A Neutrosophic Technique Based Efficient Routing Protocol For MANET Based On Its Energy And Distance

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Abstract. In the last decade, characterizing the energy in MANET based on its acceptation, rejection and uncertain part is addressed as one of the major issues by the researchers. An efficient energy routing protocol for MANET is another issue. To resolve these issues current paper focuses on utilizing the properties of neutrosophic technique. The essential idea of the protocol is to choose an energy efficient route with respect to neutrosophic technique. In this neutrosophic set, we have three components such as (T, I, F). Each parameter such as energy and distance is taken from these neutrosophic sets to determine the efficient energy route in MANET. After taking a brief survey about energy efficient routing for MANET using various methods, we are trying to implement the neutrosophic set technique to find the efficient energy route for MANET which provides the better energy route in uncertain situations. The comparative analysis between vague set MANET and neutrosophic MANET for the values of energy functions and distance functions is done by using Matlab and the result is discussed graphically

Keywords: MANET; neutrosophic set; energy efficient routing protocol; granular Computing.

1 Introduction

Wireless networking technologies play a vital role for giving rise to many new applications in internet world. Mobile ad-hoc network (MANET) is one of the most leading fields for research and development of wireless network. Now a days, wireless ad-hoc network has become one of the most vibrant and active field of communication and networks due to the popularity of mobile devices. Also, mobile or wireless network has become one of the indeed requirement for the users around the world. In this network, there are no groundwork stations or mobile switching centres and other structures of these types. The topology of Mobile ad-hoc network (MANET) changes dynamically. Each node is within others node's radio range via wireless networks. In the present era, nearly everyone has a mobile phone and most of it are smart phones. These devices are very cheaper and more powerful which make Mobile ad-hoc network (MANET) as the speed-growing network [1, 26, 36, 37]. Because of frequent braking of communication links, the nodes in mobile ad-hoc networks are free to move to anywhere. Also, a node in Mobile ad-hoc network (MANET) performs complete access to send data from one node to the other very fast and provides accurate services. Mobile ad-hoc network (MANET) is user friendly network which is easy to add or remove from the network. In this, each node contains some energy with limited battery capacity. The energy has been lost very speed in ad-hoc networks by transforming the data from one node to another node and also over all network's lifetime. Therefore the energy efficient routing indicates that the selecting route requires high energy and shortest distance. In this regard recently one of the authors has utilized implications of weighted concept lattice [31] and its implications using three-way neutrosophic environment [32-33] at different threshold [25] beyond the fuzzy logic [40]. It is shown that the computing paradigm of neutrosophic logic provides an authorization to deal with indeterminacy in the given network when compared to any other approaches available in fuzzy logic. Hence the current paper focused on introducing the concept of neutrosophic logic for analyzing the energy efficient routing protocol in Mobile ad-hoc network (MANET). Neutrosophic set was introduced by Florentin Smarandache [34] in 1995. Neutrosophic set is the generalization of fuzzy set, intuitionistic set fuzzy set, classical set and paraconsistent set etc. In intuitionistic fuzzy sets[2], the uncertainty is dependent on the degree of belongingness and degree of non-belongingness. In case of neutrosophy theory, the indeterminacy factor is independent of truth and falsity membership-values. Also neutrosophic sets are more general than IFS, because there are no conditions between the degree of truth, degree of indeterminacy and degree of falsity. In 2005, Wang et.al [38] introduced single valued neutrosophic sets which can be used in real world applications. In this case, a problem is addressed while dealing with efficient route in routing protocol based on its distance or energy. To shoot this problem, the current paper introduces a method to characterize the energy efficient route in Mobile ad-hoc network (MANET) based on its acceptation, rejection and uncertain part. In the same time the analysis of the proposed method is compared with one of the existing methods to validate the results. The motivation is to discover the precise and efficient path based on its maximal acceptance, minimum rejection, and minimal indeterminacy. The objective is to provide an optimal routing in Mobile ad-hoc network (MANET) in minimal energy utilization when compared to vague set [18]. One of the significant outputs of the proposed method is that it deals with uncertainty independent from truth and false membership-values.

