CSsEv: Modelling QoS Metrics in Tree Soft Toward Cloud Services Evaluator based on Uncertainty Environment

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Abstract

Cloud computing (ClC) has become a more popular computer paradigm in the preceding few years. Quality of Service (QoS) is becoming a crucial issue in service alteration because of the rapid growth in the number of cloud services. When evaluating cloud service functioning using several performance measures, the issue becomes more complex and non-trivial. It is therefore quite difficult and crucial for consumers to choose the best cloud service. The user's choices are provided in a quantifiable manner in the current methods for choosing cloud services. Hence, this study attempts to achieve this objective through construction. decision-making framework so-called cloud services evaluator (CSsEv). The main indicator and its sub-indicators are formed as nodes at levels(n) in tree soft sets (TSSs). Thereafter Single Value Neutrosophic Sets (SVNSs) as branch of neutrosophic sets which conjunction with the Multi-Criteria Decision Making (MCDM) technique to facilitate analysis and evaluation process for the available Cloud services providers. Hence, entropy is employed to obtain indicators and sub_indicators' weights and Complex Proportional Assessment utilizes these weights to facilitate the decision process of selecting optimal ClSPs.

Keywords: Cloud Computing (ClC); tree soft sets (TSSs); Quality of Service (QoS); Single Value Neutrosophic Sets (SVNSs); Multi-Criteria Decision Making (MCDM)

1. Introduction

Cloud computing (ClC) is a concept that draws from several cutting-edge inventions and has certain characteristics with previous computing technologies [1]. This viewpoint is predicated on [2] which described ClC as a new paradigm that allows users to access self-service, on-demand computer services (software and hardware) over the Internet, regardless of the system or position. In the same vein scholars in[3] where ClC is similar to other utilities, ClC is a new technology that distributes computing resources over the web as a service to cloud customers. Utilizing ClC paradigm [4] enables ubiquitous, practical, and on-demand network access through sharing a pool of quickly accessible configurable computer resources (such as networks, servers, storage, apps, and services). In contrast to traditional paradigms, ClC offers significant advantages since CCT services are more promptly and easily accessible around the clock with relatively cheap investment expenses [5]. Due to [6] where three service tiers included in ClC concept are (1) infrastructure as a service (IaaS) that offers assistance for users of the cloud,(2) platform as a service (Pass) renders a platform for application development, whereas SaaS gives users access to ready-made applications, and (3) software as a service (SaaS) empowers users with a range of services. ClC's use and development have thus increased dramatically to make use of ClC's benefits. This is considered a robust motivator for the exponential increase in cloud service providers (ClSPs). For instance [1] Google, IBM, Microsoft, Amazon GoGrid…etc as ClSPs, Accordingly [7], this incentive presented difficulty for cloud customers in locating the finest ClSP for their desired and essential needs. Study of [8] overcoming this issue as cloud consumer must determine what services are necessary for Quality of Service (QoS) for selecting optimal ClSP.

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Another study [6] discussed the perspectives that embraced perspective of [8] through determining a set of QoS parameters as security , availability, response time…etc to measure the performance of cloud services to select optimal ClSP amongst variety of ClSPs. For instance, cloud service measurement initiative consortium (CSMIC) considered one of perspectives has been clarified by [6] which determined a set of quality of service (QoS) indicators, dubbed the service measurement index (SMI), for gauging different aspects of a cloud service.

The issue of ClSP selection releases through deploying MCDM techniques. Due to [9]-[10] these techniques are facilitating the process of decision making for solving complex problems. Another motivator for deploying these techniques is highlighted in [11] where a wide variety of assessment criteria for different cloud services from several cloud service providers (ClSPs) must be taken into consideration in order to identify which ClSP best suits the demands of a cloud user.

Also, such problem of selection characterized with uncertainty and vague. Hence, MCDM techniques have been hybridized with other uncertainty techniques in [12] that have ability to treat with such issue.

