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**A Comparative Study Of K-Medoids And Fuzzy K-Means Clustering For The Selection Of Optimal Cloud Service Provider**

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| **ARTICLE INFO** | **ABSTRACT** |
|  | Cloud providers offer various services, including storage, computing power, and data management, making selecting the best provider for a particular application challenging. Clustering algorithms can simplify the process by grouping cloud service providers based on cost, reliability, security, and performance similarities. K-medoids and fuzzy K-means clustering are two widely used clustering algorithms that can be applied to this problem. K-medoids is a non-parametric algorithm that selects representative points, called medoids, for each cluster. At the same time, fuzzy K-means is a soft clustering algorithm that assigns each data point to multiple clusters with varying degrees of membership. By grouping cloud service providers using these algorithms, comparing and selecting the best provider for a particular application is more accessible. This paper discusses the application of K-medoids and fuzzy K-means clustering to select the best cloud service provider and highlights the advantages and limitations of each approach. |

**Introduction:**

Popular techniques used in data mining and machine learning to cluster comparable data points into groups are fuzzy K-means clustering and K-medoids. They can be used to solve the choosing the best cloud service provider issue in this situation. Cloud providers offer various services, including storage, computing power, and data management. Choosing the best provider for a particular application can be a daunting task, as there are many factors to consider, including cost, reliability, security, and performance. Clustering algorithms help simplify this task by grouping cloud service providers based on their similarity in terms of these factors. K-medoids and fuzzy K-means clustering are two approaches that can be used to perform this clustering.

K-medoids is a non-parametric clustering algorithm similar to K-means but more robust to noise and outliers. It works by selecting representative points, called medoids, for each cluster. Then, the algorithm iteratively updates the medoids until convergence. On the other hand, fuzzy K-means clustering is a soft clustering algorithm that assigns each data point to all clusters with varying degrees of membership. This allows for more flexible and nuanced clustering, as data points can belong to multiple clusters simultaneously.

In selecting the best cloud service provider, these algorithms can be used to group providers based on their similarities in terms of cost, reliability, security, and performance metrics. This can help identify clusters of providers that offer similar services and allow for easier comparison and selection of the best provider for a particular application. Overall, K-medoids and fuzzy K-means clustering are powerful tools that can aid in selecting the best cloud service provider. By grouping providers based on similarities, these algorithms help simplify choosing the best provider for a particular application.

**Literature review:**

This paper put forth a method for choosing a cloud service provider that is based on the K-means clustering technique. Using a real-world dataset, the authors assessed the performance of their methodology and demonstrated its efficacy in choosing the best cloud service provider [1]. Based on the K-means clustering technique, this research suggested a cloud service provider selection algorithm. Using a real-world dataset, the authors assessed the algorithm's performance and demonstrated its potency in choosing the best cloud service provider [2].

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method and the K-means clustering algorithm were used in this paper to suggest a strategy for choosing a cloud service provider. Using a real-world dataset, the authors assessed the performance of their methodology and demonstrated its efficacy in choosing the best cloud service provider [3]. Additionally, a fuzzy K-means clustering algorithm was suggested in this paper for choosing cloud service providers. Using a dataset of cloud service providers, the authors assessed the performance of their suggested algorithm and contrasted it with the well-known K-means clustering algorithm [4].

This paper proposed an approach for selecting the best cloud service provider using k-medoids and fuzzy k-means clustering algorithms. The authors applied these algorithms to real-world data to demonstrate the effectiveness of their proposed approach [5]. Next, this paper presented a comparative analysis of k-medoids and fuzzy k-means clustering algorithms for the selection of cloud service providers. The authors evaluated the performance of these algorithms on real-world data and provided insights on which algorithm is more effective for this task [6]. Finally, this paper reviewed clustering techniques for cloud service provider selection, including k-medoids and fuzzy k-means clustering.

The authors discussed the strengths and weaknesses of these algorithms and provided insights into their practical applications [7]. Finally, this paper proposed a hybrid approach for selecting the best cloud service provider using k-medoids and fuzzy k-means clustering algorithms. The authors evaluated the performance of their proposed method on real-world data and provided insights into its effectiveness [8].

These papers demonstrate the growing interest in using k-medoids and fuzzy k-means clustering algorithms to select the best cloud service provider and provide insights into their practical applications.

**Objectives:**

1. This comparative analysis aims to evaluate and compare the performance of K-medoids and fuzzy k-means clustering algorithms for selecting the best cloud service provider (CSP).
2. The analysis includes implementing both algorithms in Python using the Scikit-learn library, using a dataset with multiple attributes, and evaluating the performance using relevant metrics such as silhouette score and execution time.
3. The goal is to determine which algorithm is more effective in clustering CSPs and providing insights for CSP selection.

**Secure Data Sharing Scheme for Dynamic Groups in A Cloud Environment:**

A sort of encryption technique called a secure data-sharing strategy for dynamic groups in a cloud environment permits the secure sharing of sensitive data among a busy group of users in a cloud environment. The system offers strong protection against assaults or unauthorized access and ensures that only authorized users can access the data.

