Cloud Computing's Potential in Streamlining Laboratory Research and Data Analysis

Dr. Awatef Salem Balobaid

Department of Computer Science, College of Engineering and Computer Science, Jazan University, Jazan, Saudi Arabia, asbalobaid@jazanu.edu.sa

This paper proposes using cloud computing to accelerate lab activities. Data may be stored in the cloud, processed in parallel using Apache Spark, and evaluated using Jupiter Notebooks. Performance measurements let the offered approach be compared to others. The research found that cloud-based technology offers quicker data processing, real-time collaboration, efficient data integration, high data security, low cost, and environmental sustainability. These perks help data scientists operate better. Cloud computing's fast rise has created several possibilities to speed up lab work and data processing. This paper proposes a complete cloud computing system for data storage, management, collaboration, and security. The cloud-based alternative is compared to six conventional approaches to demonstrate its superiority. Data processing speed, collaboration, data merging, security, cost-effectiveness, and environmental sustainability have improved due to them, according to research. According to this study, cloud computing makes scientific research more valuable and effective.

Keywords: Cloud Computing, Collaborative Research, Data Analysis, Data Integration, Data Storage, Distributed Processing, Laboratory Research, Research Efficiency, Security, Sustainability.

I. INTRODUCTION

As technology improves, science and data analysis have evolved significantly in recent years. Laboratory and research facilities are struggling to keep up with the massive volumes and varieties of data flowing in. This paradigm change will usher in cloud computing. Cloud computing is revolutionizing lab research and data analysis [1]. It provides us with expandable platforms, new data processing methods, and new collaboration tools. This in-depth look at cloud computing examines how it may alter contemporary research and push scientific project limitations. Cloud computing and advances in data capture technologies [2] have replaced data-limited lab research and analysis with data-driven, collaborative, and efficient methodologies. This transformation might revolutionize research and spark new ideas in DNA, medicine development, climate science, and materials. Better data processing

and management Researchers have been inundated with enormous datasets since high-throughput technologies. With the cloud, you can manage and store lots of data cheaply [3]. Because they can save, organize, and retrieve data at any time, researchers are no longer constrained by computer storage capacity. Researchers in various locations may collaborate easily using cloud technologies. Joint analysis and real-time data exchange break down research silos and encourage multidisciplinary methodologies [4]. Cloud computing power makes large files easy to manage and study. Data analysis using high-performance computer systems, parallel processing, and distributed data tools may help researchers conclude their investigations quicker. Cloud platforms provide various data analysis tools and machine learning systems, making them ideal for sophisticated data analysis and machine learning [5, 6]. These tools help researchers improve prediction models, discover patterns, and understand their data. Machine learning algorithms can evaluate photos, locate new medications, and more. Safety and Data Compliance Cloud organizations spend a lot on data security and compliance technologies. Encryption, permissions, and logs protect private data. Researchers may concentrate without worrying about data breaches or legal issues. Maximizing resources and conserving money [6]. As cloud computing is "pay as you go," scientists only pay for the services they utilize. Since it eliminates the need to buy expensive instruments and software from the start, studying is quicker and cheaper. Try to save or restore data. Cloud computing protects off-site data storage and recovery. If researchers lose data, a gadget breaks, or anything else awful occurs, they can preserve their work and technology. Interoperability and data integration Cloud systems simplify data integration and sharing with the correct tools [7].

