Hybrid Neutrosophic- Promethee Method for Selection of Relay Node in WBAN

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Abstract

A wireless body area network (WBAN) is made up of small health-monitoring sensors that are implanted or placed on the human body. These sensors collect and transmit human medical and physiological data . WBANs are linked to medical servers that observe the health of patients. Because of its ability to continuously and remotely monitor patients' health, this type of network can save critical patients.WBAN is being used to establish communication links between these sensors and provide feedback to users. To provide mobility, sensor nodes must perform on electric power. As a result, the most crucial problem in WBAN is low energy consumption. It is difficult to replace the batteries in in-body sensors. To resolve this problem, we present an Neutrosophic -Promethee (Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE)method for choosing the selection of relay node, in which AHP calculates the weight of different criteria and and forwards them to the promethee technique which used for outranking them. The experimental outcomes of this study indicate that energy utilization and overall network reliability are significantly reduced.

Keywords:WBAN, MCDM method, Neutrosophic method, Promethee method.

INTRODUCTION

In WBAN data collected by continuous monitoring of various parameters offering higher versatility and resp onsiveness to the user.can be used as the various sensors. Relay nodes can be connected to the WBAN to col lect all the data from the sensor nodes and forward it to the sink which will increasethelifetime , dependability of the network. WBAN has been developed to deliver some promising applications such as sports and fitness tracking, remote healthcare, security, gaming and entertainment, streaming in real time, emotion detection, etc.The relay node is an intermediate node between the node of the parent and the node of the child. In the relay network, a network and coordinator may exchange frames with another node using a multi-hop communication.We have proposed in this paper a hybrid Neutrosophic - Promethee MCDM approach to pick the relay node to diminish energy consumption in WBAN. In the Neutrosophic method, measure the weights of different parameters, and Promethee is used to outperform them. Then the selection of relay nodes is made based on six different criteria, i.e., residual energy, traffic load, node density, signal to noise ratio, euclidean distance and node criticality.

2.Related work:

The current techniques differ in the relay node selection criteria. For multi-hop Kim and Cho[1] used the AHP MCDM technique for relay node selection in WBAN to an increases packet drop, retransmission, and low energy consumption.. Bhatia uses fuzzy AHP and Entropy weights to select the best network for cognitive radio in the wireless body area networks[2]. Paul presents the extent analysis based on the Fuzzy AHP approach for relay node selection in WBAN[3]. Gupta uses the AHP and Promethee approach and proposes a new strategy called optimal relay node selection, which selects for each collector node , two optimal relay nodes based on the likelihood of failure, the residual energy distance to the relay node, and total distance to the base station[4]. Verma proposes a Promethee method for Distributed Coverage and Connectivity Preservation for Mobile Wireless Sensor Network (PDCCPSA) intending to increase the lifetime of the network with the ability to provide persistent coverage and connectivity of the entire area being observed by turning off some nodes or scheduling sensors to work alternatively on multi- basis scheduling Algorithm[5]. Rajpoot applied various MADM approaches: PROMETHEE, TOPSIS, and AHP for optimal CH selection to enhance the lifetime of WSN[6].]. Castro was describing some multi-criteria decision-making techniques like AHP, TOPSIS,
ELECTRE for energy efficiency in Automative engineering [7]. Carli uses the Analytical Hierarchy Process mcdm method for the development of energy water and environment system in metropolitan cities [8]. Bhaskar uses AHP and TOPSIS Multi-Criteria Decision- Making Method for analyzing the material performance of silicon , ceramic [9]. Feizi presents TOPSIS and hybrid AHP- ENTROPY approach for assigning weights in mineral potential mapping [10]. To identify potential hazards in time, Wang uses the AHP - TOPSIS method for evaluating the overall risk of oil and gas pipelines[11]. G. Freen defined a four-valued refined neutrosophic set and found the optimal solution of multi-objective non-linear optimization model[12]. Mohamed uses neutrosophic theory to form the AHP decision-making model for selection of best alternative out of other [13]. An innovative group-decisions creating technique is proposed in on the basis of neutrosophic-sets for diagnosing heart issues [14]. Geographical Multipath routing scheme for WSN has been proposed by Wu and Cho .The distance to the destination location, remaining battery capacity and queue size of the candidate sensor nodes are considered for next hop relay node selection and AHP is applied for decision making. The proposed scheme reduces the packet loss rate and link failure rate[15] Energy efficient cluster-head selection for wireless sensor networks has been proposed by GAO and Jin .Energy efficiency is the primary issue in the application of the wireless sensor network. In this paper, fuzzy multi criteria decision making approach based on trapezoidal fuzzy AHP and hierarchal fuzzy integral is used to optimize the selection of cluster heads. Energy status, QOS impact and location are major factors which are responsible for CH selection and each factor has its sub-factors[16].

