Optimization of Hello Messaging Scheme in MANET On-Demand Routing Protocol Using PSO

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Abstract - Mobile Ad hoc Network (MANET) is an autonomous, self-configuring and infrastructure-less system in which various mobile nodes are connected by wireless links. In MANETs hello messages are periodically exchanged to maintain the connectivity of neighbour nodes. While discovering neighbour nodes, an unnecessary hello message causes the problem of battery drainage in MANET routing protocols like AODV and DYMO. These ad-hoc types of networks are mainly used in the smart phones and origin the problem of energy utilization when neighbour nodes are discovered to maintain the connectivity. For the MANET scenario we take Random Waypoint Model and also the relationship between hello interval and event interval is considered. In this paper both the protocols are made adaptive and then Particle Swarm Optimization algorithm (PSO) is employed to give better results by reducing energy consumption and network overhead.

Keywords - *Routing, Hello Messaging, MANET, Optimization Algorithms.*

1. Introduction

A Mobile Ad Hoc Network (MANET) consists of self configurable autonomous nodes, and these nodes work together in a distributed manner and for its operation it does not rely on any fixed infrastructure. In MANET, individual devices can move freely in any direction [1]. There are various characteristics with which we can differentiate mobile ad hoc network from other wireless network like configuration of dynamic topology, node mobility, infrastructure less and multi-hop forwarding. In MANETs route establishment and maintenance is done through local link connectivity information i.e. each node discover its local neighbours. The nodes which are out of transmission range should be connected by these neighbours. To obtain this local link connectivity information, we use periodic Hello messaging scheme. In this Hello message is broadcasted to the available neighbours and with in specific time in response of Hello message. But unnecessary hello messaging causes energy consumption and bandwidth usage if on-demand MANET routing protocols are used like AODV and DYMO [2]. The messages between neighbours are sending through Route Request (RREQ) and Route Response (RREP) exchanges. Commonly used routing strategies are reactive, proactive and hybrid. Reactive Routing Protocols discover routes only on demand basis and do not take initiative for finding a route. Routing tables are not updated constantly [1]. E.g. AODV, DYMO, TORA, ARA. Proactive Routing Protocols maintain table of each node which contain the latest information of routes to nodes, to know its local neighbourhood [3]. In this control messages are periodically exchanged. E.g. DSDV, OLSR, WRP. While the combination of Reactive and Proactive Routing Protocols fall into the category of Hybrid Routing Protocols. E.g. ZRP, FSR, HOPNET, DDR. In Manet's network scenario, each node has a property that it can be either turned off or can move away, which causes delay in the data dissemination and also affects the route maintenance [4]. So it is important that a node should discover live neighbour nodes through hello messaging.

If there are broken links in the network then these are detected using two approaches hello messaging and the feedback from the MAC (Medium Access Control) layer [5]. If the network load is low then MAC feedback works better than hello messaging but when the traffic load on the network increases then hello messaging is better approach. Before sending the packet to the next hop failed links are detected initially by periodic hello messaging. But the MAC layer protocol does not give information about the next hop and energy consumed is greater [6]. Hence hello messaging is preferred over Link layer feedback mechanism. For suppressing the unnecessary hello messages two approaches are proposed: an on-demand mechanism and a monitoring activity mechanism. The on-demand mechanism also known as hello protocol enables this protocol only when it is demanded by request-reply mechanism. The monitoring activity mechanism also known as event based hello protocol and it allows to broadcast hello packets only to those nodes that are active, and based on some threshold value called an activity timer [7].

The paper is organized as follows: In section II related work is discussed. The proposed method of dynamic hello messaging scheme is presented in section III. In section IV optimization technique named as Particle swarm optimization is discussed. In section V the results are discussed which are obtained by applying method to the MANET. Finally section VI concludes this paper with future work.

2. Related Work

Significant recent work is done for optimizing the hello messaging scheme in literature. In [8], on demand routing protocol named as Ad hoc On-demand Distance Vector (AODV) is implemented and the link connectivity information is monitored from the effectiveness of hello messages. The effectiveness of hello messages is influenced by hello message loss settings, difference between data and hello message size like factors. The effectiveness of hello messages is increased by making the reception characteristics equal to that of data packets.

In [7], the impact of hello protocols is studied on ad-hoc networks. In this, three types of hello protocols are presented namely adaptive, reactive and event-based, which reduce network overhead and congestion. These protocols are made so that they can beacon minimum and the accuracy of the neighbour table is maintained. From all these, adaptive protocol hello protocol offers the best result.