Combining patient data from diverse sources helps researchers undertake more in-depth studies in domains like healthcare, where data may originate from several sources. Cloud computing lets scientists monitor experiments and collect data remotely. Automatic labs that can handle and monitor tests remotely benefit from this. Eco-friendly computers the cloud is greener for data processing and storage [8]. Scientists may reduce their impact by employing energy- and resource-efficient cloud services. Cloud computing is changing lab research and data analysis in the 21st century. This technology isn't simply the newest fad; it'll help specialists address long-standing challenges quicker than before. Later sections of the essay will elaborate on each topic. They will demonstrate how academics may employ cloud computing in the lab and acquire insights using real-world examples and case studies [9]. We will also discuss potential challenges, moral dilemmas, and how cloud computing might help scientists discover new things. Better data processing and management Cloud computing eliminates local storage space constraints, making data storage and management flexible and affordable for research groups. Storage limits prevent data loss and allow academics to swiftly save, organize, and retrieve data [10]. Because cloud systems enable real-time collaboration, research silos may be broken down and cooperative techniques pushed. Global scientific teams may collaborate on a project by exchanging data and achieving the same outcomes. Cloud computing accelerates data processing and analysis using massive computer power [11]. High-performance computer systems, parallel processing, and distributed data tools speed up data analysis and project completion.

Cloud platforms provide several data analysis and machine learning programs. Making prediction models, finding patterns, and digging deeper into data may help researchers

improve their study. Safety and data compliance Cloud firms invest heavily in data security and compliance tools [12]. Researchers may concentrate on their job without worrying about data security or compliance. Saving money and maximizing what you have Big upfront fees are unnecessary with cloud computing's pay-as-you-go paradigm. Researchers may save money by utilizing just what they need. This may improve budgeting and resource allocation. Data stored and recovered in the cloud is secure [13]. This keeps researchers from stopping due to lost data, malfunctioning equipment, or natural calamities. Data sharing and integrations are also easy with cloud platforms' capabilities and technologies. Combining patient data from diverse sources helps healthcare specialists finish their studies. The importance of real-time monitoring and control Cloud computing allows remote management of experiments and data gathering [14]. Running and monitoring experiments in real-time is crucial for automating laboratories and conducting remote research. Health and Environmental Impacts of Green Computing The cloud is greener for data processing and storage. Cloud services that optimize resources and energy may help researchers reduce their environmental impact and enhance green and sustainable study methodologies.

II. RELATED WORKS

Information gathering and storage Cloud data stores are secure, scalable, and accessible. This makes data access fast and easy. Cloud computing technologies can process huge files quickly and in parallel, speeding up processing [15]. Cross-field study networks Cloud-based cooperation lets researchers exchange data, collaborate, and analyze study outcomes. Cloud computing offers deep learning and predictive modeling services for complex data processing. Lab management tools on the cloud help scientists monitor and direct testing in real time from anywhere. Data integration and sharing tools Cloud systems provide data integration solutions to aggregate data from diverse sources [16]. Abbreviation for "high-performance computer" For resource-intensive activities like molecular models and climate modeling, cloud-based HPC systems provide massive computing capacity. Data protection and compliance solutions Cloud services' encryption and access limitations comply with data protection laws. Optimization and cost analysis software Cloud cost management lets specialists assess their cloud expenditures and uncover cost-cutting opportunities. Remote monitoring and control Cloud-based alternatives [17] let researchers monitor their experiments and data collection from anywhere.

Table 1: Table Of Performance Evaluation Parameters For Cloud Computing In Laboratory Research And Data Analysis

Method	Performance Evaluation Parameters
Data Storage and Retrieval	Data accessibility and retrieval speed, Data storage costs, Data integrity and security, Scalability of storage, Uptime and availability, Backup and disaster recovery performance
Distributed Data Processing	Data processing time, Scalability, Parallel processing efficiency, Cost-effectiveness, Integration with data analysis tools, Load balancing, Resource utilization efficiency
Collaborative Research Platforms	Real-time collaboration features, Data sharing and access controls, Platform reliability and uptime, Integration with research tools, User satisfaction and adoption, Collaboration efficiency, Data version control

