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VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

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ÚSTAV JAZYKŮ

5G NETWORK – HOW WILL IT CHANGE OUR LIVES?

5G SÍŤ – JAK ZMĚNÍ NAŠE ŽIVOTY?

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

AUTHOR Josef Ondriska
AUTOR PRÁCE

SUPERVISOR Mgr. Jana Jašková, Ph.D.
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doc. PhDr. Milena Krhutová, Ph.D.
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Abstract

This bachelor's thesis describes the concept of fifth-generation wireless systems and discusses their main benefits and risks. The work provides a brief overview of the evolution of mobile communications networks. It describes the function of each generation and lists its characteristics. Then the paper describes the concept of the 5G network, setting out its parameters and the key factors that led to its creation. Next, work is devoted to the Internet of Things, describing its history and possible applications on 5G networks. It identifies all sorts of possible uses and explains how society will benefit from this technology. Additionally, the study examines potential dangers, whether they are fake news or real threats, such as negative impacts on human health or safety regarding personal property.

Key words

5G, wireless systems, Internet of Things, applications, health risks, cybersecurity

Abstrakt

Tato bakalářská práce popisuje koncept páté generace bezdrátových systémů a diskutuje její hlavní přínosy i rizika. Práce uvádí stručný přehled vývoje mobilních komunikačních sítí. Popisuje funkci každé generace a uvádí její vlastnosti. Dále popisuje koncept 5G sítě, uvádí její parametry a klíčové faktory, které vedly k jejímu vzniku. V další části se práce věnuje internetu věcí, uvádí jeho historii a možné uplatnění společně se sítěmi 5G. Jmenuje nejrůznější oblasti využití a definuje, jak bude společnost z této technologie těžit. Závěrem se práce zabývá možnými hrozbami, ať už jde o lživé informace, nebo skutečná rizika jako jsou negativní dopady na lidské zdraví či bezpečnost s ohledem na osobní vlastnictví.

Klíčová slova

5G, bezdrátové systémy, internet věcí, aplikace, zdravotní rizika, kybernetická bezpečnost

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Prohlášení

Prohlašuji, že bakalářskou práci na téma *5G network – how will it change our lives* jsem vypracoval samostatně pod vedením vedoucí/ho závěrečné práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

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Introduction

Recently, the transition from the fourth generation of mobile networks to the fifth generation of mobile networks has been a hotly disputed topic in the technology community. Many people are extremely concerned about this transition, and it has been associated with a great deal of controversy. On the other hand, this network brings with it a great deal of innovation, which will have a significant impact on the future growth of industry, health, households, and a wide range of other fields. To do this, the goal of this work is to investigate all the possible benefits and dangers that a 5G network could bring to society.

The thesis is divided into four main chapters, which examine the issue in detail. It provides a brief overview of previous generations of mobile networks. Each generation was revolutionary for its time and came up with several progressive technologies that were crucial to the creation of the fifth generation. Next, the work investigates the 5G network itself, examining the key factors and motivations for the creation of such a network. What are its parameters and how are they different from the previous generations? One of the key sectors that will depend on 5G will be the Internet of Things. The 5G network will become the main communication element for the ecosystem of devices and applications, creating a lot of scope for several new industries to emerge. The work describes the concept of the Internet of Things and its possibilities of use. Nevertheless, the paper also examines the possible risks, whether they are health risks or cybersecurity risks.

1 The Evaluation of Mobile Communication

The goal of mobile network development has always been to increase the possibilities of data communication, improve call quality, make it easier to connect to the Internet and provide new features. This chapter lists and briefly describes all these generations to better comprehend contemporary technologies. All these generations can be found in Figure 1 at the end of the chapter.

1.1 First generation - 1G

The first generation of mobile networks (1G) was based on an analogue system. These networks developed during the 1980s enabled voice transmission. Dahlman, Parkvall, and Skold (2014) state that the first generation of mobile networks used analogue technologies to provide mobile communications services. Later, as technology advanced and there was a constant demand for new services, there was a shift into the secure world of digital communication. Analogue mobile systems used a technique known as FDMA (Frequency Division Multiple Access). Separate frequency bands were used to transmit and receive wireless communications. The frequency bands were then divided into multiple sub-frequencies or channels to allow communication between the base station and the mobile phone. Unlike digital systems, analogue communication systems lack encryption capabilities, making them vulnerable to security issues. Analogue systems are more susceptible to noise because radio signals are continuous.

1.2 Second generation – 2G

In the 1990s, with the introduction of the second generation, the analogue system was replaced by a digital one. According to Dahlman et al. (2014), the technological standards that enabled 2G progressed in two ways. The first method combined FDMA and TDMA (Time Division Multiple Access), while the second method utilised Code Division Multiple Access (CDMA) technology. When compared to previous technologies, 2G networks have higher bandwidth. All mobile networks, beginning with 2G, use digital communications.

This not only addressed the shortcomings of the first generation in terms of safety and noise susceptibility but also means that data transmission is now possible via SMS, MMS, and others in addition to voice transmission.

1.3 Third Generation – 3G

With the introduction of digital communication via second-generation networks, there has been a massive increase in user numbers, and wireless communication has thus come to the fore. According to Bečvář, Mach and Pravda (2014), this increase resulted in the emergence of third-generation networks. The reason was simple: increased demand for mobile network usage increased demand on the network itself. Mobile applications require faster transmission capacity and a higher quality of service. As a result, at the turn of the century, a project known as 3GPP (Third Generation Partnership Project) was established to replace the inadequate 2G network with a new 3G network. This is accomplished by developing new standards. Wang and Gao (2020) claim that there are two key 3G migration paths, which are both based on Code Division Multiple Access (CDMA) technology. The first way was UMTS for GSM migration to 3G, while the second way was CDMA2000 for IS-95 and D-AMPS.

The 3G network began to support a variety of new multimedia applications and services that required rapid data transfer. Since then, users have been able to view streaming videos, share videos, play online games, or simply browse the internet.

1.4 Fourth Generation – 4G (LTE-A)

The fourth-generation systems are designed for the same reasons as previous generations. The network's capacity is limited and certainly insufficient to meet current demands. LTE (Long Term Evolution) networks, which are mistaken for 4G networks, are an intermediate step between the third and fourth generations. As Bečvář et al. (2014) report, because LTE does not match the ITU's specifications for 4G networks, it is still considered part of the 3G system. The initial version of the 4G standard supported LTE-A (Long Term Evolution-Advanced) technology.

According to Wannstrom (2013), LTE-A introduced new techniques such as Carrier Aggregation (CA) grouping, Relay Node (RN) support, and Coordinated Multi-Point (CoMP) operation. The number of combined carriers has been increased to five individual radio channels, each with a maximum width of 20 MHz. Therefore, the resulting channel has a width of 100 MHz, allowing much faster transmission speeds. At the cell boundary, the RNs in question provide better coverage and capacity. CoMP also gets the better performance, faster transmission speeds, and less interference between cells by getting multiple stations to work together.

Dahlman et al. (2014) identify two main advantages of 4G networks, including peak download speeds of up to 300 Mbps and lower latency compared to 3G networks. In terms of customer usage, 4G networks can provide reliable mobile broadband services thanks to average speeds. Because of this, a 4G mobile phone network can also work as a mobile hotspot that backs up home broadband.

1.5 Fifth Generation – 5G

5G networks are based on the LTE and 4G standards. Like the previous generation, 4G, and 5G greatly boosts the speed of data transmission in the network by up to tenfold, according to accessible sources. Therefore, video recording in Ultra HD or 3D quality will be possible. Qualcomm Technologies (2021), which had a significant share in 3G development, points out that "5G is intended to not only provide faster and better mobile broadband services but also to expand into new service areas such as critical communication and connecting the massive IoT (Internet of Things). The defining capability of 5G is that it is designed for forwarding compatibility—the ability to flexibly support future services that are unknown today."

