
Research article

Cloud Computing and Big Data Service: Challenges and Barriers

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ABSTRACT

Abstract—Big Data has arisen in recent years as a new paradigm for digital applications such as business, science, and engineering, giving plentiful data and chances to enhance and/or enable research and decision-support applications with unparalleled value. Big Data, on the other hand, poses issues for digital systems in terms of storing, transporting, processing, mining, and serving data. The use of these resources has generated amazing Big Data breakthroughs, and cloud computing offers key assistance to meet the difficulties using shared computing resources such as computation, storage, networking, and analytical software. Cloud computing has assisted in the advancement of big data by providing computational, networking, and storage capacity, while at the same time posing challenges in the processing of the information. This paper provides an overview, as well as opportunities and challenges, of transforming large amounts of data using cloud computing infrastructure. This paper presents an overview of both cloud and big data technologies, describing the current challenges and barriers with these technologies.

1. Introduction

The volume and amount of information collected by organisations from various mobile devices and multimedia is increasing at an alarming rate, and has nearly doubled in the last year. Either this massive amount of data generated can be classified as structured or unstructured data, or it is difficult to load into traditional relational databases because of its sheer volume. This massive amount of data necessitates pre-processing in order to transform the raw data into a clean data set that can be analysed [1, 2]. These data are used for analysis and decision-making in a variety of fields, including healthcare, finance, engineering, e-commerce, and various scientific fields. The advancements in data science, data storage, and cloud computing have made it possible to store and mine large amounts of data. In the case of cloud computing, parallel processing, scalability, accessibility, data security, virtualization of resources, and integration with data storage have all been improved [3, 4]. Cloud computing has eliminated the need to invest in infrastructure, such as hardware, facilities, utilities, or the construction of large data centers, which previously required investment. Cloud infrastructure scales on demand to support fluctuating workloads, which has resulted in the scalability of data produced and consumed by big data applications, as well as the scalability of data produced and consumed by other applications[2, 5]. Cloud virtualization can be used to create a virtual platform that contains both the server operating system and storage devices, allowing multiple machines to be spawned at the same time. In order to increase access, management,

analysis, and computation of data, a process of sharing resources and hardware isolation is implemented [6, 7]. Advances in information and communication technology (ICT) enable governments to conduct internal and external operations more efficiently [8, 9]. Electronic government refers to the use of ICTs to facilitate the government's basic roles and duties and achieve higher quality in the delivery of public services to people and communities. Sensors, digitizers, scanners, numerical models, mobile phones, Internet, videos, e-mails, and social networks all contribute to Big Data. Texts, geometries, photos, films, sounds, and their combinations; these data may be linked to geographical data[10]. Data management has evolved from a static paradigm to one defined by volume, velocity, diversity, truthfulness, and value[7, 11]. The initial V stands for volume, which is the most popular characteristic of Big Data. As evidenced by data collecting from social networks, enormous array of sensors from the micro (atomic) to the macro (global), and data transfer from sensors to supercomputers and decision-makers. Model and structural data are saved in a variety of data types. Veracity relates to the data's quality, precision, and reliability. For the 5th, we need to concentrate on specialised research and decision-support applications that enhance our lives, work, and prosperity [12, 13]. Big Data's development, particularly business and government use, extends its substance and significance. The original volume-based definition now includes the data itself, as well as the information and understanding gained from it. For example, the Big Earth Data Initiative views Big Data as an investment opportunity and a 'calling card' for furthering earth research and digital applications. From a data-only notion to one including data, technology, and personnel, Big Data in geospatial has developed [14, 15]. There is a detailed analysis of Big Data problems in various domains (Section 2), Cloud Computing (Section 3), Link between Big Data and Cloud Computing (Section 4), Case Study on Big Data in the Cloud (Section 5), Future work (Section 6), Conclusion (Section 5).

