

Analysis of Studies on Applications and Challenges in Implementation of Big Data in the Public Administration

Wesley Lourenco Barbosa (Author)

School of Computer Engineering
University of Uberaba
Uberaba, Brazil
e-mail: wlourenc@hawk.iit.edu

Antonio Manoel Batista da Silva (Author)

School of Electrical Engineering
University of Uberaba
Uberaba, Brazil
e-mail: antonio.manoel@uniube.br

Vinicius Silva Flausino (Author)

Dept. of Information and Institutional Research
Federal University of Triangulo Mineiro
Uberaba, Brazil
e-mail: vinicius.flausino@uftm.edu.br

Abstract— The big data – huge amount of data – era has begun and is redefining how organizations deal with information. While the business sector has been using and developing big data applications for nearly a decade, only recently the public sector has begun to adopt this technology to gather information and use it as a decision support tool. Few organizations have so many advantages to harness the potential of the big data as the public service agencies, because of the large amount of data they have access to. However, due to the current theme, there is still a long way to go. Some papers have presented ways in which governments are using big data to better serve their citizens. Nevertheless, there is still much uncertainty about the real possibility of improving government operations through this technology. By analyzing the literature related to the topic, this paper aims to present the areas of public administration that can take advantage of data analysis. In addition, raising the challenges and resilience faced for the insertion of the big data in the public sector is also important. In this way, we seek to understand how public organizations can take advantage of the data that they have, to manage and improve the efficiency and offer of public services to society. The results showed that several organizations can modernize and improve their operations with data analysis, but challenges need to be overcome. Therefore, the big data presents itself as an important tool for the modernization of public administration. (**Abstract**)

Keywords-Big data, data analysis, data science, public administration, public sector

I. INTRODUCTION

The amount of data produced on the global scale is growing at unprecedented levels. According to [1], by the end of 2015, there were 4.6 billion mobile phone users worldwide and about 3.2 billion internet users. With this large number of users, the quantity of data produced daily is gigantic. Therefore, many innovations have been developed to expand the technological capacity to generate, store and analyze data from a wide variety of sources and for a multitude of purposes. Conforming to [2], about 2.5 quintiles of data bytes are produced daily, and by 2018, 50,000 gigabytes of data will be produced per second in the world. This new conjunction of the digital age opens up a range of possibilities for the modernization of public administration through data analysis.

As stated in [3], big data is the way to better understand the demand of society and to use the citizens in the decision-making process. Civil participation in decision-making processes can not be restricted to the electoral process. "Big data is a recent topic in the academic and in the business environments, however, the speed of its growth has transformed management and society around the world" [4]. Therefore, it is important to develop academic works that clearly show the potential of the big data within public organizations. The technology opens a direct dialogue between public entities and the population, furthermore, it opens

perspectives for the creation and improvement of public services, making civil participation more effective in the decisions of the administration at all levels. To achieve this, the public administration needs to adapt to technological trends.

In accordance with [5], big data can help public healthcare, improve efficiency and transparency, which for a long time are among the main objectives of the use of Information and Communication Technologies (ICT) by the public sector. In addition, in public administration, data analysis can provide accurate information to support decision-making. Decisions that are taken on the basis of relevant and targeted information permit the development of better services based on a better understanding of people's needs and demands.

As well as the applications, the limitations and challenges faced by big data technology in the public sector also need to be detailed in more scholarly papers. Therefore, this article aims to be elucidative in describing the process of using big data in the public administration. Given the emergence of the big data as an unavoidable socio-technical phenomenon, it is necessary to question the opportunities and challenges of the adoption of data analysis technologies by the public sector. While the use of big data can help transform government operations, it also presents obstacles that need to be overcome such as financial constraints on IT investment, skilled worker shortage, poor data quality, and resistance to changing organizational culture. Although it carries some risks, the "big

data" revolution presents opportunities to modernize public administration. Hence, this can not avoid the trend of using big data as a support tool for a wide range of purposes.

Therefore, the paper presented here aims to analyze the possibilities and difficulties of implementation of big data technology in public sector organizations. From this analysis, it will be sought to verify the consequences of the application of this technology as well as its effectiveness as a tool for modernization of the current public administration. Finally, it is intended to present the impacts of this technology on public entities and society.

Scholarly papers related to public management backed by technology, such as big data, are not numerous. The connection of these two areas is a relatively new subject, not yet thoroughly explored, thus, the interest in investigating the initiatives in the public sector to use big data. It is important to make this survey to indicate the applications, advantages, and challenges of implementing this technology in public administration. Hence, this study has as academic and social relevance the intention to describe the possibilities brought by the big data to the public management. In addition, this study is considered to be of great importance, helping managers to recognize data science as the way to modernize public administration, so that it adapts to the cultural change brought about by the digital revolution.

II. ELETRONIC GOVERNMENT

The society and the State are changing profoundly, and public administration must adapt to this new conjuncture. There is a continuous and cumulative progress in the use of new information technologies in the public sector. An example of this is the emerging e-Gov project (also called "eletronic government" or "e-government"), which is present in several countries.

The strategic use of ICT has become the enabling element of a new model of public management. This new model has culminated in the emergence of so-called e-government. Electronic government can be understood as a set of modernizing actions linked to public administration, such as the use of technology for the providing of public services, changing the way government interacts with citizens, businesses and other governments.

According to [6], e-government is not restricted to the simple automation of processes and the providing of public services available through online services on the Internet, but it also encourages a change in the way government, through the use of ICTs, reaches its goals to fulfilling its role of the State. This includes improving public administration processes, increasing efficiency, transparency, citizen participation, better governance, and the preparation and monitoring of public policies.

