

TRENDS AND NEW TECHNOLOGIES IN COMPUTER NETWORKS IN MONTENEGRO

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ABSTRACT

In this paper, I will describe the current technological trends that appear in computer networks. I will talk about technologies that were created to improve current computer networks, but also build the foundation for the future of computer networks. It's about technologies: automation, software-defined wide-area networks, machine learning, and artificial intelligence. In the areas of network access and wireless networks, I will describe the 5G and Wi-Fi 6 technologies. The mentioned technologies improve business continuity, i.e. high availability of network devices and systems, as well as their behavior in case of disaster recovery. An important part of any business is prediction, which involves looking ahead and identifying the most important future trends in business and technology. Highlighting key technology trends is especially important to companies and business leaders who must address digital transformation today to remain competitive in the marketplace. Technological trends will have a significant impact on the world we live in. It will create a way of life, jobs, and human interaction. From virtual and augmented reality to artificial intelligence and quantum computing, these technologies will provide new opportunities and thus new challenges. That is why it is important to be aware of new trends and consider the potential consequences and implications of their widespread use.

Keywords: computer networks, 5G, Wi-Fi 6, machine learning, artificial intelligence

1. INTRODUCTION

In the business world, numerous trends determine the role of the network. Understanding these trends can help the IT sector better prepare for the ever-increasing expectations that business demands in various areas expect from networks. The development, growth, and maintenance of these processes can be facilitated with the help of automated processes that will enable the rapid development, deployment, and maintenance of various applications and processes whose role is to facilitate the operation of new business requirements. Developments in telecommunications and wireless technologies are already changing the world today, through fifth-generation data room connection technologies and sixth-generation wireless technologies, better known as 5G and Wi-Fi 6. The use of machine learning, artificial intelligence, robotics, and Blockchain technology is relatively new to the field. network technologies, but their potential is already very important.

„Computers, apart from being a key part of the business world, are becoming an increasingly important part for the individual as well. The continuous development of technologies must be accompanied by the comparative development of computer networks that

started with sending data over wires, and we have come to the point where today it seems to us that everything is connected and that network technologies are all around us¹.

Network technology can be separated into two simple terms: communication and sharing.

Communication is a medium that helps in both business and private environments, and thus computer networks are the basis for the development of important IT solutions. Information is a key part of effective communication. The importance of the development of new technologies, material and human resources in computer networks has never been greater than today, because they enable the functioning of the business world, and increasingly enter the sphere of private life.

In the ICT system, the concept of Disaster Recovery (DR) is different from the concept of High Availability (HA). Both DR and HA are related to Business Continuity (BC), high availability deals with the continuity of operations without interruption, while disaster recovery includes a period of downtime, which can range from a few seconds to several days.

In this paper, I will briefly describe the current technological trends that appear in computer networks. All the technologies listed in this paper improve business continuity, i.e. the high availability of devices and systems and their behavior in the event of disaster recovery.

This paper will include a brief description of trends in the field of computer networks. It was created on the basis of parts of my earlier research as well as lessons learned from lectures, which dealt with the latest trends in computer networks in the Computer Networks and Operating Systems courses at the International University in Novi Pazar, Department of Computer Sciences.



Figure 1. The future of network technologies in smart cities, Source: Sensoworks

¹ Arend C. et al, (2017) IDC FutureScape: Worldwide Enterprise Infrastructure - <https://www.idc.com/getdoc.jsp?containerId=US43137417>

2. NETWORK ACCESS AND WIRELESS NETWORKS

The flow of information in today's world is made possible by the existence of two types of network technologies. „One type is Wi-Fi technology, a type of local wireless network that is used indoors, such as an office or home. The second type is broadband mobile network technology, which is primarily intended for communication over long distances, and can also be used indoors“².

In order to ensure the future of both network technologies, it is important to continue developing the current versions. Local wireless networks are developing a technology called Wi-Fi 6. While broadband mobile networks are developing 5G mobile technology, which is already present today.

„Wi-Fi 6 and 5G are complementary technologies that will provide higher capacities and higher speeds and lower latency compared to their previous technologies. This alone will ensure the necessary infrastructure for the future needs of the ever-increasing volume of devices on the network and the exchange of information between them“³.

By 2050, 68% of the total global population will live in cities, according to UN data. By then, the world population will be 9.7 billion and 11.2 billion by 2100.