2. Big Data and Cloud Computing

Big data and Cloud computing are intertwined. Cloud computing focuses on scalable, elastic, on-demand, and pay-per-use self-service models. Big data analysis demands vast on-demand processing power and distributed storage, which cloud computing smoothly offers. Cloud computing also provides distributed processing for scalability and expansion through virtual machines. Thus, the need for contextually analysed data from huge data-driven enterprises has led to the growth of analytical platforms. Consequently, companies like Amazon, Microsoft, and Google are selling big data platforms at low cost, with analytics to create proactive and contextual experiences.

A. Big Data

Big data is a collection of structured, semi-structured, and unstructured data collected by organisations that can be mined for information and used in machine learning projects, predictive modelling, and other advanced analytics applications. Big data is also referred to as "big data analytics. Systems that process and store large amounts of data have become a common component of data management architectures in organisations, particularly when combined with tools that support big data analytics applications. "Big Data" refers to data that is large in volume, difficult to store, manage, and analyse using traditional database technologies. It is necessary to have a scalable architecture to store, manipulate, and analyse it efficiently. Smartphones and social media posts; sensors such as traffic signals and utility meters; point-of-sale terminals; consumer wearables such as fitness meters and electronic health records; and other sources all contribute to this massive volume of data. In order to uncover hidden values from this diverse and complex data, various technologies are integrated in order to transform it into actionable insights, improved decision-making, and competitive advantage. Companies utilise big data to enhance operations, customer service, customise marketing efforts, and boost sales and profitability. Businesses that properly utilise it may make quicker and more informed business choices than those that do not. For example, big data may help organisations improve their marketing, advertising, and promotions to enhance client engagement and conversion rates. Data may be evaluated in both the past and present to identify changing consumer or corporate buyer preferences, allowing firms to better respond to client demands. Big data is also

utilised by physicians to diagnose diseases and medical issues in people. The data from electronic health records, social media, the web, and other sources keeps healthcare providers and government agencies informed about infectious disease dangers and outbreaks. Big data helps oil and gas businesses locate new drilling sites and monitor pipeline operations, and utilities track power networks. Financial services organisations also employ big data for risk management and real-time market data research. Big data also helps manufacturers and shipping industries manage supply chains and improve delivery routes. Emergency response, crime prevention, and smart city programs are other government applications. The following are the characteristics of big data. The following are the characteristics of big data [16]:

- **Volume:** the amount of data that is being accumulated, which is becoming increasingly difficult to transfer, store, and process, as well as to keep up with the pace of technological advancement. Typically, this would be in the terabyte range or higher[12].
- **Velocity:** refers to the speed at which big data is generated. Data generation, transfer, collection, and analysis speed. Data generated at an ever-increasing rate must be analysed, and access to it must be instantaneous to allow for real-time access to applications that rely on it [12].
- **Variety:** refers to the rate at which new data is generated and moved around. With the advent of IoT, many organisations can now collect data at an unprecedented rate. Smart meters, smart home appliances, industrial sensors, and self-driving cars all generate and send data rapidly[12].
- **Variability:** refers to the source of the data, its context, and its value to the organisation. Quality and accuracy of big data are less controllable.
- **Value:** ability to turn data into a valuable asset. Businesses must make a case for collecting and using big data.
- **Veracity:** Refers to the degree to which big data can be trusted[16].



Figure 1 Big Data Analysis

B. Challenges and barriers of Big Data Technology

- **Data storage:** Big Data comes with storage difficulties. A large number of hard disc drives (HDDs) fail, and traditional data security techniques (e.g., RAID) are inefficient with PB-scale storage. Due to Big Data's tremendous velocity, typical storage methods cannot scale quickly enough. Cloud storage solutions (like Amazon S3) offer near-infinite storage with high fault tolerance. However, sending and storing Big Data on the cloud is pricey. To determine the data's analytical usefulness and preservation, standards and algorithms must be devised that balance storage and data transport costs[17].
- **Data transmission:** Large data transfers require sophisticated preprocessing approaches and data compression technologies. It is difficult to design effective algorithms to automatically select the suitable cloud service (location) based on spatiotemporal principles to enhance data transmission speed while reducing cost. Examples of effective network transmission models for geographic data in a cyber-infrastructure setting are[18].