The remaining part of the paper is organized as follows: Section 2 provides preliminaries about each of the set theories. Section 3 provides proposed method with its comparative analysis in Section 4. Section 5 provides conclusions and future research.

2 Overview of Mobile ad-hoc networks[28]

Mobile Ad Hoc networking (MANET) can be classified into first, second and third generations. The first generation of mobile ad-hoc network came up with “packet radio” networks (PRNET) in 1970s and it has evolved to be a robust, reliable, operational experimental network. The PRNET used a combination of ALOHA and channel access approaches CSMA for medium access, and a distance-vector routing to give packet-switched networking to mobile field elements in an infrastructure less, remote environment. The second generation evolved in early 1980’s when SURAN (Survivable Adaptive Radio Networks) significantly improved upon the radios, scalability of algorithms, and resilience to electronic attacks. During this period include GloMo (Global Mobile Information System) and NTDR (Near Term Digital Radio)were developed. The aim of GloMo was to give office-environment Ethernet-type multimedia connectivity anytime, anywhere, in handheld devices. Channel access approaches were in the CSMA/CA and TDMA molds, and several novel routing and topology control schemes were developed. The NTDR used clustering and link- state routing, and self-organized into a two-tier ad hoc network. Now used by the US Army, NTDR is the only “real” (non-prototypical) ad hoc network in use today. The third generation evolved in 1990’s also termed as commercial network with the advent of Notebooks computers, open source software and equipments based on RF and infrared. IEEE 802.11 subcommittee adopted the term “ad hoc networks.” The development of routing within the Mobile ad-hoc networking (MANET) working group and the larger community forked into reactive (routes on- demand) and proactive (routes ready-to-use) routing protocols 141. The 802.1 1 subcommittee standardized a medium access protocol that was based on collision avoidance and tolerated hidden terminals, making it usable, if not optimal, for building mobile ad hoc network prototypes out of notebooks and 802.11 PCMCIA cards. HIPERLAN and Bluetooth were some other standards that addressed and benefited ad hoc networking. With the increase of portable devices with wireless communication, ad-hoc networking plays an important role in many applications such as commercial, military and sensor networks, data networks etc., Mobile ad-hoc networks allow users to access and exchange information regardless of their geographic position or proximity to infrastructure. Since Mobile ad-hoc networking (MANET) has no static infrastructure, it offers an advantageous decentralized character to the network. Decentralization makes the networks more flexible and more robust.

3 Preliminaries

Definition of Fuzzy Set:

Fuzzy set was introduced by Zadeh in 1965 [40] and it gives new trend in application of mathematics. Every value of the fuzzy set consisting of order pair one is true membership and another one is false membership which lies between 0 and 1. Several authors [30, 39, 21-23, 27, 29] used fuzzy set theory in ad-hoc network and wireless sensor network to solve routing problems. The logic in fuzzy set theory is vastly used in all fields of mathematics like networks, graphs, topological space …etc.

Definition:[9]Intuitionistic Fuzzy Set:

Intuitionistic Fuzzy Sets are the extension of usual fuzzy sets. All outcomes which are applicable for fuzzy sets can be derived here also. Almost all the research works for fuzzy sets can be used to draw information of IFSs.

Further, there have been defined over IFSs not only operations similar to those of ordinary fuzzy sets, but also operators that cannot be defined in the case of ordinary fuzzy sets.

Definition:[17,24] Adroit System:

Adroit system [17, 24] is a computer program that efforts to act like a human effect in a particular subject area to give the solution to the particular unpredictable problem. Sometimes, adroit systems are used instead of human minds. Its main parts are knowledge based system and inference engine. In that the software is the knowledge based system which can be solved by artificial intelligence technique to find efficient route. The second part is inference engine which processes data by using rule based knowledge.

