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Pairing New Approach of Tree Soft with MCDM Techniques: Toward Advisory an Outstanding Web Service Provider Based on QoS Levels

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Abstract: Web services (WSs) have become dynamic because of technological advancements and internet usage. Hence, selecting a WS provider among a variety of WS providers that perform the same function is a critical process. However, the crucial point is that various consumers may have varied needs when it comes to the quality attributes of services, such as cost, response time, throughput, security, availability, etc. These aspects of Web services are known as quality of service (QoS), or non-functional characteristics. Hence, this issue is the robust motivator for conducting this study. The objective of this study is to evaluate a set of WSs that provide various services for various consumers and organizations. This evaluation is conducted based on a set of QoS attributes. Hence, we are applying a new approach to describe this problem in the form of leaves or branches of a tree or hierarchy. This approach is represented in a soft tree set. Also, we leveraged Multi-Criteria Decision Making (MCDM) techniques such as entropy and weighted sum methods under the authority of the Single Value Neutrosophic (SVN) Scale. The entropy technique analyzes attributes or leaves in each level contained in the tree's soft approach, obtaining attributes' weights. These weights are used to rank and recommend optimal WS providers through the application of these weights in WSM. The results of implementing entropy-WSM in a tree-soft approach indicated that WS_2 is the optimal provider. In contrast, WS_3 is the worst provider.

Keywords: Tree Soft Set; Single Value Neutrosophic; Multi-Criteria Decision Making; Quality of Service.

1. Introduction

Presently, Web services (WSs) with equivalent functionality are contrasted, taking into account non-functional characteristics that might affect the quality of service that WS provides [1]. With the use of extensible markup language (XML)-based protocols like web services description language (WSDL), universal description discovery and integration (UDDI), and simple object access protocol (SOAP), WS, based on [2], is described as a software component that facilitates interoperability among loosely coupled systems over the Internet. As stated by [3], one of the most difficult and important tasks in service-oriented architecture (SOA) is choosing WS that will best meet the demands of WS users. The World Wide Web Consortium (W3C) described WSs in [4] as software systems established with the purpose of enabling ubiquitous machine-to-machine communication across a network. In order to process requests, complete workflows, and complete intricate transactions, Web services communicate with one another and with other systems. In order to serve business objectives and data consolidation for any firm [5], WSs are generally acknowledged as the most effective standards-based technique to build SOA.

According to Figure 1, SOA consists of various parties, each of whom is responsible for an important role.

(i). Service Provider: that provides various services for a variety of consumers.

(ii). Service Consumer: that request variety of services based on several of consumers from several of service providers.

(iii). Service Broker: which represents as intermediary between N of providers, N of consumers and register for supporting consumer to get services from the responsible provider. This provider offers needed service for consumers who need this service.

(iv). Service Register: that contains all providers or as register of N of providers. This register response to request of broker about provider which provides requested service then register recommend suitable provider for broker.