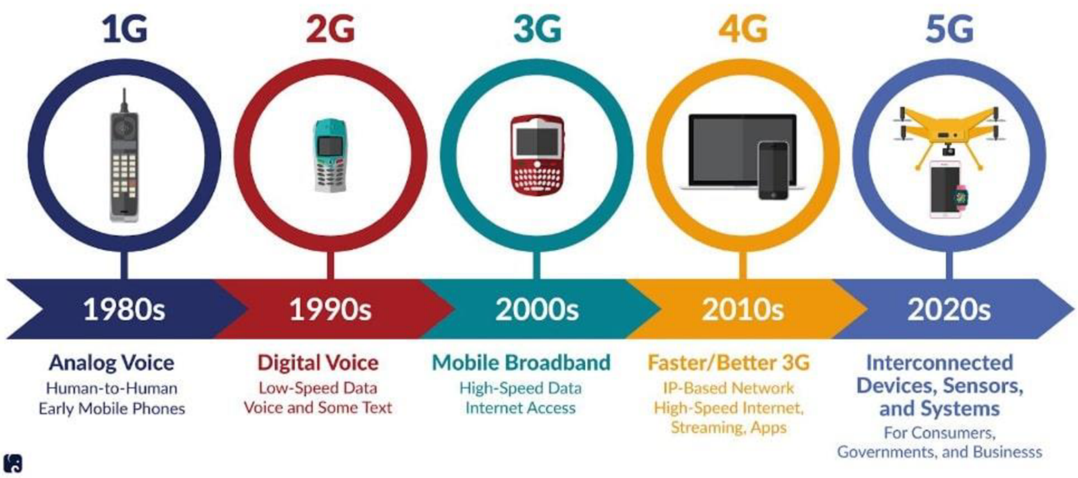

Figure 1: The Evolution of Mobile Communication (Mobile-Networks-Timeline, 2022)

2 Fifth Generation of Mobile Networks

The fifth generation is the last generation of mobile networks. It builds on previous mobile network generations, such as the 3G network, which contributed to the smartphone boom by bringing the internet to devices, or the 4G network, which allowed users to watch streaming videos and provided much quicker data transmission.

2.1 What is a 5G network

Experts agree on the definition of 5G, referring to it as the tool that will start the fourth industrial revolution. Hutajulu, Dhewanto, and Prasetio (2020) note that the goal of this next-generation network (5G) is a 1,000 times higher aggregated data rate (up to 10 Gb/s), 1-millisecond latency, lower power consumption and line costs, and support for many more types of devices. To meet these requirements and capabilities, 5G needs several technological tools that are constantly evolving. These are millimetre waves, beam formation, small cells, massive MIMO, virtualization, low latency, software-defined networks, and mobile computing technologies. When compared to the last generation of 4G, these technologies improve the level of mobile network services.

Chávez-Santiago et al. (2015) describe 5G as a significant communication medium for a wide range of applications. Smartphones, tablets, laptops, fitness wristbands, and gaming consoles – all work through mobile networks. Many sensors, video cameras, and other devices that are actively used in smart technology also need to be connected to a mobile network. 5G networks are significantly improving high-speed internet connectivity around the world and opening the door to the IoT revolution. There are already billions of IoT devices, but with a wider bandwidth and better use of the 5G network spectrum, many more devices will be able to work together without getting in each other's way.

Considering the previous descriptions, 5G could be defined as a successor to the current 4G. It is a complex group of networks with a different focus and in different frequency bands. It brings together the user segment, which is mostly made up of smartphones, watches, and other devices.

2.2 Key Drivers

As previously mentioned, the transition to a 5G network will involve more than the evolution of mobile broadband. This is a significantly larger step than, for instance, the transition to 4G networks. It is a crucial technology for the future digital world. With the introduction of 5G, new services will be abundant not only for customers and consumers but also for companies and corporations operating in any industry. The 5G Infrastructure Public-Private Partnership (5G PPP) project, which is a joint initiative between the European Commission and the European ICT industry (ICT manufacturers, telecommunication operators, and service providers), has identified 5G network key drivers. These drivers are, in fact, crucial to the evolution of networks and play a significant role in many decisions made at the time of the creation of new technologies. 5G PPP (2015) outlined the following factors:

1. **An opportunity to launch brand new services**

   Network and service capabilities will be enhanced. There are several advantages to this, including the ability to maintain a consistent user experience even in locations with high mobility, dense or sparse populations, or using a range of various means of transportation. Therefore, users will be able to remain connected at all times, no matter where they are or what they are doing at the moment. In addition, 5G will play a crucial role in the Internet of Things by offering a platform for connecting a broad array of Internet-connected devices. On top of that, services that require real-time reactivity will be developed.
2. **A unified telecom and IT infrastructure ready for multi-tenancy**

   By 2025, 5G will have integrated telecommunications and IT into a single international infrastructure with high capacity, scalability, and flexibility. This unification will allow for more efficient and dynamic use of all distributed resources, as well as the convergence of fixed, mobile, and broadcasting services. 5G thus paves the way for a virtual personal area network (PAN), which is a computer network used to connect electronic devices within a single person's workspace.
3. **A sustainable and scalable technology**

   The goal of 5G is to be a long-lasting and widely deployable technology. Firstly, the telecom industry will reduce its energy use and gather energy to compensate for the significant surge in usage. As a result, all ICT stakeholders will be able to sustain their businesses through cost-cutting measures such as human task automation and hardware optimization.

4. **A larger ecosystem, more open to new players, start-ups and other sectors**
   In addition, 5G will create an ecosystem for technical and business innovation by making network services rely heavily on software. The software industry will be strengthened by including SME developers who will be able to compete in a market that is becoming increasingly hardware-intensive. With the support of this network, many "startups" will be created. Also, 5G infrastructures will offer network solutions for vertical markets like agriculture, automotive, healthcare, energy, city management, government, manufacturing, public transportation, and many others.

2.3 Parameters

5G technology goes far beyond mobile internet access. Flier mobile internet will be beneficial in some ways, but the high-frequency part of the network, which will be extremely fast, capacitive, and have a very low response rate, will be critical in terms of technological progress. The speed of 5G networks is not the only advantage affirmed by Chen et al. (2019). 5G technology offers significantly more bandwidth and more flexibility in how bandwidth is used. This means that 5G networks can maintain stable connections for a much larger number of devices in a concentrated area. And this is the main way 5G is changing the Internet of Things.

In the past, higher speeds have been associated with higher power consumption, but 5G builds on 4G's energy-saving features to offer higher data throughput and lower power consumption. According to Usama and Erol-Kantarci (2019), the speed of data transmission and customer desire for the highest quality of service are major limits when it comes to reducing energy use. Increased base station computing capacity is needed as the number of heterogeneous devices grows, such as home security sensors, tablets, and wearable health sensors. He thinks that as traffic grows, the computing power of baseband units will need to be increased by 50%.

For all the parameters mentioned above, IMT-2020 (International Mobile Telecommunications-2020) created a list of requirements that 5G networks should achieve, published by the ITU Radiocommunication Sector (ITU-R). Requirements according to ITU-R (2017) are as follows:

- **Peak Data Rate;** The speed upgrade is represented by the transfer data rate, which indicates how much data is transferred per unit of time. Normally, the rate is given in bits per second. The minimum requirements for peak data rate are as follows:

  - The downlink peak data rate is 20 Gbit/s.
  - The uplink peak data rate is 10 Gbit/s.
- **Peak Spectral Efficiency;** is the ratio of bitrate to bandwidth. The higher the rate at the same channel width, or the narrower the channel at the same speed, the higher the spectral efficiency.
  - Downlink peak spectral efficiency is 30 bit/s/Hz.
  - Uplink peak spectral efficiency is 15 bit/s/Hz.
- **Area traffic capacity:** Network capacity represents the quantity of traffic that a network can handle at any given time. It consists of the number of concurrent voice calls and the maximum data rate. Capacity varies depending on the location.
  - 10 $Mbit/s/m^2$
- **User plane latency:** Latency represents the time delay between an action and a response. It is the time lag that occurs between a call for action and the time it takes for the network to process the request. The lower the latency, the higher the computing speed.
  - 4 ms for eMBB
  - 1 ms for URLLC
- **Connection density:** measures the number of QoS-assured devices per unit area (per km2).
  - Up to a million devices per square kilometre
- **Reliability** provides certain properties regarding the reliability of data delivery to a specified recipient or recipients.
  - 32 bit/ms in channel quality of coverage edge for the Urban Macro-URLLC
- **Mobility** - is the maximum speed of the mobile station at which the defined QoS can be reached in (km/h).
  - Pedestrian speed range: 0 to 10 km/h (1,5 bit/s/Hz).
  - Vehicle speeds range from 10 to 120 km/h (1,12-0,8 bit/s/Hz).
  - Vehicles travelling at speeds ranging from 120 km/h to 500 km/h (0.45 bit/s/Hz).

- **Bandwidth:** Bandwidth is the frequency interval of the range of electromagnetic signals transmitted in radio technology. The greater this bandwidth, the better the conditions for the data rate.
    - 100 MHz

The parameters listed are only a subset of those specified by ITU-R. Figure 2 shows the remaining parameters.

