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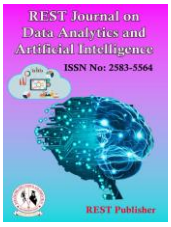

Analyzing Electroencephalograms Using Cloud Computing Techniques Using Gray Relational Analysis Method

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Abstract: *Cloud computing techniques include various methods and practices aimed at enhancing the delivery, scalability, and efficiency of cloud services. These techniques are essential for managing diverse and fluctuating workloads while maintaining cost-effectiveness. Notable techniques include virtualization, which allows for the creation of virtual instances from physical resources; load balancing, which allocates workloads across multiple resources to optimize performance; and containerization, which encapsulates applications in lightweight, portable containers. Cloud computing techniques, including virtualization and containerization, facilitate the efficient management of computing resources. Research in these domains focuses on developing strategies to optimize resource utilization, minimize costs, and enhance overall system performance. Effective management of diverse and fluctuating workloads is critical, and techniques such as automated scaling and dynamic resource allocation play a key role in adapting cloud environments to shifting demands. By addressing these aspects, research ensures that cloud systems can adeptly handle peak loads and variable usage patterns, delivering smooth and reliable experiences for both users and businesses. Alternative: IaaS, PaaS, SaaS, FaaS, CaaS. Evaluation Parameters: Performance, Scalability, Cost, Complexity. The results indicate that FaaS achieved the highest rank, while SaaS had the lowest rank being attained. The value of the dataset for Cloud computing techniques, according to the Grey Relation Analysis method, FaaS achieves the highest ranking."*

Key words: *Virtualization, Containerization, Scalability, Elasticity, Resource Allocation, Load Balancing.*

