INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATIONS AND ROBOTICS
www.ijrcar.com
Vol.5 Issue 1, Pg.: 19-23
January 2017

INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATIONS AND ROBOTICS
ISSN 2320-7345

FUZZY FITNESS FUNCTION BASED ENERGY EFFICIENT ROUTING IN WIRELESS AD-HOC NETWORK

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Abstract: - A Wireless Ad-Hoc Network (WANET) is a decentralized type of wireless net-work. The network is ad-hoc because it does not depend on the pre-existing infra-structure such as routers or access points. Each node participates in routing by forwarding data to other nodes. So the determination of which nodes forward da-ta is made dynamically on the basis of network connectivity. The main problem of this network is energy efficiency because nodes are operated on limited battery resource which is insufficient in any real life applications. Hence, the present paper proposes a routing fuzzy fitness function based energy efficient routing. The basic idea of this paper is to select the optimal path which reduces energy expenditure of WANET nodes based on fitness function. This technique is mainly enhanced the lifetime of WANET with respect to energy efficiency by calculating fitness function of each route.

Keywords: Wireless ad-hoc network. Fuzzy logic. Fitness function. Energy efficiency.

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1. Introduction

Wireless Ad-Hoc Network (WANET) [1], [2] is a collection of various devices such as lap-tops, PDAs and sensors that are collectively known as the node of WANET. Every node of this network is communicated to each other wirelessly within a comparatively limited area. These nodes can typically move in any direction they want due to its dynamic nature [3], [4], [5]. Therefore, every node has to perform the functions of a router, if some nodes die early due to lack of energy; it will not be possible for other nodes to communicate with each other. Hence, the network will get disconnected and the net-work lifetime will be adversely affected. Network lifetime is in general defined as the time interval the network is able to perform the sensing functions and to transmit data to the destination. During the network lifetime, some nodes may become unavailable due to various reasons such as physical damage, lack of power resources or additional nodes might be deployed. Therefore, the main design goal of ad-hoc net-work is not only to transmit data from the source to the destination, but also to increase the lifetime of the network [6], [7]. This can be achieved by employing energy efficient routing protocol.

The framework of the proposed routing protocol based on parameter energy and distance. These two parameters are used to find out the fitness of each and every route in an ad-hoc network. This fitness value helps to determine the statistic of the routes. Based on the simulation and comparative study with other existing protocol, it is observed that proposed routing protocol contributes to the performance improvements.

The rest of this paper is organized as follows: Section 2 provides related work done in energy efficient routing protocol for wireless ad-hoc networking. Section 3 addresses the preliminaries related to the proposed protocol. Details of the proposed protocol are described in section 4. Finally, Section 5 concludes the paper and future work is illustrates.

2. Related Works

Energy efficient routing is the main challenges of the ad-hoc network. There have been lots of work is done with energy efficient routing such as Gil Zuss-man and Adrian Segall [8] proposed a method to construct an ad-hoc network of wireless smart badges in order to acquire information from trapped survivors. Here the au-thors 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. Yu et al. [9] surveys and classifieds, 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 the wireless medium for any possible communication requests from other nodes. The authors describe two categories first are the former category that contains transmission power control and load distribution and another is the latter category that contains 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. Su et al. [10] proposed the fuzzy logic modified AODV routing (FMAR) protocol for multicast routing in mobile ad hoc networks. The main aim of this protocol is dynamically evaluate the active routes based on fuzzy. But it has a drawback that the proposed protocol didn't calculate rating values of all possible routes, it selects specific routes only, so it cannot be determined which routes are highly useful.

In an ad-hoc network, there are different uncertainties of nodes such as mobility, draining of battery power, energy consumption, etc. So, none of the above method addresses the uncertainties of node and solve the energy efficiency and network life-time issue together. In this paper, both issues are considering the uncertainty problem.

3. Preliminaries

In this section, some preliminaries are discussed which serves as an important role in designing this method. Short descriptions of these preliminaries are given below:

3.1. Fuzzy Logic

Fuzzy logic [11], [12] is a part of soft computing [13], [14] as well as artificial intelligence [15], [16]; it was introduced by Zadeh [17] which became a mathematical discipline [18] 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 etc. Many authors [19], [20], [21], [22] used fuzzy logic in ad-hoc network and wireless sensor network to solve routing problems.

3.2. Fitness Function

The Fitness function is a particular type of objective function that is used to evaluate how good a hypothesis and fitness threshold is used to determine a minimum acceptable hypothesis. In this proposed protocol fitness function is used to determine the robustness of the route based on energy efficiency. This fitness function is also helping to determine the priority of each route in an ad-hoc network that helps to select optimal route and next to the optimum route for packet transmission.