Zadeh proposed fuzzy set (FSs) [13] to deal with ambiguities and untrustworthy data utilized in decision-making. FSs are considering membership function, and an intuitionistic fuzzy sets (IFSs) advanced version of FSs is proposed by Atanassov for affording the chance to address far more difficult decision-making issues [14]. Due to the ability of IFSs to consider membership function and non-membership function. Also, indeterminacy degree beside membership and non-membership taken into consideration through Neutrosophic theory. This theory is introduced by Smarandache [15] so, this theory is more flexible comparing with FSs. Also, Smarandache [16] proposed new version of soft set as hyper soft and tree soft.

The issue of choosing a cloud service has received a lot of attention in the past year. The literature's current methodology seldom ever considers the association between QoS criteria [17].

In this scenario, we are representing the relation and association between QoS criteria through leveraging tree soft sets (TSSs) for the first time in this field. Also, MCDM techniques are interacting with Neutrosophic theory to strength MCDM in uncertainty and vague situation during decision making in ClSP selection process.

Hence, we are suggesting decision making framework where the objective of this framework is summarizing in a few points:

1. The association and relation between QoS's indicators are formed in TSSs through representing main indicators in first nodes in primary level and other indicators formed in next nodes included in later levels as sub-indicators.
2. The formed indicators and sub-indicators are contributed to evaluate ClSPs and select optimal one.
3. MCDM techniques utilized in vague environment toward evaluation process through interacting with Neutrosophic theory and the result of this interaction produces decision making framework so called cloud services evaluator (CSsEv).
4. Applying constructed CSsEv in real case study to validate accuracy of this framework.

2. Theoretical Background

Herein, we attempted to aggregate the various scholars' perspectives in prior studies. The objective of this section has been achieved through covering the following pillars.

2.1 First pillar: Analyzing and evaluating QoS's indicators based on MCDM.

Scholars concentrated on evaluating CSPs' performance as well as developing frameworks for locating suitable cloud services[6]. Hence, the selection problem has been extensively solved in literature using the MCDM techniques. For instance [18] applied Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) in complex decision making process for ranking large number of alternatives. TOPSIS's extensive use in resolving decision-making issues in the literature has led to its use in ranking cloud services relative to other MCDM techniques like complex proportional assessment (COPRAS) and multi-attributive border approximation area comparison (MABAC)[6]. Evidence of this is the study of [19] claimed that multi-criteria optimization and compromise solution VIKOR is less

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efficient than TOPSIS. scholars in [20] explored the advantages of using entropy in addition to AHP for the suggested weighting technique.

2.2 Second pillar: Boosting MCDM for decision making process in ambiguity environment.

Decision-makers can freely express their opinions about truth, indeterminacy, and falsity membership values in a neutrosophic theory, and each membership value can stand alone. Hence neutrosophic has been combined with several MCDM techniques [6]-[21] for assisting decision-makers in clearing up any uncertainty in their thinking. Accordingly, Neutrosophic set theory has grown in significance in many decision-making scenarios because it gives decision-makers the freedom to rank the options in terms of language. For instance [22] employed the decision-making trial and evaluation laboratory approach (DEMATEL) in conjunction with neutrosophic set theory to address the transport service provider selection problem. Also, this theory, in particular, uses an interval value neutrosophic set in [23] to address uncertainty, whereas CODAS is utilized to determine the optimal placement for a wind energy facility. Also, this theory employed in various purposes as in [24]-[25]-[26].

2.3 Third Pillar: Clarifying relation between QoS's indicators as supportive factor in evaluation process.

In this study, we are exploiting new extension of soft set entailed in TSSs which introduced by Smarandache who highlighted it in [16].we utilized TSSs for first time in our interested scope for illustrating determined indicators in this study as nodes involved in tree. We described TSSs according to Smarandache as:

Let V be a universe of discourse, and T a non-empty subset of V, with P(T) the powerset of T.

Let Ind be a set of indicators (parameters, factors, etc.), Ind= $\{Ind_1, Ind_2, \dots, Ind_n\}$, for integer $n \geq 1$, where Ind_1, $Ind_2, \dots$, An are considered indicators of first level (since they have one-digit indexes).

