

# A Ranking Based Model for Selecting Optimum Cloud Geographical Region

Neeraj, Major Singh Goraya, Damanpreet Singh

**Abstract:** Cloud computing has become a dominant service computing model where the services such as software, platform, infrastructure are provided to the cloud consumers on demand basis using pay as you go model. Every cloud consumer requires high performance service in minimal cost. The performance of service in cloud is measured by the parameters availability, agility, cost, and security etc. The service performance and cost are very much dependent on the cloud geographical region (CGR) where these are deployed. The services offered by the cloud service provider are installed on multiple data centers located at different CGR. In cloud environment, the selection of a service installed on the optimum CGR within the limited time overhead is a challenging and interesting problem. In this paper, the multi criteria decision making method, PROMETHEE II and objective weighting method Shannon's Entropy, based ranking model is proposed for solving the optimum CGR selection problem. The CGR dataset of Amazon Web Service is used for the numerical analysis. The sensitivity analysis is performed for validating the stability of the proposed model and getting the most sensitive parameter. The applicability and usefulness of the service selection process is validated through the experimental results on synthetic dataset. Results show that the service selection process is achieved with limited time overhead and hence suitable for online selection process in cloud.

**Index Terms:** Cloud computing, PROMETHEE, Performance, Service selection.

## I. INTRODUCTION

Nowadays, computing as a utility-based service is becoming a big wave in the field of Information Technology. In Cloud computing, services are provided to the consumers on payment basis [1]. Apart from that the cloud computing provides other enormous benefits such as higher scalability, low upfront cost, on demand service, and work from anywhere via any device. Due to various benefits and dynamic needs, small and medium organizations are adopting cloud-based services and hence the demand of cloud services are increasing day by day. High demand of cloud services has opened a lot of business opportunities for the organizations as in the role of cloud service providers. To fulfill the demand of cloud consumers many leading organizations such as Rackspace, Amazon, Google, Microsoft are in competition [2]. All the competitive cloud service providers have deployed their services on data center in different availability zones at multiple geographical regions and differs in terms of their offerings.

**Revised Manuscript Received on August 08, 2019.**

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In cloud computing, the case of whole data center outages is very rare in comparison to the server failure, but it may happen due to power outages and in extreme weather conditions. Even different type of data requires different locality in the sake of the differences in legal ethics of the country where the datacenter is deployed. In the condition of power outages, extreme weather, and legal ethics, the redundancy of data center is necessary across cloud geographical region (CGR) to ensure the services without any interruption. The decision of selecting an efficient CGR for avoiding the interruption in the service provisioning is a challenging problem. The selection of CGR is either based on single performance attribute or multiple performance attribute. A standard framework [10] of performance attribute is available in the field of cloud computing. Selecting a CGR for the cloud consumer based on conflicting criteria is manually very tough. This is a multi-criteria decision making (MCDM) problem. MCDM methods AHP [1][8], TOPSIS [11], VIKOR [12], and ELECTRE [13] are widely used in cloud environment.

In this paper, CGR selection problem of Amazon web service (AWS) is explored. In AWS, the decision for the selection of CGR for replication of data is taken by the cloud consumer. Each CGR differs in terms of distance from the cloud consumer, cost, the number of services available, and a number of availability zones available based on the geographical region where the data center is deployed. On the other hand, the cloud consumer desires the replication of the service at different CGR, but it should be close (less distance) to the cloud consumer, minimum cost, a larger number of services, and a larger number of availability zones. MCDM method, PROMETHEE II is implemented for evaluating the performance of CGRs and objective weighting method, Shannon's Entropy is used for evaluating the relative weighting of attributes desired by the cloud consumer for solving the CGR selection problem of AWS.

## A. Motivation and Contribution

In cloud, a lot of research work is done in the field of energy efficiency [3][4][5], fault tolerance [6], reputation [17] load balancing [7], and decision making systems for service selection [8] [9] etc. but there is lack of research towards CGR selection problem. Therefore, we are motivated to design a model for solving the CGR selection problem. The contribution of the paper is twofold: (1) A model for solving the AWS CGR selection problem is proposed. (2) The applicability of the presented model is proved by the experimental results for online service selection with a large scale up.



**B. Paper Outline**

In the next section, PROMETHEE II based service ranking algorithm is proposed. Section III presents the service selection model. A numerical analysis is presented in section IV. The experimental results with discussion are presented in section V. Section VI, concludes the paper and presents some future direction.

