A Reliable routing algorithm for Mobile Adhoc Networks based on fuzzy logic

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Abstract

By growing the use of real-time application on mobile devices, there is a constant challenge to provide reliable and high quality routing algorithm among these devices . In this paper, we propose a reliable routing algorithm based on fuzzy-logic (RRAF) for finding a reliable path in Mobile Ad Hoc Networks. In this scheme for each node we determine two parameters , trust value and energy value, to calculate the lifetime of routes . Every node along route discovery , records its trust value and energy capacity in RREQ packet. In the destination with the aid of fuzzy logic ,a new parameter is generated from inputs trust value and energy value of each route which is called "Reliability Value". The path with more reliability value is selected as a stable route from source to destination .Simulation results show that RRAF has significant reliability improvement in comparision with AODV.

Keywords: *Mobile AdHoc Networks, Routing, Reliability, Fuzzy logic, RRAF.*

1. Introduction

A mobile ad hoc network is an independent group of mobile users which communicate over unstable wireless links. Because of mobility of nodes ,the network topology may change rapidly and unpredictably over time. All network activity , including delivering messages and discovering the topology must be executed by the nodes themselves. Therefore routing functionality, the act of moving information from source to a destination, will have to be incorporated into the mobile nodes .Hence routing is one of the most important issue in MANET.

Routing protocols in MANETs are generally classified as proactive and reactive [1]. Reactive routing protocols [2,3,4,5,6,7],which also called on demand routing protocols, start to establish routes when required. These kind of protocols are based on broadcasting RREQ and RREP messages. The duty of RREQ message is to discover a route from source to destination node .When the destination node gets a RREQ message, it sends RREP message along the established path. On demand protocols minimize the whole number of hops of the selected path and also they are usually very good on single rate networks. There are many reactive routing protocols, such as ad hoc on-demand distance vector (AODV) [6], dynamic source routing (DSR) [4], temporally order routing algorithm (TORA)[5], associativity-based routing (ABR) [7], signal stability-based adaptive (SSA) [3], and relative distance microdiscovery ad hoc routing (RDMAR) [2]. In contrast , in table-driven or pro-active routing protocols [8,9,10,11,12], each node maintains one or more routing information table of all the participating nodes and updates their routing information frequently to maintain latest view of the network. In proactive routing protocols when there is no actual routing request, control messages transmit to all the nodes to update their routing information. Hence proactive routing protocols bandwidth become deficient. The major disadvantage of pro-active protocols is the heavy load caused from the need to broadcast control messages in the network [3]. There are many proactive routing protocols, such as destination sequenced distance vector (DSDV) [12], wireless routing protocol (WRP) [9], clusterhead gateway switch routing (CGSR) [10], fisheye state routing (FSR) [11], and optimized link state routing (OLSR) [8].

Many of the work reported on routing protocols have focused only on shortest path, power aware and minimum cost.However much less attention has been paid in making the routing protocol to choose a more reliable route. In critical environment like military operation, data packets are forwarded to destination through reliable intermediate nodes[13].In this paper, we propose a reliable routing algorithm based on fuzzy logic. In this scheme for each node we determine two parameters , trust value and energy value, to calculate the lifetime of routes . During route discovery, every node inserts its trust value and energy value in RREQ packet .In the destination , based on a new single parameter which is called reliability value , is decided which route is selected. The route with higher reliability value is candidated to route data packets from source to destination.

The rest of the paper is organized as follows: In Section 2, we briefly describe the related work. Section 3 describes our proposed routing algorithm and its performance is evaluated in Section 4.Finally,Section 5 concludes the paper.

2. Related Works

We can classify all the works that have been done in reliable routing, in three categories: GPS-aided protocols ,energy aware routing ,and trust evaluation methods .In this section, we will overview some proposed protocols that have been given to designing reliable routing protocols.

