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KEY INFORMATION TECHNOLOGIES OF INDUSTRY 4.0

KLJUČNE INFORMATIČKE TEHNOLOGIJE INDUSTRIJE 4.0

Summary: *In the last ten years, three new information technologies have emerged, representing the realization of old (by the time of emergence) theoretical concepts, but new in creativity and innovation, as well as incredible potential for the realization of revolutionary ideas and changes in all areas of human activity, which by one name they call 4th Industrial Revolution or Industry 4.0. They are: Big Data Analytics technology, Cloud Computing and Blockchain technology. Each of them individually represents the realization of new paradigms of computer data processing, which could not be practically implemented until the development of information and communication technologies, especially the Internet, Web applications, new operating systems, network technologies, mobile telephony, technologies of advancement of hardware performances, internet of things, etc. The primary aim of this paper is to get acquainted with the characteristics of these technologies and their potentials, their advantages and disadvantages in relation to traditional technologies, identification of areas and ways of their both current and future applications. The ultimate goal is to explain the incredible potential of these technologies, creating the foundation for their combined application in the creation of new Industry 4.0 products, which should result in a synergistic effect.*
Keywords: *Big Data Analytics technology, Hadoop, Mapreduce, Cloud Computing, Blockchain technology, Bitcoin, P2P network*
JEL classification: *M 150*

Rezime: *U posljednjih desetak godina, pojavile su se tri nove informatičke tehnologije, koje predstavljaju realizaciju starih (vremenom nastanka) teorijskih koncepata, ali novih po kreativnosti i inovativnosti, kao i nevjerovatnom potencijalu za realizaciju revolucionarnih ideja i promjena u svim oblastima ljudskog djelovanja, koje se jednim imenom nazivaju 4. Industrijska revolucija ili Industrija 4.0. Radi se o Big Data Analytics tehnologiji, Cloud Computing i Blockchain tehnologiji. Svaka od njih pojedinačno, predstavlja realizaciju novih paradigmi računarske obrade podataka, koje nisu mogle biti praktično realizovane sve dok se nisu dovoljno razvile ICT, a posebno Internet. Primarni cilj ovog rada je upoznavanje sa karakteristikama tih tehnologija te njihovim potencijalima, prednostima i nedostacima u odnosu na tradicionalne tehnologije, identifikacija oblasti i načina njihove, kako trenutne, tako i buduće primjene. Krajnji cilj je objašnavanje nevjerovatnih potencijala ovih tehnologija i stvaranje temelja za njihovu kombinovanu primjenu u kreiranju novih proizvoda Industrije 4.0, koja bi trebala da rezultuje sinergetskim efektom.*
Ključne riječi: *tehologije nalize velikih podataka, Hadoop, Mapreduce, klaud računarstvo, blogčein tehnologija, bitkoin, P2P mreže*
JEL klasifikacija: *M 150*

1. INTRODUCTION

"Any sufficiently advanced technology is indistinguishable from magic"
Arthur Clarke

"Technology does not drive change, it enables change"
Anon

Recently, the speed of development of new technologies, primarily information and communication technologies, is reaching unprecedented proportions and enabling such changes with the realization of which hitherto unattainable goals have been achieved. In addition, through the combined application of these new technologies, a synergetic effect is achieved regarding the increase of efficiency and effectiveness of companies, their profitability, and consequently improving the standard of living, i.e. improving the quality of life of each individual.

Throughout the history of human civilization, one of the major activities of humans has been production. Initially, people engaged in manual production, material processing and other activities, through which they sought to transform everyday materials from nature into appropriate products that would make it easier for them to solve problems from daily life. Before the advent of manufactories and the development of more modern production technology, there was an era of pre-industrialization, in which the main part of production was focused on textile production and numerous jobs in textile production, and is considered to be a transitional period between the establishment of manufactories in medieval cities and the true industrialization of the late 18th century. In the second half of the 18th century, the invention of the steam engine began, thus beginning the era of industrialization. The great upheaval that this occasioned in the production process is called the Industrial Revolution. The revolution was neither sudden nor quick, but a long and slow process during which simple hand tools were replaced by complex machines, which greatly increased the productivity of any kind of human labor. With the finding of the first source of oil, and the methods of oil exploitation, then the invention of alternating electricity, steel, gasoline engine, steamer, aircraft, telephone, begins the era of the second industrial revolution. The third industrial revolution, which can also be called the digital revolution, is the transition from analog and electronic technology to digital technology, which began to develop in the early 80s of the last century and continues to develop today. The main feature of this period was the mass production and widespread use of integrated circuits and technologies based on them, including computers, mobile phones, and fax machines.

As already mentioned, the world is on the threshold of a new industrial era, based on the ever-accelerating development of new technologies, but above all information and communication technologies (ICT) and the Internet, and various types of smart devices. Key ICTs that represent pillars of The 4th Industrial Revolutions are: Cloud Computing, Big Data, Blockchain, which provides near-absolute security, i.e. protection of information against unauthorized use (Cyber Security) and Internet of Things (IoT), which allows smart devices to connect and communicate.

The new industrial period, or the new industrial revolution, is called Industry 4.0, and refers to a new approach to industrial production in which one works closely with the latest ICTs and simultaneously uses them in the production of new products and services, which will increase his or her quality of life. Given the increasing competition in the market, and the presence of technologies with almost unlimited application potential, new ways are constantly sought to implement new developments in industrial production with the aim of surviving in the market, which is becoming more uncertain and challenging or gaining an advantage over competition and providing greater profit.

Significant progress in certain areas of research has led to the emergence of new technologies, which are associated with a new industrial paradigm and which form the basis for its application and development. These are Cloud Computing technology, Big Data technology, Blockchain technology, Internet of Things (IoT) technology, robotics, artificial intelligence, 3D technology, Smart technology, or the production of cyber-physical systems, which incorporates electronic elements into physical products (telephones, television, vehicles, buildings, houses, kitchens, cities, factories, etc.…), and nanotechnology and biotechnology. This paper will only discuss the first three of listed technologies, which we believe have the greatest (revolutionary) potential to change things for the better (for buyers and both manufacturers and sellers) and therefore represent the key IC technologies on which 4th The Industrial Revolution rests.