In [6], the advantages and disadvantages of various techniques are discussed. Information regarding neighbour discovery and link failure is addressed by three approaches: hello messaging, MAC feedback and passive acknowledgements. But passive acknowledgements do not have wide applications in ad hoc networks. From the simulation results it is shown that when the network load is low then MAC feedback gives better result than hello messages, but if the load on the network increases, and then hello messaging is better option.

In [9], relationship between the transmission frequency and the sensing timer is investigated investigate expiration value of the network and within the node's mobility. The mobility model of MANET is taken as Random Waypoint model. The factors like transmission frequency of the Hello messages and the expiration value of the sensing timer depends mainly on the node's mobility.

3. Proposed Scheme

For the proposed scheme initially present the network model and then adaptive scheme for hello messaging is formulated. Dynamic network topology is considered for the MANET scenario. For the mobility of node several mobility models are there for the assessment of MANET protocols. For the simulation of MANETs, random waypoint model is the commonly used mobility model within which each node randomly selects a destination.
In conventional hello messaging scheme before sending a packet, initially status of neighbor nodes is checked so as to get information regarding link failure with one of its neighboring nodes in the network. The problem of unnecessarily energy consumption takes place if the node broadcasts hello messages and there are no active nodes in its neighborhood. The activity of the node is monitored by the event interval [11]. Average event interval is the average time gap between consecutive events on a node. Hello messages should be suppressed first by determining the value of hello interval, to overcome the energy consumption problem. Hello Interval is the maximum interval of time between the transmissions of hello messages. Td represents the time for link failure detection based on periodic Hello messaging is represented by Tfd and the average value of Tfd is given as:

$$\text{Tfd} = (\text{Allowed Hello Loss} - 0.5) * \text{Hello Interval} \quad (1)$$

To reduce energy consumption and network overhead as our main objective, a scheme is proposed. In the proposed scheme hello interval is made proportional to the event interval of a node and uses a constant risk level. This means if the hello interval increases, the event interval also increase without increasing the risk [12]. If the hello messaging interval is extremely large, then event interval is also correspondingly large; that is by this scheme unnecessary Hello messaging is practically suppressed. The cumulative distributed function (CDF) for the event interval (y) is shown in the figure 1 where all the traffics are bounded by exponential distribution for y>1.
The CDF of y is as follows:

$$F(y, b) = 1 - e^{-y/b} \quad (2)$$

We consider F(y, b) as probability for an event that occurs before the link is refreshed. We can write this as:

$$\text{Pfd} = 1 - e^{-y/b}$$
$$\ln(\text{Pfd}) = \ln(1 - e^{-y/b})$$
$$\ln(\text{Pfd}) = \ln(1) - \ln(e^{-y/b})$$
$$\ln(e^{-y/b}) = \ln(1) - \ln(\text{Pfd})$$
$$-y/b = \ln(1 - \text{Pfd})$$

$$y = -b\ln(1-Pfd) \quad (3)$$

Here y has linear relationship with b; in the above equations the neighboring node can use the value of b such that the Hello interval is calculated to maximize Tfd. Once the value of Tfd is determined, we can calculate the Hello messaging interval of the neighboring node with equation 1. As in equation 3, the risk is probably less for sending a packet over a broken link than Pfd.

The distribution of the packet reception on each node is investigated with a set of 20 nodes. Nearly all of event intervals have less value than the default hello interval i.e. 1 sec. Most of the event intervals are larger than default hello interval i.e. 1 sec. If value of event interval is less than 1 sec, hello interval will not be modified. After applying the adaptive scheme on AODV and DYMO respectively AODV-AH and DYMO-AH are taken then we apply PSOA and compare the output of all. AODV and DYMO are modified with the proposed scheme, to give outputs AODV with adaptive Hello (AODV-AH) and DYMO with adaptive Hello (DYMO-AH), respectively.

4. PSOA

Particle Swarm Optimization is an algorithm which optimizes non-linear and multidimensional problems and it requires minimal parameters to reach the good solution. The basic principle of swarm optimization is inspired by the observed behavior of animals in their natural habitat as their previous attempts for reproduction, such as bird flocking or fish schooling [13]. For this algorithm swarm of particles is created and they move in the space, searching the best place according to their needs as given by the fitness function. For the bird flock the best place can be combination of various characteristics like space for all the birds to rest, food access and water facility. For the optimization properties two concepts are considered:

- An individual particle that is determined as a potential solution to the problem can determine its best current position. It shares and obtains knowledge from the other particles.
- A stochastic factor which is considered by velocity of particle and makes them move through space regions with unknown problem.

