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## Cybersecurity of Business Intelligence Analytics Based on the Processing of Large Sets of Information with the Use of Sentiment Analysis and Big Data

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**Abstract:**

**Purpose:** The research aims to characterize newest solutions, especially with the respect to cybersecurity aspects of Business Intelligence analytics based on the processing of large sets of information with the use of sentiment analysis and Big Data.

**Design/Methodology/Approach:** The working hypothesis refers to assumption that current regulations and security solutions for Business Intelligence analytics based on the processing of large sets of information with the use of sentiment analysis and Big Data is under extreme pressure to meet evergrowing challenges. There are more and more demands from the legal regulators as well as from the market and that creates a lot of problems with data protection. The article uses legal and comparative analysis as well as structural and functional analysis. Additionally, the interpretation method is also present.

**Findings:** Article indicates that the aforementioned issues with the respect to growing importance of internet including the Internet of Things and Internet of Everything are becoming of more and more importance and cannot go with appropriate level of cybersecurity since the data they collect is of the great importance. The trends immanent to Industry 4.0 require from business more effort and customer orientation. Growing population and access to Internet demands larger scales of business operations.

**Practical Implications:** As a result of conducting the research, it is possible to identify threats and present some recommendations for cybersecurity of Business Intelligence.

**Originality/Value:** This is a complete research for Cybersecurity of Business Intelligence analytics based on the processing of large sets of information with the use of sentiment analysis and Big Data.

**Keywords:** Cybersecurity, critical infrastructure, business intelligence, Big Data.

**JEL classification:** H56, F52, O33.

**Paper Type:** Research article.

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## 1. Introduction

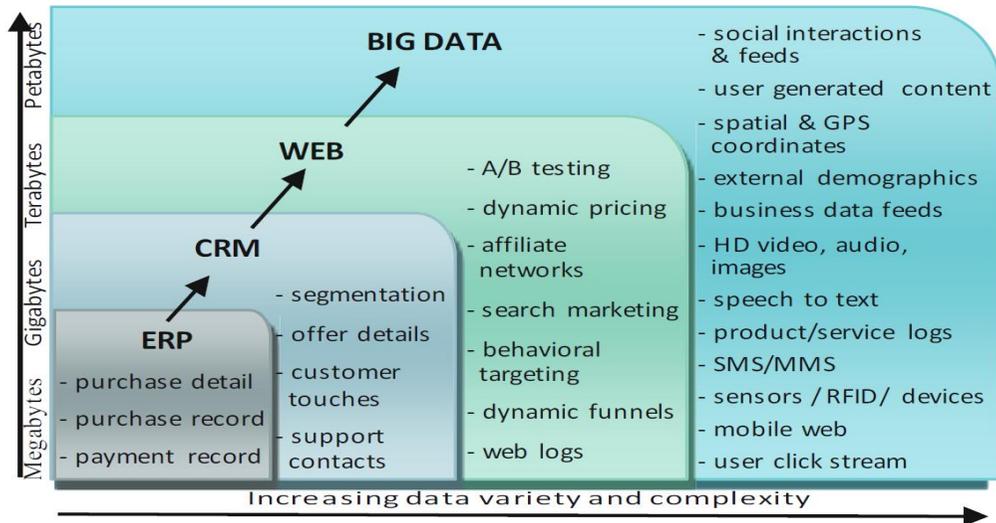
When addressing the conditions for the development of business analytics based on ICT and Industry 4.0 it is extremely important to consider the phenomena of globalization because although it has been observed for many generations already, yet its newest phase has been strongly connected with cyberspace (Jakubczak, 2016). Many strategic documents on both international and national levels recognize its importance. EU's Cybersecurity Strategy for the Digital Decade (Strategy) states: *Cybersecurity is an integral part of Europeans' security. Whether it is connected devices, electricity grids, or banks, aircraft, public administrations or hospitals they use or frequent, people deserve to do so within the assurance that they will be shielded from cyber threats. The EU's economy, democracy and society depend more than ever on secure and reliable digital tools and connectivity. Cybersecurity is therefore essential for building a resilient, green and digital Europe. Transport, energy and health, telecommunications, finance, security, democratic processes, space and defence are heavily reliant on network and information systems that are increasingly interconnected. (...) The malicious targeting of critical infrastructure is a major global risk. (...)* (European Commission, 2020).

According to reports, despite of the fact that the number of cyberattacks against digital services and finance sector being the highest, cyber readiness and awareness among businesses and individuals remain low (Annual Cost of a Data Breach Report, 2020), and there is a major shortage of cybersecurity skills in the workforce (ENISA Threat Landscape 2020, 2020). Approximately 450 cybersecurity incidents took place in 2019 involving European critical infrastructure elements (Eurostat, 2019). Also the division between conventional and hybrid war is blurred and oftentimes the attacks considered as normal hacker attacks can be in fact a part of hybrid warfare (Jakubczak, 2017).