Definition:[34] Neutrosophic Set:

A neutrosophic set is a triplet which contains a truth membership function, a false membership function and indeterminacy function. Many authors extended this neutrosophic theory in different fields of mathematics such as decision making, optimization, graph theory etc.,[3-16, 42-52]. In particular, with the best knowledge, this is the first time to calculate efficient energy protocol for MANET based on the neutrosophic technique.

Let U be the universe. The neutrosophic set A in U is characterized by a truth-membership function T_A, a indeterminacy-membership function I_A and a falsity-membership function F_A. $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard elements of [0,1]. It can be written as

$$A_{NS} = \{< T_A(x), I_A(x), F_A(x) >, x \in U, T_A(x), I_A(x), F_A(x) \in \left]^-0,1^+\right[,\} \qquad (1)$$

There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and F (x). So $0^- \leq T_A(x)+I_A(x)+F_A(x) \leq 3^+$.

Definition:[35] Let U be a universe of discourse and A the neutrosophic set A ⊂ U. Let $T_A(x), I_A(x), F_A(x)$ be the functions that describe the degree of membership, indeterminate membership and non-membership respectively of a generic element x ∈ U with respect to the neutrosophic set A. A single valued neutrosophic overset (SVNOV) A on the universe of discourse U is defined as:

$$A_{SVNOV} = \{< T_A(x), I_A(x), F_A(x) >, x \in U, T_A(x), I_A(x), F_A(x) \in [0, \Omega]\} \qquad (2)$$

where $T_A(x), I_A(x), F_A(x)$: U $\rightarrow [0, \Omega]$, $0<1<\Omega$ and Ω is called overlimit. Then there exists at least one element in A such that it has at least one neutrosophic component >1and no element has neutrosophic component <0

Definition:[35]Let U be a universe of discourse and the neutrosophic set A⊂ U. Let $T_A(x), I_A(x), F_A(x)$ be the functions that describe the degree of membership, indeterminate membership and non-membership respectively of a generic element x ∈ U with respect to the neutrosophic set A. A single valued neutrosophic underset (SVNU) A on the universe of discourse U is defined as:

$$A_{SVNU} = \{< T_A(x), I_A(x), F_A(x) >, x \in U, T_A(x), I_A(x), F_A(x) \in [\Psi, 1]\} \qquad (3)$$

where $T_A(x), I_A(x), F_A(x)$: U $\rightarrow [\Psi, 1]$, $\Psi <0<1$ and Ψ is called lowerlimit.Then there exists at least one element in A such that it has at least one neutrosophic component<0 and no element has neutrosophic component >1

Definition:[35] Let U be a universe of discourse and the neutrosophic set A⊂ U. Let $T_A(x), I_A(x), F_A(x)$ be the functions that describe the degree of membership, indeterminate membership and non-membership respectively of a generic element x ∈ U with respect to the neutrosophic set A. A single valued neutrosophic offset (SVNOF) A on the universe of discourse U is defined as:

$$A_{SVNOF} = \{< T_A(x), I_A(x), F_A(x) >, x \in U, T_A(x), I_A(x), F_A(x) \in [\Psi, \Omega]\} \qquad (4)$$

where $T_A(x), I_A(x), F_A(x)$: U $\rightarrow [\Psi, 1]$, $\Psi <0<1<\Omega$ and Ψ is called underlimit while Ω is called overlimit. Then there exist some elements in A such that at least one neutrosophic component >1, and at least another neutrosophic component < 0

Example 1: Let A={(x_1,<1.2, 0.4,0.1>),(x_2 ,<0.2, 0.3,-0.7>)},since $T(x_1)$=1.2 >1 , $F(x_2)$= - 0.7 <0

Definition:[35]The complement of a single valued neutrosophic overset/ underset/offset A is denoted by C(A) and is defined by

$$C(A) = \{(x, < F_A(x), \Psi + \Omega - I_A(x), T_A(x) >, x \in U\} \quad (5)$$

Definition:[35]The intersection of two single valued neutrosophic overset/ underset/offset A and B is a single valued neutrosophic overset/ underset/offset denoted C and is denoted by C= A$\cap$ B and is defined by

$$C = A \cap B = \{(x, < \min(T_A(x), T_B(x)),\ \max(I_A(x), I_B(x)),\ \max(F_A(x), F_B(x))), x \in U\} \quad (6)$$