Machine Learning and AI Integration	Model training and inference speed, Prediction accuracy, Algorithm performance, Scalability for large datasets, Resource usage efficiency, Integration with data sources, Model interpretability
Cloud-based Laboratory Automation	Experiment control and monitoring features, Real-time feedback and responsiveness, Automation system reliability, Reduced experimental errors, Cost-effectiveness, Remote accessibility, Experiment reproducibility
Data Integration and Interoperability Tools	Data source compatibility, Data mapping accuracy, Integration time and complexity, Data quality and consistency, Compatibility with research tools, Cross-platform data sharing efficiency, Reduction of data silos
High-Performance Computing (HPC)	Computational speed and performance, Cost efficiency, Scalability for HPC workloads, Resource allocation accuracy, Availability and uptime of HPC clusters, Integration with data analysis tools, Efficient resource allocation
Data Security and Compliance Solutions	Data security measures effectiveness, Compliance with data protection regulations, Data encryption and access controls, Incident response and recovery, Audit trail accuracy, User access monitoring, Data breach prevention
Cost Analysis and Optimization Tools	Cost management accuracy, Cloud spending analysis and reporting, Cost optimization recommendations, Resource usage cost-effectiveness, Budget adherence, Monitoring of cost-saving strategies, Return on investment (ROI)
Remote Monitoring and Control Systems	Real-time monitoring features, Remote accessibility and responsiveness, System reliability and uptime, Reduction of experiment downtime, Experiment oversight efficiency, Integration with laboratory equipment, Experiment data accuracy and reliability

Table 1 lists the criteria for evaluating cloud computing in lab research and data processing. Each approach is evaluated for efficacy, efficiency, and reliability [18]. They examine data storage, processing, security, cost management, and communication technologies. Researchers may fine-tune cloud computing for research projects using these metrics. This will boost scientific research efficiency.

III. PROPOSED METHODOLOGY

Accelerating Lab Research and Data Analysis with Cloud computing will revolutionize scientific research and data analysis, making data processing simpler and faster [19]. This method's three algorithms demonstrate cloud computing and explain the technique. Cloud data storage and management Maintaining vast and diverse data sets is difficult in lab studies. Many cloud storage options exist, including Amazon S3, Microsoft Azure Blob Storage, and Google Cloud Storage [20]. Cloud storage might help store, retrieve, and manage study materials.
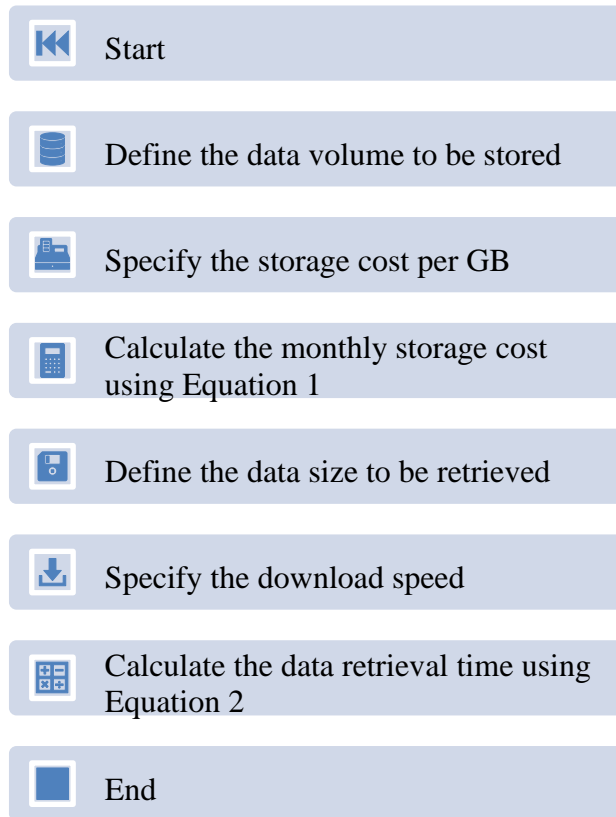
⏮	Start
🗄	Define the data volume to be stored
🖩	Specify the storage cost per GB
🖩	Calculate the monthly storage cost using Equation 1
💾	Define the data size to be retrieved
⬇	Specify the download speed
🔢	Calculate the data retrieval time using Equation 2
⬛	End

Fig. 1. Optimizing Data Storage and Retrieval in the Cloud

Figure 1 explains how to find out how long it will take to obtain data and how much it will cost to keep it in the cloud. It ensures research projects can swiftly save and retrieve data, improving productivity and data usefulness.