The modernization of public administration requires that public sector entities adopt an integrated and balanced approach of social and institutional dimensions. In this sense, e-government is evolving and preparing to ensure the necessary modernization of the public sector. Through advanced electronic and mobile services, e-government aims to improve the relationship between people and their government, making public services more effective, accessible and in consonance with people's needs. It also aims to increase

the participation in decision-making and make public institutions more transparent and responsible.

It is in this context that the big data is inserted. This technology can potentially lead to innovation and stimulate new or improved services, new insights and ideas. This increases the awareness of the government actions and enables people to monitor and contribute to these efforts. The data strengthens the capacity of governments to formulate and implement integrated policies and enhances the potential for policy integration among government agencies. Therefore, data are in fact the basis of policy integration. To fully achieve the proper use of the data, governments need to be able to make sense of the amount of information they have, which requires analytical tools. Thus, the access to the necessary tools to transform data into useful information is vital. Through powerful algorithms, big data tools and methodologies extract patterns, trends and correlations in the data and present the results using advanced visualization techniques.

The potential of the big data analysis to transform information and data into useful insights, and to support complex and interdependent decision-making processes, is increasingly being recognized by governments. The benefits of using big data for policy integration and service delivery can be significant and tangible for e-government. Big data represents a great opportunity for governments to make use of the data they have at their disposal. The insight into these data enables a more complete view of the challenges and opportunities for social development, thus contributing to the creation of more efficient public policies in line with the needs of the population. The next topic presents a short description of the big data technology.

III. BIG DATA

Efforts to collect, store, and analyze large amounts of data are not new to the technology world. Many companies have collected large amounts of data on their customers to better understand their preferences and provide better services and products. Data analysis is present in almost every aspect of modern society, including mobile services, retail, manufacturing, the financial sector, industries, and science.

The concept of big data began to emerge in the early 2000s. Since then many attempts have been made to find a precise definition for this term. The modern definition of "Big Data" was first presented to the computing world by Roger Magoulas in 2005, in order to define a large amount of data that traditional data management techniques could not manage and process due to its complexity and its size [7]. In addition, [8] stated that "the big data is defined by its size, comprising a large, complex and independent collection of data sets". This data set can not be manipulated with standard data management techniques because of the inconsistency and unpredictability of the possible combinations. However, after reviewing definitions to big data from major technology organizations, the definition presented by Gartner was the most appropriate version found for this paper. "Big data is high-volume, high-velocity, high-variety information assets that demands cost-effective and innovative forms of information processing that enable enhanced insight and

decision-making" [9]. Gartner's definition is broader and encompasses the main aspects of big data.

IV. BIG DATA IN GOVERNMENTS

In today's information society, data is the fuel that powers several entities, and they are rapidly transforming the way people live and work. Big data is treated as the next frontier of innovation, competition and productivity [10]. That is why big data is drawing so much attention and being applied in an increasing number of sectors of the global economy. In the private sector, the big data is already being widely used in many industries such as logistics, healthcare, retail, manufacturing, financial services, and etc. A study conducted by [11], found that the first companies that adopted analytical techniques for big data presented far superior results compared to its competitors, becoming much more productive than those who have trusted their strategies to specialists and experienced professionals. Although the private sector leads the pace of adoption of big data, this technology can also be widely used in the context of the public sector.

Recognizing the impact of big data applications on society, governments in some countries have begun to invest heavily in initiatives aimed at developing this technology. The United States, for example, in March 2012 invested more than \$ 200 million in a big data research and development initiative to improve the tools and techniques needed to access, organize and gain knowledge from a large amount of data [12]. In 2014, in the UK, the government allocated £73 million to fund studies to leverage the potential of the big data in the country's public administration [13]. In Australia, the government launched the Australian Public Service for Big Data Strategies in 2013. The purpose of this program was to outline the potential of the big data analysis to increase the value of the national government's and the Australian people's information assets [14]. The Japanese government has allocated £87.5 million for the research and development of big data projects, including a project to develop a high-speed network infrastructure with 400 Gbps (billions of bits per second) capacity and another for the development of data analysis [15]. In France, the Ministry of Digital Affairs was created in 2014. This Ministry published a bill on the Digital Republic, outlining the general orientation for the big data policy for France [16].

Therefore, big data technology creates opportunities and challenges for governments. Opportunities include generating efficient analyzes for significant improvement in government service delivery, using real-time information for e-government experiences, monitoring and visualizing government performance for public decision-making in a dynamic and participatory manner; And producing useful insights for the modernization of governments [17].

The challenges of big data for the government are institutional and technical. According to [18], institutional challenges include the creation of a governance structure to efficiently address some key issues: standardization of data structures, enabling the interoperability of information; privacy guarantees to gain the trust of citizens who share information; Data sharing and inter-organization linkages for creating custom systems. Reference [19] stated that the technical challenges are exemplified by shortage of skilled workers, the underdevelopment of relevant software tools, the integration of multiple sources and data formats, and the storage and access of data.

V. METHODOLOGY

For the development of this work, a scientific research of a basic nature was used, seeking to generate new knowledge and contribute to the advancement of the field of study of big data applied to the public sector. The approach used was qualitative research, with the purpose of describing, understanding and explaining the object of study. Regarding the objectives, the present research is characterized as an exploratory study. With regard to the methodological procedures, we opted for a bibliographical research based on the theoretical references already analyzed, and published on written and electronic materials, such as books, scientific articles, and web pages of recognized organizations. It is of great importance for the development of this scientific investigation to use materials published by researchers who have already explored more widely the topic of this paper.

