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Cloud service ranking with an integration of k-means algorithm and decision-making trail and evaluation laboratory approach

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ABSTRACT

The present research focuses on ranking cloud services by using the k-means algorithm with multi-criteria decision-making (MCDM) approaches that are the prime factor in the decision-making process and have been used to choose cloud services. The tools offered by MCDM can solve almost any decision-making problem. When faced with a selection challenge in the cloud environment, the trusted party would need to weigh the client's choice against a predetermined list of criteria. There is a wide range of approaches to evaluating the quality of cloud services. The deep learning model has been considered a branch of artificial intelligence that assesses datasets to perform training and testing and makes decisions accordingly. This paper presents a concise overview of MCDM approaches and discusses some of the most commonly used MCDM methods. Also, a model based on deep learning with the k-means algorithm based decision-making trial and evaluation laboratory (kDE-MATEL) and analytic network process (ANP) is proposed as k-means algorithm based decision-making trial and evaluation laboratory with analytic network process (kD-ANP) for selecting cloud services. The proposed model uses the k-means algorithm and gives different levels of priority and weight to a set of criteria. A traditional model is also compared with a proposed model to reflect the efficiency of the proposed approach.

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1. INTRODUCTION

Cloud computing has come to mean creating software and providing related services through the internet. The information technology (IT) industry is adopting it rapidly, which is predicted to continue. Therefore, there is a need to consider the potential downsides and expenses of integrating with the various cloud services now on the market. However, a related issue with this approach is that business leaders need more expertise to compare. Through a service level agreement (SLA), the cloud computing service guarantees to provide all the current service features at the required standard [1]. Various multi-criteria decision-making (MCDM) techniques may be us to compare multiple service providers. MCDM is a technique for choosing alternatives through decision-making [2]. Defense, education, economics, information technology, and other sectors benefit from MCDM techniques. Ultimately, the objective of mobile device management (MDM) is to zero in on and choose alternatives that align with the decision-makers beliefs and preferences. Many potential paths will likely need to be examined when deciding on a course of action. If this is the case, it is necessary to locate as many feasible solutions as possible and select the one that serves users' requirements in the cloud environment most efficiently. Research considers a cloud service to be an independent actor, and when we say, "a cloud user trusts a cloud service". There are different types of cloud services but their ranking requires consideration of multiple criteria. Trust management is the mechanism for automated decision-making that could be applicable. The resemblance between the needs of cloud services and services provided was then determined [3]. The ranking of cloud service providers will thereafter be done. The ranking model proposed by the trust management system has focused on quality of service (QoS) where system accuracy, execution time, and complexity are considered.

Research in the areas of MCDM methods, trust management, cloud computing, and cloud services have all been identified. The major goal of this kind of study is to rank cloud services. There are a variety of approaches used to categorize cloud services, each with its own set of advantages and disadvantages. Traditional methods for making decisions based on several factors are time-consuming. In addition, the high error rate of conventional MCDM raises the need for higher precision. Certain rankings may be duplicated. Consequently, a better system for making highly accurate multi-criteria judgments in a minimal amount of time without superfluous grades has to be proposed. They are meant to outperform traditional cloud service ranking methodologies in terms of scalability and adaptability. This article's goal is to offer a brief introduction to MCDM methodologies and to go into some of the most popular MCDM approaches. In addition, we offer deep learning and k-means algorithm-based decision-making trial and evaluation laboratory (DE-MATEL) and analytic network process (ANP cluster approach-based) model for selecting cloud services. The proposed model uses the k-means technique to provide different criteria in a set of different relative importance and weight. The study compares the proposed technique against a more traditional paradigm to determine its efficacy.

Section 2 contains the background details of various techniques. In section 3 various MCDM approaches are discussed. Section 4 is the literature review section where different research works are discussed with the methodology and outcomes. There is a comparison table of existing research which compares the objectives, methodology, and limitations of research. In section 5 the problem statement is discussed where issues with conventional cloud service ranking are considered. Section 6 focused on the proposed work where the process flow of the proposed model has been elaborated. In this, the proposed work is considered the domain of MCDM methods, trust management, cloud computing, and cloud service. The parameters of a deep learning model are set to their default values, including epochs, hidden layer, and learning rate. Section 7 followed by the result and discussion part that has compared the accuracy and error of the previous and proposed approach. The suggested DEMATEL-ANP method is put to the test with ten different cases. Section 8 contains the conclusion part where the outcome of the research is elaborated with the future scope of research.

