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An Integrated Framework for Selecting Best Cloud Service Provider with Multi-Criteria Decision Making Methodology

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Abstract

Choosing a cloud service provider is an essential choice for businesses looking to take advantage of cloud computing. A review of the most important considerations when selecting a cloud service provider is given in this study. Several criteria are considered when evaluating cloud service providers: performance and dependability, security and compliance, scalability and flexibility, cost and pricing, service and support, compliance and data location, integration and interoperability, vendor lock-in, reputation and references, and future roadmap and innovation. Organizations may choose a provider that satisfies their unique requirements, fits with their business goals, and guarantees a safe and effective cloud environment by carefully evaluating these factors. A well-chosen cloud service provider may improve security, promote scalability, encourage innovation, and increase business operational efficiency. We used the multi-criteria decision-making (MCDM) methodology to rank the criteria and select the best cloud service provider. We used the VIKOR method as an MCDM methodology to compute the criteria weights and rank the alternatives. We show that performance is the best criterion. We analysed changes in the parameters of the VIKOR method to show different ranks. We conclude the results are stable.

Keywords: Multi-Criteria Decision-Making; VIKOR Method; Cloud Service Provider, Decision-Making..

1 | Introduction

Customers may access pooled computer resources through the Internet, including storage, software, and processing power under the cloud computing service delivery paradigm. A group of resources that are made accessible to consumers on demand is referred to as a "cloud." It altered our expectations about getting processing power that is highly available, versatile, and requires little administration work. Consequently, while CSPs care for their technological infrastructure, businesses may focus on their core competencies. CSPs are suppliers that hire out various services to their customers, often delivering them per-user basis based on customer demand. A Service Level Agreement (SLA) between customers and CSPs governs their connection[1-3].

Investing in CC technology is surging because of its many benefits for organizations, such as economies of scale. Consequently, more cloud services are available, along with more CSPs offering these services. Big IT

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companies like Microsoft, Amazon, and Google are increasingly battling to provide their customers with dependable services that live up to their expectations [4-6]. The growth of CC technology is encouraged by this competitive climate, which also motivates many IT firms to improve the quality of their services. All CSPs at different prices, quality levels, and feature sets provide similar services. In contrast, storage space may be less expensive from a single source. It might be costly to compute. When faced with many cloud computing options, customers confront a significant challenge in deciding which cloud service provider (CSP) best suits their requirements [7, 8].

Ensuring future performance and compliance with laws, regulations, and standards necessitates this. However, picking the incorrect CSP might lead to noncompliance with utilizing the cloud for data storage, compromised data security or integrity, and an inability to provide future services. Potential corporate benefits of cloud computing include:

- Lower costs.
- More mobility and collaboration.
- Enhanced catastrophe resilience.
- Easier upgrades and maintenance.

However, cloud computing has several potential drawbacks, including concerns about privacy and security and the risk of vendor lock-in. Cloud computing is a flexible and dynamic way to provide IT support that may help businesses[9, 10]. Before using a cloud computing solution, weighing the advantages and disadvantages, just as with any new technology, is crucial. In today's IT environment, businesses rely on cloud storage solutions to manage and preserve critical data [11-13]. Selecting the right cloud storage provider is a crucial choice that impacts an organization's general efficacy, performance, and handling of information approach. This decision-making approach falls under the category of multi-criteria decision-making (MCDM), which is concerned with identifying options utilizing a variety of factors. Because choosing a cloud storage provider might have far-reaching effects, it's a critical MCDM problem. Businesses must choose from various cloud service providers that differ in cost, dependability, security, scalability, and other crucial factors[14], [15]. A lousy choice might lead to failures, security breaches, disruptions, or more costs. Thus, selecting the best cloud storage provider based on an organization's unique needs and preferences requires a thoughtful process[16-18].

2 | VIKOR Method

This section discusses the steps of the VIKOR method [19, 20] as shown in Figure 1.

Figure 1. The steps of the VIKOR method.

Step 1. Build the decision matrix.

The decision matrix is built based on a set of criteria and alternatives. Where m is the number of alternatives and n is a number of criteria.

$$R_{mn} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \tag{1}$$

$i = 1,2, \dots m; j = 1,2, \dots n$

Step 2. Compute the positive and negative values.

$$r_{ij_{max}} = \max[r_{ij}, i = 1,2, \dots m] \tag{2}$$

$$r_{ij_{min}} = \min[r_{ij}, i = 1,2, \dots m] \tag{3}$$

Step 3. Compute the utility measure.

