Tendencies in the use of Big Data analytics at a global level

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***Abstract*—The current issue of processing big volumes of data leads to a more and more increased interest in the Big Data analytics, as their usage generates solutions for problems in different areas. Taking into consideration the fulminant growth of the data volumes and their complexity, the use of Big Data analytics is becoming a necessity in essential fields such as health, education, banking, marketing and not only. The current society, based on knowledge, makes organizations orient more and more towards obtaining useful information from the data they have with a view to predicting certain evolutions and taking decisions which would offer a certain advantage over their competitors. In this paper, we will expose the current state in the development of Big Data, the main fields in which Big Data has become an indispensable tool, as well as the usefulness of Big Data in developing and implementing the new technologies based on artificial intelligence.**

Keywords — Big Data, Big Data analyses, data analysis, automatic learning.

I. INTRODUCTION

The need to handle big volumes of data is not new, dating from the 1960s-1970s when the first data centers appeared and the development of relational data bases started. Despite the fact that discussions about issues related to big data volumes have been taking place since the '90s when the development of the Internet started, the „Big Data" term became known in 2005 when Hadoop, the Open Source framework developed by Apache was created, which allows the processing of structured and unstructured data from various digital sources.

With the development of artificial intelligence and the appearance of gadgets based on it, the global volume of data has grown rapidly, thus increasing the interest for quick, precise and effective processing of this data. According to the annual Cisco report about the development of the Internet (2018-2023) it is estimated that in the year 2023 the number of Internet users will reach 5.3 billion, which represents a growth of 1.4 billion users compared with the year 2008 (Fig. 1.) [1]. Also, according to the same report, a major growth of the global connections M2M is foreseen (a growth of approximately 2.4 times, from 6.1 billion in 2018, to 14.7 billion in 2023) (Fig. 2.) [1].

Thus, given the circumstances, the use of Big Data is becoming a more and more appropriate choice, due to its ability to provide quick solutions to complex problems, which involves big volumes of data, whose interpretation presupposes the use of advanced and, at the same time, profitable technologies. As a consequence, despite the fact that the concept of „Big Data" has been known for a long time, its usefulness is just starting to be enforced, by developing the technologies used and extending its applicability fields.

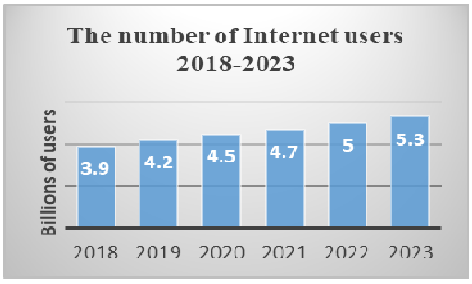

Fig 1. Evolution of Internet users (2018-2023) [1]

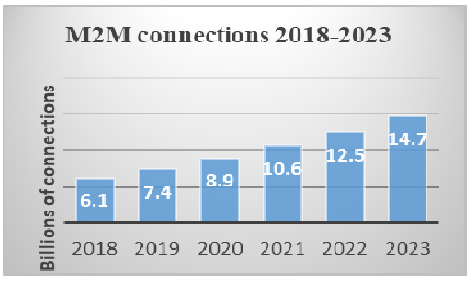

Fig. 2 Evolution of M2M connections (2018-2023) [1]

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In this context, our paper aims to give a brief description of Big Data concept and what Big Data analytics means, as well as an brief overview of already developed applications and trends in the use of Big Data analytics to achieve the goals of sustainable development. The paper is structured as follows: Section II presents the concept of Big Data and Big Data analytics, Section III shows Big Data applications, whereas Section IV unveils some trends in Big Data developments.

II. BIG DATA ANALYTICS

At present, it is not access to data that poses the greatest challenge but interpreting it. According to Oracle, the concept of Big Data refers to „big, complex and varied sets of data, which cannot be managed with the help of the traditional data processing software" [2]. Throughout time, various other definitions have been provided for this concept, such as:

- Big Data represents sets of information with a big volume, huge speed and/or great variety which needs profitable and innovative methods of processing which allow for an improvement in the perspective, the way in which decisions are made and the automation of processes [8].
- Big Data is a term which describes the process of storing and analysing some sets of great dimensions and/or huge complexity, using a series of techniques and tools which include NoSql databases, MapReduce and automated learning [9].
- Big Data consists of the process of applying an increased power of calculation and the latest instruments in the field of artificial intelligence and automated learning to some very big, and frequently very complex, sets of data [10].