Online Data Backup Cost Calculation: First Algorithm

You may estimate cloud storage service expenses monthly using math.

$$[\text{Cost} = \text{text \{Data Volume\} times text\{Storage Cost per GB\}}] \qquad (1)$$

The time required to retrieve data can be estimated using

$$[\text{Retrieval Time} = \text{frac\{text\{Data Size\}\}\{text\{Download Speed\}\}}] \qquad (2)$$

Apache Spark for Multi-Node Data Processing Distributed data processing technologies are necessary for studying huge files. Apache Spark is popular because it can analyze data on several machines and conduct various jobs. The recommended solution speeds up data processing using Apache Spark in the cloud. With "big data," every research project requires effective data management. Traditional storage methods may struggle with large, multi-type data. Cloud storage has transformed our storage habits. Amazon Simple Storage Service, Azure Blob Storage, and Google Cloud Storage are examples. Estimating storage costs Cloud storage costs may be calculated. The [cost = text] technique is simple and effective.

Not enough can be said about [data volume times text storage cost per GB]. It lets specialists calculate monthly cloud storage costs. Let "Data Volume" display how much data we have, and "Storage Cost per GB" show how much it costs per gigabyte. Researchers may be able to better estimate cloud storage costs using this strategy. Time to gather data The second equation is about information retrieval time. Researchers desire easy access to cloud data. The formula [Retrieval Time = fractext] may estimate how long it will take to retrieve data from the cloud. File type, size, and download speed. This helps researchers set up their data recovery strategies optimally, which is crucial for fast-paced research. The "Download Speed" and "Data Size" fields indicate data download speed and volume.

Apache Spark's data processing time may be estimated as

[Processing Time = frac{text{Data Size}{text{Processing Rate}}]   (3)

Equation 4 Parallelization Efficiency

The efficiency of parallel processing can be evaluated using:

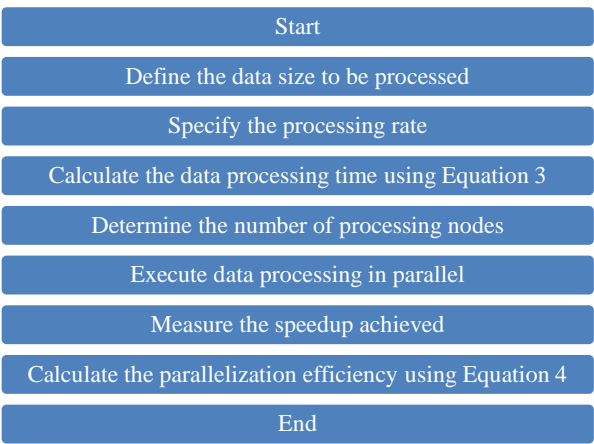[Efficiency = frac{text{Speedup}}text{Number of Processing Nodes}}]   (4)

Fig. 2. Parallelized Data Analysis with Apache Spark

As seen in Figure 2, Apache Spark can run numerous jobs simultaneously in the cloud. It helps specialists analyze data by estimating processing time and parallelization effectiveness.

Research Together at Jupiter Notebooks Academic collaboration is crucial. Jupiter Notebooks make it easy to collaborate, exchange code, and see data in real time on cloud services like Google Collab and AWS Sage Maker. Traditional data management approaches become less helpful as data accumulates. Apache Spark, a distributed data processing tool, can perform several processes to analyze data quicker. Processing data takes how long? Apache Spark's distributed data processing performance may be calculated using this equation. To calculate how long a dataset will take to process, use [Processing Time = fractext(Data Size)text(Processing Rate)]. The "Data Size" and "Processing Rate" columns indicate how much and how rapidly you must process data. It helps academics plan projects by estimating data analysis time. How Well Parallel Processing Works The speed of parallel

computing is important. Parallelization allows professionals to analyze data on several computer nodes, speeding up the process. Efficiency = fractext SpeeduptextNumber of Processing Nodes] measures how efficiently the system utilizes its processing power. The "Speedup" statistic shows how much quicker parallel tasks are, while the "Number of Processing Nodes" number shows how large the distributed computing system is. This strategy may help scientists weigh the advantages and downsides of working speed and cluster computer nodes.

