Vol-2, Issue-2 PP. 419-426 ISSN: 2394-5788

GLOBAL JOURNAL OF ADVANCED RESEARCH
(Scholarly Peer Review Publishing System)

Energy Consumption Model in Wireless Ad-hoc Networks using Fuzzy Set Theory

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ABSTRACT

Energy-saving is a critical issue for almost all kinds of portable devices. In this paper, we consider the design of energy-saving protocols for wireless ad-hoc network (WANETs) that allow ad-hoc node to select most suitable route which has enough energy and short distance with minimum number of queue length packet. The basic input parameters to evaluate energy efficient route lifetime are queue length packet, distance and energy. Based on the comprehensive simulation using MATLAB and NS2, it is observed that proposed routing protocol contributes to the performance improvements in terms of energy efficient routing based on three input parameters and one output parameter. Finally a comparison will be done with existing protocols and the simulation results shows that the protocol is quite efficient in regard both parameters.

Keywords

WANET, Fuzzy Set Theory, Energy Efficiency

1 INTRODUCTION

In modern era use of wireless network increases rapidly. There are many forms of pervasive networks. Therefore, most commonly it is called Wireless Ad-hoc Networks (WANETs). As such networks are based on wireless communication, they provide ease of access but in many instances they are considered less secure than other communication system. 'Ad hoc' means that, in such networks, users or 'nodes' are constantly communicating with each other. In other words, these networks are based on node-to-node communication. A node can be used either that desire certain features or dedicated equipment to manage the service. Based on the fundamental concepts of WANETs, many other categories have emerged. The most common are: wireless mesh networks, wireless sensor networks and Mobile Ad-hoc Networks (MANETs). MANETs are those networks that offer high levels of mobility for users and take many forms. One of the most useful forms of MANETs is VANETs. The hierarchy of WANET is given in Figure 1.

WANET [1-3] is a collection of autonomous wireless nodes that may move unpredictably forming a temporary network without any fixed base of infrastructure. In this network nodes are play not only the role of an end system but also acts as a router that forwards packets to desire destination nodes. These nodes are capable of both single and multi-hop communication. Mobility and the absence of any fixed infrastructure make WANETs very attractive for military and rescue operations, sensor networks and time-critical applications.

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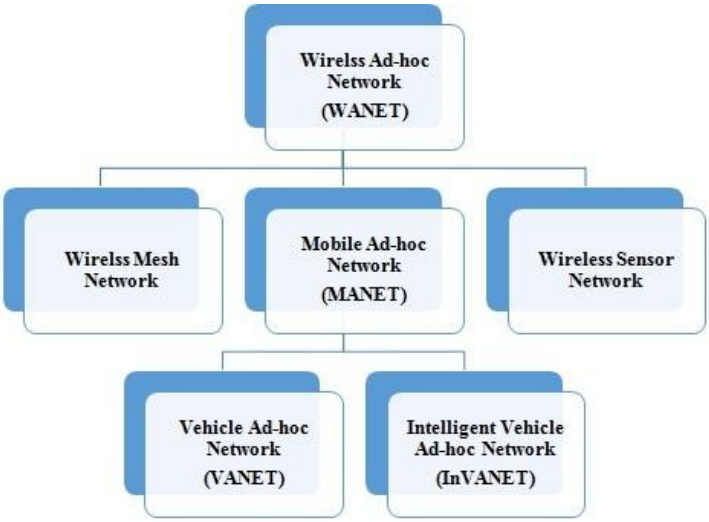

Fig 1: Hierarchy of wireless ad-hoc networks

The framework of proposed protocol based on fuzzy logic. This fuzzy logic system controls by decision maker to evaluate energy efficient route selection by input and output parameters.

Rest of paper is organized as follows; Section 2 illustrates the relevance of related work done in energy efficient routing in wireless network. Section 3 gives an idea about preliminaries of this proposed method. The proposed method is discussed in section 4. Section 5 presents simulation results of our approach and its effectiveness compared with other existing protocols. Finally, section 6 concludes the paper.