In PSO, each member is represented by particle having velocity and position of each of them [14]. The particle's best position is evaluated by the maximum fitness value. Each particle in the search space adjusts its position based upon the best position of itself (pbest) and on the best position by its neighborhood (gbest) [15].Each particle updates its position and velocity as by the following equation:

v[ ] = v[ ] + c1 * rand() * (pbest[ ] - present[ ]) + c2 * rand( ) * (gbest[ ] - present[ ]) (a)
present [ ] = present[ ] + v[ ] (b)

Where v[ ] is denoted as the particle velocity,
present [ ] is the particle's current value (solution)
pbest[ ] and gbest[ ] are particle best and global best
rand () is any arbitrary number between (0,1)
c1, c2 denotes learning factors.

5. Evaluation

In this section, results of the projected scheme are shown on energy consumption, throughput, and network overhead for a packet with MATLAB by considering different simulation parameters taking account of density of node, number of flows, mobility speed, and probability of failure detection.

Table:1 Simulation Parameters

Parameter	Value
Mobility model	Random way point model
Topology Size	1000m * 1000m
No of nodes	20
Size of packet	210 bytes
Traffic type	Exponential
Simulation time	30

The value of Pfd is set to 20%. The parameters which are used for the simulation are shown in Table 1.

Fig 3 shows the output after PSOA is applied. By taking various numbers of nodes we calculate the remaining energy of nodes. AODV-AHPSO gives better results than AODV and AODV-AH. Table 2 depicts the assessment of energy between various protocols like AODV, AODVAH, and AODV-AHPSO.

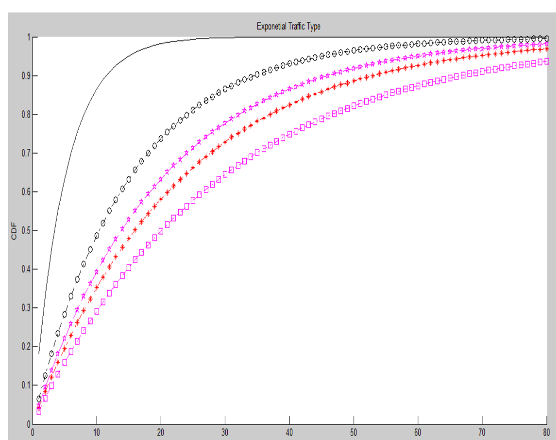

Fig. 1 Event interval Distribution (> 1sec)

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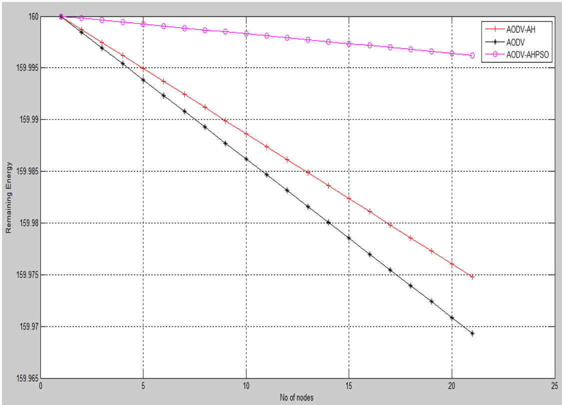

Fig 2 AODV-AHPSO extends the battery life time

Table:2 Assessment of remaining energy between AODV, AODV-AH, AODV-AHPSO

Remaining Energy			
No. of nodes	AODV	AODV-AH	AODV-AHPSO
5	159.992	159.995	159.999
10	159.986	159.989	159.998
15	159.976	159.983	159.997
20	159.970	159.980	159.996

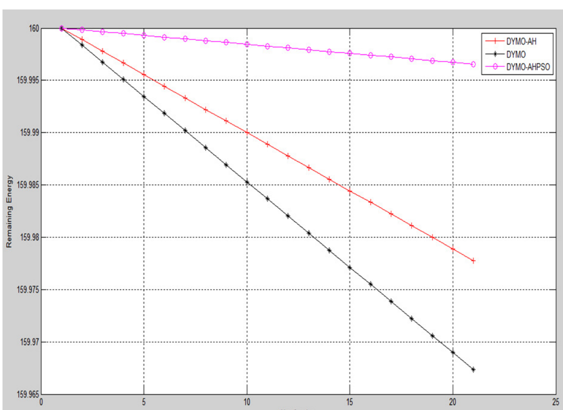

Fig 3 DYMO-AHPSO extends the battery life time

Table: 3 Assessment of remaining energy between DYMO, DYMO -AH, DYMO –AHPSO

Remaining Energy			
No. of nodes	DYMO	DYMO-AH	DYMO-AHPSO
5	159.994	159.997	159.999
10	159.987	159.993	159.998
15	159.978	159.986	159.996
20	159.972	159.984	159.994