The first stage consisted in determining the basic concepts that should be explored by this work, such as big data and e-government. Once this was done, it was necessary to adopt a bibliographic search strategy. For the accomplishment of the bibliographic search, it was necessary to define the contextualizing environment, the research problem and the general objectives of the research. Once the research knowledge area is determined, the keywords that will be used in the search for references must be chosen. For the article presented here, the keywords chosen were: "big data public sector", "big data public administration", "big data public management", and "big data public sector". These keywords are important because they are directly related to the relevance and pertinence of the materials returned by the search engines on the given topic.

After setting the keywords to be used, the next step was to choose the search engines most appropriate to the research topic, according to their relevance and the ease of obtaining the scientific papers. The selected libraries and search engines were: CAPES periodicals, Scielo, Google Academic, Microsoft Academic, JURN, Athenus, SweetSearch, Data4Policy and Springer Link. Previously 20 research resources were used, but from a preliminary analysis of the quality of the returned results, 9 of them were selected for a more in-depth search of the results. This quality was measured according to the origin of the results returned, prioritizing the materials of educational institutions, publications in newspapers and magazines in the field of computing and public management, moreover papers from internationally recognized organizations.

For the exploratory bibliographic review in the specialized literature, we delimited the sample to 5 articles from each repository and search tool used. The access and choice of these scientific works, stored in open access repositories, was made from the titles of the works and metadata from the text. This led to a set of 45 scientific articles published by different agencies and institutions that, to varying degrees, correlated the big data topic with public administration. The search for the articles was performed by inserting the keywords in the search engines. It was established that only papers published between 2012 and 2017 should be considered. Furthermore, works developed by private organizations was discarded, being considered for analysis only those that have been developed by government agencies, educational institutions or high profile international organizations, such as UN and GARTNER.

In view of the objectives presented in this paper, to explore the possibilities of applications and challenges of big data in the public administration, these 45 preselected articles were

analyzed again. In this new stage, we analyzed the abstract, summary and introduction of the researches, reducing the sample to the 20 works most pertinent to this paper's objectives. At the beginning of this analysis, some preconditions were defined, namely, to address issues such as e-government or use of ICTs in the public sector, conceptualization of the big data, case study or description of a big data application in public administration, or presentation of topics related to the challenges of implementing this technology in the public sector.

With the works gathered, we conducted a thorough analysis of the description of the objects of study by the authors. From this analysis, the main points of the cases studied were highlighted to present the results. Limited to investigate the "what?" and "why?" of the importance of big data for the public sector, this study aimed to list the solutions deployed, advantages and challenges to be faced.

VI. RESULTS

The potential benefits that can be obtained by using big data, as well as the challenges it poses, differ from one sector to another. Several sectors such as information technology, marketing, financial and insurance industries are increasingly using big data technology, hence these areas have a greater experience in implementing big data in their organizations. Government sectors, however, are not evolving fast enough in this area. Even so, the public administration can obtain substantial improvements with the adoption of big data in its activities.

The results presented here were obtained in the literature review of the 20 selected papers. The survey of big data applications in public administration as well as the obstacles to be overcome will be presented in this section.

Much effort has been made to improve communication and collaboration between various government agencies. With the big data, the potential use of this data takes on another dimension. Next, the possibilities of applying big data in the public sector will be briefly discussed in specific fields of public administration, such as environmental protection, education, transportation, healthcare, and public safety. Table I shows the areas of the public sector that can benefit from adopting data analysis, as well as a brief description of how this would be applied in the respective area.

TABLE I. BIG DATA APPLICATIONS IN PUBLIC SECTOR

Area	Description
Electronic Government	Big data can stimulate collaboration, promote greater openness of information, and usher in a new era of policy and decision-making through e-government [20]. Transparency, accountability and the effectiveness of public sector institutions can be facilitated by e-government, especially through open data. Government can use analytical data processes to integrate multiple sources, improve transactions and results, reduce costs, and increase citizen satisfaction.
Open Government Data	Open government data sets a new approach that can help public sector institutions to improve the quality of their decision-making processes and public services. This approach supports the promotion of effective participation in decision-making processes, reduce wasted resources and free up

Area	Description
	opportunities for innovation [21].
Health Care Services	Initiatives such as the use of electronic health records are able to combine and analyze a variety of data, helping to accurately diagnose patient conditions. Machine learning algorithms can analyze many more factors in patients' medical records than physicians and, by adding features, a substantial increase might be achieved in the model's ability to distinguish people who have a disease from those who do not [22].
Education	According to [23], data analysis for online monitoring, analysis of preferences and classifications of learning styles can be used to improve the learning process.
Public Safety	As stated in [24], predictive policing is the application of data analysis techniques to identify targets for police intervention and to prevent crime through statistical predictions. This model, based on criminology, suggests that criminals follow a common pattern. With big data it is possible to identify overlaps in the patterns that indicate the probability of the crime.
Profiling	One of the possibilities of the big data is to analyze social media and extract characteristics of its users. Reference [25], defines profiling as the process of collecting information about a user to build its profile. Advanced techniques of social data analysis can identify an aggressive person or one who could potentially commit a crime only by inferring the tone of the individual's online words and actions.
Transportation	Authorities can obtain a more accurate understanding of users' demand. Mapping the routes and types of transport used - buses, cars, trains, subways, motorcycles - traffic authorities can use this data to improve transport route planning [26]. In addition, with this information it is possible to map management strategies for unplanned events such as congestion, accidents and blackouts.
Environment	Analysis of immense amounts of environmental data can obtain information about climate change, deforestation trends, pollution, air quality, etc.
Taxation	Big data can support tax authorities and finance departments to store and process huge amounts of tax data, generating accurate tax collection forecasts, avoiding and detecting tax evasion, and facilitating auditing of tax processes [27].
Events Detection	Social networks like Twitter permit real-time events detection. By analyzing and grouping the content of Twitter messages, it is possible to immediately infer the occurrence of events from these data. The spatial and temporal pattern of messages significantly reduces the rate of false positives of catastrophic events, for example [28].

a. Source: the author (2017).