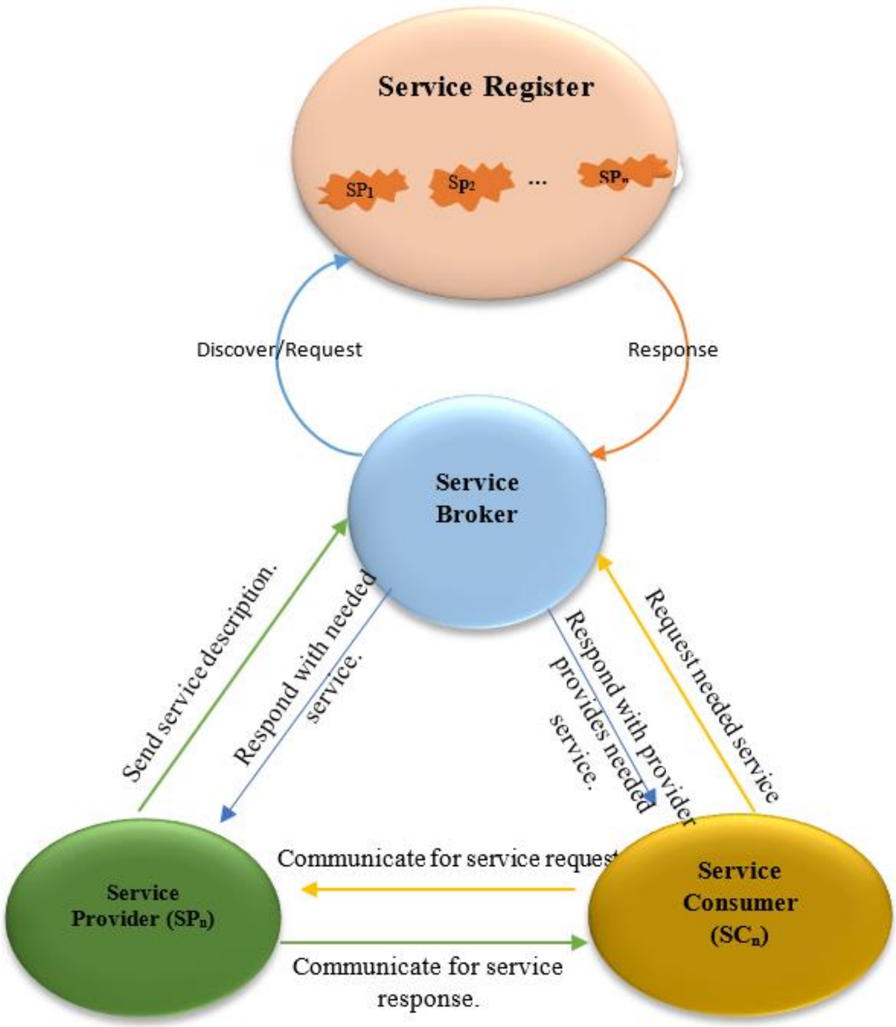

Figure 1. Service oriented architecture framework.

Despite the abundance of functionally equivalent online services, there exist differences in quality of services (QoS) amongst them. Because of this exponential increase, it is now difficult to choose the required Web service from the many that offer the same functionality. Scholars as Subbulakshmi et al. [6] classified QoS into (1) functional which described attributes associated with the kind, name of operation, and the semantics and format of the data they receive or produce.(2) non-functional which includes response time, availability, throughput, dependability, security, Latency….etc. In this context, QoS is a key differentiator between various web services and is used to characterize the non-functional aspects of web services [7]. Hence, QoS in [8] provided by the WS to the end-user is described by the QoS parameters. The end user inquiry indicates the needed WS's anticipated quality. Accordingly, the process of selecting appropriate WS for satisfying consumer's requirements is conducted based on QoS criteria. From the perspective of [9] WS selection is formulating through leveraging techniques of MCDM which have ability to treat with the conflict of QoS's criteria. The problem of selecting WS based on QoS is described in hierarchy architecture.

Hence, this study embraces perspective in [9] to be a motivator for constructing tree soft evaluator model. The notion of tree soft is highlighted and embraced by Smarandache [10] where this notion considers the first approach represents the selection problem in form of leaves in the levels of tree. The constructed tree soft evaluator model treats with work hierarchically through employing soft tree sets with MCDM techniques toward choosing optimal WS based on hierarchical of QoS's criteria.

2. Previous perspectives and studies

This section clarifies the prior studies and perspectives that embraced the techniques that contributed to our study. Hence, this section reflects and aggregates various studies based on surveys conducted to apply techniques to solve the problem of WS selection.

2.1 MCDM as solver techniques in WS selection: prior works

Plenty of studies have used MCDM techniques to select WS according to QoS's criteria [11]. For instance, a QoS assessment indicator system for SPs in KI-C is built into [12]. The weights of the assessment indicators are also determined using the Decision-Making Trial and Assessment Laboratory (DEMATEL) technique. The rank-sum ratio (RSR) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are used to assess and grade the SPs, respectively. In the same vein [3], WSs' weights are calculated by deploying the Analytic Hierarchy Process (AHP) used for weight calculation and have been ranked by employing the Technique of Order Preference by Similarity to Ideal Solution (TOPSIS) method. Also, TOPSIS was applied with fuzzy in [13] for enhancing QoS-conscious semantic WS selection and ranking. Other MCDM techniques, as in [14], where the service selection problem is formulated and an integrated decision model using fuzzy AHP techniques and WASPAS, or weighted aggregated sum product assessment, is constructed for solving this problem,. Trustworthy cloud service providers are obtained in [15] through the fuzzy PROMETHEE method based on Shannon entropy.

Generally, we are exploiting the ability of MCDM techniques to treat multi-attributes and criteria and representing these attributes in the form of leaves in a tree by applying the tree soft approach.