The utility measure is computed based on positive and negative criteria as:

$$U_i = \sum_{j=1}^{n} \frac{w_j[r_{ij_{max}} - r_{ij}]}{[r_{ij_{max}} - r_{ij_{min}}]} \tag{4}$$

$$U_i = \sum_{j=1}^{n} \frac{w_j[r_{ij} - r_{ij_{max}}]}{[r_{ij_{max}} - r_{ij_{min}}]} \tag{5}$$

Step 4. Compute the regret measure

$$g_i = \max of \left\{ \frac{w_j[r_{ij_{max}} - r_{ij}]}{[r_{ij_{max}} - r_{ij_{min}}]} \right\} \tag{6}$$

Step 5. Compute the VIKOR index.

$$D_i = \propto \left[\frac{(U_i - U_i^-)}{U_i^+ - U_i^-} \right] + (1 - \propto) \left[\frac{g_i - g_i^-}{g_i^+ - g_i^-} \right] \tag{7}$$

Where $\begin{Bmatrix} U_i^+ = \max[U_i] \\ U_i^- = \min[U_i] \\ g_i^+ = \max[g_i] \\ g_i^- = \min[g_i] \end{Bmatrix}$

3 | Application

This section offers the results of the VIKOR method to select best cloud service provider based on a set of criteria as shown in Figure 2.

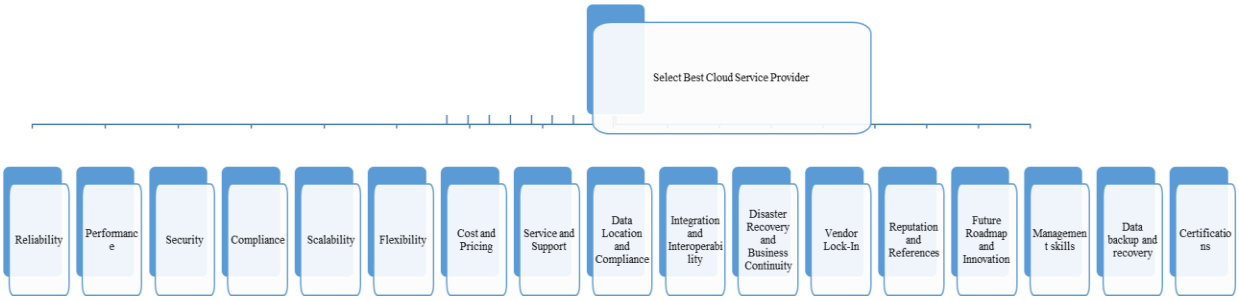

Fig. 2. The cloud service provider criteria.

Step 1. Build the decision matrix by Eq. (1) based on a set of 17 criteria and 10 alternatives to select best cloud service provider. We used a scale between 1 to 9 to evaluate the criteria and alternatives by the experts and decision makers.

Then we compute the weights of criteria as shown in Figure 2. The reliability and performance are the highest weight and vendor lock in criterion is the least weight.

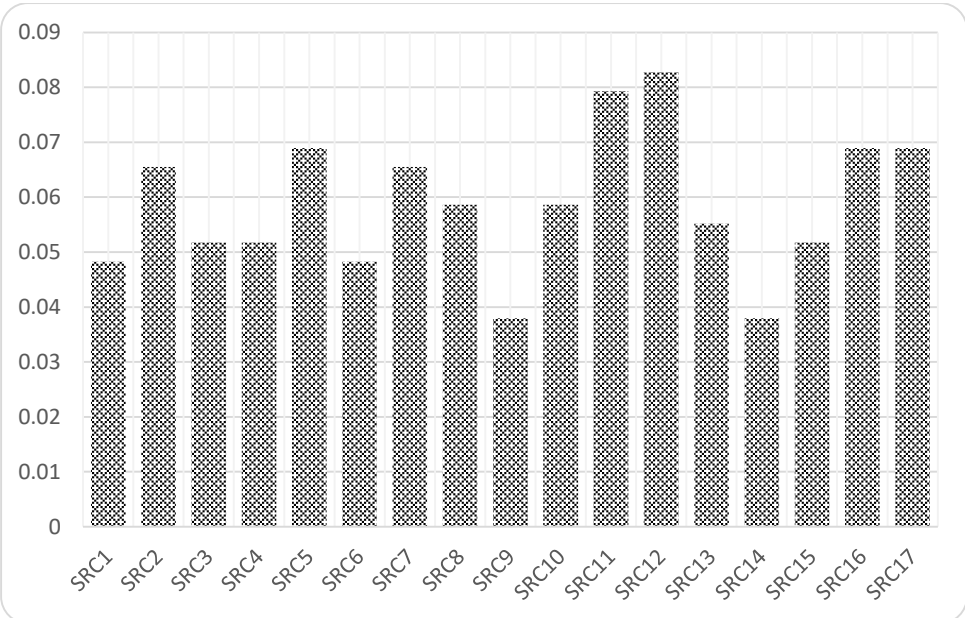

Figure 2. The weights of cloud service provider criteria.