**II. PROMETHEE II BASED RANKING ALGORITHM**

The following steps elaborate the PROMETHEE II based ranking algorithm:

*Step 1:* Calculate the relative weights  $w_j$  of attribute using Shannon's entropy method

$$e_j = \sum_{i=1}^m n_{ij} \ln(n_{ij}) / \ln(m) \quad |j = 1, \dots, n$$

$$w_j = \frac{1 - e_j}{\sum_{i=1}^n (1 - e_i)} \quad |j = 1, \dots, n$$

where  $n_{ij}$  denotes the normalized value of the decision matrix,  $e_j$  denotes the entropy value of  $j^{th}$  attribute, and  $w_j$  denotes the weightage of  $j^{th}$  attribute.

*Step 2:* Calculate the value of  $R_{ij}$  by normalizing the decision matrix. In decision matrix, the attributes can be either positive (higher attribute value is better e.g. security) or negative (lower attribute value is better e.g. CPU time).

If attribute value is positive

$$R_{ij} = \left( \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \right) \quad (1)$$

If attribute value is negative

$$R_{ij} = \left( \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} \right) \quad (2)$$

*Step 3:* Calculate the preference function,  $P_j(i, i')$  with respect to the other.

$$P_j(i, i') = \begin{cases} 0, & \text{if } R_{ij} \leq R_{i'j} \\ R_{ij} - R_{i'j}, & \text{else } R_{ij} > R_{i'j} \end{cases} \quad (3)$$

*Step 4:* Calculate the aggregated preference function  $\pi(i, i')$  considering the attribute weights.

$$\pi(i, i') = \left[ \sum_{j=1}^m w_j \times P_j(i, i') \right] / \left[ \sum_{j=1}^m w_j \right] \quad (4)$$

*Step 5:* Determine the leaving outranking flow  $\phi^+(i)$  and entering the outranking flows  $\phi^-(i)$ .

The leaving outranking flow is defined as:

$$\phi^+(i) = \frac{1}{n-1} \sum_{i'=1}^n \pi(i, i') \quad i \neq i' \quad (5)$$

The entering outranking flow is defined as:

$$\phi^-(i) = \frac{1}{n-1} \sum_{i'=1}^n \pi(i', i) \quad i \neq i' \quad (6)$$

*Step 6:* Calculate the outranking flow  $\phi(i)$  for each CSP

$$\phi(i) = \phi^+(i) - \phi^-(i) \quad (7)$$

*Step 7:* Determine the ranking of CSPs by sorting the outranking flow. Higher the value higher is the ranking.

$$\text{Best CSP} = \text{sort}(\phi_1, \phi_2, \phi_3, \dots, \phi_n) \quad (8)$$

**III. PROPOSED SERVICE SELECTION MODEL**

We have proposed a service selection model which selects services required by the cloud consumer from the optimum CGR. as shown in Fig. 1. The proposed service selection model has basically three components such as: Cloud consumer, cloud broker, and CGR. The functionalities of the entities which are as follows:

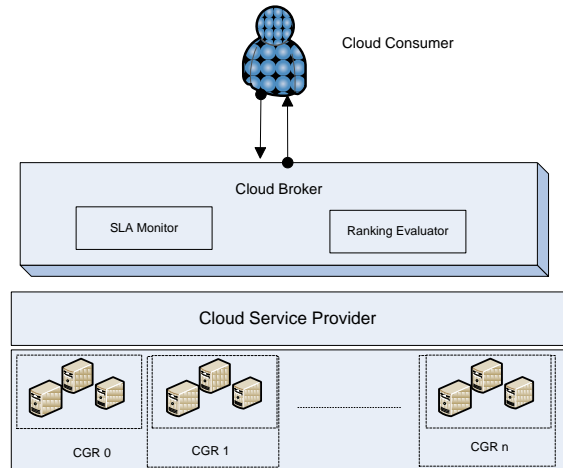
*Cloud Consumer:* Cloud consumer is the entity which requests the services in the form of performance attributes.

*Cloud Broker:* Cloud broker is a third-party entity which selects the services from the optimum CGR of a CSP on behalf of cloud consumer. Cloud broker uses mainly two tools:

*Service level agreement (SLA) Monitor:* SLA monitor keeps track of the service performance of the CGR.