China, India, and Nigeria together will account for 35% of the projected urban population growth between 2018 and 2050. Over 700 cities from all over the world presented their smart city projects at the Smart City Congress in Barcelona this year.

A smart city is a city in which urban planning is conceived with the ultimate goal of connecting all segments using the most modern technologies. This connection, which frankly collects a large amount of data, is used for the efficiency of city services, the improvement of the environment, and the convenience of the population's life.

Since smart and sustainable urban planning affects everyone, it is crucial that we know and understand what technologies are involved in building smart cities and how they can help achieve the ultimate goal of urban transformation into smart cities of the future.

2.1 5G TECHNOLOGY

5G technology is the fifth generation of the technological standard of broadband mobile networks that, while encouraging investment in innovation in various areas, brings changes to everyday life. 5G technology began to be introduced at the beginning of 2019 and has been introduced to date in a large number of countries, mostly in large cities where there is a need for a large number of devices in a small space. It was conceived to respond to the ever-increasing growth in the number of devices and enable the rapid transfer of the large amount of data they generate.

² Andra U., (2019) *Connecting the Unconnected: 5G and Wi-Fi 6 Will Play a Pivotal Role in Bridging the Digital Divide* - <https://blogs.Cisco.com/sp/5g-and-wi-fi-6-bridging-the-digital-divide>

³ Andra U., (2019) *Connecting the Unconnected: 5G and Wi-Fi 6 Will Play a Pivotal Role in Bridging the Digital Divide* - <https://blogs.Cisco.com/sp/5g-and-wi-fi-6-bridging-the-digital-divide>



Figure 2. The impact of 5G technology on today's world,
Source: <https://www.emfexplained.info/?ID=25916>

The fifth generation brings higher speeds, lower latency and better connectivity compared to its predecessors and enables the development of a new generation of applications and services that can change the world.

5G technology has three main advantages compared to previous technologies:

- Improved broadband mobile access that will provide higher data transfer speeds between devices in addition to higher data capacity.
- Great increase in communications between devices or in other words the Internet.
- Great reduction in latency when communicating between devices that enables real-time remote control of devices. This opens up the possibility of technological advancement in the fields of robotics, communications, security systems, medicine the auto industry, etc.

5G technology will impact human communities by enabling billions of devices to be connected and creating smart cities, schools, homes, and vehicles. Healthcare and education will be greatly improved and thus a better and safer life will be made possible. In the industry itself and the business world, the flow of a larger amount of data will be enabled, which will help the business and thus accelerate its development. It will open up space for innovation, better user experience, savings, and long-term growth.

„Also, new technologies such as virtual and augmented reality will become available to a large number of people“⁴.

⁴ Anderson N., (2019) Are You Prepared for the Coming 5G and Wi-Fi 6 Disruption? [https://www.wwt.com / article/are-you-prepared-5g-wifi-6-disruption](https://www.wwt.com/article/are-you-prepared-5g-wifi-6-disruption)

2.2 WI-FI 6

„Wi-Fi 6, like earlier Wi-Fi 5 and Wi-Fi 4 technologies, is based on IEEE 802.11 network standards and comes with improvements that will help process more and more data from various devices,- while paying special attention to the safety of users who use it“⁵.

The main advantage of Wi-Fi 6 technology is a speed increase of up to 40% compared to Wi-Fi 5 technology. This is achieved by better coding of data, which increases the bandwidth of the wireless network. Compared to the previous standard, due to constant advances in technology, chips that encode and decode signals are becoming more and more powerful and can store ever larger amounts of data.

„Because of this progress, the amount of data packed into the same radio waves has also increased. Likewise, there have been major improvements in speed on networks using the 2.4 GHz frequency. Although the industry has switched to networks that use the 5 GHz frequency in recent years, with this progress it is possible to use the 2.4 GHz frequency in addition to the 5 GHz frequency, which is better in closed spaces because it passes through the walls themselves better“⁶.

One of the new features brought by Wi-Fi 6 is that smart devices such as laptops, tablets, mobile phones and others that have Wi-Fi 6 technology enabled have a longer battery life.. This contributes to saving on the device's battery itself - because Wi-Fi will spend more time in idle mode, thus saving energy“⁷.