The main goal of this paper is to get acquainted with the most important elements and characteristics of technologies, which form the basis of the emergence and progress of the 4th industrial revolution, and their potentials and prospects, as well as a comparative analysis of advantages and disadvantages over traditional technologies. Another, no less important goal of this paper, related to creating the basis for their combined application in creating new products of the 4th Industrial Revolution, is to identify the most suitable areas and ways for their, both current and future applications.

In order to achieve this goal, it was necessary to conduct research using appropriate combinations of numerous methods, such as method of analysis and synthesis, deductive method of inference, method of abstraction and concretization, method of generalization and specialization, method of proof and refutation, comparative analysis and compilation, the method of content analysis of scientific literature, as well as other methods.

2. INDUSTRY 4.0: CONCEPT DEVELOPMENT, SIGNIFICANCE AND RESEARCH

The 2006 High-Tech Strategy for Germany gave rise to the concept of Industry 4.0 (BMBF 2006; Topčić 2020), and the term "Industry 4.0" was officially introduced in 2011 at the Hanover Fair in Germany (Kagermann et al. 2011). There is Industry 4.0. described as the integration of information and communication technologies into an industry with the intention of achieving networking within the entire value chain (Barreto et al. 2017).

Since that moment, all the leading developed countries of the world have been intensively paying attention to Industry 4.0 and its segments through various normative and legal documents: Germany since 2014, through national projects of high technologies (BMBF 2014), USA through the national strategy of innovational development - A National Strategic Plan for Advanced Manufacturing (NSTC 2012), UK in the national project "Eight great technologies" (UK Department for Business, Innovation and Skills 2013), France through the strategic program New Industrial France (2015) has developed a plan of scientific and technological modernization for 2016–2020 (NISTEP 2015), China is encouraging a number of projects to implement the Industry 4.0 concept through the Made in China 2025 strategic plan developed in 2015 by The State Council of China (Ma 2018) Other countries are also taking part in the practice of developing national strategies for the development and encouragement of industry 4.0.

Simultaneously with these processes, Industry 4.0 is increasingly present in scientific papers and research. At the same time, the frequency of conceptual and theoretical papers is higher, although recently empirical contributions have become quite numerous (Dohale and Kumar 2018; Piccarozzi et al. 2018). In scientific papers focusing on Industry 4.0 and individual segments of Industry 4.0, the authors deal with: analysis of current literature, possibilities and practice of application of Industry 4.0 and its individual segments, as well as implications for scientists and managers (see Dohale and Kumar 2018; Piccarozzi et al. 2018; Oztemel and Gursev 2018).

3. BIG DATA

Thanks to the continuous emergence of new technologies and the rapid development of information and communication technologies, which have the potential to enable the realization of some old but advanced concepts, a huge amount of information is being generated in the world today, which doubles every three years (Marr 2018). In order to have at least an approximate representation of what the 1,200 exabytes amount of information looks like, which is estimated to have been generated in 2013 (Mayer-Schönberger and Cukier 2013), in the case these data were in the form of printed books, they would cover the entire United States surface in a thickness of 52 layers. Due to the fact that such a large amount of data at that time was almost impossible to store (due to the high cost of external memory), let alone process (especially not in real or reasonable time) using traditional methods of storing and processing data, a new paradigm of storage, processing and managing the large amount, variety and speed of data processing called the Big Data concept has emerged. The practical implementation of this concept was only possible when new technologies such as Hadoop technology with its associated components HDFS operating system and MapReduce technology emerged, which will be discussed in more detail later.

According to data from April 2014, every minute internet users send 204 million emails, generate 1.8 million likes on Facebook, send 278,000 tweets, post 200,000 images on Facebook, and 216,000 images on Instagram, search 2.4 million terms on Google, upload 72 hours of new video content; Skype users get 23,300 hours of connectivity, Amazon makes $ 83,000 in online sales, Apple users download 48,000 apps, etc. (Knoblauch 2014).

According to the data on December 1, 2019, at around 6.30 pm, there were approximately 4.4 billion internet users and about 1.7 billion websites, about 198 billion e-mails were sent per day, about 5.3 billion google searches were made, about 5 million blog posts have been posted, about 580 million tweets have been created and sent, 5.4 billion videos have been uploaded, about 64.3 million photos have been uploaded on Instagram, there were 2.36 billion active facebook users, 354.3 million active tweeter users, 287.5 million skype calls, about 109 thousand hacked pages, 543 thousand computers sold, 3.3 million smartphones sold, 337 thousand tablets sold, 5.6 billion GB of internet traffic was generated etc. (Internet Live Stats 2019).

All these huge amounts of data, which are generated minute by minute and grow exponentially, need to be stored somewhere, and if needed processed too, then the processing results analyzeed, the results of the analysis presented, and finally concrete business solutions proposed based on the results obtained. Realization of these activities in real time, and the very often unexpected and surprising conclusions are made possible by the Big Data concept. It is a concept that falls within the field of Artificial Intelligence or more precisely the field of Machine Learning, although it does not attempt to "teach" a computer to think like a human (Mayer-Schönberger and Cukier 2013, 11).

