IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Hadoop as a Service: Cloud Computing Paradigm for Big Data Processing

Sanyami Srivastava[1], Akshat Pandey[2], Goldi Soni[3]

[1] *Student, BSc IT, Amity University Raipur, Chhattisgarh, India*
[2] *Student, BSc IT, Amity University Raipur, Chhattisgarh, India*
[3] *Asst. Professor, Dept. of Information Technology, Amity University Raipur, Chhattisgarh, India*

Abstract : The contemporary digital landscape is witnessing an unprecedented surge in data generation, known as the "big data explosion." In response to this phenomenon, innovative technologies like Hadoop have emerged to facilitate distributed storage and processing of large datasets. Hadoop, coupled with cloud computing, has revolutionized data management and analysis for organizations across various sectors. Hadoop as a Service (HaaS) represents a convergence of these technologies, offering managed Hadoop clusters in the cloud. This paper provides an overview of Hadoop, discusses the advantages of HaaS for big data processing, delves into its architecture, compares it with traditional deployment models, examines security and privacy considerations, and explores future trends and challenges. Overall, HaaS enables organizations to leverage the power of Hadoop for data processing and analytics without the complexities of infrastructure management, driving innovation and competitiveness in today's data-driven world.

Keywords: Cloud computing, Hadoop as a Service (HaaS), Hybrid cloud, Traditional Hadoop deployment, HDFS, MapReduce

1.INTRODUCTION

In the contemporary digital landscape, the proliferation of data has reached unprecedented levels, creating both challenges and opportunities for businesses and organizations across various sectors. This surge in data generation, often referred to as the "big data explosion," has necessitated the development of innovative technologies and platforms to effectively capture, store, process, and analyze vast volumes of data in a timely and efficient manner. Among the most prominent solutions to emerge in response to this data deluge is Hadoop, an open-source framework designed to facilitate distributed storage and processing of large datasets across clusters of commodity hardware. Coupled with the paradigm of cloud computing, Hadoop has revolutionized the way organizations manage and derive insights from their data assets.

1.1. Overview of Hadoop

Hadoop, named after a toy elephant belonging to the son of one of its creators, Doug Cutting, is a robust and scalable framework that forms the cornerstone of big data processing and analytics. Originally developed by Cutting and Mike Cafarella in 2005, Hadoop was inspired by Google's MapReduce and Google File System (GFS) papers, which outlined a distributed computing model for processing large-scale datasets across clusters of commodity servers. Hadoop's core components include the Hadoop Distributed File System (HDFS) for distributed storage and Apache MapReduce for parallel processing of data. Additionally, the Hadoop ecosystem comprises various complementary tools and libraries, such as Apache Hive, Apache Pig, Apache HBase, and Apache Spark, which extend its capabilities for data storage, processing, querying, and analysis.

1.2. The importance of big data processing

The exponential growth of data in recent years has underscored the critical importance of effective big data processing for organizations seeking to gain actionable insights, drive informed decision-making, and gain a competitive edge in their respective industries. Big data encompasses a diverse array of data types, including structured, semi-structured, and unstructured data, generated from sources such as social media, sensors, mobile devices, transactional systems, and the Internet of Things (IoT). This data abundance presents both challenges and opportunities for organizations, as they grapple with the complexities of capturing, storing, and analyzing data at scale. However, by harnessing the power of big data analytics, organizations can unlock valuable insights into customer behavior, market trends, operational efficiency, and strategic opportunities, enabling them to optimize processes, mitigate risks, and drive innovation.

1.3. Introduction to the cloud computing paradigm

Cloud computing, often touted as the "next frontier" in IT infrastructure, has emerged as a transformative paradigm for delivering computing resources, including servers, storage, databases, networking, and software, over the internet on a pay-as-you-go basis. Unlike traditional on-premises infrastructure, which requires significant upfront investment in hardware and software provisioning, cloud computing offers scalability, flexibility, and cost-efficiency, allowing organizations to scale resources up or down dynamically in response to changing demand. The cloud computing model encompasses three primary service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), each offering varying degrees of abstraction and management responsibilities for users.