2.2 General perspective of tree soft set: fundamental principles

The approach of tree soft set is introduced by Smarandache [10] who is founded of this approach. This approach was founded based on a soft set idea. Tree soft is described and defined by Smarandache as:

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

Let A be a set of attributes (parameters, factors, etc.), $A = \{A_1, A_2, \dots, A_n\}$, for integer $n \geq 1$, where A_1, $A_2, \dots, A_n$ are considered attributes of first level (since they have one-digit indexes).

Each attribute A_i, $1 \leq i \leq n$, is formed by sub-attributes:

$A_1 = \{A_{1,1}, A_{1,2}, \dots\}$ $A_2 = \{A_{2,1}, A_{2,2}, \dots\}$ $A_n = \{A_{n,1}, A_{n,2}, \dots\}$

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

And so on, as much refinement as needed into each application, up to sub-sub-…-sub-attributes (or attributes of m-level (or having m digits into the indexes):

$A_{i1,i2,\dots,im}$

Therefore, a graph-tree is formed, that we denote as Tree(A), whose root is A (considered of level zero), then nodes of level 1, level 2, up to level m.
We call leaves of the graph-tree, all terminal nodes (nodes that have no descendants).
Then the TreeSoft Set is:

$$F: P(Tree(A)) \rightarrow P(H)$$

Tree(A) 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(A).

All node sets of the TreeSoft Set of level m are:

$$Tree(A) = \{A_{i1} \mid i1= 1, 2, ...\}$$

3. Methodology of selection process

Herein, the study took advantage of surveys conducted for prior studies, which produced the outcomes in the previous section. Hence, we are exploiting entropy as a technique of MCDM to obtain QoS's weights, which are represented in a soft tree in a hierarchy form toward selecting the optimal WS. The process of selection is performed based on several steps.

Step 1. Construct the tree set.

- Determining influential attributes/criteria of QoS as main attributes (A_n) in level 1 in form $\{A_1, A_2,\ldots A_n\}$. the inherent attributes /criteria of main in level 1 form in level 2 which entails sub-attributes related to level 1 as $\{A_{1i}, A_{2i},..A_{ni}\}$.
- Set of candidates of WSs as $\{WS_1, WS_2,\ldots WS_n\}$ are recommended to contribute to selection process.

Step 2. Analyzing and valuing attributes of level 1 and 2.

- LEDM: Linguistic expert's Decision Matrices are constructed for evaluating WS_n over attributes (A_n) in level 1 $\{A_1, A_2\ldots A_n\}$. Also, Linguistic expert's Decision Matrices are constructed for evaluating WS_n over attributes (A_{ni}) in level 2 $\{A_{1i}, A_{2i},..A_{ni}\}$.
- Constructed decision matrices are valuing based on scale of single value Neutrosophic sets (SVNSs).
- Entropy technique starts to implement in constructed decision matrices for WS_n over attributes (A_n) in level 1 and WS_n over attributes (A_{ni}) in level 2 through following sub-steps:

Step 2.1. The various decision matrices are transformed into crisp matrices through Eq. (1).

$$\boldsymbol{s}(\mathrm{Q_{ij}}) = \frac{(2+\mathcal{g}-\partial-\wp)}{3} \quad (1)$$

Where: $\mathcal{g}$, ∂, $\wp$ refers to truth, false, and indeterminacy respectively.

Step 2.2. Eq.(2) is employed in crisp matrices to aggregate it into single decision matrix.

$$D_{Mt_{ij}} = \frac{(\sum_{j=1}^{N} \mathrm{Q_{ij}})}{N} \quad (2)$$

Where:

Q_{ij} refers to value of criterion in matrix, N refers to number of decision makers.

Step 2.3. Normalizing the aggregated decision matrix by Eq. (3).

$$\mathrm{X}_{\mathrm{ij}} = \frac{D\_Mt_{ij}}{\sum_{j=1}^{m} D\_Mt_{ij}} \quad (3)$$

Where:

$\sum_{j=1}^{m} D\_Mt_{ij}$ represents sum of each criterion in aggregated matrix per column.

Step 2.4. Entropy for normalized matrix computes by Eq. (4).

$$e_{j} = -h \sum_{i=1}^{m} \mathrm{x_{ij}} \ln \mathrm{X_{ij}} \quad (4)$$

Where:

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

WS refers to number of alternatives.

Step 2.5. Compute weight vectors through employing Eq. (6).

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

Step 3. Selecting optimal web services.

- WSM is an essential technique in soft tree for attributes with various levels. This technique is exploiting generated aggregated matrix toward rank WSs based on leaves of soft tree (i.e. Attributes).