The basic characteristics of business conditions of companies in the contemporary environment are the exponential growth of dynamism and complexity. Dynamic growth refers to the process of permanent changes in the environment, the intensity of which ranges from small but frequent to deep, comprehensive and radical, which is becoming more frequent, while the increase in complexity occurs as a result of increasing changes and relates to the increase in the number of influencing factors to the business as well as the growth of their mutual relations. A factor that significantly influences the enormous increase in business complexity is the accelerated growth in the amount of data available, which is a result of the rapid development of information and communication technologies, and above all the Internet, and the improvement of hardware capacities (higher capacity at a lower cost and increased speed of access to external memory, then higher processor capacity and speed) as well as software capacity, which refers to the increased number of new applications. "According to Eric Schmidt, President of Google, a total of 5 exabytes of data were created from the onset of civilization until 2003, representing the amount of data that is being created today within two days." (Lazarević 2015, 38)

The vast amount of data generated and stored (meaning available) applies to almost every area of life and business, from nutrition, medicine, sports and entertainment, through manufacturing, commerce, finance, marketing and telecommunications, to management of security system and protection of environment. Such exponential growth in the amount of data generated and stored in electronic form at the same time required new approaches to their processing, based on the use of information and communication technologies that go beyond the limitations of human cognitive and analytical capabilities. This has led to the development and realization of a new concept in data analytics called "Big Data Analytics".

Generally speaking, the Big Data concept is based on the application of sophisticated statistical and mathematical algorithms and methods on huge amounts of data in order to increase the accuracy, that is, increase the probability of the results obtained. Big Data is a concept that is based on predictions, and the special quality it possesses is based on the ability to perform well because it uses large amounts of data, and with the passage of time and the use of new data produces more qualitative and accurate results.

In addition to the basic condition for the successful operation of a system that refers to a very large amount of data, an additional condition is needed, such as high processing power (processor speed, word processor length) and the memory space on which all this data will be stored, as well as special technologies for more efficient storage, access and processing of these data, and later analysis and presentation of the results obtained (Hadoop and Spark technologies). Since these limiting factors, necessary for its implementation, have not been sufficiently developed or were too expensive a few years ago, Big Data technology is only emerging at the present time, when these conditions can be ensured without significant financial investment.

After all, Big Data can be defined as a technology that enables the collection, storage in electronic form and processing of large amounts of structured, semi-structured and unstructured data in real (reasonable) time (Stupar et al. 2018, 256). According to another definition, which places emphasis on data analytics tools and techniques, Big Data is all data that cannot be managed or analyzed using standard data analysis tools and techniques (Manyika et al. 2011).

Figure 2: Increasing the amount, variety and complexity of data
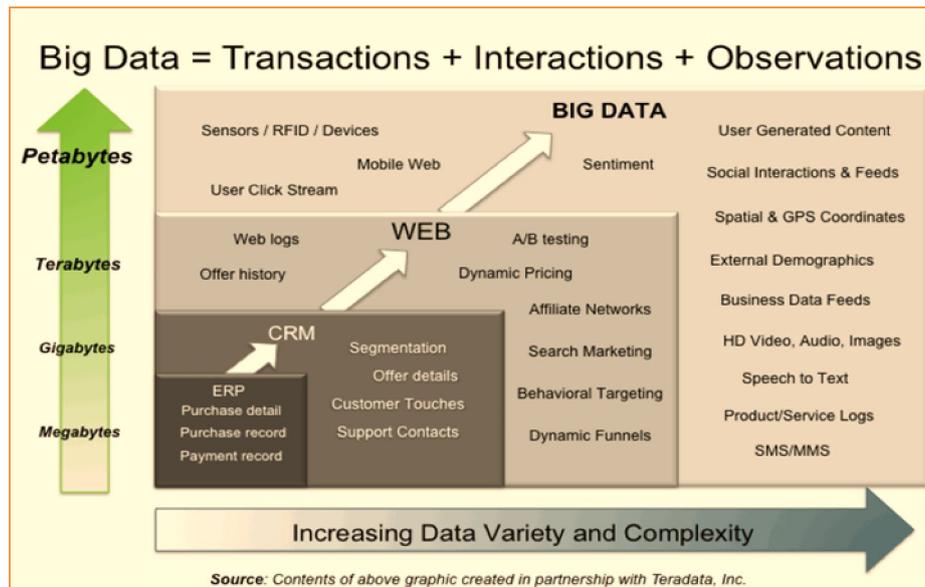
Source: Marjanović 2014

3.1. Features of data that is subject of the Big Data concept

The most commonly used definition of the Big Data concept, which focuses on the characteristics of large datasets that are subject of data collection, storage in digital form and analysis (processing), is the definition, often referred to as "3V" by initial letters:

- Volume -a large amount of data that is collected, stored, processed and distributed for analysis
- Velocity - the speed at which new data arrives is enormous and greater than the speed of data processing, and it is a permanent kind of collecting of large amount of data in real time.
- Variety - data is available in a variety of formats and sources, and is in fact mostly unstructured. According to IDC's 2011 International Data Corporation report, unstructured data accounts for more than 90% of all data (Gantz and Reinsel 2011).

Some authors (Zhang 2013) also mention the concept of "4V", where the fourth characteristic starts from the assumption that the data itself has a certain value, and some other authors, as the 4th characteristic instead of value, use veracity - truthfulness (reliability, predictability, accuracy of the data) in terms of the quality of the collected inputs (data) which can vary significantly (and thus affect the accuracy of the analysis, that is, the output, according to the principle of GIGO or Garbage In Garbage Out)). Some again add the 6th dimension of the data "6V" where the 6th dimension is viscosity, which means the data efficiency. Other dimensions of the Big Data concept are also in circulation, such as the complexity of data management given that they come from different sources, the vagueness or uncertainty associated with the results of analysis, verification, that is, checking that the data meet the required characteristics before analysis and validation, or checking after analysis that the purpose of the data is satisfied and consistent, that is, whether the same conclusions can be drawn from the same dataset in repeated analysis (Kocijan 2014).

The latest ten-character approaches, beginning with the letter "V" ("10V" approach) (Jyoti 2018), and forty-two features with the initial letter "V" ("42V" approach), (Shafer 2017), and especially this last one, form the basis for further distinguishing of "ordinary" data from the data that underlies the Big Data concept.