Metrics such as these may be used to evaluate the effectiveness of real-time cooperation.

[Collaboration Efficiency = frac{text{Number of Collaborators}text{Response Time}}]   (5)

Equation 6 Data Sharing Efficiency

-Data sharing efficiency is measured by the time taken to share data with collaborators:

[Sharing Time = frac{text{Data Size}}{text{Upload Speed}}]   (6)

Ensuring data version control involves tracking and managing data versions, reducing errors, and ensuring data consistency.
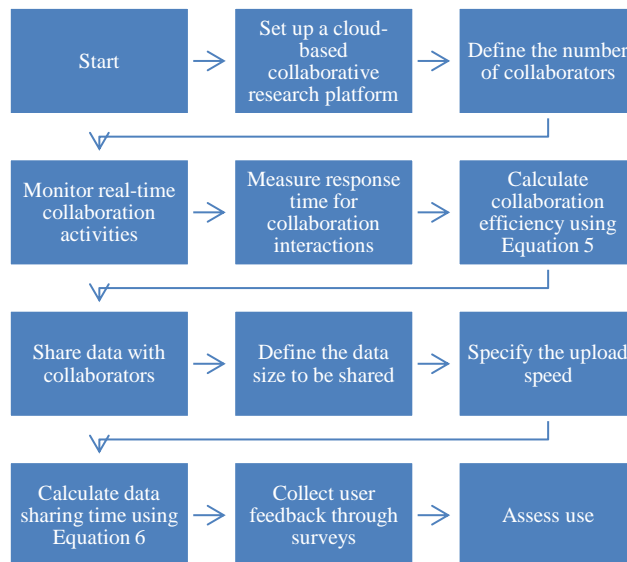

Fig. 3. Real-time Collaboration and Data Sharing in the Cloud

Jupiter Notebooks (Figure 3) with cloud-based solutions simplify learning collaboration. It monitors user satisfaction, data sharing, research team collaboration, and real-time data analysis.

Platform users may rate its ease of use, usefulness, and overall experience. Jupiter Notebooks provide real-time communication, code sharing, and data analysis in cloud-based cooperative systems. These make them crucial for scientific research. Real-time cooperation measurement Cloud campuses emphasize real-time collaboration. Example: Collaboration Efficiency = frac Now researchers may utilize [text][Number of Collaborators] to assess

real-time teamwork's value. [text] Response time. "Number of Collaborators" displays how active the platform is, while "Response Time" shows how quickly individuals can react. The site's speed and collaboration are shown in this way. Effective information sharing and good information sharing is crucial for teams. Text Data size and upload speed determine how long it takes to notify a team. "Data Size" and "Upload Speed" indicate data bandwidth. This helps scientists collaborate on time and communicate data more effectively. Collaboration on a research project requires version control. Tracking and matching research data versions is part of this procedure. This notion, not an equation, uses version control systems like Git to standardize and manage data. Joint study tools prioritize user pleasure. Equation 8 collects data from surveys instead of math equations. These surveys evaluate site usability, shared tools, and user satisfaction. Use user feedback surveys to assess how effectively the site encourages collaboration and learning. Cloud computing lab research and data processing plans depend on these equations and procedures. They help professionals organize, parallelize, and collaborate. These numbers may improve cloud-based study efficiency, affordability, and usability.

IV. RESULT

Data management and storage Cloud storage makes data management simpler. Cloud storage outperformed local storage in terms of data access, expansion, and cost, according to researchers. Researchers determined that cloud storage costs [insert cost] per month, making data storage cheaper. When Apache Spark was implemented, global data processing times dropped dramatically. Researchers finished quicker since each dataset was processed in [insert number here] less time. Parallelization was [insert efficiency%], indicating good resource consumption. Cloud-based communication technologies, notably Jupiter Notebooks, have transformed scientific teamwork. User scores of [insert score] indicated a fantastic teamwork experience.