The development of ICT information technologies, which began during the third technological revolution in the second half of the 20th century, enabled the emergence of computerized business analytics, which is developing now. The development of computerized business analytics based on the use of Business Intelligence analytical platforms and Big Data database and analytical systems as well as Data Science, Data Analytics technology would not be possible without the development of ICT information technologies and advanced data processing technologies typical of the current fourth technological revolution known as Industry 4.0. Also, the technologies of database and analytical Big Data systems would not have developed without the previous three technological revolutions preceding the present stage of technological progress, which in the second half of the twentieth century led to the development of computer science and the Internet. Previous technological revolutions that enabled the development of current solutions for advanced data processing Industry 4.0 was primarily the industrial revolution of the eighteenth and nineteenth centuries, a revolution based on the development of electricity and the popularization of the mass production model based on the

production line at the turn of the nineteenth and twentieth centuries, and the IT revolution in the second mid-twentieth century. These three technological revolutions created the technological foundations for the development of Industry 4.0 technology, including Big Data database and analytical systems. The development of information and Internet technologies that led to the creation of Big Data systems is presented in Figure 1.

**Figure 1.** Development of information, Internet technologies and Big Data.



**Source:** J. Bloem, M. Van Doorn, S. Duivestijn, E. Van Ommeren, *Creating clarity with big data*, Sogeti VINT, 2012, p. 2.

Acquiring, processing and analyzing big data is currently an important aspect of the sciences related to the improvement of computational techniques using modern instruments of information technology and advanced data processing (Chang, 2019). The faster and faster development of ICT information technologies, the development of new Internet media and computerized, advanced data processing technologies Industry 4.0 increases the importance of the application of analytics based on such technologies and formulas of analytical platforms as Big Data, Business Intelligence, Data Science, Data Analytics, etc. in processes of supporting the management of economic entities (Opolska-Bielńska, 2019). These innovative applications should contribute to the activation of economic processes and thus contribute to the improvement of functioning in terms of economic efficiency of both individual economic entities and, indirectly, the entire economy (Antkiewicz, 2008).

The effective functioning of business entities needs secure acquisition, processing, collection, archiving and sharing various types of information for other entities, including unclassified and classified information or personal data. Since the beginning of the development of the Internet, the information resources of the global World Wide Web have been constantly growing as presented in Figure 2.

**Figure 2.** What happens on the Internet in 1 minute?

**Source:** A. Banafa, *The Future of Big Data and Analytics, Conference Paper, November 2015*, (<https://www.researchgate.net/publication/284826598>), access: 21.09.2019, p. 14.

Data downloaded from the Internet may be collected and processed on the Big Data Analytics database and analytical platforms. Structured and unstructured data collected from various websites and social networks, including e.g., images published on Facebook, e-mail content, text comments from blogs, GPS signals from mobile phones, posts by tweets and other social media, etc. Collected in Big Data systems Data sets are typically about 10 percent structured information and 90 percent unstructured data. Various types of unstructured data most often come from various forms of Internet users' activity, i.e., from the above-mentioned content of e-mails, tweets, posts on social networks, the content of telephone calls or photos, videos and other works published and disseminated on social media and online platforms, calls to telephones mobile phones, etc. Therefore, it is important to maintain high standards of personal data protection, including sensitive data that Internet users post on social networking sites. This data should be filtered and removed during analytical processes carried out in Big Data database systems (Banafa, 2019).

The development of analytical techniques Big Data Analytics is determined by the improvement of the instruments of quantitative sciences and quantitative research, which include primarily (Banafa, 2019):

- Statistical instruments that use numbers to quantify data.
- Advanced, computerized data processing technology (data mining) uses the knowledge of statistics and programming languages to search for specific formulas and information contained in the data.

- Typical for the current technological revolution, Industry 4.0 - machine learning technology - (machine learning), which use data mining to build forecasting models used to predict the effects of future processes.
- Dynamically developing technology of artificial intelligence in recent years, which has been using models built on the basis of machine learning in order for machines to operate in an intelligent way, e.g., when playing a game or driving a car (e.g., the Watson IBM supercomputer).

The use of knowledge in the field of quantitative sciences, i.e., statistics and econometrics, enables the improvement of model building issues related to the estimation of utility functions, stochastic dominance, medium risk models, portfolio optimization and other models. These models are used in analytics carried out on large data sets in Big Data database systems. Therefore, analytical processes carried out on large sets of Big Data using Data Analytics or Business Intelligence analytical techniques enable the improvement of management processes for specific risk categories that may materialize in the context of running a business and in other areas of activity of enterprises, public and other organizations (Chang, 2019).

