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Implementation of Big Data Analytics and its Challenges in Digital Transformation Era: A Literature Review

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Abstract

The reliance on technology to support various aspects of human life has become very relevant and significant. The steadily increasing volume of data (called big data) plays an important role in machine learning, Internet of Things (IoT) and other intelligence applications. The interaction between big data and operations in various aspects of human life is a concern, this systematic literature review provides a descriptive aspect of the literature review, the research results offer a comprehensive overview of existing big data implementations ranging from 2019 to 2023. Other than this, we discuss the general challenges for researchers in using various big data sources in different crises. This study, especially revealing the implementation and challenges of big data in general, is expected to provide a knowledge base for researchers to delve deeper and more specifically.

Keywords: Big Data, Big Data Analytics, Implementation, Challenges, Systematic Literature Review

1. Introduction

Big Data refers to a collection of data that has enormous volume, high rate of generation, and high complexity. The concept of "Big Data" first became popular in the 1990s, but in the current digital era, it has gained importance in academia and industry due to its potential to provide valuable insights through the analysis of vast and complex data. Big Data is a term that has been defined by experts with various approaches that are addressing important aspects of this phenomenon. Big Data is a representation of data that has three main characteristics: volume, velocity, and variety [1]. A large volume of data reflects the enormous quantity of data that is generated and managed by a system or organization. Velocity can refer to the growth rate of data as well as the speed at which the data can be processed and analyzed. Whereas, data variety is used to indicate that Big Data consists of various types of data that come from various sources.

As researchers have defined Big Data as datasets that have a volume, velocity, and variety that make them difficult to manage in traditional ways [2]. They are highlighting the high significance of using advanced technologies and data analytics to explore, analyze, and generate useful information from Big Data. While some argue that Big Data encompasses the evolution of technologies and analytical techniques that allow us to gain deep insights from very large and complex data [3].

The implementation of Big Data has extended to many fields, including business, healthcare, scientific research, government, and many other sectors [4]. In the field of the enterprise, Big Data is used to enhance operational efficiency, develop a better understanding of consumer behavior, and optimize marketing strategies. To illustrate, e-commerce enterprises such as Amazon and Alibaba have been utilizing Big Data to generate product recommendations that are personalized to customers' preferences based on their shopping records and online personal behavior. In the healthcare sector, Big Data is being harnessed for genomic analysis that enables the identification of genetic patterns associated with certain diseases, thus accelerating the development of more effectively drugs and therapies. In scientific

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research, Big Data has a crucial role to play in weather prediction, epidemiological analysis, and research exploration in various fields of science. Likewise, in government, the use of Big Data may assist in public policy, crime analysis, and evidence-based decision-making.

Despite its tremendous potential, the implementation of Big Data is still facing a large number of challenges that need to be solved. One such primary challenge is the issue of data privacy and security. With huge volumes of data, the protection of personal and sensitive data becomes a critical concern [5]. The organizations also need to ensure that the data that they collected and analyzed is being secured and protected from any security hazards. Data quality is a major challenge in the implementation of Big Data. The data that is incomplete, inaccurate, or inconsistent may lead to faulty or unreliable analysis. This issue is a concern highlighted by the researcher in his works on Big Data, where he highlights the necessity of ensuring good data quality before conducting further analysis [6]. In recent years, issues of interoperability have become an obstacle in the integration of data from various sources with varying formats and structures. Furthermore, the require for infrastructure that is capable of managing a large volume of data and fast computations is also becoming a challenge, especially for organizations that are in development stage of the technology. The other aspect is that there is a lack of experts skilled in complex data analysis, such as data scientists and Big Data analysts.

Essentially, the implementation of Big Data not only involves technical aspects, but it also includes a change in culture and processes within the organization. Thus, the significance of appropriate development of strategies, the training of qualified employees, and the subsequent integration of Big Data into the broader business strategy [7]. In this study, we will explore the implementation of Big Data and its challenges. By gaining a deeper understanding of Big Data, it would be possible to take the full advantage of the potential of existing data.

2. Literature Review

Management Information Systems (MIS) and Big Data are strongly related in the context of information management and decision-making at the managerial level. MIS is a system designed to collect, store, manage, and process data into information that is useful for the decision-making process at the managerial level. [8]. At the other end, Big Data refers to large data volume, fast processing speed, and high data variability.