Definition:[35]The union of two single valued neutrosophic overset/ underset/offset A and B is a single valued neutrosophic overset/ underset/offset denoted C and is denoted by C= A$\cup$ B and is defined by

$$C = A \cup B = \{(x, < \max(T_A(x), T_B(x)),\ \min(I_A(x), I_B(x)),\ \min(F_A(x), F_B(x))), x \in U\} \quad (7)$$

The following table 1, describe the neutrosophic oversets, neutrosophic undersets, neutrosophic offsets and Single valued neutrosophic sets

Types of neutrosophic sets	Ψ **(under limit)**	Ω **(overlimit)**
neutrosophic oversets	0	1<Ω
neutrosophic undersets	Ψ <0	1
neutrosophic offsets	Ψ <0	1<Ω
Single valued neutrosophic sets	0	1

Table 1. Some type of neutrosophic sets

It can be observed that, the algebra of neutrosophic set provides an independent way to deal with indeterminacy beyond the truth and false membership-values of a vague set. However characterizing the distance of routing protocol in MANET based on its truth, falsity and indeterminacy membership-values is complex problem. To deal with this problem, one of the algorithms is proposed in the next section with an illustrative example.

4 PROPOSED PROTOCOL

In this section, a method is proposed to characterize the efficient routing path in MANET based on the neutrosophic technique using energy and distance. In this proposed protocol, energy function may be low, medium and high and also in a similar way distance may be short, medium and long. To represent these levels a neutrosophic set based membership function μ , Indeterminacy σ and non-membership γ is defined in this paper.

All these energy membership functions $E_L, E_M and E_H$ and distance membership functions $D_S, D_M and D_L$ are given in Table 2 and Table3.

Linguistic value	**Notation**	**Neutrosophic range**	**Basic value**
Low	E_L	(E_L^+, E_L^0, E_L^-)	(0,0.9,1.8)
Medium	E_M	(E_M^+, E_M^0, E_M^-)	(1.8,2.7,3.5)
High	E_H	(E_H^+, E_H^0, E_H^-)	(3.5,4.4,5)

Table 2. A neutrosophic set based representation of energy function

Linguistic value	**Notation**	**Neutrosophic range**	**Basic value**
Short	Ds	(DL+,DL0,DL-)	(0,9,17)
Medium	DM	(DM+,DM0,DM-)	(17,26,34)
Large	DL	(DH+,DH0,DH-)	(34,42,50)

Table 3. A neutrosophic set based representation of distance function

The a single valued neutrosophic overset/ underset/offset are characterized by three memberships, the truth-membership, indeterminacy-membership and false membership functions as described in definitions above.

It gives an interpretation of membership grades. Low, medium and high of the energy and distance functions are written as follows:

Neutrosophic Energy function values:

$\mu(E_L)$ = (0.3, 0.7, 1.2), $\mu(E_M)$ = (1.4, 2.3, 3), $\mu(E_H)$ = (3.2, 4, 4.8)

$\sigma(E_L)$ = (0.4, 0.9, 1.4), $\sigma(E_M)$ = (1.3, 2.6, 3.2), $\sigma(E_H)$ = (3.4, 3.8, 4.6)

$\gamma(E_L)$ = (0.2, 0.6, 1.4), $\gamma(E_M)$ = (1.2, 2.5, 3.4), $\gamma(E_H)$ = (3, 4.2, 4.5)

Neutrosophic Distance function values:

$\mu(D_s)$ = (0.2, 4, 10), $\mu(D_M)$ = (12, 20, 32), = (30, 38, 44)

$\sigma(D_s)$ = (0.5, 5, 12), $\sigma(D_M)$ = (10, 23, 30), $\sigma(D_L)$ = (29, 41, 49)