Each indicator Ind i, $1 \leq i \leq n$, is formed by sub- indicators:

$Ind_1 = \{Ind_{1,1}, Ind_{1,2}, \dots\}$ $Ind_2 = \{Ind_{2,1}, Ind_{2,2}, \dots\}$ $Ind_n = \{Ind_{n,1}, Ind_{n,2}, \dots\}$

where the above $Ind_{i,j}$ are sub indicators (or indicators of second level) (since they have two-digit indexes). Again, each sub-attribute $Ind_{i,j}$ is formed by sub- indicators (or indicators of third level): $Ind_{i,j,k}$

And so on, as much refinement as needed into each application, up to sub-sub-…-sub- indicators (or indicators of m-level (or having m digits into the indexes): $Ind_{i1,i2,\dots,im}$

So, a graph-tree is formed, that we denote as Tree (Ind), whose root is Ind (considered of level zero), then nodes of level 1, level 2, up to level m.

We call the leaves of the graph-tree, all terminal nodes (nodes that have no descendants).

Then the TreeSoft Set is: $F: P(\text{Tree}(Ind)) \rightarrow P(T)$

Tree (Ind) is the set of all nodes and leaves (from level 1 to level m) of the graph-tree, and P(Tree(A)) is the powerset of the Tree (Ind).

All node sets of TSSs of level m are: Tree (Ind) = $\{ Ind_{i1} \mid i1 = 1, 2, \dots \}$

3. CSsEv: Cloud Services Evaluator Methodology

The evaluation process is conducted for evaluating candidates ClSPs after that selection process is starting to select optimal ClSP and worst one. These processes are implemented through the following steps.

Step 1: Determining nodes of TSSs

- Nodes of TSSs are determined where QoS'S indicators represents main nodes (Ind_n) in level 1 in form $\{Ind_1, Ind_2, \dots Ind_n\}$.
- Next nodes represents sub-indicators (sub_Ind) in next sub_levels which inherent of main level 1 =$\{sub\_Ind_{1i}, sub\_Ind_{2i}, .. sub\_Ind_{ni}\}$.
- Set of candidates of ClSPs as $\{ClSP_1, ClSP_2, \dots ClSP_n\}$ are recommended to contribute to evaluation and selection processes.

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Step 2: Appreciating Indicators/sub-Indicators from main level1 to level $_{in}$

- Decision Matrices are constructed based on Linguistic expert's for evaluating $ClSP_n$ over indicators (Ind_n) in level 1 $\{A_1, A_2 \ldots A_n\}$. Also, Decision Matrices are constructed based on Linguistic expert's for evaluating $ClSP_n$ over sub-indicators (sub_Ind_{ni}) in sub_level s $\{sub\_Ind_{1i}, sub\_Ind_{2i}, .. sub\_Ind_{ni}\}$.
- Linguistic expert's for evaluating $ClSP_n$ inspired from scale of single value Neutrosophic sets (SVNSs).

Step 2.1 Entropy technique begins to work in constructed decision matrices for $ClSP_n$ over indicators/ through following sub-steps:

Step 2.2: crisp matrices are generated through Eq.(1) in various decision matrices.

$$s(\partial_{ij}) = \frac{(2+\mathscr{g}-q-\wp)}{3} \quad (1)$$

Where:

$\mathscr{g}, q, \wp$ refers to truth, false, and indeterminacy respectively.

Step 2.3: Crisp matrices are conjunction into an aggregated decision matrix.

$$Q_{ij} = \frac{(\sum_{j=1}^{N} \partial_{ij})}{F} \quad (2)$$

Where:

∂_{ij} refers to value of criterion in matrix, F refers to number of decision makers.

Step 2.4: aggregated decision matrix employed Eq.(3) to be normalized matrix

$$D_{ij} = \frac{Q_{ij}}{\sum_{j=1}^{n} Q_{ij}} \quad (3)$$

Where:

$\sum_{j=1}^{n} Q_{ij}$ represents sum of each criterion in aggregated matrix per column

Step 2.5: normalized matrix computes its entropy by Eq. (4).

$$e_j = -h \sum_{i=1}^{n} D_{ij} \ln D_{ij} \quad (4)$$

Where:

$$h = \frac{1}{\ln (ClSPs)} \quad (5)$$

ClSPs refers to number of alternatives.