Step 3.1. Eqs. (7), and (9) are employed in aggregated matrix.

$$\text{Norm}_{\text{Agg\_matij}} \frac{C_{ij}}{\text{sum}(C_{ij})} \quad \text{, For Benficial key indicators} \tag{7}$$

$$Z = \frac{1}{C_{Ij}} \tag{8}$$

$$\text{Norm}_{\text{Agg\_matij}} = \frac{Z}{\text{sum}(Z)} \quad \text{, For Non} - \text{Benficial key indicators} \tag{9}$$

Where:

C_{ij} indicates to each element in the aggregated matrix.

Step 3.2. The obtained QoS criteria's weights of entropy technique are applied in the following Eq. (10) to generate weighted matrix.

$$\text{weighted\_matrix}_{ij} = \text{weight}_i * \text{Norm}_{\text{Agg}_{\text{matij}}} \tag{10}$$

Where:

$\text{weighted\_matrix}_{ij}$ is weighted decision matrix.

Step 3.3. Global score computes through Eq. (11).

$$V(\text{weighted\_matrix}_{ij}) = \sum_{j=1}^{n} \text{weighted\_matrix}_{ij} \tag{11}$$

Where: $V(\text{w\_matrix}_{ij})$ is global score values.

4. Real case study

To validate the accuracy of our methodology for selecting optimal WS. This process is performed by applying the constructed soft tree model-based hybrid mathematical techniques.

Herein, four WSs contributed to our case study. Also, criteria and attributes are determined to be leaves of the soft tree model, as shown in Figure 2. In this problem of selecting optimal WS, there are three experts related to our search field who rate determined candidates over determined attributes in soft tree's levels.

4.1 Entropy based tree soft set: Calculating attributes Level 1's weights.

- Firstly, LEDM are produced through using SVNSs scale in Ref. [16] and these matrices are transformed into crisp matrices based on Eq. (1).
- Eq. (2) contributes to develop Table 1 which represents an aggregated matrix for attributes $\{A_1, A_2\}$.
- This matrix is normalized by Eq. (3) to produce Table 2.
- entropy (e_j) is calculated by utilizing Eq.(4) to generate Table 3 and Figure 3 showcases vector weight's QoS criteria/attributes. According to this Figure we noticed that A_1 is the highest criterion with highest value of weight while A_2 is least one.

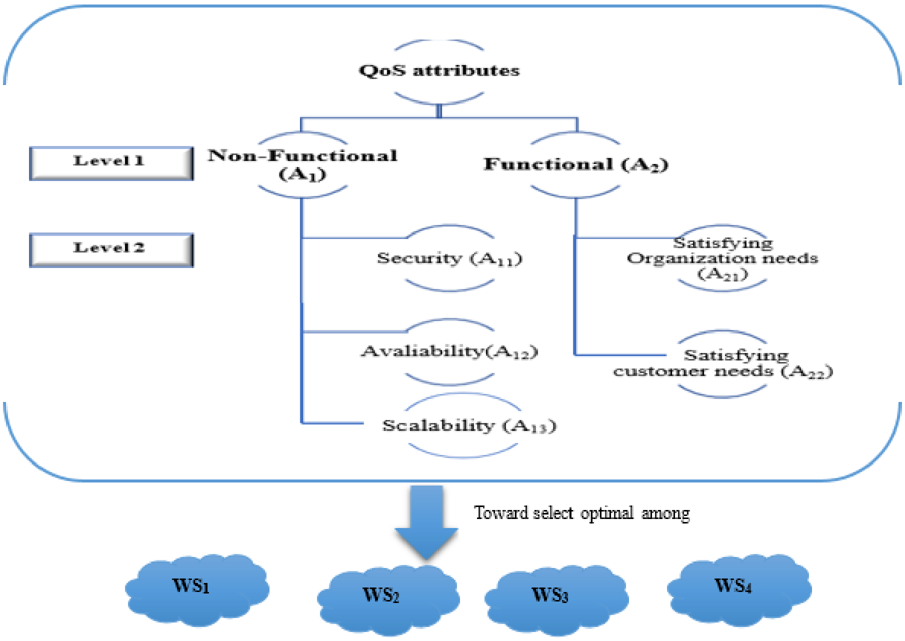

Figure 2. Determined leaves in soft tree model.

Table 1. An aggregated matrix of attributes A_1, A_2 at level 1.