2 RELATED WORK

Energy efficient routing is the main challenges of the ad-hoc network. There have been a lots of work are done on energy efficient routing such as Rong Zheng and Robin Kravets [4] proposed an extensible on-demand power management framework for ad hoc networks. It is used for adapting traffic load. In this framework nodes maintain soft-state timers that determine power management transitions. These timers are set and refreshed on-demand by monitoring routing control messages and data transmission. And nodes that are not involved in data delivery may go to sleep. But it has a limitation that this framework does not considered load balancing issues because the correct policy for load balancing is depend on the communication goals of the network. Dario Pompili and Marco Vittucci [5] proposed PPMA, a new probabilistic predictive multicast algorithm for ad hoc networks that leverages the tree delivery structure for multicasting, overcoming its limitations in terms of lack of robustness and reliability in highly mobile environments. PPMA exploits the non-deterministic nature of ad hoc networks, by taking in account of the estimated network state evolution in terms of node residual energy, link availability and node mobility forecast to maximize the multicast tree lifetime. Huang et al. [6] proposed a traffic-load oriented power saving mechanism (TPSM) to save battery power. In this mechanism all hosts are dividing into clusters and classify the traffic load of a node into three weights (0, 1 and 2). Cluster head and gateways constitute the backbone of the network. They adopt the sleeping strategy weight = 2 for relaying the packets and other nodes dynamically adjust the sleeping strategy according to the traffic load analyzed by the clustered head. In order to save battery power, the nodes should turn their radios off when they have no packet to send or receive. Wang et al. [7] proposed swarm intelligence inspired based routing algorithm for MANET. In this algorithm, the network information

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can be collected and updated in a decentralized and dynamic way through the localized cooperation among these swarm agents. In this paper, first time the authors provide a comprehensive comparison about current swarm intelligence inspired routing algorithms in MANETs in the aspects of network metrics and simulation environment. Then the authors make a detailed study about the energy consumption of the swarm intelligence inspired routing problem in MANETs. Weifa Liang and Yuzhen Liu [8] proposed an energy-efficient on-line algorithm by considering on-line disjoint path routing. The main aim of this routing is to maximize the network capacity, i.e. maximize the number of messages routed successfully by the network without any knowledge of future disjoint path connection request arrivals and generation rates. Specifically, in this paper the authors first present two centralized on-line algorithms for the problem. One is based on maximizing local network lifetime, which aim to minimize the transmission energy consumption, under the constraint that the local network lifetime is no less than □ times of the optimum after the realization of each disjoint path connection request, where □ is constant with $0 < □ \leq 1$. Another is based on the exponential function of energy utilization at nodes, and the competitive ratio of this latter algorithm is also analyzed if admission control mechanism is employed. But it has a limitation that this algorithm does not consider which routes are more efficient and which are less efficient in the context of energy efficiency because energy efficient routing is also a part of maximizing the network capacity. Kalantari et al. [9] proposed a soft computing method (RWSN) for energy efficient routing in wireless sensor network. The main aim of this method determines reward of each route using reward function. This function determines which action has been good and which have been loaded. But it has a drawback that the proposed method does not considered queue length packet as parameters of energy efficient routing. Das et al. [10] proposed a soft computing method (ERPC) for energy efficient routing in wireless sensor network. The main aims of this method to demonstrate a strategy of power consumption system in wireless sensor network by using the concept of complete bi-partite graph. The basic parameters of this strategy are power and distance. Finally, it assigns priority to each route and determines the best and worst routing in wireless sensor network. But it has a limitation that the proposed method does not consider queue length packet as a parameters of energy efficient routing. Because energy efficient routing is not considering only energy and distance, it also covers hop count. Das et al. [11] proposed a method (IECR) for energy efficient routing in wireless sensor network. The main aims of this method to generate some values for each and every route based on fuzzy inference engine. These values determine the different nature of the routes. Therefore, this value helps to determine which route is best and which route is worst for routing in term of energy efficiency. But it has a limitation that the proposed method does not considered queue length packet as a parameters of fuzzy inference engine. Because energy efficient routing cannot determines by using two parameters such as energy and distance.

However, none of the above methods address the energy efficient routing and network lifetime issues together. In the proposed method, we consider both these issues based on parameters queue length packet, distance and energy. The main advantage of this proposed method decision maker select and reject the route based on knowledge of inference system. So it helps to repair and maintain routes completely before they crashed.