In the currently operating business entities, the key problem that arises in the situation of conducted business analyzes is their time-consuming nature (Grzegorek, 2017). If the company's management needs to periodically carry out analysis to verify their results on an ongoing basis with the changing factors of the economic environment and market conditions, to apply corrections to previously generated reports and operational plans, the entirety of these processes, so it usually requires large amounts of man-hours of employees of analytical departments and managers. In such situations, computerized analytical platforms built in the The Financial Industry 4.0 formula are particularly useful and analytical techniques for conducting business analyzes according to the Business Intelligence formula significantly increase efficiency and reduce the number of man-hours spent on analytical processes (Gendron, 2014).

Achieving a company's competitive advantage can be increased when the information necessary for the management decision-making processes in corporations is obtained, collected, organized and presented in the form of Business Intelligence analytical reports on an ongoing basis (Prokopowicz, 2017).

Analytical processes based on the Business Intelligence formula are defined as a business analytics process consisting in transforming multi-criteria data sets into knowledge necessary for effective and efficient company management. The analytical process carried out according to Business Intelligence consists in organizing and processing data stored in the company's IT system and presenting processed information in the form of extensive reports, enabling real-time multi-criteria, thorough analysis of the company's situation (Fan, 2015). Analyzes carried out according to the Business Intelligence formula give the management staff new possibilities to analyze large data sets in real time, and therefore these solutions for

the use of information technology for the needs of analytical and decision-making processes are becoming more and more useful for entrepreneurs (Tomczak, 2019).

IT companies operating in Poland that provide business entities with specialized software used in analytical and decision-making processes, have also been offering programs for SMEs to generate Business Intelligence analytical reports for several years. In recent years, concepts of building IT platforms have been developed, in which the generation of Business Intelligence analytical reports is combined with data processing technology in the cloud and based on huge data sets collected in Big Data (Olszak, 2014).

## **2. The Scope and Methods of Research**

The study was based on a desk research analysis using quantitative data available for cybersecurity of Business Intelligence analytics based on the processing of large sets of information with the use of sentiment analysis and Big Data. Complex analysis of available literature, legal acts and practical cases was also conducted. In particular the theoretical issues were determined based on the analysis of available books, articles and legal regulations. As mentioned before the practice examples were taken under considerations as thoroughly analyzed. The research methods used in the study included a critical analysis of the literature, legal acts, comparative analysis and secondary data analysis.

Addressing the methodology of sentiment analysis carried out on Big Data Analytics database and analytical platforms it is very important to take under consideration several issues as below. The sentiment analysis was developed on the basis of analytical data obtained from the Big Data database system built and used for research purposes.

In the context of the dynamic development of business analytics in recent years based on the use of analytical platforms installed in Big Data, Business Intelligence and Data Science systems, Data Analytics, etc., in the information resources collected on the Internet, there are many texts, publications, comments and posts regarding this issues (Prokopowicz, 2017). The study of the content of these huge collections of information with the use of sentiment analysis and the statistical processing of the results of the analyzes carried out may be helpful in identifying the currently dominant trends in the field of opinions and assessments formulated by Internet users with regard to specific issues. Many companies and institutions are interested in the implementation of analytics based on Business Intelligence, Big Data, Data Science, Data Analytics, etc., for the purpose of conducting predictive analyzes of complex processes taking place both inside the organization and in the environment of a specific economic entity, including a company, financial or public institution (Banafa, 2019).

Based on the literature review, it appears that the above-mentioned issues of predictive analytics will develop intensively in the coming years. The analysis of big data, carried out with the use of the mentioned Big Data systems, etc., allows for the quantitative examination of a wide spectrum of thousands records of various categories of data downloaded from many websites, containing information on important human issues - social, scientific, political, business and other (Grzegorek, 2017). Many research centers around the world are developing instrumentalized analytical methods for the processing and verification of content downloaded from the Internet contained in large data sets for the purpose of their practical scientific and business use (Sun, 2015).

The authors of this article conducted a sentiment analysis, the aim of which was to examine the awareness of Internet users in the field of information technologies, the technological revolution Industry 4.0 and various risk categories, including the risk associated with the implementation of innovative technologies and business operations (Opolska-Bielńska, 2019). In order to analyze the sentiment of opinions, assessments, and correlations between the key issues of a specific issue, several key keywords were selected that played the role of the so-called sentiment analysis columns. The selected keywords played an important role in the search for various types of texts on the Internet, in which the issues of information technology development, the technological revolution Industry 4.0 and various categories of technological and financial risk as well as other significant determinants influencing the development of analytics based on Business Intelligence were described in various aspects. , Big Data, Data Science, Data Analytics, etc., i.e., particularly important technological aspects of The Financial Industry 4.0.