4. Proposed Method

Energy efficiency is a significant area of research in WANET. In this network, the uncertainty of nodes is mainly due to their mobility, draining of battery power and energy consumption. This problem effect various application areas such as E-commerce, Disaster etc. [23]. One way of handling this uncertainty is to prevent nodes from failure through the energy efficient routing. This can be achieved by the soft computing techniques. In this proposed method, fuzzy logic works as an intelligent techniques to handle unicast, multipath as well as broadcast by evaluating the fitness value of each route with the help of input parameters energy and distance [24], [25. Therefore, in this method a source node selects the best route in term of the remaining route lifetime. Best route in term of the remaining route lifetime depends on the fitness value of the route. The membership functions of input variables are given in Table 1 and Table 2. In Table 1 and Table 2 ranges of linguistic values EL-, EL, EL+, DS-, DS, DS+ and so on are defined as increasing in nature. The fitness value is calculated by using a fitness function which is given in Eq. 1. The possible linguistic behavior of different fitness values is given in Table 3.

Fitness function (F) =1-mean of fuzzy index ....(1)

where fuzzy index contains three basic linguistic elements such as low, medium and high for first input parameter energy and short, medium and long for second input parameter distance.

Table 1: Membership functions for Energy

Linguistic value	**Low**	**Medium**	**High**
Notation	EL	EM	EH
Range	(EL-, EL, EL+)	(EM-, EM, EM+)	(EH-, EH, EH+)
Range Value	(0, 0, 0.4)	(0.1, 0.5, 0.9)	(0.6, 1, 1)

Table 2: Membership functions for Distance

Linguistic value	**Low**	**Medium**	**High**
Notation	DS	DM	DL
Range	(DS-, DS, DS+)	(DM-, DM, DM+)	(DL-, DL, DL+)
Range Value	(0, 0, 0.4)	(0.1, 0.5, 0.9)	(0.6, 1, 1)

Table 3: Linguistic value for Fitness Function

Linguistic value	**Notation**
Very Bad	FVB
Bad	FB
Less Bad	FLB
Satisfactory	FS
Medium	FM
Less Good	FLG
Good	FG
Very Good	FVG
Excellent	FE

In Table 4, rule-base is designed to evaluate the fitness value of each and every route. In Table 1 and Table 2 three types linguistic values are given. So total possible alternative routes are 3 X 3 =9. Each and every rule-base indicates the nature of routing in ad-hoc network. Correspondence range values are given in Table 5. And mean of fuzzy index and their fitness value evaluated in Table 6.

Table 4: The nature of input parameters for different alternative routes

Route	**Energy**	**Distance**
R1	EH	DS
R2	EH	DM
R3	EH	DL
R4	EM	DS
R5	EM	DM
R6	EM	DL
R7	EL	DS
R8	EL	DM
R9	EL	DL

Table 5: The value of the alternative routes

Route	Energy	Distance	Route	Energy	Distance
R1	(0.6, 1, 1)	(0, 0, 0.4)	R6	(0.1, 0.5, 0.9)	(0.6, 1, 1)
R2	(0.6, 1, 1)	(0.1, 0.5, 0.9)	R7	(0, 0, 0.4)	(0, 0, 0.4)
R3	(0.6, 1, 1)	(0.6, 1, 1)	R8	(0, 0, 0.4)	(0.1, 0.5, 0.9)
R4	(0.1, 0.5, 0.9)	(0, 0, 0.4)	R9	(0, 0, 0.4)	(0.6, 1, 1)
R5	(0.1, 0.5, 0.9)	(0.1, 0.5, 0.9)			

Table 6: The fitness value of alternative routes

Route	Fuzzy index	Mean of fuzzy index	Fitness value
R1	(0.3, 0.5, 0.7)	0.5	0.5
R2	(0.35, 0.75, 0.95)	0.6833	0.3167
R3	(0.6, 1, 1)	0.8666	0.1334
R4	(0.05, 0.25, 0.65)	0.3166	0.6834
R5	(0.1, 0.5, 0.9)	0.5	0.5
R6	(0.35, 0.75, 0.95)	0.6833	0.3167
R7	(0, 0, 0.4)	0.1333	0.8667
R8	(0.05, 0.25, 0.65)	0.3166	0.6834
R9	(0.3, 0.5, 0.7)	0.5	0.5

Table 7: The fitness value of alternative routes

Route	Fitness value	Linguistic value	Notation
R7	0.8667	Very Good	FVG
R4	0.6834	Good	FG
R8	0.6834	Good	FG
R1	0.5	Medium	FM
R5	0.5	Medium	FM
R9	0.5	Medium	FM
R2	0.3167	Bad	FB
R6	0.3167	Bad	FB
R3	0.1334	Very Bad	FVB

In Table 7, routes are arranged based on their fitness value. The highest fitness value is shown in the first and the lowest fitness value shown in the last. Therefore, routes according to their fitness values are R7 > (R4, R8) > (R1, R5, R9) > (R2, R6) > R3. In energy efficient routing R7 is the optimal route and R4 or R8 is next to the optimum route.

5. Conclusion and Future Work

In this paper, we use fuzzy logic and a fitness function as a soft computing technique for designing this proposed protocol. The fuzzy logic is basically used to calculate fitness value of each route. This fitness value helps to define the nature of the route such as which route is efficient with respect to energy. It also helps to increase the lifetime of the network. The future work includes identifying the statistic of network lifetime based on different parameters and deciding some threshold statistic for fitness to each route. After a certain period review all data for determining that what threshold values are most favourable for energy efficient routing. And finally, choose the optimal energy efficient routes and also next to optimal energy efficient routes according to the network statistic.

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