1. INTRODUCTION

Cloud computing offers significant cost advantages due to its fault tolerance, which is achieved using inexpensive nodes. Centralized cloud management eliminates the need for enterprises to bear the escalating costs of managing data centers. This centralized approach enhances resource utilization compared to traditional systems, allowing users to take full advantage of lower costs. Tasks that previously required thousands of dollars and several months can now be completed for just a few hundred dollars within a few days. [1] In addition to Many Businesses have explored or implemented internal cloud computing systems alongside public cloud services. For ISPs, telecom service providers, and IT suppliers, cloud computing has become a crucial business strategy. Additionally, countries such as Japan and the United States have prioritized cloud computing as a key component of their strategic initiatives. national strategy. A few of the adopters are listed in the table below for each type. [2] To supply tenants and clients with services, cloud providers combine computing and communication components into a single infrastructure. By combining these two technologies, a Cloud Oriented Federated Computing and Networking System (CFCNS) is produced. Virtualizing the CFCNS allows for the use of cloud features. infrastructure and slicing its resources, utilizing virtualized servers accessed through virtualized networks.[3] Several organizations collaboratively develop and provide a shared cloud infrastructure along with common policies, requirements, values, and concerns. This creates a community cloud, which achieves democratic equilibrium and economic scalability. Either one of the collaborating companies or a third-party vendor may oversee the cloud infrastructure. It is managed by various organizations and offers support to a particular neighborhood. with shared interests. Community clouds are generally more secure than public clouds. [4] Several organizations collaboratively develop and provide a shared cloud infrastructure along with common policies, requirements, values, and concerns. This creates a community cloud, which achieves democratic balance and economic scalability. One of the collaborating businesses or a third-party provider may be in charge of managing the cloud infrastructure. It promotes a particular neighborhood and is overseen by several organizations. with shared interests. Community clouds are generally more secure than public clouds. [5] Therefore, Scheduling is essential for the efficient and effective allocation of resources for each activity in cloud computing. Currently, there are various types of scheduling mechanisms available, including workflow scheduling, cloud service scheduling, heuristic scheduling, static scheduling, and dynamic scheduling. Resources both internal and external are preserved in the cloud, and depending on the work at hand, different criteria may apply for things like bandwidth, storage, resource charges, and reaction time. [6] Two-stage task scheduling is discussed, involving a load balancing algorithm to meet users' changing needs and achieve high use of available resources. Mapping jobs to virtual machines and then these virtual machines to host resources is how load balancing is achieved. This method enhances a cloud computing environment's overall performance, job response time, and resource consumption. [7] This approach can reduce the inherent transmission cloud computing delays, reduce energy use, and decrease network demand. To support these objectives, the iFogSim toolkit accommodates a wide range of fog computing scenarios. [8] Our survey offers recommendations for addressing issues with various techniques. Unlike previous studies, we did not encounter threats to validity due to accidental inconsistencies during the literature review, primary study selection, quality assessment, or data extraction. We also talk about these obstacles and the steps taken to lessen the risks they pose, such as planning, decision-making, and addressing both internal and external dangers. [9] End users are eager to minimize their while adhering to QoS requirements such application response time, availability, and performance, in the cloud. Since sought resources are controlled from a common pool, cloud datacenter service providers are consequently concentrated on improving resource allocation performance. The quantity and cost of energy needed to power and cool ICT resources can be decreased by service providers by increasing the datacenter's energy efficiency. [10] An algorithm or system should function properly in unforeseen situations. This implies that the algorithm should continue to be scalable even as the number of tasks and demand rises. High scalability is crucial for maintaining good performance in a load balancing algorithm. [11] A dynamic algorithm or system seeks and prefers to balance a load on the lightest server across the network. Since this procedure requires real-time network contact, there may be an increase in computer traffic. Decisions for managing loads are made based on the status of the computer. [12] The goal of load balancing is to increase resource utilization and reduce task reaction time, which will improve system performance at a reduced cost. It also aims to give jobs requiring instantaneous execution priority over others, and to offer scalability and flexibility for applications that could need more resources in the future. In order to improve total load balancing, load balancing also aims to reduce energy consumption and carbon emissions, prevent bottlenecks, provision resources, and meet quality of service criteria. [13] A private cloud within an enterprise provides specific and restricted access to a designated group. It offers computing services exclusively for the use of a particular organization or group. Although it uses the same architecture as scalable and available public clouds, it operates within a confined system. Key advantages of a private cloud include enhanced data security and control, addressing concerns that are often lacking in public clouds. [14] Each ant begins with an initial task and chooses a resource according to the probability function outlined earlier. The ant then creates a sequence of tasks that adhere to priority constraints. This sequence is used to determine the mapping of tasks to resources. [15] Because cloud computing is remote and depends on virtualization technologies, traditional resource allocation strategies are not appropriate. Because of the heterogeneity of hardware, different skill levels, workload evaluations, and unique characteristics, cloud computing creates new issues for resource management and adaptation. In order for cloud applications to achieve their service level goals, several elements are essential. and consumers. [16] The advantages of this type of encryption include ease of implementation and minimal user intervention. Vula employs encryption techniques on personal computers and extends this method to the cloud, allowing users to access their data securely. Online technology offers full disk encryption, ensuring data confidentiality in the cloud. These encryption methods provide benefits such as encrypting data partitions and securing data while it is at rest. [17] Because the cloud system automatically manages and optimizes computer resources, cloud customers do not need to undertake these tasks themselves. Transparency is ensured for both the service provider and the customer through the monitoring, management, and reporting of resource utilization. [18] In cloud environments, autonomic fault tolerance is required. Should a server fail, the system should automatically reroute user requests to a backup server. To address this, a cloud virtualized system architecture utilizing HA Proxy has been proposed and implemented. [19] Each algorithm tackles different issues from various perspectives and offers a variety of solutions. Certain algorithms that are currently in use have drawbacks, including poor performance, long processing times, hunger, and load changes in particular situations. Overloading any one node should be avoided by a good load balancing technique. The objective is to assess the effectiveness of developed load balancing algorithms for cloud computing between 2004 and 2015. [20].