The application of Big Data in Management Information Systems can deliver significant incremental and enhanced value. By leveraging the advanced technology and data analysis methods, the SIM enables managers to process and analyze greater and more diverse data from various sources, such as sensors, mobile devices, social media, etc. This enables managers to gain deeper insights, understand trends, patterns, and tendencies from existing data. Thus, SIM that is being driven by Big Data provides greater capabilities in supporting more precise and accurate decision-making [9].

2.1. Implementation of Big Data

Implementation, as the experts say, refers to the specific process or action of putting a certain concept or strategy into a practical or actionable situation. When it applies to Big Data, Big Data implementation simply denotes the use of appropriate technological tools, as well as methodologies and corresponding strategies to manage, accurately analyze, and obtain knowledge and insights from voluminous and heterogeneous data. Big Data implementation may involve the process of gathering, storing, extracting, and synthesizing data by utilizing the relevant technological advancements and tools [10]. This implementation also entails the utilization of analytical methods which include machine learning, data mining, and statistical analysis to generate potentially reliable information from the prevailing data thus enabling a more improved decision-making process.

The researchers have described the implementation of Big Data as an approach to convert data to usable and reliable information to support decision-making [2]. This requires the adoption of Big Data technological advancements into the organizational framework, the cultivation of the required data analysis competencies, and the deployment of appropriate analysis methods following business or other objectives.

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2.2. Challenges in Big Data Implementation

Challenges, in the context of Big Data, are hindrances or impediments faced in the gathering, organizing, and analyzing of massive and highly complex data. Some experts have listed various challenges that may impede the process of implementing Big Data. Data quality issues are a major challenge in Big Data. For instance, inadequate, inaccurate, or inconsistent data can lead to unreliable analysis [6]. Big Data requires an appropriate technology infrastructure for processing massive volumes of data and rapid computing. This is including cloud computing, scalable data storage, and other technology infrastructure [4].

A lack of people with skills in complex data analytics is also a big challenge. Organizations in particular require a team that is both adequately well-trained and have considerable knowledge in data analytics [11]. Data privacy and security issues which include both private and delicate data require a stringent protection to anticipate data misuse or leakage [5]. Big data, which is frequently derived from multiple sources with a variety of formats, also requires data integration to obtain a more comprehensive representation of the data [3]. These challenges indicate that the implementation of Big Data is not a straightforward matter, thus organizations need to deliberate meticulously to overcome the existing challenges.

3. Method

This research was conducted using a systematic literature review (SLR) based method, using Google Scholar to collected data. A total of 43 articles were obtained, which focused on the implementation of Big Data Analytics and the challenges faced in the implementing Big Data Analytics. The Preferred Reporting Item for Systematic Analysis and Meta Analysis (PRISMA) of this study focused on the implementation of Big Data Analytics and the challenges faced in implementing Big Data Analytics as the main basis for this systematic literature review. The stages in this study can be seen in figure 1 below.

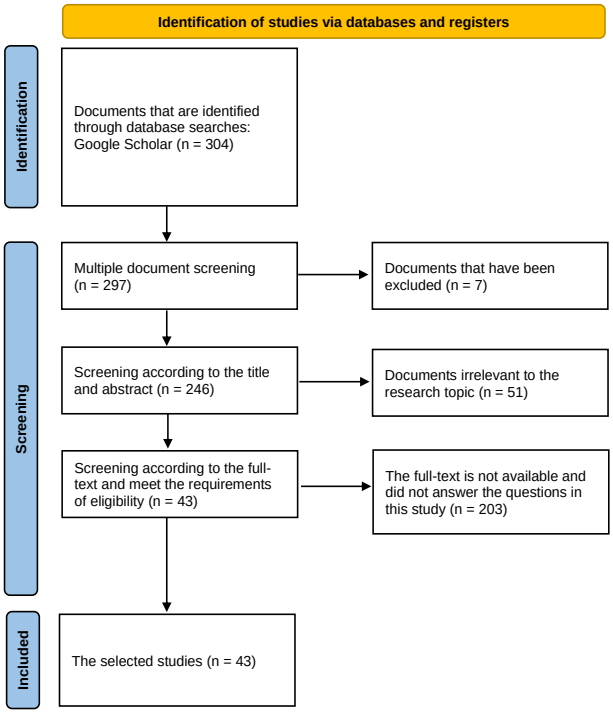

Figure 1. Diagram of PRISMA

3.1. Research Question

At this stage, we determined the questions that were relevant to the research topic, which were as follows:

1. In which sectors is Big Data Analytics implemented?

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2. What are the challenges faced in the implementation of Big Data Analytics?