Parameter	Desired Range	Use Case	802.11ax capability
Peak data rate	DL/UL: 20/10 Gbps	eMBB	19.2 Gbps DL/UL (8x8 HE160)
Peak spectral efficiency	DL/UL: 30/15 bits/s/Hz	eMBB	60 bits/s/Hz (8x8)
5%ile user spectral efficiency	DL/UL: 0.3/0.21 bits/s/Hz DL/UL: 0.225/0.15 bits/s/Hz	eMBB: Indoor Hotspot eMBB: Dense Urban	Expected to Meet
5%ile user experienced data rate	DL/UL: 100/50 Mbps	eMBB	Expected to Meet
Avg Spectral efficiency	DL/UL: 9/6.75 bits/s/Hz/TRxP DL/UL: 7.8/5.4 bits/s/Hz/TRxP	eMBB: Indoor Hotspot eMBB: Dense Urban	Expected to Meet
Area traffic capacity	10 Mbps/m^2	eMBB: Indoor Hotspot eMBB: Dense Urban	Expected to Meet
User Plane Latency	4 ms 1 ms	eMBB URLLC	Can meet
Control Plane Latency	20 ms (Encourage 10 ms)	eMBB/URLLC	Can meet for STA initiated
Connection density	10^6 connected devices/km^2	mMTC	Not in focus for eMBB
Energy efficiency	Efficient data transmission in high loads Low energy consumption in absence of data High sleep ratio and long sleep duration	eMBB	Can meet
Reliability	1-10^{-5} success probability for transmitting a Layer 2 PDU within 1ms at coverage edge for Urban Macro-URLLC	URLLC	Not in focus for eMBB
Mobility (defined only for UL)	1.5 bit/s/Hz UL @ 10 kph 1.12 bit/s/Hz UL @ 30 kph	eMBB: Indoor Hotspot eMBB: Dense Urban	Can meet
Mobility Interruption Time	0 ms	eMBB and URLLC	~ 2-3 ms
Bandwidth	Scalable: Min 100 MHz, up to 1 GHz		160 MHz

Figure 2: All IMT-2020 Parameter (Rakesh-Table5, 2022)

2.4 Use cases

Massive amounts of data can now be collected in the field and analysed remotely, in nearby areas using edge computing or in remote locations using cloud computing. This will affect both the traditional and digital sectors. According to the Accenture (2020) study, 79 percent of businesses globally believe that 5G will have a significant impact on their organization, and 57 percent think it will be revolutionary. According to Vavruška and Očko (2020), there are five general use cases (can be seen in Figure 3):

- **Fixed-Wireless Access (FWA)**

    A wireless network, also known as a wireless local loop, provides point-to-point broadband connectivity. The FWA wireless network is a so-called last-mile solution, through which the telecommunications service provider can directly access end-users. With the use of 5G, it will be possible to provide high-speed internet even in isolated places where it would be impractical to connect using expensive optical fibres.

- **Consumer smartphones and other devices**

From the very beginning, 5G networks have targeted mobile phones and smartphones. Operators offer fast mobile internet to all customers whose phones support this technology. This is the first sector where we can see the rapid penetration of this trend. People with 5G phones can already connect to the network and enjoy the benefits of high-speed internet. Not surprisingly, the mobile industry initially focused primarily on smartphones. There are not many facilities yet that support 5G. In the years to come, however, these devices will emerge. Virtual reality is already one of the hot favourites. With the glasses, people will be able to meet in virtual reality, be it through games or holograms, at various meetings or conferences. VR is so far from its beginnings, and only with the advent of 5G will its great potential become apparent.

- **Wearables**

Wearables are a new class of smart devices that users wear on their bodies. These are mostly sensors connected to humans or animals, medical monitoring devices or implanted chips. They take the form of watches, bracelets, necklaces, or clothing. They will be useful in many sectors, such as agriculture, health care, and others. Wearable devices have the potential to provide features such as augmented, virtual, and mixed reality; artificial intelligence; and pattern recognition. The only problem they have right now is that their batteries do not last very long. In the future, wireless charging could fix this problem.

- **Property-attached sensors**

They are generally a source of information for some control system that measures a particular physical or technical quantity and converts it into a signal that can be remotely transmitted and further processed in measurement and control systems. Sensors attached to inanimate objects are aimed mainly at collecting data that can be used to improve the safety and management of machinery (fault indication) in real estate (smart home), cities (smart city), farms (smart agriculture), and others. These sensors will be an essential component of the Internet of Things. The 5G network connection will enable an increase in the number of such sensors.

- **Robotic devices**

The last cases of use are 5G automated production lines, automated cars, and other types of robotic devices. These robots must be multifunctional and intelligent enough to adapt to and communicate with one another, as well as with humans. A breakthrough in these areas is likely in the next few years. High-quality wireless connectivity, which 5G can provide, is also essential. Connectivity through cables is sophisticated and, in an ever-changing environment, also completely inefficient

Figure 3: The Fifth Generation use Cases (Vavruška and Očko, 2020, p.19)

3 Internet of Things (IoT)

Simply defined, the Internet of Things is a system of interconnected electrical devices that can transmit data over the Internet. These devices must have their Internet protocol (IP) address and be physically or wirelessly connected to a network (depending on the type of used technology). So, they become part of the LAN/WAN and make up an ecosystem where devices can talk to each other without any help from a person.

Khan, Rehmani, and Rachedi (2016) define the Internet of Things as follows: "IoT is a worldwide network of interconnected objects uniquely addressable, based on standard communication protocols, and allows people and things to be connected anytime, anyplace, with anything and anyone, ideally using any path/network and any service." (p. 17).

The idea of connecting appliances to the internet and being able to control them remotely originated in the 1990s. At first, it was all about individual attempts. According to Suresh et al. (2014), the first "internet device" was created by John Romkey in 1990; it was a toaster that could be turned on and off over the Internet. The concept of the Internet of Things came about later. In the research, Kuyoro, Osisanwo, and Akinsowon (2015) mention that the very term "Internet of Things" was first mentioned nine years later as a headline in Kevin Ashton's presentation for the Procter & Gamble Company supply chain. He came up with the idea of significantly reducing waste, losses, and costs. The computer was supposed to collect data and let employees know when things needed to be replaced, repaired, or recalled.

In the present form of the IoT, the Internet has gone through several stages of development. Khanna and Kaur (2019) divide it into five possible phases, shown in Figure 4:

1. Pre-Internet: This is a time when there was no Internet. People first communicated using a landline, and later began using mobile phones and the Short Message Service (SMS). Thus, there was only human-to-human communication.
2. With the emergence of the World Wide Web (WWW), people could now send large email messages, share information, and entertain themselves.
3. The Internet of Services (IoS) is a phase in which static web content has been replaced by a collaborative space for content sharing and co-creation. With the development of

Web 2.0, the Internet now targets appliances. emerging services such as e-productivity and e-commerce.

4. The Internet of People-The fourth phase is when people are connected in real-time not only via SMS and phone but also through social media and many other mediums such as Facebook, Twitter, Skype, YouTube, etc. However, there is still human-to-human communication.
5. Internet of Things-Internet-connected devices exists in the present day. Machine-to-machine (M2M) communication is now possible. So, these devices can talk to each other and do many different things that can be directed or programmed based on how they are made and what they can do.

The real boom in the spread of IoT devices and their history, according to Ziegler et al. (2015), occurred after 2011, when the arrival of IPv6 provided enough IP addresses for all devices and allowed the Internet of Things to spread massively around the world. All the market's major players, including Apple, Samsung, Google, and Cisco, have begun to focus on the Internet of Things. On the other hand, Khanna and Kaur (2019) state that this is not the final stage. In the years to come, we can expect to see the implementation of artificial intelligence into the Internet of Things, which will give rise to (IoTAI). As a result, the devices will be able to make their own decisions without human intervention.

