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Probability Based Optimized Energy Efficient Routing Algorithm for Mobile AD-HOC Network

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Abstract: Mobile Ad-Hoc Network is a collection of mobile nodes equipped with transferable radios, but it is built without any centralized infrastructure such as base station. In MANET broadcasting is a predictable operation for discovering route. Despite the fact, that the flooding for broadcasting is simple, this is inefficient and result in redundant message relays. The high retransmission is caused by normal flooding scheme which leads to media congestion and packet collisions that can degrade the throughput and network performance significantly. In this paper, we proposed a Probability based Optimized Energy Efficient Routing Algorithm for Mobile Ad-Hoc Network in which the route request packets are randomly controlled to increase the lifetime of network and to reduce the packet loss in the flooding algorithm. The proposed algorithm can effectively reduces the propagating messages of Route Request (RREQ). Comparing with the typical AODV protocol, the proposed algorithm is proven to be efficient with longer network lifetime and evenly consumes the node residual energy which improves the network throughput and reduces the routing overhead.

Key words: MANET · AODV · Optimized Energy Efficient Routing Algorithm · ETX · Network Lifetime · Routing overhead

INTRODUCTION

In Mobile Ad-Hoc Network (MANET), the majority of the nodes are mobile devices and they use battery as their energy source. MANET is a distributed network where nodes network organize themselves and communicate each other. For mobile nodes, battery is a key factor and network not able to function, if its battery worn out [1, 2]. The design of dynamic routing protocols with less overheads and good performances are the major challenges in MANETs. The protocols like Dynamic Source Routing (DSR) and Ad-Hoc On-demand Distance Vector Routing (AODV) are the two on-demand routing protocols and when a new route is requested they could improve the MANETs scalability [3-5]. Due to the mobility of nodes in MANETs, there will be frequent breakages in their links that may lead to the path failure and route discovery problems, which could reduce the packet delivery ratio and increase the routing protocol overheads and end to end delay [6]. This makes routing overhead a crucial problem in route discovery. And flooding algorithm was used in the reactive routing protocols to find the routing path by forwarding Route Request packets (RREQ) to all its neighbor nodes. Too much of RREQ packets makes node run-out of battery, so it is necessary to reduce the unnecessary RREQ packets transmission [7- 8]. Various algorithms were proposed to enhance the efficiency of energy consumption. According to the node residual energy a new algorithm was proposed that controls the forwarding RREQ packets probability, in which a node with more residual energy is selected for routing process [9-10]. Based on AODV protocol an energy-efficient routing protocol was proposed by considering the remaining mobiles nodes energy capacity and power transmission [11-13]. But these methods didn't consider the route link quality, which decreases the lifetime of the network by wasting node residual energy with poor link quality. An improved broadcasting algorithm was proposed based on probability in which RREQ messages are reduced by using broadcasting probability along with consideration of nodes residual energy [14-15]. Then to find the shortest path between source nodes and destination nodes, currently most of the routing protocols use hop count as a route selection metric. In MANET, it is appropriate to use hop count as their only routing metric with dynamic

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network topology and insensitive to data rates, packet loss, link quality, link capacity, channel diversity, interference and other routing requirements. By measuring the ratio of packet delivery links between neighboring nodes, a metric called Expected Transmission count (ETX) provides high throughput [16-17]. In this paper, we proposed a probability based optimized energy efficient routing algorithm, which utilize both expected transmission count and node residual energy as their routing metric. With good link quality the proposed algorithm creates the routing path via ETX metric. The residual energy nodes are evenly used in the network by using the residual energy as their routing metrics. The flooding of RREQ packets are controlled by this proposed algorithm, which reduces the routing overhead and finds the effective routing path comparing other protocols.

Proposed Optimized Algorithm: The proposed probability based optimized energy efficient routing algorithm controls the forwarding process of the request packet in order to decrease the network congestion and the packet loss in the AODV protocol. The data packets to be transmitted, forwards the RREQ packets from source node to its one hop neighbor nodes. A RREQ packet that received in each node forwards it to their all one-hop neighbor nodes in the distinctive AODV protocol. But in the proposed method, forwarding probability is calculated and decided whether RREQ packets to be forwarded or discarded. In this paper two different routing metrics are employed, first is an ETX metric in which qualities of link between nodes is presented and obtain the link ETX value heuristically by using the probe packets.