2. PRELIMENIRES

Decisions on which cloud services to employ have often been made using MCDM methods. MCDM provides a set of techniques that may be used in almost every decision-making scenario. The analytical hierarchy process (AHP), standard measurement index (SMI), technique of order preference by similarity of ideal solution (TOPSIS), elimination et choice translating reality (ELECTRE), preference ranking organization methods for enrichment evaluation (PROMETHEE), and outranking methods are only a few of the numerous tools available. In the event of a cloud-based selection problem, a reliable third party would have to evaluate the client's proposed solution in light of certain established standards. The quality of cloud services may be assessed in a variety of ways. The deep learning model has been seen as a subfield of artificial intelligence (AI) that uses data analysis for training testing and decision-making.

2.1. Cloud computing

Cloud computing is storing data in the cloud and accessing computing power through the internet rather than on a local host server. Several data centers performing similar functions are common in big clouds. As the cloud relies on resource sharing to accomplish coherence, the “pay as you go” model used by most cloud providers may help to minimize initial capital costs. However, it may also lead consumers to suffer unplanned operational expenses. For promoting rapid innovation, adaptive resources, and economies of scale, cloud computing entails making various computing services available through the internet [4].

It provides three distinct service models which are infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). These Service model also knowns as an internet Stack and meet a unique business need [5]. All the offered Services through computing stack are utilized efficiently between consumers through deployment model. The deployment models are divided into four categories (Public, Private, Community and Hybrid) based on their location demand and availability. This article explains what cloud computing is, the variations between the three service models, their benefits and drawbacks, and how the correct virtual desktop infrastructure (VDI) solution may help users get the most out of the three primary categories of service models [6], [7].

2.2. Trust management in cloud computing

It is used for ranking cloud services. Numerous service providers now provide comparable service functions. Trust management computes cloud service trust ratings to provide QoS for system correctness, execution speed, and time complexity [8]. This system will ensure users can access protected data via reputable cloud service providers and QoS. Businesses of various sizes and in a variety of industries are relying on the cloud for a variety of services [9].

2.3. Need for research work

The current state of affairs guarantees that moving data, apps, or infrastructure to the cloud will be difficult. The full potential of cloud computing has yet to be realized due to many constraints. The service provider must consider existing applications, data, and infrastructure demands and settings, which offer many challenges. These issues can be divided into two: Different systems affect workload parameters differently and have different setup performances [10]. From a business perspective, this is indeed the case. In addition, each cloud service provider offers unique features and customization choices for their services [11], [12]. Because of this, it may be difficult for businesses to choose the cloud service provider that offers the features and capabilities that are the most suitable for their needs [13]. Several publications have discussed vendor selection strategies after researching connected topics and finding related research [14], [15]. The various criteria decision making (MCDM) approach is one of these strategies, and it is used to structure and make decisions on multiple criterion-based challenges [16], [17]. Most of the studies that were looked at did not consider the interdependencies and relationships between the criterion and the parameters [18], [19]. Researchers assume that the criteria’s relative importance and weight are comparable while using MCDM in their inquiries [20]. This technique aims to supplement MCDM by helping to address the interactions and dependencies between criteria [21].

3. MULTI CRITERIA DECISION MAKING APPROACHES

Many powerful MCDM techniques exist to investigate the issues and identify the most suitable solution [22]. A list of philosophers, from the most ancient times forward, has considered the topic of decision. Decision-making using multi criteria decision analysis (MCDA) techniques considers many factors at once [23]. If someone wants to make good judgments in an organization, they will likely have to weigh several, sometimes competing factors. Every business must balance the competing priorities of cost and a measure of service quality. Multi-criteria decision-making is considering the analysis of different available choices that span daily life [24]. It plays a significant role in application-related social sciences, engineering, medicine, and many other areas. A brief overview of various MCDM techniques is presented in Table 1.