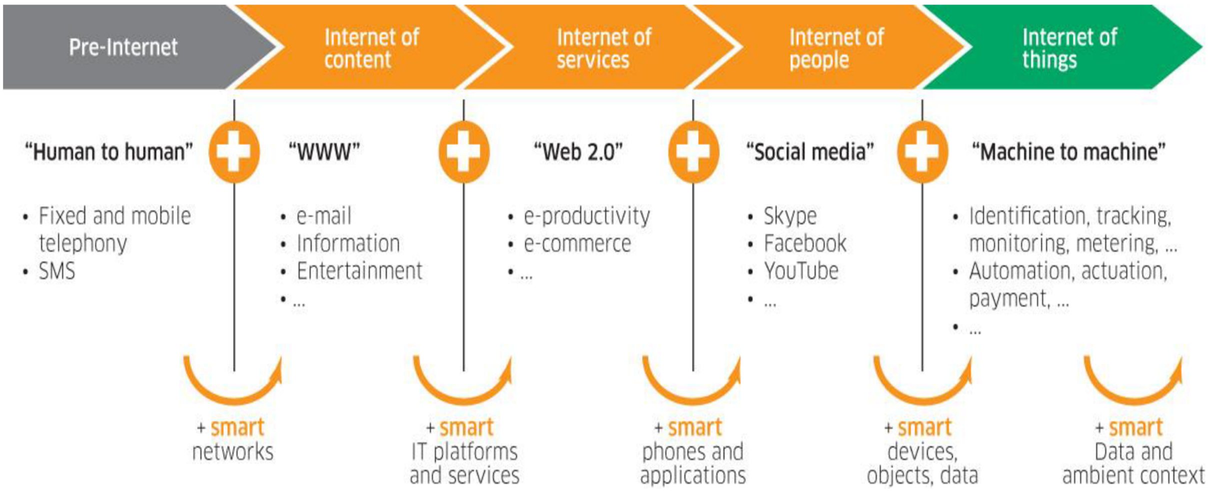

Figure 4: Transformation from Pre-Internet to Internet of Things (Mirco Medium- 1280)

3.1 IoT and 5G Networks

Primarily, IoT anticipates billions of devices communicating with each other. 5G will be the main facilitator of this communication. As reported in its work by Minoli and Occhiogrosso (2019), machine-type communications, including metre reading and asset monitoring, have been possible in prior generations of mobile technology but only as "over the top" specialised apps or as an afterthought in 4G standards such as Narrowband-IoT or LTE-M. 5G is the first specification to offer machine transmissions from the start; the specification supports enormous machine-type communications and assures that the Radio Access Network (RAN) meets these requirements. Developing the 5G RAN must consider other factors beyond typical revisions to meet the growing demand for IoT connectivity.

Each of the IoT devices contains vast amounts of data that are automatically selected and processed, and their analysis can detect and prevent, for example, health problems. In the corporate world, we estimate the durability or malfunction of individual machines. Connecting to an Internet of Things gateway or other edge device allows IoT devices to communicate the sensor data they gather with one another. According to Akpakwu et al. (2017), data either gets transferred to the cloud to be evaluated or is processed locally. These gadgets will sometimes interact with other connected devices and take action depending on the information they receive from one another. In a 5G network, the data stream is sent through a transmission system utilising the MIMO technology (Multiple Input, Multiple Output), which involves the use of multiple antennas for both transmission and reception. This results in an improvement to the received signal, an extension of the distance that is achievable, and an increase in the overall data throughput.

Akpakwu et al. (2017) state that, in many aspects, the theme of 5G is the interaction of two inexorable forces: the growth of extremely dependable, high-bandwidth communications and the increasing expansion of accessible computational power throughout the network. Despite this, the computer's power does not stop at the network. In addition, the network's endpoint devices, such as laptops and smartphones, are becoming more intelligent and powerful. A more dynamic and powerful computing environment is emerging as telecoms begin to revamp their networks in anticipation of the arrival of 5G. This new environment will hasten the adoption of IoT applications and services across industries. Individuals anticipate that 5G will allow new use cases such as monitoring systems and visual inspection; automated operations in large-scale distant areas such as mines; linked cars; and other applications (can be seen in Figure 5). However, people must adapt their approach to designing apps and AI models to take advantage of the most cost-effective computer resources as they become more widely available. Even edge devices that link to the network's edge may now run these AI models, enabling more efficient and secure processing of data.

Figure 5: What 5G is About? (ATI- Europe Shaping 5G)

As well as increasing speed, 5G networks will be more reliable, resulting in better connections. As Minoli and Occhiogrosso (2019) say, any IoT device that relies on real-time updates, such as locks, surveillance cameras, and other monitoring systems, must have a steady and dependable network. However, having a 5G network that can manage a larger number of connected devices would allow users to enjoy higher device dependability. Thus, the next-generation network will bring high-speed connections, low latency, and broader coverage to IoT devices. Companies must first invest in 5G-compatible products in order to benefit from these enhancements. When it comes to ensuring that new equipment and software operate and execute as intended, manufacturers must also adopt quality assurance testing. Bugs will limit the benefits that 5G might provide, and as a result, many new gadgets will fail.

3.2 Use of IoT

The main uses of IoT are to improve the human perception of the world and make routine activities more efficient. The same applies to 5G networks, which are an essential part of the modern Internet of Things. Through these two main pillars of digital transformation or digitization of the world, there is an opportunity to start an entirely new era in which all activities are made easier, faster, and more effective. This also confirms Vavruška and Očko (2020) "5G with IoT will let us feel the presence of remote people and objects, access information and see objects in previously unthinkable ways; take human creativity to another level; expand our economy; better use scarce resources and benefit from robotic technologies" (p.21).

The use of the Internet of Things is constantly increasing, and therefore it is appropriate to clarify the basic division of the use that currently exists. According to Campbell et al. (2017), we can distinguish IoT with the use of 5G networks into two specific groups, namely Massive Internet of Things (IoT) and Mission Critical Services (MCS), as shown in Figure 6.

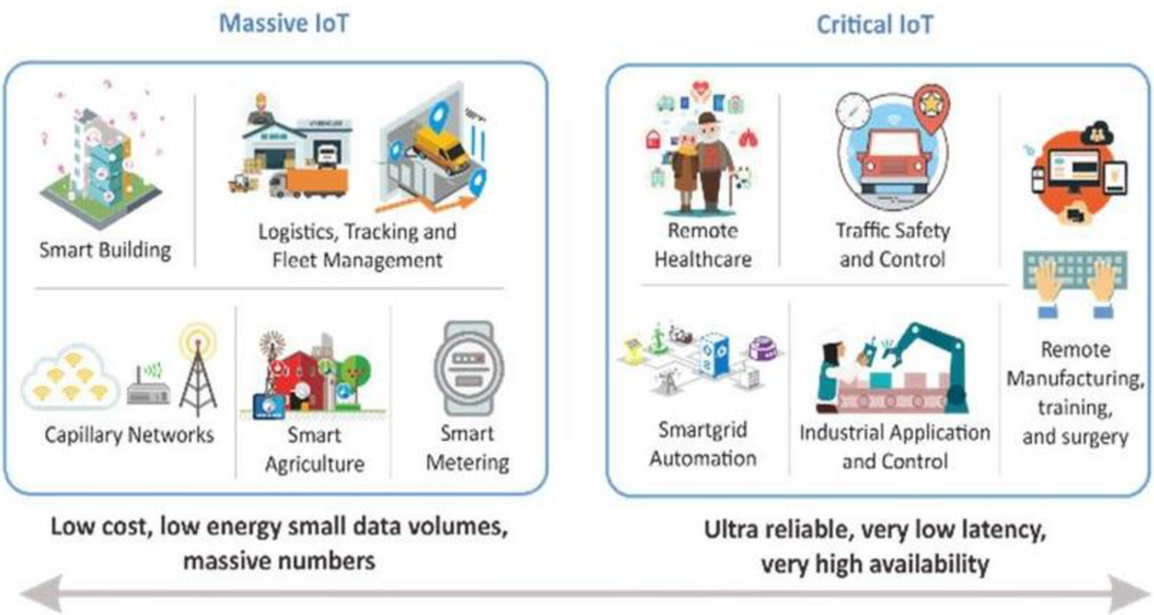

Figure 6: Difference between MIoT and MSC (Nashiruddin & Hidayati, 2019, p.1)

3.2.1 Massive Internet of Things

Campbell et al. (2017) define "Massive IoT" as a high number of connected devices, objects, and machines that require interaction and connectivity even at more distant locations. These "devices" needless data but report it regularly to the cloud, all with low power consumption and good coverage.

Smart agriculture

Automation and smart systems will also be able to be applied in sectors such as agriculture. This will lead to the creation of smart farms. Phasinam et al. (2021) argue that mobile devices can play a big role in ensuring smart agriculture through the Internet of Things. These mobile devices can be used to monitor agricultural activities. including the use of cameras, sensors, and mobile applications.

