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Evaluating Blockchain Cybersecurity Based on Tree Soft and Opinion Weight Criteria Method under Uncertainty Climate

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Abstract

In the era of digital transformation (DT), many digital technologies have emerged and have had a positive impact on society. Nevertheless, because of certain issues with existing technologies, innovative technology has developed to eradicate them. Fog computing (FC) plays a vital role as an intermediate between edge layer and cloud computing (CC) to resolve limited resources and capabilities. In the same vein, blockchain technology (BCT) is responsible for resolving privacy and security issues that IoT suffers from. Due to using cryptography rules and hashing which is utilized in BCT to prevent any trickery. Hence, BC shows promise as a possible remedy for the cybersecurity issue, especially in financial services and transactions. In the context of cybersecurity, it's critical to comprehend how financial sector businesses might handle these issues by investigating the use of BCT for financial transactions. Thereby, we constructed Tree Soft Evaluator (TrSEV) framework to evaluate security for enterprises (ENs) that embrace BCT as a cyber security method. The initial and important step in the evaluation process is determining the influenced criteria. In our problem, we modeled the determined criteria of BCT in Tree soft (TrSo) model. After that these criteria are analyzed and obtaining weights for it. Hence, we harnessed Opinion Weight Criteria Method (OWCM) as a novel multi-criteria decision-making (MCDM) technique to obtain criteria weights, and weighted sum model (WSM) is utilized for ranking enterprises and recommending optimal and worst enterprise. Finally, the techniques harnessed in our constructed framework are employed under the authority of Neutrosophic theory, precisely Single value Neutrosophic sets (SVNSs).

Keywords: Blockchain Technology, Digital Transformation, Opinion Weight Criteria Method, Tree Soft, Single Value Neutrosophic sets.

1 | Introduction

Lately, Information communication technology (ICT) offered digital solutions which are represented in Industry 4.0 (Ind 4.0) which concentrates on utilizing AI-driven technology and digitization to boost efficacy and versatility. Hence, Crises such as the COVID-19 epidemic undoubtedly provided a catalyst [1] for a swift transition to new digital transformation and digitalization modes of operation, which increased the flexibility

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of sectors and organizations. Confirming for that this tendency has been leveraged by [2] in a variety of organizations and industries, including finance, data management, supply chain management, medical care management, and government supremacy. Despite that [3] stated that the fundamental values of social justice and sustainability are given less attention in Ind 4.0. Thereby [4] addressed the deficiencies with Ind 4.0 by deploying Ind 5.0 where humans and machines coexist and collaborate in harmony. Accordingly, the concept of society 5.0 has emerged where humans are positioned at the center of innovation, maximizing the benefits of technology results in increased sustainability, social responsibility, and quality of life [1].

With time and the development of unpredictable circumstances and catastrophes, technology has permeated every aspect of our existence. The idea of the Internet of Things (IoT) according to [5] emerged globally in intricate ecosystems, and where employed for collecting data from different resources based on smart equipment. Whilst [6] described IoT as a vast network of physical objects connected through the Internet. Smart objects, or things, can communicate and share information because ultra-cheap sensors, actuators, and chips are becoming more and more common, and wireless networks are becoming more and more widespread. After that, the technology of cloud computing (CC) is leveraged for storing, handling, and processing the collected data from smart equipment. Afterward, fog computing (FC) emerged as in [7] to tackle cloud limitations. From the perspectives of scholars [8] for IoT systems to be deemed secure, they must address several issues, including client privacy, secure data transfer and bootstrapping, physical security design, key management, authentication, and access control methods.

In tandem with these technological advancements [5], Blockchain technology (BCT) and distributed ledgers gained prominence in technology. Due to the ability of BCT to improve security, privacy, capacity, and peer-to-peer capabilities. Additional cybersecurity-related benefits including data ownership, data openness and audibility, and fine-grained access restrictions may be obtained with BC-based systems [9]. Considering these advantages, financial institutions in [10] have been exploring ways to apply BCT to strengthen their position both financially and in terms of cybersecurity.