Hadoop as a Service (HaaS) represents a convergence of these two transformative technologies, combining the scalability and flexibility of cloud computing with the distributed computing capabilities of the Hadoop framework. HaaS providers offer managed Hadoop clusters and infrastructure resources on a cloud-based platform, enabling organizations to leverage Hadoop's powerful capabilities without the overhead of infrastructure provisioning, configuration, and management. By outsourcing the complexities of Hadoop deployment and maintenance to third-party providers, organizations can focus on extracting value from their data and driving business outcomes, rather than managing IT infrastructure.

In summary, Hadoop as a Service (HaaS) represents a compelling solution for organizations seeking to harness the power of big data processing and analytics in the cloud. By leveraging the scalability, flexibility, and cost-efficiency of cloud computing, coupled with the distributed computing capabilities of the Hadoop framework, organizations can unlock new insights, drive innovation, and gain a competitive advantage in today's data-driven world. In the subsequent sections of this paper, we will delve deeper into the architecture, benefits, challenges, and future trends of Hadoop as a Service, exploring its implications for businesses and researchers alike.

2.1. HADOOP AS A SERVICE (HAAS)

Hadoop as a Service (HaaS) is a cloud-based solution that provides managed Hadoop clusters and infrastructure resources for big data processing. It eliminates the need for organizations to provision, configure, and manage Hadoop infrastructure, allowing them to focus on data analytics and insights generation.

The evolution of HaaS has been driven by the growing demand for scalable and cost-effective solutions for processing large datasets in the cloud. Initially, organizations relied on on-premises Hadoop deployments, which required significant upfront investment in hardware and software infrastructure. However, as cloud computing gained traction, HaaS emerged as a viable alternative, offering the scalability, flexibility, and cost-efficiency of the cloud combined with the distributed computing capabilities of Hadoop.

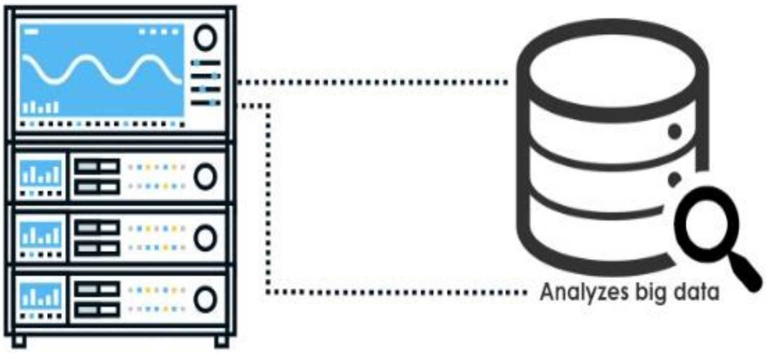

Fig1.Big Data Analysis

2.2. Advantages of using HaaS for big data processing

The advantages of using HaaS for big data processing are manifold. Firstly, it eliminates the need for organizations to invest in and manage complex Hadoop infrastructure, reducing operational overhead and freeing up resources for strategic initiatives. Secondly, HaaS provides scalability on-demand, allowing organizations to scale resources up or down dynamically in response to changing workload requirements. Finally, HaaS offers cost savings by shifting from capital expenditure (CapEx) to operational expenditure (OpEx), paying only for the resources consumed on a pay-as-you-go basis. Overall, Hadoop as a Service (HaaS) represents a compelling solution for organizations seeking to leverage the power of Hadoop for big data processing in the cloud.