Relay Node Selection Scheme based on MCDM technique for WBANs

In the proposed system for the Relay Node Selection, sensor nodes arrange themselves according to the ranking of the index value obtained by using six criteria. An advertisement is broadcasted by the relay node to its adjacent node within its transmission range. Our technique focuses on extending the Network Lifetime and Network Stability period and increasing the execution of the WBAN.

The presented technique is actualized using the following five phases:

- Initialization Phase
- Relay Candidate's Discovery based on different criteria
- Determining the grade of criteria importance
- Hybrid Neutrosophic –Promethee for evaluation of the Relay Node
- Data Transmission

In this paper MCDM Technique based onNeutrosophic-Promethee method is used as the relay node selection scheme.

3.1. Initialization Phase

Firstly, the sensor nodes are rested upon the body according to the x and y coordinates as illustrated in Table 1. An aggregate of 8 sensor nodes is used and the sink is situated at the mid-section.Electrocardiogram (ECG) and pulse sensors are placed closer to the sink which contains the necessary information of the patient which requires the least constriction, unwavering high quality, and enhanced life. The sensors transfer the information straight to the sink.Contrasting sensors take after their parent hub and send their data to drop through the forwarder hub.It provides vitality of centers, which allows the system to work for an elongated time deployment, the sink hub communicates a Hello Control parcel which contains data about its area.

Table 1: Location of sensor nodes on patient's body

Node no.	1	2	3	4	5	6	7	8	Sink
x-coordinate(m)	0.2	0.6	0.7	0.5	0.1	0.3	0.5	0.3	0.4
y-coordinate(m)	1.2	1.1	0.8	0.6	0.8	0.5	0.3	0.1	0.9

3.2 Relay Candidate's Discovery based on different criteria

Relay candidate discovery is percolated using a control message called Relay Node Exploration. Neighbor revelation is practiced in stage 2. A Hello control bundle is communicated among all the sensor nodes in their transmission range by utilizing the Carrier Sense Multiple Access (CSMA) method. If the node does not receive an acknowledgment message, it will broadcast a relay node discovery message to the discovery node and sets the discovery time. The Hello control bundle contains critical data, for example, Residual energy (criteria-1, C1); Traffic load (C2); No of neighbors (C3); Signal to noise ratio (C4); Hop distance (C5); Node criticality (C6); and node location and ID data which are illustrated in Fig 2. All SNs refresh their neighborhood table in the wake of accepting the Hello control parcel from neighboring nodes. The selected blueprint works for the on-body sensors as relay nodes as in body sensors or devices have lesser battery holding capacity which requires replacement after a certain period. Thus it is inadequate to use on body devices or sensors as relay nodes.

- **Residual Energy(E_{resi})**

  Relay Nodes absorb more energy than the other nodes while assembling, processing and routing data. Energy is an essential criterion in WBAN. Residual Energy is the leftover battery of the sensor node and the initial energy of the sensor node is predefined. Sensor nodes have limited energy capacity. The estimated value of residual energy can be calculated using this formula:

E_{resi} =E-E_{min}/ E_{max}-Emin

Where E = Initial Energy of the node; E_{min} , E_{max} = Minima, Maxima E_{resi} in the neighboring nodes

Higher the E_{resi} value lesser will be the energy criticality of the node.