Scholars provided a list of arguments that corroborate the reasons for deploying BCT in various services, especially financial. (i) BCT employs a decentralized system to safeguard data while guaranteeing that its integrity is maintained[11]. (ii) this technology makes it possible to execute transactions in a decentralized way at a cheaper cost and with outstanding performance[12].(iii) BCT has largest impact on financial services, due to [13] utilized Bitcoin and other cryptocurrency alternatives have been affecting financial services.

Generally speaking, BCT is becoming more and more popular as an avenue for boosting commerce, transparency, and financial transactions. Hence, there are many perspectives that embraced the notion of evaluating the importance and influence of BCT in various industries. For instance, Alsaqer et al. [14] employed analytical hierarchy process (AHP) and technique for order of preference by similarity to the ideal solution(TOPSIS) as techniques of MCDM for evaluating BC model and select optimal one. In the same vein [15] constructed framework for selecting BC consensus protocol through using Simple Additive Weighting (SAW), TOPSIS, and IseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR).

Consequently, we are exploiting these techniques as an approach to healing our problem which represents in implementing these techniques. Hence, these techniques are motivator for this study for constructing framework for evaluating the influence of BCT as cybersecurity method for enterprises which embracing this technology in their financial services. To guarantee that this framework is used in all circumstances where there is ambiguous or perplexing information for partners or individuals who contribute to the evaluation process. we are implementing the utilized MCDM techniques under authority of Neutrosophic theory which introduced by Smarandache[16] as an advocate or supporter in these circumstances of uncertainty.

Finally, this study follows set of steps through leveraging modern techniques in constructing decision making framework.

Firstly, through surveys conducted for prior studies, we determine the latest effective techniques. These techniques are considered the main catalyst for the second step. Hence, Secondly, tree soft technique (TrSoT) which introduced by Smarandache [17] is exploited for modelling the evaluation and selection process based on influenced criteria and sub-criteria. Thirdly, MCDM techniques under authority of Neutrosophic to obtaining weights for criteria and sub-criteria which modeling by TrSoT after that these weights exploited to evaluate these criteria and sub-criteria to obtain the optimal enterprise which deploying BCT as cybersecurity method. Finally, optimal enterprise is recommending as optimal one.

2 | Background of Volunteered Techniques Toward cybersecurity.

In this study, we illustrate the previous studies which embraced the utilized techniques in decision making process in BCT through this section. Also, this section illustrates the essential concepts which contribute to construct Tree Soft evaluator (TrSEv) for evaluating enterprises based on cybersecurity BCT.

2.1 | MCDM Techniques in evaluation BCT

The BCT validated its efficiency in healthcare environment. Hence authors in [18] evaluated BC platforms through rough Analytic Hierarchy Process (RAHP) and rough Compromise Programming (RCP). Entropy and CRITIC are techniques of MCDM which exploited in [19] to obtain indicators' weights and WSM, TOPSIS, and VIKOR are utilized for ranking process. BCT implemented in supply chain (SC) in [20] for gaining competitive advantage. By enhancing chain and logistics operations in the areas of trust, transparency and accountability, collaboration, information sharing, financial exchanges, and SC integration, BC may help sustainable energy SCs. Thus, the authors applied various techniques for analyzing challenges of implementing BC in renewable energy SCs as gray evaluation based on distance from average solution (EDAS-Gray) and the gray stepwise weight assessment ratio analysis (SWARA-Gray). The findings are validated using an additional set of hybrid techniques, which include the gray weighted sum method (WSM-Gray), the gray complex proportional assessment (COPRAS-Gray), and the gray technique for order of preference by similarity to ideal solution (TOPSIS-Gray). In the same vein [21] examined the obstacles to BCT adoption in the Construction Supply Chain Management (CSCM) domain by dissecting its interconnections.