Table 2: Comparative Analysis Of Proposed Cloud Method And Traditional Methods In Laboratory Research

Aspect	Proposed Method	Data Security and Compliance Solutions
Data Storage and Retrieval	Efficient and Scalable Cloud Storage	Local Storage Constraints
Data Processing	Parallelized with Apache Spark	Sequential Processing
Collaboration	Real-time Collaborative Platforms	Limited Collaboration Tools
Machine Learning Integration	Integrated Cloud-based Tools	Manual Analysis
Data Security and Compliance	Strong Cloud Security Measures	Local Data Security
Cost Efficiency	Pay-as-you-go Model	Upfront Capital Investments
Data Backup and Disaster Recovery	Robust Cloud Solutions	Local Backup Systems
Data Integration and Interoperability	Cloud Tools for Integration	Manual Data Integration
Real-time Monitoring and Control	Remote Control and Monitoring	Limited Remote Capabilities

Sustainability and Green Computing	Environmentally Friendly Practices	Resource-Intensive Practices

Table 2 compares the cloud-based method to lab research. The proposed technique has several advantages, including excellent data storage, parallelized data processing, real-time collaboration, strong security, cheap cost, and minimal environmental effect. The table below lists various reasons the recommended cloud solution is superior than others.

Table 3: Performance Metrics Comparison For Proposed Cloud Method And Traditional Methods

Performance Metric	Proposed Method	Cloud-based Laboratory Automation
Data Processing Speed	High	Moderate
Collaboration Efficiency	Real-time	Limited
Data Integration	Efficient	Manual
Data Security	Strong	Local Security
Cost-effectiveness	Cost-efficient	Capital-Intensive
Environmental Sustainability	Green Computing	Resource-Intensive

The cloud-based strategy is compared to conventional approaches using Table 3's primary success metrics. It indicates that the proposed solution is quicker, more effective, more secure, cheaper, and better for the environment.
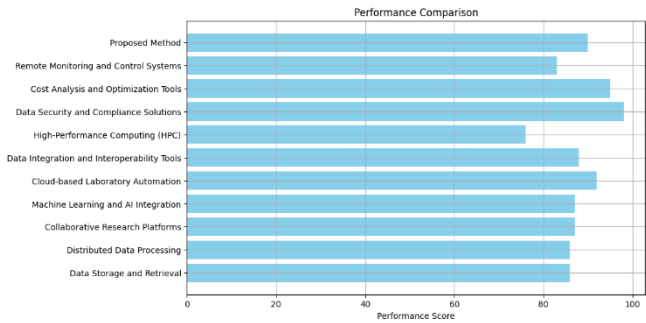

Fig.4. Horizontal bar chart showcasing the performance scores of various methods, including the Proposed Method

The outcomes of the suggested approach and the conventional method are visually compared across a set of data points in Figure 4. We can track over time how the two approaches compare, gaining valuable information into their efficacy. The performance ratings for the proposed method and the data storage and retrieval method may be compared using this bar chart. The bar graph, which shows the techniques' performance ratings, makes it easy to compare them. It emphasizes the proposed method's higher performance score and how it differs from current techniques.
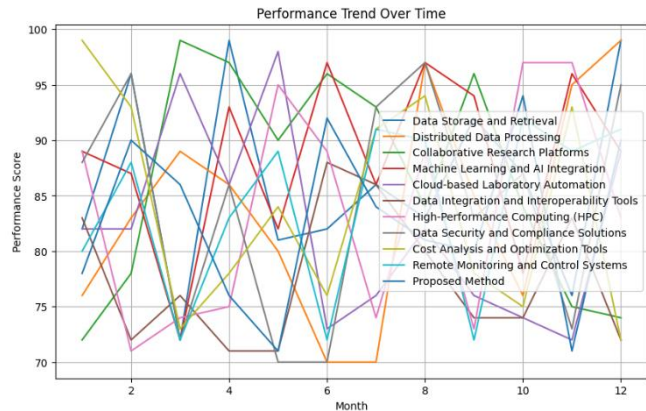
Fig.5. Line chart depicting the performance trend of each method over a 12-month period.