2.3. Architecture of Hadoop as a Service (HaaS) encompasses three main aspects:

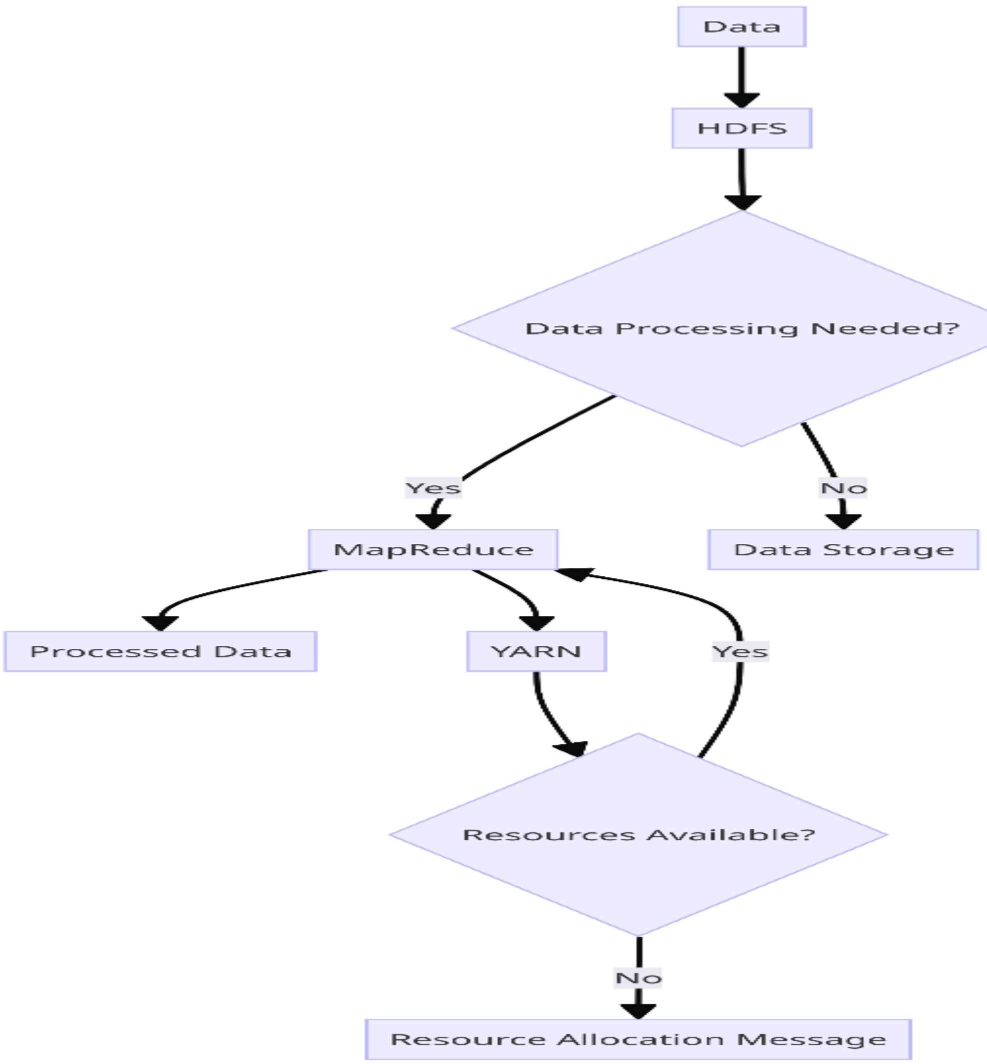

Fig.2.Data Processing Flowchart

Hadoop as a Service (HaaS) architecture comprises several key components, deployment models, and considerations for scalability and reliability. Let's delve into each aspect in detail:

2.3.1. Components of Hadoop ecosystem:

- Hadoop Distributed File System (HDFS): HDFS is the primary storage system used by Hadoop for distributed storage of large datasets across multiple nodes in a cluster. It breaks down files into blocks and replicates them across different nodes for fault tolerance and high availability.
- MapReduce: MapReduce is a programming model and processing engine for parallel processing of large datasets in a distributed computing environment. It consists of two main phases: the map phase, which processes input data and generates key-value pairs, and the reduce phase, which aggregates and summarizes the output from the map phase.
- YARN (Yet Another Resource Negotiator): YARN is the resource management and job scheduling component of Hadoop, responsible for allocating compute resources to different applications running on the cluster. It decouples resource management from processing frameworks like MapReduce, allowing multiple processing engines to run concurrently on the same cluster.
- Hadoop Ecosystem Tools: In addition to HDFS, MapReduce, and YARN, the Hadoop ecosystem includes a wide range of tools and frameworks for data ingestion, storage, processing, querying, and analysis. These include Apache Hive, Apache Pig, Apache Spark, Apache HBase, Apache Kafka, Apache Sqoop, and many others, each serving specific use cases and requirements.

2.3.2. Deployment models for HaaS:

- Public Cloud: In the public cloud deployment model, Hadoop clusters are hosted and managed by third-party cloud providers, such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). Organizations can provision Hadoop clusters on-demand and scale resources dynamically based on workload requirements, paying only for the resources they consume.
- Private Cloud: In the private cloud deployment model, organizations deploy and manage Hadoop clusters within their own data centers or private cloud environments. This approach offers greater control over security, compliance, and data governance but requires upfront investment in hardware infrastructure and ongoing maintenance.
- Hybrid Cloud: The hybrid cloud deployment model combines elements of both public and private clouds, allowing organizations to leverage the scalability and flexibility of the public cloud for bursty workloads while maintaining sensitive data and applications on-premises or in a private cloud environment. Hybrid cloud architectures enable seamless data integration and workload mobility across different cloud environments.

2.3.3. Scalability and reliability considerations:

- HaaS platforms are designed for scalability, allowing organizations to dynamically scale resources up or down based on workload demands.
- Reliability is achieved through redundancy and fault tolerance mechanisms built into Hadoop and cloud infrastructure, ensuring high availability and data integrity.
- Organizations must consider factors like data locality, network bandwidth, and data replication strategies to optimize performance and reliability in HaaS environments.

3.1. COMPARISON HAAS WITH TRADITIONAL HADOOP DEPLOYMENT

Traditional Hadoop deployment involves setting up and managing Hadoop clusters on-premises or in private data centers, requiring organizations to invest in hardware infrastructure, software licenses, and IT expertise to deploy, configure, and maintain their Hadoop environments. In contrast, Hadoop as a Service (HaaS) abstracts away the complexities of infrastructure management by providing managed Hadoop clusters and infrastructure resources through the cloud. Let's delve deeper into the differences between traditional Hadoop deployment and HaaS, followed by a cost analysis and performance comparison.

Table 1: Comparison between Traditional Hadoop Deployment and Hadoop as a Service (HaaS) based on Deployment Models, Cost Analysis, and Performance Comparison.

Criteria	Traditional Hadoop Deployment	Hadoop as a Service (HaaS)
Differences between deployment models	Organizations manage and maintain on-premises Hadoop clusters, requiring expertise in infrastructure provisioning, configuration, and maintenance.	HaaS providers handle infrastructure provisioning, configuration, and management, allowing organizations to focus on data processing and analytics.
Cost analysis	Significant upfront investment in hardware infrastructure, software licenses, and data center facilities. Ongoing operational expenses for hardware maintenance, software updates, and IT personnel.	Pay-as-you-go pricing model based on usage metrics such as compute and storage resources. No upfront capital expenditure on infrastructure. Operational expenses are based on resource consumption.
Performance comparison	Performance may vary depending on the quality of hardware infrastructure, network latency, and resource utilization. Scalability may be limited by hardware constraints.	HaaS offers scalable infrastructure resources and optimized performance based on cloud provider capabilities. Resources can be scaled up or down dynamically to meet workload demands.