The main purpose of the sentiment analyzes was to verify the meaning and correlations between key words and to identify key issues and concepts regarded by Internet users to be particularly important in the field of the studied issue. In addition, the conducted sentiment analyzes proved to be helpful in determining the high level of significance of information technology issues, the technological revolution Industry 4.0 and various categories of technological and financial risk as important determinants of the development of analytics based on Business Intelligence, Big Data, Data Science, Data Analytics, etc., i.e., significant technological aspects of The Financial Industry 4.0. The literature review shows the high importance of The Financial Industry 4.0 in the context of the development of business, economic and financial analytics techniques as well as in predictive analyzes of determining the development of enterprises and institutions in the coming years. The realized sentiment analyzes were used as an alternative instrument to verify this type of thesis.

In order to carry out sentiment analyzes in accordance with the research assumptions set out above, several keywords were selected that played the role of the so-called columns, i.e. analytical reference phrases for the study of correlation, dependencies, frequency of occurrence in various Internet texts, publications, posts, etc., both of

these keywords and related or accompanying other terms, words and phrases (Warren, 2016). Due to the multifaceted nature of the subject matter under study, the conducted research project concerning the conducted sentiment analysis was divided into several stages, for which several sets of key terms were selected. The results of the conducted research presented below come from the first stage of the planned research project consisting of successive individual stages of the sentiment analyzes carried out. The division of the entire research project into several stages of consecutive sentiment analyzes for specific key terms was related to the technical capabilities of the analytical platform installed in the Big Data database system, which was used during the research project (Grzegorek, 2018). For selected keywords, the sentiment analysis was carried out with the use of Google Trends analytical instruments.

An analytical application known as an Internet robot of the Big Data system was built for the purpose of analyzing the sentiment on the Internet resources of information concerning the issues of data transfer security in the Internet. The Big Data system robot was built in the formula of a specialized ICT system operating on the Big Data database system platform for the purpose of targeted monitoring and data collection from the indicated websites and web portals (Ostańska, 2019). The Big Data system robot downloads and collects data from Internet information portals, including social networks, which provide information in the Open Data formula for each Internet user without the need for authorization, i.e., logging in to a specific portal. Each information downloaded from the Internet and registered by a robot of the Big Data system, in addition to the downloaded data, is supplemented with technical information containing a link to the page from which it was downloaded, the date of its publication or download depending on the scope of data returned by the website (The Internet of Everything, The age of Internet ubiquity has arrived, 2014).

A Big Data robot can monitor changes in the state of information resources contained on monitored websites in order to periodically update the data downloaded from these websites. Monitoring of the information content of selected websites and web portals conducted permanently or cyclically by the robot of the Big Data system allows you to update the information downloaded and stored in the Big Data database system on an ongoing basis, which is the material necessary to analyze the sentiment of Internet users in a specific field of knowledge (Celiński, 2019).

Big Data robot is adapted to the structure of a specific Big Data database system to perform its functions effectively. The currently developed Big Data database systems have modular structure of interconnected system modules, applications that can be independently expanded (Gwoździewicz, 2017). The key modules include a module for monitoring the state of data on selected websites, a module for collecting data, archiving, monitoring and making backup copies. Collecting data from selected websites and web portals from the technical side consists in downloading the content from the source in the original unchanged content and form of information.

Archiving consists in collecting the downloaded data and securely storing it in the Big Data database system and making this data available for other system modules, in which the collected data is analyzed and processed according to specific formulas and analytical tasks (Prokopowicz, 2017).

The process of obtaining and archiving data should be monitored on an ongoing basis in order to verify the correctness of the process, including ongoing monitoring of the issues of reliability, objectivity and immutability of the intended analytical processes of the collected data. Due to the fact that every ICT system is exposed to the occurrence of failures that are difficult to predict, data downloaded from the Internet should be protected against permanent damage. The key issue of the downloaded data security system is making backup copies of the archived data. The issue of improving techniques and instruments ensuring a high level of security of the collected data is necessary to minimize the risk of destruction or loss of research material, which may be caused, inter alia, by cybercriminals trying to break into Big Data database systems (Gołębiowska, 2017).

In addition, an important element of the structure of the Big Data database system is the Internet data monitoring module. This module is equipped with dedicated software that monitors information sources in a defined formula, i.e. selected specific websites and web portals. When new data appear on these pages or new information is published, the system application of the data status monitoring module downloads this new data and sends it to the archiving module. The process of data monitoring and archiving takes place simultaneously.

Another essential element of the structure of the Big Data database system is the module for collecting data from selected websites and web portals. This module consists of many simultaneous robots, the so-called agents, each of which interacts with the monitored source, selected websites at specific and defined time units. Periodicity, including the frequency of data download actions, is determined individually for each agent robot in the range from 1 minute to 365 days. Therefore, the monitoring of websites depending on the dynamics of changes and the number of published data sets and articles containing specific information per unit of time is freely defined according to the planned analytical needs. Besides, the scanning frequency can also be changed depending on the time of day, day of the week, season etc. Each robot-agent assigned to a monitored website that is a data source can simulate the behavior of a human browsing specific websites. Therefore, the way the Big Data robot works does not break the so-called rules of netiquette used by the Internet users (Matosek, 2017).