3 PRELIMINARIES

In this section some preliminaries are discussed which serves as an important role to design this protocol. The short descriptions of these preliminaries are given below:

3.1 Fuzzy logic

The fuzzy set theory [12-20] is a theory of graded concepts. It is the extension of conventional set theory and handles the concept of partial truth between completely true and completely false. In the real life, the human brain processes many fuzzy attributes (Large, Long, Small, Good, Tall, Expensive, Sporty, Costly, Intelligent, old, young, Superior, Genius etc.) as comparative interpretations. One of the most important facts about the analytical capacity of human brain is its ability to summarize information into labels of fuzzy sets, which bear an approximate relation to the primary data. Human reasoning is not based on a two-valued logic or even a multi-valued logic, but a fuzzy logic. A large part of fuzzy logic is the concept of fuzzy sets.

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3.2 Energy efficiency

WANET is highly active and distributed in nature as the nodes are powered by batteries with limited capacity. Since these energy sources have a limited lifetime, energy availability is one of the most important constraints for the operation of the WANET. There are different sources of energy consumption in an ad-hoc network node. The energy consumption occurred due to sending a packet, receiving a packet, the node when idle mode and the node when sleep mode which occurs when the wireless interface of the node is turned off. And power failure of a node not only affect the node itself but also its ability to forward packets on behalf of others and thus the overall network lifetime. Therefore, energy efficiency indicates to reduce the amount of energy required to provide some operations in WANET.

4 Proposed protocol FIEE

Transmission of information from one node to another node carried out under best circumstances. The word best circumstance is precisely defined by decision maker. It is the node (at appropriate distance chosen by decision maker from destination) having enough power and minimum queue length packet. In this proposed method queue length packet is 56, distance is 150 meter and energy is 7.5 joule. These three input parameters are linguistic variable assuming multiple values. The state of each route determined by membership function of three input parameters and one output parameter which are given in Table 1, Table 2, Table 3 Table 4.

Table 1: Membership function of queue length packet

Linguistic Values	Notation	Range
Low	L_Q	(0, 0, 16)
Medium	M_Q	(4, 20, 36)
High	H_Q	(24, 40, 56)

Table 2: Membership function of distance

Linguistic Values	Notation	Range
Low	L_D	(0, 0, 50)
Medium	M_D	(0, 50, 100)
High	H_D	(50, 100, 150)

Table 3: Membership function of energy

Linguistic Values	Notation	Range
Low	L_E	(0, 0, 2.5)
Medium	M_E	(0, 2.5, 5)
High	H_E	(2.5, 5, 7.5)

Table 4: Membership function of lifetime

Low	Medium	High
L_{LT}	M_{LT}	H_{LT}

In above four memberships function defined corresponding to each input parameters (queue length packet, distance and energy) and one output parameter WANET lifetime. Each input parameters directly effect to the lifetime (LT) of WANET. Queue length packet is an evaluation parameter for Lifetime of WANET. When the queue length packet is high, the probability of route broken is also high. Therefore, consequently the rules should be as follows:

Q1: If Queue length is HQ, then LT is LLT.
Q2: If Queue length is MQ, then LT is MLT.
Q3: If Queue length is LQ then LT is HLT.

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Distance is also an evaluation parameter for Lifetime of WANET. When the distance is high, the probability of route broken is also high. Therefore, consequently the rules should be as follows:

D1: If Distance is HD, then LT is LLT.
D2: If Distance is MD, then LT is MLT.
D3: If Distance is LD then LT is HLT.

If the energy is low, the probability of the link broken will be high. Thus, the rules for the relationship between energy and lifetime should be as follows:

E1: If Energy is HE, then LT is HLT.
E2: If Energy is ME, then LT is MLT.
E3: If Energy is LE then LT is LLT.

Contrarily to the relationships between queue length and LT and between distance and LT, the LT is a direct ratio to the energy. Considering the former two criteria, the membership function for energy criterion should be considered as the dimensionless index [0, 1]. Based on the concept of reverse energy is limit, so reverse energy defined by reverse conversion of above first two fuzzy implications. Therefore, based on three input parameters, one output parameter and the concept of reverse energy the fuzzy rule matrix is evaluated for route selection which is given in Table 5.