Figure 4 shows the energy utilized per received packet over different numbers of flows between DYMO, DYMO-AH, and DYMO-AHPSO. The consequence of energy consumption is less when the number of flows is less than 5. As there is increment in number of flows, the outcome of the energy consumption increases as more number of nodes will contribute in forwarding. In this,few neighboring nodes are involved in communication, while others are involved in increasing their Hello intervals.

Figure 5 shows the number of Hello packets for various numbers of nodes. By the proposed scheme the numbers of Hello packets are reduced by as a large amount that is half in number.

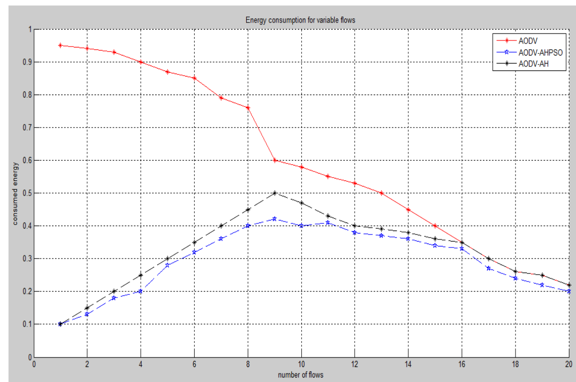

Fig 4 Energy consumption for variable flows in AODV

Network overhead deceases as the number of nodes increases. The effect is shown for the reason that, as the amount of nodes increases, the amount of received Hello packets and the amount of Hello packet broadcasters by a node as well increase.

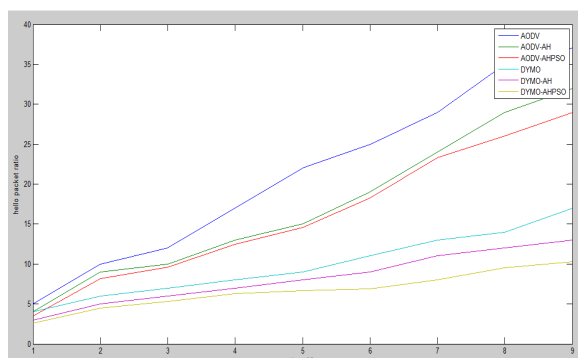

Fig 5 Network Overhead

Figure 6 shows the impact of PFD on the throughput when there are variations in the max speed. Hello interval is longer in case of high Pfd as low Pfd uses shorter hello interval. Even then there is significant difference in throughput between high Pfd and low Pfd. This is because the lesser number of links are affected; a link will be affected only when some event has to be forwarded before refreshing the link and also the neighboring node moves away.

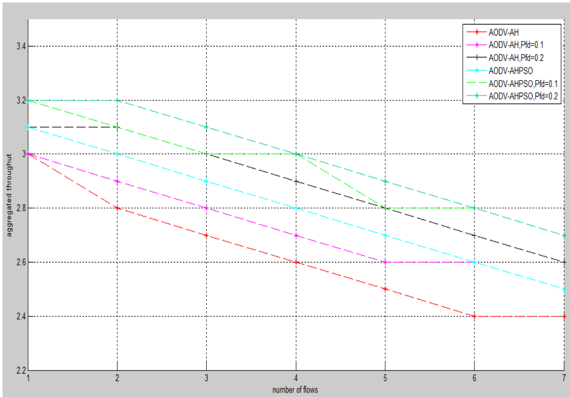

Fig 6 Throughput for Pfd and various max speeds

6. Conclusion

So here in this paper, we optimize an adaptive Hello messaging scheme with Particle swarm optimization technique to practically suppress the unnecessary Hello messages and to reduce the battery drainage problem. By this optimization scheme the difficulties related to battery utilization and network overhead are solved. These are the significant problems that influence the MANETs performance. For the future work, the proposed scheme should be deployed in various scenarios and also in the large scale networks. The value of hello interval should be optimized using more different optimization techniques.

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