The so-called robots-agents of the data collection module can operate on one or many selected websites depending on the number of websites and web portals selected for ongoing monitoring. In addition, in order to ensure optimal system performance, each robot-agent of the data collector has its own separate database in

which it saves the downloaded data and therefore limits the amount of data exchange with the archiving module to the necessary minimum.

Each of the robots-agents of the data collector works in the following three modes: production, configuration and debugging. The production mode is based on the fact that the agent informs the monitoring module only about problems and errors that occurred during its operation and conducted interactions with monitored websites. In the configuration mode, the agent not only informs about errors but also about the work progress. On the other hand, the last debugging mode allows you to diagnose at what stage of data retrieval a specific problem occurred. The described robot of the Big Data system usually works in the 7/24/365 mode, and data is downloaded from selected websites continuously.

Data downloaded by specific robots-agents are stored in the data archiving module with a relational database and it is later used by the reporting module generating data for external software, in which the sentiment analysis process takes place in a specific file format compatible with the specific software used during this analysis (Grzegorek, 2011). The data collected in the archiving module can be used repeatedly and retrieved according to the needs from a specific time range or according to the needs of analytical defined criteria, including keywords or specific terms. An important element of the structure of the Big Data database system is the reporting module. This module allows you to generate a report in an Excel format file, which can then be used for the next stages of the analytical process (Wehbe, 2015). The modular structure of the Big Data system robot organized in this way enables the expansion of the entire system with further system elements and functions, and can collect data made available on websites in both unencrypted (http) and encrypted (https) versions (Lee, 2016).

Currently, there are practically no technical restrictions on the possibility of collecting data from other types of internet services such as ftp, e-mail (newsletters) and API to other systems, e.g. library systems, press agency systems, etc. The issue that determines the effectiveness of the Big Data database system is the correct selection of specific data sources, i.e. websites and web portals from which data is collected. The substantive quality of the data collected by the robot of the Big Data system is determined by a specific set of criteria for selecting data sources defined by the analyst conducting the sentiment analysis (Olszak, 2012). Data collected by the system should be standardized (Tomczak, 2019).

### **3. Improving the Security of Data Transfer in the Environment of Big Data Systems and Cloud Computing in the Internet**

The fourth technological revolution, the significant attribute of which is the development of Industry 4.0 technology, is determined by the development of advanced information processing techniques, including Big Data database technologies, cloud computing, machine learning, Internet of Things, artificial

intelligence, Business Intelligence and other advanced data processing technologies as Mining. The aforementioned technologies are successively implemented in the developed and improved security procedures and IT risk management systems, including the collection and processing of data in Big Data database systems (Gwoździewicz, 2010).

The most popular approach is to follow Big Data Security Principles with recognized framework for information privacy—Privacy by Design (Cavoukian, 2021). The paradigm of the aforementioned states *that in the age of big data, privacy cannot be assured just by compliance with laws and regulations* but is has to *be ingrained in organizational design, and hence becoming the default mode of operation*. The principles of privacy can be modified and adopted for big data security - foundational principles for big data security can be recognized as follows:

1. Preventative and proactive security;
2. Security by default—minimal access privilege;
3. Security embedded into design and operation;
4. Defense in depth;
5. End-to-end security;
6. Visibility and transparency for trustworthiness;
7. User-centric;
8. Real-time monitoring;
9. Accountability and traceability.

Protective measures or subsystems consist of deterrence, avoidance, prevention, mitigation, detection, response, recovery, and correction should be part of the big data security management system (Tang, 2015). The Association for Data-driven Marketing & Advertising (ADMA, 2013) have described the big data security best practices:

1. Implementation of end-to-end security measures;
2. Implementation of encryption and key management protocols and systems;
3. Implementation of layered security;
4. Assessment and implementation of vulnerability penetration testing;
5. Clear communication of security policies and the consequences for non-compliance (ADMA, 2021).

In order to review an organization's preparedness for big data security it is useful to turn to big data security maturity model build upon the Capability Maturity Model by Software Engineering Institute (SEI) at Carnegie Mellon University (Paulk, 1995). There are 5 levels in capacity maturity model: initial, repeatable, defined, managed, and optimizing. The software development predictability, effectiveness, and manageability improve as the organization moves up the maturity levels. Respectively, at the:

1. level of *Nonexistent*, the awareness of big data security risk and challenges is absent.
2. *Initial stage*, the entity is aware of the importance of big data security management with the respect to big data security challenges. It starts to deploy new or undocumented processes. The aforementioned can be done *ad hoc*, thus unpredictable results can be observed.
3. *Developing stage*, a complex assessment of big data security risk is done, certain key areas are identified and big data security processes documented.
4. *Defined level*, there is standardization of big data security processes that are already part of business operations.
5. *Managed level*, performance metrics are established to enable measuring of big data security processes against them. Continuous improvement is normal part of the operations.
6. *Optimizing level*, big data security processes are adjusted to achieve optimal results - most sophisticated level of security within the resource constraints.