The basic steps of the scheme are as follows:

1. Group formation: To grant access to the data, the data owner establishes a flexible group of authorized users. Depending on the requirements of the data owner, the group membership can be adjusted dynamically.
2. Key Generation: The data owner creates a public key (PK) and a master secret (MSK). While the PK is shared with the group members, the MSK is kept private.
3. Encryption: Using the PK and a set of policies that specify the circumstances under which the data can be accessed, the data owner encrypts the information. The cloud is then used to store the encrypted data.
4. Key Distribution: Based on each group member's identity and group policies, the data owner produces a secret key (SK) for them. The SK is then safely given to the appropriate user.
5. Decryption: In order to access encrypted data, a user must have a valid SK that complies with the access guidelines established by the data owner. The user can then decrypt the data using the SK.

The key features of a secure data-sharing scheme for dynamic groups in a cloud environment are:

1. Dynamic Group Membership: The scheme allows for the dynamic addition or removal of users from the group.
2. Access Control: The scheme provides fine-grained access control by defining policies that determine the conditions under which data can be accessed.
3. Secure Key Distribution: The scheme ensures secure key distribution to authorized users.
4. High Level of Security: The scheme provides a high level of security by encrypting the data and ensuring that only authorized users can access it.
5. Flexibility: The scheme is flexible as it allows the data owner to define policies based on their specific requirements.

A secure data-sharing scheme for dynamic groups in a cloud environment can be used in various applications such as collaborative projects, online education platforms, and healthcare systems where the secure sharing of sensitive data among a dynamic group of users is necessary.



Figure1 Diagram of the Secure Data Sharing Scheme

The diagram of the secure data-sharing scheme has the procedures listed below, as shown in Figure 1. Distribute the key first over fewer communication channels, and after that, the group manager securely hands over the user's private keys. Then, any group member can use the source based on fine-grained access control, and users whose access has been revoked are also restricted from using the cloud during that time. After that, the collusion attack is preserved using a secure data sharing system that refers to the revoked users decreased to achieve the original data file until it attains the untrusted cloud. Then, based on the polynomial function, the scheme obtains the user revocation with high security.

At last, a secure data sharing scheme attains better effectiveness, which indicates that the prior users are reduced to updating the private keys. In contrast, the new user enters into the group or revoked the user from a group. Therefore, the secure data sharing scheme provides more security levels in the cloud environment.

Additionally, there are five operations that make up the secure data-sharing system: system initialization, user registration for an existing user, file upload, user revocation, new user registration, and file download. The system startup procedure is first carried out using the group manager. The next step is to register current users with the cloud, group manager, and user manager. Next, the group manager and cloud are used to implement user revocation and file download.

The group manager follows a similar procedure to that used for existing user registration in order to perform new user registration with identity. The group member then calculates the parameters using the same data file identity and random number. The group manager then sends the data list to the cloud for the new user data file's authentication.

Additionally, the clouds authenticate the group manager's identity and save the message while the transmission is successful. On the basis of the secure data-sharing system, the security and communication overhead still pose a difficult problem for users whose access has been cancelled. As a result, the suggested K-Medoids and Fuzzy K-means method detects BCSP in the cloud environment while reducing communication and security overhead.

The key features of a KP-ABE scheme for constant ciphertext length are:

1. Selective Access: The scheme allows for demanding access to encrypted data based on a set of attributes or policies.
2. Constant Ciphertext Length: The length of the ciphertext produced is regular regardless of the number of attributes or policies associated with it.
3. Scalability: The scheme is scalable as it can handle many attributes or policies.
4. Security: The scheme provides high protection as the ciphertext remains encrypted until the user has the appropriate set of attributes to decrypt it.
5. Flexibility: The scheme is flexible as it allows for adding or removing attributes or policies without requiring changes to the ciphertext or the private key.

KP-ABE scheme for constant ciphertext length can be used in various applications such as cloud computing, healthcare systems, and IoT devices where access to sensitive data needs to be selectively provided to users based on certain attributes or policies.

**Proposed K-Medoids and Fuzzy K-Means Algorithm:**

Here's a proposed K-medoids and Fuzzy k-means algorithm for selecting the best cloud service provider based on performance metrics:

**K-medoids Algorithm:**

1. Input the performance data of cloud service providers.
2. Set the number of clusters, K, to be formed.
3. Initialize the medoids for each group randomly.
4. Calculate the distance between each data point and the medoids.
5. Assign each data point to the closest medoid and form K clusters.
6. Finally, recalculate the medoids for each group.
7. Repeat steps 4-6 until the medoids no longer change or a predetermined number of iterations is reached.
8. Select the best cloud service provider based on the performance metrics of the medoids in each cluster.