The specific characteristics of Big Data consist, according to specialized literature, of the defining „5V": volume, velocity, variety, veracity and value [3, 4]. George Firican, from British Columbia University extends this set of characteristics, mentioning ten decisive properties of Big Data: volume, velocity, variety, variability, veracity, validity, vulnerability, volatility, visualization and value [5]. These characteristic properties of Big Data will be described in the following lines.

Volume: this characteristic Big Data property refers to the huge quantity of data that is generated, collected and processed, the quantity of data reaching values which can be measured in petabytes, exabytes or even zettabytes [6]. It is understandable that storing and processing these huge volumes of data with a view to obtaining consistent results represents a real challenge for the companies which own them, as they have to explore new possibilities to handle them effectively.

Velocity refers to the rapidity with which data is generated and the necessity to process it quickly [7]. To keep the pace with this more and more increased velocity of data generation, it is necessary to constantly improve the storing capacity and especially the information processing capacity. Processing velocity is crucial especially if we refer to those fields which need a real-time information processing, situations in which a lower velocity of processing will not lead to reaching the proposed target due to the fact that a piece of information obtained too late is not always valid and becomes, in most situations, useless. A possible solution to this problem could be distributed processing, a variant often adopted in the area of IoT.

Variety refers to the fact that the data comes from various sources such as web pages, documents, social media applications, gadgets which contain data collecting sensors etc [11]. Another defining characteristic of this data is that it often is of different types and formats. The challenge in this case is to find optimum solutions to process these packets of structured, semi-structured and unstructured data by choosing the right instruments and applications.

Variability reflects both the number of data inconsequences and the inconsequences in the data flow [5]. The flow of data loading may have fluctuations with different causes, one of them being, for example, the emergence of some data loading peaks when it comes to social networks when certain events appear or take place [11].

Veracity refers somehow to data quality, taking into account the moment and the context when it is collected as well as its source of origin. Data veracity is very important given that in every situation it is desired that the data obtained is not compromised because of using imprecise data. In order to limit the negative effects and the risks that may arise in case some possibly inconsistent data is used, it will be subjected to cleaning, filtering and normalization processes, meant to ensure the best possible accuracy, before it enters the proper analysis process.

Validity is a property quite similar to veracity, the difference being that it refers strictly to the accuracy and correctness of data which is about to be used in the analysis process. In order to ensure the quality of the results obtained, it is necessary that the data collected goes through an in-depth cleaning process.

Vulnerability is another extremely important aspect which deals with ensuring data safety. Any gap in the data security system can be exploited and it can become extremely dangerous considering both the big volume of potentially compromised data, its value and, in certain situations, even the large number of people who can be affected as a consequence of a possible cyber attack (such an example could be represented by compromising the user accounts in a certain IT system).

Volatility refers to the time period in which certain data is usable/relevant. Considering the high costs needed to store and ensure the safety of big data volumes, companies have to take decisions about establishing some policies in this respect. It is, nevertheless, a major problem which must be approached carefully, given the fact that a balance must be maintained between the process of increasing lucrativeness and the process of ensuring a functional data recovery system.

Visualization of the data reflects the difficulty of processing and interpreting it. Taking into consideration that fact that classical instruments are not, generally speaking,

adequate to work with these big data packets because of functionality limitations and the inefficiency regarding the response time, for an efficient processing it is necessary to use various other instruments such as tree maps, parallel coordinates, circular network diagrams, cone trees etc [5].

Value of the data signifies the extent to which the data is significant for the proposed analysis. Practically, this characteristic can be considered the most important of them all due to the fact that it directly determines how valuable the result obtained after the analysis of the respective data is.

As an advanced analytics form, Big Data analytics aims to discover hidden information like patterns, correlations, trends or behavior to support decisions.

Given the Big Data features mentioned above, it is a complex process, through which raw data is refined into useful information. Fig 3. presents this process.