- **Traffic Load (TL)**

  Traffic Load (TL) of the sensor optimizes the amount of data that will be dispatched by the sensor. The traffic load of the sensor is defined as the ratio of the reserved time slots of the sensor in a frame added by one to the number of the time slots of a frame.

  It can be represented as:

  TL=(t+1)*p/q*p

  TL=(t+1)/q

  Where p=Maximum amount of data transmitted of a time slot; q= Time Slots; t= Reserved Time Slots in a frame

  When the incoming traffic is higher than the outgoing traffic then Traffic Congestion is experienced. Traffic load should be minimal, so that patient's data arrive at the proper time

- **Node Density (ND)**

  There is an immediate connection between the number of neighbors and the relay node. Hypothetically, according to the rule, nearer the neighbor's approach to the ideal number, more likely a sensor node turns into a relay node. In this way, the assessment estimation of the number of neighbors is estimated as:

$$ND= (ND_i-ND_0)/ND_0$$

Where ND_i =c number of neighbors of the sensor;ND_0 = Ideal number of neighbors
When the quantity of neighbors is equivalent to the ideal number, the assessment estimation of the number of neighbors ought to achieve 1.

- **Signal to Noise Ratio (SNR)**

A WBAN node could utilize a huge measure of vitality if there are numerous retransmissions. To limit the number of retransmissions a WBAN node chooses its transmission control in such a route so that the collector can get a parcel with an adequate SNR to disentangle the bundle effectively.SNR is defined as the ratio of the signal power to the noise power expressed in decibel (dB). A ratio higher than 1:1 indicates more signal than noise.An SNR of zero indicates that the desired signal is virtually equivalent to the excessive noise.

$$P_{rxv}=P_{txv}-P_{Ls}-P_{Fs}-G_{txv}+G_{rxv}$$

Where P_{rxv} = Received power; P_{txv} = Transmitter power; P_{Ls} = Path loss; P_{Fs} = Loss due to the fading processes; G_{txv} = Transmitter antenna gain; G_{rxv} = Receiver antenna gain

- **Euclidean Distance (Dist)**

Herethe distance of the sensor node with the sink node and neighboringnode is considered. Only one node with the maximum distance will exist that can be reached in a given number of hops, in a 2D network.

$$Dist=(nodeX-sinkx)^2 + (nodeY-sinky)^2$$

Where node X, node Y = x, y-coordinate of the particular sensor node; sink X, sinkY= x, y coordinate of sink node. The node with the shorter distance to the destination is preferred as a relay node.

- **Node Criticality (NC)**

The Body Area system is the intricate and specific type of sensor system in which nodes are characterized in particular positions. WBAN is characterized by observing the patient ailment status by setting the organ checked sensors. As per the malady and patients, the node criticality is characterized. To give successful correspondence, some improved routing methodology is required.

3.3 Determining the grade of criteria importance

Suppose thereare (n > m) nodes in its correspondence go, nodes that are more remote to the goal node than the source node are not evaluated. Picking m nodes from staying qualified hubs depends on AHP. Beginning the second bounce, every node in the m-way chooses its next jump node, additionally utilizing AHP. AHP is a decision-making strategy that deteriorates an intricate issue into a pecking order of straightforward sub-issues (or variables), incorporates their significance to the issue, and finds the best arrangement. Here AHP is utilized to decide the criteria importance (weights) which are qualified to be chosen as the next bounce hand-off. It is done in 3 stages:

Step-1: Flock data and plan the following next-hop routing nodes choice issue as a choice order of autonomous elements.

Step-2: Decide and calculate the neighborhood weights or local weights of choice components or options of each level.

Step-3: Combine the outcomes to accomplish the overall weight of every option node or each alternative node and pick the node with the most significant weight as the qualified next bounce transfer nodes.

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Neutrosophic MCDM method : A neutrosophic is applied in the relay node selection problem for the ranking of the node. The Neutrosophic Promethee method is used to solve the relay node selection problem. Fig. 2 represents conceptual flow of relay node selection to obtain ideal solution. Neutrosophic is a handy technique for ranking several substitutes according to the closeness to the ideal solution.