2. MATERIALS AND METHODS

A process derived from early GRA (Grey Relational Analysis) models fundamentally depends on the correlation coefficients of specific points for general models. GRA models assess integrated or overall perspectives and similarities based on how closely related or similar the models are to each other, considering their proximity in the evaluation.[21] As far as we are aware, this is the first thorough prospective study carried out in real-world clinical settings to investigate the potential benefits of a 12-month lifestyle intervention on histological features associated with NASH. Until now, only a few studies have explored this area. examined the effects of lifestyle changes on NAFLD. Variations in study designs—such as differing methods of intervention, lack of standardized endpoints, diverse NAFLD phenotypes, and varying follow-up durations—along with relatively small patient samples in previous trials have resulted in inconclusive recommendations regarding weight loss strategies for treating NAFLD. [22] Strong protein-protein interactions with GRA6, mostly mediated by hydrophobic interactions, enable GRA4 to associate with network barriers. GRA6, that has undergone phosphorylation exhibits a higher affinity for network membranes inside the vacuole. Furthermore, a multimeric complex that is consistently related to an intravacuolar network—possibly implicated in the transport processes formed when cross-linked GRA4 and GRA6 bind particularly to GRA2. of proteins or nutrients into the vacuole. [23] The field of information systems known as gray systems utilizes gray theory, a method adept at mathematically analyzing systems to tackle uncertainty and incomplete data. This approach is particularly effective for addressing problems involving discrete data and missing information. Gray Prediction, Gray The five primary components of the program are Relational Analysis (GRA), Gray Decision, Gray Programming, and Gray Control. theory. [24] We describe an expanded fuzzy GRA technique for MCDM issues, in which the criteria weights are unknown and the Triangular fuzzy integers with interval values are used to represent the criteria values. utilizing linguistic variables. Optimization models grounded in the basic ideas of classical GRA have been created to ascertain these weights. After that, interval-valued triangular fuzzy estimates are used in the computational stages of the expanded GRA method for MCDM to rank the alternatives and select the preferred option. [25] Analyzing amino acid hydrophilicity and hydrophobicity offers valuable insights into prediction of secondary structure, protein folding, and protein interaction sites. Epitopes are influenced greatly by secondary structures. The inner sections of proteins, known as α-helices and β-turns, have a high potential for hydrogen bonding, which aids in the preservation of protein structure and promotes robust interactions with antibodies. [26] The Grey Relational Analysis, or GRA, looks at This accomplished by reducing the range of performance attribute values for each choice to a single value in Multi-Attribute Decision Making (MADM) scenarios. This simplifies the original problem to a single-attribute decision-making problem, which facilitates the use of the GRA process to compare alternatives with varying attributes. Grey relational generation, or translating each option's performance into a corresponding sequence, is one of the primary processes in the GRA process. Create a reference sequence, commonly referred to as the is deemed to be the best one.

Creation of a weight matrix and decision matrix For an MCDM issue with m criteria and n choices, let $D = x_{ij}$ be a decision matrix, where $x_{ij} \in R$

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \qquad 1$$

Decision matrix normalization Equation 2 or 3, respectively, is used to evaluate the normalization of the two types of data, i.e., better when higher type or better when lower type. Following normalization, the data falls between 0 and 1.

$$M_{ij} = \frac{N_{ij} - \min(N_{ij})}{\max(N_{ij}) - \min(N_{ij})} \qquad 2$$

$$M_{ij} = \frac{\max(N_{ij}) - N_{ij}}{\max(N_{ij}) - \min(N_{ij})} \qquad 3$$

Where $i, j = 1,2,3, \cdots, n$

Step 1. $Deviation = the \max value\ after\ normalization - value\ of\ the\ current\ row$ 4

Step 2. Calculation of Gray relation coefficient

$$C_{ij} = \frac{\Delta_{min} - \xi\Delta_{max}}{Current\ value - \xi\Delta_{max}}, where\ \xi\ is\ distinguishing\ coefficient \qquad 5$$

Step 3. Calculation of Gray relation grade

It's the average gray relation coefficient. Additionally, it is still unclear how human proteins interact with bacterial pathogens in networks. As demonstrated by our research, C-GRAAL is able to locate large, conserved areas in aligned human-pathogen protein-protein interaction (PPI) networks. Initially, these matched regions are populated with proteins with unique biological properties, aiding in the identification of patterns in pathogen interactions with the host. cells. [27] Time difference and loading magnitude were not included in the multivariate analysis since they did not exhibit significant differences between tertiles. The age variable was split at 65 years of age, while the other variables were classified dichotomously. The next step involved performing a multivariate logistic regression analysis to find independent RPA factors. using these variables as dependent factors. [28] Efforts were undertaken to identify and engage with relevant experts. In this process, 20 professionals were selected to finish the surveys. These experts meet at least one of the following requirements: they are enrolled in a master's program in project management, they have notable portfolios in sustainable development and project management, and they possess in-depth knowledge of the construction projects under study. related engineering disciplines, or having practical experience in researching, conducting, and managing infrastructure projects. [29] Gray relational analysis (GRA) is an essential method for examining gray data in uncertain systems. This study highlights that, due to variations in the shape and threshold of different sequences, A particular model that is sensitive to data normalization is the absolute GRA (AGRA) model. Hence, normalization should be conducted as an initial step before performing gray correlation analysis.[30]

3. ANALYSIS AND DISSECTION

TABLE 1. Cloud Computing Techniques

Alternative	Performance	Scalability	Cost	Complexity
IaaS	85	90	70	75
PaaS	80	85	65	70
SaaS	75	70	80	60
FaaS	90	80	60	65
CaaS	82	88	72	70