„One of the main problems with the current Wi-Fi 5 network technology is a large number of users connected to the same access point, and it often happens that the network itself slows down traffic or even stops working due to an excessive number of devices connected to it. Wi-Fi 6, with its advanced technologies and the development of new chips, eliminates the problem of network downtime and, in the case of a large number of users connected to the network, improves the speed up to 4 times compared to the previous technology“⁸.

This progress will be most evident in public places where we have a large number of people, such as sports and cultural events at airports, hotels, large shopping centers, and large offices.

2.3 WI-FI 6 AND 5G TOGETHER IN THE FUTURE

„WI-FI 6 and 5G technologies meet the basic conditions that future applications require, which are requirements for high speeds and very low latency“⁹.

As Wi-Fi technology has much lower costs of reflection, deployment, and scaling compared to mobile technologies, especially in places where there are large numbers of people, it will continue to be dominant for business and home environments, i.e. for devices such as desktop computers, tablets, smart TVs and printers. The fifth-generation mobile technology will be oriented toward mobile devices, smart cars, and smart cities because it enables a greater range compared to Wi-Fi wireless technologies.

⁵ Hoffman C., (2020) *Wi-Fi 6: What's Different, and Why it Matters* - <https://www.howtogeek.com/368332/wi-fi-6-what%E2%80%99-s-different-and-why-it-matters/> IDC, (2018) *Multicloud is the New Normal* - https://www.cisco.com/c/dam/global/en_uk/solutions/cloud/overview_cloud_business_cloud_advisor_infobrief_eng_FY18Q3.pdf

⁶ Hoffman C., (2020) *Wi-Fi 6: What's Different, and Why it Matters* - <https://www.howtogeek.com/368332/wi-fi-6-what%E2%80%99-s-different-and-why-it-matters/> IDC, (2018) *Multicloud is the New Normal* - https://www.cisco.com/c/dam/global/en_uk/solutions/cloud/overview_cloud_business_cloud_advisor_infobrief_eng_FY18Q3.pdf

⁷ Hoffman C., (2020) *Wi-Fi 6: What's Different, and Why it Matters* - <https://www.howtogeek.com/368332/wi-fi-6-what%E2%80%99-s-different-and-why-it-matters/> IDC, (2018) *Multicloud is the New Normal* - https://www.cisco.com/c/dam/global/en_uk/solutions/cloud/overview_cloud_business_cloud_advisor_infobrief_eng_FY18Q3.pdf

⁸ Hoffman C., (2020) *Wi-Fi 6: What's Different, and Why it Matters* - <https://www.howtogeek.com/368332/wi-fi-6-what%E2%80%99-s-different-and-why-it-matters/> IDC, (2018) *Multicloud is the New Normal* - https://www.cisco.com/c/dam/global/en_uk/solutions/cloud/overview_cloud_business_cloud_advisor_infobrief_eng_FY18Q3.pdf

⁹ Anderson N., (2019) *Are You Prepared for the Coming 5G and Wi-Fi 6 Disruption?* <https://www.wwt.com/article/are-you-prepared-5g-wifi-6-disruption>

„The difference between WI-FI 6 and 5G technology is in network management. Wi-Fi technology uses the so-called unlicensed frequency spectrum for data transmission, which means that every house can have its own Wi-Fi network without obtaining a license for its use. However, as "neighboring" networks use the same frequency spectrum, there may be interference in data transmission“¹⁰.

„5G technology uses a licensed frequency spectrum, licensed by mobile network operators. Performance such as speed and latency on devices will depend on the proximity of 5G base stations. While there will be no interference due to multiple devices in the same place because the spectrum of frequencies is large and each mobile operator has its spectrum“¹¹.

Due to the advantages and disadvantages of both technologies, they cannot function independently on a global level, but will cooperate and provide the basis for the development of new technologies, applications, and business solutions.

