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INTELLIGENT AND EFFICIENT ROUTING FOR MANET: A SOFT COMPUTING TECHNIQUE

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Abstract: - Mobile Ad-hoc Network (MANET) is a dynamic infrastructure less wireless network. Each node of this network operated by battery with limited capacity. Thus, energy consumption is a vital issue in the design of new routing protocol. So in this paper, we propose an approach using soft computing technique. The basic idea of this approach is to select best path in term of energy efficiency.

Keywords*:* MANET, Intelligence System, Energy Efficiency, Fuzzy logic.

1. Introduction

In modern era, application of Mobile Ad-hoc Network (MANET) increases rapidly. It used in various sector of life such as E-commerce, Multi-media, Disaster management etc. [1], [2], [3], [4]. MANET [5], [6] is composed of more than one mobile nodes which can move freely in an infrastructure-less environment. It does not have centralized controllers, which makes it different from traditional wireless networks. Mobile nodes can typically move in any direction they want due to its dynamic nature. The main role of this node is not only responsible for network traffic but also has to forward packet. Therefore, dynamic topology, unstable links and limited energy are special features for MANET when compared to wired networks. But a vital problem in MANET is finding an energy efficient route between source and destination node.

The framework of the proposed protocol in based on intelligent system that control by fuzzy logic system. This intelligent system takes three parameters such as hop count, packet and energy to resolve energy efficiency issue in routing. The main advantage of this protocol is that intelligent system divide entire route in two categories A and B. Category A contains the routes those having same linguistic behavior and Category B contains the routes those having different linguistic behavior. Finally, it assigns priority to each route based on some priority scale. The range of all priorities is divided between 0 and 1. This priority statistic helps to determine energy efficient route.

Rest of this paper is organized as follows: Section 2 provides related work done in energy efficient routing for ad-hoc network. Section 3 addresses the preliminaries related to the proposed method. The details of proposed method describes in section 4. Finally, Section 5 concludes the paper with future work.

2. Related Works

Several studies have dealt with measuring energy consumption in the wireless interfaces of mobile nodes such as Kumar et al. [7] proposed an energy consumption model for wireless ad-hoc network using fuzzy set theory. In this proposed method, three input parameters are used such as packet, distance and energy to evaluate route lifetime of the network. It evaluated by NS-2 and MATLAB and justify it effectiveness with existing approaches. Das and Sachin Tripathi [8] proposed an energy efficient routing protocol for MANET based on vague set. Vague set is also known as extended fuzzy set. Two parameters are used as extended fuzzy set such as energy and distance. The author extends this work in [9]. In this extended approach, the authors enhanced analysis parts of the proposal. Wang et al. [10] proposed a power-aware protocol to select a stable manager from mobile hosts by fuzzy based inference systems based on the factors of speed, battery power, and location. In the Power aware manager phase, the authors elect an appropriate power-aware manger to take care of the intra-cell and inter-cell tasks. This proposed protocol uses the multi mobile agent to divide the manager workload in the power aware multi mobile agent phase. Furthermore, the authors divided the multi mobile agents into two parts, the power-aware intra-mobile agent (PAI-MA) and power-aware inter-mobile agent (PIE-MA). The PIA-MA is responsible to support the workload of manager in intra-cell and the PIE-MA is responsible to inter-cell, but it has a limitation that hop count not consider here for managing the power of ad-hoc networks. In [11], El-Hajj et al. proposed a fuzzy based hierarchical energy efficient routing scheme (FEER) for large scale mobile ad-hoc networks that aims to maximize the network's lifetime. It aggregates the important parameters such as residual energy, traffic and mobility that characterize a wireless node to elect cluster heads and prolonged the network lifetime. Yu et al. [12] surveys and classifies the energy-aware routing protocols proposed for MANETs. They minimize either the active communication energy required to transmit or receive packets or the inactive energy consumed when a mobile node stays idle, but listens to wireless medium for any possible communication requests from other nodes. The authors describe two category first is former category that contain transmission power control and load distribution and another is latter category that contain sleep/power-down mode. In many situations, it is not clear that which particular algorithm is the best for this situation; each protocol has its own advantages or disadvantages. So authors facilitate the research efforts in combining the existing solutions to offer a more energy efficient routing mechanism. Gil Zussman and Adrian Segall [13] proposed a method to construct an ad-hoc network of wireless smart badges in order to acquire information from trapped survivors. Here the authors investigate the energy efficient routing problem that arises in such a network, and they have shown that since smart badges have very limited power sources and very low data rates, which is inadequate in an emergency situation. This problem is formulated as any cast routing problem in which the objective is to maximize the time until the first battery drains out.