	A_1	**A_2**
WS_1	0.477777778	0.455555556
WS_2	0.522222222	0.588888889
WS_3	0.222222222	0.672222222
WS_4	0.366666667	0.427777778

Table 2. Normalized matrix of attributes A_1, A_2 at level 1.

	A_1	**A_2**
WS_1	0.300699301	0.2124352
WS_2	0.328671329	0.2746114
WS_3	0.13986014	0.3134715
WS_4	0.230769231	0.1994819

Table 3. Entropy of normalized matrix of attributes A_1, A_2 at level 1.

	A_1	**A_2**
WS_1	-0.361333665	-0.329087269
WS_2	-0.365711611	-0.354907298
WS_3	-0.275120609	-0.363641621
WS_4	-0.338385477	-0.32157114
$\sum_{i=1}^{m} X_{ij}$	-1.340551363	-1.369207329
$-h \sum_{i=1}^{m} X_{ij} \ln X_{ij}$	0.966537533	0.987198484

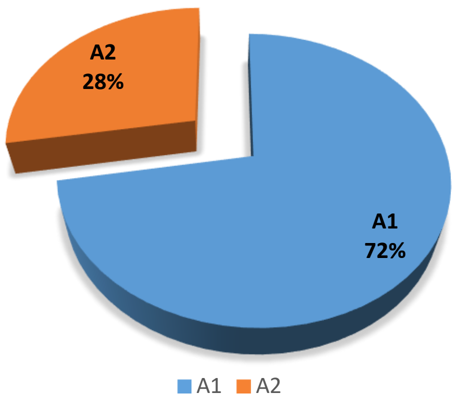

Figure 3. Weights of attributes in Level 1.

4.2 Entropy based tree soft set: Calculating attributes Level 2's weights

- The previous steps in sub-section 4.1 are repeated to obtain weights of attributes at level 2.

4.2.1 Calculating non-functional attributes' weights at level 2.

- Table 4 showcases an aggregated matrix for {WS_1, WS_2, WS_3, WS_4} over attributes {A_{11}, A_{12}, A_{13}}.
- Table 5 generated through normalizing the aggregated matrix.
- Entropy is represented in Table 6.
- Final weights for {A_{11}, A_{12}, A_{13}} are illustrated in Figure 4. Attribute A_{11} at level 2 is the best one which represents security non-functional. Otherwise, attribute A12 is availability non-functional considers the worst one.

Table 4. An aggregated matrix of non-functional attributes A_{11}: A_{13} at level 2.

	A_{11}	A_{12}	A_{13}
WS_1	0.611111111	0.566666667	0.538888889
WS_2	0.633333333	0.555555556	0.666666667
WS_3	0.255555556	0.533333333	0.4
WS_4	0.255555556	0.666666667	0.661111111

Table 5. Normalized matrix of non-functional attributes A_{11}: A_{13} at level 2.

	A_{11}	A_{12}	A_{13}
WS_1	0.348101266	0.244019139	0.237745098
WS_2	0.360759494	0.23923445	0.294117647
WS_3	0.14556962	0.229665072	0.176470588
WS_4	0.14556962	0.28708134	0.291666667

Table 6. Entropy of Normalized matrix of non-functional attributes A_{11}: A_{13} at level 2.

	A_{11}	A_{12}	A_{13}
WS_1	-0.367337985	-0.344191098	-0.341534194
WS_2	-0.367810093	-0.342179724	-0.35993395
WS_3	-0.280527334	-0.337867921	-0.306106069
WS_4	-0.280527334	-0.358274552	-0.35937524
$\sum_{i=1}^{m} X_{ij}$	-1.296202746	-1.382513296	-1.366949453

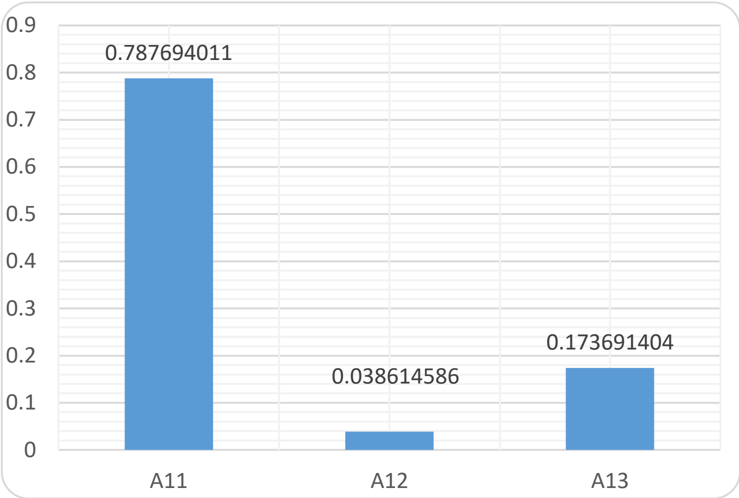

Figure 4. Weights of non-functional attributes A_{11}:A_{13} in Level 2.

