, the possibility that the 5G network can support multiple devices ("up to 1 million devices") per square kilometre. Finally, we remark that all results may be a bit optimistic since radio channels in 5G networks (which are not yet commercially available) will exhibit larger and faster variations and thus will trigger more spurious retransmissions than radio channels in 4G networks (from which our data is taken) [5].



Source: Written by 5G Network Architecture - Authors' research

Figure 1. View of the OSI layers of the network architecture reference model and therefore of the 5G network layers - Source: Authors' research

Figure 1 shows a comparison of therefore the OSI layers of the reference network architecture model and therefore the layers of the 5G networks.

The phenomenal success of wireless mobile communications is mirrored by a rapid pace of technology innovation. From the second generation (2G) mobile communication system debuted in 1991 to the 3G system first launched in 2001, the wireless mobile network has transformed from a pure telephony system to a network that can transport rich multimedia contents. The 4Gwireless systems were designed to fulfill therequirements of International Mobile Telecommunications-Advanced (IMT-A) using IP for all services [6].

In 2014, IMT-2020 Promotion Group proposed in the white paper 5G vision and demand [7] that the future mobile communication system (5G) will solve 1000 times or more the need for greater capacity, 10-100 times the mass device connections, 5-15 times improvement of the spectral efficiency compared to 4G, spectrum resources scarcity problems etc. Although the data transmission rates of 4G is up to hundreds of megabit per second, sometimes even up to Gigabit per second, which almost enables to meet the requirements of broadband mobile communication applications in next period of time. With the continued growth in popularity of smart terminals and requirements of new mobile business, it will still be difficult to meet the future demand by the current transmission rates of wireless communications [8].

Companies are preparing infrastructure and equipment, but also entire network architectures have to be adapted to achieve high speeds and low latencies. The Layers in the 5G network stack are (Figure 1): utility applications, open transport protocol, top network layer, lower network layer, and open wireless architecture.

Last summer, companies (ISP - Internet Services Providers) successfully tested 5G technology, which achieved speeds of up to 20 Gbit/s on a live network. In the Republic of Croatia, 5G network capabilities were presented on the islands of Rab and Cres, which give residents of islands and isolated areas the benefits of modern technologies. Company Experts are working intensively on the latest radio technologies, which are being tested in multiple places. Recently, frequencies in the millimetre range, which are specific to 5G technology, have also been used in test work. Demonstrated speeds and capacities 5G technologies will, in the future, enable gigabit speeds throughout Croatia, which are basic prerequisites for digitalization, steady development and global competitiveness [9].

The technological solutions of companies already meet the requirements for 2025, according to which all citizens of the European Union should be provided with a minimum internet access speed of

100 Mbit/s. For the competitive development of the 5G network in Croatia, it is necessary to further relieve the burden and divert resources to infrastructure [9].

The 5G network provides even greater network bandwidth and is widely used (which is also highlighted in this chapter (down)). The 5G network can be deployed and is widely used in robotics. Managing a robot from a remote location across the cloud office is certainly an innovation. Robot work replaces human work, but the processing power required to adapt to the circumstances of the robot is very high. To manage the robot, the logic of the robot can be stored in a computer cloud, while all data between the robot and the computer cloud can be exchanged over a 5G network [7].

For the past decade, Samsung has been at the forefront of 5G R&D, and the fruit of its work is the transformation of 5G from an ambitious theoretical concept into reality.

High-Performance Computing (HPC) is also an innovation as a branch of computing that deals with scientific and engineering tasks which are so computationally complex that calculations cannot be performed with a general-purpose computer. The machines used in HPC are often referred to as supercomputers. The next limit is the supercomputing of calculations at the exascale level (i.e. at least 10^{18} or 1 billion billion calculations per second), which is expected to be reached in 2021 or 2022. Therefore, the Euro HPC project will provide 5G digital infrastructure to the European public sector and industry, and in particular to SMEs. Companies will thus receive not only faster communication and business process development, but also better access to supercomputers in order to develop innovative products.