$\gamma(D_s)$ = (0.3, 6, 8), $\gamma(D_M)$ = (14, 21, 28), $\gamma(D_L)$ = (32, 40, 47)

Recently, several authors tried to deduce the neutrosophic values in various fields [40]. The current paper tried most suitable and ideal solution deduced by considering true members function μ for the better solution. These neutrosophic values are used for efficient route selection in MANET which is given below in table 3. By comparing different routes of the MANET, rating of the route is calculated by the Eq. 8 as given below:

$$NR_{i,j} = {meanof \quad \mu(E_i)} \Big/ {meanof \quad \mu(D_i)} \qquad (8)$$

From the rating of different route given in Table 4, each value of $NR_{i,j}$ is a neutrosophic route having different values which determine the nature of the route in MANET.

S.No	Neutrosophic possible route
1	If Energy is $\mu(E_L)$ and (Distance is $\mu(D_s)$,then the route is R1.
2	If Energy is $\mu(E_L)$ and (Distance is $\mu(D_M)$, then the route is R2.
3	If Energy is $\mu(E_L)$ and (Distance is $\mu(D_L)$,then the route is R3.
4	If Energy is $\mu(E_M)$ and (Distance is $\mu(D_s)$,then the route is R4.
5	If Energy is $\mu(E_M)$ and (Distance is $\mu(D_M)$,then the route is R5.
6	If Energy is $\mu(E_M)$ and (Distance is $\mu(D_L)$,then the route is R6.
7	If Energy is $\mu(E_H)$ and (Distance is $\mu(D_s)$,then the route is R7.
8	If Energy is $\mu(E_H)$ and (Distance is $\mu(D_M)$,then the route is R8.
9	If Energy is $\mu(E_H)$ and (Distance is $\mu(D_L)$,then the route is R9.

Table 4. A neutrosophic technique based efficient route selection

Route number	Neutrosophic Rating of route	Enlightenment of Rating
R1	0.154929	Good
R2	0.034375	Bad
R3	0.019642	Very Bad
R4	0.471830	Excellent
R5	0.104687	Poor
R6	0.059821	Very poor
R7	0.873239	Very excellent
R8	0.19375	Very good
R9	0.110714	Medium

Table 5. Enlightenment of rating of different routes in Neutrosophic Technique

Hence, each neutrosophic route has a specific rating in MANET. Table 4 provides a way to defined different neutrosophic routes by considering various energy functions and as well as distance functions. Following that the sequences of different routes based on their rating is given in Table 5. The decreasing order according to rating on the routes is R3 < R2< R5 < R9 < R1 <R8 < R4 < R7.Table 5 represents that based on neutrosophic ordering defined by the proposed method route R7 is one of the best energy efficient route among them for the given MANET.

5 Comparative Analysis

While comparing vague set and neutrosophic set, vague set is equivalent to intuitionistic fuzzy set because both of them having only truth and false membership functions. Also neutrosophic set is the generalization of fuzzy and intuitionistic fuzzy sets. Hence the results obtained by using neutrosophic set is better than the results obtained by using vague set. In this section, the comparative analysis among neutrosophic and vague set based routing protocol is discussed. The membership values of energy and distance functions of vague set Manet and neutrosophic set Manet are given in Table 6. Comparison between Vague set rating of route (VSR) and Neutrosophic rating of route (NRR) are given in Table 7.