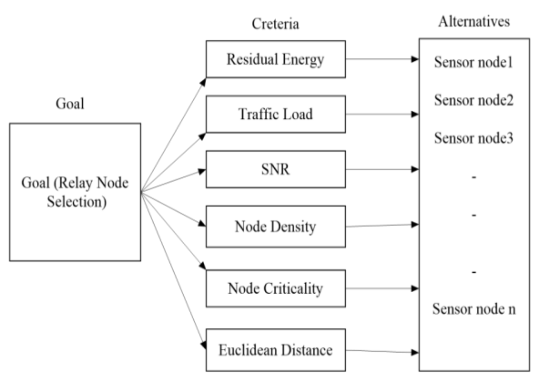


Figure: Neutrosophic Method For relay node

Step 1: Acquire expert information in Neutrosophic environment.

- Determine the aim of the study.
- Determine the study goal, criteria, and alternative.
- Collect experts prospective.
- Create an aggregated pairwise matrix.
- Use the neutrosophic scale mentioned in Table 1
- Convert expert's aggregation into crisp values.

Step 2: Decomposition and construct the hierarchy.

- The problem can be performing at various levels in the form of hierarchy.
- The first level of the hierarchy represents the overall main solution of the problem, the second level represents the decision criteria and sub-criteria and the third level is composed of all possible alternatives of the final solution.
- The pair-wise comparison is used to generate the neutrosophic judgment matrix. The ambiguity of decision-makers is represented by triangular neutrosophic numbers (B_{xy}^{k}).
- Create a pairwise matrix of decision making judgments using the following form:

$$M^{k}=\begin{bmatrix} B_{11}^{k} & \cdots & B_{1z}^{k} \\ \vdots & \ddots & \vdots \\ B_{y1}^{k} & \cdots & B_{yz}^{k} \end{bmatrix}$$

Where $B_{xy}^{k} = B_{yx}^{-k}$.

***Step 3:** Use the Neutrosophic scale mentioned in the Table given below:*

Table 1: Neutrosophic Triangular Scale (Linguistic Terms)

Sr. No	Neutrosophic scale	Significance Level	Neutrosophic Range
1.	1~	Evenly significant	$\tilde{1}$ = < ;0.50, 0.50, 0.50>
2.	3	A little significant	$\tilde{3}$ = < ;0.30, 0.75, 0.70>
3.	5	Powerfully significant	$\tilde{5}$ = < ;0.80, 0.15, 0.20>
4.	7	Completely Powerfully significant	$\tilde{7}$ = < ;0.90, 0.10, 0.10>
5.	9	Absolutely significant	$\tilde{9}$ = < ;1.00, 0.00, 0.00>
6.	2		$\tilde{2}$ = < ;0.40, 0.60, 0.65>

7.	4	Sporadic values between two close scales	$\tilde{4}$ = < ;0.35, 0.60, 0.40>
8.	6		$\tilde{6}$ = < ;0.70, 0.25, 0.30>
9.	8		$\tilde{8}$ = < ;0.85, 0.10, 0.15>

3.4Hybrid Neutrosophic -Promethee for relay node selection

Assigning a preference function; in the first place, an evaluation matrix is required, which represents the performance of each alternative in relation to each criterion. Using this matrix, the alternatives are compared in pairs with each criterion. The results are expressed by the preference functions, which are obtained for each pair of alternatives and may be 0 or 1.Although 0 indicates no difference between the alternatives and 1 indicates a significant difference between them.
Estimating the outranking degree of the alternatives; a global preferences matrix is obtained by multiplying the preferences by the weights of the parameters and removing the single values.the sum of this matrix's row expresses the strength of an alternative (dominance), while adding that matrix's column expresses how much the other ones (sub) dominate an alternative. A linear ranking of alternatives is calculated by removing the value of the subdominance from the dominance value.In this method, decision makers have the responsibility ofallocating weights on different criteria and selecting a preferencefunction. The main advantage of this method is dealing withquantitative and qualitative data at the same time, and has the ability to avoid incomparability.The Promethee-algorithm is applied for selecting a relay node as follows:

Step 1 : Normalize the Evaluation Matrix.