According to Ayaz et al. (2019), the Internet of Things can be used to improve the monitoring policies of agricultural farms. They state that the Internet of Things increases production efficiency and reduces farmers' losses in agriculture. The Internet of Things will give farmers a clear update on their farms regarding temperature, the humidity of the farm, and the moisture content of the soil. All of these will help the farmers to have smart agriculture being practised in the long run. This will lead to a significantly greater increase in crop yield.

Smart Cities

Smart cities aim to make life easier for their residents and reduce the costs associated primarily with running urban infrastructure. Huang et al. (2020) say that, with population growth, the Internet of Things is one of the most important tools that can be used to make cities smarter.

Samih (2019) states that the private sector and governments need to invest more resources in information and communication technologies (ICT). The government's investment in ICT will help the government grow huge smart cities. The integration of the IoT into cities will help in city design, city planning, and improvement of the waste management aspect. Samih (2019) agrees that the IoT can be closely related to designing smart cities in the most significant manner. It will play a huge role in ensuring that the different challenges that affect the operationalization of cities are solved. He further stresses the challenges that the IoT can address to ensure that there are smart cities, including traffic, energy usage, crime prevention, employment, education, and health. Implementation of such technology can resolve all these challenges and make cities smarter.

Smart Homes

Smart homes will offer greater comfort within the control of household appliances and their interconnection. The advantage of 5G is the ability to remotely control all these devices, even though a single application on a smartphone. As Taiwo and Ezugwu (2021) note, the Internet is a critical aspect of building a modern classic home. He says that the Internet of Things (IoT) has been a key part of making sure that homes have grown beyond their physical structures and into more advanced technological systems.

According to Taiwo and Ezugwu (2021), smart homes are characterised by major technological components, devices, and storage data systems that make up a critical modified smart home. The IoT helps create monitoring systems in homes in the form of surveillance cameras. Smart homes are designed so that there is one central command system that controls all the operational systems in the home. The central system keeps strict monitoring of the appliance system and captures events that move towards the home. Taiwo and Ezugwu (2021) further explain that there is a robust automation system in the house in which all activities in the house are kept under strict monitoring. The smart house's automation system is fundamental in ensuring that all the dangerous aspects that would cause harm to the home are detected. These include gases, trespassers in homes, and fires. Finally, the system makes an alarm and notices the house owner.

You, Pau, and Salerno (2019) state that the Internet of Things helps to improve security in the home and helps in integrating the use of machinery in homes. All these, according to them, make up a smart home.

3.2.2 Mission Critical Services

According to Campbell et al. (2017), the critical Internet of Things includes fewer endpoints that process massive amounts of data. The main aspect is Ultra-Reliable Low Latency

Communications (URLLC). The critical Internet of Things will be used for applications and devices that go beyond massive data collection but depend on high bandwidth and low latency. Due to its low latency, the 5G network is essential for critical IoT.

Autonomous Vehicles

In recent years, autonomous driving systems have become an increasingly important part of the equipment for cars of the future, and automobile manufacturers are putting a lot of money into this technology. Krasniqi et al. (2016) argue that the Internet of Things has taken over the automotive industry. The IoT has transformed automotive vehicles from being driven by people to being driven by themselves. He further argues that automotive vehicles are controlled by other electronic devices that give them direction.

There will be one major benefit from this. According to Fernández and Gómez (2021), autonomous vehicles will contribute to reducing the number of accidents and deaths on the road by eliminating the human factor. However, to increase protection, it is necessary to significantly strengthen the protection of the IT systems that ensure the operation of autonomous vehicles. Further recommendations of the study are systematic validation of AI models and data, implementation of AI safety policies, or rigorous risk assessment associated with the development of AI in autonomous driving. Faisal et al. (2019) divide autonomous driving into five categories:

- Level 0: Advanced functions only display warnings and provide immediate emergency assistance. Examples: lane departure warning, mirror blind object warning, emergency braking
- Level 1: Automated steering functions control the brake and accelerator or steering. Examples include adaptive cruise control and automatic mid-lane keeping.
- Level 2: Automated steering functions control the brake, accelerator, and steering at the same time. Examples: automatic mid-lane keeping running at the same time as adaptive cruise control.
- Level 3: The autonomous steering system takes full control of the car under certain conditions, but if they cease, it is taken over by the driver, who may not otherwise hold the steering wheel. Examples: automatic steering of the car in a traffic jam or on a motorway.

- The level 4-the complete autonomous driving system operates in well-defined areas. The driver is not required to take over, and the steering wheel and pedals do not need to be fitted.
- Level 5: The autonomous driving system works everywhere and always. The steering wheel and pedals do not need to be fitted in the car.

Drones

According to Zemrane et al. (2019), the Internet of Things and Drone network systems play a fundamental role in conducting critical environmental monitoring. Moreover, drone systems on the Internet of Things are important in collecting information regarding environmental welfare. The drone systems integrate the information from the sky in the form of humidity information, heat information, and signals of digital spaces and put them in a central system known as the Unmanned Aerial Vehicle (UAV). This system assesses and analyses that information and takes it forward for critical processing. According to Lakshman et al. (2021), the different applications used by drones are also more integrated into the Internet of Things, and the relationship between drones and the IoT is more grounded in sharing these applications. Possible uses of drones are as follows:

- More efficient agriculture.
- Air pollution monitoring
- Cartography
- environmental monitoring
- security
- delivery service

According to Saeed et al. (2019), one of the current goals for the future is drone autonomy. This means ensuring that different systems and devices can exchange data immediately when they meet in the air. This would allow the drone to fly itself without a pilot and perform various tasks.

Smart Grid

Are power electrical and communication networks that allow regulating the production and consumption of electricity in real-time shown in Figure 7. Zheng, Gao, and Lin (2013) state that the smart grid consists of transmission and distribution systems that are equipped with a certain degree of intelligence such as the ability to automate, communicate, and regulate. The advantage of such communication and data processing is the economically efficient use of the power system, which leads to lower losses and increases, energy efficiency. To achieve a modernized smart grid, a wide range of technologies should be developed and implemented. Kabalci (2016) classified these technologies into the following key technological categories:

- Smart grid and smart energy infrastructure
- Smart measurement and metering
- Advanced communication technologies

Yang (2020) states, that the Internet of Things plays a fundamental role in making clear electric power. Clear electric power plays a huge role in making a smart grid. He further stresses that the IoT helps improve the information flow through systems that bring together the information related to the energy systems. The use of the IoT has also helped to ensure that consumers of energy have a variety of ways to make use of their devices.

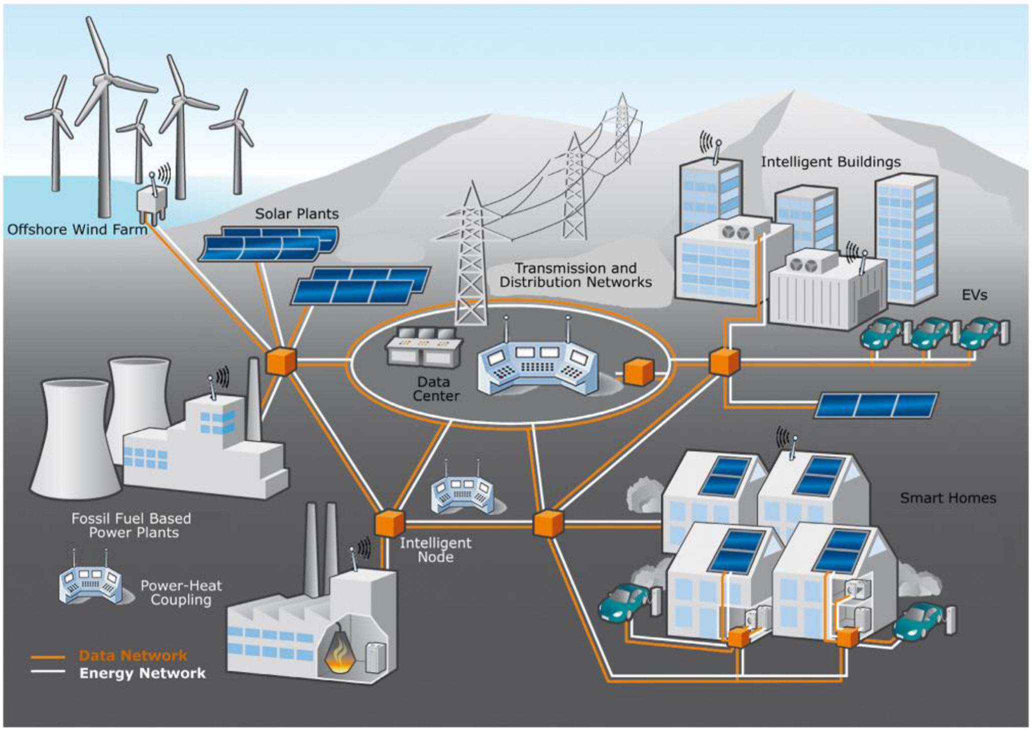

Figure 7: Smart Grid Principle (Kabalci, 2016, p.4)

However, the Internet of Things will also impact other industries. Vavruška and Oko (2020) list, for example, industrial automatization, healthcare, education, and many others

4 Risks Associated with the 5G Network

A 5G network, however, does not only provide benefits; it also carries significant concerns that could have a severe influence on the launch of the 5G network. So, this chapter talks about the possible risks that come with 5G networks and how these risks might affect society

4.1 Controversy & Hoaxes Linked to 5G Network

Many disinformation and conspiracy theories still circulate about the 5G network. Yablokov (2015) argues that conspiracy theories "work by helping to unite the audience as a 'people' against an imaginary 'other' represented as a secret power bloc" (p. 302).