The European Union does not currently have the most powerful supercomputers in the world, and those that depend on non-European technical solutions cannot meet the growing needs of European science and industry. For this reason, European industrial companies and leading scientific centres are forced to implement the most complex budgets for their projects outside the European Union. In doing so, there is a real security risk of protecting the privacy, data and safeguarding of the technological secrets of particularly sensitive projects, which now depend on third-party and competing computer centres.

The use of high-performance computing is having an increasing impact on industries and businesses in terms of product design, design and production cycles, accelerating the development of new materials by lowering costs, increasing resource efficiency, shortening and optimizing the decision-making process. For example, car development and production cycles can be reduced from 60 to 24 months thanks to the use of supercomputers. High-performance computing is also essential for national security and defense, for example in the development of complex encryption techniques, monitoring and responding to cyberattacks, the introduction of effective forensics or nuclear simulation [10], [11].

The European Commission expects the Euro HPC project to enable more successful problem solving and accelerate development in a number of areas such as Earth and climate science, safe, clean and efficient energy, health, sustainable architecture, marine research, cybersecurity and defence, green and integrated urbanism, etc. [10], [11].

3. Research Results on the Development of Active Mobile Networks

In the survey method, the sample referred to a total of 113 respondents who were sent a survey in the form and by e-mail via WEB 2.0 and WEB 3.0 tools. The survey was created using the Google Forms web application tool that is part of Google Drive. The sample is a total (N=113) of the surveyed respondents. The sample is representative of valid analysis because respondents were randomly selected (regardless of whether the respondent was a user of the service of any ISP or not). Based on the results of the survey, the following findings were obtained and feedback from the respondents was obtained (in the order of the questions below:

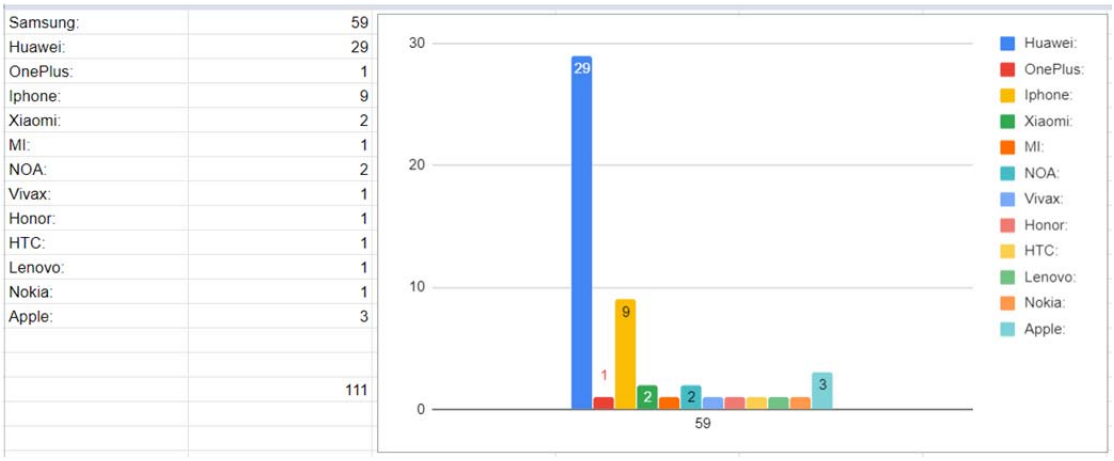


Figure 2. View of the brands and models of mobile phones used by the respondents - Source: Authors' research

Figure 2 shows the bar graph of the brand and the cell phone models used by the respondents. Most respondents use Samsung's mobile phones (59 respondents), while Huawei's mobile phones use 29 respondents. The third most commonly used cell phone is the iPhone. The iPhone is used by 9 respondents while the NOA mobile device is used by 2 respondents.