While the potential benefits of big data for management are significant and real, including some successful initiatives already implemented, there are still many obstacles to overcome. Thus, to provide a comprehensive and holistic view of the factors that challenge the implementation of data analysis technologies, this paper will present the key elements categorizing them according to the aspects they encompass. Starting from the most global aspect, we have the institutional challenges, which are directly related to the beginning of the implementation of information systems in public organizations. This process includes social policies and responsibilities of the State in fulfilling its role. The next element is the organizational challenges. The organizational

implications include the impact on management structures as well as cultural and behavioral changes of the involved public agents and the population. Finally, there are the technical challenges of big data systems, which involve infrastructure and the operational procedures required to operate efficiently a large system of data analysis.

The institutional obstacles challenge the State to ensure a smooth transition in the modernization process of public administration. Governments need to take responsibility for the social order as well as the prudent use of technologies to improve their efficiency. Table II, below, presents the challenges pointed out by the authors studied for the deployment of the disruptive technology of big data in the public sector.

TABLE II. INSTITUCIONAL CHALLENGES

Issue	Description
Financial Investment	Need for high initial investments to implement data analysis technology and acquisition of appropriate equipment, capable of processing the huge data flow [29].
Data Ownership	The challenge here is to determine who is the legal "guardian" of the civilians' data. The government must take responsibility for the use and protection of that data. In a way, all public data are also private data, insofar as they are personal information or sensitive data from public organizations. Governments and public organizations are responsible for these data, hence, they are allowed to use them in exchange of providing better public services [30]. Therefore, governments and public agencies will have to define rules to decide how to deal with data property inconsistencies.
Data Security Policies	The purpose of data protection is to ensure the privacy and security of information. In accordance with [31], in the public sector this is a particularly difficult challenge because government agencies must implement policy changes that address real-time threats. Despite the good intentions in using big data as an effort to improve the delivery of public services, the collection and analysis of personal data by governments raises concerns about civil liberties.
Civil Liberties	Profiling is one of the potential applications of the big data that needs careful evaluation. As Stated by [32], "user profiling information can include various attributes such as geographic location, academic and professional experience, membership in groups, interests, preferences, opinions, etc." Reference [33] argue that profiling individuals can increase the risks of discrimination and exclusion. One possibility of profiling with big data is based on forecasting models in order to anticipate possible threats. According to [34], increasing forecasting capacity with the big data also increases the responsibility to prevent such threats from making governments more conservative in how they address social issues.
Equality	The issue of equality concerns the treatment, in the public sector, of individuals and groups who do not fully participate in the information society, because they do not have the resources, the means, time or knowledge to do so. The risk here is that governments might start to depend too much on big data that they end up forgetting to involve these people in understanding their own needs and disregard them during the decision-making process [35].
Civil Collaboration	Regarding to the population, the challenge is to disseminate the concept of electronic participation.

Issue	Description
	While e-participation is still an evolving concept, there is vast evidence that e-participation technologies expand opportunities for civic engagement, including increased possibilities for people to participate in decision-making processes and service delivery to make societies more inclusive [36].
Biased Data	When it comes to decisions about what kind of information should be collected, interpreted, and disclosed for use during policy-making processes, the political leaning can make that data biased, since that kind of decision is made by a person. In the political sphere, ownership of data is a source of power. According to [37], "disputes over data control, how and when it will be used can make policy issues contentious."

a. Source: the author (2017).

From the broader dimension of the role of the State entity to a more centered in public organizations dimension, Table III below presents the organizational challenges to big data technology in the public sector.

TABLE III. ORGANIZATIONAL CHALLENGES

Issue	Description
Privacy and Interdepartmental Collaboration	Privacy issues can inhibit the adoption of big data by public sector organizations. Collecting and manipulating sensitive data is a controversial topic of interest to many groups within and outside government. Conforming to [38], government departments may not want to share data they consider proprietary with other government agencies. Adequate management is needed to reduce this potential barrier, showing that mutual collaboration will be of benefit to all involved.
Organizational Culture	Modernization of technology causes a tremendous impact in organizations. In public entities, any change in the current organizational structure can be perceived with some resistance. People tend not to immediately accept changes in their routines.
Civil Collaboration	Regarding to the population, the challenge is to disseminate the concept of electronic participation. While e-participation is still an evolving concept, there is vast evidence that e-participation technologies expand opportunities for civic engagement, including increased possibilities for people to participate in decision-making processes and service delivery to make societies more inclusive [39].
Legacy Systems	Most legacy systems were developed without process models or data models that are now required to support big data integration [40]. Therefore, the modernization of legacy systems is necessary. Legacy systems retain valuable data too important to be lost in the modernization process.
Recruitment of Talents	With the interest of organizations in the implementation of big data projects, the profession of data scientist has gained great importance. However, finding skilled workers is no easy task. Reference [41] states that the data scientist "normally demands training in Computer Science and Mathematics as well as the necessary management analytical skills".

a. Source: the author (2017).

