Blockchain Communication Platform Selection in IoT Healthcare Industry using MARCOS

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Abstract

The Internet of Things (IoT) healthcare industry is under tremendous pressure to simplify its secure data communication processes. Patients are beginning to consider healthcare services, such as those relating to wellness promotion, illness prevention, diagnosis, care, and recovery, as ongoing cycles. With the prevalence of chronic illnesses on the rise and public perceptions of healthcare shifting, many people increasingly see modern health services as ongoing commitments. Using data provided through the most cutting-edge technology, efficient healthcare systems should reliably provide all their patients with access to the high-quality, comprehensive medical treatment they can afford. So, this study presents a neutrosophic multicriteria decision-making (MCDM) model to optimize the selection of blockchain communication platforms in IoT healthcare applications. To identify the best blockchain platform for use in healthcare, the Measurement of Alternatives and Ranking according to the Compromise Solution (MARCOS) technique was created. The proposed model improves the efficiency, accuracy, and reliability for better Blockchain secure communication in the IoT healthcare industry.

Keywords: Blockchain; Secure data communication, IoT; Healthcare; MARCOS; MCDM; Neutrosophic sets

1. Introduction

When it comes to data distribution, communication, storage, and management, blockchain technology is a huge step forward. Blockchain, from a technological standpoint, is a decentralized, public, immutable, authenticated, secure, and pseudo-anonymous database constructed from a network of computers. Since it is distributed, a complete copy exists in as many locations as there are within the network. Due to the inability to tamper with transaction records, blockchain is also considered to be immutable. Blockchain's decentralized nature also guarantees the authenticity of data blocks throughout the chain[1]–[3].

There are many applications for blockchain technology, but we'll focus on three here. Agreements, which are essentially a set of scripts used to generate a legally binding contract via the blockchain, are one of the most important applications of blockchain technology. Smart contracts allow for the development of a business transaction with little central coordination. The validation of a paper or data to uncover any fiddling with the contents is an additional important use of blockchain technology[4]–[7]. The use of blockchain technology to aid in fraudulent activities has the potential

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to greatly decrease the occurrence of fraudulent activities. Blockchain technology also has significant potential in the area of proof of identity. Vaccine passports, marriage licenses, birth certificates, and contracts are just a few examples of how blockchain has been utilized to bolster proof of identity.

While the majority of early blockchain applications were in the financial goods and services sector, the technology is increasingly being used in other sectors, like healthcare.

This paper's goal is to provide and create the conditions to aid in selecting a blockchain platform that can meet the requirements of a healthcare organization's blockchain deployment. To do so, a case study must first establish the primary considerations for selecting the appropriate blockchain platform. Second, a brand-new approach is created to complete the decision-making procedure related to blockchain platform selection.

The MARCOS framework, which stands for "Measure of Options and Ranking according to COmpromise Solution," is a seven-step process for evaluating and ranking potential solutions[8]–[10]. This strategy is based on the assessment of alternatives and their evaluation with respect to a compromise solution. As a part of the compromise, utilitarian functions are calculated based on the gap between anti-ideal and perfect solutions[11]–[13]. The most significant advancement made by this study is the creation of a novel approach that will aid decision-makers (DMs) in the resolution of complex situations. Moreover, the MARCOS approach may provide input to Future Members Representing Decision Making. The MARCOS method is integrated with the neutrosophic sets to overcome the uncertainty[12], [14].

2. Mathematical Equations

A subset of neutrosophic sets, known as single-valued neutrosophic sets, has just one possible value. Some preliminary information is included in this part, including definitions, actions, and distance measurements among pairs of single-valued neutrosophic sets[15]–[20].