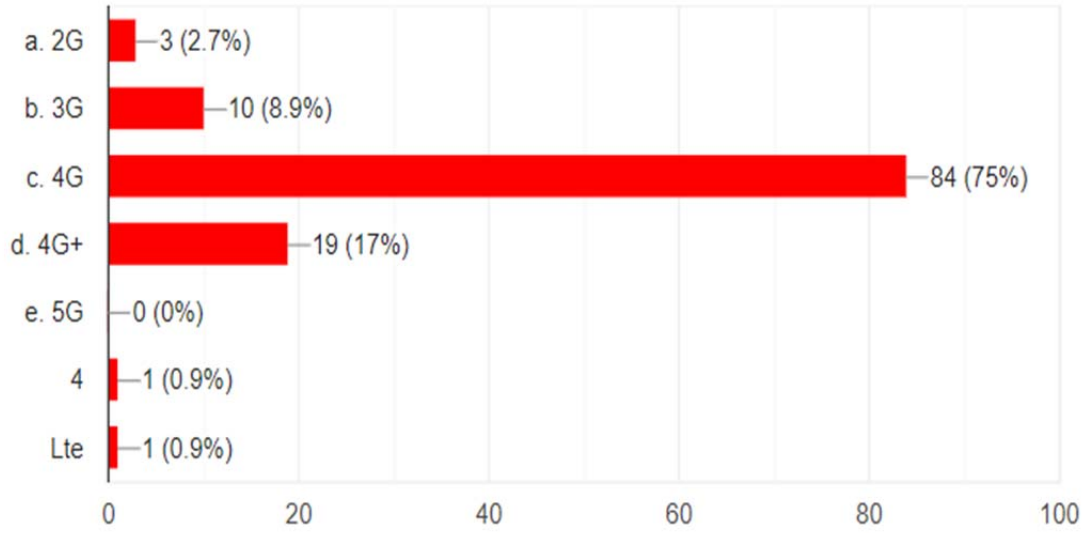


Figure 3. Display of connection speeds or active networks used by users on a mobile device - Source: Authors' research

Figure 3 shows the connection speeds or active networks used by users on a mobile device. Most respondents use a 4G active network on their mobile device in a covered area (designated by connection). The 4G and beyond mobile access technology promises to deliver high data rates from 100 Mbps to 1Gbps along with a high quality-of-service (QoS) provision for a variety of applications [12]. The active 4G network is used by 84 respondents, i.e. 75% of respondents, while the 4G + active network is used by 19 respondents, i.e. 17%. The 3G connection is still used by 10 respondents, i.e. 8.9% of respondents. The 5G link to the survey in the respondents has not yet "fully come to fruition".

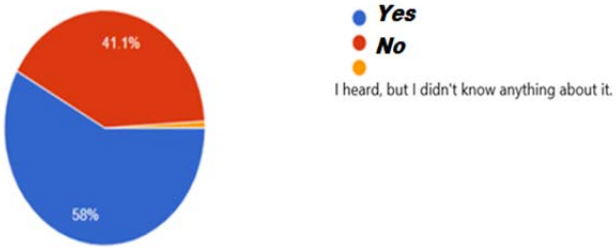


Figure 4. View of respondents' survey results for AirFlash 5G Microwave Enterprise solution - Source: Authors' research

Figure 4 shows the result of a survey of respondents' awareness of the AirFlash 5G Microwave Enterprise Solution. 41.1% said they had not heard of the AirFlash 5G Microwave Enterprise Solution, while more than 50% (58%) had heard of the AirFlash 5G Microwave Enterprise Solution. One

respondent stated that he had heard about the AirFlash 5G Microwave Enterprise solution but did not know anything about it.

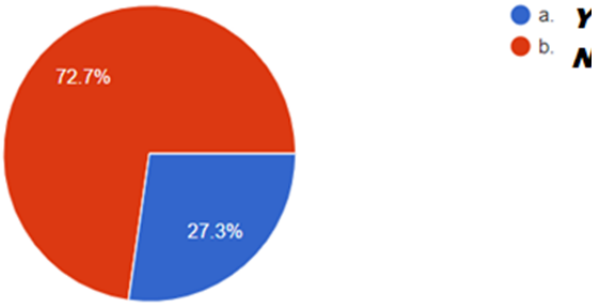


Figure 5. View of the results on knowledge of authentication in a 5G network due to the new architecture - Source: Authors' research

Figure 5 shows the result of knowledge of authentication in a 5G network due to the new architecture. Authentication in the 5G network due to the new architecture will also have to be performed between third parties such as service providers. The information that authentication in the 5G network will have to be performed due to the new architecture and between third parties such as service providers, 27.3% of respondents are familiar with it, while 72.7% of respondents are not aware that authentication in the 5G network will have to be performed due to the new architecture as well, between third parties such as service providers.

