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An Efficient On-Demand Routing Protocol for MANETs using Dumpster- Shafer Belief Theory

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Abstract— **The vision of Mobile Ad Hoc Network (MANET) is wireless internet, where users can move anywhere anytime and still remaining connected with the rest of the world. Broadcasting is a fundamental operation in MANETs where a source node transmits a message that is to be disseminated to all the nodes in the network. Network wide broadcasting in Mobile Ad Hoc Network provides important control and route establishment functionality for a number of unicast and multicast protocols. Broadcasting in MANET poses more challenges than in wired networks due to node mobility and scarce system resources. Broadcasting is categorized into deterministic and probabilistic schemes. This paper proposed the probabilistic broadcasting protocol because of its adaptability in changing environment. Probabilistic broadcasting is best suited in terms of ad hoc network which is well known for its decentralized network nature. Probability, counter and distance based scheme under probabilistic scheme are discussed in this paper. Besides the basic probability scheme this paper also includes their recent advancements. Rebroadcast is one of the initial tasks for route discovery in reactive protocols. This paper proposed a methodology having better performance in terms of reachability, saved rebroadcast and average latency in rebroadcasting a route request message by using Dumpster- Shafer belief method. Simulation results are presented, which shows reachability, saved rebroadcast and average latency of the probabilistic broadcast protocols.**

Index Terms— **Bayesian Approach, D-S Theory and Belief Theory**

I. INTRODUCTION

A Mobile Ad-Hoc Network (MANET) is a temporary network having collection of wireless mobile nodes without using central access, infrastructure or centralized administration. There are number of characteristics in Mobile ad-hoc networks having verity of features, such as the dynamic network topology, limited bandwidth and energy constraint in the network. Mobile ad hoc network is significant for military operation to provide communication between squads, emergency case in out-of-the-way places, medical control etc. Routing in ad-networks has been a challenging task ever since the wireless networks came into existence. The major reason for this is the constant change in network topology because of high degree of node mobility. A number of protocols have been developed for accomplish this task. Some of them are DSDV and AODV routing protocols. For communication nodes in the network should be able to sense and discover with nearby nodes. But transmission range of MANIT network interfaces is very limited; so for exchanging data within the node across the network may be required multiple network "hops". One of the simple ways for routing is to send packets to the destination from the source node through intermediate nodes using the geometric information of all the nodes in the network. Getting accurate geometric information is still not easy. Where as one another supplement is to determine the route by means of actively asking all the neighbours and their neighbours for information regarding path to the destination.

Route establishment and maintenance overhead gradually increase in case of on-demand routing protocol. Whereas relative costs of these two components vary from one protocol to another. Whenever a route has to be discovered, the protocols have to perform some form of flooding of route request packets until the destination node is reached. Route maintenance involves re-establishment of a route, especially in the scenario of link failure or node failure.

For computing the route from source to destination, many of the protocols like AODV [1] flood in all directions, while there are some protocols like FRESH [2] which employ a directional search. In FRESH, historic information regarding when two nodes have been in direct contact is maintained in the form of encounter ages. By maintaining time information also, they were able to steer the direction of the route requests. In our approach, we are improving the performance of route discovery by improving the cost of route establishment using a history based Bayesian method, along with the relative region of the destination node.

II. RELATED WORK

In case of table-driven routing protocols, for instance Destination Sequenced Distance-Vector (DSDV) [3], every node maintains a routing table consisting of topology information that is updated frequently using flooding. Whereas on-demand routing protocols unlike table-driven routing protocols determine the path to node during the connection establishment process, but need to store entire topology in each node. These protocols do not need to send periodic beacon messages to exchange information on the route. Dynamic Source Routing (DSR) [4] protocol, a protocol is a request to route to the destination by flooding route request packets in networks. In [5], use both time and space information to compute the route from source to destination and maintained the historic traffic information in each node along with the details on relative region from which the requests had come from by just expanding the current broadcast cache used in AODV. By using a Bayesian method, they have limited the flooding of broadcast requests.

III. PROBABILISTIC PROTOCOL

Among the deterministic and probabilistic approaches probabilistic scheme is one of the best ways to reduce rebroadcast. In a probabilistic scheme, nodes rebroadcast the message with a pre determined probability p. the studies in [6], [7] shows that probabilistic broadcast incurs significantly lower overhead as compared to blind flooding. Several probabilistic schemes have been proposed in the past [8], [9]. These include *probability-based, counter-based* and *distance-based* [8], [9], [10].

Each probability model is represented by the equation:

$$P = f(N, P)$$

Where P is the probability that a node forwards the broadcast packet and N is the number of nodes in the network. The function f depends on the specific protocol being analysed.