Definition 1:

$$A\ single\ valued\ neutrosophic\ set\ is\ demonstrated\ by\ a\ truth\ membership\ function\ T_n(z)$$
$$an\ indeterminacy - membership\ function\ I_n(z)$$
$$and\ a\ falsity - membership\ function\ F_n(z)$$
$$For\ all\ x, . T_n(z), I_n(z), F_n(z) \epsilon [0,1].$$
$$For\ the\ sum\ of\ three\ membership\ functions\ of\ a\ single - valued\ neutrosophic\ set,$$
$$the\ relation\ of\ 0 \leq T_n(z) + I_n(z) + F_n(z) \leq 3\ is\ valid\ for\ all\ z.$$

Definition 2:

$$Some\ operation\ sets\ are\ defined\ between\ two\ single - valued\ neutrosophic\ sets\ as\ follows:$$
$$Let\ n = \langle T_n(z), I_n(z), F_n(z) \rangle and$$
$$s = \langle T_s(z), I_s(z), F_s(z) \rangle.$$
$$be\ two\ single - valued\ neutrosophic\ sets.$$
$$Then\ addition, multiplication, union, and\ the\ intersection\ of\ these\ two\ sets\ can\ be\ computed$$

$$n \oplus s = \langle T_n(z) + T_s(z) - T_n(z) \times T_s(z),$$
$$I_n(z) \times I_s(z), F_n(z) \times F_s(z) \rangle\ for\ all\ z.$$

$$n \oplus s = \left\langle \begin{matrix} T_n(z) \times T_s(z), I_n(z) \\ I_s(z) - I_n(z) \times I_s(z), F_n(z) + F_s(z) - Fn(z) \times Fs(z) \end{matrix} \right\rangle$$

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$$n \cup s = \left\langle \begin{matrix} max\left(T_n(z), T_s(z)\right), \\ min\left(I_n(z), I_s(z)\right), \\ min\left(F_n(z), F_s(z)\right) \end{matrix} \right\rangle for\ all\ z$$

$$n \cap s = \langle \min(T_n(z), T_s(z)),$$
$$max(I_n(z), I_s(z)), max(F_n(z), F_s(z))\rangle for\ all\ z.$$

Definition 3:

$Euclidean\ distance\ of\ single - valued\ neutrosophic\ sets\ is\ defined\ as\ follows$:

$Let\ n = \{(z_1|T_n(z_1), I_n(z_1),$

$F_n(z_1)), \dots, (z_m|T_n(z_m), I_n(z_m), F_n(z_m))\}\ and$

$s = \{(z_1|T_s(z_1), I_s(z_1), F_s(z_1)), \dots, (z_m|T_s(z_m),$

$I_s(z_m), F_s(z_m))\}\ be\ two\ single\ valued\ neutrosophic\ sets\ for$

$z_i \in X(i = 1,2, \dots, m).$

$Euclidean\ distance\ between\ these\ two\ sets\ is\ defined.$

$$d\_Eucl(n, s) = \sqrt{\sum_{i=1}^{m} \{\left(T_n(z) - T_s(z_i)\right)^2 + \left(I_n(z_i) - I_s(z_i)\right)^2 + \left(F_n(z_i) - F_s(z_i)\right)^2\}}$$

$distance_{normalized}$

$$d\_Eucl(n, s) = \sqrt{\frac{1}{3m} \sum_{i=1}^{m} \{\left(T_n(z_i) - T_s(z_i)\right)^2 + \left(I_n(z_i) - I_s(z_i)\right)^2 + \left(F_n(z) - F_s(z_i)\right)^2\}}$$