*Ranking Evaluator:* Ranking evaluator tool takes multiple attributes of alternatives as input and generates the ranking score of the alternatives by using the MCDM method.

*Cloud Service Provider:* CSP is the organization which provides the cloud-based services. Each CSP has multiple CGRs where the same services are installed.



**Fig. 1 CGR mapping model**

**Table 1 QoS dataset**

	Services	Availability Zones	Distance	Cost
CGR <sub>1</sub>	128	9	13053	0.114
CGR <sub>2</sub>	124	6	13401	0.114
CGR <sub>3</sub>	128	2	11645	0.1165
CGR <sub>4</sub>	69	3	13765	0.1335
CGR <sub>5</sub>	59	6	13595	0.13
CGR <sub>6</sub>	137	12	7607	0.114
CGR <sub>7</sub>	44	5	3802	0.0869

#### IV. NUMERICAL ANALYSIS

In this section, the process of ranking based service selection in cloud environment is presented. The analysis is presented on Amazon Web Service (AWS) cloud geographical region (CGR) selection problem. The attribute dataset [16] of seven CGRs of AWS with four attributes (number of services available, number of availability zones, distance, and cost) is presented in Table 1. It is assumed that all the CGR satisfies the required attributes of the cloud consumer. The ranking of the CGR is evaluated by using the algorithm given in section 2 and presented in Fig. 2. The attribute's weights are evaluated using entropy method.

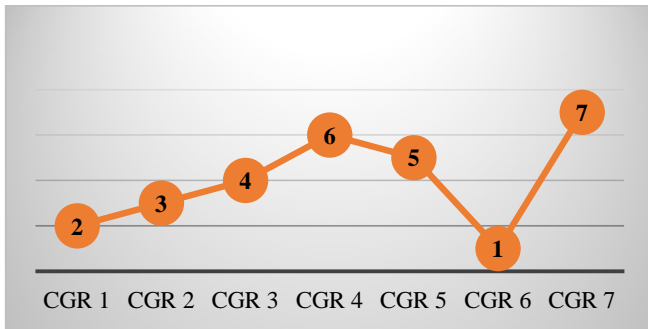
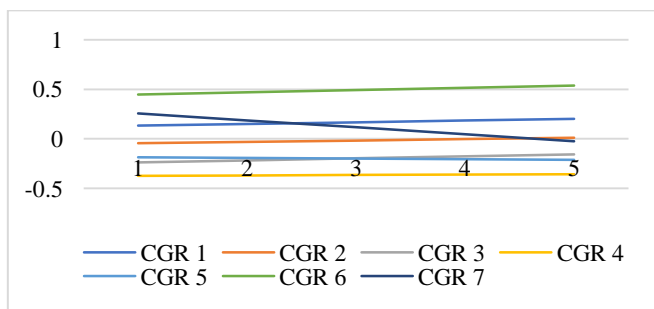