A. Probability-Based Scheme

In the probability based scheme, this is a simple probabilistic approach of probability 1 or 0 for rebroadcasting. A node will broadcast either with probability 1 or with probability 0. That means with probability 1 it behaves like a flooding approach where as with 0 probability it is not broadcasting a single packet.

B. Counter-Based Scheme

In the Counter-Based scheme, a node v will only rebroadcast if it receives less than a threshold (T) number of copies of a packet before its RAD expires. Each node keeps track of duplicate packets with a counter; the counter is incremented by 1 for each duplicate packet received before the RAD expires. For a random node v to receive a duplicate packet (and increment its counter) from a random node u, three events must occur:

1) Node u must be a neighbour of node v.

2) Node u must transmit the packet.

3) Node u must transmit the packet before v's RAD timer expires.

The probability Q that node v increments its counter (i.e. events A, B, and C have all occurred) is equal to P (1□2 □ 3).

C. Distance-Based Scheme

In the Distance-Based scheme, a node v will not rebroadcast if it receives its initial packet from a source node s that is within a threshold distance D. Consider an annulus area centred at v, with the radius of the inner circle equal to D and the radius of the outer circle equal to the transmission distance R. (The annulus area is the area outside the circle with radius D and inside the circle with radius R.) If node s is in the annulus area, then v will start a RAD and wait for duplicate packets. During the RAD, if any duplicate packet is received from a node u within a distance of D to v, then v will not rebroadcast. We define the following events to determine the probability of v receiving a duplicate packet from a random node u, such that u is within a distance of D to v, before its RAD expires:

1) Node u is within distance D of node v.

2) Node u transmits the packet.

3) Node u transmits the packet before v's RAD timer expires

The probability that node v receives this kind of packet is equal to P (1□2 □ 3)

IV. DEMPSTER SHAFER THEORY

Dempster Shafer Theory is also called as Evidence theory or Theory of Belief Functions [11]. Recently, belief theory, also known as Dempster-Shafer, or Evidence theory, has emerged as an important tool to manage and handle uncertainty and imprecision or even lack of information .This theory defines a sample space named frame of discernment (or simply frame), which is a finite set of mutually exclusive and exhaustive hypotheses in a problem domain under consideration. Dempster-Shafer theory is used to computes the probability that evidences support the attack or normal class. It is suitable for anomaly detection on unseen network traffic by using limited information on the uncertainty. With the Combination of accumulative evidences from an insufficient amount of information, it is capable of making decision on data whether it is normality or abnormality. The use of Dumpster Belief theory steadily spreads out, mostly because it is used to cope with large amounts of uncertainties that are inherent of natural environments. This new approach considers sets of propositions and assigns to each of them an interval [Belief, Plausibility].

In which the degree of belief must lie. Belief (usually denote Bel) measures the strength of the evidence in favour of a set of proposition. It ranges from 0 (including no evidence) to 1(denoting certainty).

Possibility (PI) is denned to be $Pl(s) = 1 - Bel(\neg s)$

It also ranges from 0 to 1 and measure the extent to which evidences in favour of ¬s leave room for belief in ¬s.

V. PROPOSED WORK

The proposed probabilities On–demand Routing Protocol for MANET, using Dumpster- Shafer belief theory is a novel way of finding route to the destination based on summing up the mutually probabilities (affinity) of each node towards the particular destination with another node, which is calculated using belief theory [12], [13].The protocol also makes sure that the data travels through shortest route only, thereby minimizing the time delays between sending and receiving of data packet. Another important feature of PORPDSB is that it sends data through two disjoint paths, and the data is sent through both the paths alternatively. This is done so as to reduce traffic through one path and also to avoid the loss of battery power that may occur a result of standby mode of nodes in second path, as they might only be waiting for the data packet to be received. In PORPDSB, each node maintains a history table, which contains the destination node's id and the value of the attributes used for calculating the mutually affinity index with each node along the route with respective node, along with the status whether a route reply (Rrep) was received or not for every route request (Rreq) sent. This history is used in calculating mutually affinity index while sending or rejecting a Rreq from a particular node or not.

Each intermediate node upon receiving Rreq checks their routing table (rt) to find if the path to the destination is known or not. If known, a Rrep is generated back to the node which generated the Rreq otherwise, node first compares the hop count in Rreq with last known hop count for same destination. If hop count in Rreq is higher; the Rreq is discarded (to ensure minimum hops route). Then node compares the stored mutual affinity value for that particular destination in their RT with the mutual affinity contained in Rreq. If mutual affinity in RT is greater, Rreq is rejected (to ensure only highest affinity requests are forwarded and stale routes are avoided) otherwise node will add its pair mutual affinity in the Rreq and will broadcast the Rreq. Since the mutual affinity of destination for itself will be 1(highest), hence, upon receiving a Rreq, destination replies back by adding 1 to the mutual affinity contained in the Rreq. Upon receiving Rrep, intermediate nodes will again check their RT to see if route affinity in Rrep is higher than RT affinity. If it is less, Rrep is rejected, otherwise it sent to the node from which it received Rreq with highest affinity. When a route reply is received by the source, it accepts best two Rreps based upon the affinity contained in them. Upon route failure, intermediate node first tries to repair route locally. If route couldn't be repaired locally, route error (Rerr) is generated and sent back to the previous node, which forwards it to be sent to the source. The source upon receiving Rerr will start a fresh route discovery if it has lost both the paths to destination (ensuring reduction in control packet overhead). In case if other path is still exists, it will only mark its backup path as INVALID, and will start sending data through only one path.