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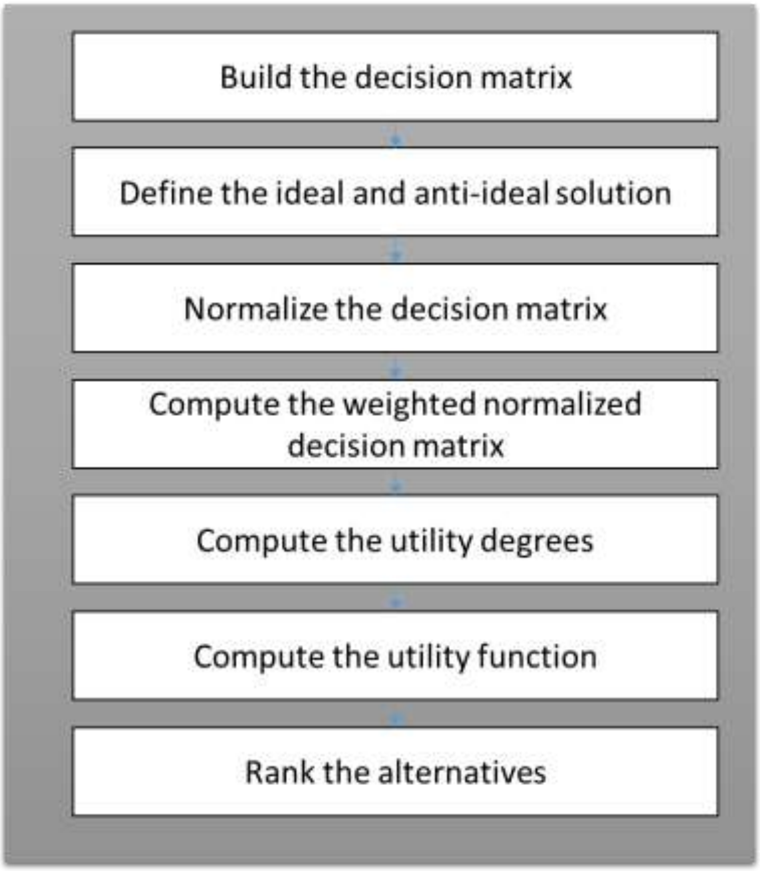

Figure 1: The steps of the methodology.

3. The MARCOS method

The MARCOS methodology's underlying algorithm is outlined. The MARCOS approach focuses on establishing a connection between potential solutions and anchor values. Alternative utility functions are calculated and ranked in terms of optimal and anti-ideal responses based on the established connections. Figure 1 shows the stages of the MARCOS technique.

Step 1: Build the judgment background

In this stage, the standards and substitutions are composed of previous works. Then the experts assessed the standards and alternatives.

Step 2: Describe the perfect and anti-ideal result

In this step, the judgment background is extended to add perfect and anti-ideal results.

$$X = \begin{matrix} AAI \\ A1 \\ A_m \end{matrix} \begin{bmatrix} x_{aa1} & \cdots & x_{aan} \\ \vdots & \ddots & \vdots \\ x_{ai1} & \cdots & x_{ain} \end{bmatrix}$$

The perfect solution is the best result and the ant-ideal result is the worst alternative.

Step 3: Normalize the judgment background

$n_{ij} = \frac{x_{ai}}{x_{ij}}$ if cost

$n_{ij} = \frac{x_{ij}}{x_{ai}}$ if positive

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Step 4: Compute the weighted normalized judgment background

$$v_{ij} = w_j * n_{ij}$$

Step 5: Calculate the utility degrees

$$K_i^+ = \frac{S_i}{S_{ai}}$$

$$K_i^- = \frac{S_i}{S_{aai}}$$

$$S_i = \sum_{i=1}^{n} v_{ij}$$

Step 6: Compute the utility function

$$f(k_i) = \frac{K_i^- + K_i^+}{1 + \frac{1 - f(K_i^+)}{(K_i^+)} + \frac{1 - f(K_i^-)}{(K_i^-)}}$$

$$f(K_i^+) = \frac{k_i^-}{k_i^- + k_i^+}$$

$$f(K_i^-) = \frac{k_i^+}{k_i^- + k_i^+}$$

Step 7: Order the substitutions founded on the values of the utility function

4. Outcomes

This section discusses the expected outcomes of using the proposed MCDM method for better data communication in IoT healthcare applications, especially for those applications that use blockchain as the main security procedure.

Step 1: Build the decision matrix

There are seven criteria and five alternatives. The criteria are security, community, functionality, scalability, capacity, latency, and availability. The specialists have assessed the criteria and substitutions by the dingle-valued neutrosophic numbers. Then compute the weights of seven criteria as shown in figure 2. Then build the judgment background between criteria and alternatives. Criterion 4 is the highest value and criterion 3 is the lowest weight of the seven criteria.