Step 2.6: Compute weight vectors through deploying Eq.(6).

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n}(1 - e_j)} \quad (6)$$

Step 3: Ranking ClSPs and recommend optimal ClSP

COPRAS based on SVNSs as subjective technique of MCDM for ranking set of candidates of alternatives through the following steps.

Step 3.1: weighted decision matrix (WD) is generated as in Eq (7).

$$WD_{ij} = w_j * D_{ij} \quad (7)$$

Where:

w_j vector of entropy's weights

Step 3.2: Eq.s (8) ,(9) are deployed for calculating Sum of weighted decision matrix to

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$$S_{+i} = \sum_{j=1}^{n} WD_{+ij}\,, \text{ for beneficial criteria} \quad (8)$$

$$S_{-i} = \sum_{j=1}^{n} WD_{-ij}\,, \text{ for nonbeneficial criteria} \quad (9)$$

Step 3.2: the relative importance of alternatives is calculated by Eq.(10).Also, quantity utility U_i for each alternative is calculated based on Eq. (11) to rank the alternatives.

$$Q_i = s_{+i} + \frac{s_{-min} \sum_{i=1}^{m} s_{-i}}{s_{-i} \sum_{i=1}^{m}(s_{-m/}s_{-i})} \quad (10)$$

Where:
I = 1, 2,…,m, and s_{-m}= s_{-i} all criteria are beneficial.

$$U_i = \left[\frac{Q_i}{Q_{max}}\right] \times 100\% \quad (11)$$

Where:
the alternative with the highest U_i is the best one.

4. An Empirical Case Study: Validation of CSsEv framework

We validate the constructed framework of CSsEv through applying it on real case study. Hence, four ClSPs contributed to the evaluation process as candidates.

4.1 Obtaining Optimal Cloud over Indicators at Level 1 in Tree soft.

4.1.1 Tree soft set of indicators and sub-indicators has been designed.

1. At main level 1: there are three indicators of QoS which represent as primary nodes as {Ind_1, Ind_2, Ind_3} ={Security, Service quality, Management services} [27].
2. At level 2: there are six sub-indicators which represent as sub_nodes of primary nodes as {$sub\_Ind_{1.1}$, $sub\_Ind_{1.2}$ }of Ind_1={Confidentiality, Integrity};{$sub\_Ind_{2.1}$, $sub\_Ind_{2.2}$ }of Ind_2={Service stability, Reputation of vendor};};{$sub\_Ind_{3.1}$, $sub\_Ind_{3.2}$ }of Ind_3={Monitoring , Configuration}

4.1.2 Valuing indicators in TSSs :At Level 1

3. Three Neutrosophic decision matrices are constructed based on Linguistic for three experts. Utilizing SVNSs linguistic scale of [28] for evaluating four ClSPs over three indicators in level 1. Also, this scale is used for evaluating four ClSPs over six sub_indicators in level 2.
4. Three Neutrosophic decision n matrices become crisp matrices by Eq.(1).
5. These crisp matrices are aggregating into an aggregated decision matrix as listed in Table 1.
6. Table 2 represents normalized matrix based on Eq.(3).
7. Eq.(4) is employed for computing entropy for normalized matrix as in Table 3.
8. Final indicators' weights is obtained in Figure 1 through executing Eq.(5).

Table 1: an aggregated matrix of Indicators at level 1

	Ind_1	Ind_2	Ind_3
$ClSP_1$	0.477777778	0.222222222	0.538888889
$ClSP_2$	0.288888889	0.627777778	0.7
$ClSP_3$	0.5	0.633333333	0.538888889
$ClSP_4$	0.433333333	0.367777778	0.166666667

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Table 2: Normalized matrix of Indicators at level 1

	Ind_1	Ind_2	Ind_3
$ClSP_1$	-0.356713893	-0.254485409	-0.35563586
$ClSP_2$	-0.301182196	-0.366726066	-0.367794449
$ClSP_3$	-0.35993395	-0.366956989	-0.35563586
$ClSP_4$	-0.348419443	-0.321078433	-0.210577352
$\sum_{i=1}^{m} X_{ij}$	-1.366249482	-1.309246898	-1.289643521
$-h\sum_{i=1}^{m} X_{ij} \ln X_{ij}$	0.985065877	0.943967013	0.929832979