Figure 3. Big Data dimensions according to the 10 V concept

Source: Authors adapted from Jyoti 2018

3.2. Hadoop

Due to the fact that Yahoo and Google had (and still have) a wealth of information, their managers were among the first to understand the value and importance of the data they have, so they tried to find a way to make the best use of that data, giving it some meaning and value. In 2003, Google released a document called the Google File System (GFS) detailing the architecture of the distributed file system they had already created and used for a long time. Subsequently (2004), Google published another document called MapReduce: Simplified Data Processing on Large Clusters (Dean and Ghemawat 2004).

Shortly afterwards, Nutch was created on NDFS (Nutch Distributed File System) which was very similar to GFS and on MapReduce. The Hadoop product comes from Nutch, and it gets its definite physionomy when one of its creators - Doug Cutting joined Yahoo in 2006. The web browser was still called Nutch, and some of the parallel processing software was named Hadoop (named after a toy - an elephant named Hadoop that son of Doug Cutting, creator of Nutch, played with). In 2008, Yahoo promoted Hadoop as an open-source software project. Today, the Hadoop platform and the entire ecosystem of technology is maintained and managed by the non-profit Apache Software Foundation (ASF).

Together with Spark technology, Hadoop is virtually synonymous with Big Data, since the practical implementation of the concept and the goals set would not be possible or achievable without it. Therefore, Hadoop is synonymous with the processing of large amounts of data, which is used by a huge number of companies around the world to provide real-time information quickly and easily.

The theoretical concept behind Hadoop technology is based on the ability to break down big data processing problems into smaller parts, or into simpler ones, so that the analysis of smaller parts of the problem can be performed faster and cheaper. By breaking down complex problems into smaller and simpler parts (subtasks), that is, problems that can later be solved, or processed in parallel or more precisely at the same time, and after completing the processing of subtasks, the obtained intermediate results (solutions) can be collected and grouped or integrated to obtain the final results, enormous savings are achieved in processing speed, that is, shortening the time required to produce the end results.

3.3. Hadoop components

Hadoop is a system software technology that is written in Java and is considered a computer environment (ecosystem or framework) that is based on the HDFS operating system (Hadoop Distributed File System) as a basis for storing data and MapReduce components that is an interface for processing large amounts of data stored with the HDFS operating system.

The four core modules in the Hadoop platform are (SAS Institute 2014):

1. Hadoop Common - libraries and tools used by other Hadoop modules,
2. Hadoop Distributed File System (HDFS) - A Java-based extensible system that stores data on distributed servers before organizing them,

3. MapReduce - software model for parallel processing of large datasets,
4. YARN (Yet Another Resource Negotiator) - a resource management platform for scheduling and utilizing resource requests that come from distributed applications.

4. CLOUD COMPUTING

"Cloud is about how you do computing, not where you do computing."
Paul Maritz, VMware CEO

Cloud Computing is a new concept based on earlier distributed services models created over the last decade, including Utility computing, On-demand computing, Grid computing and Software-as-a-service. Rarely does any computer science term have as many definitions as different translations. When defining any term, it is first and foremost necessary to determine its essence, or its basic meaning, and then to choose the appropriate word or words, which will, to the greatest extent and in the best way, reflect and represent the essence of that term. It is considered by some authors to be a model for providing information services, by others a specific information system architecture and by some a new information technology, while many identify it as On Demand Computing and Utility Computing.

Cloud Computing is, in fact, a new paradigm for computing, representing the realization of a revolutionary idea from the 1960s. Namely, the idea that computer data processing is performed and billed as a service such as the use of electricity, telephone, water and utilities has existed for several decades, but it could not be realized until the technological conditions for its realization were achieved. The technological framework of "cloud computing" was made possible by three technological trends: the maturation of the Internet as an access point to services, advances in computer hardware components and innovations in operating systems and application-based solutions, thus finally creating the conditions for the realization of such an idea.

Just as the use of electricity requires adequate infrastructure (thermal power plants or hydropower plants, power transmission cables, distribution networks, etc.), so the use of Cloud Computing services requires an Internet infrastructure consisting of servers, networks, network protocols, databases and data warehouses, software applications, etc. One of the important reasons for the rapid adoption and popularization of the Cloud Computing concept is finding a viable solution to overcome the problem of constantly increasing needs for computing resources (working or external memory capacity, processor speed, etc.) or less frequently reducing demand due to rapid changes in modern markets and in relation with these changes of user requirements.

Figure 4. The cloud computing stack consists of SaaS, PaaS, and IaaS
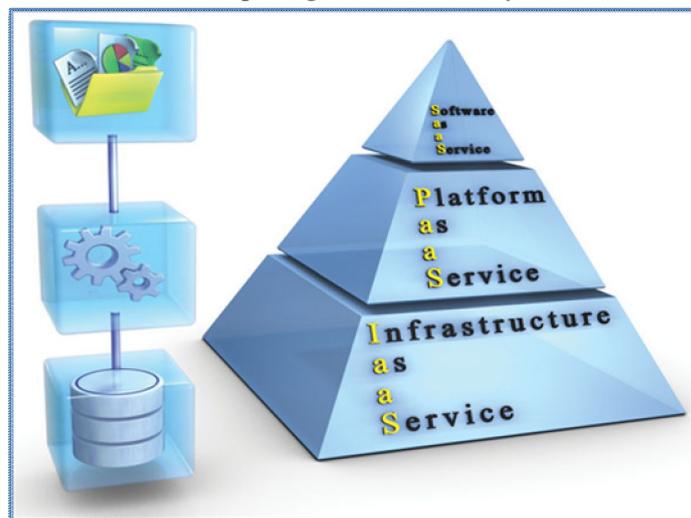
Source: Turban et al. 2015

While there is no unique definition of Cloud computing, it is indisputable that the number, characteristics and functionality of the core elements of the concept, as well as the overall goals, are consistent across all different understandings of the concept. Everyone has a common basic idea - renting computer resources (computers, applications, services) as needed. One of the main reasons for the increasing popularity of cloud computing is the reduced cost of investing in computing infrastructure. Users are offered software, data access, data storage and other services without having to possess either hardware or software or some specific IT knowledge to control the technological infrastructure, but simply use the resources provided, located in the cloud, i.e. on the Internet, accessed through a web browser.