Table 1. Comparison of MCDM Techniques

MVDM method	Strength	Weakness
Multi attribute value theory (MAVT)	Make a MAVT-compatible preference order on the options and assign a real number to each one.	-
Multi-attribute utility theory (MAUT)	The use of probabilities and expectancies in the face of unknowns is common practice. Simple but effective structure for uses involving potentially hazardous decisions	-
Outranking methods	Allows for immediate use with partial preference functions	-
AHP	The ability to adapt to changing circumstances Data entry is made simple and quick using the pair-wise comparison form's handy layout.	An issue with decomposition It is necessary to do large comparisons using just two variables. (n(n−1)/2) Challenges with a 9-point scale
TOPSIS	Any number of criteria and characteristics may be fed into it. What it means in terms of how matter is arranged. Think about how far away someone is from the perfect answer.	Misleading information for the user. Neglecting the Uncertainty in Weightings
ELECTRE	Choose the optimal course of action from a range of potential courses Build a single one or several fuzzy analysis that takes into account ordering relationships. Allows for the incorporation of qualitative and quantitative standards.	Not easily grasped a harmony of dissonance For this purpose, matrices are used.
PROMETHEE	Simultaneously address both qualitative and quantitative factors. Use fewer external factors	Is plagued by the issue of rank reversal if one can avoid it, one should not systematically organize a choice issue

The table presents the benefits and drawbacks of various MCDM approaches [25]–[28]. In the present research, MCDM has been used for cloud ranking where ambiguity issues have been resolved by a hybrid approach where AHP and TOPSIS are considered with time stamps [29]. The term "cloud service provider" refers to an organization or firm that provides consumers access to various services, including varying degrees of depth and breadth of functionality through the internet [30]. However, since both cloud services and cloud service providers are expanding quickly, it is becoming more difficult for customers to select one that best meets their needs [31]–[33]. In conventional research, the author presented a strategy that may assist the customer in responding to the abovementioned issue. To assess and rank cloud service providers using intelligent data, a hybrid version of the MCDM method has been created. In addition to that, this technique takes into account the interdependencies and linkages that exist between the various performance metrics [34]. To do this, we utilize k-means to cluster similar cloud providers together, and then we employ MCDM methods with the help of the decision-making trial and evaluation laboratory-analytic network process (DEMATEL-ANP) to rank the clusters and make decisions [35]. Table 1 shows the comparative analysis of different MCDM techniques.

4. LITERATURE REVIEW

The present section contains the literature review, whereby many research studies are examined in combination with their respective methodologies and results. A comparative table has been provided, which outlines the purpose, methodology, and limitations of many current research studies. MCDM approaches were investigated in the article [1]. When developing MCDM, the author took into consideration cloud service ranking. In some research work Multicriteria while deciding on cloud service adoption and selection has been considered [2]. Some of the research looked into the viability of using the decision-making process to choose a cloud service [3]. Many authors rambled on about different strategies for making decisions based on multiple criteria [4]. Abdelaziz *et al.* [5] considered the cloud computing service paradigm and described the MCDM strategy. Alabool *et al.* [6] also conducted a review based on the MCDM approach for evaluating cloud services and focused on cloud services as a fuzzy multicriteria dilemma [7]. Conventional work described a hybrid MCDM strategy for cloud adoption [8] and offered evidence supporting multi attribute decision making (MADM) approaches based on the healthcare industry. Previous research work has created a list of critical factors for cloud computing adoption and ranked them. Sharma *et al.* [9] uses many techniques to make decisions based on multiple criteria. Work has been conducted to review the MCDM approach to selecting the optimal materials for design [10]. Bruno and Genovese [11] have offered many approaches to MCDM and its applications and considered cloud provider selection a complex, multicriteria challenge [12]. Some research conducted a comparative examination of different MCDM strategies to select resources for mobile crowd computing [13]. Previous research has conducted a review on using multiple criteria decision analysis in environmentally responsible industrial decision-making [14] and studied to combine MCDM techniques with building information modeling (BIM) [15]. For cloud service ranking, there are different researches in the area of MCDM Methods. Their methodology and limitations are explained in Table 2 (see in appendix).

5. PROBLEM STATEMENT

Several studies have been spotted in MCDM techniques, trust management, cloud computing, and cloud services. Ranking cloud services is the primary focus of such research. Different mechanisms are applied to classify cloud services, but these schemes have limitations. Conventional techniques take much time while performing MCDM. Moreover, the issue with traditional MCDM is the need for more accuracy due to the high error rate. There is a chance of redundant ranks. Thus, there is a need to propose a more efficient mechanism to make highly accurate multi-criteria decisions in a minimum amount of time without redundant grades. Such systems are supposed to be more scalable and flexible than conventional cloud service ranking schemes.