**Fuzzy k-means Algorithm:**

1. Input the performance data of cloud service providers.
2. Then, set the number of clusters, K, to be formed.
3. Initialize the membership matrix, U, randomly such that each data point is assigned a degree of membership between 0 and 1 for each cluster.
4. Calculate the centroid for each cluster using the membership matrix.
5. Calculate the degree of membership for each data point in each cluster using the Euclidean distance between the data point and the group's centroid.
6. Update the membership matrix based on the degree of membership of each data point.
7. Repeat steps 4-6 until the membership matrix no longer changes or a predetermined number of iterations is reached.
8. Select the best cloud service provider based on the performance metrics of the centroids in each cluster.

These algorithms can cluster cloud service providers based on their performance metrics and select the best provider from each cluster based on the performance of the medoids or centroids. The K-medoids algorithm assigns each provider to a single cluster, while the Fuzzy k-means algorithm assigns each provider a degree of membership for each cluster, allowing for a more nuanced and flexible representation of the performance characteristics of each provider.

**Chi-Squared Distribution**

The proposed algorithm is generated to measure the chi-squared distribution's quantiles effectively. Chi-squared distribution comprises one-way chi-squared distribution and two-way chi-squared distribution using the proposed K-Medoids and Fuzzy K-Means clustering algorithm, which is illustrated as follows.

1. **One-way chi-squared distribution**

Using proposed algorithms, the one-way chi-squared distribution is performed with the aid of the Budget and the actual. The results are attained based on the Budget and fundamental values, shown in Table 4.7 below.

**Table1 Budget Vs. Actuals**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Excellent** | **Good** | **Satisfactory** | **Fair** | **Poor** |
| **Budget** | 2 | 2 | 2 | 2 | 2 |
| **Actuals** | 3 | 1 | 2 | 2 | 2 |

As illustrated in Table 1, the result is compared based on the Budget and actuals using different class levels during the proposed algorithm. Expectation (E) and Observed (O) are represented as the Budget and Actuals. The mathematical formulation of the Budget and the actuals are written below.

∑$\sum\_{}^{}\frac{\left(O-E\right)^{2}}{E}=1$, Significance level =5=0.05, Degree of freedom = n-1 = 5-1 = **4** (1)

From Equation (1), Ho is denoted as a hypothesis through which the same records are broadcasted among Budget and Actuals and returned as Expectations and Observations. After that, the tabulated value is **9.49**, efficiently attained based on the chi-squared table. Since the chi-square value will be smaller than the tabulated value

(i.e., 1 is smaller than 9.49). Therefore, Hypothesis Ho is accepted in a significant manner.

**2. Two-way chi-squared distribution**

K-Medoids and Fuzzy K-Means methodologies initially perform the way chi-squared distribution and then implement the two-way chi-squared distribution. Then the resultant table is explained in Table 2.

**Table 2 K-Medoids Vs. Fuzzy K-Means**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Excellent** | **Good** | **Satisfactory** | **Fair** | **Poor** |
| **K-Medoids** | 3 | 1 | 2 | 2 | 2 |
| **Fuzzy K-Means** | 3 | 1 | 2 | 2 | 2 |

Table 2 compares the results of the two proposed K-Medoids and the Fuzzy K-Means algorithm based on the five classes.

Chi-squared value is utilized between the two Actuals, and the importance of chi-squared gets **0** (Zero). Then the tabulated value is returned as 3.84, that are significantly achieved according to the chi-squared table. A Chi-square value is smaller than the tabulated value (i.e., 0 is smaller than 3.84). Hence, the resultant value of the proposed K-Medoids and Fuzzy K-Means algorithm is the same; therefore, Hypothesis Ho is accepted with better efficiency. Thus, the proposed K-Medoids and Fuzzy K-Means algorithm achieves efficient cloud service between the providers with lesser encryption time, ensuring the security and communication overhead in an optimized manner.

**Results and Discussion:**

The results obtained from the comparative analysis of K-medoids and Fuzzy k-means clustering for selecting the best cloud service provider are presented in this section. The study used a dataset containing performance data of various cloud service providers, such as response time, throughput, latency, and resource utilization.

After implementing the K-medoids and Fuzzy k-means algorithms and tuning their parameters, the performance of each algorithm was evaluated based on their ability to cluster the cloud service providers into groups with similar performance characteristics.

The evaluation results show that both algorithms could effectively cluster the cloud service providers into groups based on their performance metrics. However, the Fuzzy k-means algorithm performed better than the K-medoids algorithm regarding clustering accuracy and flexibility. In addition, the Fuzzy k-means algorithm was able to assign each cloud service provider to a cluster with a degree of membership that indicates the level of similarity between the cloud service provider and the cluster centroid. This allows for a more flexible and nuanced representation of the performance characteristics of each cloud service provider, as compared to the K-medoids algorithm, which assigns each provider to a single cluster.

Furthermore, the Fuzzy k-means algorithm was more effective in handling noisy data and outliers as it assigns a degree of membership to each data point instead of forcing it into a single cluster. This allows for a more robust and accurate clustering of the cloud service providers.

In conclusion, the comparative analysis showed that the Fuzzy k-means algorithm outperformed the K-medoids algorithm regarding clustering accuracy, flexibility, and robustness. Therefore, it can be recommended for use in selecting the best cloud service provider based on performance metrics.

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