The dataset assesses five cloud computing alternatives Function as a Service (FaaS), Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and Container as a Service (CaaS) as examples based on four criteria: Performance, Scalability, Cost, and Complexity. In terms of performance and scalability, FaaS excels with the highest performance score of 90, indicating superior speed and efficiency, closely followed by IaaS and CaaS. IaaS leads in scalability with a score of 90, reflecting its strong capability to manage growing workloads, while PaaS and CaaS are also competitive. SaaS shows lower performance and scalability scores, suggesting it may not be ideal for high-demand or expanding applications. Regarding cost and complexity, PaaS is the most cost-effective option with a score of 65, and FaaS is also economical at 60. On the other hand, SaaS has the highest cost score of 80, indicating higher expenses. Complexity-wise, SaaS is the least complex to implement with a score of 60, while IaaS and PaaS present moderate complexity, balancing functionality with manageability. Overall, FaaS stands out for its high performance, cost-effectiveness, and relative simplicity, while SaaS is more expensive with lower performance and scalability. IaaS offers excellent scalability and performance but with moderate complexity and cost.

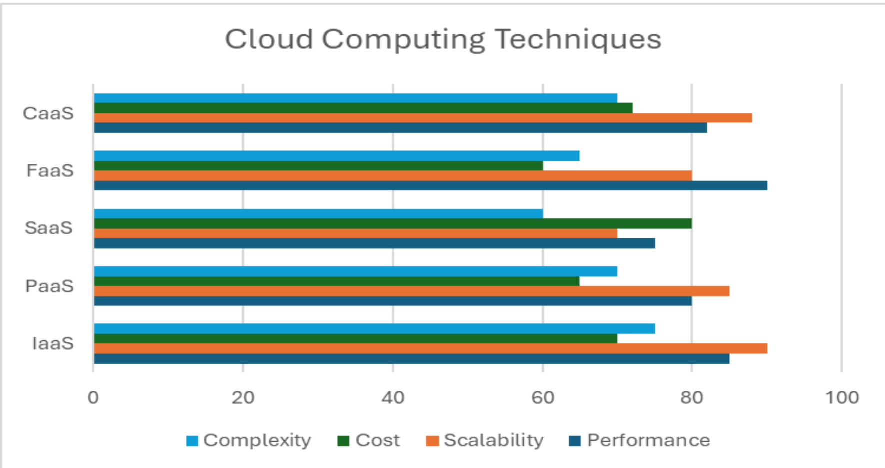

FIGURE 1. Cloud Computing Techniques

Figure 1 shows the Alternative are IaaS, PaaS, SaaS, FaaS, CaaS and Evaluation Parameters are Performance, Scalability, Cost, Complexity.

TABLE 2. Normalized Data

Performance	Scalability	Cost	Complexity
0.667	1	0.5	0
0.333	0.75	0.75	0
0	0	0	1
1	0.5	1	1
0.467	0.9	0.4	0

The normalized dataset offers a comparative view of five cloud computing alternatives—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Function as a Service (FaaS), and Container as a Service (CaaS)—across four parameters: Performance, Scalability, Cost, and Complexity, with values scaled from 0 to 1. In terms of performance, FaaS leads with a normalized score of 1, representing the highest performance among all alternatives. It also scores well in scalability with a value of 0.5. IaaS exhibits strong performance (0.667) and ranks highest in scalability (1), making it a top option for managing growing workloads. SaaS, however, scores the lowest in both performance (0) and scalability (0), indicating it may not be ideal for high-demand applications. Regarding cost and complexity, FaaS and SaaS are relatively cost-effective with normalized scores of 1 and 0.5, respectively, while IaaS scores lower at 0.4. SaaS is the least complex with a score of 1, signifying it is the simplest to manage. IaaS and PaaS have moderate complexity, whereas FaaS and CaaS show higher complexity scores. Overall, FaaS excels in performance and cost-effectiveness, SaaS offers ease of management but falls short in performance and scalability, and IaaS provides strong scalability and performance with moderate complexity and cost.