Table 5: Fuzzy rule matrix for route selection

Rule No	Energy	Queue	Distance	Selection
R1	H	L	L	ACCEPT
R2	M	M	M	ACCEPT
R3	L	H	H	REJECT
R4	L	L	M	REJECT
R5	L	M	L	REJECT
R6	L	L	H	REJECT
R7	L	H	L	REJECT
R8	M	M	H	ACCEPT
R9	M	H	M	ACCEPT

From Table 5, the sequence of the priority of the routes to be accepted are R1, R2, R9 and R8, and other route should be rejected by decision maker.

5 SIMULATION RESULTS AND ANALYSIS

The simulation of proposed method is done by MATLAB and NS2. MATLAB is used to coded fis-file for WANET route lifetime. Four fis-file coded for RWSN, ERPC, IECR and proposed protocol. Each and every fis-file coded based on input and output parameter. Some m-files are coded to evaluate each fis-file and generate defuzzification values. These values are used to compare result of proposed protocol with existing protocol RWSN, ERPC, IECR by X-graph utility of NS2. The final performances of the proposed method with other protocols are shown is Fig 2, Fig 3 and Fig 4. Fig 2 illustrates route selection of different protocol. Fig 3 illustrate surface diagram of route selection of proposed protocol. And Fig 4 is illustrating ratio of route selection of different protocols.

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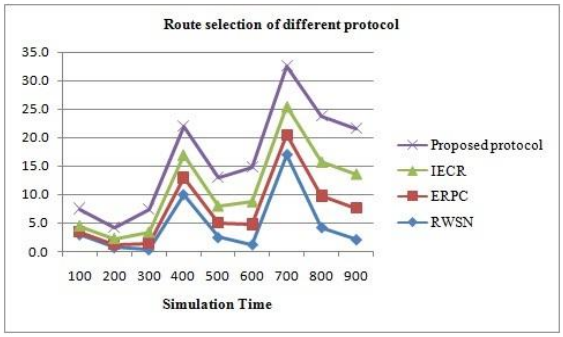

Fig 2: Route selection of different protocol.

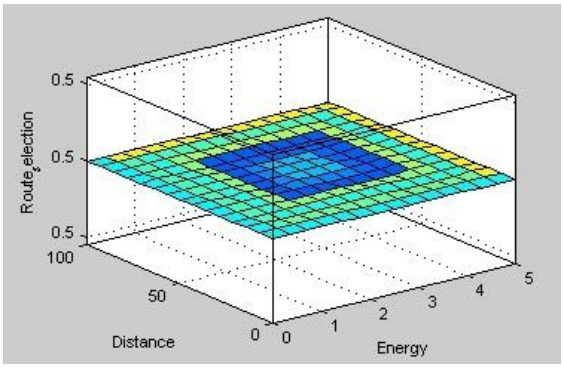

Fig 3: Surface diagram of route selection of proposed protocol.

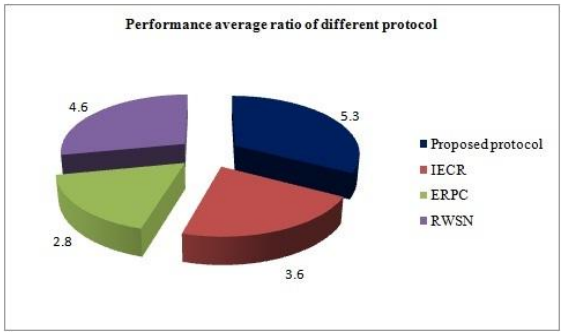

Fig 4: Ratio of route selection of different protocols.

6 CONCLUSION AND FUTURE WORK

Routing in WANET has concerned a lot of devotion in the recent years and introduced unique challenges compared to traditional data routing in wired networks. So reducing energy consumption is the most important concern based on others evaluation parameters of WANET. So fuzzy logic derive from fuzzy set theory as an intelligent tools shows great

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compatibility with WANETs characteristic and can be applied in different energy conservation scheme of them. In real world required real-time energy saving in WANET to achieve real-time communication. So with the growing demand for real time operations in WANET this paper deals with queue length packet, distance and energy as input parameters to evaluate lifetime of WANET for reducing energy consumption scheme by using fuzzy logic.

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