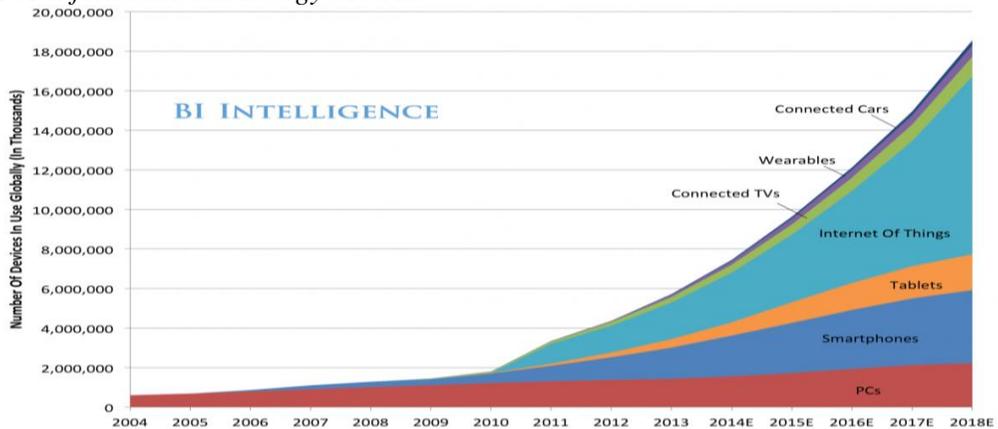
The current development of ICT and Industry 4.0 applications of information technology, including Big Data technology and cloud computing, is largely determined by the development of techniques and devices enabling access to the Internet. The development of the Internet is correlated and determined by the development of information technologies as well as techniques and devices enabling access to the Internet.

Figure 3 below on the issue of the development of Internet access technologies from the level of various ICT information technology devices shows that the share of Internet of Things devices and mobile devices has been growing significantly in recent years, mainly smartphones used as devices enabling access to the Internet and the use of various information services available via the Internet. In addition to information services, Internet users more and more often use mobile devices to make payments related to e-commerce purchases and electronic online banking transactions. On the other hand, in the field of information services, Internet users increasingly gain knowledge from various social networks and portals specialized in the provision of specific information services, e.g., on geolocation in the field, means of public communication, necessary formalities carried out by citizens with institutions and public offices.

Figure 3 shows a significant increase in the number of different devices that allow citizens to access the Internet. Part of the society uses the Internet from desktop computers, however, the number of mobile users of the global network who access the Internet from mobile devices, mainly using smartphones, is growing rapidly. In the following years, the development of the Internet technology based on intelligent solutions is expected, including the use of such new technologies as artificial intelligence, learning machines, the Internet of Things, Big Data database systems, Machine to Machine and other advanced information processing technologies typical

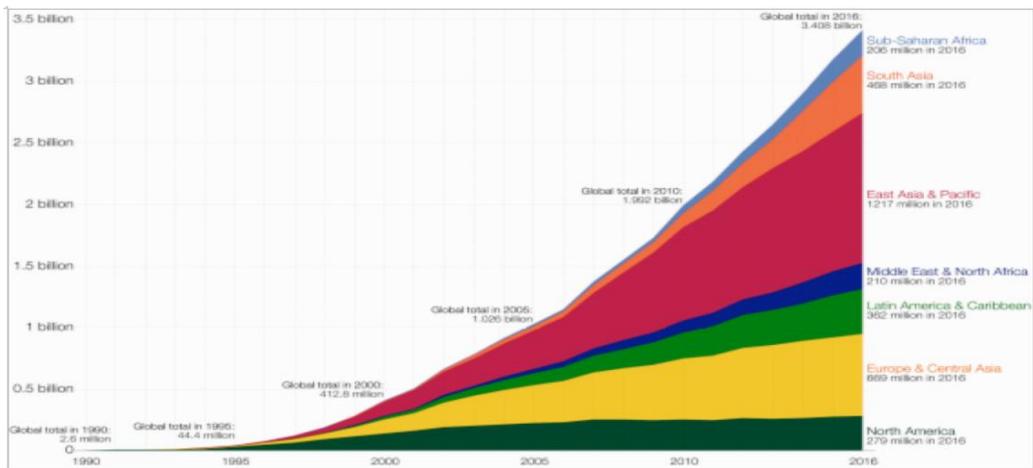
of the current fourth technological revolution referred to as Industry 4.0 (The Internet of Everything, The age of Internet ubiquity has arrived, 2014).

**Figure 3.** Development of the Internet access technology from the level of various ICT information technology devices.



**Source:** The Internet of Everything, The age of Internet ubiquity has arrived, (in:) BI Intelligence Estimates, 24.10.2014, (<https://www.businessinsider.com/the-internet-of-everything-2014-slide-deck-sai-2014-2?IR=T>).