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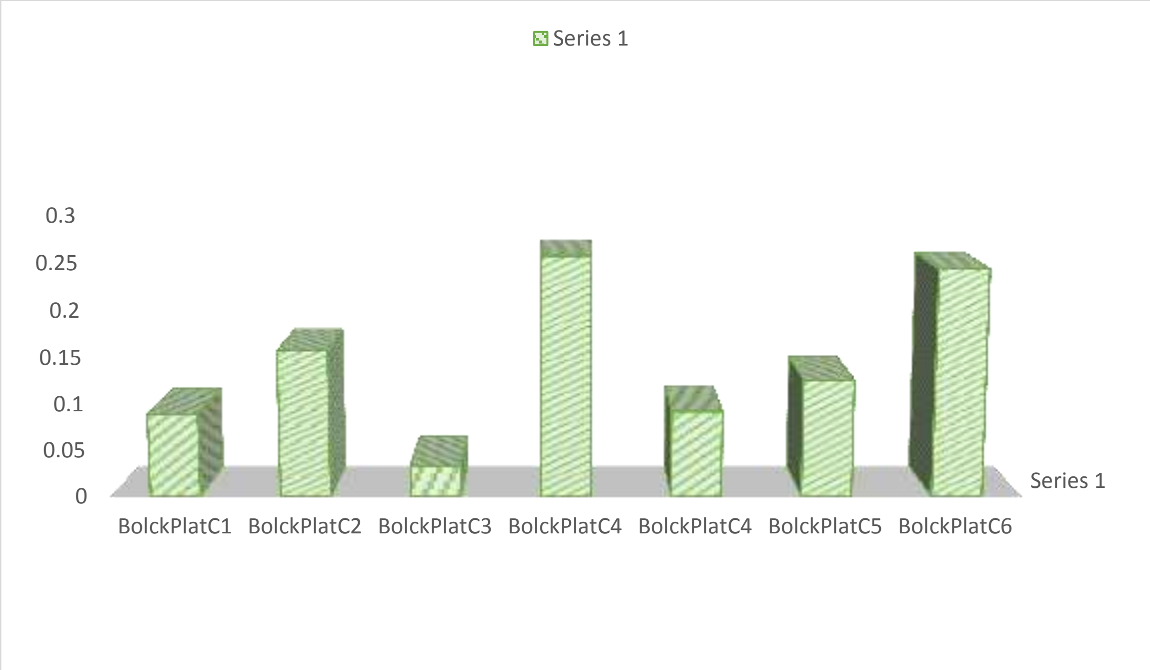

Figure 2: The weights of criteria.

Step 2: Describe the perfect and anti-ideal result

In this step, the decision matrix is extended to add the perfect and anti-ideal results

Step 3: Normalize the judgment background

Then normalize the judgment background as shown in table 1.

Table 1: The normalization judgment background.

	BlockPlat C1	BlockPlat C2	BlockPlat C3	BlockPlat C4	BlockPlat C5	BlockPlat C6	BlockPlat C7
AAI	3.714286	6.416667	2.666667	6.230769	5.5	7.666667	2.863636
BlockPlat A1	1.428571	1	1.083333	5.076923	5.5	7.666667	2.863636
BlockPlat A2	1	5.75	2.666667	6.230769	4.6875	3	1
BlockPlat A3	3.095238	5.166667	1	1.923077	2.25	3	1.636364
BlockPlat A4	3.142857	5.25	1.75	4.846154	4.9375	1	2.045455
BlockPlat A5	3.714286	6.416667	1.555556	1	1	1.25	1.636364
AI	1	1	1	1	1	1	1

Step 4: Compute the weighted normalized judgment background

Multiply the weights of criteria by the normalization matrix to obtain the weighted normalized judgment background as shown in table 2.

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Table 2: The weighted normalization judgment background.

	BlockPlat C1	BlockPlat C2	BlockPlat C3	BlockPlat C4	BlockPlat C5	BlockPlat C6	BlockPlat C7
AAI	0.332933	1.006536	0.089636	1.605688	0.508403	0.966387	0.697861
BlockPlat A1	0.332933	1.006536	0.089636	1.605688	0.508403	0.966387	0.697861
BlockPlat A2	0.128051	0.156863	0.036415	1.308339	0.508403	0.966387	0.697861
BlockPlat A3	0.089636	0.901961	0.089636	1.605688	0.433298	0.378151	0.243697
BlockPlat A4	0.277444	0.810458	0.033613	0.495583	0.207983	0.378151	0.398778
BlockPlat A5	0.281713	0.823529	0.058824	1.248869	0.456408	0.12605	0.498472
AI	0.089636	0.156863	0.033613	0.495583	0.207983	0.12605	0.243697

Step 5: Compute the utility degrees

Then compute the values of s and k for positive and negative criteria.