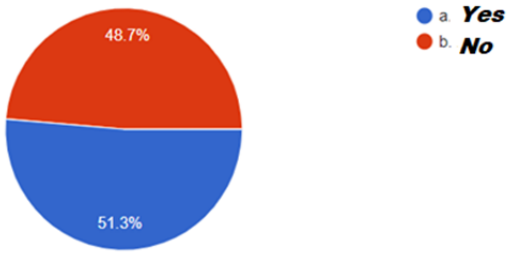


Figure 6. Displaying user awareness of sending IP packets with false source IP address - Source: Authors' research

Figure 6 shows the user being informed about sending IP packets with false source IP address. 51.3% of respondents are aware of the fact that it is easy to send IP packets with a false source IP address, while 48.7% of respondents are not familiar with the ease of sending IP packets with a false source IP address.

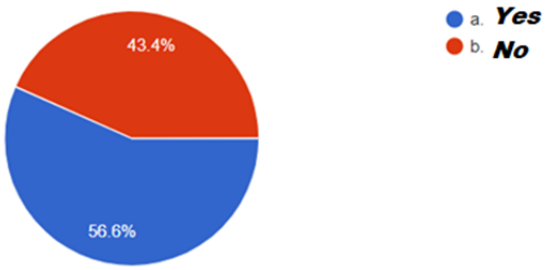


Figure 7. View of respondents' results on how to store configuration secrets in plain, unencrypted text can cause system vulnerability and threat to applications on mobile devices - Source: Authors' research

Figure 7 shows the result of informing respondents how storing configuration secrets in plain, unencrypted text can cause system vulnerability and threat to applications on mobile devices. 56.6% of respondents said they knew how storing configuration secrets in plain, unencrypted text could cause system vulnerabilities and threat to mobile applications. 43.4% of respondents stated that they were unaware that storing configuration secrets in plain, unencrypted text could cause system vulnerability and threat to mobile applications, which is a concern.

Figure 8. View of the results of the agreement of the respondents with the statement that with 5G connection the possibility of faster attack on mobile devices, i.e. software part of mobile devices will be increased and that the security of mobile networks will be endangered - Source: Authors' research

Figure 8 shows the result of the agreement of the respondents with the statement that with the 5G connection the possibility of faster attack on mobile devices will increase, i.e. software part of mobile devices and that the security of mobile networks will be compromised. 70.4% of respondents agree that the possibility of faster attack on mobile devices will increase with 5G connection. software part of mobile devices and that the security of mobile networks will be endangered, which proves the scientific assumption of $\mathbf{H_{11}}$ which reads: "5G connection will increase the possibility of faster attack on mobile devices, i.e. software part of mobile devices and will endanger the security of mobile networks in the opinion of respondents working in the ICT sector. " 24.1% of respondents disagree with the statement that the possibility of faster attack on mobile devices

will increase with 5G connection, software part of mobile devices and that the security of mobile networks will be compromised. Also, under the "Other" option, interesting considerations are written regarding the seventh question (Figure 8), such as:

- "I think that reducing latencies (i.e. ping - the time it takes for a data packet to arrive from sender to recipient) and increasing speeds will certainly make more DDoS attacks possible, but I also think that when they built the new network architecture they also thought about security and improving security aspects. ",
- "Not completely ... Depends on many factors."
- "It's already compromised with a 4G connection now.".

Figure 9. Showing the level of utility of threat assessment using the list of threats that at the top of the list have threats against the application layer of the highest-risk computer network - Source: Authors' research

Figure 9 shows the levels of utility of threat assessment using the list of threats that, at the top of the list, there are threats against the application layer of the highest-risk computer network. The highest number of respondents 43.2% rated 3 as threat assessment, i.e. they stated that threat assessment was not useful (50%) and was equally useful (50%) i.e. not useful (50:50 ratio). Also, 25.2% of respondents rated 4 as threat assessments, that is, threat assessments were useful, while 24.3% of respondents rated threats as being of great benefit. At least the respondents gave a rating of 1, i.e. they stated that threat assessment was not useful at all.