3.2. Differences between Traditional Hadoop Deployment and HaaS:

3.2.1. Infrastructure Provisioning and Management:

- Traditional Hadoop Deployment: Organizations are responsible for provisioning, configuring, and managing the hardware infrastructure required for their Hadoop clusters, including servers, storage, networking equipment, and data center facilities. This entails significant upfront capital expenditure and ongoing operational overhead.
- Hadoop as a Service (HaaS): HaaS providers handle the provisioning, configuration, and management of the underlying infrastructure, allowing organizations to focus on data processing and analytics rather than infrastructure management. HaaS abstracts away the complexities of infrastructure provisioning, enabling organizations to quickly deploy and scale Hadoop clusters on-demand.

3.2.2. Software Installation and Configuration:

- Traditional Hadoop Deployment: Organizations must install, configure, and maintain the Hadoop software stack, including components such as Hadoop Distributed File System (HDFS), MapReduce, Apache Hive, Apache Pig, and Apache Spark. This requires expertise in Hadoop administration and software deployment.
- Hadoop as a Service (HaaS): HaaS providers offer pre-configured Hadoop clusters with the necessary software components and tools already installed and configured. Organizations can simply provision Hadoop clusters with a few clicks, eliminating the need for manual software installation and configuration.

3.2.3. Scalability and Flexibility:

- Traditional Hadoop Deployment: Scaling traditional Hadoop clusters involves adding or replacing hardware infrastructure, which can be time-consuming and costly. Organizations must anticipate future growth and provision resources accordingly, leading to potential over-provisioning or under-provisioning.
- Hadoop as a Service (HaaS): HaaS offers seamless scalability, allowing organizations to scale resources up or down dynamically in response to changing workload demands. With HaaS, organizations can adjust compute and storage resources on-the-fly, ensuring optimal resource utilization and cost efficiency.

3.3. Security and Privacy Considerations

Ensuring the security and privacy of data is paramount for organizations, especially when leveraging cloud-based solutions such as Hadoop as a Service (HaaS) for big data processing and analytics. In this section, we will discuss the key security and privacy considerations associated with HaaS, focusing on data security and compliance with regulations such as GDPR (General Data Protection Regulation) and HIPAA (Health Insurance Portability and Accountability Act).

3.3.1. Data Security in HaaS:

- Encryption: HaaS providers typically offer encryption mechanisms to protect data both in transit and at rest. Data encryption helps safeguard sensitive information from unauthorized access and interception, ensuring confidentiality and integrity.
- Access Controls: HaaS platforms implement robust access control mechanisms to restrict access to data and resources based on user roles, permissions, and authentication credentials. Role-based access control (RBAC) and multi-factor authentication (MFA) are commonly
- employed to enforce access policies and prevent unauthorized access.
- Network Security: HaaS providers employ network security measures such as firewalls, intrusion detection/prevention systems (IDS/IPS), and virtual private networks (VPNs) to protect against network-based attacks and unauthorized access to data.
- Data Segregation: HaaS platforms ensure logical and physical segregation of data between different tenants to prevent data leakage and unauthorized access. Isolation mechanisms such as virtual private clouds (VPCs) and containerization technologies help ensure data separation and isolation.
- Security Auditing and Logging: HaaS providers offer comprehensive logging and auditing capabilities to track user activities, monitor access to data and resources, and detect security incidents or anomalies. Security logs and audit trails enable organizations to investigate security breaches and enforce compliance with security policies and regulations.

3.4. Compliance with Regulations (e.g., GDPR, HIPAA):

GDPR Compliance: The GDPR is a European Union (EU) regulation that governs the protection of personal data and privacy of EU residents. Organizations leveraging HaaS must ensure compliance with GDPR requirements, including data minimization, purpose limitation, consent management, and data subject rights. HaaS providers may offer GDPR-compliant data processing agreements (DPAs) and certifications to demonstrate adherence to GDPR principles and requirements.

HIPAA Compliance: HIPAA is a US federal law that sets standards for the protection of health information and requires healthcare organizations and their business associates to implement safeguards to ensure the confidentiality, integrity, and availability of protected health information (PHI). HaaS providers serving healthcare organizations must comply with HIPAA requirements, including encryption of PHI, access controls, audit logging, and risk assessments.