**Figure 4.** The use of the Internet by citizens of different continents of the world since 1990



**Source:** M. Roser, Internet, Empirical View, Growth of the Internet, (in:) Website: OurWorldInData.org, <https://ourworldindata.org/internet> (for:) Internet users are people with access to the worldwide network, World Bank, World Development Indicators, 2016, (<http://data.worldbank.org/data-catalog/world-development-indicators>), International Telecommunications Union. OurWorldInData.org.

The conducted research shows that the development of Internet ICT information technologies and the implementation of advanced data processing technologies typical of the current 4th technological revolution, Industry 4.0, is strongly correlated with the successively increasing scale of the availability and use of the Internet by citizens. Figure 4 (the use of the Internet by citizens of individual continents of the world since 1990) shows the dynamic increase in the number of Internet users on a global scale, including the community inhabiting individual continents.

The conducted research shows that the improvement of data transfer security technology increasingly concerns the processing and movement of data, including various categories of information on the Internet. However, before the improvement of security procedures and IT risk management systems, including the collection and processing of data in Big Data database systems, it was much earlier, i.e., in the 1990s, that electronic banking security systems were improved mainly in financial sector institutions. and then internet banking and now mobile banking. The pioneers in the improvement of these Internet data transfer risk management systems and the improvement of electronic internet banking security systems were and still are commercial banks, which are developing these forms of banking (Prokopowicz, 2011).

In recent years, Poland has continued the process of developing electronic internet banking and the growing interest of bank customers in using this form of settlements and payments. Therefore, it should be stated that the Internet electronic banking is a particularly important determinant that determines the currently ongoing processes of implementing new IT solutions to banking systems and thus the evolution of transaction platforms for financial operations (Prokopowicz, 2016). The most dynamically developing fields of ICT, which determine the next stages of progress in the field of the Internet electronic banking, include the dissemination of standards for conducting financial operations carried out in the so-called cloud as well as the use of large data sets located in the so-called Big Data platforms (Chen, 2014) (Figure 5).

The wording of the so-called cloud means cloud computing is a service enabling the storage, archiving and use of the data collected in this way, which is accessed via the Internet, through computers located elsewhere. Usually, this technology means the ability to use large computing power and memory disks via the Internet, and therefore limiting expenses on own IT equipment (e.g., operating memory) (Szpor, 2017). Using this technology, the so-called Clouds also have other positive aspects that can be described as increasing the user experience (Prokopowicz, 2017). Well, the data located in the cloud can be accessed from any device connected to the Internet, i.e. not only a computer, also from a tablet, smartphone or other online device connected to the Internet (Grzywacz, 2016).

**Figure 5.** Schematic structure of data processing system in a computing cloud.



**Source:** J. Fan, F. Han, H. Liu, *Challenges of Big Data Analysis*, 26.10.2013, DOI: 10.1093/nsr/nwt032, (<https://www.researchgate.net/publication/255687770>), access: 15.09.2019, p. 27.

In correlation with the aforementioned development of information technologies, ICT and Industry 4.0, in recent years the amount of data stored in the cloud on external servers, usually free of certain disk capacities, i.e. part of what is more and more commonly referred to as Big Data, has also been growing dynamically (Strang, 2016). Institutions and companies whose effective operation is currently based on the above-mentioned cloud and Big Data technologies estimate that by 2020 the amount of data components in this way on external servers will have increased many times, which means an increase in the capacity of data storage devices, including large disk capacity, which connected in the cloud with servers enabling communication via the Internet, will create a kind of external data warehouses, which are now referred to as Big Data (Prokopowicz, 2017).

The technological solutions of Big Data that have been developing in recent years are not only large databases, data warehouses allowing for multi-faceted analyzes of huge sets of quantitative data made for the needs of periodic reports submitted to the managerial staff. The currently emerging trends in the development of technology based on Big Data dataset platforms allow for multi-threaded calculations and the reported results of analyzes, usually in real time, and the analyzes carried out on huge data sets allow for comprehensive, multi-faceted risk assessments at the level of the entire entity, i.e. in the company formula *firm-wide risk* (Prokopowicz, 2016). The results of this type of analysis provide the management boards of banks with information on the bank's exposure to a specific risk category and the required level of collateral for given parameters of transactions.

Constantly improved Big Data (Prokopowicz, 2017) technology solutions that function in integration with cloud computing platforms are by financial institutions that have the ability to carry out complex risk analyzes in real time, taking into account many criteria and obtaining a precise result according to the multifaceted parameters (Grzegorek, 2011). In addition, the results of the analyzes may also

include the verification of the company's or bank's current exposure to various risk categories, including liquidity, profitability, credit risk, combined with the issue of financial instruments valuation, research on customers' behavior and seasonal and cyclical changes in demand for individual financial products (Libuda, 2016).