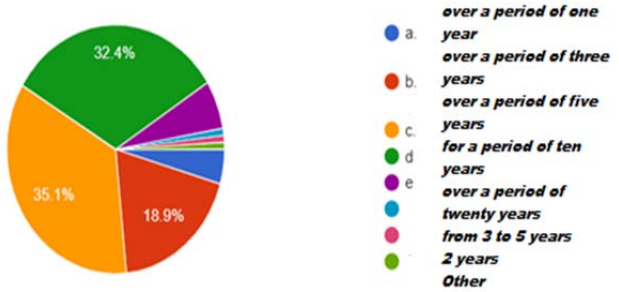


Figure 10. Respondents' view of the early implementation and use of the 6G network and the time period (deadline) for which it could be used (6G network) for commercial purposes - Source: Authors' research

Figure 10 shows the respondents' thoughts on the early implementation and use of the 6G network and the time period (period) for which it could be used (6G network) for commercial purposes. 35.1% of respondents (the largest number) stated that the implementation and use of the 6G network for commercial purposes would be possible in a period of 5 years, while 32.4% of the respondents stated that they expect to implement and use the 6G network in the time period (up to 10) years, which proved the scientific assumption of $\mathbf{H_{21}}$ which reads: "Within 5 to 10 years, 6G networks will be implemented and used for commercial purposes in the opinion of respondents working in the ICT sector". 18.9% of respondents indicated that they expect to implement and use the 6G network within a time period (up to 3 years). Also, it is worth pointing out one interesting conclusion of the respondents (related to this issue) that deals with the development of computer networks "whole life", i.e. more than 25 years, which reads: "If we take into account the development of mobile networks so far, we can see that on average every 10 years a new version of the mobile network (2G, 3G, 4G) appears. So by that point the 6G network (connection) should be in 2030. "

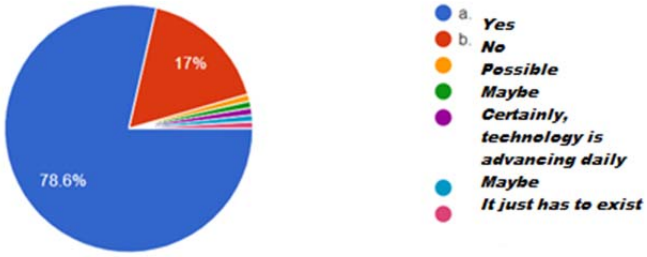


Figure 11. View of the respondents' opinion (since the 6G research has already started) on the possibilities of existence and implementation of the latest generations of standards for mobile communication of the 7G network - Source: Authors' research

Figure 11 shows the opinions of the respondents (since the 6G network research has already started) on the possibilities of existence and implementation of the latest generations of standards for mobile communication of the 7G network. Most respondents (78.6%) opted for "Yes", that there is a possibility (in the future) and implementation of the latest generations of standards for mobile communication of the 7G network, while 17% of respondents said that there is no such possibility of existence and implementation of the latest generations of standards for mobile communication of the 7G network, which proved the scientific assumption $\mathbf{H_{31}}$ which reads: "As research into the 6G network has already begun, it is possible to implement the latest generation of 7G mobile communications standards in the opinion of respondents working in the ICT sector." There are

also two interesting findings of the respondents (related to this issue):

- "… it just has to exist, everything is always upgraded, we previously thought there would be no 5G connection but here it is, it is getting closer…",
- "… technology is advancing every day, and I think there will always be a trend: 'faster, more, better', because that is the goal of ICT companies - constant progress. I doubt someone will say somewhere, "Ok, that's enough now, we will not develop anymore." Therefore, there will be many more variants, just not with many significant improvements … ".

4. Conclusion

The research work "Development of xG Active Mobile Networks" describes the theoretical concepts of 5G connection and outlines the advantages and disadvantages of 5G connection (active mobile network). Also in the first part of the paper there are innovative examples of the application of 5G connection in science and technology (robotics, etc.), using the scientific method of content analysis and also designing (scientific modelling method), which shows a comparison of therefore the layers of the OSI reference model of network architecture and therefore the layers 5G network.