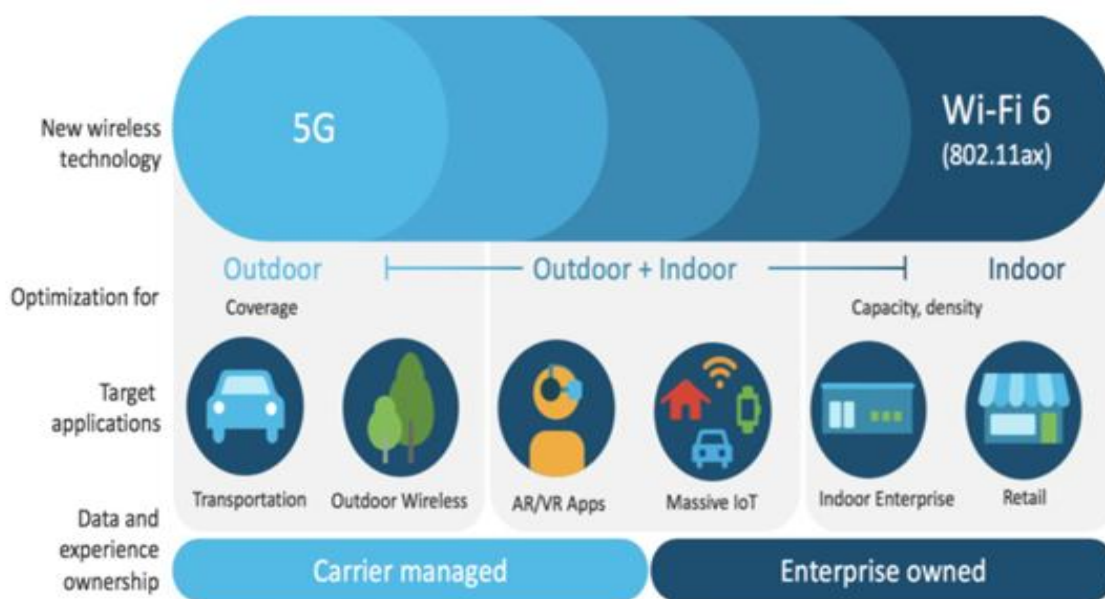


Figure 3. Application of 5G and Wi-Fi 6 technology,
Source: <https://medux.com/blog/next-generation-wifi-6>

3. AUTOMATION IN COMPUTER NETWORKS

„Network automation is the process of automating the configuration, management, testing, deployment, and operation of physical and virtual devices within the computer network itself“¹².

Innovations in the fields of virtualization, open-platform controllers, Software Defined Networks (SDN), Intent-Based Networking (IBN), and programmability contribute to automation.

3.1 SOFTWARE-DEFINED NETWORKS

¹⁰ Andra U., (2019) Connecting the Unconnected: 5G and Wi-Fi 6 Will Play a Pivotal Role in Bridging the Digital Divide - <https://blogs.cisco.com/sp/5g-and-wi-fi-6-bridging-the-digital-divide>

¹¹ Anderson N., (2019) Are You Prepared for the Coming 5G and Wi-Fi 6 Disruption? <https://www.wwt.com/article/are-you-prepared-5g-wifi-6-disruption>

¹² Buvat J. et al, (2018) Reshaping the Future Unlocking Automation's Untapped Value - <https://www.capgemini.com/wpcontent/uploads/2018/10/Report-%E2%80%93-Reshaping-the-Future-Unlocking-Automation%E2%80%99s-Untapped-Value.pdf>

„Due to the increasing demand for new applications with as little maintenance costs as possible, IT companies face the problem of maintaining so many new applications and devices in a the classic way - by opening new departments and hiring more people. They are turning to a new trend that increasingly accepts IT as a service, leaving some services such as network functionalities and devices to be managed by external companies or, if possible, by internal business users“¹³

Therefore, looking at the ever-increasing number of network devices, the complexity of networks, and the increasingly difficult management and control of networks and monitoring of new security requirements, led to the creation of a new technology called software-defined network management (Software Defined Networks - SDN). „The very definition of a software-defined network is that it "physically separates the control from the data room layer in such a way that the central controllers have an abstract view of the network". The architecture of software-defined networks consists of infrastructure, control, and application layers that serve to redirect traffic, manage and control devices and applications that send requests to network devices“¹⁴.

The main advantages of software-defined networks are the possibility of automating network functionalities, the possibility of implementing the network as a service, better management of server load, and better and safer access to private networks. In addition, better monitoring of network systems and visibility of applications in the network is enabled.

3.2 VIRTUALIZATION

The virtualization model, which has already radically changed computer services in the world, has also been adopted in computer networks in the form of network functions virtualization (Network Functions Virtualization - NFV). Virtualizing network functions is a way to reduce costs and speed up the deployment process for network engineers by separating functions like encryption from dedicated devices or moving them to virtual servers. (IDC, 2018).