The small-size probe packets are periodically broadcasted by each node to its neighbor node.
The ETX is derived as,

$$ETX = 1/_{p_f p_r} \tag{1}$$

In which p_f and p_r represents the forward and reverse packet delivery ratio, these parameters are heuristically obtained. In t cycles probe packets are broadcasted in each node. One node delivery ratio of the probe packet at time t is derived below,

$$r(t) = \frac{count(t-\omega, t)}{\omega / \tau} \tag{2}$$

In the above equation numerator represent the probe packets that one node received from (t-w) Seconds to t seconds and the denominator represent the probe packets that one node receives in w seconds. The Equation 2 shows that the number of probe packets is counted to calculate the delivery ratio of each node. Periodically each node stores and calculates the ETX metric between its neighbor node and it node itself.

The proposed algorithm uses node residual energy as another routing metric which shows the energy consumption efficiency in the network. Node i residual energy and the maximum residual energy is defined as E_i and E_{max} respectively. Similar to AODV protocol, the request packets are forwarded from node i to its one-hop neighbor, when forwarder node i is set to forward by using the forwarding probability(p_f). Similarly when request packets are not set to forward from the forwarder node i it discards it. Consider the example shown in Figure 1. When data packets to be transmitted from source node S, the Route Request (RREQ) packets are forwarded from node S to its neighbor nodes A and B. Node A has high residual energy and between Node S and Node A, the ETX value is good. For this case, Node B has low residual energy and the value of ETX between Node S and Node B is bad. According to the existing algorithm, Node A and Node B has the higher and

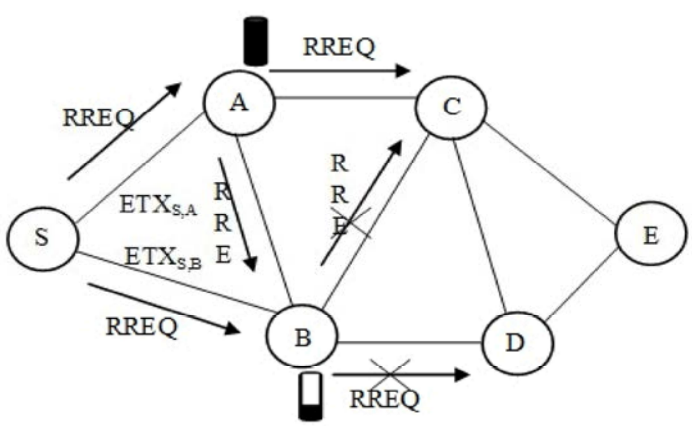

Fig 1: Example of Proposed System

lower forwarding probabilities. Because of lower forwarding probability, RREQ packets are discarded by the forward nodes when every node has lower residual energy which makes the routing process to fail incessantly. To overcome this problem, in this paper have to include name of proposed algorithm, this method considers both one-hop neighbor nodes residual energy and all nodes average value of residual energy in the network.

The proposed algorithm is described by assuming the two factors. First it is assumed that the residual energy average value E_{avg} of each node in the network is known by all nodes. The information about residual energy, which received periodically from each node is used to calculate the E_{avg} using the network controller. As second factor, from the hello packets each node knows the one-hop neighbor nodes residual energy which is broadcasted periodically by each node to indicate the little information and its existence of the node.

Operation: When source node required a routing path, the RREQ packet is broadcasted by source node to its one-hop neighbor nodes. Then the RREQ packets received by forwarder node calculate the ETX value and its residual energy using the forwarding probability. This proposed algorithm compares the residual energy average value E_{avg} of all nodes with the predefined threshold residual energy, E_{th}.