The ongoing development of ICT information technologies and analytics using advanced data processing technologies Industry 4.0, including Data Analytics, Data Science conducted on large data sets collected on Big Data database systems platforms, generates an increase in the importance of improving the security systems of information stored and analyzed in these systems Big Data. Currently, various security tools for data collected in Big Data database systems are used. The basic principle is the parallel application of several types of IT security and compliance with certain procedures for the analysis and protection of systems against the potential materialization of operational risks, including technical risks related to the computer equipment used and specific database technologies as well as personnel risks related to the employees who operate these systems (Matosek, 2017).

An important issue is also whether the built database systems are directly online connected to the Internet or are not permanently connected to the Internet and certain data from the Internet are periodically added to Big Data databases after their appropriate analysis by anti-virus software that detects malicious worms, such as key-loggers and other malicious software created by cybercriminals and used to steal information from database systems of data warehouses and Big Data.

If the Big Data Analytics database and analytical platforms in which the data downloaded from the Internet is collected, then the transmitted data should be encrypted, and the system gateways connecting the Big Data database with the Internet should be equipped with a good firewall and other security filtering the incoming information. If employees operating the Big Data database system use specific e-mail boxes, these should only be company mailboxes and verified in terms of data transfer security on the Internet. The company should have strictly defined security procedures for the use of e-mail boxes, because in recent years cybercriminals have been sending ransomware viruses hidden in e-mail attachments, used to encrypt hard drives used in the databases of company computers and servers.

#### **4. Conclusions**

Cybersecurity awareness in era of growing importance of internet and technical development addressing critical infrastructure is crucial. As explained in this article, it has to be addressed upon two levels - external - legislative and internal - an entity level. There are many regulations that address the problem and it is important to adjust them regularly. With the respect to provision of security by a company there are several approaches and manners that shall be considered - Big Data Security Principles with recognized framework for information privacy—Privacy by Design,

big data security best practices and big data security maturity model build upon *the Capability Maturity Model*.

The conducted research shows the growing importance of ICT and Industry 4.0 information technologies and security in the context of the issues of potential applications of these technologies, including the improvement of business analytics, which dominate in publications. Therefore, the possibilities of using Business Intelligence in the processes of analyzing the economic activity of enterprises, financial institutions, public and other entities are also growing. Business Intelligence multifactorial complex analytical models are used to analyze the quantitative results of conducted scientific research. Correctly applied econometric methods allow for objective processing of large sets of quantitative data, thanks to which research theses are verified (Prokopowicz, 2017).

The use of ICT information technology in the field of econometric and statistical analysis allows for the automation, standardization, objectification of the conducted processes of verification of quantitative data describing complex processes, etc., and reduction of the costs of the conducted analyzes. The computerized processes of using econometric and statistical tools to analyze large sets of quantitative data enabled the development of analytics based on the use of advanced data processing technology Industry 4.0, including data processing in cloud computing, Big Data database systems, the use of Business Intelligence analytical platforms, Internet of Things technology, learning machines, artificial intelligence, etc. Without statistical methods, the effective development of advanced analytics Data Analytics, Data Science, etc. it was not possible. Therefore, without the use of complex econometric models in the verification and analysis processes of large quantitative data sets, the development of scientific research would be much slower than progressing (Opolska-Bielńska, 2019).

The above considerations show that the processes of managing business entities are increasingly supported by computerized analytical platforms equipped with systems such as Business Intelligence, Data Science, Big Data Analytics, which facilitate multi-criteria analyzes and reporting. This reporting would not be possible without the use of complex econometric models, the formulas of which are entered in computerized analytical platforms. Complex, multi-criteria analyzes carried out with the use of complex econometric models for the verification of the activities of large companies require aggregation and analytical processing of large data sets in Big Data database systems (Chang, 2018).

Some IT companies produce applications helpful in conducting economic analyzes, such as Business Intelligence platforms. Increasingly, large and medium-sized companies use these platforms, adapting them to the specifics of their business. In connection with the above, the effective use and continuous improvement of specific complex, multi-factor econometric models used in Business Intelligence, Data Science, Big Data Analytics, etc., significantly supports the processes of

organization management and, by using also statistical methods, allows for the development of various types of predictive analyzes (Tomczak, 2019).

In connection with the development of ICT information technologies and analytics using advanced data processing technologies Industry 4.0, including Data Analytics, Data Science conducted on large data sets collected on Big Data database systems platforms, the importance and possibilities of Business Intelligence applications in the field of system improvement are also growing in the terms of supporting management processes and analyzing the effectiveness of business activities. Due to the fact that during the SARS-CoV-2 (Covid-19) coronavirus pandemic, there was an increase in the scale of digitization and internationalization of economic processes (Golczak, 2020), so the legitimacy of using Business Intelligence and Big Data Analytics in business entities has also increased.

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