3. Preliminaries

Some preliminaries are given which helps to understand proposed method in proper way:
Fuzzy logic [14], [15], [16], [17] is part of soft computing method [18], [19] which is a part of artificial intelligence technique [20], [21]. It was introduced by Zadeh [22] which became mathematical discipline [23] to express human reasoning in rigorous mathematical notation. It is a multi-valued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, small/big, short/long etc. Many authors [24], [25], [26], [27], [28] used fuzzy logic in ad-hoc network.
Fuzzy logic considers as an intelligent system [29] and has been shown to yield promising results for many applications that are difficult to be handled by conventional techniques [30], [31]. Fuzzy logic is used to convert crisp data to fuzzy data by the help of fuzzification method and process this data by the helps of inference engine after processing data convert it again into crisp data by the helps of defuzzification. Inference is an assumption or conclusion that is rationally and logically made, based on the given facts or circumstances. So it is based off of facts, so the reasoning for the conclusion is often logical. And inference engine is used to apply reasoning to compute fuzzy outputs. The main ethics of fuzzy logic system can easily implement human experiences and preferences vie membership functions and fuzzy rules, from a qualitative description to a quantitative description that is suitable to solve any complex problem. Fuzzy membership functions can have different shapes depending on the designer's preference and/or experience. The fuzzy rules [32], [33], which describe the control strategy in a human-like fashion, there are four modes of derivation of fuzzy control rules: (1) expert experience and control engineering knowledge, (2) behavior of human operators, (3) derivation based

on the fuzzy model of a process, and (4) derivation based on learning. These four modes do not have to be mutually exclusive. The basic architecture of fuzzy intelligent system is given in Fig 1.

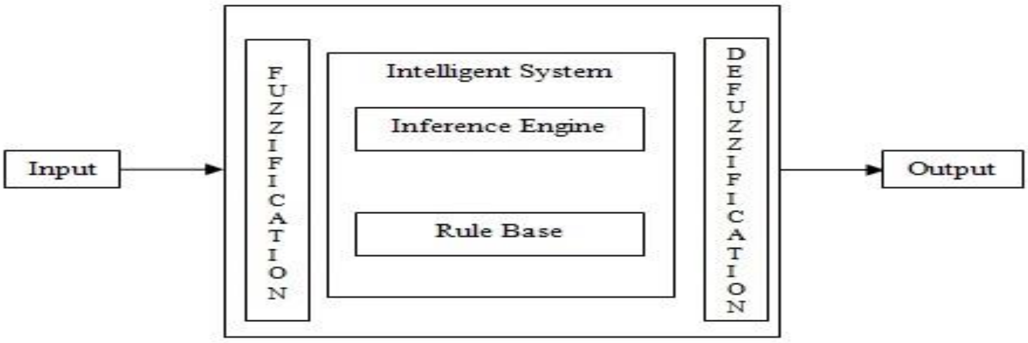

Figure 1: Architecture of fuzzy intelligent system.

4. Proposed Method

In MANET, there are different types of energy consumption that have been identified such as energy consumed while sending a packet, energy consumed while receiving a packet, energy consumed while in idle mode and energy consumed while in sleep mode which occurs when the wireless interface of the mobile node is turned off. It should be noted that the energy consumed during sending a packet is the largest source of energy consumption of all modes. Therefore, a source mobile node in the MANET has more than one route to each destination. But intelligent system should be select best route in term of priority statistic. Best route in term of priority statistic depend on three input variables such as minimum number of hop count, less number of transmitted packet and high residual energy and output variable priority scale.

In proposed routing protocol behaviour of routes can be categorized as two distinct parts first category is Category A: that contain routes of same linguistic behaviour and second category is Category B: that contain routes of different linguistic behaviour. The linguistic behaviour of each possible route determine by the linguistic behaviour of input parameters hop count, packet and energy. The details of linguistic behaviour of each input and output variables are given in Table 1, Table 2. The output variable priority scale is calculated by the help of Eq. 1.