According to Doseděl (2020), the first widespread controversy is that 5G networks pose a high health risk to all living organisms. Previously, the same was said of 4G and 3G. It is claimed that electromagnetic radiation emitted by 5G networks is harmful to humans. It is true that radiation in the high-frequency spectrum, such as X-ray and gamma radiation, can destroy DNA and cause cancer. This radiation is called ionising radiation, which can be seen in Figure 8. However, 5G is much lower in the spectrum, where the radiation level is significantly lower. Therefore, 5G belongs to the non-ionising part of the spectrum, along with 4G, microwaves, and radio waves, which have been perfectly safe for many years and talking about radio waves for almost a century.

This is also confirmed by Meese, Frith, and Wilken (2020). Sensitivity to electromagnetic radiation is by no means the only problem that people believe is caused by wireless signals. At the beginning of 2000, there was a significant public debate about Wi-Fi, mobile tower base stations, etc., and their association with various types of cancer. The dangers of exposure to electromagnetic fields, which are described as being caused by the electricity of various types, have been addressed by many popular publications of dubious quality. The list of alleged symptoms of exposure to electromagnetic radiation is long. Exposure to this type of radiation from mobile phones and Wi-Fi is reportedly linked to anxiety, infertility, brain tumours, heart disease, breast cancer, attention deficit hyperactivity disorder (ADHD), depression, diabetes, etc. While concerns about exposure to electromagnetic fields have increased with the development of 5G, few of them are new. The same concerns were expressed in the 1990s and early 2000s when activists focused on the dangers of non-ionising radiation. In simple terms, electromagnetic radiation is typically divided into two types: ionising radiation (such as X-ray radiation) and non-ionizing radiation from cell phone power grids and towers. Ionizing radiation can disrupt atoms on a structural level, while non-ionizing radiation does not have that ability, a distinction that some people question, and that essentially gets to the heart of the problem.

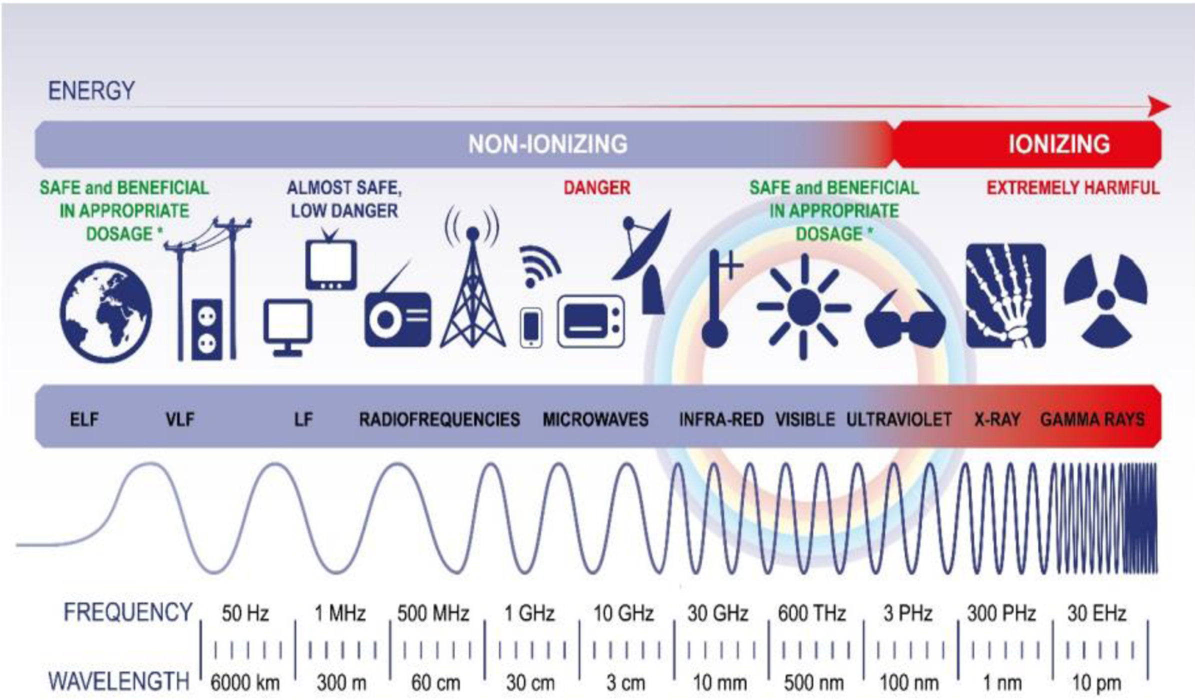

Figure 8: Electromagnetic Spectrum (Karaboycheva, 2020, p.3)

Especially on social networks, there were widespread claims that wireless network technology had fuelled the emergence of the coronavirus pandemic. According to Heilweil (2020), "the first reference to a link between 5G and the coronavirus pandemic appeared on a French conspiracy website called Les moutons enragés, which means' The rabid sheep’ in free translation." A January 20 post reported that the spectrum of millimetre waves used by 5G technology and COVID-19 disease could be linked, citing reports of 5G towers being installed in Wuhan before the outbreak. Three months later, conspiracy theorists with similar claims set mobile phone towers on fire in Europe.

Research by Bruns, Harrington, and Hurcombe (2020) shows that the COVID/5G conspiracy theory is the result of a clash of long-standing conspiracy beliefs about the alleged health dangers of 5G, as well as about vaccines, global elites, China, and other established targets of suspicion, including the coronavirus crisis. Proponents of conspiracy theories on Facebook have both readily retroactively incorporated emerging information about the virus, its presumed origin, impacts on human health, and likely remedies into their already existing worldviews, beliefs, and ideologies, and cynically exploited the real fears of their fellow Facebook users about the effects that the virus might have on themselves and their loved ones to support their conspiracy narratives and encourage further sharing of their messages. But these kinds of things don't just happen on Facebook. They also happen on several other popular social media sites, though they are different depending on how the technology works there.

4.1.1 Health Risks

There is a lot of speculation about health risks associated with the implementation of the network. Karaboycheva (2020) points out that when 5G is activated, it emits electromagnetic radiation. An electromagnetic field (EMF) is created when high-frequency electromagnetic radiation, such as that emitted by 5G, interacts with matter. EMFs are thought by some to be harmful to one's health. 5G's impact on health is becoming a major worry. Moreover, Deivakani et al. (2021) state that cataracts may be influenced by frequent exposure to radiation. Due to the increased electromagnetic sensitivity brought on by 5G, some people may experience dizziness and a racing heart. There will be changes in behaviour if alterations in the brain or nervous system are seen in morphological, EMR, electrophysiological, and chemical parameters. As a result of radiation impacts, short-term and long-term health difficulties such as aches and pains, headaches and burning sensations, anxiety, tension, irritation, and long-term difficulties such as malignancies, brain tumours, damaged DNA, and modified cells are all possible.

On the contrary, Clyde & Co (2020) claim that the future dangers are unknown due to a lack of data and the long latency time for health disorders. Therefore, 5G is not necessarily covered by the safe nature of current generation radio frequencies. It is currently classified by the International Agency for Research on Cancer (IARC) as possibly carcinogenic suggesting minimal evidence of carcinogenicity in humans and animals. The non-ionizing nature of IARC radiation does not cause DNA or tissue damage. No public health problems are expected if total exposure remains below international criteria.