Internet Service Providers (ISPs), instead of using or buying expensive traditional hardware solutions, can now buy and use cheaper servers, switches, and storage to run virtual machines that are used to perform network functions. In this way, a large number of functions are collected in one physical server, which enables the reduction of costs, energy, and the space itself that would be occupied by traditional hardware solutions. If there is a need to add new network functions, in this case, a new virtual server is simply added to the existing infrastructure.

3.3 INTENT-BASED NETWORKING

The core goal of network teams is to continuously deliver applications, services, and protection. While software-defined networks offer important advances in automation, they are only part of the solution. Organizations also need continuous network monitoring and optimization to support increasingly dynamic and digitally driven business models. To achieve this, networks must understand the purpose of the business change itself and monitor the dynamic conditions in the network, so that they can continuously adapt to that purpose. Because of these changes, the online world is turning in the direction of Intent-Based Networking (IBN).

¹³ Rosencrance L., (2021) *Software-defined networking (SDN)* <https://www.techtarget.com/search/networking/definition/software-defined-networking-SDN>

¹⁴ Rosencrance L., (2021) *Software-defined networking (SDN)* <https://www.techtarget.com/search/networking/definition/software-defined-networking-SDN>

3.4 CONTROLLERS WITH OPEN PLATFORMS

Interfaces for programming applications (Application Programming Interface - API) on the controllers allow the controller to integrate and exchange information with the neighboring network, information services, heterogeneous infrastructures, and other domains in the line of business. „This turns the network into an open platform that can accept policies from applications and devices, take advantage of the automation of centralized higher domain policies, and verify that the system itself meets the needs of the business“¹⁵.

3.5 PROGRAMMABILITY AS A NETWORK FOUNDATION

In order for Intent-Based Network Controllers (IBN Controllers) and systems to scale and realize their full potential, they must be built on a programmed physical or virtual network infrastructure. Programmed devices, interfaces, and programmable integrated circuits form the basis for an intelligent network. In order to adopt more effective automated systems, IT teams are moving away from traditional command line interface (CLI) based technologies to access network management. Instead, data room interface models that provide consistency, openness, structure, and efficiency are increasingly being adopted.

4. SOFTWARE-DEFINED WIDE AREA NETWORKS (SD-WAN)

„As today's trends lead to an increasing number of services in the cloud, and IT systems become more and more distributed, there is a problem of maintaining such large systems that are constantly increasing. This creates the need for software management of networks in a large geographical area (Wide Area Networks - WAN), which consist of many local area networks (LAN), and this management is called Software Defined Wide Area Networks (SD-WAN)“¹⁶.

SD-WAN networks work on the principle of centralized management of the broadband network using a central management application, which in most cases is located in the cloud. By doing so, the system control is separated from the hardware components of the system, and because of this, network management is simplified and service provision is improved. „As the number of cloud services increases, and thus the number of devices and applications increases, traditional methods of maintaining wide area networks, e.g. individually manually configuring routers and gateways with the help of scripts, I can no longer keep up with that growth and additional complexity of the system. The aforementioned challenges are successfully solved by the SD-WAN network and offer simpler management of large and complex networks“¹⁷.

Equipment using SD-WAN technology is managed in such a way that network administrators write business-aligned rules and run them on a specific part of the system. Operational rules are automatically generated and downloaded to all SD-WAN devices at the time of system policy creation or modification.

„The advantages of SD-WAN network technology are“¹⁸:

- cost savings,
- agility,
- performance monitoring,

¹⁵ Arend C. et al, (2017) IDC FutureScope: Worldwide Enterprise Infrastructure - <https://www.idc.com/getdoc.jsp?containerId=US43137417>

¹⁶ Sturt R., (2021) What is SD - WAN? - <https://www.netify.co.uk/learning/what-is-sd-wan>.

¹⁷ Sturt R., (2021) What is SD - WAN? - <https://www.netify.co.uk/learning/what-is-sd-wan>.

¹⁸ Sturt R., (2021) What is SD - WAN? - <https://www.netify.co.uk/learning/what-is-sd-wan>.

- speed of implementation.

Cost savings are achieved by the fact that SD-WAN technology makes it easier to move a non-critical part of the traffic to a much cheaper broadband part of the Internet. „Likewise, centralized management based on business policies allows network engineers to place more or less traffic on broadband networks at any time without having to reconfigure routers and gateways. Another area of cost savings is that network engineers will no longer need to travel to remote locations to configure new devices since management is centralized“¹⁹.