Priority Scale = 1 – mean (input parameters)………….. (1)

where input parameters are hop count, packet and energy chosen by intelligent system for both categories. The pseudo code of proposed method is given in Algorithm 1.

The output parameter priority scale is based on two category which has calculated between range 0 and 1. Here, intelligent system evaluates priority scale for k routes, where k=m + n, here m denote total number of route of Category A and n denote total number of route of Category B. The details of both categories are given in Table 3 and Table 4.

Table 1: Linguistic behaviour of input variables

Linguistic Variable	Hop-Count	Packet	Energy
Very Low	H_{VL}	P_{VL}	E_{VL}
Low to Very Low	H_{LVL}	P_{LVL}	E_{LVL}
Low	H_{L}	P_{L}	E_{L}
Medium Low	H_{ML}	P_{ML}	E_{ML}
Medium	H_{M}	P_{M}	E_{M}
Medium High	H_{MH}	P_{MH}	E_{MH}
High	H_{H}	P_{H}	E_{H}
High to Very High	H_{HVH}	P_{HVH}	E_{HVH}
Very High	H_{VH}	P_{VH}	E_{VH}

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Table 2: Membership functions for priority scale

Linguistic Variable	Priority Scale	Range of Priority Scale
Very Low	PR_{VL}	(0,0,0.125)
Low to Very Low	PR_{LVL}	(0,0.125,0.25)
Low	PR_{L}	(0.125,0.25,0.375)
Medium Low	PR_{ML}	(0.25,0.375,0.5)
Medium	PR_{M}	(0.375,0.5,0.625)
Medium High	PR_{MH}	(0.5,0.625,0.75)
High	PR_{H}	(0.625,0.75,0.875)
High to Very High	PR_{HVH}	(0.75,0.875,1)
Very High	PR_{VH}	(0.875,1,1)

Algorithm 1: Proposed routing method

Step 1: START
Step 2: Initialize source and destination node
Step 3: Source node floods the request packet to its neighbour
Step 4: Non-destination node re-flood request
Step 5: Destination node determined three parameters for route such as hop count, packet and energy
Step 6: Destination node reply back to the source node with route parameters
Step 7: Assume that destination node return R1, R2, …… Rk routes
Step 8: Intelligent system determine priority scale based on two types route category such as same nature and different nature and different behavior)
Step 9: Assign priority scale to each member of the category for k route
Step 10: Finally source node selects two comparatively stable disjoint routes
Step 11: STOP

Table 3: Route details of Category A

Routes	HC	P	E
R_1	VL	VL	VL
R_1	LVL	LVL	LVL
. . .	. . .	. . .	. . .
R_m	VH	VH	VH

Table 4: Route details of Category B

Routes	HC	P	E
R_1	VL	other than VL	other than VL
R_2	LVL	other than LVL	other than LVL
. . .	. . .	. . .	. . .
R_n	VH	other than VH	other than VH

In this section, a hypothetic example is illustrates for proposed method. Table 5 is illustrates the detail values of Category A which having same linguistic nature. Data is taken my MATLAB simulator, here value of m is 9. Table 6 is illustrates the details of fuzzy suitability index and priority scale for Category A. And same is illustrates for Category B in Table 7 and Table 8 which highlight for dissimilar linguistic nature.

Table 5: Value of input parameters for Category A

Routes	HC	P	E
R_1	(0,0,0.125)	(0,0,0.125)	(0,0,0.125)
R_2	(0,0.125,0.25)	(0,0.125,0.25)	(0,0.125,0.25)
R_3	(0.125,0.25,0.375)	(0.125,0.25,0.375)	(0.125,0.25,0.375)
R_4	(0.25,0.375,0.5)	(0.25,0.375,0.5)	(0.25,0.375,0.5)
R_5	(0.375,0.5,0.625)	(0.375,0.5,0.625)	(0.375,0.5,0.625)
R_6	(0.5,0.625,0.75)	(0.5,0.625,0.75)	(0.5,0.625,0.75)
R_7	(0.625,0.75,0.875)	(0.625,0.75,0.875)	(0.625,0.75,0.875)
R_8	(0.75,0.825,1)	(0.75,0.825,1)	(0.75,0.825,1)
R_9	(0.875,1,1)	(0.875,1,1)	(0.875,1,1)