Cloud computing is based on virtualization and the modern Web, enabling it to quickly and dynamically provide various types of computing resources in the form of services, which are provided electronically with minimal management effort, that is, minimal interaction between providers of these services. Service providers must ensure that services are available in a reliable and scalable manner so that multiple clients can use them simultaneously, either directly on demand or in the way and time they need it.

The term of computer resources refers to all computers, applications, services, etc. One of the main reasons for the increasing popularity of cloud computing is the reduced costs of investing in computing infrastructure. Users are offered software, data access, data storage and other services without having to possess knowledge, expertise or control over the technological infrastructure, but simply use the resources provided, located in the cloud, i.e. on the Internet, accessed through a web browser.

Cisco Company defines Cloud Computing as "a model that provides resources and services separate from the infrastructure on which they are based and provided on a demand basis and on a larger scale in a multi-tenant environment". (Cisco n.d.)

Cloud computing is a model that provides comprehensive, convenient on-demand network access to a shared pool of customizable computing resources (eg, networks, servers, warehouses, applications and services) that can be quickly secured and used with minimal management effort or provider interaction service (service provider). This cloud model consists of five essential features, three service models and four deployment models, which will be discussed in detail below. (National Institute of Standards and Technology n.d.)

4.1. Cloud capabilities

As mentioned earlier, "Cloud Computer" allows the user to run the program on the server through an Internet browser without the need for the user to install any additional program on their local computer. It is enough for the user to find the web site on which the corresponding program is located and run it through a browser. The features that Cloud applications can use are:

- Access the website of the application through: desktop, laptop, tablet, iPad or smartphone.
- Access and use any group of individual user information and programs.
- Using email (Gmail, Yahoo, Hotmail),
- Using social networks
- Store and use pictures, music (audio), videos, games,
- Word processing, creating and running presentations, using spreadsheets on remote servers, etc.

What is important to note is that the cloud provides the user with the convenience of not having to install the programs he or she uses or use their own storage media, since all of its data is stored on those remote servers in the cloud.

4.2. The benefits of Cloud for the end user

The potentials of Cloud, which present benefits to the end user, are:

- Access to shared computing resources at the request over the network
- Sharing network resources, servers, host media, applications and services

- A model for using computer resources (servers, disks, operating systems and applications) in such a way that those resources are rented, not purchased
- The ability to rent the resources when the user needs them and to the needed extent
- The resources required are acquired quickly and released with minimal effort or interaction from the service provider
- The end user pays only for as many computer resources as she/he actually uses (pay as you go)
- The user does not have to take care of purchasing hardware and installing and maintaining software (system software, such as the operating system or database and application management system) on that hardware
- All required resources are pre-prepared and configured, so the user does not need to take care of them
- There is no need for additional software licensing, as "server farms or computer farms" are used. (Stupar et al.2020, 75-100)

4.3. Cloud Computing Services

From its begining to today, cloud computing has been constantly changing. At the wery beginning of Cloud Computing development, these were just a few services. Today Cloud Computing offers diferent services (Stipić and Bronzin 2012) with three basic models of Cloud Computing services (see Figure 5.).

IaaS or Infrastructure-as-a-Service is a type of service whose basic feature is that the cloud service provider leases the computer infrastructure to the client, and she/he uses it as if it were her/his own. This is a model by which cloud computing providers offer access to remote servers, networks and storage capacity. They supply clients with these on-demand resources from their large pools of such resources located in their data centers. With this type of service, it is the client's responsibility to take care of their own software applications on leased servers. To deploy their applications, IaaS users install their operating system, their database management system, and their software application on the computers of cloud computing providers.

Figure 5. Management overview in CC models
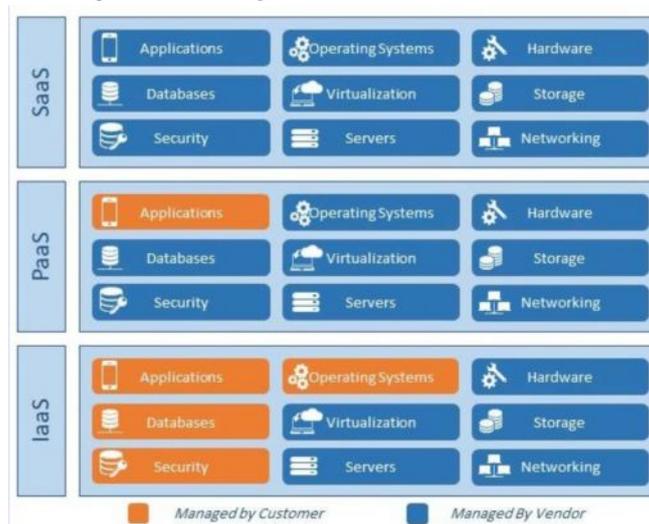
Source: Alqaryouti and Siyam 2018

SaaS or Software-as-a-Service is the oldest concept of "cloud computing" and the first accepted in practice. Existing applications available on the Internet are offered to private and business users (Hotmail, Gmail, Yahoo, etc.). This model provides access to applications and services implemented in the form of a hosted service without first installing it on the user's computer. Installation and maintenance of the application is the responsibility of the SaaS service provider. The applications that are the subject of the service are available from different user devices using a user

interface (e.g. web browser). SaaS makes applications available online in the form of a hired service as needed, rather than having the user buy the program they need and install it on their own computer.

PaaS or Platform-as-a-Service is a type of service, offering a complete platform, both hardware and software (from hardware, ie server, operating system, DBMS to software development technologies such as Java and NET and networking capabilities over the Internet), where companies can run their own business applications as if they were on their own infrastructure. The PaaS model enables the user to run existing applications and to develop and test new Web applications in a fast and easy way.