Step 6: Compute the utility function

Then compute the value of the utility function.

Step 7: Order the substitutions founded on the values of the utility function

Figure 3 shows the rank of alternatives. Alternative 1 is the best substitute and substitutes 5 is the worst alternative.

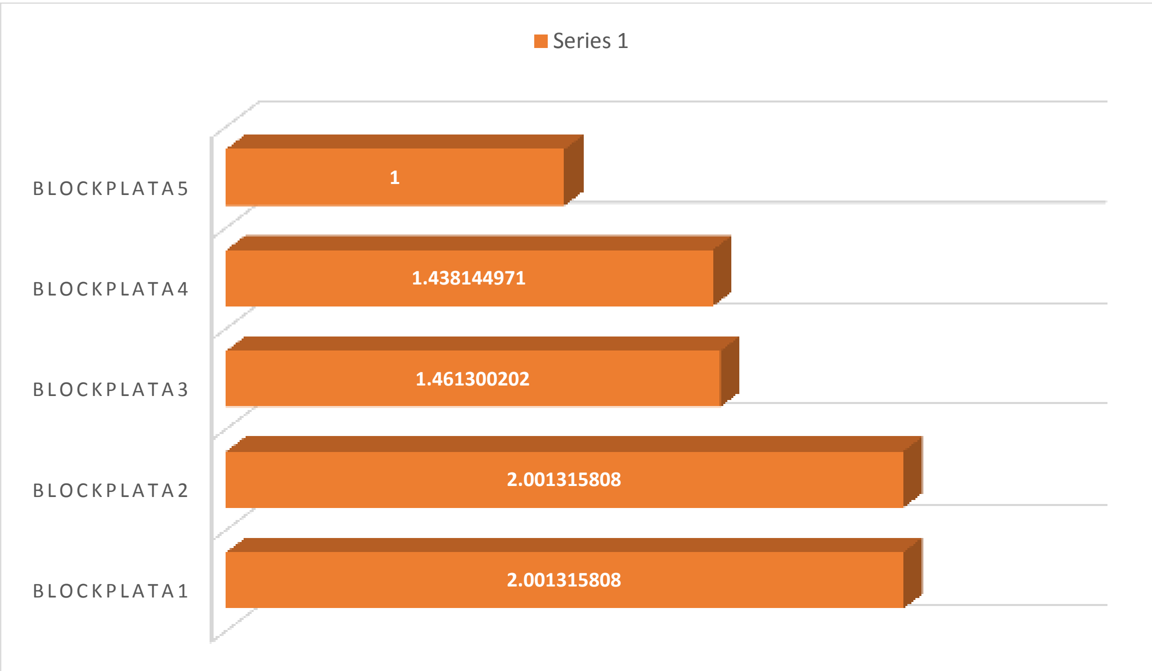

Figure 3: The rank of alternatives.

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5. Conclusion

Workers in the healthcare sector need vast troves of individual patient's health data to make informed choices. The difficulty arises from several factors that make relevant information unavailable. Blockchain technology has the potential to mitigate the negative effects of these factors on healthcare applications, especially in IoT environments. While there has been some study on how to choose a blockchain platform that is suitable for local conditions in future blockchain deployments, there are presently no large-scale studies focusing on any one industry, much alone healthcare. In order to solve the issue of making decisions based on several factors, the authors of this work propose a new technique they name MARCOS. The foundation of the recently created MARCOS strategy is the specification of the link between alternatives and benchmarks. The utility of options is calculated and ranked in regard to the reference values based on these predefined relationships. Additionally, a novel perfect based on the MARCOS method is created to solve the issue of blockchain platforms.

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