4.2.2 Calculating functional attributes' weights at level 2.

- Table 7 showcases an aggregated matrix for {WS_1, WS_2, WS_3, WS_4} over attributes {A_{21}, A_{22}}.
- Table 8 generated through normalizing the aggregated matrix.
- Entropy is represented in Table 9.
- Final weights for {A_{21}, A_{22}} are illustrated in Figure 5. Attribute A_{21} at level 2 is the best one which represents satisfying organization needs. Otherwise, attribute A_{22} is satisfying customer needs considers the worst one.
- Figure 6 represents final weights for tree's attributes from A_1 until A_{11}: A_{22}. According to this Figure the security (A_{11}) is optimal with weight =0.57whilst availability (A_{12}) is least with weight = 0.028.

Table 7. An aggregated matrix of functional attributes A_{21}: A_{22} at level 2.

	A_{21}	**A_{22}**
WS_1	0.444444444	0.361111111
WS_2	0.727777778	0.7
WS_3	0.255555556	0.472222222
WS_4	0.316666667	0.605555556

Table 8. Normalized matrix of functional attributes A_{21}: A_{22} at level 2.

	A_1	**A_2**
WS_1	0.25477707	0.168831169
WS_2	0.417197452	0.327272727
WS_3	0.146496815	0.220779221
WS_4	0.181528662	0.283116883

Table 9. Entropy of normalized matrix of functional attributes A_{21}: A_{22} at level 2

	A_1	**A_2**
WS_1	-0.348373593	-0.300326349
WS_2	-0.364712203	-0.365551013
WS_3	-0.281383991	-0.333507342
WS_4	-0.30974993	-0.357263907

$\sum_{i=1}^{m} X_{ij}$	-1.304219716	-1.35664861
$-h\sum_{i=1}^{m} X_{ij}\ \ln X_{ij}$	0.940342416	0.978143648

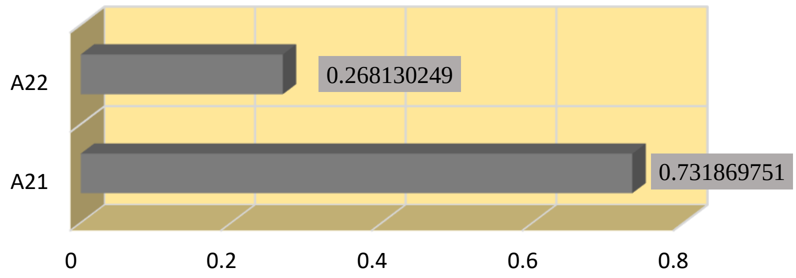

Figure 5. Weights of functional attributes A21:A22 in Level 2.