$Rij= (Yij- min(Yij)/max(Yij)-min(Yij)$ - for valuable criteria

$Rij = [max(Yij)-Yij]/ max(Yij)-min(Yij)$ - for non valuable criteria.

Step 2). Calculate the Evaluative difference :- compute the estimate difference of i^{th} alternative with respect to additional alternatives.

Step 3).Determine the Prefernce function Pj(b,c)

$Pj(b,c) =0$ if $Rbj<Rcj$ or $(D(Mb –Mc)<=0$

$Pj(b,c) = (Rbj-Rcj)$ if $Rbj>Rcj$ or or $(D(Mb –Mc)>=0$

Step 4).Analyze the aggregrated preference function :- weights are multiplied with preference func.

Step 5). **Determining the leaving outranking and entering outranking flows:-** Average the rowwise elements is leaving flow and average of column wise is enterining flow

Step 6). **Determine the positive flow and negative preference flows**:-The flows of positive and negative preferences are aggregated into net flows of preferences.

Step 7) . Determine the ranking of all alternative Determining the ranking of all alternatives depend on positive preference and negative preference flows.

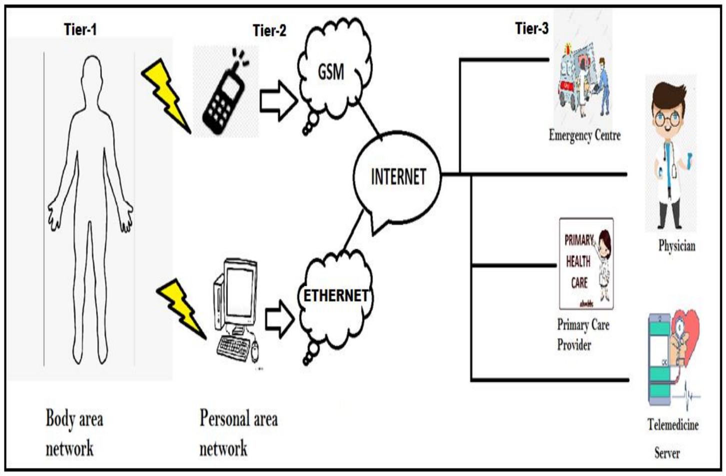
3.5. Data Transmission

In this phase, data is gathered and information is sent by the member nodes to the relay nodes in scheduled time. Transmission can use the minimum amount of energy on the basis of received signal-strength of the relay node advertisement and assumption of radio channel. The Relay node must keep a working state to get the data to originate from its individuals. At the point when an edge of information from every one of the individuals is received, the relay node applies information combination to aggregate the received information into a single bundle. At that point, the Relay node sends the amassed information to the BS specifically. It uses Hybrid AHP-Promethee to evaluate all the available nodes based on the criteria Information and transmit data to the destination.

4. Performance Evaluation

4.1. Network Model

The WBAN system works in 3 tiers – 1) Intra WBAN Communication 2) Inter WBAN Communication and 3) Beyond WBAN Communication. In tier 1, the data is collected by the sensor nodes from physical stimuli and transmitted to an access point in tier 2 which ensures communication between the personal devices and an external network[31]–[35]. In tier 3, the database is maintained by every user with their medical history. The 3-tiers WBAN network model are shown in figure.



4.2 Energy Model

Entire sensor nodes within the WBAN remain dynamic for whole period, so all the nodes require energy for detecting, dispensing, and transmitting of data. Energy spent on transmitting the data can be evaluated by Eq. (16):

$En_{trans}= En_{T\_elec}* p + En_{amp}* p * d$ (16)

Energy spent for receiving data is evaluatedby Eq. (17):

$En_{rec} = p * EnR_{\_elec}$ (17)

In WBAN, transmitting of datahappens over the human body hence forth some loss ought to be there. Thus to accommodate that loss, alteration co-efficient ‘n’ isinvolved in for calculating energy as given Eq. (18).

$En_{trans}= En_{T\_elec}* p + En_{amp}* n *p * d^2$ (18)

Where En_{trans}= Transmission-energy; En_{rec} = reception-energy, En_{T_elec} = Energy neededbytransmittercircuit; En_{amp} = Amplifier-energy;En_{R_elec} = Energy needed by receiver circuit.