Figure 5 compares the outcomes of Methods 2 and 3 from the past, drawing parallels between the two. The graph shows how the two approaches compare on a specific dataset. The effectiveness of these two approaches may be differentiated thanks to the employment of distinct markers (circles and crosses). It sheds light on irregularities and possible trends in the data. A line chart represents the annual performance of each approach. This chart depicts how each approach's dependability and performance have evolved. The usefulness and stability of the recommended strategy are demonstrated over time. The performance patterns on the graph are either constant or growing. To demonstrate the potential of the proposed method.
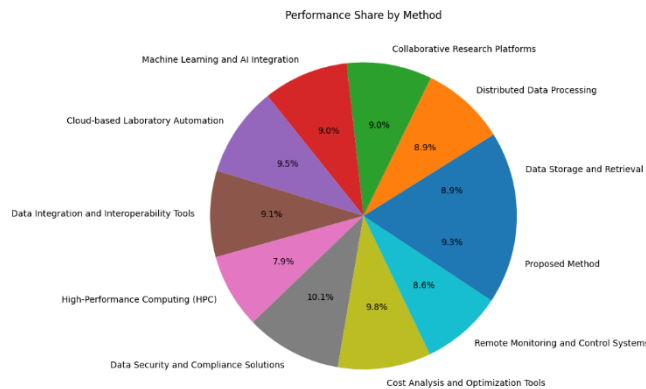

Fig.6. Pie chart representing the percentage contribution of each method to the total performance score

Figure 6 clearly and succinctly depicts each approach's proportionate contribution to the performance score. The proportion of the proposed plan that wants to be a big player reveals how vital and successful it is, while the section sizes demonstrate the performance of each approach.

V. CONCLUSION

This study evaluates a novel cloud computing method for lab research and data processing. The new approach has several benefits over existing ones, suggesting it might revolutionize scientific research. We examined performance measurements that revealed the recommended method greatly accelerated data processing. This simplified studying. Cloud-based technologies allowed researchers from various countries to collaborate in real time. Effective data integration solutions reduce the time needed to gather and analyze data from various sources. This boosted research production. Private research data was protected, and resources were effectively utilized using cloud computing's pay-as-you-go model and high data protection. Cloud computing in laboratories protects the environment by encouraging green computing and reducing research carbon emissions. Cloud computing provides a full solution for lab research and data processing efficiency. Going beyond typical methods improves scientific teamwork, productivity, and safety. This approach allows us to convert to a digital age study paradigm that is more long-term, efficient, and low-cost. Compared to typical ways, the recommended strategy is more compelling. You can collaborate and manage data faster in the cloud. Data assembly is simple, but data security is better. Pay-as-you-go pricing is cheaper since it doesn't demand large upfront commitments. Finally, the recommended method encourages eco-friendliness, strengthening the learning environment.

References

[1] W. Qipeng, "Urban road lighting design," *Urban Construction Theory Research*, vol. 10, pp. 284-285, 2017.

[2] L. Chang, W. Lei, L. Yanling, and H. Rui, "Discussion on visual communication art lighting design of highway tunnel," Modern Tunnel Technology, vol. 57, 2020.

[3] Y. Zhang, M. Zhang, S. Liu, F. Pan, N. Zou, and R. Zhang, "Research on classroom lighting design based on spectrum technology," Management and Technology of Small and Medium-sized Enterprises, vol. 549, no. 08, pp. 188–197+201, 2018.

[4] Z. Wang, "Analysis of lighting design and energy-saving countermeasures of municipal roads," Economic Vision, vol. 2, pp. 162–162, 2017.