The beginning of the implementation of a data analysis project in the public sector should start with an assessment of where the most important challenges lie. Surely dealing with

institutional and organizational issues is extremely important. However, in addition to an information management and organizational intelligence project, the big data is also an information technology project.

Therefore, public agencies need to be aware of what technical implementation issues they will face. Organizing information, filtering, and deciding which tools and technologies will generate insights useful for informed decision-making is also a critical factor to the success of a big data project. According to the papers analyzed, the technical aspects that make more challenging the implementation of big data projects in public sector are:

- Volume, variety and velocity
- Data heterogeneity, inaccuracy and incompleteness
- Scalability
- Time constraints
- Information security
- Low-quality, non-computerized data sources
- Unstructured IT projects
- Lack of integration with most existing information systems
- Need for training of employees or recruiting new ones to be possible the use of sophisticated data mining tools.

In light of the foregoing, the discussion section is presented next.

VII. DISCUSSION

Big data is an emerging and critical technology that governments need to learn to deal with. With an increasing volume of data being generated at all times, data analysis technologies are slowly being adopted by the public sector to get knowledge from these data. However, besides the sheer volume, the speed with which data are generated and the variety of these data represent a challenge to the public administration that was accustomed to dealing with traditional structured data. To encourage big data implementation initiatives, many studies need to be developed to present the advantages and challenges of inserting the disruptive technology into the public domain. There is a gap in the research of big data applied to public administration. Much of the existing researches focuses on the application of this technology in the private sector. It is very easy, for example, to find papers that detail commercial parameters, such as profit maximization and investment returns, obtained by adopting data analysis in private organizations. Nevertheless, for the public administration, the search for articles related to the adoption of big data returned few results. Therefore, this work sought to present applications and challenges of using big data in public sector. The importance of covering this topic is because both political agents and the population need to recognize their roles as an integral and fundamental part to collaborate with the modernization and improvement of public administration.

Through the analysis of papers related to the topic, this article aimed to present the impacts of big data in the public sphere, both with regard to the provision of public services, as the new opportunities for organization and structure of the public service that can transform the role of governments in societies. Table I puts into perspective what may be the future of the interaction between the services provided by the State and the population. The debate on e-government started with the beginning of the use of ICT to improve services in the

public sector. According to [42], the use of ICT in public administration is often associated with the automation of public services, the computerization, and systems integration. In fact, the beginning of the implementation of e-government in the late 1990s was really focused on the computerization of public offices, the digitization of much of the data and the use of the global computer network in the provision of public services. However, with the expansion of access to the internet, the increase of online transactions and the emergence of social networks, e-government has gained another role. This 2.0 version of e-government needs to deal with a huge amount of information that alters the relationship between the State and society. In agreement with [43], the new role of e-government is to focus on operational efficiency projects, initiatives such as open government efforts to promote transparency in public service, citizen participation, and interdepartmental collaboration.

To gain advantages of this open data initiative, big data is the ideal technology to analyze these available data. Moreover, several areas within public sector can modernize their activities if they incorporate this new technology into their operations. The predictive diagnosis in health saves money with the treatment of diseases in the initial stages, epidemic outbreaks can also be predicted, enabling the combat and prevention in areas at risk [44]. In education, clustering of learning styles can generate teaching approaches directed to the cognitive abilities of each student. Public security authorities can adopt the predictive approach to prevent crimes from happening, or for investigation purposes, video frames and image databases can be crossed to identify wanted suspects. The transportation area can obtain useful insights on efficient routes and the trend of commuting in a city, enabling the creation of urban traffic plans based on a representative amount of data. Tax evasion can be prevented if strict control over financial transactions is maintained. These were some of the examples presented by the studies analyzed.

The potential that new digital technologies have to change the relationship between government agencies and civil society is promising. The big data initiatives come, then, to sustain this progress. Civil participation through social media is a new reality that the public sector needs to adapt. Fundamental changes occur due to social transformations and technological advances. Data analysis in public administration involves some important changes in the role of governments and their relationship with citizens. These changes can be understood as electronic democracy, which aims to give voice to people not only in elections but also in the political decision-making processes that have direct implications for society. According to [45], electronic democracy seeks to take advantage of developments in online decision-making to engage all interested parties in policy-making. Initiatives such as Avaaz already allow people to organize and make inroads into the political and legislative spheres. Big data adds a new dimension to the political debate. Before, matters of interest to society were discussed only within parliaments, and people could only express their opinions at the ballot box. With social networks the reflexes and reactions are immediate. Big data can capture the reaction and opinion of people through social networks and directly influence political decisions.

Big data presents, besides the opportunities, challenges for governments. With access to an incredible amount of information, governments need to adopt data analysis to generate significant improvement in service delivery, making policy decision-making a more dynamic and participatory

process that produces insights for the transformation of public administration. However, despite all the advantages that big data can bring to the public sector, there are still a number of issues that need to be overcome in order to achieve the level of governance required for the e-government 2.0.