A reliable path has more stability than a command path. Some of reliable routing protocols propose a GPS-aided process and use route expiration time to select a reliable path. In [14] Nen-chung Wang et al, propose a stable weight-based on-demand routing protocol (SWORP) for MANETs. The proposed scheme uses the weight-based route strategy to select a stable route in order to enhance system performance .The weigth of a route is decided by three factors:the route expiration time, the error count , and the hop count . Route discovery usually first finds multiple routes from the source node to the destination node. Then the path with the largest weigth value for routing is selected .

In [15], Nen-Chung Wang and Shou-Wen Chang also propose a reliable on-demand routing protocol (RORP) with mobility prediction. In this scheme, the duration of time between two connected mobile nodes is determined by using the global positioning system (GPS) and a request region between the source node and the destination node is discovered for reducing routing overhead. the routing path with the longest duration of time for transmission is selected to increase route reliability. In [16], Neng-Chung Wang etal, propose a reliable multi-path QoS routing (RMQR) protocol for MANETs by constructing multiple QoS paths from a source node to a destination node. The proposed protocol is an on-demand QoS aware routing scheme. They examine the QoS routing problem associated with searching for a reliable multi- path (or uni-path) QoS route from a source node to a destination node in a MANET. This route must also satisfy certain bandwidth requirements. They determine the route expiration time (RET) between two connected mobile nodes by using global positioning system (GPS). Then use two parameters, the route expiration time and the number of hops, to select a routing path with low latency and high stability.

some other proposed protocols are considering energy and trust evaluation as a factor of reliability . In [17], an approach has been proposed in which the intermediate nodes calculate cost based on battery capacity. The intermediate node take into consideration whether they can forward RREQ packet or not . This protocol improves packet delivery ratio and throughput and reduces nodes energy consumption[13].In [18], Gupta Nishant and Das Samir had proposed a method to make the protocols energy aware .They were using a new function of the remaining battery level in each node on a route and number of neighbours of the node. This protocol gives significant benefits at high traffic but at low mobility scenarios[13].In [19], a novel method has been discussed for maximizing the life span of MANET by integrating load balancing and transmission power control approach. The simulation results of this mechanism showed that the average required transmission energy per packet was reduced in comparison with the standard AODV. In [20] Pushpalatha & Revathy have proposed a trust model in DSR protocol that categorize trust value as friend, acquaintance and stranger based on the number of packets transferred successfully by each node[13].The most trusted path was determined from source to destination.Results indicated that the proposal had a minimum packet loss when compared to the conventional DSR.Huafeng Wu & Chaojian Shi1 [21] has proposed the trust management model to get the trust rating in peer to peer systems, and aggregation mechanism is used to indirectly combine and obtain other node's trust rating[13]. The result shows that the trust management model can quickly detect the misbehaviour nodes and limit the impacts of them in a peer to peer file sharing system[13].all above papers used the separate parameters such as battery power ,trust of a node or route expiration time individually as a factor for measuring reliability of route. In this paper, we consider both energy capacity and trust of nodes for route discovery .

3. Proposed Model

In this section we propose our novel reliable routing algorithm which is improved version of [22].

3.1 RRAF Mechanism

Trust value and battery capacity are the two main parameters in this method that make the routing algorithm more reliable. Before explaining the algorithm, trust estimation and power consumption mechanism are described below.

Trust Evaluation: Trust value of each node is measured based on the various parameters like length of the association, ratio of number of packets forwarded successfully by the neighbors to the total number of packets sent to that neighbor and average time taken to respond to a route request [13,20]. Based on the above parameters trust level of a node i to its neighbor node j can be any of the following types:

a)Node i is a stranger to neighbor node j

Node i have never sent/received message to/from node j .Their trust levels between each other will be low. Every new node which is entering an ad hoc network will be a stranger to all its neighbors.

b) Node i is an acquaintance to neighbor node j

Node i have sent/received few messages from node j. Their trust levels are neither too low nor too high to be reliable.

c) Node i is a friend to neighbor node j

Node i have sent/received a lot of messages to/ from node j. The trust levels between them are reasonably high .

The above relationships are represented in Fig.1 as a membership function.