However, Kim et al. (2020) conclude that results from existing studies cannot be directly applicable to humans as most of these studies have been conducted using cell or animal models. No study confirms a direct threat to humans. Therefore, a preventive international norm is required. Nevertheless, the World Health Organization (2020) claims that the outcomes are mixed. No research indicates the health risks associated with 5G. However, research has examined the relationship between health risks and EMF.

4.1.2 Tissue Heating

According to a bit of research conducted by Deniz et al. (2017), cell phones operate at frequencies ranging from 1.8 to 2.2 GHz. These frequencies promote tissue healing. When skin absorbs electromagnetic radiation, it causes tissue warmth. Brain and body temperature will increase somewhat due to this.

Sacco, Pisa, and Zhadobov (2021) researched that EMF-related tissue heating becomes worse with age. In addition, the more they absorb, the greater the EMF levels become. This is due to the thinner skin and decreased blood flow characteristic of the elderly. On the other hand, tissue heating is thought to be brief and insignificant. Low-frequency EMFs are also cited by the Federal Communications Commission (2016). Tissue heating is impossible at these concentrations.

4.1.3 Cognitive Functions

From research by Simkó and Mattsson (2019), it is not yet known how 5G exposure affects cognitive function. EMFs from different sources have been studied in the past. Researchers experimented to see if using a mobile phone affects one's cognitive abilities. According to the findings, those who use their phones for at least 90 minutes a day have trouble paying attention.

Unresolved evidence was discovered by Deivakani et al. (2021). Researchers combed through 43 papers looking at the relationship between electromagnetic fields (EMFs) and cognitive performance. Their findings show no clear relationship between electromagnetic fields (EMFs) and cognitive issues.

4.1.4 Harm to Birds & Animals

In most studies, mice or rats have been used as subjects. Recent research by Deivakani et al. (2021), for example, established a relationship between mobile phone EMFs and DNA damage in mice and rats. Another study by Nunez (2021) indicated that electromagnetic fields (EMFs) might affect the neurological system. Snails and frogs were among the creatures studied for their reactions to electromagnetic fields and whether electromagnetic fields (EMFs) hurt animals.

Due to the adoption of 3G technology, there has been an increase in the number of birds leaving their nests and health issues such as impaired mobility, degradation of their plumage, and even mortality. As Deivakani et al. (2021) provide in their study, Rock Doves, House Sparrows, Collared Doves, Magpies, and White Storks are among the many bird species adversely affected by this non-ionising mm-wave radiation. The non-ionising EMF radiation is hurting avian populations and bee populations. In November 2018, 287 birds were killed in the Netherlands due to the country's experimentation with 5G. This is also confirmed by Simkó and Mattsson (2019). Birds and other creatures are dying due to the harmful frequencies generated by devices in places saturated with 4G "non-ionising" radiation. Humanity is the last to be spared from the effects of 5G, no matter how long it is used. You can figure out how much damage radiation does to a plant by keeping track of how much radiation it takes over time.

There is some disagreement among experts on the dangers of EMFs and 5G. Scientific competence may be enhanced by bringing experts from different fields of study, such as physics, engineering, and medicine, into a single team. Because the signal is contained inside the fibre, several experts have promoted optical fibre technology as a safe alternative to 5G. There is no comparison between optical fibre and wireless in terms of potential, and its potential is much greater than that of 5G. Unlike wireless technologies, investments in optical fibre could lead to faster speeds in the future.

4.2 Cyber Security

However, it is not only health risks that need to be associated with 5G networks. Park et al. (2021) mention the various types of services that are part of 5G networks, such as extended mobile broadband (eMBB), massive machine-type communications (MTC), and ultra-reliable low latency communications (uRLLC), pose a threat to users. Personal information and their privacy are particularly at risk. According to 5G Security Issues (2019), the developments show how 5G networks are built to be more secure than prior generations of networks. SS7 and Diameter security flaws have been fixed in 5G, a significant improvement above 4G. However, this does not imply that 5G networks are impenetrable. Therefore, this chapter discusses security concerns with 5G. As 5G networks are used for more things, like remote surgeries, self-driving cars, and automated manufacturing, the chance of harm and negative effects grows.

4.2.1 Potential Risks

As 5G networks are rolled out to new locations, the potential for harm and repercussions grows exponentially. As Cavey (2022) affirms, it takes time for telecom networks to adapt. The changeover from one generation to the next is generally a multi-step process that takes years to complete. For the foreseeable future, 4G, 3G, and 2G networks will be utilised alongside 5G networks. Various operators and nations will transition to 5G at varying rates. Mobile carriers will have to deal with security issues not just for 5G but also for the transition to and integration with older networks.

New signalling protocols in the network core are required for next-generation mobile networks. It is now up to telecommunications providers to deal with the vast spectrum of risks on the Internet.

According to Olimid and Nencioni (2020), slices of a network are created using "network slicing." Because each slice is given its own set of resources (such as bandwidth and the quality of the service it provides), it also has its own set of security rules. Operators will now have to design a bigger number of slices with more complexity and service needs rather than simply one network. A serious security risk is involved. The risk of a security breach increases as the complexity of the system and the number of parameters increase. In particular, multi-operator 5G network infrastructure construction and/or virtual mobile operator use of a single 5G network. Additional issues as the Internet of Things (IoT) expands: The security of IoT devices is not always considered throughout the design process. Insecure IoT devices on an organisation's network constitute a new vulnerability for an attacker to exploit. There will be a decrease in network visibility with the introduction of 5G technology. As Giess (2021) suggests, Secure Access Service Edge (SASE) is an effective WAN security solution, but enterprises may be unable to see network traffic to detect anomalies or attacks without it.

4.2.2 Defending & Securing Against Cyber Security Issues

Operators must begin by safeguarding older networks to provide a strong foundation for 5G networks. Signalling information crossing the network's boundaries should be analysed instantly by operators to guarantee security and prohibit unauthorised traffic. Security policies may be kept current with the help of this study. With this thorough and methodical method, 5G networks can be safe from the start.

According to 5G Security Issues (2019), using SDN, NFV, and network slicing in the service-oriented 5G network, carriers may swiftly adjust their networks based on the market's needs. One drawback, though, is the difficulty of keeping track of all the moving parts. This raises the need for security audits to identify vulnerabilities and ensure that security rules are being properly implemented. Security audits should be conducted regularly when deploying a new 5G network. This helps keep track of network security changes and respond to them quickly.

Security is not a one-time event but rather a continuous process. Despite putting a lot of effort into 5G security standards, there are still a lot of unknowns. As Cabrera (2021) states, service providers must stay up to date on the latest 3GPP and GSMA guidelines to keep 5G networks safe. There must be the careful implementation of recommendations. Every network is different, even though they are all generic. Implementing new security rules, whether as a result of employee input, third-party audits, or ongoing monitoring, should be part of a systematic approach. Before and after installation, it is necessary to conduct verification. This means that having the correct architecture and equipment for 5G security is not enough. It necessitates the development of processes, procedures, and cross-team cooperation.

If a company's innovation goals depend on 5G, it must implement the technology safely and efficiently. Managing the transition to 5G may be challenging and depends on company resources. According to 5G Security Issues (2019), managed security services, which include alternatives like next-generation firewalls, secure remote access solutions, secure web gateways, and wider SASE products, are often the most cost-effective method to support the 5G plan. Managed security services allow for collaboration with security professionals on the development and optimum use of 5G technology, all while helping to keep the flow of vital information secure. As a result, companies will be able to create and scale solutions with the least amount of effort and risk possible. New 5G technologies, such as virtualisation and unique use cases, pose new dangers for network operators. It will still need the dedicated efforts of telecom suppliers accountable for specific implementation and the operators themselves, who are responsible for correct setup and accordance with guidelines, to achieve long-term security in 5G networks.

Conclusion

The purpose of this thesis was to investigate the concept of the fifth generation of mobile networks as well as to determine whether the replacement of the fourth generation will be beneficial and whether or not any risks will arise as a result of the implementation. To achieve this goal, the task was to study the available resources and use them to reach the conclusions of this study.

The fifth generation is very innovative in many aspects. This is not only because of its powerful parameters, which will ensure a huge increase in the speed and stability of the wireless Internet for its users, but mainly from an industry perspective, the 5G network will be a revolution. Low latency and high capacity will ensure real-time communication for the Internet of Things. This will be a big step that will start Industry 4.0. Every object will be controlled remotely with great precision. In the years to come, this technology will be complemented by artificial intelligence, enabling these devices to make their own decisions. There will be a complete overhaul of the world, which will be split into the real and the virtual.