Table 6: The priority scale for Category A

Routes	Fuzzy suitability index	Priority scale
R_1	(0, 0, 0.125)	0.708333
R_2	(0, 0.125, 0.25)	0.708333
R_3	(0.125, 0.25, 0.375)	0.666667
R_4	(0.25, 0.375, 0.5)	0.625
R_5	(0.375, 0.5, 0.625)	0.583333
R_6	(0.5, 0.625, 0.75)	0.541667
R_7	(0.625, 0.75, 0.825)	0.483333
R_8	(0.75, 0.825, 1)	0.475
R_9	(0.875, 1, 1)	0.375

Table 7: Value of input parameters for Category B

Routes	HC	P	E
R_1	(0,0,0.125)	(0.125,0.25,0.375)	(0.125,0.25,0.375)
R_2	(0,0.125,0.25)	(0.125,0.25,0.375)	(0.25,0.375,0.5)
R_3	(0.125,0.25,0.375)	(0.625,0.75,0.875)	(0,0.125,0.25)
R_4	(0.25,0.375,0.5)	(0.5,0.625,0.75)	(0.625,0.75,0.875)
R_5	(0.125,0.25,0.375)	(0.125,0.25,0.375)	(0.5,0.625,0.75)
R_6	(0.5,0.625,0.75)	(0.75,0.825,1)	(0.875,1,1)
R_7	(0.625,0.75,0.875)	(0.25,0.375,0.5)	(0.125,0.25,0.375)
R_8	(0.75,0.825,1)	(0.875,1,1)	(0,0,0.125)
R_9	(0.875,1,1)	(0,0.125,0.25)	(0.75,0.825,1)

Table 8: The priority scale for Category B

Route	F	Priority scale
R_1	(0.083333, 0.166667, 0.291667)	0.680556
R_2	(0.125, 0.25, 0.375)	0.666667
R_3	(0.25, 0.333333, 0.5)	0.638889
R_4	(0.458333, 0.541667, 0.708333)	0.569444
R_5	(0.25, 0.375, 0.5)	0.625
R_6	(0.708333, 0.816667, 0.916667)	0.463889
R_7	(0.333333, 0.458333, 0.583333)	0.597222
R_8	(0.541667, 0.608333, 0.708333)	0.519444
R_9	(0.541667, 0.65, 0.75)	0.519444

By combining data of Table 6 and Table 8, we define some category of priority statistic which is given in Table 9. The range of each priority statistic belongs between 0 and 1. The priority statistic (i.e. i=1, 2,….13) may assume any linguistic variables that are listed as linguistic behavior as column in Table 9.

Table 9: Priority statistic table for route

Sl. no	Category of priority	Route members	Linguistic behaviour	Name of priority scaling
1	C_1	{ R_{11}, R_{12} }	Very Excellent	P_{VE}
2	C_2	{ R_{21} }	Excellent	P_E
3	C_3	{ R_{13}, R_{22} }	Very Good	P_{VG}
4	C_4	{ R_{23} }	Good	P_G
5	C_5	{ R_{14}, R_{25} }	Less Good	P_{LG}
6	C_6	{ R_{27} }	Fair	P_F
7	C_7	{ R_{15} }	Medium	P_M
8	C_8	{ R_{24} }	Satisfactory	P_S
9	C_9	{ R_{16} }	Less Poor	P_{LP}
10	C_{10}	{ R_{28}, R_{29} }	Poor	P_P
11	C_{11}	{ R_{17}, R_{18} }	Very Poor	P_{VP}
12	C_{12}	{ R_{26} }	Bad	P_B
13	C_{13}	{ R_{19} }	Very Bad	P_{VB}

From Table 10, the sequence of the priority of the different categories are selected as C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13 based their rating scale. Therefore, R11 and R12 are better than R19. In the multicast routing, the second selected route is R21.

5. Conclusion and Future Work

In this paper, illustrates energy efficient routing for ad-hoc network using intelligence technique. Fuzzy logic plays the role of intelligence technique by the help of fuzzification, defuzzification and inference engine. These phases are help to evaluate energy efficient route properly. In real life, all routes are not highly useful or acceptable in many situations. So, future work includes identify the statistic of the network based on different parameters and deciding some threshold statistic for rating priority to each routes. And evaluate it by the NS-2 simulate based on any energy efficient routing available in the simulator.

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