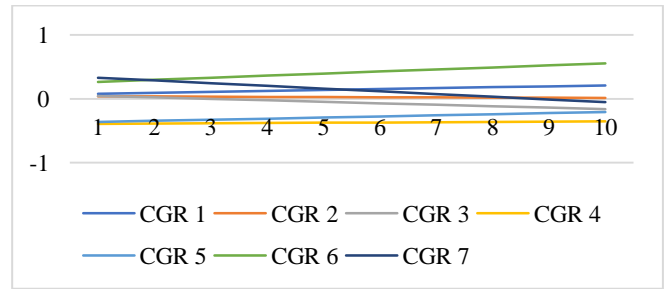
Fig. 2 Ranking of CGR

##### A. Sensitivity Analysis

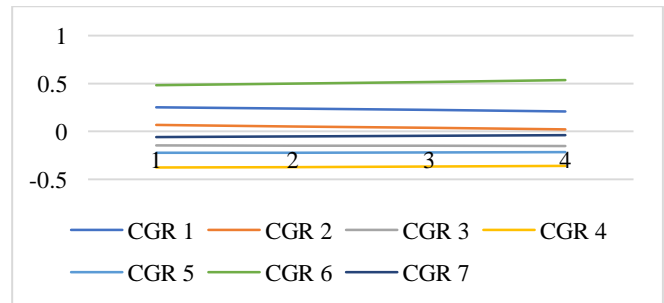
The sensitivity analysis [15] is performed to show the change in the ranking (CIR) of CGRs by changing the relative weights of attributes. The analysis also finds out the most sensitive attribute whose change in weight changes the ranking of the CGRs. In order to fix attribute weight value equal to 1, the remaining dependent criteria are proportionally increased and decreased. In this paper, each attribute is dependent on cost therefore, the sum of the relative weight of attribute and cost is assigned to cost, and another attribute is assigned 0 weight. At the first iteration, +5% weight is assigned to attribute and -5% cost weight value is decreased. This process carries on until the cost weight becomes below 5%. The process is repeated for all CGR's attributes with respect to cost. The maximum change in ranking (CIR) in PROMETHEE II method for attribute services is 4 as shown in Fig. 3(a), availability zone is 6 as shown in Fig. 3(b), and distance is 4 as shown in Fig. 3(c). The CIR value for PROMETHEE II with all variations in weight is shown in Fig. 3



a. Number of services vs cost



b. Number of Availability zones vs cost

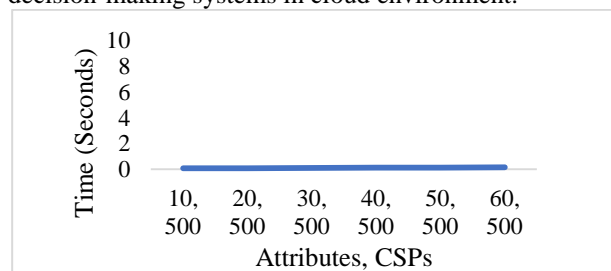


c. Distance vs cost

Fig. 3 Sensitivity analysis of PROMETHEE II based ranking algorithm

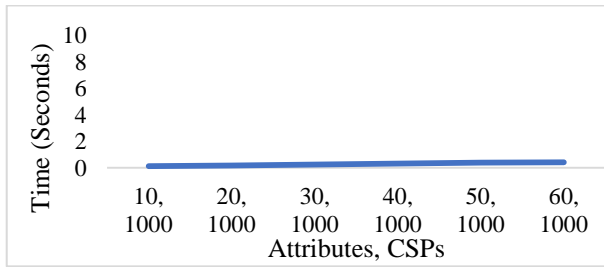
#### V. EXPERIMENTAL RESULTS AND DISCUSSION

The experiment is performed using JAVA programming language, running in Windows 10 Home Single Language with Intel(R) i7-4510 U CPU @ 2.00 2.60 GHz processor with 8 GB RAM. The ranking overhead is calculated on synthetic data generated through uniform distribution. The results are noted with different variation. At the start, the number of CGR is fixed to 500 and the number of attributes is scaled up from 10 to 60 with an increment of 10. The number of CGR is varied a maximum of 5000 with a, increment of 500. The mapping process takes 10 seconds in maximum scaleup of 60 attributes and 5000 CSPs. Results show when the number of CGRs are fixed to 500 and the number of attributes is varied from 10 to 60 the algorithm takes less than 1 second as shown in Fig.3(a). When the number of CGRs are fixed to 1000 and the number of attributes are varied from 10 to 60 the algorithm takes less than 1 second as shown in Fig.3(b). that the number of attributes and the number of CSPs can be scaled up to 60 attributes and 5000 CSPs within 10 seconds as shown in Fig. 2. The limited overhead of service selection process shows that the proposed PROMETHEE II based decision-making algorithm is efficient for online decision-making systems in cloud environment.

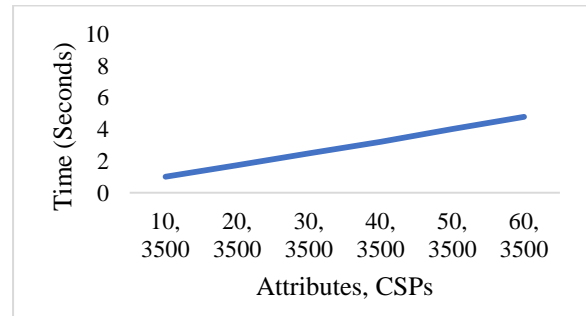


a The number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 500.