4.3 Parameter Evaluation

To access the proposed convention, a broad set of investigations has been done utilizing of simulation software.The execution of the proposed system is accessed by looking at the chosen execution measurements that is stabile period, network lifetime, path loss, network throughput, network delay and average energy consumption. Sensors are placed on particular points over body. At first, all sensors are equipped with constrained energies(0.5J for each sensor node). At the point when the sensor nodes convey throughout the recreation, they exhaust and stop transmissions whenever the energy sources are vanished.

5. Results analysis

Assembling the simulation results of hybrid AHP-TOPSIS by using simulation software for two separate cases to test the energy-consumption efficiencyby selection of relay node.**:**All biosensor nodes are static, and data is sent towards sink by the relay node using proposed AHP-Promethee method for WBAN problem and analysis the results in terms of th
roughput, energy consumption, stability period, network life timeand delay for Neutrosophic and hybrid Neutrosophic Promethee - method.

5.1Energy consumption

The proposed protocol uses multi-hop node communication. A forwarder node is used to transfer the data from the node which is farthest to the sink node. The next node is chosen on the basis of Neutrosophic -Promethee technique. Selecting the next node at each round with contributing to less energy consumption. Multi-hop technique also helps in load balancing over the nodes.

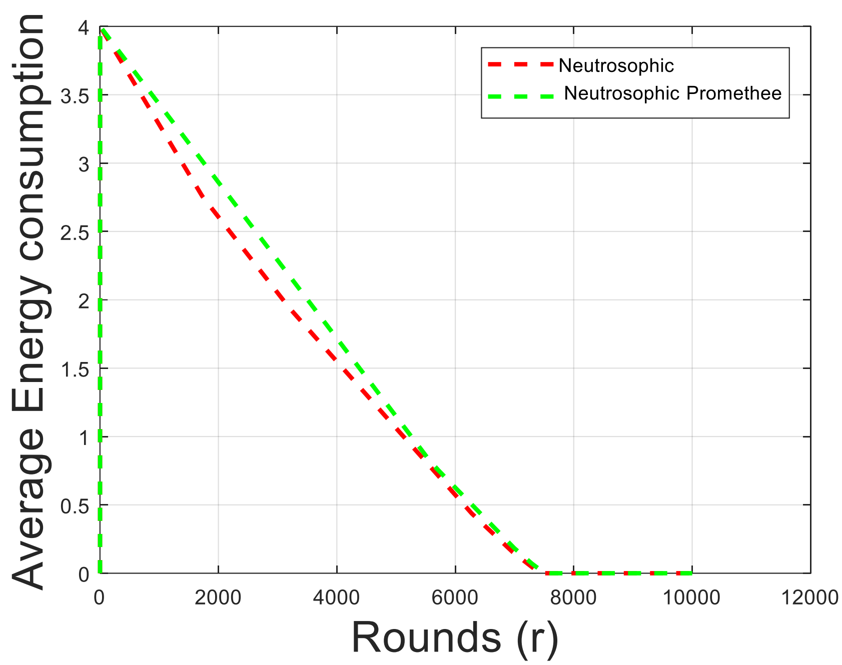


Figure. 5Analysis of average energy consumption

This type of architecture would ensure higher energy in the nodes resulting in the transmission of additional data-packets towards sink and increasing network productivity. Also, relay node selection using Neutrosophic -Promethee consumes lesser energy rather than using Neutrosophic alone. Figure5 illustrates the analysis of average energy-consumption with respect to both methods.

5.2 :Throughput

Throughput is defined as quantity of bundles per second at the sink. Connects between agreeable nodes and sink are of high information rates, though, connects between source nodes and important nodes have low information rates. Nodes that transfer information through helpful nodes are permitted to convey a more significant number of parcels than the nodes utilizing non helpful or coordinate correspondence. It is obvious that Neutrosophic -Promethee produces higher throughput than neutrosophic as shown in figure 6. The number of packets is collected at the sink if the relay node is selected by Neutrosophic Promethee method.