Table 3. Entropy of Normalized matrix of Indicators at level 1

	Ind_1	Ind_2	Ind_3
$ClSP_1$	0.281045752	0.120048019	0.277142857
$ClSP_2$	0.169934641	0.339135654	0.36
$ClSP_3$	0.294117647	0.342136855	0.277142857
$ClSP_4$	0.254901961	0.198679472	0.085714286

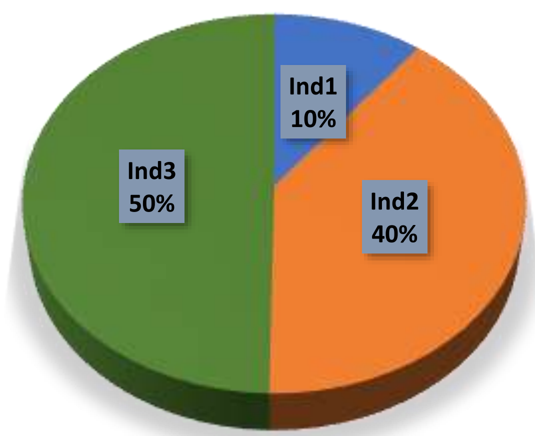

Figure 1: Weights of Indicators in Level 1

4.1.3 Ranking ClSPs and recommend optimal ClSP: At Level 1

1. Eq.(7) plays a critical role in normalized matrix to generate weighted decision matrix as in Table 4.
2. Considering all indicators are beneficial, we applied Eq.(8) to obtain sum weighted.

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3. Quantity utility U_i for each alternative is calculated based on Eq. (11) to rank the alternatives and results illustrated in Figure 2.ClSP$_2$ is optimal cloud provider otherwise ClSP$_4$ is worst cloud provider.

Table 4: Weighted decision matrix of Indicators at level 1

	Ind$_1$	**Ind$_2$**	**Ind$_3$**
ClSP$_1$	0.024313606	0.028852563	0.186557868
ClSP $_2$	0.01470125	0.081508491	0.242332901
ClSP $_3$	0.025444471	0.082229805	0.186557868
ClSP $_4$	0.022051875	0.047750992	0.05769831

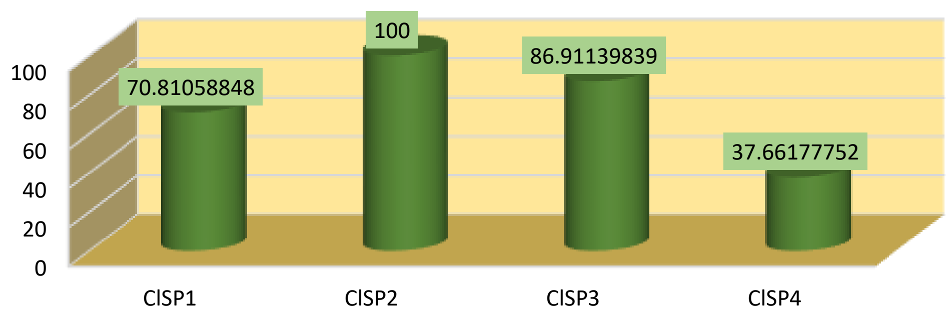

Figure 2: Ranking ClSPs over Indicators in Level 1

4.2 Obtaining Optimal Cloud over Indicators at Level 1 in Tree soft.

We repeat the previous three steps to evaluating and ranking ClSPs over sub_indicators at level 2.

4.2.1 Valuing Sub_indicators in TSSs : At Level 2

1. Three Neutrosophic decision matrices are constructed for {Ind $_{1.1}$, Ind $_{1.2}$ }; {Ind $_{2.1}$, Ind $_{2.2}$ }; {Ind $_{3,1}$,and Ind $_{3.2}$ }
2. These matrices are transformed into crisp matrices based on Eq.(1) and Eq.(2) aggragated each sub_indicator into aggregated matrix belongs to main node (indicators) at level 1.
3. Figure 3 indicated that sub_indicator 1.1 outperforms sub_indicator 1.2.
4. Figure 4 indicated that sub_indicator 2.1 outperforms sub_indicator 2.2.
5. Figure 5 indicated that sub_indicator 3.1 outperforms sub_indicator 3.2.