The challenges of big data for the government have institutional, organizational and technical aspects. The institutional challenges, presented in Table II, require the establishment of a governance structure to effectively deal with some key issues. Data protection and privacy guarantees are necessary to gain the trust of citizens who share information. To this end, specific laws need to be created to deal with aspects related to the use of personal data. The situation is different when big data is used by government agencies to support their goals. Reference [46] explain that if big data is used for the development of economic policies, health epidemiological researches or for studying the traffic in a large metropolis, there is no problem. In these cases, general standards and statistical correlations are used to promote the efficiency and effectiveness of public policies. However, if the big data is used by the police, a different issue arises, because "while the big data is about processing large amounts of data and detection of general patterns, police need to investigate and possibly arrest individuals based on concrete facts" [47].

There is a particular danger when profiling is applied to specific individuals. According to [48], the exacerbated confidence in the capacity of statistical forecasts can turn data analysis into a tool of discrimination. Big data analysis can find correlations in the data, even in cases where there is no direct cause and effect between two phenomena. In these cases, if applied at the individual level, potentially unfair and discriminatory conclusions may arise. Because of the potential impact on the citizen and the potential for mismatch between profiles and individuals, the big data used for public safety must be carefully implemented to prevent injustices from happening. As stated in [49], "big data features such as the extensive use of automated decisions and predictive analytics can lead to broader undesirable changes in the development of our societies." It is necessary to consider consequences that can lead to discrimination, the reinstatement of existing stereotypes and the segregation and social exclusion of those who do not have access to information technologies. To regulate and implement big data, the potential impact on the citizens must be taken into account.

Government departments tend to be large bureaucracies that are rooted in tradition and are very resistant to change. To address the organizational challenges presented in Table III, it is necessary to ensure government support in the form of leadership. Public agencies tend to be very protective of their data [50]. For the big data to reach its maximum potential, there must be interoperability of information, data sharing and binding agreements between public organizations. However, organizational inertia can hinder the growth of new ideas and new methodologies. Nevertheless, as the value of data analysis is demonstrated, more and more organizations will see the big data as a fundamental tool to improve their operations.

To reap the full potential of data analysis and improve the efficiency of public sector operations, big data requires investment in people and resources, and the shortage of skilled professionals is a relevant point. Apart from the difficulty of finding qualified professionals, there are also the technical challenges that need to be addressed. As technical challenges, we might mention the underdevelopment of software tools, the integration of multiple sources and formats of data, storage and

access to data, as well as the lack of integration between systems and non-structuring of legacy systems [51]. This means that many organizations are wasting the main opportunities of big data.

Finally, the limitation of this paper was the impossibility of concretely verifying the impact of data analysis in the public sector. This is a difficult challenge because, in the public sector, the metrics that define the success of an initiative are much more complex than simpler measures in the private sector, such as increased profit or added value. Regarding data analysis, although its objectives are important, the real effectiveness and advantages of the insertion of this technology in the public sector is still questioned. It is therefore impractical to build a single utility function to check the effectiveness of the big data because it is not clear how to measure this satisfaction. At times, some more descriptive theoretical alternatives can be identified; however, the data of a qualitative measure would be more understandable and would facilitate the understanding of the advantages of incorporating big data in the provision of public services.

VIII. CONCLUSION

This paper reviewed the opportunities and implications of the adoption of big data technology in public sector as well as some important challenges that this technology causes. The promises and potential of data analysis in the transformation of government services are substantial. From e-government to digital government, big data analysis can foster collaboration among public agencies and between government and society. It can also create solutions to challenges in agriculture, health, education, transportation, public safety and many other applications. Big data inaugurates a new era of policy and decision-making. Big data initiatives represent a significant promise to modernize public administration, focusing its actions and decisions on promoting social welfare.

Although the opportunities to apply the big data analysis in the public sector are plentiful, many challenges need to be addressed before this potential can be fully achieved. This paper addressed three aspects of the difficulties that the public sector must overcome when deciding to incorporate data analysis into its operations. These challenges are multifaceted, and attempts have been made to address the most central points of strategy, organization, and technology. Thus, the institutional, organizational and technical challenges must be overcome before government agencies can provide efficient services and fully data-driven operations.

There are a number of political and managerial issues that govern the big data. These issues have not yet been answered because this is a very new area and still not broadly explored. The presumed technical orientation of this topic makes the academic works too oriented to the technologies and little is explained regarding the interdisciplinary correlations of big data in the public sector. While this paper has been limited to answering "what?" and "why?", future efforts will be directed to detailing the "how?", considering a holistic approach that can lead to the development of a governance model for the implementation of big data in public administration. There is a need for future research that presents such a model and how it can be applied to guide politicians, managers and public sector leaders in implementing innovative tools that improve the providing and management of public services.

In conclusion, big data is a tool that can bring many benefits to the public sector. It is necessary to define a path of evolution that effectively allows integrating existing technologies with public sector activities and finding ways for the big data to add value to the public service structure. It is not a matter of breaching with everything that exists in the public administration, but a way of integrating the systems in a manner that can contribute to the State's ability to fulfill its duty and promote social welfare.