Fig. 3. Big Data analytics process [12]

III. BIG DATA APPLICATIONS

At present, the Big Data phenomenon is gaining more and more field in various areas, due to the fact that it allows to obtain valuable results within a relatively short time frame, under the circumstances of approaching some optimum exploitation solutions. As a consequence, an orientation towards valorizing the Big Data potential becomes obvious in fields such as: marketing, media, banking, health, education, research, smart cities, agriculture, environment, transportation, aviation, telecommunication, resource management, infrastructure, security, public services, commerce and so on.

In the following, we will present some interesting applications that use Big Data in some of the above-mentioned fields.

Big Data in health. In the field of health, Big Data is generally used to discover certain correspondences between various factors in order to create new medicine and to predict the evolution of certain diseases or the probability of their appearance. In this respect, the genomic research based on Big Data, has increased and it is meant to identify the biomarkers and the genes specific to a certain illness in order to identify the possible health problems a pacient may have in the future. With the help of the Big Data analytics, hidden patterns, unknown correlations and other perspectives by examining some sets of data at a large scale are discovered [13]. The increased efficiency in this case is due to the fact that by using Big Data much bigger volumes of data can be analysed in a relatively short period of time. An example of such a study is the project "Precision Medicine Initiative", initiated in 2017 in the USA in order to accelerate progress towards the era of precise medicine, the short-term objective being to obtain some results regarding cancer and diabetes, and the long-term objective being to obtain certain information applicable to the field of health, in general [14].

Also, using Big Data has proved to be useful also when it comes to predicting the evolution of certain pandemics or the risk of their appearance. The most recent contribution of Big Data in this respect has to do with the COVID-19 pandemic, which, through the considerable impact it has had on society, has led to a major mobilization in the field of research in medicine, a continuous struggle to control it taking place. In this case, given the huge volume of data generated, the use of Big Data, of artificial intelligence and the appropriate instruments and working techniques had a determining role in understanding the pandemic and gaining control over its spread in a timely manner [15].

Big Data in education. When it comes to the field of education, there is an upward trend in the use of Big Data, given the permanent growth of the studies made in this area, which, in general, cover four main research topics: the trainees' behaviour and performance, modeling and storage of educational data, improving the educational ecosystem and integrating big data in the curriculum [16]. Given the changes that appeared in the educational system at a global level over the past two years, largely due to the COVID-19 pandemic, it is understandable that the volume of data in this field has grown enormously, by moving some activities in the online and the sudden evolution of educational platforms. Thus, both the volume of educational materials and the applications and working instruments in this field have increased.

There are many studies made in the field of education by using Big Data, one of them being that made in 2019 by Youngsik Hwang from Indiana University, USA, in order to discover a conceptual model which generates the way in which the use of data creates a better internal structure of an institution and affects its institutional efficiency [17]. In this study, three different entities form higher education were taken into consideration: student, parent, institution. The conclusions of this study lead to the idea that, although the use of Big Data in education is still at the beginning, we have the premises to obtain some remarkable results in the future when it comes to doing some educational reforms meant to increase institutional performance.

Big Data in the financial field. Taking into consideration the big number of events in the financial field which take place on a daily basis and the constant growth of transactions in the online environment, the use of Big Data in this field has become a necessity, although the concept of Big Data in finance and banking is a relatively new one.

According to a recent study, there are some financial areas which can be remarked for their direct connection to Big Data: financial markets, online credit companies, financial management, bank credit risk analysis. The conclusions of this study attest to the fact that Big Data has revolutionized the financial industry especially by means of the real time information of the capital market and by a growth in the level of detecting and preventing fraud as well as by increasing accuracy of the risk analyses through the process of automated learning [18].

Big Data and Smart cities. The concept of smart city is considered more and more, due to the impact that its implementation has when it comes to improving performance in various fields such as: public services, transportation, energy, health etc. Using the Big Data analytics has major contributions to making the activity in these fields efficient, both by finding some solutions to reduce costs and resource consumption and by increasing the level of comfort of the citizens and improving the services offered. The concept of *smart city* originated in the 1980s, and, so far, it has had an accelerated development pace.