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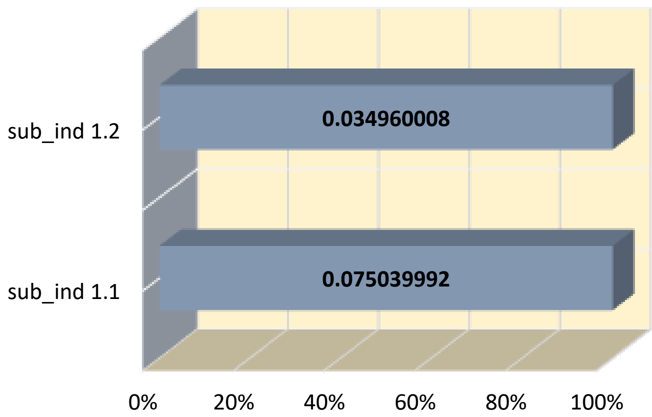

Figure 3: Final Weights of Sub Indicators 1.1 to 1.2 in Level 2

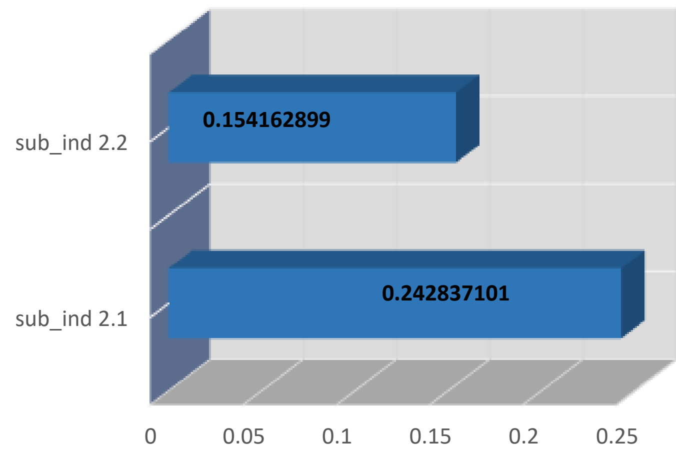

Figure 4: Final Weights of Sub Indicators 2.1 to 2.2 in Level 2

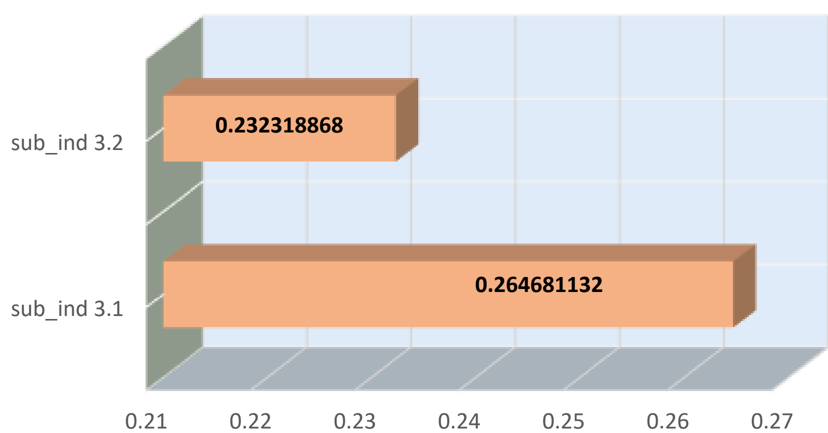

Figure 4: Final Weights of Sub Indicators 2.1 to 2.2 in Level 2

5. Conclusion

In the modern age, ClC has completely changed the way businesses operate. Selecting the best service provider for a given activity has grown challenging due to the growing number of cloud service providers (ClSPs) and the increased demand for cloud computing among consumers. This issue is considered catalyst for us to construct decision making framework. Herein, the constructed framework so-called CSsEv for evaluating set of candidates of ClSPs alternatives. By providing a linguistic evaluation for cloud services with incomplete or inaccurate knowledge, it assists cloud customers in identifying the optimal cloud service for their functional and non-functional requirements and lowers the likelihood of suffering significant losses over time. Thus, this framework employed various techniques for achieving its objective. Firstly, the influenced indicators and sub_indicators of QoS have been clarified into form of nodes of tree. Hence, TSSs applied for the first time in this field. Secondly, Neutrosophic theory in particular SVNSs is exploited and amalgamated with entropy to obtain weights for indicators and sub-indicators. These weights are leveraging for ranking ClSPs through employing COPRAS to achieve this objective. In this study we determined three indicators as primary nodes in initial level and six

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sub_indicators as sub_nodes in level 2 which branched from primary nodes Finally, we applied CSsEv framework in real case study to ensure its authenticity. The results of application indicated that $ClSP_2$ is optimal cloud provider according to Quantity utility U_i in contrast $ClSP_4$ is worst cloud provider as in Figure 2.

6. Future Directions

In this field we can employ other extensions of soft set aside from TSSs as hyper soft set to utilize in this field for first time. Also, other extensions of Neutrosophic as Type-2 neutrosophic sets (T2NSs) or bipolar Neutrosophic to amalgamate with MCDM techniques for selecting right ClSP to fulfill customers' need.