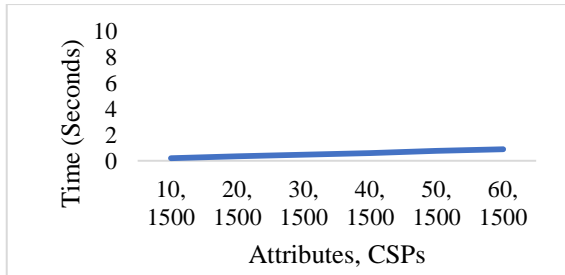
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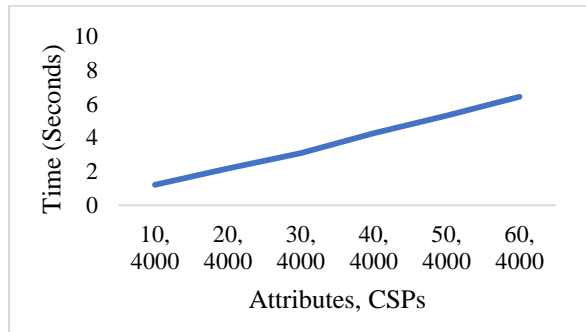
bThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 1000.



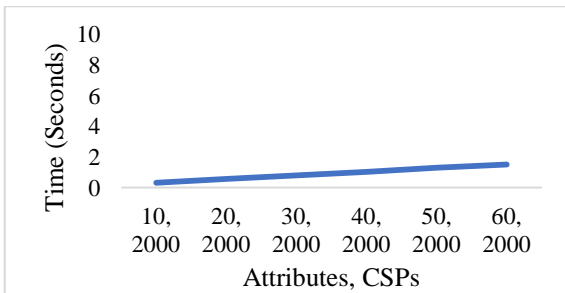
gThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 3500.



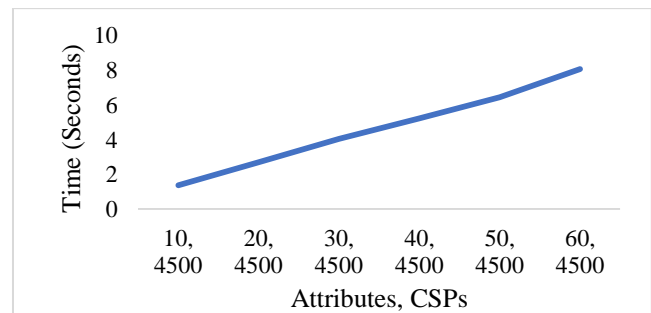
cThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 1500.



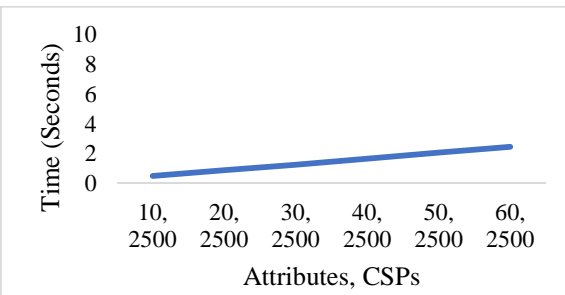
hThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 4000.



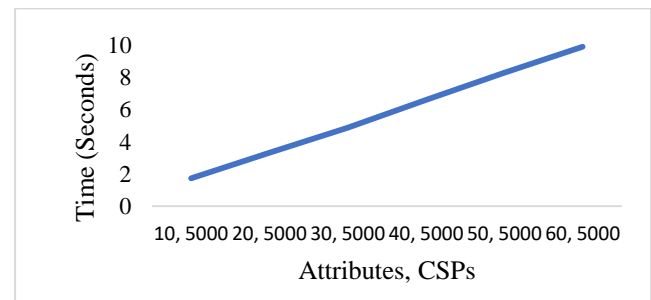
dThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 2000.



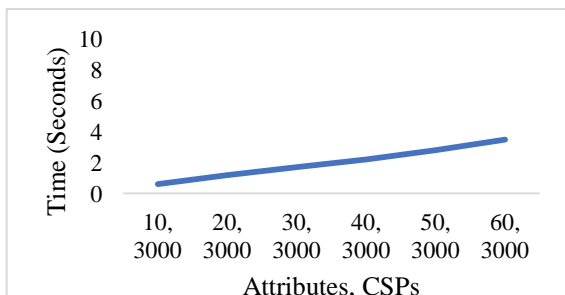
iThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 4500.



eThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 2500.



jThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 5000.



fThe number of attributes is varied from 10 to 60 and the number of CSPs are fixed to 3000.