2.2 | Key concepts of Tree Soft Technique (TrSoT)

The concept of TrSoT introduced by Smarandache [17] also, he is founder for Neutrosophic theory. Whilst Smarandache described and defined this concept as:

Let $\mathfrak{H}$ be a universe of discourse, and $\mathcal{H}$ a non-empty and subset of $\mathfrak{H}$, whilst the powerset of $\mathcal{H}$ denoted as P($\mathcal{H}$).

-Main nodes encompass main attributes/criteria/factors and symbolled as $\mathfrak{R}$. Accordingly, $\mathfrak{R}$ has set of $\mathfrak{R}_s$ with (one-digit indexes) = $\{\mathfrak{R}_1, \mathfrak{R}_2, \ldots \mathfrak{R}_n\}$.

-Sub-nodes which have two-digit indexes and symbolled as:

$\{\mathfrak{R}_{11},.. \mathfrak{R}_{1n}\}$ are sub-nodes of $\mathfrak{R}_1$, $\{\mathfrak{R}_{21},.. \mathfrak{R}_{2n}\}$ are sub-nodes of $\mathfrak{R}_2$, and $\{\mathfrak{R}_{31},.. \mathfrak{R}_{3n}\}$ are sub-nodes of $\mathfrak{R}_3$

-Generally, a graph-tree is formed, that we denote as Tree($\aleph$), whose root is considered of level zero,

-then nodes of level 1, level 2, up to level n.

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

Then the TreeSoft Set is: F: P(Tree(ℵ)) → P($\mathcal{H}$).

-All node sets of the TreeSoft Set of level m are: Tree(ℵ) = {ℵi1 | i1= 1, 2, ... }

3 | Methodology of Tree Soft evaluator (TrSEv)

Here in, we are employing MCDM techniques under authority the scale of Neutrosophic theory to encourage decision makers (DMs) to treat incomplete information and uncertainty during evaluation process. Thereby, our constructed TrSEV implement in our problem through following steps.

Step 1: Modelling criteria and sub-criteria as nodes into TrSo.

-Determining set of alternatives of enterprises which contribute to evaluation process based on TrSEV.
-Determining the influenced criteria and sub-criteria which contribute to evaluating security of enterprises which embracing BCT as cybersecurity method.
-DMs panel is formed for rating enterprises based on modelled criteria and sub-criteria into TrSo.

Step 2: Valuation modelled criteria and sub criteria based on OWCM.

-OWCM is applying for the first time in such a problem. This technique of MCDM is introduced by MANDIL et al.[22].
2.1 Rating main criteria in level 1 of TrSo.
-Decision matrices are constructed based on number of DMs for evaluating alternatives based on main criteria through utilizing single value Neutrosophic scale (SVNS) as in [16].
-The constructed Neutrosophic matrices are convert to deneutrosophic matrices through Eq. (1)

$$\mathrm{De_{ij}} = \frac{2 + \hbar - \mathcal{F} - \ell}{3} \tag{1}$$

Where:
$\hbar, \mathcal{F}, \ell$ refer to truth, false, and indeterminacy respectively.
-Deneutrosophic matrices are aggregated into single matrix called aggregated matrix by Eq. (2).

$$\wp_{\mathrm{ij}} = \frac{\sum_{\mathrm{ij}}^{\mathrm{n}} \mathrm{De_{ij}}}{\mathbb{N}} \tag{2}$$

Where:

$\mathrm{De_{ij}}$ refers to value of criterion in deneutrosophic matrices, $\mathbb{N}$ refers to number of decision makers

-Eq. (3) is exploited for normalizing an aggregated matrix.

$$\partial_{\mathrm{ij}} = \frac{\wp_{\mathrm{ij}}}{\wp_{\mathrm{j}}^{\max}} \tag{3}$$

Where:

$\wp_{\mathrm{j}}^{\max}$ refers to max number in $\wp_{\mathrm{ij}}$ matrix per column, $\wp_{\mathrm{ij}}$ refers to each element in $\wp_{\mathrm{ij}}$ matrix .