Energy Evaluation: We defined that every node is in high level which means it has full capacity (100%).The node will not be a good router to forward the packets If the energy of it falls below 50%.

FuzzyLogic Controller: A useful tool for solving hard optimization problems with potentially conflicting objectives is fuzzy logic.

In fuzzy logic, values of different criteria are mapped into linguistic values that characterize the level of satisfaction with the numerical value of the objectives. The numerical values are chosen typically to operate in the interval [0, 1] according to the membership function of each objective .Fig.1 represents the trust value membership function. According to three types of trust value: friend , acquaintance and stranger, we define three fuzzy sets :high, medium and low, respectively. we also determined three fuzzy sets for node's energy. For energy capacity between 50 % to 100% of total capacity ,we define high set, for 0% to 100% we define medium set and for 50% to 100% we define low set. The above relationships are represented in Fig.2 as energy value membership function and Fig.3 shows the membership function of reliability value.

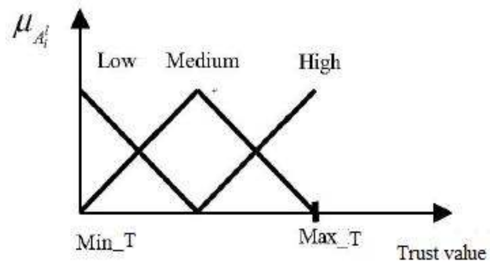

Fig. 1 Membership function for trust value.

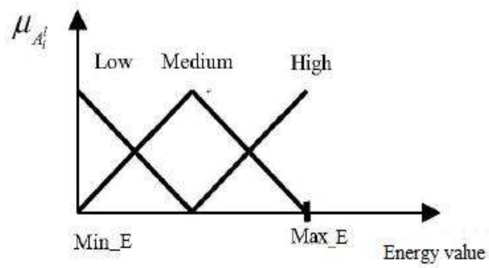

Fig. 2 Membership function for energy value.

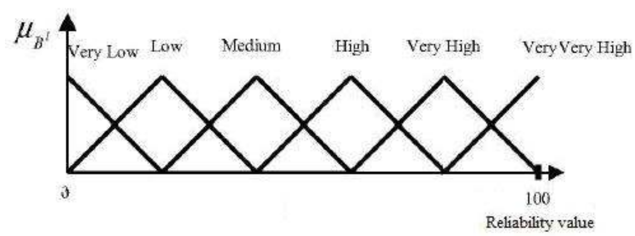

Fig .3 Membership function for Reliability value.

Reliability Evaluation: Reliability factor take different values based on six rules that dependent upon varied input metric values i.e. energy and trust values .A fuzzy system decides for each two input values which values appear in output.

The fuzzy system with product inference engine , singleton fuzzifier and center average defuzzifier are of the following form:

$$f(x) = \frac{\sum_{i=1}^{6} \bar{y}^{l} \left(\prod_{i=1}^{2} \mu_{A_i^l}(x_i) \right)}{\sum_{i=1}^{6} \left(\prod_{i=1}^{2} \mu_{A_i^l}(x_i) \right)} \qquad (1)$$

In Eq.1 , x_i represents crisp input i[th] (energy or trust values), $\mu_{A_i^l}(x_i)$ represents fuzzy membership function for input i[th] , and $\overline{y}^l$ is center average of output fuzzy set l[th] .

The rules are as follows:

Rule1: if trust value is high and energy value is high then reliable value is very very high.

Rule2: if trust value is medium and energy value is high then reliable value is very high.

Rule3: if trust value is high and energy value is medium then reliable value is high.

Rule4: if trust value is medium and energy value is medium then reliable value is medium.

Rule5: if trust value is low and energy value is medium then reliable value is low.

Rule6: if trust value is anything and energy value is low then reliable value is very low.

3.1.1. Route discovery procedure

Step1: A source node starts to flood RREQ packets to its neighboring nodes in a MANET until they arrive at their destination node. Each RREQ consists of sourceid,destinationid,energy value and trust value of nodes along the path.