If E_{avg} is larger than E_{th}, there is no need of making the forward probability higher, since node think that network in good state of energy. If E_{th} is larger than E_{avg}, node assume that the network has a low state of energy and push the forward probability higher by using the proposed algorithm. Each node describes the residual energy of neighbor node's maximum value as new $E_{max}(E^{N}_{max})$ with previous value $E_{max}(E^{P}_{max})$ to calculate the new forwarding probability.

$$p_f = \left[p_{min} + E_i A \left[1 + \frac{(ETX_{i-1,i} - ETX_{max})}{(1 - ETX_{max})} \right] \right]^{1/\alpha}$$

$$A = \begin{cases} \dfrac{1 - p_{min}}{2 \times E^{P}_{max}}, & \text{If, } E_{th} < E_{avg}, \\ \dfrac{1 - p_{min}}{2 \times E^{N}_{max}}, & \text{If, } E_{th} \geq E_{avg}, \end{cases}$$

Consider Figure 2 in that forwarding probability P_f to be calculated by node C, before that node C residual energy average value E_{avg} of all nodes is compared with E_{th}. From the example shown in Figure 2, $E_{avg} < E_{th}$.

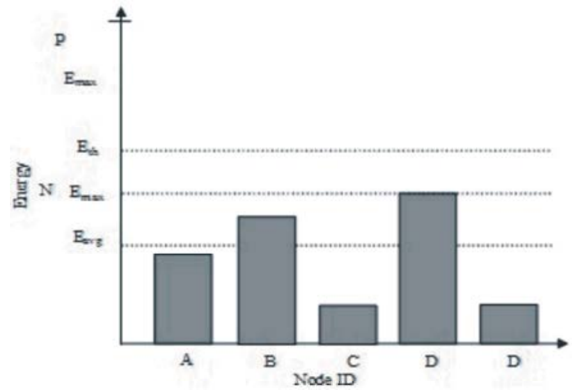

Fig 2: Example of Proposed algorithm

So, nodes C have to apply the proposed algorithm. From this example node D has the higher residual energy. Therefore with the node D residual energy, the previous E_{max} value of node C is replaced. Additionally, forwarding probability P_f of node C is calculated and decides whether RREQ packets to be forwarded or not.

In this proposed algorithm, the entire network energy condition is represented by global factor (E_{avg}). Additionally, the one-hop neighbor nodes residual energy is considered by this algorithm and updates the E_{max} value. Consequently, this proposed algorithm considers both global and local networks energy condition together. Figure 3 shows the flow chart of the proposed algorithm.

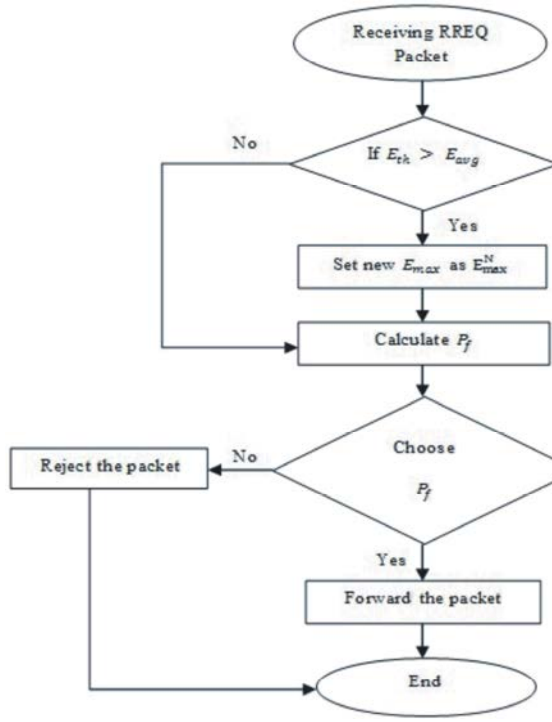

Fig 3: Proposed algorithm Flow Chart

RESULT

In this section the performance of the proposed algorithm is compared with the AODV protocol. Generally the lifetime of the network is defined as the difference in time between the start of simulation and the time when residual energy becomes zero in the node. In this paper, the lifetime of network concept is extended and measured the starting time of the simulation and the time when residual energy becomes zero in the nTh node. As shown in Figure 4, when compared with typical AODV protocol, the lifetime of the network in the proposed algorithm is 12 % higher and while comparing this result with typical AODV protocol, all the nodes in the network uses the residual energy more evenly in the proposed algorithm. The residual energy of all nodes is measured and the residual energy variance is calculated. When variance is smaller this proposed algorithm uses the residual energy of all nodes more evenly. In Figure 5 the residual energy variance result of all nodes in the network is shown. The residual energy variance of the nodes in the proposed algorithm is smaller when compared with typical AODV.