Step 2. Compute the positive and negative values by Eqs. (2) and (3). All criteria are positive except the cost criterion is negative.

Step 3. Compute the utility measure by Eqs. (4) and (5). As shown in Table 1.

Table 1. The utility degree.

	SRC_1	SRC_2	SRC_3	SRC_4	SRC_5	SRC_6	SRC_7	SRC_8	SRC_9	SRC_{10}	SRC_{11}	SRC_{12}	SRC_{13}	SRC_{14}	SRC_{15}	SRC_{16}	SRC_{17}
Ser_1	0.02069	0	0.012931	0.008621	0	0.013793	0.037438	0.025123	0.037931	0	0.029741	0	0.009195	0.010837	0.007389	0	0.039409
Ser_2	0.048276	0.065517	0.051724	0.051724	0.029557	0.013793	0.037438	0.025123	0.010837	0.058621	0	0.031034	0.055172	0.037931	0.029557	0.029557	0
Ser_3	0.02069	0.00936	0.012931	0.043103	0.039409	0.027586	0	0.033498	0.037931	0.035172	0.009914	0	0.036782	0.037931	0.051724	0.039409	0.029557
Ser_4	0.027586	0	0	0	0.029557	0.006897	0.037438	0.008374	0	0.011724	0.07931	0.072414	0.055172	0.037931	0.022167	0.029557	0.039409
Ser_5	0.013793	0.028079	0.019397	0.025862	0	0.006897	0.065517	0.025123	0	0.035172	0.039655	0.072414	0	0	0	0.068966	0.049261
Ser_6	0.034483	0.028079	0.038793	0.008621	0.068966	0	0.037438	0.008374	0	0.035172	0.059483	0.072414	0.036782	0.016256	0.007389	0.059113	0.068966
Ser_7	0.006897	0.037438	0.045259	0.034483	0.029557	0.02069	0	0.008374	0.016256	0.011724	0.039655	0.010345	0	0.032512	0.029557	0.029557	0.059113
Ser_8	0	0.065517	0.038793	0.025862	0.049261	0	0.037438	0	0.016256	0	0.069397	0.041379	0.009195	0	0.022167	0	0.029557
Ser_9	0.006897	0.065517	0.051724	0.017241	0.009852	0.048276	0.046798	0.033498	0.016256	0	0.069397	0.082759	0.027586	0.021675	0.036946	0.019704	0.068966
Ser_{10}	0	0.018719	0.006466	0	0.029557	0.02069	0.046798	0.058621	0.032512	0.035172	0.039655	0.051724	0	0.005419	0.014778	0.029557	0.039409

Step 4. Compute the regret measure by Eq. (6).

Step 5. Compute the VIKOR index by Eq. (7), to rank the alternatives. Figure 4 shows the rank of cloud service provider. The alternative 1 has the highest rank and alternative 9 is the lowest rank.