REFERENCES

- [1] WORLD BANK. World Bank Development Report 2016: Digital Dividends. Washington, 2016. Available at: <documents.worldbank.org/curated/pt/.../pdf/102725-PUB-Replacement-PUBLIC.pdf>. Accessed on: March 8th 2017.
- [2] IBM. What is big data? 2012. Available at: <https://www.01.ibm.com/software/in/data/bigdata/>. Accessed on: March 08th 2017.
- [3] SANT'ANNA, Yan. Big data: O Uso da Tecnologia da Informação como Provedora da Gestão Pública Integrada. 2015. 60 f. TCC (Graduação) - Curso de Gestão de Comércio Internacional, Faculdade de Ciências Aplicadas, Universidade Estadual de Campinas, Limeira, 2015. Available at: <www.bibliotecadigital.unicamp.br/document/?down=000949995>. Accessed on: March 13th 2017.
- [4] [29] GONÇALVES, Joanna. Business Intelligence Suportado por Tecnologia Big data na Gestão Estratégica das Empresas – Estudo de Caso. 2015. 15 f. Dissertação (Mestrado) - Curso de Mestrado em Gestão Empresarial, Utad: Universidade de Trás-os-montes e Alto Douro, Vila Real, 2015. Available at: <https://repositorio.utad.pt/handle/10348/6345>. Accessed on: March 13th 2017.
- [5] [31] [34] [37] [38] [50] MILAKOVICH, Michael E.. Anticipatory Government: Integrating Big data for Smaller Government. 2012. 13 f. Tese (Doutorado) - Curso de Ciências Políticas, University Of Miami, Coral Gables, Florida EUA, 2012. Available at: <ipp.oii.ox.ac.uk/.../Anticipatory Government Oxford.pdf>. Accessed on: March 14th 2017.
- [6] ABRANSON, Mark A.; MEANS, Grady. E. E-government 2001 - IBM endowment for the business of government. Rowman & Littlefield Publishers, 2001. Available at: <goo.gl/kLA7Ib>. Accessed on: March 22th 2017.
- [7] ULARU, Elena Geanina et al. Perspectives on Big data and Big data Analytics. Database Systems Journal. Bucharest, abr. 2012. Available at: <www.dbjournal.ro/archive/10/10_1.pdf>. Accessed on: March 28th 2017.
- [8] MIKE2.0. Big data Definition. Available at: <http://mike2.openmethodology.org/wiki/Big_Data_Definition>. Accessed on: March 28th 2017.
- [9] GARTNER. Big data. Available at: <http://www.gartner.com/it-glossary/big-data>. Accessed on: March 28th 2017.
- [10] MCKINSEY GLOBAL INSTITUTE. Big data: The next frontier for innovation, competition, and productivity. Mckinsey & Company, 2011. 156 p. Available at: <https://bigdatawg.nist.gov/pdf/MGI_big_data_full_report.pdf>. Accessed on: March 31th 2017.
- [11] PEARSON, T.; WEGENER, R., Big data: The organizational challenge, Report from Bain and Company, 2013. San Francisco, CA, Available at: <http://www.bain.com/Images/ BAIN_BRIEF_Big_Data_The_organizational_challenge.pdf> Accessed on: March 31th 2017.
- [12] WHITE HOUSE. Big data: Seizing Opportunities, Preserving Values. Washington, 2014. 85 p. Available at: <https://obamawhitehouse.archives.gov/sites/default/files/docs/big_data_privacy_report_may_1_2014.pdf>. Accessed on: March 31th 2017.
- [13] DEPARTMENT FOR BUSINESS, INNOVATION & SKILLS. Appendix 3: Skills Foresight Big data Analytics: Big data Analytics. Solihull: EU Skills Group, 2014. 42 p. Available at: <https://www.euskills.co.uk/sites/default/files/Skills Foresight Big data Analytics for print v1.pdf>. Accessed on: March 31th 2017.
- [14] AUSTRALIAN GOVERNMENT. The Australian Public Service Big data Strategy: Improved understanding through enhanced data-analytics capability. 2013. 27 p. Available at: <cc.yimcdn.com/.../140325AIIA_response_Big_Data_Strategy.pdf>. Accessed on: March 31th 2017.
- [15] BRITISH EMBASSY TOKYO (Org.). Japan: Big data For A Bigger Economy. Tokyo: Open To Export C.I.C., 2013. Available at: <http://opentoexport.com/article/japan-big-data-for-a-bigger-economy/>. Accessed on: March 31th 2017.
- [16] GOIN, Maxime; NGUYEN, Le Thy. A Big Bang in the French Big data Policy: Big data as a growth driver. 2015. State Secretariat for Education, Research and Innovation. Available at: <https://globalstatement2015.wordpress.com/2015/10/30/a-big-bang-in-the-french-big-data-policy/>. Accessed on: March 31th 2017.
- [17] [18] [19] GAMAGE, Pandula. New development: Leveraging 'big data' analytics in the public sector. Public Money & Management, [s.l.], v. 36, n. 5, p.385-390, 10 jun. 2016. Informa UK Limited. Available at: <http://dx.doi.org/10.1080/09540962.2016.1194087>. Accessed on: March 31th 2017.
- [20] BERTOT, John Carlo; CHOI, Heeyoon. Big data and e-Government: Issues, Policies, and Recommendations. In: ANNUAL INTERNATIONAL CONFERENCE ON DIGITAL GOVERNMENT RESEARCH, 14., 2013, Quebec City. Proceedings... New York: ACM, 2013. Available at: <http://dl.acm.org/citation.cfm?id=2479730>. Accessed on: April 1st 2017.
- [21] [36] [39] ONU. United Nations E-Government Survey 2016: E-Government in Support of Sustainable Development .New York: United Nations, 2016. 242 p. Available at: <https://publicadministration.un.org/egovkb/en-us/reports/un-e-government-survey-2016>. Accessed on: April 2nd 2017.
- [22] GROVES, Peter et al. The 'big data' revolution in healthcare: Accelerating value and innovation. New York: Mckinsey & Company, 2013. 22 p. Available at: <http://www.mckinsey.com/~media/mckinsey/industries/healthcare/systems_and_services/our_insights/the_big_data_revolution_in_healthcare/the_big_data_revolution_in_healthcare.ashx>. Accessed on: April 11th 2017.
- [23] RIJENAM, Mark Van. Four Ways Big data Will Revolutionize Education. 2015. Available at: <https://datafloq.com/read/big-data-will-revolutionize-learning/206>. Accessed on: April 11th 2017.
- [24] PERRY, Walter L. et al. PREDICTIVE POLICING: The Role of Crime Forecasting in Law Enforcement Operations. Santa Mônica, CA: Rand Corporation, 2013. 189 p. Available at: <www.rand.org/content/dam/rand/pubs/research_reports/RR200/.../RAND_RR233.pdf>. Accessed on: April 11th 2017.
- [25] [32] HASAN, Omar et al. A Discussion of Privacy Challenges in User Profiling with Big data Techniques: The EEXCESS Use Case. Milan, v. 5, n., 2013. Available at: <eexcess.eu/wp-content/.../2013/07/2013.07_BigData-2013-04.pdf>. Accessed on: April 12th 2017.
- [26] MOURA, Aristoteles Lamartine Teles; AMORIM, Dinani Gomes. BIG DATA: O IMPACTO E SUA FUNCIONALIDADE NA SOCIEDADE TECNOLÓGICA. Revista Opara: Ciências Contemporâneas Aplicadas, Petrolina, v. 04, n. 01, dez. 2014. Available at: <http://revistaopara.facape.br/article/view/121>. Accessed on: April 14th 2017.
- [27] WEF. World Economic Forum. Big data, Big Impact: New Possibilities for International Development, 2012. Disponível em <http://www3.weforum.org/docs/WEF_TC_MFS_BigDataBigImpact_Briefing_2012.pdf>, Accessed on: April 14th 2017. [28] DAVIES, Ron. Big data and data analytics: The potential for innovation and growth. EPRS | European Parliamentary Research Service, 2016. 8 p. Available at: <http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/589801/EPRS_BRI(2016)589801_EN.pdf>. Accessed on: April 14th 2017.
- [30] GUDIPATI, Mahesh et al. BIG DATA: TESTING APPROACH TO OVERCOME QUALITY CHALLENGES. Infosys Labs Briefings, v. 11, n. 01, 2013. Available at: <http://wwpi.com/wp-content/uploads/2014/07/www.infosys.com_infosys-labs_publications_Documents_testing-approach.pdf>. Accessed on: April 14th 2017.
- [33] KERR, Ian; EARLE, Jessica. Prediction, Preemption, Presumption: How Big data Threatens Big Picture Privacy. Ottawa: University of Ottawa,