- **Data management:** Big Data's diversity and veracity need new technologies to clean, store, and organise unstructured data. It is difficult to automatically produce metadata to characterise Big Data and related operations. High-dimensionality (3D space and 1D time) and complexity (e.g., space–time connection and dependence) of geographic data make metadata generation difficult. Besides generating metadata, Big Data challenges DBMSs since standard RDBMSs lack scalability for handling and storing unstructured Big Data [19].
- **Data processing:** Analysis of Big Data requires significantly more computer power than standard computing paradigms can provide. Almost infinite on-demand processing capacity is available through cloud computing. The virtualization and shared nature of cloud computing makes it difficult to manage and ensure data location[20]
- **Data analysis:** Data analysis is critical in the Big Data value chain for information extraction and prediction. However, interpreting Big Data tests the algorithms' complexity and scalability. In order to fill this gap, either new methods or tools for preparing data are required. Spatiotemporal thinking, computation, and applications are a high-priority research subject in the geospatial domain[21]
- **Data visualization:** Visualizing Big Data reveals hidden patterns and relationships to enhance decision-making. The SAS (2012) outlined five essential Big Data visualisation features as follows. Online-based interactive interfaces to preview, filter, or sample data before visualisations; in-memory processing; and readily disseminated answers through mobile devices and web portals. Nevertheless, seeing and interpreting Big Data in real-time requires human engagement[22].
- **Data integration:** Integrative data analysis and cross-domain partnerships are required to achieve Big Data's 5th Value (value)[23].
- **Data architecture:** System architecture is challenged by how Big Data is altering scientific study. So, smooth integration of tools and GIS services is still a goal. These tools must also be integrated into reusable processes, and data must be shared throughout communities. Equipping other research disciplines with equivalent cyber infrastructure is both crucial and difficult [24].
- **Data security:** Using data encryption methods and techniques to protect Big Data is difficult. Due to efficiency and scalability difficulties, previous data encryption research concentrated on small-to-medium-sized data. These strategies and methods do not operate well with extremely unstructured, diverse data. Effective data access control and security management policies for Big Data must include new data management methods and storage architectures.
- **Data privacy:** Personal health information is stored in social media and medical records, posing privacy issues. Another example is monitoring staff travel and productivity using data gathered from devices such as smartphones and computers[25].
- **Data quality:** Location accuracy in social media data ranges from meters to hundreds of kilometers, and real-time data redundancy control and filtering should be performed. The last challenge with Big Data is maintaining data integrity across various contributors[26].

C. Sources of Big Data

- **Internet of Things:** The Internet of Things (IoT) creates data streams globally from networked mobile devices, computers, sensors, RFID tags, and cameras. The IoT sensors create big data with rich spatiotemporal information. Increasing agricultural productivity and developing smart cities are two areas where this technology can play a major role [27].
- **Social sciences:** Twitter and Facebook generate around 500 million tweets per day and 200 billion tweets per year, amounting to an enormous amount of data for social scientists to study. Around 6000 tweets per second are produced by Twitter users globally, equating to 1.5 trillion Tweets per day. Many economists, political scientists, sociologists, and other social academics employ Big Data mining to examine social interactions and digital footprints [28].
- **Astronomy:** Using improved sky survey technology, astronomers are creating a spatiotemporal map of the cosmos. Large Hadron Collider generates 60 TB of experimental data per day and 15 PB per year, in addition to observational data. Big Data may be used to study how Earth develops and safeguard Earth from space impacts, such as planetary defense[24]

- **Business:** Business activities create vast volumes of unstructured (variety and veracity) data. Big Data enhances business intelligence and analytics for strategy, optimization, and competitiveness. Many data processing solutions have been developed for distributed and scalable storage environments to manage and analyse this data. Building spatiotemporal statistical models from business data is still difficult[29].
- **Industry:** Ad-hoc networks for self-control and self-optimization are emerging in the fourth industrial revolution. A semi-structured data model allows for real-time queries and random access to Big Data without time-consuming operations and data joins. Industry 4.0 problems include networking, data integration, data analytics, and intelligence for Cyber-Physical Systems[30].