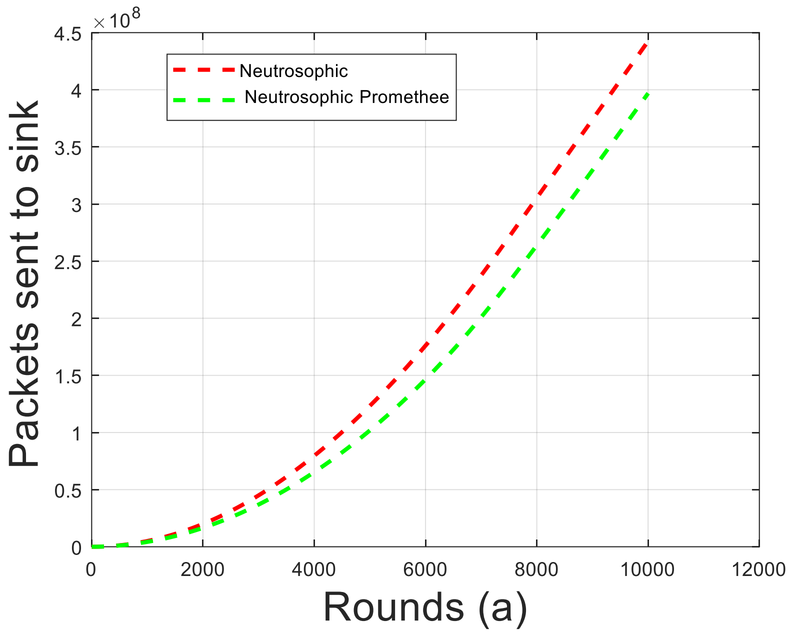


Figure 6: Analysis Of Network Throughput

5.3 :Stability period

The proposed protocol uses multi-hop node communication for a better solution in WBAN. A relay nodeselection using the Neutrosophic - Promethee method expands both stable periods as well as network lifespan of WBAN. Next node is selected in each round, and it has a significant role in balancing the consumption of energy amongst the sensors. Figure delineates that the proposed convention has a more extended stability period. This is because of the election of a newer forwarder in individual rounds. Thus, every sensor expends practically equivalent energy in every round and all of them expire at the same time. Figure7 depicts the no. of alive nodes for both methods.

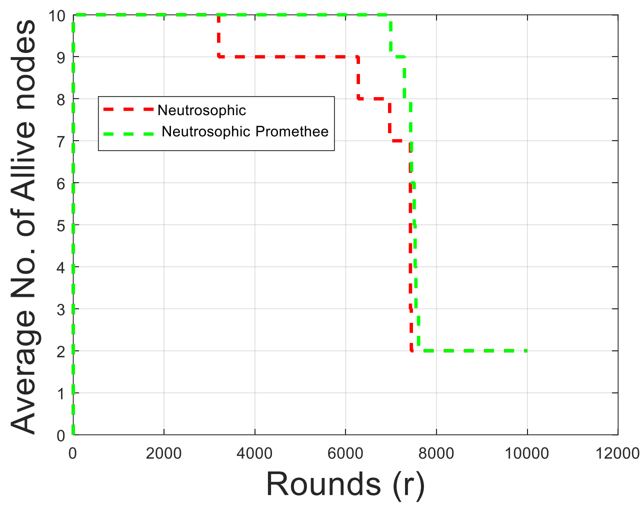


Figure.7.Analysis of number of alive nodes

5.4 :Network lifetime

Network lifetime is a period of network operations from beginning till the first node expires. The time period after the demise of Figure8.Analysis of number of dead nodes So, Neutrosophic -Promethee method encounters first dead node much later within the lifespan of the network in comparison with AHP as shown in figure8.