The result proves that in the proposed algorithm the residual energy is more evenly poised. In this algorithm, the RREG packets are not frequently forwarded which result in slight routing delay comparing with AODV protocol. The routing setup delay is measured as the time difference between the first RREQ packets from source node to destination node. The routing setup delay of the proposed algorithm is 0.3 ms higher than the typical AODV as shown in Figure 6.

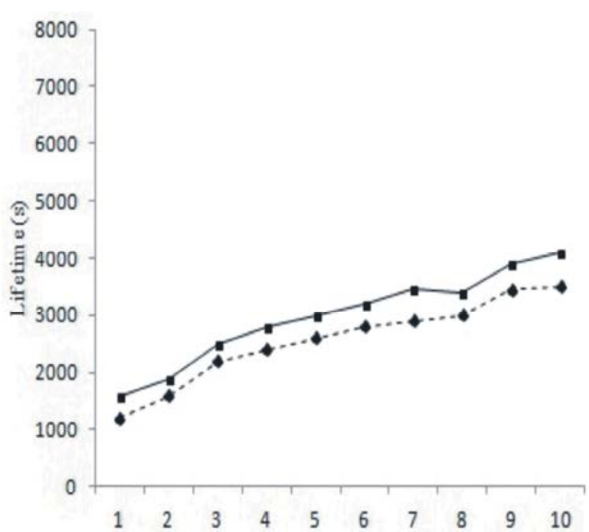

Fig 4: Network Lifetime Comparison

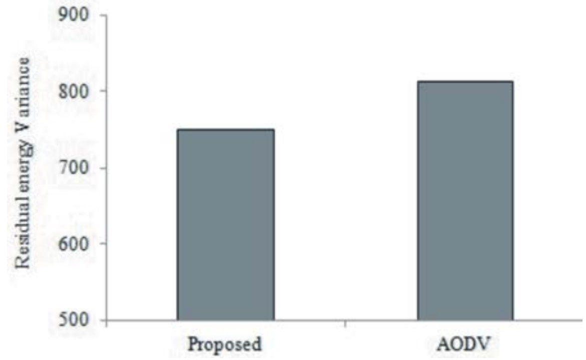

Fig 5: Residual Energy Variance Comparison

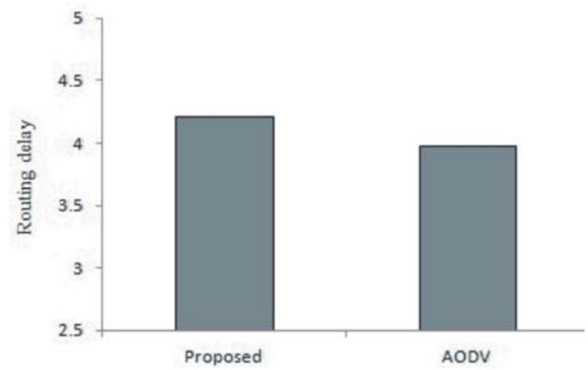

Fig 6: Residual Delay Comparison

This is because the forwarded RREQ packets are decreased by randomly controlling the RREQ packets. Since the lifetime of the network in the proposed algorithm is higher, this reduces the route overhead and the routing failure compared with typical AODV protocol.

CONCLUSION

In this paper, probability based optimized energy efficient routing algorithm is proposed which utilizes both ETX value and the node residual energy at the same time as the routing metrics. This proposed algorithm randomly controls Route Request packets via ETX value and residual energy that ease the energy efficient route system. In a network like MANETs, nodes energy efficiency is a key factor for the network performance. The result shows that, in the proposed algorithm network lifetime is longer and the residual energy of every node is evenly consumed, when compared with the existing and the typical AODV protocol. Although the routing success probability and the routing setup delay is slightly decreased and increased. The result proves that the proposed algorithm can reduce the routing overhead and is more effective.

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