3.2. Inclusion dan Exclusion Criteria

At this stage, the criteria of the data that were found are being determined, whether the data is eligible to be used as a data source for this research or not. The following are the criteria for data to be considered eligible as a source of research data, namely:

1. The data obtained has a time range from 2019 to 2023.
2. Data obtained from Google Scholar sources.
3. The data used are only English journal papers that related to the implementation and challenges in the implementation of Big Data Analytics.
4. Data that is accessible or downloadable.

3.3. Quality Assesment

At this stage the data that has been collected will be then evaluated according to the following questions:

QA1: Are the journal papers published in the following ranges from 2019 to 2023?

QA2: Are the journal papers discuss about the implementation and challenges in the implement of Big Data Analytics?

3.4. Data Collection

The data collection procedure was conducted by selecting research articles that have relevance to the implementation and challenges in the implementation of Big Data Analytics. Therefore, research articles were retrieved from the Google Scholar database using the following keywords:

“big data analytics” AND “implementation” AND “challenges”

It was adjusted by "Title, Abstract, and Key", to ascertain that the retrieved articles were on the topic of implementation and challenges in the implement of Big Data Analytics. We found 304 articles, and they were screened by criteria that matched the inclusion and exclusion requirements of this study.

4. Results and Discussion

In this study, we utilize a literature review on Big Data Analytics, with a focus on the aspects of Big Data Analytics Implementation and Challenges faced in implementing Big Data Analytics.

4.1. Overview of Big Data

Big Data is a new kind of thinking that has changed the production and lifestyle of society, leading to the development and realization of various new technologies, and also playing an important role in stimulating national development [12]. Big Data is perceived as two factors: Big Data and analytics [13]. Big data relates to the vast amount of data that organizations may be able to store in gigabytes, while analytics is comprised of the various tools and procedures used to analyze the data. [14]. Big data itself contains 7V characteristics: volume, variety, velocity, variability, veracity, value, and validity [15], [16]. Some convergence trends, such as IoT, sensors, cloud computing, big data, artificial intelligence, blockchain, all contribute to the proliferation of vast amounts of data known as big data analytics [14], [17]. Through the analysis and process of a vast amount of complex data, it is favorable to more efficiently extract the values contained within the data, fully master the basic laws of data, and it is more conducive for the development of related industry information technology [17]. The results of the analyzed data set may be useful as a model for better decision-making, which may be tactical, strategic, and operational in scope [13].

4.2. Implementation of Big Data Analytics

Big Data Analytics encompass multiple disciplines and it is being harnessed in many aspects of life for sustainable development by highly professional processing of valuable data [14], [17], [18]. The descriptions below demonstrate the implementation of Big Data Analytics in certain aspects as listed in Table 1.

Table 1. Implementation of Big Data Analytics

No	Sector	Sources
1.	Protection and Security	[19]
2.	Aquaqulture and Fisheries	[20]
3.	Education	[17],[21],[22]
4.	Business	[16]
5.	Financial	[23], [24]
6.	Medical and Healthcare	[25], [26], [27]
7.	Manufature and retail	[18], [28], [29], [30]
8.	Government and company	[31], [32], [33]
9.	Tourism	[26]
10.	Transportation	[34]