-The average score of the decision matrix is calculated as following.

$$\mathcal{B} = \frac{1}{N} \sum_{i=1}^{m} \partial_{ij} \tag{4}$$

Where:
N refers to number of alternatives.
-Preference variation for each criterion is calculate as in Eq. (5)

$$\mho_{j=\sum_{j=1}^{m}[\partial_{ij-\mathcal{B}}]^2} \quad (5)$$

Where:

-The deviation in preference values is calculate based on Eq. (6).

$$\mathcal{E}_{j=1-\mho_j} \quad (6)$$

-Finally, weights for criteria is calculate as in Eq. (7)

$$\omega_{j=\frac{\varepsilon_j}{\sum_{j=1}^{m}\varepsilon_j}} \quad (7)$$

2.2 Rating sub- criteria in node 2 of TrSo.
-Decision matrices for each sub-criteria which inherent and belongs to main criterion at level 1.
-Applying SVNs in [16] to rate alternatives based on sub-criteria by DMs.
-We are following the previous steps in steps of 2.1 until sub-criteria's weights are obtaining.

Step 3: Ranking alternatives of enterprises and recommend optimal one.

Final step in our problem entails in ranking the determined alternatives through exploiting weights of criteria and sub-criteria in TrSo. Herein, we are leveraging WSM technique as ranker for alternatives based on criteria and sub-criteria.

-An aggregated matrix which obtained from previous step is leveraging for normalizing this matrix based o Eq. (8) until Eq. (10).

$$\Omega_{ij=\frac{\wp_{ij}}{\sum_{j=1}^{n}\wp_j}}\text{, For Benficial criteria} \quad (8)$$

$$\mathbb{C}_{ij} = \frac{1}{\wp_{ij}} \quad (9)$$

$$\Omega_{ij=\frac{\mathbb{C}_{ij}}{\sum_{j=1}^{n}\mathbb{C}_j}} \quad \text{, For Benficial criteria} \quad (10)$$

-Weights of main criteria in level 1 are multiply by normalized matrix for obtaining weighted decision matrix as in Eq. (11).

$$\text{weighted}_{ij=}\ \omega_j * \Omega_{ij} \quad (11)$$

-Global score computes through Eq. (11).

$$V(\text{weighted\_matrix}_{ij}) = \sum_{j=1}^{n} \text{weightd}_{ij} \quad (12)$$

4 | Case Study

We are validating the ability and accuracy of our TrSEV in a real case study. Hence, we communicated with four enterprises (EN(n)) which represented as candidates of alternatives in his study. Herein, we determined two main criteria and four sub-criteria which modelled in TrSo as in Figure 1. ENs are evaluating based on main and sub criteria in Figure 1 by three DMs who related to our scope.

4.1 The influenced criteria and sub-criteria of BCT cybersecurity are modelled into TrSo as in Figure1.

4.2 Valuation main criteria weights based on OWCM and SVNs

4.2.1 Three Neutrosophic decision matrices for main criteria in level 1 are constructed through rating it by three DMs based on scales of SVN in [16].

4.2.2 Eq. (1) deneutrosophic these matrices and aggregated into an aggregated matrix by Eq. (2) and the matrix illustrated in Table 1.

4.2.3 Table 2 represents normalized matrix based on Eq.(3).

4.2.4 After that, Eq. (5) contributes to generate Preference variation for each criterion through leveraging average scores are results of Eq. (4) as listed in Table 3.

4.2.5 Eq.(6) responsible for calculating the deviation in preference values and results are leveraging in Eq.(7) to obtain final criteria's weights as recorded in Figure 2.

4.3 Valuation sub- criteria weights based on OWCM and SVNs

4.3.1 Three Neutrosophic decision matrices are constructed for each sub-criterion which is inherent from main criterion in level 1.