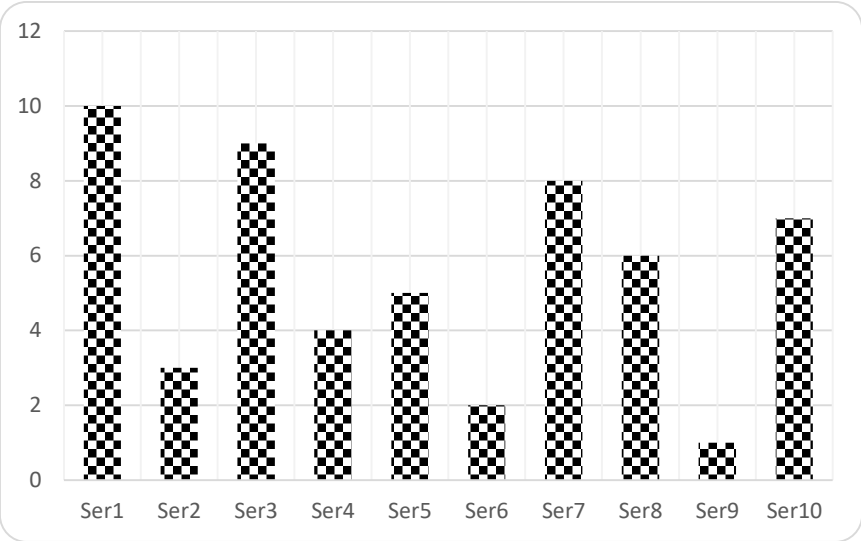

Figure 4. Rank of 10 cloud service provider.

4 | Analaysis

We analysis the rank of alternatives to show the stability of the results. We change the value of ∝ parameter between 0.1 and 1. We obtain the ten ranks of alternatives as shown in Figure 5. We show the alternative 1 is the best alternative in all ranks and alternative 9 is the worst in all ranks.

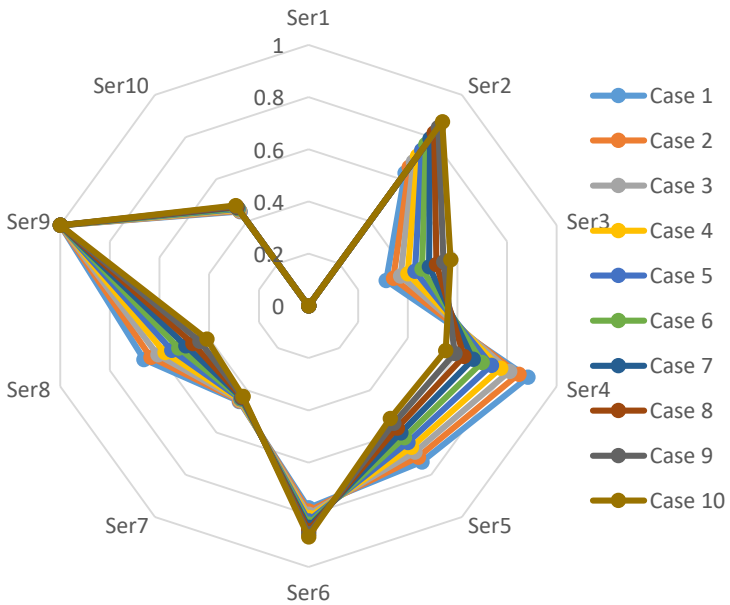

Figure 5. The rank of cloud service provider alternatives under changing in ∝ parameter.

5 | Conclusions

To properly use the advantages of cloud computing, organizations need to make the crucial choice of which cloud service provider to choose. Organizations may choose which supplier best fits their needs and goals by assessing various parameters. Essential considerations include vendor lock-in, reputation and references, future roadmap and innovation, data location and compliance, reliability and performance, security and compliance, scalability and flexibility, cost and pricing, service and support, integration and interoperability, disaster recovery and business continuity, and integration and interoperability. By thoroughly assessing these

factors, companies can ensure that the cloud service provider offers dependable services with excellent uptime, robust security, and adherence to relevant laws. Flexibility and scalability ensure the service can adapt to the expanding and changing demands of the company. The most economical option is determined in part by cost and price factors. Sufficient service and assistance are essential for quickly resolving any problems or questions.

Compliance and data location are crucial, particularly for businesses that must adhere to strict regulations around data residency. Integration and interoperability features make seamless integration with current systems and applications possible. Plans for business continuity and disaster recovery safeguard data and reduce downtime. Data portability and flexibility are maintained by assessing the possibility of vendor lock-in. Evaluating references and reputation provides information about the supplier's track record and client satisfaction. Last but not least, being aware of the provider's innovation strategy and future roadmap guarantees that its products meet the changing demands of the company. Organizations may choose a cloud service provider that fulfils their short-term needs and lays the groundwork for long-term success by carefully weighing these factors. Organizations may gain scalability, improve security, stimulate innovation, and maximize operational efficiency when they work with the appropriate supplier. Organizations may successfully harness the potential of cloud computing and achieve a competitive advantage in the digital arena by choosing cloud service providers with knowledge. We used the VIKOR method as a MCDM methodology to rank the cloud service providers and select best one. We used a 17 criteria and 10 alternatives. We show the performance is the best criterion. The alternative 1 is the best alternative 9 is the worst.

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Author Contributaion

All authors contributed equally to this work.

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Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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