4.4. Types of Cloud Computing

Private Cloud is a type of Cloud Computing in which cloud service users own their own private cloud, which means that they administer, maintain and use it themselves. They are raising their applications to a technological level that ensures the application of the basic concept of "cloud computing". They must provide all the necessary resources as in conventional computing (hardware, human and network) and must manage them, either individually or with the assistance of specialists, in the same way as in conventional computing. Some analysts do not consider the private cloud as a "cloud" at all.

The public cloud represents that kind of platform, which is accessible and open to the public, regardless of whether they are individuals or organizations. It is owned by a cloud service provider and is implemented in a manner similar to any public (utility) service, e.g. gas, water or electricity supply services. After the service is performed, the service provider invoices what the user actually used, on a Pay-As-You-Go basis. It represents the realization of an outsourcing concept, that is, the idea that customers only lease cloud storage services and data processing services from a service provider and do not engage in administration and maintenance. In this way, the same cloud services are used by multiple users, who share information, which is why they are called public cloud. An example of using public services is companies that often store their data using Amazon Web Services (AWS), Microsoft's Azure, or Google's infrastructure. Because these companies host their data and applications on remote servers, they use the public cloud because they are publicly available cloud services.

A hybrid cloud is a combination of private and public cloud features. Used when companies design their own, private cloud for their important data and applications, and for some other applications that require more users, lease infrastructure from large (professional) cloud service providers, or when a user who builds their IT infrastructure over the private cloud, wants to increase its scope with additional services from the public cloud so that it is invisible (unknown and irrelevant) to the users of the service what part of the infrastructure (own or leased) the services currently operate. Any company can choose either public or private cloud, or any option, that combines the two, so it can be closer to one or the other. The two basic dimensions by which it is possible to estimate how much each "computer cloud" is public and how private, are related to control and ownership of the service and access to the service, so the following combinations are possible: full or partial implementation and ownership, i.e. complete or partial control, and access to the service, which can be extremely exclusive, or completely liberal, when the service is accessible to everyone. The most commonly used combination is the cloud bursting configuration or burst cloud, in which the user uses a private cloud or computer center (data center) during normal load, accessing one or more external clouds during high load periods as needed. Using such a hybrid model, the company only pays for additional resources when it needs them.

Shared cloud or utility cloud is used when multiple clients choose to use the same service and split the cost so that they pay less than each using a public cloud individually. Each client has lower costs than building their own private cloud, while providing a higher level of security and privacy than a public cloud. This cloud model is the sharing of IT infrastructure between multiple partner companies that share common goals, interests and resources. It has all the features of a public cloud infrastructure, but has been implemented as a closed-end solution for a specific community, or group of institutions or companies.

4.5. Cloud Security

When it comes to security in general, and then also the security of information in the cloud, it should be said that it is not a state of absolute security but a process of maintaining an acceptable level of risk. Information in the Cloud must be protected from (CARNet CERT and LS&S 2001):

- unauthorized changes, i.e. ensure integrity,
- leakage of classified information, i.e. ensure confidentiality,
- unauthorized access, i.e. ensure availability.

Some of the basic questions to which potential future users of the cloud service seek answers relate to the physical location, or place (state, city, street, computer) where their data will be transferred and possibly processed, primarily because of the security of that data at that location, and the likelihood of misuse of that information. The answer from the providers of these services is completely logical and reasonable, but to clients, whose security is foremost, unexpected: "The physical location is the least important, and this fact contributes to the greater security of this data, as far as the possibility of destruction, manipulation and misuse of these data is probably more secure in the cloud than it is with clients." Replacing the company's IT infrastructure with cloud and entrusting IT services and data to the cloud service provider brings with it a huge burden, which is reflected primarily in the financial savings for a company that chooses to take this step. With the move to cloud computing, the need to buy and maintain software and hardware, as well as a full-time team of professionals in charge of acquiring and maintaining the company's IT infrastructure, has ceased. Their job is taken over by a professional provider, so they can devote themselves to improving the core business of the company.

All of these things related to the relocation of IT resources, data and jobs to providers may sound very tempting, but many potential cloud service users still fear the fact that their data and resources that serve them to perform important tasks are no longer in their company, which is why they are often restrained from entering into contracts to provide such services. They are aware of the fact that there are many potential problems and risks of such a move. Due to the fact that their data and resources are physically not near or near them, a large number of potential users fear the risk of data misuse or destruction. The greater the importance of data and infrastructure placed on the management of the cloud provider, the greater the need for security and the establishment of many security barriers to safeguard data from unauthorized access and prevent possible manipulation and destruction of data.

5. BLOCKCHAIN

„The Blockchain is an incorruptible digital legder of economic transactions that can be programmed to record not just financial transaction but virtually everything of value."
Don & Alex Tapscott, authors of the book Blockchain revolution (2018)

In general, any exchange of things is transaction-based. A transaction can be defined as the transfer of ownership of a thing from one entity to another, with one entity losing ownership and the other acquiring ownership. A transaction is called the purchase or sale, payment, provision or use of a service, debt or receivable, increase or decrease, receipt or giving, etc. All today's services are based on this principle. In order for the exchange to take place to the satisfaction of both entities, there must be trust between them. When subjects do not trust each other, they usually find a solution by hiring a third entity, called an intermediary. The best, but not the only example are banks. States, courts, attorneys, notaries, prosecutors, real estate agencies and various types of other institutions appear as intermediaries managing records of various transactions. And it is not the ultimate goal of the exchange to eliminate the intermediary and the commission it charges, but to increase the security and speed of transactions, reduce costs, eliminate the potential for fraud, achieve the advancement and liberalization of the transaction business model. Information technology that has the potential to support the achievement of these goals and is therefore considered technology of the future is blockchain technology (Stupar 2019).