3. Cloud computing

Cloud computing is a method of delivering computing services such as servers, storage, databases, networking, software, analytics, and intelligence over the internet to enable faster innovation, more flexible resources, heavy computation, parallel data processing, and cost savings at a larger scale. Because it totally abstracts computing, storage, and network resources from workloads, as they are required, it enables firms to focus on their core businesses while taking advantage of the availability of prebuilt services[31]. The IEEE Computer Society defines cloud computing as "a paradigm in which information is constantly stored in servers on the Internet and cached temporarily on clients that include desktops, entertainment centers, computers, notebooks, handhelds, and so on." According to Foster et al. (2008), the cloud is a large-scale distributed computing paradigm in which a pool of virtualized, scalable, and manageable storage, computing power, platforms, and services is made available to customers on-demand via the Internet [32]. Cloud computing is a collection of virtualized and scalable resources that can host applications and provide required services to users and can be charged on a usage basis, similar to a utility [33]. The widely accepted definition of cloud computing, according to Mell and Grance, is the US National Institute of Standards and Technology (NIST) [34]. The definition, which states that cloud computing is a model for providing ubiquitous, adequate, and on-demand access to shared and configurable computing resources (e.g., servers, networks, storage, applications, and services) with minimal effort and service provider interaction. Cloud computing has distinct characteristics and features that set it apart from other computing paradigms (for example, client-server and grid computing). Al-Karawi et al. distinguished cloud computing from other types of computing and identified four cloud-computing features: user-centric interfaces, on-demand services, QoS, and autonomous systems[3]. The characteristics of cloud computing for big data imply that effective use of cloud computing may be helpful in the way of implementing efficient e-government services. Cloud computing has the key capabilities that make it suitable for use in an e-government implementation. Realizing the benefits of cloud computing for big data applications may result in a revolution in big data. However, NIST defined five comprehensive characteristics for cloud computing, which can include all mentioned features as follows [34]:

- **Access to a large network:** The Internet provides virtually unlimited access to resources regardless of location or device (e.g., mobile phones, tablets, laptops, and workstations).
- **Self-service on demand:** Computing resources, such as server and processing time, as well as storage server, are easily provided as needed.
- **Pooling of resources:** The resources to serve various clients, with physical and virtual resources dynamically assigned and reassigned based on client requests.
- **Service that is measured:** Controlling and optimising resource use through the assignment of a measured capability appropriate to the type of service (e.g., storage, processing and bandwidth).
- **Elasticity that responds quickly:** Resources can be provisioned and scaled quickly outward and inward in response to demand.