Table 6. Membership values of energy and distance function

Notation	Base Value of Energy function		Notation	Base Value of Distance function	
	VM	NM		VM	NM
EL	(0,1.8)	(0,0.9,1.8)	Ds	(0, 17)	(0,9,17)
EM	(1.8, 3.5)	(1.8,2.7,3.5)	DM	(17, 34)	(17,26,34)
EH	(3.5, 5)	(3.5,4.4,5)	DL	(34, 50)	(34,42,50)

Table 7. Comparison between Vague Set Rating of route(VSR) and Neutrosophic Rating of route (NRR):

Route number	Vague Set Rating of route(VSR)	Neutrosophic Rating of route (NRR)	Enlightenment of Rating	
			VSR	NRR
R1	0.011842	0.154929	Very Bad	Good
R2	0.021176	0.034375	Bad	Bad
R3	0.105882	0.019642	Satisfactory	Very Bad
R4	0.059211	0.471830	Medium	Excellent
R5	0.105882	0.104687	Less Good	Poor
R6	0.529412	0.059821	Good	Very poor

R7	0.1	0.873239	Very good	Very excellent
R8	0.178824	0.19375	Excellent	Very good
R9	0.894118	0.110714	Very excellent	Medium

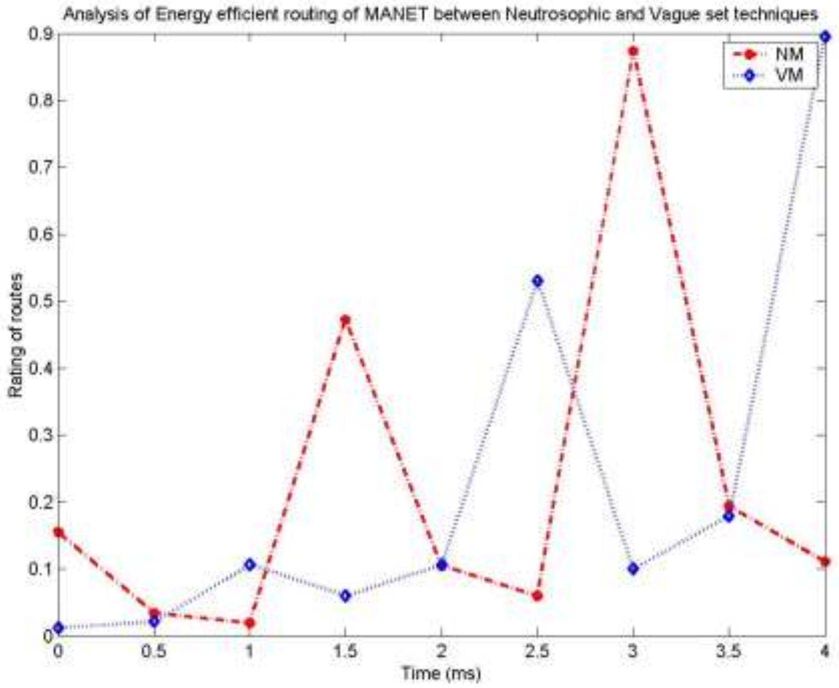

Figure. 1: The comparison of energy efficient MANET using neutrosophic and vague set

The graph for rating of routes of MANET using neutrosophic set and vague set techniques are plotted in Figure 1 for the values of energy functions and distance functions by using Table 6 and Table 7 with the help of Matlab software. It provides an information that, the efficient energy routing of mobile ad-hoc network using neutrosophic set technique(NM) is much better than the efficient energy routing of MANET using vague set technique(VM) in uncertain environment. However, the proposed method is focused on static environment in case the node and data set changes at each interval of time then the proposed unable to represent the case precisely. To deal with dynamic environment author will focus in near future to introduce the extensive properties of neutrosophic set and its applications to wireless ad-hoc network(WANET), flying ad-hoc network(FANET) and vehicular ad-hoc network(VANET).

Conclusion and future work

This paper utilizes properties of single valued neutrosophic for finding an efficient routing protocol for MANET based on distance and energy. In this regard, several algorithms are proposed to characterize it based on truth and falsity membership-values of a defined vague set. However the current paper aimed at dealing with uncertainty in routing protocol of MANET based on its truth, falsity and indeterminacy membership-values, indeterminacy. It is shown that the proposed method provides a precise representation and selection of energy efficient routing protocol when compared to vague sets as shown in Table 6 and 7. In future, the authors will focuses on investigating the energy efficient routes for WANET, FANET, VANET for dynamic environment

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