4.3.2 The steps in 4.2 are followed for generating weights of sub-criteria in Level 2.

4.3.3 Finally, Figure 3 involved the final sub-criteria's weights.

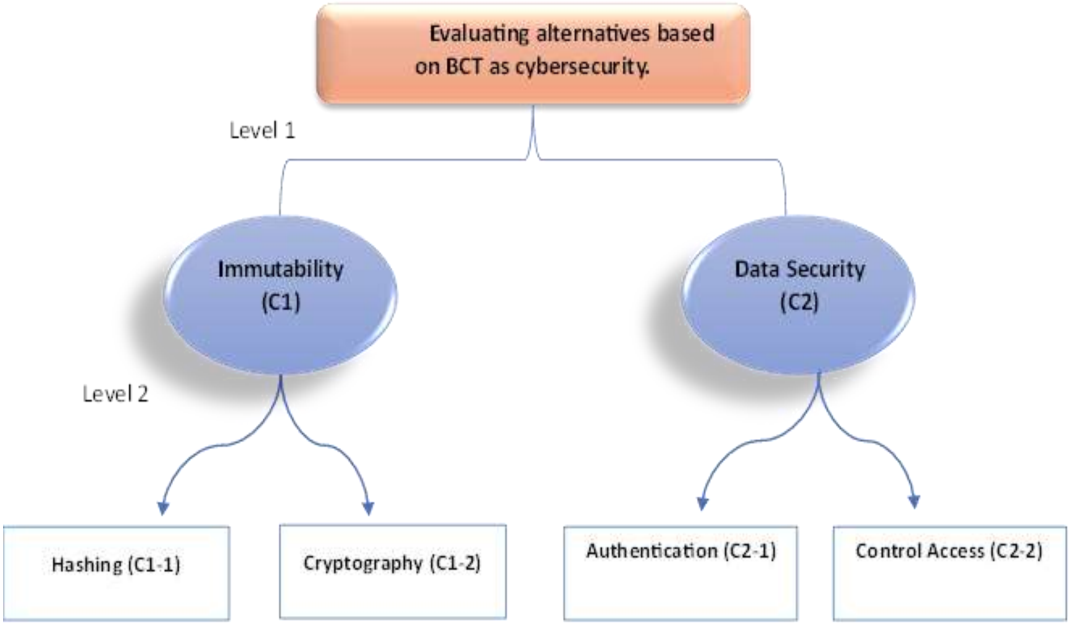


Figure 1. Modelling criteria and sub-criteria in Tree Soft.

Table 1. An aggregated decision matrix for Level 1.

	C1	C2
EN1	0.683333333	0.455555556
EN2	0.555555556	0.666666667
EN3	0.427777778	0.672222222
EN4	0.366666667	0.633333333

Table 2. Normalized matrix

	C1	C2
EN1	1	0.67768595
EN2	0.81300813	0.991735537
EN3	0.62601626	1
EN4	0.536585366	0.94214876

Table 3. Preference variation matrix.

	C1	C2
EN1	0.065585961	0.050718018
EN2	0.004775597	0.007893074
EN3	0.013897151	0.009429855
EN4	0.042980369	0.001541049

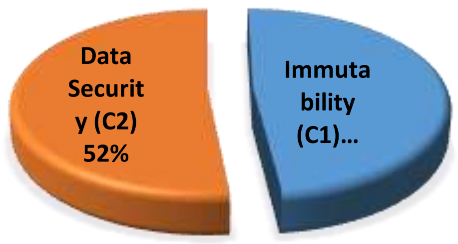
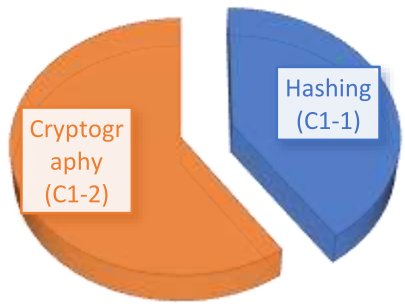
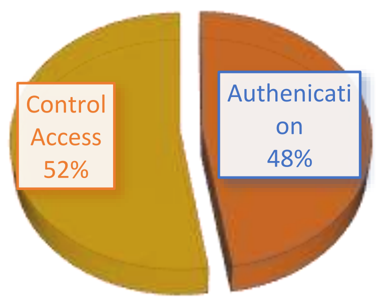


Figure 2. Final criteria weights at Level 1.