Fig. 3 Ranking overhead of the proposed algorithm with different variations

## VI. CONCLUSION

In cloud, service selection based on multiple attributes is a challenging issue.

In the cloud environment, the same services offered by the CSPs are different in performance on the basis of offered attributes because of the deployment of services at different CGR. When the number of CGRs are in hundreds or more and offers the performance of service in terms of multiple attributes then it becomes very tedious to the cloud consumer to manually select a service. In this paper, brokerage-based service selection model is proposed which automatically selects a service deployed in optimum CGR for the cloud consumer. PROMETHEE II and Shannon's entropy method is used for ranking the services having multiple attributes. The proposed service selection model selects the optimum AWS CGR among the competitive CGR for the cloud consumer (located in India in Asia Pacific region). The results in terms of overhead with larger scale-up proves the applicability of the proposed model for cloud based online systems. Sensitivity analysis results validates the stability of the proposed model and finds out the most sensitive attribute. In future, we will plan to develop a new ranking method to reduce the overhead of cloud service mapping process.

## REFERENCES

1. Garg, S.K., Versteeg, Buyya, R. S., "A framework for ranking of cloud computing services", *Futur. Gener. Comput. Syst.* 29 1012–1023, 2013.
2. Somu, N., M.R., G. R., Kirthivasan, K., & V.S., S. S., "A trust centric optimal service ranking approach for cloud service selection", *Future Generation Computer Systems*, 86, 234-252, 2018.
3. Garg, N., & Goraya M.S., "Task Deadline-Aware Energy-Efficient Scheduling Model for a Virtualized Cloud", *Arabian Journal for Science and Engineering*, 43(2), 829-841, 2018.
4. Garg, N., Singh D., & Goraya M. S., Energy-Aware Hardware and Software Approach in Cloud Environment. *International Journal of Computer Science & Communication Networks*, 7(3), 66-69, 2017.
5. Garg, N., & Goraya M.S., A Survey on Energy-Aware Scheduling Techniques in Cloud Computing Environment. *International Journal of Computer Science and Information Security (IJCSIS)*, 14(10), 523-528, 2016.
6. Hasan, M., & Goraya, M. S., Fault tolerance in cloud computing environment: A systematic survey. *Computers in Industry*, 99, 156-172, 2018.
7. Thakur, A., & Goraya, M. S., A taxonomic survey on load balancing in cloud. *Journal of Network and Computer Applications*, 98, 43-57, 2017.
8. Yadav N., & Goraya, M.S., Two-way Ranking Based Service Mapping in Cloud Environment, *Futur. Gener. Comput. Syst.* 81 53–66, 2018.
9. Yadav, N., Singh, M., & Singh, D., Mutual Reputation Based Service Mapping in Cloud Environment. *Seventh International Conference on Advances in Computing Electronics and Communication ACEC2018, 2018*.
10. The cloud service measurement initiative consortium, service measurement index (SMI), Carnegie Mellon, Silicon Valley, <http://www.cloudcommons.com/about-smi>.
11. RĂDULESCU, C. Z., & RĂDULESCU, I. C., An Extended TOPSIS Approach for Ranking Cloud Service Providers. *Studies in Informatics and Control*, 26(2), 2017.
12. Lin, C. K., Chen, Y. S., & Chuang, H. M. (2017). Optimisation of implement performance of cloud information systems by Delphi-VIKOR. *International Journal of Applied Systemic Studies*, 7(4), 282.
13. Silas, S., Rajsingh, E. B., & Ezra, K, Efficient Service Selection Middleware using ELECTRE Methodology for Cloud Environments. *Information Technology Journal*, 11(7), 868-875, 2012.
14. Zhaoxu, S., & Min, H, Multi-criteria Decision Making Based on PROMETHEE Method. *2010 International Conference on Computing, Control and Industrial Engineering*, 2010.
15. Global Sensitivity Analysis for Importance Assessment. (n.d.). *Sensitivity Analysis in Practice*, 31-61. doi:10.1002/0470870958.ch2.
16. Regions and Availability Zones. (n.d.). Retrieved from <https://docs.aws.amazon.com/AWSEC2/latest/CloudConsumerGuide/using-regions-availability-zones.html>
17. Yadav, N, Singh, M., & Singh, D., Mutual Reputation Based Service Mapping in Cloud Environment. *Seventh International Conference on Advances in Computing Electronics and Communication ACEC2018, 2018*

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