TABLE 3. Deviation sequence

Performance	Scalability	Cost	Complexity
0.33333	0	0.5	1
0.66667	0.25	0.3	0.6667
1	1	1	0
0	0.5	0	0.3333
0.53333	0.1	0.6	0.6667

The deviation sequence dataset illustrates the variations in performance, scalability, cost, and complexity among five cloud computing alternatives—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Function as a Service (FaaS), and Container as a Service (CaaS). Each value reflects how much each alternative deviates from the average for each parameter. Performance and Scalability: FaaS shows the highest deviation in performance (1), indicating it has the most significant positive impact in this area compared to other options. It also leads in scalability with a deviation of 1, demonstrating superior scalability. Conversely, SaaS has a deviation of 0 in both performance and scalability, suggesting it deviates minimally from the average in these metrics, making it less prominent in these areas. Cost and Complexity: IaaS exhibits a high deviation in complexity (1), reflecting that it is notably more complex than average. FaaS and CaaS have lower deviations in complexity, indicating they have moderate complexity levels. Regarding cost, SaaS and CaaS have the highest deviations (0.6 and 0.5, respectively), showing they have a considerable impact on cost compared to other alternatives.

TABLE 4. Grey relation coefficient

Performance	Scalability	Cost	Complexity
0.6	1	0.5	0.3333
0.42857	0.6667	0.7	0.4286
0.33333	0.3333	0.3	1
1	0.5	1	0.6
0.48387	0.8333	0.5	0.4286

The grey relation coefficient dataset assesses five cloud computing alternatives—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Function as a Service (FaaS), and Container as a Service (CaaS)across four parameters: Performance, Scalability, Cost, and Complexity. These coefficients measure how closely each alternative aligns with the ideal solution for each parameter. Performance and Scalability: FaaS scores highest in performance with a grey relation coefficient of 1, indicating it is closest to the ideal in this area. For scalability, IaaS leads with a coefficient of 1, demonstrating it performs optimally compared to the other alternatives. SaaS, however, has the lowest coefficients in both performance (0.333) and scalability (0.333), showing it is least similar to the ideal in these metrics. Cost and Complexity: FaaS and SaaS have high grey relation coefficients for cost (1 and 0.5, respectively), suggesting they are close to the ideal in terms of cost-effectiveness. In terms of complexity, SaaS has a coefficient of 1, indicating it is closest to the ideal in terms of ease of management. Conversely, IaaS and PaaS have lower coefficients, reflecting higher complexity.

TABLE 5. GRG

	GRG
IaaS	0.608
PaaS	0.548
SaaS	0.5
FaaS	0.775
CaaS	0.55

SaaS and CaaS: Software as a Service (SaaS) has the lowest GRG at 0.5, reflecting its weaker performance and scalability compared to the other alternatives. Container as a Service (CaaS) scores slightly higher at 0.55, suggesting it is somewhat closer to the ideal than SaaS but still lags behind FaaS and IaaS. In summary, FaaS stands out as the most aligned with the ideal solution, while SaaS and CaaS offer lower overall alignment, with IaaS and PaaS positioned in between. The Grey Relational Grade (GRG) values indicate how closely each cloud computing alternative matches the ideal solution when considering performance, scalability, cost, and complexity. The GRG provides a comprehensive measure of how well each alternative meets the desired criteria across these parameters. Overall Ranking: Function as a Service (FaaS) leads with the highest GRG of 0.775, signifying it is closest to the ideal solution among all alternatives. This high GRG reflects FaaS's strong performance and scalability, along with favorable cost and complexity characteristics. IaaS and PaaS: Infrastructure as a Service (IaaS) follows with a GRG of 0.608, demonstrating a good balance of high scalability and performance, though it has moderate scores for cost and complexity. Platform as a Service (PaaS) has a GRG of 0.548, showing solid performance but not as high as FaaS or IaaS, particularly in scalability and cost efficiency. SaaS and CaaS: Software as a Service (SaaS) has the lowest GRG at 0.5, reflecting its weaker performance and scalability relative to other alternatives. Container as a Service (CaaS) has a slightly higher GRG of 0.55, indicating it is closer to the ideal than SaaS, but still falls short compared to FaaS and IaaS.

TABLE 6. Rank

	Rank
IaaS	2
PaaS	4
SaaS	5
FaaS	1
CaaS	3

The ranking dataset evaluates five cloud computing alternatives—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Function as a Service (FaaS), and Container as a Service (CaaS) based on their overall effectiveness across performance, scalability, cost, and complexity. Top Performers: Function as a Service (FaaS) is ranked first, indicating it is the most favorable option across all evaluation criteria. This top position highlights FaaS's exceptional performance, scalability, and advantageous cost and complexity characteristics. High Middle Range: Infrastructure as a Service (IaaS) is ranked second, demonstrating strong performance and scalability. However, it scores moderately in cost and complexity. Container as a Service (CaaS) is in the third position, showing good performance in most parameters but falling short of the excellence seen in FaaS or IaaS. Lower Range: Platform as a Service (PaaS) is ranked fourth, offering decent value but not matching the top three alternatives, especially in scalability and cost efficiency. Software as a Service (SaaS) ranks fifth, indicating lower performance and scalability compared to the other options, making it the least favorable choice overall.