Other Regulatory Requirements: In addition to GDPR and HIPAA, organizations may need to comply with other industry-specific regulations and data protection laws, such as the Payment Card Industry Data Security Standard (PCI DSS), Sarbanes-Oxley Act (SOX), and California Consumer Privacy Act (CCPA). HaaS providers may offer compliance certifications, attestations, and third-party audits to demonstrate compliance with regulatory requirements and industry standards.

In summary, Hadoop as a Service (HaaS) providers implement robust security measures to protect data and ensure compliance with regulations such as GDPR and HIPAA. By leveraging encryption, access controls, network security, data segregation, and auditing/logging capabilities, HaaS enables organizations to securely process and analyze big data while adhering to regulatory requirements and safeguarding sensitive information from unauthorized access or disclosure.

Table 2: Overview of Compliance with Regulations, including GDPR, HIPAA, PCI DSS, SOX, and CCPA.

4. FUTURE TRENDS AND CHALLENGES IN HADOOP AND CLOUD COMPUTING

As technology continues to advance, the landscape of Hadoop and cloud computing is expected to undergo significant changes, presenting both opportunities and challenges for organizations. In this section, we will explore some of the future trends and challenges in Hadoop and cloud computing.

4.1. Future Trends:

- Adoption of Advanced Analytics: One of the key trends in Hadoop and cloud computing is the increasing adoption of advanced analytics techniques such as machine learning, artificial intelligence (AI), and deep learning. Organizations are leveraging these advanced analytics capabilities to extract actionable insights from large volumes of data, enabling data-driven decision-making, predictive analytics, and personalized experiences.
- Hybrid and Multi-Cloud Deployments: Another trend is the growing adoption of hybrid and multi-cloud architectures, where organizations leverage a combination of public cloud, private cloud, and on-premises infrastructure to deploy and manage their workloads. Hybrid and multi-cloud strategies offer flexibility, scalability, and resilience, allowing organizations to optimize cost, performance, and data sovereignty.
- Edge Computing: With the proliferation of Internet of Things (IoT) devices and the increasing volume of data generated at the edge of the network, edge computing is emerging as a key trend in Hadoop and cloud computing. Edge computing enables organizations to process and analyze data closer to the source, reducing latency, bandwidth usage, and reliance on centralized data centers.

Regulation	Description
GDPR (General Data Protection Regulation)	European Union regulation governing the protection and privacy of personal data of EU residents.
HIPAA (Health Insurance Portability and Accountability Act)	US federal law regulating the protection of health information and patient privacy.
PCI DSS (Payment Card Industry Data Security Standard)	Set of security standards designed to ensure the protection of payment card data.
SOX (Sarbanes-Oxley Act)	US federal law mandating strict financial reporting requirements to prevent corporate fraud and accounting scandals.
CCPA (California Consumer Privacy Act)	California state law providing consumers with enhanced privacy rights and control over their personal information.

- Serverless Computing: Serverless computing, also known as Function as a Service (FaaS), is gaining momentum as organizations seek to simplify and streamline their application development and deployment processes. Serverless computing abstracts away the complexities of infrastructure management, allowing organizations to focus on writing code and delivering value to end-users without worrying about provisioning, scaling, or managing servers.

4.2. Challenges:

- Security and Privacy: One of the primary challenges in Hadoop and cloud computing is ensuring the security and privacy of data stored and processed in the cloud. Organizations must implement robust security measures, encryption mechanisms, access controls, and compliance frameworks to protect sensitive information from unauthorized access, data breaches, and regulatory violations.
- Performance and Scalability: As the volume, velocity, and variety of data continue to grow exponentially, organizations face challenges related to performance and scalability in Hadoop and cloud computing environments. Optimizing data processing

algorithms, resource utilization, and cluster management techniques is critical for achieving high performance and scalability in large-scale data processing workflows.