6. PROPOSED WORK

The proposed work is considered the domain of MCDM methods, trust management, cloud computing, and cloud service. Cloud computing has been utilized extensively for MCDM systems used for trust management and cloud servers. The issue with such a system is accuracy, error rate, and performance. Thus, there is a need to present a system that should lower an error rate together with performance to make the MCDM system more accurate [33]. The proposed work considers integrating optimization mechanisms with deep learning to enhance the performance and accuracy of MCDM in the cloud.

6.1. Process flow of research work

The deep learning model considers the dataset for training, and then divides this dataset for training and testing in the proportion of 80/20. The parameters of a deep learning model are set to their default values, including epochs, hidden layer, and learning rate. After completing training and testing, a confusion matrix is produced to illustrate the categorization of cloud services in preparation for ranking.

For MCDM, many qualities of the dataset have been taken as x-train and x-test. In contrast, the associated weightage has been considered a y-train and y-test for ranking. At the outset, the study collects the records that present cloud services and takes into consideration the criteria c1, c2, c3, ... cn for making decisions as shown in Figure 1.

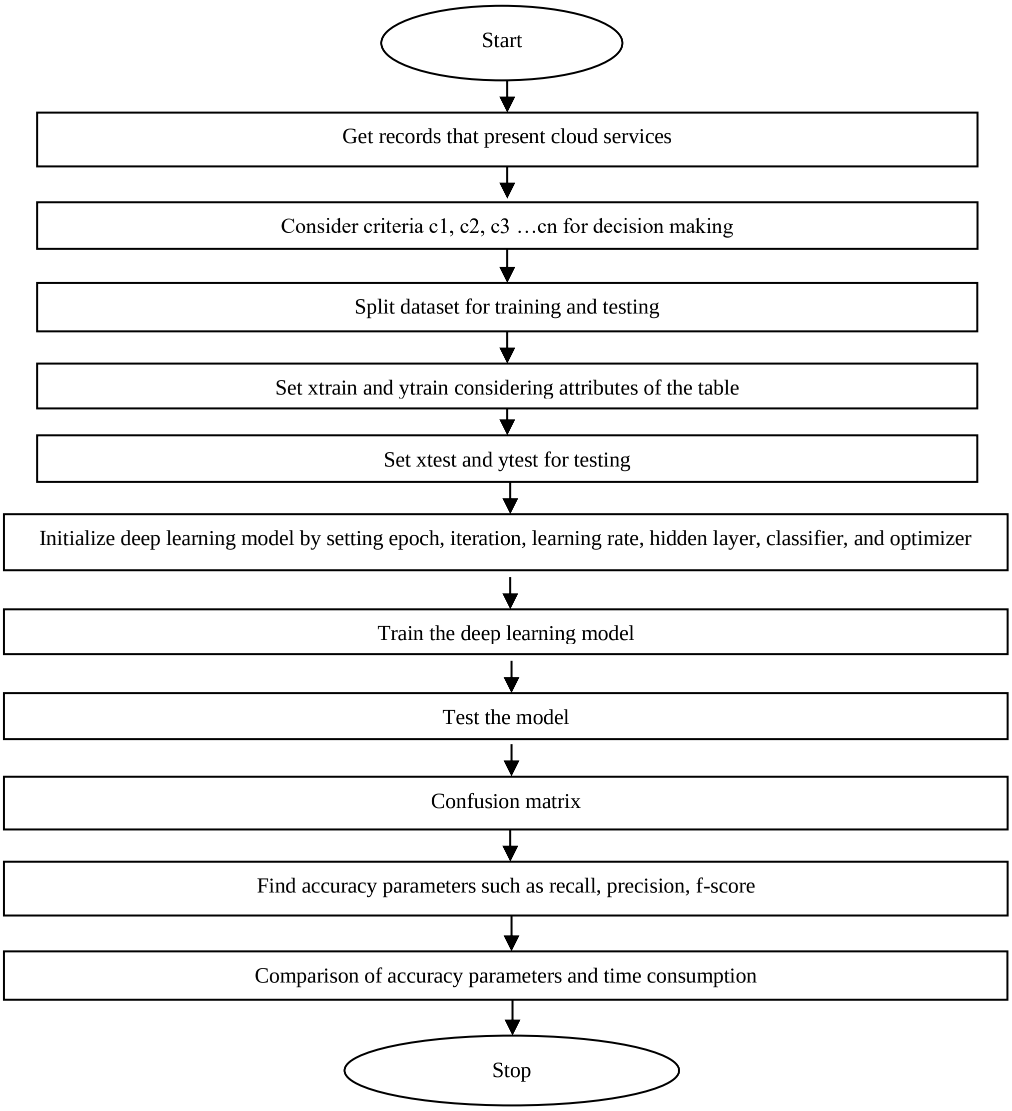

Figure 1. Process flow of research work

At this point, records have been divided into two components, which are training and testing. After this step, research will establish the x-train and y-train, which will examine the QoS attributes of the service provider alternatives. Also, the study will set x-test and y-test, which will be used for testing (minimum and maximum value of parameters). It begins training the deep learning model after initializing it by specifying parameters such as epoch, iteration, learning rate, hidden layer, classifier, and optimizer. Now, put this model through its paces and produce a confusion matrix. After generating the confusion matrix, the subsequent step calculates several accuracy parameters, such as recall, precision, F-score, and accuracy. Ultimately, the study would compare the accuracy metrics and the time used.