Step2: If the intermediate node N receives a RREQ packet and it is not the destination , then the information of node N is added to the RREQ packet which is appended to packet fields.After that , node N reforward the packet to all the neighboring nodes of itself.

Step 3: If node N receives a RREQ packet and node N is the destination , it waits a period of time . therefore , the destination node may receive many different RREQ packets from the source. Then it calculates the value of reliability value for each path from source to the destination using the information in each RREQ packet. Finally , destination node sends a route reply(RREP) packet along the path which has a maximum reliable value.

4. Simulation and results

The simulation environment is constructed by an 1500m ×300m rectangular simulation area and 50 nodes, distributed over the area . Initial energy of a battery of each node is 4 Watts which is mapped to 100%.Simulation results have been compared with AODV.Simulation study has been performed for packet delivery ratio, throughput and end to end delay evaluations.

Packet delivery ratio: The fraction of successfully received packets, which survive while finding their destination. This performance measure also determines the compeletness and correctness of the routing protocols[23].

End to End Delay : Average end to end delay is the delay experienced by the successfully delivered packets in reaching their destinations. This is a good metric for comparing protocols and denotes how efficient the underlying routing algorithm is, because delay primarily depends on optimality of path chosen[23].

Throughput: It is defined as rate of successfully transmitted data per second in the network during the simulation. Throughput is calculated such that , it is the sum of successfully delivered payload sizes of data packets within the period , which starts when a source opens a communication port to a remote destination port , and which ends when the simulation stops. Average throughput can be calculated by dividing total number of bytes received by the total end to end delay[23].

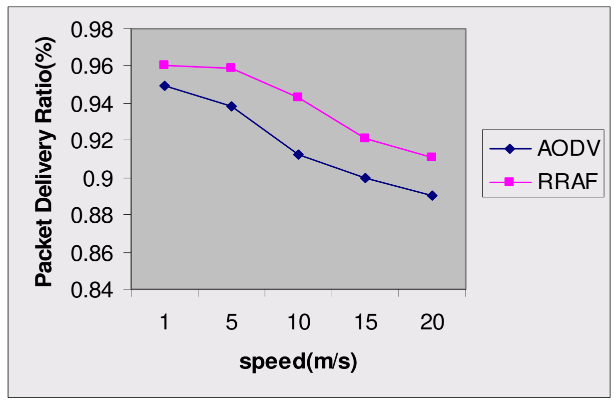

Fig.4 packet delivery ratio at different speed.

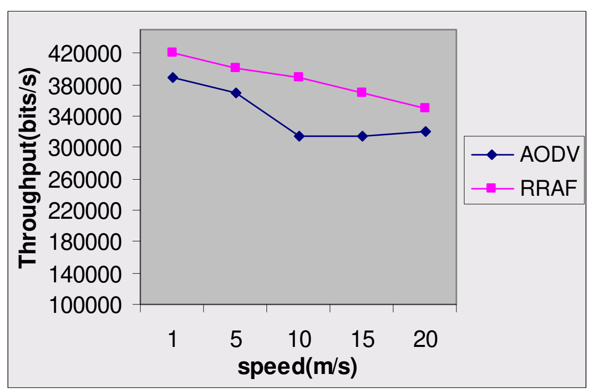

Fig.5 Throughput at different speed.

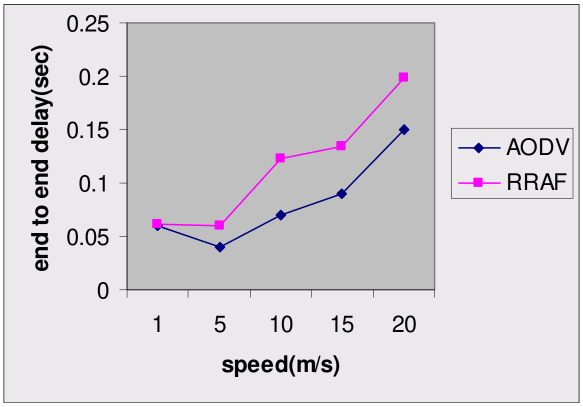

Fig.6 end to end delay at different speed.