The implementation of Big Data Analytics on the Cloud Computing platform is deployed as a service where the use of firewall, encryption secure protocol, antivirus software, cryptographic solution on cloud-based big data can further strengthen the protection of data that is transmitted across the network from cyber-attacks, thus it can become a solution to security problems [19], [35]. For example, in the education sector, Big Data Analytics is commonly utilized to build remote interactive digital learning transmission classrooms, network-based professional teaching resource libraries and 3D virtual reality technology application center as a form of school-company cooperation in the integration of industry and education, which is expected to obtain qualified human resources [17]. In Taiwan, the implementation of Big Data technology in the aquaculture and fisheries sector is an interesting example, including the use of *Unmanned Condition Monitoring* (UAV), Smart Feeding, *Support Vector Machine* (SVM), *Intelligent Cage Aquaculture* (ICA), etc [20]. The applicability of the ICA system in the aquaculture and fisheries sector is designed for the cultivation of marine fish (tilapia, cuttlefish, crab, shrimp) in AIoT intelligent cages immersed under the sea, featuring underwater cameras, integrated sensors, and communication systems. The entire data is gathered using a *Remotely Operated Vehicle* (ROV), intelligent UAV, and autogiro integrated into an Omni IoT system. This system can set up an intelligent algorithm that can automatically provide feed. All data is stored in a cloud system which is linked to a data management center on land. The cloud data center used belongs to the *National Taiwan Ocean University* (NTOU). Resultantly, the fish survival rate increased by 12.06% after the system was launched [36].

The implementation of Big Data Analytics in the finance sector consists of products such as microfinance, crowdfunding and P2P, and credit risk control anti-fraud [23], [24]. Anti-fraud mainly aims to deal with risky behaviors such as transferring large amounts and modifying passwords after logging in at different places. The system retrieves all credit applications, and through specification and comparison with historical information, it can identify old lists and real-name users with poor historical records. The anti-fraud system uses automated data access software and automated task scheduling tools, from collecting data to processing and analyzing data, data storage and data feedback [23]. In the operation of business, the implementation of Big Data Analytics is claimed to improve business operations, such as using Hadoop software to effectively provide users with an innovative service pattern called Analytics as a Service [16]. Furthermore, the usability of social media, files from weblogs obtained from e-commerce sites to assist businesses comprehend consumer behavior, market patterns, client preferences and other beneficial business data [13].

The transformation and implementation of Big Data in the medical and healthcare sector have become an industry development trend, such as adopting machine learning algorithms (decision tree (DT), k-nearest neighbors (k-NN), naive bayesian (NB) algorithm) to make decisions and draw inferences about a person's health hazards [27]. The American Public Health Association launched *'Flu near you'*, a platform for tracking the spread of flu and incorporating Big Data processing methods to predict possible flu outbreaks in the future [25]. The implementation of Big Data Analytics in the manufacturing industry, such as the digital factory model (DFM) and Process Monitoring for Quality (PMQ). DFM is the system established to integrate manufacturing information and knowledge about machine products. On the other hand, PMQ is intended to tackle the many intellectual and practical challenges posed by the application of AI in manufacturing, by employing real-time process data to allow for monitoring and controlling the process, i.e., detecting and eradicating the defect [18], [30].

4.3. Challenges of Implementing Big Data Analytics

The challenge of the long-term usage of a vast amount of data is how to effectively synthesize "semi-structured" and "unstructured" data into structured data to acquire valuable knowledge [37]. Additionally, the design of storage systems is to be considered and the tools for data analytics are enhanced to be effective and accurate. The combination of these data sets is extremely complex. There are numerous challenges that may be embarked upon in this integration such as privacy, data analysis, data curation, visualization, ambiguity of data management, data storage, speed, cost, and complexity [38]. In a similar context, another study conducted in China revealed that the challenges of implementing technology based on Big Data Analytics in the industrial and educational integrated in China are still constrained. The constraints faced include inadequate development of informatization infrastructure, insufficient informatization skills of teachers who are still persisting with traditional concepts and do not have appropriate informatization skills training, high cost of informatization construction, and lack of specific laws and regulations regarding the rights, responsibilities, and obligations of both parties [17]. The following are some cases of general challenges in the implementation of Big Data Analytics that have been observed in this study are listed in Table 2.