7. RESULT AND DISCUSSION

Ten test cases evaluate the output of the proposed DEMATEL-ANP approach. The procedure mentioned above was implemented using deep learning in the MATLAB environment. The effectiveness, accuracy, error rate, and time consumption of the suggested technique are compared to those of the standard methodology given in [34].

Table 3 presents the comparative analysis of accuracy in the case of the conventional approach and the present approach. This table shows that the proposed work has provided better accuracy as compared to the conventional approach in all cases. Table 4 presents the comparison of rate error in the case of previous and present work. It has been observed that the proposed approach provides less error as compared to the conventional approach. Table 5 presents a comparative analysis of the consumption of time in the case of the conventional approach and the present work. The proposed approach shows time of consumption as compared to the conventional approach. Also, Figures 2, 3, and 4 graphically present the accuracy rate, error rate, and consumption time by considering Tables 3, 4, and 5. It is observed that the curve of the proposed work is lower than conventional because the proposed work is consuming less time.

Table 3. Comparative analysis of accuracy

Case	Conventional approach ([34])	Proposed approach
1	90.247	93.520
2	90.435	93.395
3	90.203	93.429
4	90.124	93.215
5	90.252	93.997
6	90.527	93.320
7	90.017	93.533
8	90.339	93.733
9	90.503	93.721
10	90.210	93.567

Table 4. Comparative analysis of error

Case	Conventional approach ([34])	Proposed approach
1	9.753	6.480
2	9.565	6.605
3	9.797	6.571
4	9.876	6.785
5	9.748	6.003
6	9.473	6.680
7	9.983	6.467
8	9.661	6.267
9	9.497	6.279
10	9.790	6.433

Table 5. Comparison of consumption of time

Case	Conventional approach ([34])	Proposed approach
1	10.0131	8.740748
2	10.60096	8.989631
3	10.40969	8.394775
4	10.89935	8.377032
5	10.1684	8.013706
6	10.22234	8.011738
7	10.25964	8.491359
8	10.07717	8.342056
9	10.57245	8.52155
10	10.54658	8.053334