Fig.4 shows the packet delivery ratio with different mobility speeds.When mobile nodes moved at higher mobility speeds, both protocols decreased the packet delivery ratio. The reason is that the routing path was easy to break when the mobility speed increased , but we can see that RRAF transmits and receives more data packets than AODV. This is because RRAF always chooses the most stable route for transmission packets along the path instead of choosing the shortest path.
In Fig.5 the simulation result shows that throughput of both methods reduces when the speeds increase. When the speed of the mobile node increased, the routing path was more unreliable. The reason is that there were more chances for routes to break when the speed of the mobile node was faster. Thus, the number of rebroadcasts increased.Since RRAF has chosen more reliable route than AODV, we can see that it has performed better at all speeds .
Fig.6 shows average end to end delay with speed as a function .Here it is clear that AODV has less delays than RRAF. Higher delay in the proposed method is because of the time it has wasted for discovering the route with longer life, so the packets would in the meanwhile stay in the buffer until a valid route is found . This takes some time and will, therefore , increase the average delay while AODV chooses the shortest path as a valid path.
Fig.7 shows the performance of packet delivery ratio under various pause times. The results in Fig. 7 illustrate that packet delivery ratio in RRAF is better compared to AODV,and The results in Fig. 8 show that RRAF experiences a high end to end delay because route selection is based on trust and energy level not on the minimum number of hops.

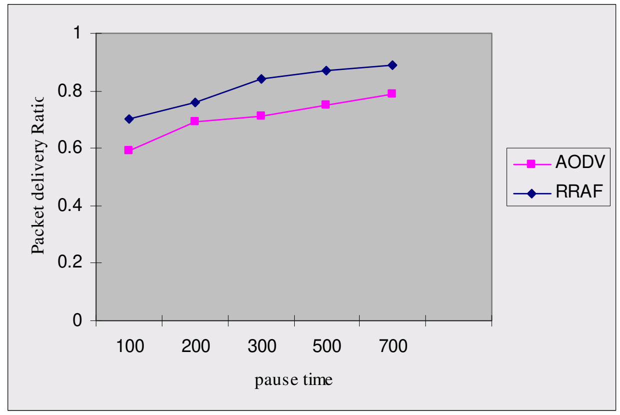

Fig.7 Packet delivery ratio at different pause time.

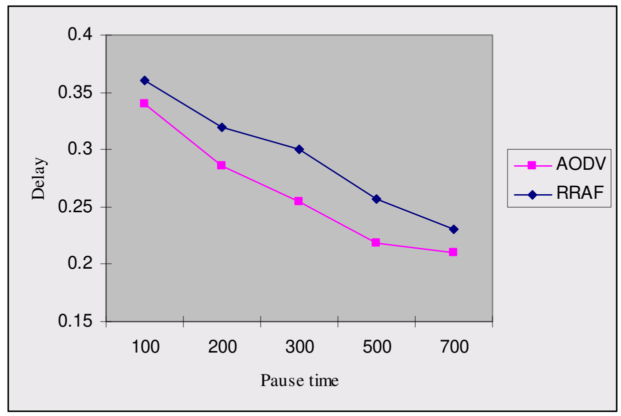

Fig. 8 End to end delay at different pause time.

5. Conclusions

Since in MANET, mobile nodes are battery powered and nodes behaviour are unpredictable, wireless links may be easily broken. Hence it is important to find a route that endures a longer time. In this paper, we have proposed a reliable routing algorithm based on fuzzy logic approach. In this scheme, we determine three parameters: trust value , energy value and reliability value that are used for finding a stable route from source to destination . During route discovery, every node records its trust value and energy capacity in RREQ packet .In the destination ,based on reliability value , is decided which route is selected .The path with more reliability value is candidated to route data packets from source to destination. The simulation results show that the proposed method has significant reliability improvement in comparison with AODV.

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