In the research on the topic: "**Development of xG Active Mobile Networks**" the following hypotheses (scientific assumptions) were proved based on the second part of the research paper:

> ***H_{11}*** *which reads: "A 5G connection will increase the possibility of faster attack on mobile devices software part of mobile devices and will endanger the security of mobile networks in the opinion of respondents working in the ICT sector"*

based on the results of a survey of respondents agreeing that a 5G connection will also increase the possibility of faster attacks on mobile devices, i.e. the software part of mobile devices and that the security of mobile networks will be endangered (70.4% of respondents agree with this statement),

> ***H_{21}*** *which reads: "Within 5 to 10 years a 6G network for commercial purposes will be implemented and used according to the opinion of respondents working in the ICT sector"*

based on the survey results showing that 35.1% of the respondents (the largest number) stated that the implementation and use of the 6G network for commercial purposes would be possible in a period of 5 years, while 32.4% of the respondents stated that they expect the implementation and use of the 6G network in the time period (within) up to 10 years,

> ***H_{31}*** *which reads: "as research into the 6G network has already begun, it is possible to implement the latest generations of 7G mobile communications standards in the future in the opinion of respondents working in the ICT sector"*

based on the results of the survey, which shows that the majority of respondents (78.6%) chose the option "Yes", i.e. there is a possibility to implement the latest generation of standards for mobile communication of the 7G network in the future.

References

[1]. Pratap Singh, A., Nigam, S. & Kumar Gupta, N. (2007). A Study of Next Generation Wireless Network 6G, International Journal of Innovative Research in Computer and Communication Engineering, 4(1), 871-874.

[2]. Zhang, Y., Wang, F., Wang, D. & Guo, D. (2020). Slicing Resource Allocation for eMBB And URLLC in 5G RAN, *Wireless Communications and Mobile Computing,* 2020, 1-11.

[3]. Samaresh, B., Sudip, M. & Athanasios, V.V. (2017). Software-Defined Networking for Internet of Things: *A Survey, IEEE Internet of Things Journal, 4*(6), 1994- 2008.

[4]. Cengiz, K. (2018). Next-Generation Infrastructure and Technology Issues in 5G Systems, *Journal of Communications Software And Systems, 14*(1), 33-39.

[5]. Arvidsson, A. & Westberg, L. (2019). Transport Bottlenecks of Edge Computing in 5G Networks, *Journal of Communications Software And Systems, 15*(1), 59-65.

[6]. Wang, C., Haider, F., Gao, X., You, X., Yang, Y., Yuan, D., Aggoune, H., Haas, H., Fletcher, S. & Hepsaydir, E. (2014). Cellular Architecture and Key Technologies for 5G Wireless Communication Networks, *IEE Communications Magazine, 52*(2), 122-130.

[7]. Umrežavanje sadržaja, *FER - Diplomski studij, Informacijska i komunikacijska te hnologija, Telekomunikacije i informatika, Računarstvo u oblaku i usluge zasnovane na računarstvu u oblaku*, Retrived from: https://www.fer.unizg.hr/_download/repository/7._Racunarstvo_u_oblaku_i_usluge_zasnovane_na_racunalnom_oblaku_.pdf [accessed: 6 November 2019].

[8]. Yunzheng, T., Long, l., Shang, L., & Zhi, Z. (2016). A Survey: Several Technologies of Non-orthogonal Transmission for 5G, *Wireless Communication over ZigBee for Automotive Inclination Measurement, 12*(10), 1-15.

[9]. A1. (2019). Hrvatska digitalna kompanija novog doba - spremni među prvima u Europi uvesti 5G tehnologiju, *Lider poslovni Tjednik, Lider media d.o.o., 697*.

[10]. Tokić, I. (2019). Superračunala uskoro na Raspolaganju europskim energetičarima, *Nove tehnologije – EGE, 3*(1), 90-92.

[11]. Vilceanu, C., Grecea, C. & Herban, S. (2017). Spatial data geoportal for Local Administration – smart solution for a secure and valuable cultural heritage, *Journal of Geodesy, Cartography and Cadastre, 7*(1), 12-18.

[12]. Kashaf, A., Tiwana, M.I., Usman, I. & Tiwana, M.I. (2017). Self-organizing inter-cell interference coordination in 4G and beyond networks using genetic algorithms, *Automatika, 58*(1), 48-54.