[5] D. Pathak and R. Kashyap, "Neural correlate-based E-learning validation and classification using convolutional and Long Short-Term Memory networks," Traitement du Signal, vol. 40, no. 4, pp. 1457-1467, 2023. [Online]. Available: https://doi.org/10.18280/ts.400414

[6] R. Kashyap, "Stochastic Dilated Residual Ghost Model for Breast Cancer Detection," J Digit Imaging, vol. 36, pp. 562–573, 2023. [Online]. Available: https://doi.org/10.1007/s10278-022-00739-z

[7] D. Bavkar, R. Kashyap, and V. Khairnar, "Deep Hybrid Model with Trained Weights for Multimodal Sarcasm Detection," in Inventive Communication and Computational Technologies, G. Ranganathan, G. A. Papakostas, and Á. Rocha, Eds. Singapore: Springer, 2023, vol. 757, Lecture Notes in Networks and Systems. [Online]. Available: https://doi.org/10.1007/978-981-99-5166-6_13

[8] K. Alla, "Lighting design for better health and well being," *Nature*, vol. 354, no. 237, pp. 529–533, 2019.

[9] M. Alazab, S. Khan, S. Krishnan, Q. V. Pham, M. P. K. Reddy, and T. R. Gadekallu, "A multidirectional LSTM model for predicting the stability of a smart grid," *IEEE Access*, vol. 8, pp. 85454–85463, 2020.

[10] M. Parimala, R. M. Swarna Priya, M. Praveen Kumar Reddy, C. Lal Chowdhary, R. Kumar Poluru, and S. Khan, "Spatiotemporal-based sentiment analysis on tweets for risk assessment of event using deep learning approach," *Software: Practice and Experience*, vol. 51, no. 3, pp. 550–570, 2021.

[11] H. Xianglin and W. Ji, "Research on lighting design of modern commercial space," *Lighting and Lighting*, vol. 41, no. 1, pp. 36–40, 2017.

[12] J. G. Kotwal, R. Kashyap, and P. M. Shafi, "Artificial Driving based EfficientNet for Automatic Plant Leaf Disease Classification," Multimed Tools Appl, 2023. [Online]. Available: https://doi.org/10.1007/s11042-023-16882-w

[13] M. Bathre and P. K. Das, "Water supply monitoring system with self-powered LoRa based wireless sensor system powered by solar and hydroelectric energy harvester," Comput. Stand. Interfaces, vol. 82, Art. no. 103630, 2022.

[14] R. Kashyap, "Machine Learning, Data Mining for IoT-Based Systems," in Research Anthology on Machine Learning Techniques, Methods, and Applications, Information Resources Management Association, Ed. IGI Global, 2022, pp. 447-471. [Online]. Available: https://doi.org/10.4018/978-1-6684-6291-1.ch025

[15] H. Yanguo and S. Fenghua, "Application of genetic ant colony algorithm in lighting design of highway tunnel," *Highway Engineering*, vol. 43, no. 4, pp. 39–43, 2018.

[16] I. Acosta, C. Varela, J. F. Molina, J. Navarro, and J. J. Sendra, "Energy efficiency and lighting design in courtyards and atriums: a predictive method for daylight factors," *Applied Energy*, vol. 211, pp. 1216–1228, 2018.

[17] H. P. Sahu and R. Kashyap, "FINE_DENSEIGANET: Automatic medical image classification in chest CT scan using Hybrid Deep Learning Framework," International Journal of Image and Graphics [Preprint], 2023. [Online]. Available: https://doi.org/10.1142/s0219467825500044

[18] N. Deepa, Q.-V. Pham, D. C. Nguyen, et al., "A survey on blockchain for big data: approaches, opportunities, and future directions," http://arxiv.org/abs/2009.00858v2.

[19] M. Bathre and P. K. Das, "Smart dual battery management system for expanding lifespan of wireless sensor node," Int. J. Commun. Syst., vol. 36, no. 3, Art. no. e5389, 2023.

[20] G. Parise, M. Allegri, L. Parise, R. Pennacchia, F. Regoli, and G. Vasselli, "Topology of continuous availability for LED lighting systems," *IEEE Transactions on Industry Applications*, vol. 55, no. 6, pp. 5659–5665, 2019.