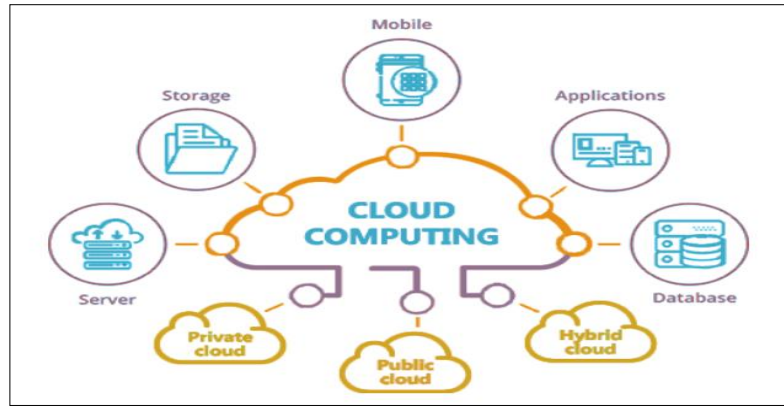


Figure 2 Cloud computing

The NIST defines cloud computing as having three different models of cloud services: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Cloud Service Providers (CSP) run and maintain computing resources, operating systems, and application software in the SaaS model. The CSP is responsible for providing, running, and maintaining system software and computing resources in the PaaS model, whereas the user has little control over the operating system and hardware resources. Finally, in the IaaS model, the CSP provides a set of virtualized computing resources (e.g., storage capacity, processing power, memory, and network bandwidth) to the customer, who uses these virtual resources to run and maintain the operating system and software applications. All of these services can be deployed using one of four different deployment models: public, private, hybrid, or community [34]. The public cloud is a model in which services are delivered over a network that is open to the public. In the private cloud, infrastructure is dedicated to a single organisation. The term "hybrid cloud" refers to both public and private cloud models. The community model, on the other hand, shares resources among several related organisations from the same community that have similar concerns and needs [34]

A. Cloud Advantages

- **Implementation Simplicity:** Public organizations can easily deploy cloud computing without the need for expensive hardware, software licenses, or application implementation.
- **Savings on expenses:** Agencies could save or even remove ICT upfront costs while lowering operational costs by only paying for things used and reducing or redeploying ICT staff.
- **Scalability:** When consumer strengthening the capacity, organisations can add and subtract network load capacity rather than acquiring additional hardware and software.
- **Accessibility:** Cloud computing can boost employee mobility by allowing access to information and services from any location and on a variety of devices.
- **Access to Information:** Technology Capabilities: It enables smaller organisations to gain access to powerful hardware, software, and ICT personnel.

1. Link between Big Data and Cloud Computing

Cloud computing makes all of this possible via the use of hardware virtualization. As a result, big data and cloud computing are two ideas that are compatible with one another since cloud computing allows large data to be accessible, scalable, and fault-tolerant. It is critical to understand Big Data and Cloud Computing's role and future in our current economy. In the last 15 years, massive volumes of data from every imaginable source of data collection or creation have accumulated in the most diverse formats. Since the cost of sensing and collecting data has continued to fall significantly, many new innovative ways of looking at the hidden value of data collected through observation of every trend in human life, with value delivery as its definitive economic driver, have emerged. Big data and Cloud computing are intertwined. Cloud computing focuses on scalable, elastic, on-demand, and pay-per-use self-service models. Big data analysis demands vast on-demand processing power and distributed storage, which cloud computing smoothly offers. Cloud computing also provides distributed processing for scalability and expansion through virtual machines. Thus, the need for contextually analysed data from huge data-driven enterprises has led to the growth of