SD-WAN improves the performance of cloud-based applications by making it easier to deploy access points in remote offices. It eliminates the need for round-trip traffic through a central Internet access point and can reduce latency and improve user experience for cloud-based applications.

„Deploying network technology and equipment in a new location is much easier with SD-WAN technology than with the traditional approach of deploying and configuring routers and gateways. A network engineer designs a network node on a central management application and then the SD-WAN device is sent to a remote location and connected by someone with little or no IT skills. After switching on, the device joins the network and connects to the central SD-WAN controller, which secures and configures the new devices and then places them on the network“²⁰.

5. MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

„A large number of devices and the arrival of new technologies make it difficult for network engineers to design, monitor and manage the network, so today more and more attention is being paid to the development of machine learning and artificial intelligence (AI) technologies“²¹.

The role of artificial intelligence is; to mediate real-time communication between computer networks and ensure that all interactions between them receive the best possible quality of service from available connections. „And if machine learning and artificial intelligence will create a new approach to the design of computer networks, the human element itself will not disappear, but artificial intelligence will show us new ways of designing faster and more profitable networks, but still the construction of the network must be done by people. The combination of human intellect and creativity with the great computing power of artificial intelligence will create a situation where new design and management techniques can emerge“²².

In addition to the simpler design of computer networks, artificial intelligence will also help in the management, maintenance, and protection of computer networks. „Today, networks are monitored with algorithms that look for irregular accumulations of traffic and activity that may be the result of malicious activity, such as distributed denial of service attacks. As the artificial intelligence driving these algorithms becomes more intelligent, it will find increasingly faster and safer methods of predicting future threats and cleaning the network itself of unwanted traffic“²³.

Because of all these possibilities provided by artificial intelligence for computer networks, it actually represents a revolution in the world of networks and network technologies. Especially if you consider that the world today is at a turning point in which it will be decided how we use the networks. It will change forever thanks to technologies like the Internet,

¹⁹ Sturt R., (2021) What is SD - WAN? - <https://www.netify.co.uk/learning/what-is-sd-wan>.

²⁰ Sturt R., (2021) What is SD - WAN? - <https://www.netify.co.uk/learning/what-is-sd-wan>.

²¹ Apostolopoulos J., (2019) Improving Networks with Artificial Intelligence - <https://blogs.cisco.com/networking/improving-networks-with-ai>

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²³ Apostolopoulos J., (2019) Improving Networks with Artificial Intelligence - <https://blogs.cisco.com/networking/improving-networks-with-ai>

autonomous vehicles, and increasingly connected smart city systems. Artificial intelligence is causing and will continue to cause a complete rethinking of whether current business models and services are conducive to providing the best possible user experience and the very profitability of those models.

6. BLOCKCHAIN TECHNOLOGY

Blockchain technology is transforming the entire global digital economy. It is a completely new concept. Integrating Blockchain technology into smart cities will play a major role in connecting all smart city services in the future. The mentioned technology can be used in smart contracts. Smart contracts enable transparent and integrity transactions without the need for an intermediary. Which makes the process easier, cheaper, safer, and faster. Blockchain technology will help in processing invoices and various types of transactions, managing facilities, or facilitating and sharing energy through a smart grid.

7. CONCLUSION

„As today's world becomes increasingly driven by exponential growth in the technological needs of the business and private worlds, it becomes increasingly digitized, distributed, connected and diverse“²⁴.

Also, due to this inexorable growth, IT teams are finding themselves reaching a point where the complexity of networks exceeds the ability to effectively manage and secure the networks themselves. What has already become a need today are new systems that combine technologies such as automation and machine learning, (Buvat et al., 2018) that help simplify technological operations in various systems. Now we are coming to the threshold of a new era of networking in the technological world, in which the traditional outdated ways of building and managing the network will be broken and the future will be embraced more. That future will be driven by technologies that can solve all the challenges required by the new world in completely new ways. By using them in crisis management, we can change the approach from reactive to proactive management and thereby increase the efficiency of procedures, i.e. reduce losses.

By doing so, these technologies will support the growing needs of the market for increased scale of use, agility, and security, and thus will enable the continuation of new trends that will further change the digital world. By increasing the security of network systems, business continuity is improved and improved, with its two basic components: high availability and disaster recovery.

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