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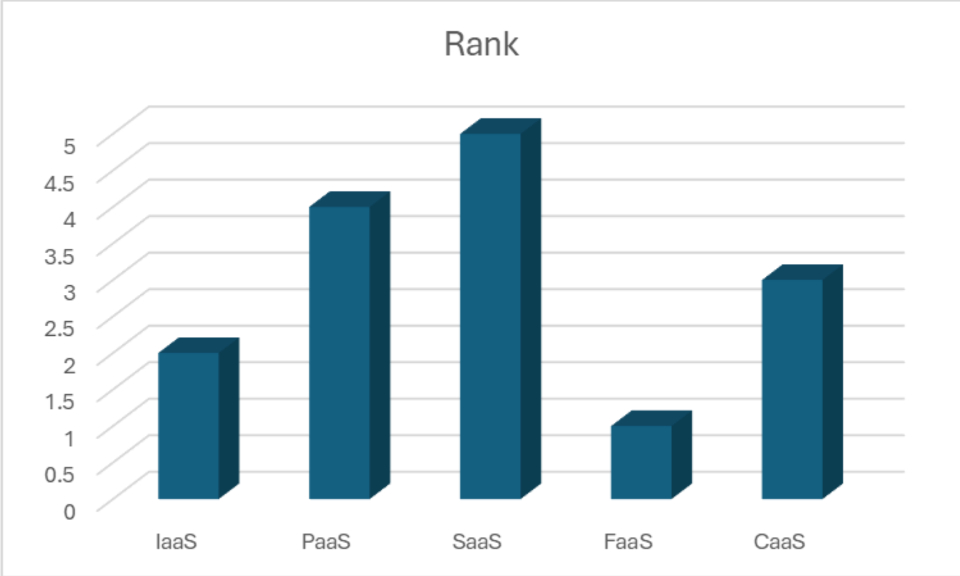

FIGURE 2. Rank

Figure 2 shows the ranking dataset evaluates five cloud computing alternatives—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Function as a Service (FaaS), and Container as a Service (CaaS) based on their overall effectiveness across performance, scalability, cost, and complexity. Top Performers: Function as a Service (FaaS) is ranked first, indicating it is the most favorable option across all evaluation criteria. This top position highlights FaaS's exceptional performance, scalability, and advantageous cost and complexity characteristics. High Middle Range: Infrastructure as a Service (IaaS) is ranked second, demonstrating strong performance and scalability. However, it scores moderately in cost and complexity. Container as a Service (CaaS) is in the third position, showing good performance in most parameters but falling short of the excellence seen in FaaS or IaaS. Lower Range: Platform as a Service (PaaS) is ranked fourth, offering decent value but not matching the top three alternatives, especially in scalability and cost efficiency. Software as a Service (SaaS) ranks fifth, indicating lower performance and scalability compared to the other options, making it the least favorable choice overall.

4. CONCLUSION

For the chosen in encryption algorithms, sequence complexity values will only exceed their threshold values for randomness in the Random Excursions Variant test and the Random Excursions test. These two tests are not applicable due to an insufficient number of cycles. evaluations of eight contemporary encryption techniques on traditional desktops, RC6, AES, Blowfish, DES, and RC4 showed slightly better results compared to other methods, with these techniques achieving higher P-values in a very secure range. Cloud computing, as a business model, must account for users' preferences regarding resource availability and allocation. To enhance user satisfaction, IaaS (Infrastructure as a Service) cloud computing should focus on improving priority-based resource allocation. Further research is advised to explore prioritization strategies for resource allocation, given the limitations of available resources. Load balancing is essential for distributing excessive dynamic workloads across all nodes in a cloud environment to achieve high user satisfaction and optimal resource utilization. It ensures that computing resources are allocated both efficiently and fairly. Cloud computing in healthcare offers advantages such as addressing trust, privacy, and security concerns, although these issues still need to be resolved before healthcare providers can fully embrace and trust e-health solutions. solutions. Security and interoperability challenges have slowed the adoption of cloud computing. However, with robust practices in its design, deployment, and utilization, cloud-based systems have the potential to significantly advance and transform the future of healthcare.

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