- Cost Management: Cost management and optimization are ongoing challenges for organizations leveraging Hadoop and cloud computing services. Balancing resource utilization, cost-efficiency, and performance requirements while minimizing operational expenses and cloud infrastructure costs requires careful planning, monitoring, and optimization strategies.
- Data Governance and Compliance: Organizations must establish robust data governance frameworks and compliance mechanisms to ensure the integrity, confidentiality, and availability of data in Hadoop and cloud computing environments. Compliance with regulations such as GDPR, HIPAA, PCI DSS, and industry-specific standards requires organizations to implement data classification, access controls, audit logging, and data protection measures.
- In summary, the future of Hadoop and cloud computing is characterized by emerging trends such as advanced analytics, hybrid and multi-cloud deployments, edge computing, and serverless computing. However, organizations must address challenges related to security, performance, cost management, and data governance to realize the full potential of these technologies and drive innovation in the digital age.

5. Conclusion

In conclusion, Hadoop as a Service (HaaS) represents a pivotal advancement in the realm of big data processing and analytics, seamlessly integrating the scalability and flexibility of cloud computing with the distributed computing capabilities of the Hadoop framework. Through this research, we have delved into the intricacies of HaaS, examining its architecture, advantages, security considerations, and future trends. HaaS offers businesses a compelling solution to leverage the vast potential of big data, enabling them to extract valuable insights, drive innovation, and gain a competitive edge in their respective industries.

The adoption of HaaS holds significant implications for both businesses and researchers. For businesses, HaaS presents an opportunity to streamline data processing workflows, reduce operational overhead, and accelerate time-to-insight. By embracing HaaS, organizations can focus on deriving actionable insights from their data rather than managing complex IT infrastructure, ultimately driving business outcomes and achieving strategic objectives. For researchers, HaaS offers a fertile ground for exploring emerging trends, challenges, and innovations in cloud computing, big data analytics, and distributed systems. Future research endeavors may focus on optimizing performance and scalability in HaaS environments, enhancing security and compliance mechanisms, and evaluating the impact of HaaS on business performance and competitiveness.

Moving forward, it is imperative for organizations to continue investing in research and development to address key challenges and capitalize on emerging opportunities in Hadoop as a Service. By staying abreast of evolving trends, harnessing the power of advanced analytics, and maintaining a strong focus on security and compliance, businesses can unlock new avenues for growth, innovation, and success in the digital age.

References

1. Li, L., Mu, X., Li, S., & Peng, H. (2020). A review of face recognition technology. *IEEE Access, 8,* 139110–139120.
2. Ni, H. (2020). Face recognition based on deep learning under the background of big data. *Informatica, 44*(4).
3. Guo, S., Zhang, Y., Wu, Q., Niu, L., Zhang, W., & Li, S. (2018). The performance evaluation of a distributed image classification pipeline based on Hadoop and MapReduce with initial application to medical images. *Journal of Medical Imaging and Health Informatics, 8*(1), 78–83.
4. Liu, J., Tang, S., Xu, G., Ma, C., & Lin, M. (2020). A novel configuration tuning method based on feature selection for Hadoop MapReduce. *IEEE Access, 8,* 63862–63871.
5. Zhu, Y., & Jiang, Y. (2020). Optimization of face recognition algorithm based on deep learning multi feature fusion driven by big data. *Image and Vision Computing, 104,* Article ID 104023.

6. Mody, R. N., & Bhoosreddy, A. R. (1995). Multiple odontogenic keratocysts: a case report. *Annals of Dentistry, 54*(1-2), 41–43.

7. Garg, H. (2020). Digital twin technology: revolutionary to improve personalized healthcare. *Science Progress and Research, 1*(1), 1.

8. Ahmed, B., & Ali, A. (2020). Usage of traditional Chinese medicine, western medicine and integrated Chinese-Western medicine for the treatment of allergic rhinitis. *Science Progress and Research, 1*(1), 1–9.

9. Shahabaz, A., & Afzal, M. (2021). Implementation of high dose rate brachytherapy in cancer treatment. *Science Progress and Research, 1*(3), 77–106.