Table 2. Challenges of Implementing Big Data Analytics

No	Challenges	Sources
1.	Data acquisition and metadata	[39]
2.	Data quality, Accuracy, accessibility	[40], [41], [42], [30], [43]
3.	Data Storage	[40], [41], [43]
4.	Lack of digital literacy	[42]
5.	Scalability, cost	[44], [29], [40], [45], [46]
6.	Management or organizational support	[47], [48], [49], [50]
7.	Financial Capacity	[47]
8.	Data uncertainty	[51]
9.	Data privacy, security, ethics, legal	[52], [41], [39], [48], [42], [47], [44], [49], [46], [29], [53], [54], [55], [37]
10.	Data visualization & representation	[46], [56], [55], [37]
11.	Heterogenity	[56], [54]

As part of metadata analysis, enormous amounts of data are classified and then analyzed to identify patterns and values contained in the data. The majority of organizations have various policies in place to secure their vulnerable information. The security of sensitive information is an essential issue in metadata analysis because there are so many security risks in the data environment [41], [48], [52]. As a consequence, the security of information is a significant issue for big data analytics, and particularly for developers of security management systems [43]. The security of metadata can be advanced by using "Authentication", "Authorization", and "Encryption" methods [37]. Data security can consist of legal, technical and conceptual concerns [48]. Throughout the process of analysis, the data becomes part of a vast and complex system and thus sharing personal data about the client and there are privacy risks in the process.

Management and Organizational Challenges

Implementing Big Data Analytics is extremely challenging unless the support of executives, management, financial, technical capabilities and data talent is in place. Management is responsible for determining the direction of big data project initiatives. Besides, Big Data Analytics is more likely to be successfully implemented if employees are properly and effectively trained to carry out the tasks [47], [48]. Data storage and data management are crucial to big data to overcome the problems or challenges that exist in the form of data growth rates, increased access times, and data transfers [39].

Data Visualization and Representation Challenges

These are one of the major challenges for data analytics systems to properly visualize the ultimate results of data storage. Data visualization has an important role to play in the data analytics process and assists in revealing new insights, facilitates an easy-to-use, interactive and dynamic analytical view [15], [48].

Data quality, Accuracy, and Accessibility Challenges

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The data quality, accuracy and accessibility that are used in big data analytics become extremely imperative to derive accurate insights for decision-making [15], [40], [41], [42].

The data utilized in Big Data Analytics must be relevant and it ultimately depends on accuracy. Data scientists invest 50-80% of their time in performing accuracy and the preparation of data before rendering it truly usable. Simultaneously, purifying the data takes 30-80% of the development time and budget. Hence, relevant data requires a lot of work, and it becomes both a challenge and an opportunity to improve data quality. Since poor quality data contains errors and incomplete values, it can be a serious problem as it results in financial losses, inefficiency and failure to comply with rules and regulations. While implementing Big Data Analytics, it is suggested to conduct filtering, clustering, and feature selection on the data is required for real-time detection, which can improve the detection accuracy [43].

5. Conclusion

Big Data may be defined as datasets that have a tremendous volume, high growth rate, and increasing complexity. Big Data has been the topic of increasing dominance in the world of information technology and modern business. This phenomenon denotes the accelerated growth of data generated by both humans and machines from various data sources such as sensors, mobile devices, social media, and business transactions. Big Data is about more than simply large amounts of data, it also implies high-speed of data processing and high data variability. With advancement in technology, we are increasingly able to collect, store, manage, retain, and effectively analyze data on an unprecedented scale.

In a world where data is being considered as a valuable asset, Big Data offers the opportunity to obtain profound insights from the existing data. Big Data also entails the evolution of technologies and analytical techniques that enable us to explore information that was previously unseen. In this context, the implementation of Big Data is not feasible and faces various challenges, such as data privacy and security issues, poor data quality, insufficient utilities, and inadequate IT skills in analyzing complex data. Consequently, there is a requirement for a robust strategy, a substantial investment, and the acquired IT professionals with the expertise and capability to manage the data.

6. Declarations

6.1. Author Contributions

Conceptualization: FLS, AM, and SNN; Methodology: AM; Software: FLS; Validation: FLS, AM, and SNN; Formal Analysis: FLS, AM, and SNN; Investigation: FLS; Resources: AM; Data Curation: AM; Writing Original Draft Preparation: FLS and SNN; Writing Review and Editing: AM and FLS; Visualization: FLS. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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6.4. Institutional Review Board Statement

Not applicable.

6.5. Informed Consent Statement

Not applicable.

6.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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