Final weights for sub-criteria at Level 2 of C1



Final weights for sub-criteria at Level 2 of C2.

Figure 3. Final weights for sub-criteria at Level.

4.4 Recommending the optimal EN based on value of WSM based on SVNs score.

4.4.1 The aggregated matrix for criteria which generated from step 4.2 is leveraging in Eq. (8) and considering the determined criteria are beneficial to generate normalized matrix and listed in Table 4.

4.4.2 According to Eq.(11) weighted decision matrix is generated and obtained in Table 5.

Eq.(12) is implemented to generate global score for each EN. Final, ranking for ENs is obtained in Figure 4. Which indicated that EN2 is the optimal otherwise, EN4 is the worst

Table 4. Normalized Matrix

	C1	C2
EN1	0.1626599	0.096821476
EN2	0.13224382	0.141689964
EN3	0.10182774	0.142870714
EN4	0.08728092	0.134605466

Table 5. Weighted Decision Matrix.

	C1	C2
EN1	0.33606557	0.187643021
EN2	0.27322404	0.274599542
EN3	0.21038251	0.276887872
EN4	0.18032787	0.260869565

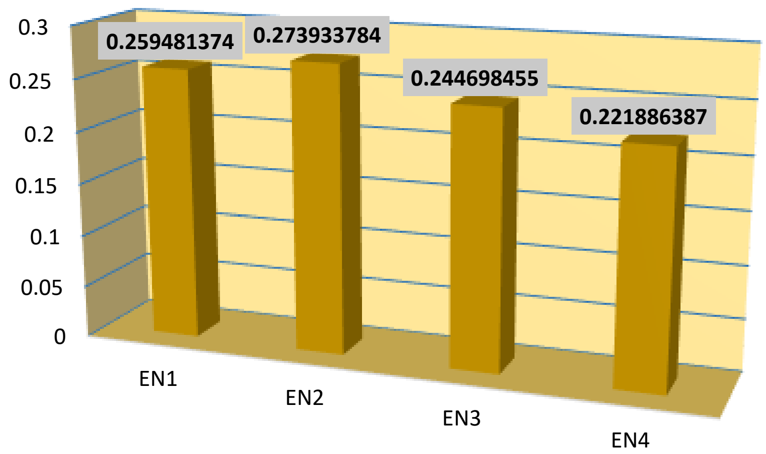


Figure 4. Final Ranking for enterprises.

5 | Conclusion

This study exploited digital transformation (DT) and discussed its ability to transform human life Positively. For instance, IoT makes people's daily life much easier by facilitating data exchange and comprehensive decision-making. Despite the importance and vital role of IoT in various industries, it suffers from some issues and concerns. One of the important concerns is security and privacy. BCT might be an effective solution to security and privacy issues in IoT. Hence, this study discussed and highlighted the role of BCT to guarantee security and protect privacy information in financial services for enterprises.

Accordingly, we analyzed its effect as cybersecurity method in finical services through analyzing the influenced criteria and its sub-criteria which deployed in evaluating the enterprises which embracing BCT cybersecurity in its services. Thereby, the influenced criteria and its sub-criteria are modelled through leveraging TrSoT which modelled it into levels. Each level includes a set of nodes, and each node represents criterion. Whilst TrSoT considered the first step in our study. After that criteria in TrSo are analyzed through utilizing constructed TrSEV framework where OWCM is a novel technique of MCDM which employed for first time in this problem to obtain weights for each criterion in each node. The finding of this technique demonstrated that data security (C2) is optimal with the highest weight in level 1. After that, WSM is exploited in our problem of evaluation as ranker technique of MCDM to rank four enterprises. The findings of this technique indicated that EN2 is optimal in contrast to EN4 is worst one. To bolster our constructed TrSEV in uncertainty circumstances, Neutrosophic theory has been harnessed in utilized techniques for evaluation security of enterprises which embracing BCT in its financial services and transactions.

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Author Contributaion

All authors contributed equally to this work.

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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.

Conflicts 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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