References

[1] Tomar, A., Kumar, R. R., & Gupta, I. (2023). Decision making for cloud service selection: a novel and hybrid MCDM approach. *Cluster computing*, *26*(6), 3869–3887. DOI:10.1007/s10586-022-03793-y

[2] Cloud, H. (2011). The nist definition of cloud computing. *National institute of science and technology, special publication*, *800*(2011), 145.

[3] Kumar, A., Sah, B., Singh, A. R., Deng, Y., He, X., Kumar, P., & Bansal, R. C. (2017). A review of multi criteria decision making (MCDM) towards sustainable renewable energy development. *Renewable and sustainable energy reviews*, *69*, 596–609.

[4] Raut, R. D., Priyadarshinee, P., Gardas, B. B., & Jha, M. K. (2018). Analyzing the factors influencing cloud computing adoption using three stage hybrid SEM-ANN-ISM (SEANIS) approach. *Technological forecasting and social change*, *134*, 98–123.

[5] Büyüközkan, G., Uztürk, D., & Maden, A. (2023). Influential factor analysis for cloud computing technology service provider. *Technological forecasting and social change*, *192*(December 2022). DOI:10.1016/j.techfore.2023.122531

[6] Kumar Tiwari, R., & Kumar, R. (2022). A framework for prioritizing cloud services in neutrosophic environment. *Journal of king saud university - computer and information sciences*, *34*(6), 3151–3166. DOI:10.1016/j.jksuci.2020.05.009

[7] Ardagna, D., Casale, G., Ciavotta, M., Pérez, J. F., & Wang, W. (2014). Quality-of-service in cloud computing: modeling techniques and their applications. *Journal of internet services and applications*, *5*(1), 1–17.

[8] Saha, M., Panda, S. K., & Panigrahi, S. (2022). A Survey on Applications of Multi-Attribute Decision Making Algorithms in Cloud Computing. *ECS transactions*, *107*(1), 12887–12900. DOI:10.1149/10701.12887ecst

[9] Karabasevic, D., Popovic, G., Stanujkic, D., Maksimovic, M., & Sava, C. (2019). An approach for hotel type selection based on the single-valued intuitionistic fuzzy numbers. *Int. rev*, *1*, 7.

[10] Abdel-Monem, A., Mohamed, S. S., & Aziz, A. S. (2023). A Multi-Criteria Decision Making Methodology for Assessment Performance of Electrocoagulation System. *Multicriteria algorithms with applications*, *1*(1), 19–30.