2012. Available at:<<https://fpf.org/wp-content/uploads/Kerr-Earle-Prediction-Preemption-Presumption.pdf>>. Accessed on:April 14th 2017.
- [35] [42] [43] [45] MORABITO, Vincenzo. Big data and Analytics for Government Innovation. Big data And Analytics, [s.l.], p.23-45, 2015. Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-10665-6_2. Available at:<http://www.springer.com/cda/content/document/cda_downloaddocument/9783319106649-c2.pdf?SGWID=0-0-45-1493705-p176905968>. Accessed on:April 15th 2017.
- [40] RISING, Carl Johan; KRISTENSEN, Michael; TJERRILD-HANSEN, Steffen. Is Big data too Big for SMEs?: Leading Trends in Information Technology. 2014. 25 f. Curso de Master In Science And Engineering, Stanford University, Stanford, 2014. Available at:<<https://web.stanford.edu/class/msande238/projects/.../GainIT.pdf>>. Accessed on:April 15th 2017.
- [41] TAURION, Cezar. Big data e o caos conceitual, ITBoard - Computerworld Brasil, setembro, 2012. Disponível em <<http://itboard.com.br/article/44058133/>>. Accessed on:April 16th 2017.[44] CHIAVEGATTO FILHO, Alexandre Dias Porto. Uso de big data em saúde no Brasil: perspectivas para um futuro próximo. Epidemiol. Serv. Saúde, Brasília , v. 24, n. 2, p. 325-332, June 2015 . Available at:<http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2237-96222015000200325&lng=en&nrm=iso>. Acesso em April 20th 2017.
- [46] [47] SLOOT, Bart van Der; VAN SCHENDEL, Sascha. Ten Questions for Future Regulation of Big data: A Comparative and Empirical Legal Study. Tilburg - Netherlands: Jipitec, 2016. 36 p. Available at:<https://www.jipitec.eu/issues/jipitec-7-2-2016/4438/van_der_sloot_van_schandel_big_data_survey_jipitec_7_2_2016.pdf>. Accessed on:April 21th 2017.
- [48] [49] BUTTARELLI, Giovanni. Meeting the challenges of big data: A call for transparency, user control, data protection by design and accountability. European Data Protection. Brussels: EDPS - European Data Protection Supervisor, 2015. 21 p. Available at:<https://edps.europa.eu/sites/edp/files/publication/15-11-19_big_data_en.pdf>. Accessed on:April 22th 2017 .
- [51] GÓMEZ, Liliana Fernández; HEEKS, Richard. Measuring the Barriers to Big data for Development: Design-Reality Gap Analysis in Colombia's Public Sector. 62. ed. Manchester,: Centre For Development Informatics Global Development Institute, Seed, 2016. 13 p. Available at:<http://hummedia.manchester.ac.uk/institutes/gdi/publications/workin_gpapers/di/di_wp62.pdf>. Accessed on:April 22th 2017.