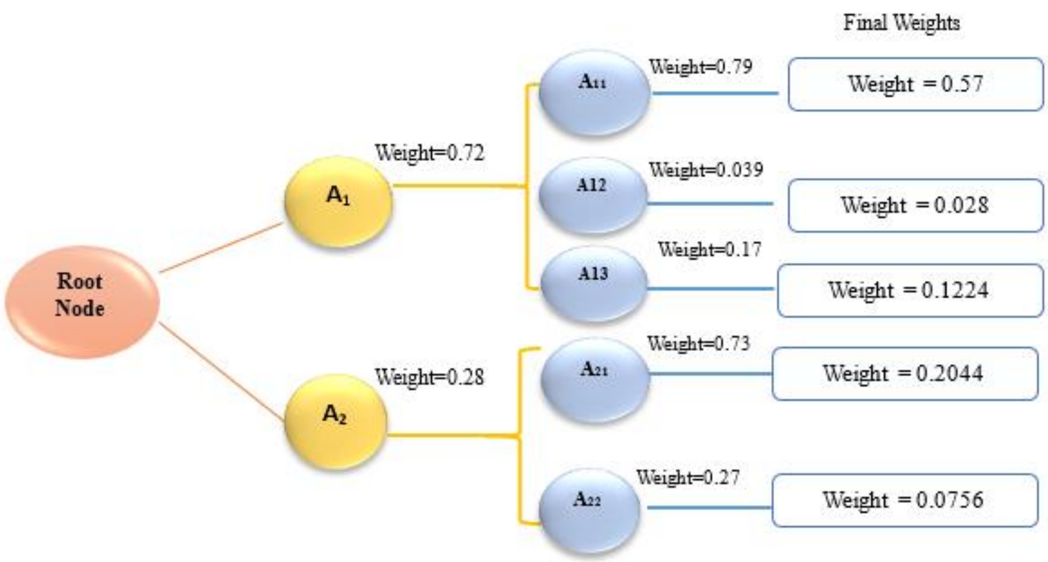

Figure 6. Final weights of attributes in tree soft.

4.3 WSM based tree soft set: Selection of optimal WS

- We are exploiting an aggregated matrix that generated from entropy based tree soft for selecting best WS based on QoS attributes/criteria described in hierarchy form in tree soft.

4.3.1 Recommending best WS from candidates over A_1:A_2

- Weighted decision matrix is constructed based on Eq. (10) as listed in Table 10.
- Final ranking for WSs from WS_1 to WS_4 which is illustrated in Figure 7. We demonstrated that WS_2 is the optimal one.

Table 10. Weighted matrix of attributes A_1: A_2 at level 1.

	A_1	A_2
WS_1	0.217494038	0.058782077
WS_2	0.237726041	0.075986587
WS_3	0.101160017	0.086739406
WS_4	0.166914029	0.055197804

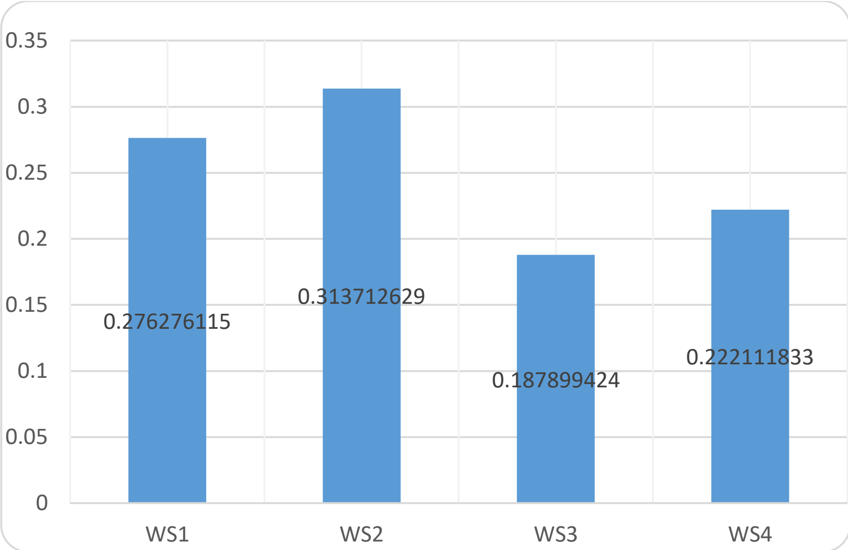

Figure 7. Ranking web services based on attributes in Level 1.

4.3.2 Recommending best WS from candidates over A_{11}:A_{13} non-functional in Level 2.

- Eq. (10) helped in obtaining weighted decision matrix from normalized matrix and entropy's weights (explained in sub section 4.2.1) and the produced weighted matrix is obtained in Table 11.
- Ranking of WSs candidates are illustrated in Figure 8 where WS_2 is the optimal one.

Table 11. Weighted matrix of attributes A_{11}: A_{13} at level 2.

	A_{11}	A_{12}	A_{13}
WS_1	0.198417722	0.006832536	0.0291
WS_2	0.205632911	0.006698565	0.036
WS_3	0.082974684	0.006430622	0.0216
WS_4	0.082974684	0.008038278	0.0357