analytical platforms. Therefore, companies like Amazon, Microsoft, and Google are selling big data platforms at low cost, with analytics to create proactive and contextual experiences. Cloud computing is a brilliant new way to provide IT services. Cloud computing has many suppliers and users. It encompasses software, hardware, and subscription-based services delivered through the internet in real time. Data is captured and stored in the cloud utilising big data techniques. Cloud computing delivers on-demand resources and services. The most common big data analytics models are software as a service, platform as a service, and infrastructure as a service (IaaS). Clients may now request cloud analytics and analytics as a service (AaaS). Analytics as a Service (AaaS) delivers cloud-based subscription-based data analytics tools and methods for quick and scalable data integration, transformation, and analysis. Create a software-based virtual desktop, servers, storage, operating system, and network resources. A virtual environment is created on an existing server to execute required applications without interfering with other users' services. It lets several consumers and organisations share a single physical instance of a resource or application. It accomplishes this by giving physical storage a logical name and responding with a reference to it. With virtualization, numerous workloads on several physical servers may be condensed into a single virtual computer. Physical server reduction minimises data center complexity, capital and administrative expenses. Compared to a multi-node arrangement, this optimises resource use and power consumption. Virtual machines are very flexible and portable, allowing workloads to be moved to different physical servers for scheduled or unforeseen maintenance. In terms of resource usage, cost, and data management, virtualized big data systems like Hadoop outperform physical infrastructure. Virtual data combines many data sources and increases data availability in diverse situations. Fast data flow through the network allows for speedier processing. Big data privacy and security are essential considerations. Maintaining privacy and security in the cloud is difficult since data is housed and processed by third-party services. The more big data there is, the greater the danger to privacy and security. Mobile health has transformed several aspects of health care. Various health care mobile apps have assisted users in maintaining their lifestyle, health, and fitness. Since everything is sent over mobile internet, data privacy may be threatened if the network is not adequately protected or exposed to outsiders. Diverse new laws and privacy rules must be maintained between providers and consumers to ensure user trust and data security. Big data security in the cloud is critical to safeguard data from hostile hackers and manage vast disc space safely [3, 35]. These studies, however, propose the aforementioned benefits based on cloud computing characteristics and do not empirically test these benefits. Following that is a brief description of each benefit.

2. Case Study on Big Data in the Cloud

Big data storage and processing need scalability, resilience, and availability. It does so through hardware virtualization. Cloud computing makes huge data accessible, scalable, and fault-resistant. Businesses see big data as a lucrative potential. As a result, new firms like Cloudera, Hortonworks, Teradata, and others have begun focusing on Big Data as a Service (BDaaS) (DBaaS). Google, IBM, Amazon, and Microsoft all allow users to consume big data on demand. Next, we offer Nokia and RedBus as examples of effective big data utilisation in cloud contexts. There are several case studies of big data on cloud computing.

A. Nokia

Nokia mobile phones are used by many people for telecommunication. Nokia gathers a large amount of data from mobile phones on a petabyte scale for business decision strategies using a Hadoop data warehouse for analytics[36].

B. Redbus

Redbus is an Indian online bus ticketing service. Redbus uses Google's data infrastructure to improve customer service and ticketing. [36].

C. Tweet Mining in Cloud

Noordhuis et al. [36] employed cloud computing to collect tweets. All calculations were done using Amazon cloud infrastructure. Then a page-ranking algorithm was applied to the tweets. About 50 million nodes and 1.8 billion edges were crawled.

4. Future Work

Developing effective tools and technology may help solve many problems. Technology may be built to handle large volumes of streaming data quickly. The present tools and methodologies do not efficiently separate valuable data from large volumes of data. Using effective tools and procedures, structured data may be extracted from unstructured data

to be stored in a relational database.

5. Concluding Remarks

Large amounts of data are being generated daily, and big data systems, in particular, analytic tools, have emerged as a significant driver of innovation, providing a means to store, analyse, and extract information from petabyte-scale datasets. Cloud environments have a significant impact on big data solutions because they provide fault-tolerant, scalable, and readily accessible settings for large data systems. Despite the fact that big data systems are strong tools that allow both businesses and scientists to get insights from large amounts of data, there are several challenges that need additional examination. Additional work will be required in the development of security procedures as well as the standardisation of data formats. Another critical component of Big Data is scalability, which is often achieved by manual rather than automated methods in commercial settings. In order to address this issue, further study must be conducted. Because of our research in this area, we want to leverage adaptive methods in order to build solutions for achieving elasticity across a variety of dimensions in big data systems operating on the cloud. To do this, the researchers will look at the methods that adaptive software may employ to trigger scalability at various stages within the cloud stack. As a result, data surges may be accommodated in an autonomous and reactive manner. Here, we offer an introduction to big data in cloud settings, stressing its benefits and demonstrating that the two technologies operate very well together, while also outlining the problems that both technologies must overcome in order to be successful.

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