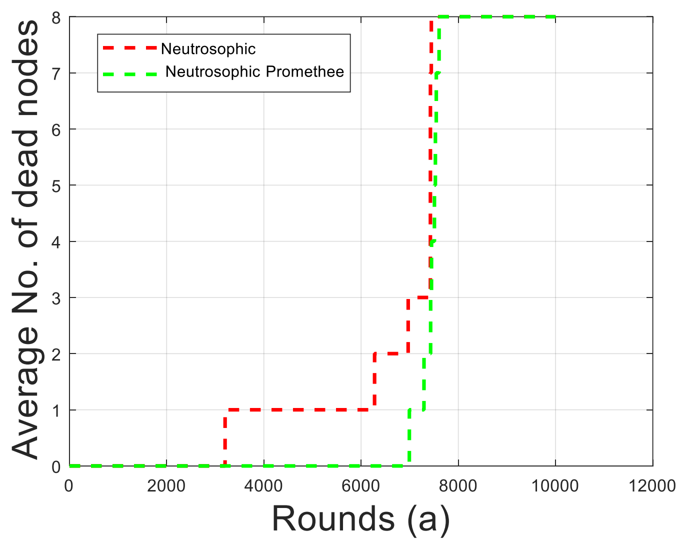


Figure 8 : Analysis of Dead Nodes

5.5 :Network delay

Network delay is a vital design and performance characteristic of telecommunication network. How much time a bit of data will take to travel from one node to another or endpoint to another is specified by the delay of network. Depending upon the specific location of the communicating nodes the delay may differ.Delay is the major concern for the users as patient's data should be transmitted at a proper time. Since Neutrosophic Promethee finds the best alternative i.e. closest to ideal solution.So, the proposed Neutrosophic - Promethee method ensures a much lesser delay period than Neutrosophic as shown in figure9.

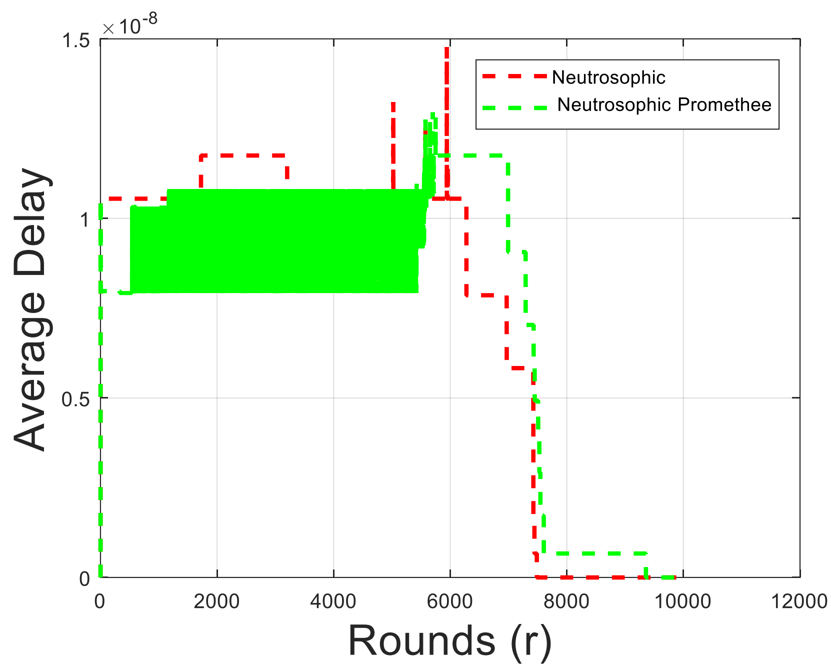


Figure 9. Analysis of Network delay

6. Discussions

From the experimental analysis, it can be clearly understood that the proposed hybrid Neutrosophic - Promethee performance better than AHP on various scenarios in terms of residual energy, traffic load, node density, SNR, Euclidean distance, node criticality. This paper proposes the use of hybrid Neutrosophic - Promethee methods of MCDM for developing an energy-efficient routing protocol for the selection of relay node in WBAN. The proposed methodology can be implemented in the field of energy planning by taking into considerations all the requirements and goals.. The proposed methodology provides us with the ranking of nodes with the first rank is chosen as the relay node. The experimental results show that the Neutrosophic-Promethee method outperforms the NeutrosophicMethod with respect to throughput, energy consumption, delay, pathloss, stability and dead nodes.

Conflicts of interest

Authors declare that there is no conflict of interest.

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