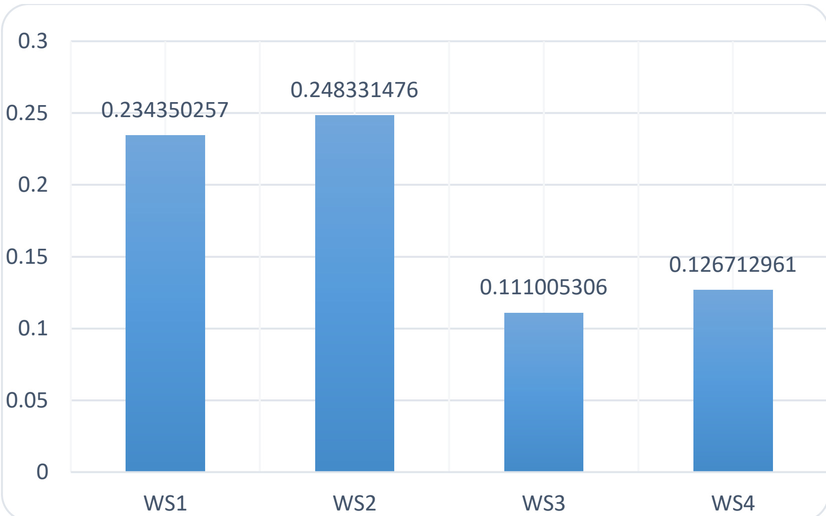

Figure 8. Ranking web services based on non-functional attributes in Level 2.

4.3.3 Recommending best WS from candidates over A_{21}:A_{22} functional in Level 2.

- Normalized matrix and entropy's weights are exploited to produce weighted matrix via Eq. (10) is obtained in Table 12.

- Ranking of WSs candidates are illustrated in Figure 9 where WS_2 is the optimal one.

Table 12. Weighted matrix of attributes A_{21}: A_{22} at level 2.

	A_{21}	A_{22}
WS_1	0.052076433	0.012763636
WS_2	0.085275159	0.024741818
WS_3	0.029943949	0.016690909
WS_4	0.037104459	0.021403636

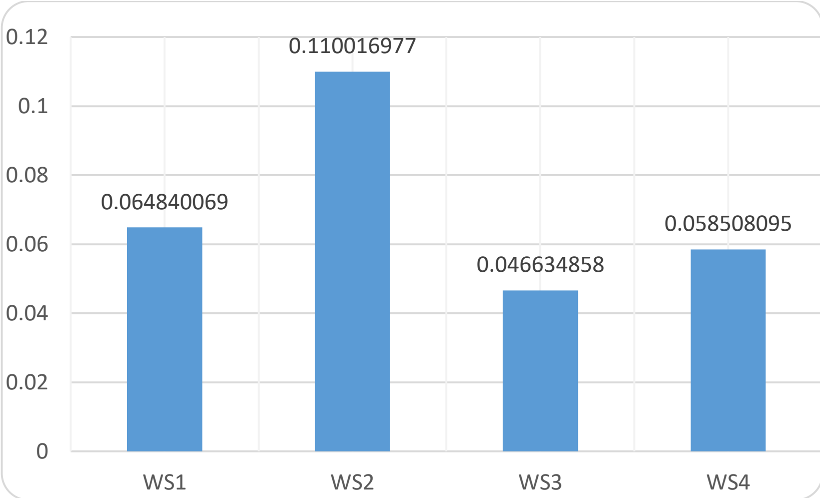

Figure 9. Ranking web services based on functional attributes in Level 2.

5. Conclusions

Making use of web services to complete complicated tasks online is becoming increasingly useful. Hence, it is important to select an appropriate WS that satisfies the customer's and organization's needs.

Plenty of prior studies which are relevant for our scope are analyzed selecting optimal WSs or service providers (SPs) through QoS. The selection process based on QoS conducted in this study according to functional and non-functional attributes.

The problem of selecting optimal WS or SPs represents in selection according to set of attributes fall under functional and non-functional. Also, these attributes are branched into sub-attributes. Accordingly, this problem can represent in hierarchy form. Hence, this study exploited surveys conducted for previous studies and volunteering tree soft approach for first time to describe this problem into set of levels. Each level entails a set of attributes. Also, MCDM techniques are employed in WSs selection tree soft to analyze attributes in each level and recommend the optimal WS among set of candidates.

Herein, entropy technique implemented in WSs selection tree soft to obtaining attributes' weights in each level through preferences of experts who related to our scope. The rating is performed through applying SVN scale as in [16]. The results of implementation of entropy indicated that security (A_{11}) is optimal attribute otherwise availability (A_{12}) is least based on its final values of its weights. After that WSM is leveraged the generated weights of attributes to rank WSs candidates and recommend the best and worst WS. In our case, there is an agreement on recommending WS_2 as optimal candidate based on its ranking in various levels of tree from level A_1 to level A_{22}. In contrast to WS $_3$ is the worst one.

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

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

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

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