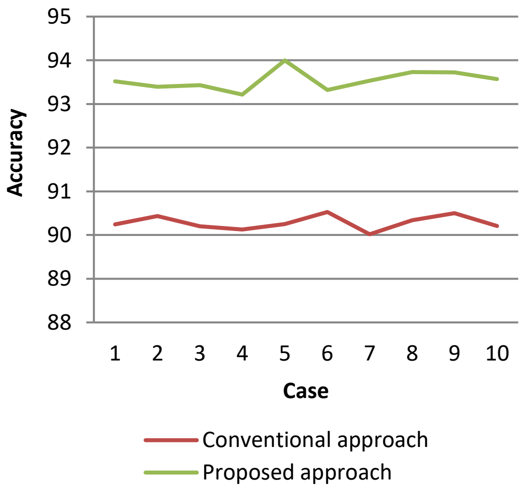

Figure 2. Comparative analysis of accuracy

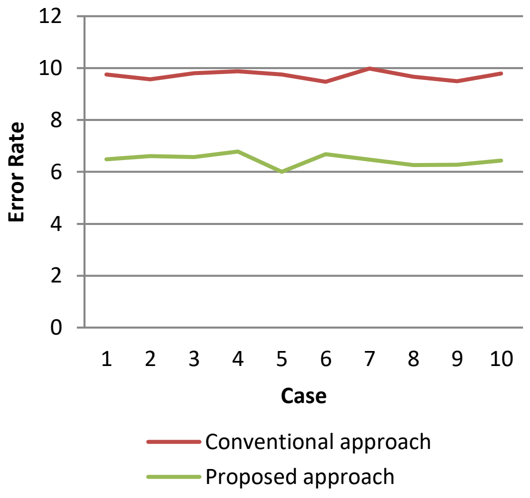

Figure 3. Comparative analysis of error rate

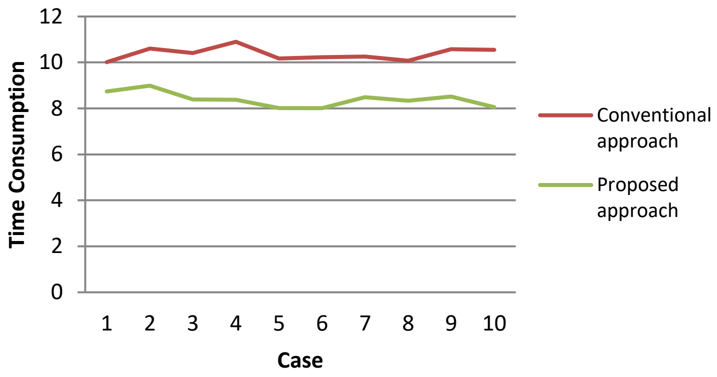

Figure 4. Comparison of error rate

8. CONCLUSION AND FUTURE SCOPE

This paper discusses a variety of strategies, each with its own set of advantages and limitations. The proposed research is state-of-the-art in MCDM techniques, trust management, cloud computing, and cloud services. Trust management and cloud servers, which rely heavily on MCDM systems, have seen significant adoption of cloud computing. The system's accuracy, error rate, and performance are the main problems. For this reason, a system that can simultaneously improve MCDM's accuracy and efficiency is needed. The proposed approach involves incorporating optimization mechanisms into deep learning to enhance the accuracy and speed of MDCM on cloud platforms. In this way, the proposed work has provided an efficient, innovative solution for deep learning. Further research would consider different ways to use MDM and the cloud services that use MDM principles. Multi-criteria decision-making techniques solve almost any decision-making problem. Among these tools are AHP, SMI, TOPSIS, ELECTRE, PROMETHEE, the outranking approach, and many more. Cloud computing applications and services can benefit from more advanced techniques. For future projects, exploring more sophisticated methods of evaluating the quality of cloud services would be beneficial.

APPENDIX

Table 2. Literature survey

S. No.	Ref	Objective	Methodology	Limitation
1	[1]	A review on MCDM methods for cloud service ranking (CSR)	MCDM, Cloud service	Scope of work is limited
2	[2]	MCDM in cloud service selection and adoption	Decision-making, Cloud service	Need to introduce more technical work
3	[3]	MADM approach to choosing a CSR model	Cloud computing service, Decision-making	Research is limited to traffic flow
4	[4]	MCDM for cloud computing service in the cloud	Cloud service, MCDM	Lack of efficiency
5	[5]	Methodology for selecting and rating cloud services based on several factors	Cloud service, MCDM	Need to improve the performance and accuracy
6	[6]	MCDM for evaluating cloud services: a systematic literature review	MCDM, cloud service	There is a lack of performance
7	[7]	Cloud service selection as fuzzy multi-criteria problem	Cloud service, multi-criteria problem	Research is limited to traffic flow
8	[8]	Evidence from the healthcare industry supporting a hybrid MCDM approach to cloud adoption	Cloud computing, MCDM	There is less technical work
9	[9]	MCDM methods for prioritizing crucial aspects of cloud computing adoption	MCDM, Cloud computing	Lack of security and accuracy
10	[10]	Reviewing on application of MCDM in the selection of material for optimal design	MCDM	There is a lack of performance
11	[11]	To review MCDM methods and their applications	MCDM	Lack of technical work
12	[12]	Cloud provider selection a complex multicriteria problem	Multicriteria problem, Cloud provider	The performance of this research is very low
13	[13]	Resource selection in mobile crowd computing: a comparative study of MCDM techniques	Crowd computing, MCDM	Did not considered real life solution
14	[14]	Review of MCDM analysis in sustainable manufacturing decision making	MCDM	Need to consider optimization technique
15	[15]	Combining MCDM methods with BIM: a review	MCDM, BIM	Need to enhance the scope of work

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