Scientists disagree about health risks. It is a relatively new technology, and negative impacts on our health may become apparent only with time. However, from the information available so far, the World Health Organization has declared it a safe technology. A real threat already known is the possibility of attacking devices that will communicate using 5G. Companies need to ensure the most effective security in the future so that no one can hack into these devices and applications.

To summarize, fifth-generation networks will unquestionably play an essential part in the evolution of society and other technologies in the coming years and decades. In addition, it will bring a wide range of advantages. However, we must remain pragmatic and keep monitoring health risks and working toward the future to make sure that these conveniences are not abused, and that people are safe when they use them.

Extended Abstract

Jedním ze současných témat, které je velmi diskutované mezi širokou veřejností, je přechod na mobilní sítě páté generace. Jedná se o technologii, která by dle nejrůznějších expertů, měla být revoluční. Od roku 2020 začínají operátoři pokrývat světové metropole touto sítí za účelem poskytnutí co nejlepších služeb a síly signálu. Již nyní se mohou uživatelé jejichž telefon podporuje 5G, k této síti připojit a vyzkoušet si výhody s ní spjaté. Za touto sítí je však mnoho otazníků. Na sociálních sítích a v mediích se šíří lživé zprávy, které na tuto technologii vrhají špatné světlo. Tato bakalářská práce se zaměřuje na pozitivní i negativní aspekty této technologie. Cílem práce je z dostupné literatury vyvodit rizika, která s provozem této sítě mohou nastat, a především zjistit jaké jsou výhody této sítě a jak naši společnost v budoucnu ovlivní. Autor čerpá jak z odborné literatury, tak z nejrůznějších článků nebo webových stránek, které se konceptem 5G sítí zabývají.

Z úvodu autor popisuje koncept celulární rádiové sítě a rozlišuje různé generace mobilních sítí čímž dává čtenářovi obecný pohled na to, jak se bezdrátová komunikace vyvíjela. Každá generace mobilní bezdrátové komunikace přinesla několik různých vymožeností a pokroků, které dali za vznik právě té aktuální. V kapitole jsou tedy tyto generace popsány, jak šli chronologicky za sebou a co v danou dobu nabízeli.

V druhé kapitole autor vymezuje onu pátou generaci. Popisuje její vlastnosti a koncept s odkazem na jiné autory. Od zmíněných autorů interpretuje jejich myšlenky a pohledy na 5G síť jako takovou. Dále pak autor diskutuje, jaké byli hlavní motivace, které daly za vznik této sítě. Podrobně vysvětluje a uvádí všechny klíčové faktory, které byly hnacím motorem pro vznik páté generace. Při vývoji této technologie byly předem vytyčené parametry, které síť bude muset splňovat. Autor uvádí jednotlivé parametry s minimálními požadavky ať už jde o rychlost, odezvu nebo šířku pásma. Kapitola se uzavírá možnými příklady užití v praxi. Autor uvádí pět odlišných skupin příkladů s využitím 5G sítě. A popisuje, proč je 5G síť pro tyto skupiny tak zásadní.

Třetí kapitola se zaměřuje na internet věcí, který je nedílnou součástí 5G. Pro internet věcí jsou 5G sítě klíčové zajišťují mu možnost masivní komunikace až pro milion zařízení na kilometr čtvereční a možnost komunikovat v reálném čase bez odezvy. Proto autor popisuje i koncept internetu věcí, jelikož v něm 5G najde své největší využití. Autor stručně vytyčuje historii internetu a rozděluje ji do pěti etap, popisuje i samotný vznik internetu věcí a uvádí příklad jeho prvního použití v praxi. Popisuje, jak probíhá komunikace internetu věcí na platformě 5G a jak celý proces funguje. Uvádí, jak se získávají data a co se následně se získanými daty děje, kam tečou, kde se vyhodnocují. Mapuje různé možnosti využití internetu věcí, které rozděluje do dvou základních skupin, a to masivního internetu věcí, umožňujícího komunikaci miliónům zařízení, které bude zásadní pro takzvaná chytrá města, chytré domácnosti nebo pro inteligentní zemědělství. Druhou skupinou jsou pak aplikace a zařízení závislé na real-time komunikaci. Jde o tak zvané klíčové komunikační a informační systémy. Na těchto systémech je například závislé autonomní řízení, inteligentní síť monitorující spotřebu a výrobu elektrické energie, průmyslová automatizace pomocí robotů, nebo využití bezpilotních dronů v různých oborech.

Závěrem se autor zabývá možnými riziky. Nejprve se věnuje kontroverzím a hoaxům které jsou s 5G spjaty. Z dostupných zdrojů na internetu nachází ty nerozšířenější a ověřuje jejich pravdivost. Z nastudované literatury pak vyvozuje dvě zásadní rizika. Prvním rizikem je možné nebezpečí ohrožující zdraví člověka a druhým je bezpečnost s ohledem na osobní vlastnictví, kdy může dojít k neoprávněnému nabourání třetí strany do aplikací nebo zařízení podporujících 5G. Co se týče zdravotních rizik nejsou odborníci za jedno. Z některých studií vychází najevo, že vysílače signálu pro 5G mohou způsobovat zvyšování tělesné teploty, a to především u lidí v pokročilém věku. Nicméně nebylo prokázáno, že by měl být signál 5G životu nebezpečný jako je tomu například u rentgenového záření. V důsledku toho, že nebylo nikým potvrzeno přímé ohrožení života, světová zdravotnická organizace označila toto záření za bezpečné. Co se týče možnosti napadení zařízení komunikujících pomocí sítě 5G tak jsou obavy oprávněné. Ovšem s těmito riziky se potýkaly i předešlé generace. Je tedy nutné, aby technologické společnosti pracovali na co nejlepším zabezpečení a předcházeli možnému zneužití. S každou novou aplikací vznikají nové cesty, jak napadnout tyto nové systémy a je tedy jasné, že na bezpečnosti se bude muset pracovat neustále.

Z dostupných zdrojů je tedy možné potvrdit, že 5G síť bude pro následující desetiletí revoluční technologií. S internetem věcí velmi zasáhne do sektorů jako je průmysl a služby. Bude usnadňovat každodenní život nás všech. 5G a internet věcí se stanou neodmyslitelnou součástí našich životů a budou vznikat nová odvětví která budou na těchto technologiích stavět. Nicméně je důležité pokračovat ve sledovaní možných nebezpečí ať už zdravotních nebo digitálních a těmto hrozbám včas předcházet.

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List of abbreviations

5G	Fifth Generation
FDMA	Frequency Division Multiple Access
TDMA	Time Division Multiple Access
CDMA	Code Division Multiple Access
SMS	Short Message Service
MMS	Multimedia Messaging Service
3GPP	Third Generation Partnership Project
CDMA	Code Division Multiple Access
UMTS	Universal Mobile Telecommunication System
GSM	Global System for Mobile Communications
D-AMPS	Digital - Advanced Mobile Phone System
IS-95	Interim Standard 95
LTE-A	Long Term Evolution – Advanced
RN	Relay Node
CoMP	Coordinated Multi-Point
CA	Carrier Aggregation
HD	High Definition
3D	Three Dimensional
IoT	Internet of Things
MIMO	Multiple Input Multiple Output
ICT	Information and Communication Technology
IT	Information Technology
PAN	Personal Area Network
SME	Small and Medium-sized Enterprises
IMT	International Mobile Telecommunication
eMBB	Enhanced Mobile Broadband
URLLC	Ultra-Reliable Low Latency Communications
QoS	Quality of Service

FWA	Fixed Wireless Access
LAN	Local Area Network
WAN	Wide Area Network
IP	Internet Protocol
WWW	World Wide Web
M2M	Machine to Machine
RAN	Radio Access Network
AI	Artificial Intelligence
MIoT	Massive Internet of Things
MSC	Mission Critical Services
UAV	Unmanned Aerial Vehicle
DNA	Deoxyribonucleic Acid
WiFi	Wireless Fidelity
ADHD	Attention Deficit Hyperactivity Disorder
EMF	Electromagnetic Field
EMR	Electronic Medical Records
IARC	International Agency for Research on Cancer
mMTC	Massive Machine Type Communication
SASE	Secure Access Service Edge
SDN	Software Defined Network
NFV	Network Functions Virtualisation
GSMA	Global System for Mobile Communications

List of figures