In the research "Applications of big data to smart cities", published in 2015, as a consequence of identifying situations in which the Big Data analysis can be used in order to implement the concept of smart city, seven stages on which attention should be focused in order to put this plan into practice are enumerated [20]:

- Identifying the mission, vision and operating objectives related to putting the concept of smart city into practice;
- Establishing the policies, principles, resources and orientation regarding the use of ICT and Big Data;
- Designing and building an adequate infrastructure to implement the concept of smart city;
- Identifying the priorities and using them to determine the fields in which a major effect can be obtained through little investment;
- Integrating the infrastructure, services and smart applications to improve the citizens' level of comfort;
- Using the data collected to optimize the services and identifying the areas which need improvement;
- Creating some new opportunities for development by monitoring the current evolution and analyzing the effects produced as a result of the current implementation.

The emergence and evolution of the implementation systems for the infrastructure of smart cities is largely due also to the fulminant development of IoT, which generates huge quantities of data through the internet connected devices, their number and diversification being in a continuous growth.

Big Data in agriculture. Big Data plays an important role as regards the transition from classical agriculture to intelligent agriculture, which presupposes the use of advanced technology to increase productivity. Whether we talk about the improvement of the route traveled by agricultural machinery with the help of the GPS, or about optimizing costs and production by interpreting the data offered by various sensors, using Big Data technologies plays an essential role in modern agriculture. A relevant example of the role of Big Data in developing smart agriculture is the model of the crop monitoring system developed in China and implemented since 1998 in order to track yield for seven important crops: wheat, corn, rice, soy, cotton, colza and sugar cane. In this respect, the system performs a monitoring with the help of the satellites and takes over certain parametres from the soil with the help of the WSN networks (wireless sensor networks) [21].

In the paper "Agricultural remote sensing big data: Management and applications" they describe the role that Big Data plays in implementing the systems for the improvement of productivity in agriculture and a series of requests that Big Data technologies must fulfil for subsequent development, are identified: quick and reliable remote sensing data, the efficient organization of data, the capacity to process data at a global scale, developing some instruments dedicated to drawing information by means of remote sensing and so on [21].

Big Data in telecommunication. Given the continuous diversification of the services offered by the suppliers in the field of telecommunication and the increase in the number of users, the volume of data that they collect is in a continuous expansion. Thus, using the Big Data technologies in this field is an adequate solution to increase profitability and to improve the quality of the services offered but also to generate ideas to increase the level of data security and protection. In order to keep the pace with the evolution of the telecommunication systems, the companies in the area have to adopt new technologies and approach methods, in order to optimize the consumption of resources. In this respect, one of the main concerns is developing the wireless networks, in the detriment of the classical ones, but handling the continually growing complexity of these systems is currently the great challenge. Despite these challenges, using the Big Data technologies is beneficial the Big Data analytics helping the network operators create an efficient resource management, offer better and better services and have an efficient network maintenance and lower operating costs [22].

Big Data in the field of transportation. Another important field in which the use of Big Data is more and more frequent is that of transportation. Companies in this field channel their efforts to improve services, increase productivity and optimize costs. In this respect, Big Data proves to be a useful tool which supplies valuable information with the help of which companies optimize their transportation time and the respective costs by selecting the routes which offer an increased productivity, taking into account various factors such as traffic situation, the drivers' physiological condition, meteorological factors etc. Also, with the help of Big Data other data regarding transportation, distribution and storage of the goods is obtained. In a recently published article, about the application of Big Data and Data Mining technologies in the field of road transport, the authors identify a series of fields in which using these technologies has a major impact [23]:

- Analysis of the data regarding the loading of transport nodes;
- Assessing time waste as a consequence of erroneous supply chains;
- Researching the prognosis methods of the transport systems congestion;
- Assessing the drivers' physiological condition;
- Analysis and prediction of the influence of the meteorological factors on the route;
- Researching the emergency situations based on road accident statistics;

IV. TRENDS IN USING BIG DATA ANALYTICS

Considering the increasing number of situations in which the use of Big Data analytics represents an important factor in optimizing activity in certain areas, we can notice that orienting towards the use of Big Data analytics has become a necessity for more and more companies from various fields of activity. The accelerated development of technology, the increase in its accessibility and the different changes regarding consumers' orientation towards using certain gadgets, applications, tools, also establish the directions towards which Big Data analytics are heading. Taking into consideration the above mentioned as well as the numerous studies and research regarding the trends in using the Big Data analytics, a series of main development directions can be identified:

- *Orientation towards smartphone*. The use of smartphones has a sustained growth, as well as M2M connections, which makes it do that they produce most of the data. Thjs development is also sustained by an increase in connectivity speed, an extension in the coverage areas and the more and more increased accessibility. According to Cisco, more than 70% of the global population will have mobile connectivity by 2023, the speed of mobile connectivity and WI-FI will treble by 2023 (in comparison with 2018), and 5G speed will be 13 times higher than the average mobile connection by 2023 [1].
- *Orientation towards wearable data analytics and IoT*. Another side of current technological development is the one represented by wearable technology. The growth in the diversity of these smart gadgets and the appearance of new functions have led to a constant development of the field. As a consequence, wearable technology generates an important data flow for IoT, which is also under constant expansion. The sustained evolution of this field allows the collection of an impressive volume of data from individuals, especially dealing with health (vital parameters, behavioral data), one of the major objectives of collecting it being to make decisions after identifying some symptoms or some parameters which indicate abnormalities [24].
- *Edge computing*. As for processing of big volumes of data, optimum solutions are essential to be found, both. Such a solution is edge computing and it presupposes processing the data straight from the gadgets which collect it or in, as close as possible, computational nodes. The use of edge computing considerably reduces processing time and improves the quality of the results, this being a method through which the data loses its value as it is not processed in due time.
- *Quantum calculation*. Considering the enormous volumes of data collected in order to be processed, it is vital for optimum solutions to be encountered in order to process it within time span that it as short as possible, especially since there are situations when the respective data is only valuable for a very short period of time. In this respect, quantum computers are a solution for the quick and efficient data processing.
- *Cloud and hybrid cloud computing*. In order to make data processing cost-efficient, companies tend to use more and more cloud computing and hybrid cloud computing solutions. Choosing such a solution brings a series of advantages such as cost-efficiency an increase in the processing speed, an increase in productivity and performance, flexible scaling etc [25].
- *Machine learning and AI technologies*. Using ML and AI tools represents, in certain circumstances, a solution to process big data volumes. In this situation, the bigger the data volume, the more efficient the result, as access to big data quantities increases speed and the capacity of machine learning [26].
- *Data lakes*. Searching for optimum solutions regarding the storage and handling big data volumes, companies tend to orient towards using data lakes, which is detrimental to data warehouses. Apart from reduced maintenance costs, data lakes offer a series of other advantages, such as: versatility (by storing different types of data, be they structured, semi-structured or unstructured), high accessibility, adaptability, multiple functions.

V. CONCLUSIONS

Considering the above-mentioned, we have identified some areas of utmost importance in which the Big Data analytics play an essential role in setting the trends for development and evolution.

The numerous fields in which the Big Data analytics have contributed to obtaining valuable results, as well as the general tendency to integrate new technologies and methods in various other fields and branches of activity support the idea that using Big Data has or will become indispensable for the companies which handle big volumes of data, in the context of an improvement in the quality of services and lucrativeness. Current studies point to the fact that Big Data has fully proven its usefulness in essential fields such as health, education, finances, telecommunication, transportation, agriculture, even if in certain circumstances, exploiting the Big Data capabilities is still at the beginning.

Also, the development of IoT and a growth in the need to continually adapt to the requirements to increase the quality of services and data security determine companies to adopt new solutions, most of the times based on the opportunities offered by Big Data. In this respect, an essential contribution of the Big Data analytics to developing smart cities, is noticed.

Taking into consideration the variety of fields in which Big Data represents the optimum possibility regarding the efficient data management and the need to handle bigger and bigger and more and more complex volumes of data, it can be said that Big Data is and will continue to be a useful tool in finding competitive solutions for a wide range of sectors of activity.

Considering the continuous changes regarding the new Big Data Analytics technologies, companies have to implement the right solutions to keep a high level of performance and profitability.

ACKNOWLEDGMENTS

This work is supported by the project "Center for the transfer of knowledge to enterprises in the field of ICT - CENTRIC", POC-A1-A1.2.3-G-2015, SMIS Code 2014+ 119722 (ID P_40_305), 5 / AXA 1 / 1.2.3 / G / 13.06.2018, Subsidiary contract no. 15569 / 01.09.2020 / HR / ASSIST"

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