10. Li, Z. (2022). Treatment and technology of domestic sewage for improvement of rural environment in China-Jiangsu: a research. *SPR, 2*(2), 466–475.

11. Salihu, S. O., & Zayyanu, I. (2022). Assessment of Physicochemical parameters and Organochlorine pesticide residues in selected vegetable farmlands soil in Zamfara State, Nigeria. *Science Progress and Research (SPR), 2,* 2.

12. Asaithambi, S. P. R., Venkatraman, S., Venkatraman, S., & Venkatraman, R. (2021). Proposed big data architecture for facial recognition using machine learning. *AIMS Electronics and Electrical Engineering, 5*(1), 68–92.

13. Zhang, B. (2019). Distributed SVM face recognition based on Hadoop. *Cluster Computing, 22*(S1), 827–834.

14. Phan, A.-C., Cao, H.-P., Tran, H.-D., & Phan, T.-C. (2019). Face recognition using gabor wavelet in MapReduce and Spark. In *World Congress on Global Optimization,* Springer.

15. Awan, M. J., Khan, M. A., Ansari, Z. K., Yasin, A., & Shehzad, H. M. F. (2021). Fake profile recognition using big data analytics in social media platforms. *International Journal of Computer Applications in Technology.*

16. Ong, P., Chong, T. W., & Lee, W. K. (2020). Development of class Attendance system using face recognition for faculty of mechanical and manufacturing engineering, universiti tun hussein onn Malaysia. In *Challenges and Applications for Implementing Machine Learning in Computer Vision,* IGI Global.

17. Mbah, C., Ogechukwu, I., & Anarado, I. (2019, December). Face recognition trends: a guide for advanced national security research IN Nigeria. In *International Conference on Engineering Adaptation and Policy Reforms,* 1*(1), 40–50.

18. Chernenkova, A. (2021). Facial Recognition Technology in Russia: Do the Citizens of Russia Accept it. *University of Twente,* Enschede, Netherlands, Master's thesis.

19. Wirianto, M. (2021). The development OF face recognition model IN Indonesia pandemic context based ON dcnn and arcface loss function. *International Journal of Innovative Computing Information and Control, 17*(05), 1513–1530.

20. Wright, D. B., Boyd, C. E., & Tredoux, C. G. (2003). Inter-racial contact and the own-race bias for face recognition in South Africa and England. *Applied Cognitive Psychology, 17*(3), 365–373.

21. Sagar, R., Jhaveri, R., & Borrego, C. (2020). Applications in security and evasions in machine learning: a survey. *Electronics, 9*(1), 97.

22. JhaveriH, R. H., Ramani, S. V., Srivastava, G., Gadekallu, T. R., & Aggarwal, V. (2021). Fault-resilience for bandwidth management in industrial software-defined networks. *IEEE Transactions on Network Science and Engineering, 8*(4), 3129–3139.

23. Gao, W., Cao, B., Shan, S., et al. (2007). The CAS-PEAL large-scale Chinese face database and baseline evaluations. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 38*(1), 149–161.

24. Sharma, S., & Kumar, V. (2020). Voxel-based 3D face reconstruction and its application to face recognition using sequential deep learning. *Multimedia Tools and Applications, 79*(25-26), 17303–17330.

25. VenkateswarLal, P., Nitta, G. R., & Prasad, A. (2019). Ensemble of texture and shape descriptors using support vector machine classification for face recognition. *Journal of Ambient Intelligence and Humanized Computing,* 1–8.

26. Zangeneh, E., Rahmati, M., & Mohsenzadeh, Y. (2020). Low resolution face recognition using a two-branch deep convolutional neural network architecture. *Expert Systems with Applications, 139,* Article ID 112854.

27. Banerjee, S., & Das, S. (2018). Mutual variation of information on transfer-CNN for face recognition with degraded probe samples. *Neurocomputing, 310,* 299–315.