5.2. The emergence of blockchain technology

Blockchain technology is the result of the combined application of a number of different and equally revolutionary technological achievements in the field of cryptography and P2P computer networks (networks of distributed computers or Peer to Peer network or partner network), distributed or decentralized network created from connected standalone computers. These networks are built in a way that enables connection, exchange and joint processing of information with all other computers in the network, without giving privileges to any computer - a member of the network, or without central authority.

This technology was first used to support the creation and exchange of the first cryptocurrency - Bitcoin, introduced in 2008. Then Satoshi Nakamoto published a document, "Bitcoin: A Peer to Peer Electronic Cash System", describing "the true version of electronic money through a peer-to-peer network" called Bitcoin (Nakamoto 2008). Technology that enables operation of Bitcoin, Nakamoto defined as: "An electronic payment system based on cryptographic evidence instead of belief, allowing two willing parties to direct transactions without the need for a third, independent party" (Nakamoto 2008).

Blockchain has found a powerful solution to the problem of digital distrust by allowing with no altering or deleting of important information recorded in the public domain. The basic features of blockchain are transparency, timeliness and decentralization. Many identify blockchain technology with bitcoin, although these are two different concepts. Blockchain technology can be said to support the functioning of bitcoin in the same way that internet technology is to support email.

5.3. What is blockchain?

The basic idea behind blockchain technology is taken from accounting, and refers to recording and storage of the financial expression of all business events, or transactions, that have occurred since the company was founded. According to the principles of double bookkeeping, every business event in a company is recorded by changing the balance in the respective pairs of bookkeeping accounts, that is, the balance on one of those accounts, which make up a pair (debit), and another account from that pair or more of them reduce (approve) the total for the same transaction amount or vice versa. An up-to-date record of all changes (transactions) in the accounts and the balances of those accounts is recorded in the general ledger or balance book (Stupar 2019, 341).

By analogy, a ledger with all changes (transactions) in all ledger accounts since the company was established is the same as a blockchain record (master blockchain file) with all transactions from the beginning of record keeping.

Traffic accounting (change) in company ledger accounts is stored in one place (usually on a company computer or somewhere in the cloud) and there is no transaction verification by third parties, and blockchain address register (the address in the blockchain is the same as the accounting records), together with the transactions that relate to them, is stored on a large number of dislocated computers of powerful features (server or node) around the world, which participate in the verification of each transaction, and their owners receive an appropriate reward for it.

In the first case, it is the internal general ledger of one company balance, and in the second case it is a public (global) book of balances of all transactions, which may relate to dealing with cryptocurrencies, real estate, gems, etc. In the first case, it is a central record, that is, record in one location (computer), so it is possible that anyone who has access to this data can simply and easily manipulate the content of transactions. In the second case, manipulating the content of transactions in a blockchain file (changes of any kind) is virtually (but not theoretically) impossible, since they are stored in the same form on a large number of deployed computers around the world, so transactions that could possibly be manipulated, should be changed on all of these computers, which seems virtually impossible.

The second level of protection against the manipulation of the content of transactions, that is, ensuring the immutability of the content of once written transactions in a blockchain file is the linking

of transaction blocks into a transaction chain (blockchain). This is done by having a hash[1] - the content code of the previously written block in each transaction block that is (currently) being written to the blockchain.

If someone tries to change at least one character in any (previous) block of transactions written in, it requires changing the hash of that transaction block in the next block, because the modified content of the block does not match the (previous) block of code written in (hash), of the block transaction. Therefore, for the sake of manipulation validity, the hash - code of the modified block in the next block should also be changed, and subsequently, in all other blocks in the blockchain file. Aditionally, such a modified file should be distributed to all servers (nodes) around the world, which seems practically impossible.

The importance of the famous saying "Time is money" gets special value today when financial transactions in an accelerated and dynamic digital environment are much slower than activities where there are no traditional intermediaries, such as sending emails, messaging with Viber, Skype, Whats - Up or work on the Cloud. This fact that banks are slow and inefficient is well known and greatly annoys clients of banks. Why is it like that? Banks are not inefficient and slow because they do not monitor the speed of change in the environment, but because of the need to prioritize the security of information in relation to the speed of their exchange. The bank is, traditionally, the place where its clients' money is safe. As soon as security and trust are not the priorities of the banks, they will not fulfill their basic functions and will disappear. Of course, this applies not only to banks, but to a number of intermediaries in different types of transactions.

In order to solve this problem, banks and other intermediaries must provide the following conditions (Đorđević 2016):

- Information should move through a secure network
- Information should not be manipulated during or after the transaction
- Transaction information must be delivered to the correct recipient
- The speed of information sharing with all parties involved must be as high as possible
- Real-time access to information must be provided for all parties involved.

Blockchain is the technology that provides the aforementioned conditions. Blockchain uses a powerful mathematical algorithm that can provide maximum security for transactions using cryptographic methods.

Blockchain is a public, digital and decentralized ledger based on a distributed database that permanently records all transactions between two parties from the start of the application, which does not need to use a separate (third) entity to monitor the transactions, but which contains encrypted data that is not possible to change or interfere with.

"What does that mean? In classic bank transactions between two users, let's call them Ivica and Marica, the bank plays the role of supervisor and notary of transactions. If Ivica sends Marica 10 kunas from his account, the bank will note that Ivica's account is lower by 10 kuna and Marica's higher by equal amount. Why is there a third, independent entity at all? Because it ensures that one user will not intentionally deceive another. This, of course, works under the assumption that Ivica and Marica trust in an independent controller, a bank, which in turn gives the bank considerable power and a source of profit." (Arunović 2018)

Blockchain eliminates a third party, centralized and intermediary, that is to be trusted by both parties to the transaction. This third party in the blockchain is replaced by a decentralized network of "some" computers that validate transactions through a specific mathematical algorithm. The owner of "some" computers can be anyone who applies for such a business and provides the availability and possibility of updating records (blockchain file) to all participants in the transaction at any time of the day, and by confirming the transaction to earn, or "mine" bitcoins or other digital currency that is being "mined". The basic task of miners is to confirm the transactions of the participants in the transaction and to ensure their validity.