[11] Kumar, R. R., Tomar, A., Shameem, M., & Alam, M. N. (2022). OPTCLOUD: An Optimal Cloud Service Selection Framework Using QoS Correlation Lens. *Computational intelligence and neuroscience*, *2022*. DOI:10.1155/2022/2019485

[12] Petrovic, I., & Kankaras, M. (2020). A hybridized IT2FS-DEMATEL-AHP-TOPSIS multicriteria decision making approach: Case study of selection and evaluation of criteria for determination of air traffic control radar position. *Decision making: applications in management and engineering*, *3*(1), 146–164.

[13] Smarandache, F., & Abdel-Basset, M. (2021). *Neutrosophic Operational Research: Methods and Applications*. , Neutrosophic Operational Research: Methods and Applications.

[14] Atanassov, K. T., & Atanassov, K. T. (1999). Interval valued intuitionistic fuzzy sets. *Intuitionistic fuzzy*

Doi: https://doi.org/10.54216/IJNS.230204
Received: June 21, 2023 Revised: October 19, 2023 Accepted: November 19, 2023

sets: theory and applications, 139–177.

[15] Smarandache, F. (1999). A unifying field in Logics: Neutrosophic Logic. In *Philosophy* (pp. 1–141). American Research Press.

[16] Smarandache, F. (2023). New Types of Soft Sets: HyperSoft Set, IndetermSoft Set, IndetermHyperSoft Set, and TreeSoft Set. *International journal of neutrosophic science*, *20*(4), 58–64. DOI:10.54216/IJNS.200404

[17] Garg, S. K., Versteeg, S., & Buyya, R. (2013). A framework for ranking of cloud computing services. *Future generation computer systems*, *29*(4), 1012–1023.

[18] Mousavi-Nasab, S. H., & Sotoudeh-Anvari, A. (2017). A comprehensive MCDM-based approach using TOPSIS, COPRAS and DEA as an auxiliary tool for material selection problems. *Materials & design*, *121*, 237–253.

[19] Jahan, A., Ismail, M. Y., Sapuan, S. M., & Mustapha, F. (2010). Material screening and choosing methods–a review. *Materials & design*, *31*(2), 696–705.

[20] Shameem, M., Kumar, R. R., Nadeem, M., & Khan, A. A. (2020). Taxonomical classification of barriers for scaling agile methods in global software development environment using fuzzy analytic hierarchy process. *Applied soft computing*, *90*, 106122.

[21] Mohamed, M. (2023). Toward Smart Logistics: Hybrization of Intelligence Techniques of Machine Learning and Multi-Criteria Decision-Making in Logistics 5.0. *Multicriteria algorithms with applications*, *1*(1), 42–57.

[22] Liu, F., Aiwu, G., Lukovac, V., & Vukic, M. (2018). A multicriteria model for the selection of the transport service provider: A single valued neutrosophic DEMATEL multicriteria model. *Decision making: applications in management and engineering*, *1*(2), 121–130.

[23] Karaşan, A., Boltürk, E., & Kahraman, C. (2019). A novel neutrosophic CODAS method: Selection among wind energy plant locations. *Journal of intelligent & fuzzy systems*, *36*(2), 1491–1504.

[24] Ismail, M. M., Ahmed, Z., Abdel-Gawad, A. F., & Mohamed, M. (2024). Toward Supply Chain 5.0: An Integrated Multi-Criteria Decision-Making Models for Sustainable and Resilience Enterprise. *Decision making: applications in management and engineering*, *7*(1), 160–186.

[25] Hussein, G. S., Zaied, A. N. H., & Mohamed, M. (2023). ADM: Appraiser Decision Model for Empowering Industry 5.0-Driven Manufacturers toward Sustainability and Optimization: A Case Study. *Neutrosophic systems with applications*, *11*, 22–30.

[26] Al-baker, S. F., & Mohamed, M. (2024). Exploring the Influences of Metaverse on Education Based on the Neutrosophic Appraiser Model, *23*(01), 134–145.

[27] Büyüközkan, G., Uztürk, D., & Maden, A. (2023). Influential factor analysis for cloud computing technology service provider. *Technological forecasting and social change*, *192*, 122531.

[28] Mohamed, M. (2023). Financial Risks Appraisal based on Dynamic Appraisal Framework. *Neutrosophic and information fusion*, *2*(1), 50–58. DOI:10.54216/nif.020104

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