Due to the fact that doing this job requires significant investment in equipment and paying for the costs of electricity, administration and maintenance of computers, it is logical that potential miners

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[1] A hash function is any function that can be used to map (convert) digital input data of arbitrary size into a series of fixed-size digital data (hash value). A qualitative hash function is one in which small differences in input data result in very large differences in output data.

will not apply for such work without first calculating costs and revenues. In order for someone to do these jobs, there must be a proper reward for entering and doing such work.

Thus, the participants in the blockchain network are users and "miners". Users cooperate with the miners because the miners maintain the system, that is, record transactions, and the users are important to miners, because they generate transactions for them, which they must confirm (validate) and on which they can earn new amounts of cryptocurrency. Why do miners need to confirm (validate) transactions? In a situation where there is no central authority, all partners (participants) in a blockchain decentralized system must agree, or by consensus, confirm each transaction before it is entered in the blockchain file. They are assisted by algorithms (demanding mathematical formulas) for reaching consensus[2]. There are more of them present but most commonly used are Proof of Work (PoW) and Proof of Stake (PoS).

Proof of Work is the most commonly used method of consensus, that is, confirmation of a block of transactions. In order to validate a block, a miner, or node, must solve a very complex mathematical problem. Why? Very hassle-free, with the help of advanced computers, hash can be created from the data contained in the transaction block. For this reason, the blockchain network had to intentionally make things more difficult by using something called "proof of work". The hash (digital signature) of the new block must be generated according to the current specification of the blockchain algorithm, and this parameter is called difficulty (or the difficulty of the mathematical task). The goal achieved by that is consuming the electricity, which is necessary to prove that the miner has worked and solved the problem. The miner will charge these costs and will be rewarded with a certain amount of cryptocurrency including the transaction price. This process is called mining. The generation of an adequate digital signature of the new block is proof of work in the Proof of Work blockchain system. Miners are competing to be the first to digitally sign a new block and add it to the chain of previous blocks, because that alone provides the appropriate reward in a certain amount of cryptocurrency, which is fixed by the blockchain protocol and the variable amount of cryptocurrency that network users willingly give for their transactions to stimulate miners to verify their transaction. If a miner or a group of them owns the node and maintains the network by more than 50% of the total computing power of the entire network, they can manipulate the system. However, even then, it is not possible to modify transactions already entered, but it is possible to stop recording subsequent transactions.

The Proof of Stake method or "proof of stake" is not a mining method, i.e. no new blocks are logged into a block chain by a mining contest. The new blockchain digital signature generator to be entered in the blockchain must have proof of deposit and a certain amount of cryptocurrency in the account. In doing so, two criteria are key ones for deciding on a potential signatory to a new block of transactions: what amount of cryptocurrency is stored on the account and how long that money is stored on the account.

The greater the amount involved and the longer the time the money is on the account, the more likely it is that the participant in the blockchain will be the future signatory (verifier) of the new block of transactions. In that case, he will be awarded a transaction fee from the block of transactions he has confirmed. If a new transaction block verifier tries to verify fraudulent transactions, he then risks losing all of his stake, both quantitatively and monotonously, because of the expected lower cryptocurrency value that would result from a possible fraud.

Some nodes handle transactions while others confirm them. To avoid or punish fraudulent attempts, nodes lock one part of their assets into a virtual safe with a simple digital signature on ownership.

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[2] Consensus is a decision-making process based on the consent of the majority of users, the primary purpose of which is verification (validation) of transactions.

CONCLUSION

The major advancement of Big Data technology over traditional computing technologies is the ability to store, process in real time and analyze huge amounts of data, both structured and unstructured, in various formats and concepts. Despite the fact that there are other technologies for storing and manipulating large amounts of data, such as Spark technology, Big Data identifies with the advent of Hadoop technology. The two basic elements of Hadoop technology are HDFS (Hadoop Distributed File System) and MapReduce.

HDFS is a specific type of system software (operating system) that allows you to store huge amounts of data quickly and easily on relatively inexpensive hardware, while another element of Hadoop technology - MapReduce, enables you to process that data quickly by dividing the complex processing task into simpler subtasks and then executing them in parallel, and integrating processing results into the end result. Big Data is mainly used to analyze huge amounts of business data and discover new, that is, hidden laws between data, to support better management decisions.

Cloud Computing is by far the most significant and radical innovation in the use of computer services of any kind, both in terms of drastically reducing the cost of managing IT systems, and in terms of releasing the huge amount of human resources in companies that were needed in traditional forms of IT usage and engagement in more creative or more useful businesses. The idea that users of various computer services access the hardware and software resources of computer service providers over the Internet (Cloud) and pay for this service as a utility on a Pay-As-You-Go principle has led most companies to pay off more than to buy their own equipment, develop their own software, pay staff to develop and maintain the information system.

In the simple fact that all of this (contracting with the cloud service provider) is becoming redundant and unnecessary, one can see the revolution of this technology, which is still intensely refined. In combination with Blokchain technology, which can significantly increase the level of data security in the Cloud (which is otherwise the biggest drawback of Cloud) and Big Data technology, which will not be able to be used by small and medium-sized businesses due to the rapid generation of huge amounts of data of which storage requires huge computing resources, cloud computing technology will only gain in importance in the future.

And finally, when it comes to blockchain technology, it should be said that, although it is a relatively new technology, it does signal significant changes in the approach taken so far to implement, process and control transactions. Blockchain technology enables digital information (transaction) to be exchanged between all the nodes (servers) participating in the system and which are large in number. Each node maintains a copy of each relevant information (transaction), so there is no need for a central authority to control the information. This is why control is also distributed, which means that each node can be sure that the information written on the blockchain is correct. This fact also implies the greatest potential of this technology, which is to raise the security of digital data to the highest possible level at the moment, and to eliminate in many fields of application those intermediaries in the exchange of transactions, which exist only because of lack of trust between the exchange entities.

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