VI. MUTUAL AFFINITY INDEX

Mutual Affinity index (AI) is a probability based upon historical data. Through this we can find out how much likely it is for a particular node to transfer the data packet to the desired destination. It is calculated by using the belief Theory [14], [15].

$$P\left(\frac{w}{l}\right) = \{\frac{P\left(\frac{l}{w}\right)P(w)}{P\left(\frac{l}{w}\right)P(w)+P\left(\frac{l}{m}\right)p(m)}$$

Here, w is the class showing whether reply was received for the RREQ sent. And L = { l_1,……., l } i.e. the various attributes upon which the probability will depend. P (L) does not depend upon W_I is used only for normalization. So P (W/L) will be maximum when P(L/W) P(W) is maximum[6]. Hence,

$$M_{ai}(\frac{w_i}{l_j}) = \pi_{j=1}^{m}\left[l_{ij_1} + l_{ij_2} + l_{ij_3} + \cdots + l_{ij_k}\right]/n_i$$

$$M_{ai} = \pi_{j=1}^{m}\left[\frac{\sum_{r=1}^{k} w_{ijr}}{n_i}\right]$$

Now since we are multiplying the probabilities of each and every attribute hence; even if one of the attributes has a zero probability; the whole index will become zero. Because of this; zero probability will be replaced with a very low probability (0.001).

In the example below, source P broadcasts a request for destination Q. It calculates its mutual affinity index with respect to it neighbours node and puts it in the Route Request (R_{req}). Upon receiving RREQ, nodes a , b and c compare the mutual affinity index in RREQ with respect to P fixed the maximum affinity in their Routing Table (RT). Now each intermediate node (i.e. a, b, c) will forward route reply (RREP) to previous node if RREP contains higher affinity than that in their RT as shown in Fig.1. Source S upon receiving RREP, chooses route through b and j , while discards RREP from a,c since it had affinity lower than best two replies received by P. Now P starts sending data through both paths alternatively.

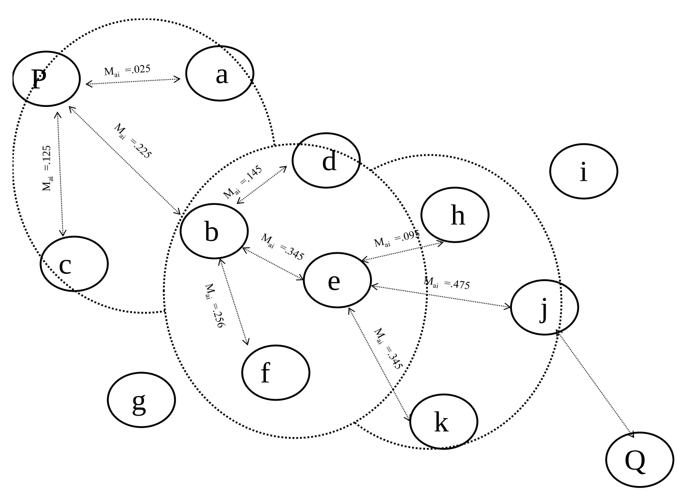

Fig. 1: Route Hunting through mutual affinity index

VII. ALGORITHM (ROUTE GENERATION)

Assumption
n= total number of node in network
mj= number of neighbor node with respect to each source node i
p= source node
rreq= route request message
history (i,j)= two dimensional table having entry of mutually affinity index of i node with respect to j node ie hij

```
Algorithm (route hunting)
for( i=1 ;i>n;i++)
for (j=1;j>m;j++)
{
sender  pi sending rreq →mj
if ( mai (pimj)> max  mai( hij))
modify (history (max hij= mai (pimj))
mj→rrpy  to pi
else
hij→rrpy  to pi
}
```

VIII. PERFORMANCE RESULTS

Proposed methodology simulated by using the network simulator NS2 using 802.11 wireless network. The paths of all moving nodes were generated randomly, and the payload used was 1400 bytes. For calculating delivery ratio, network size used was 10 nodes, as shown in Fig. 2. For the results shown in Fig. 3 and Fig. 4, simply show throughput and routing load respectively.

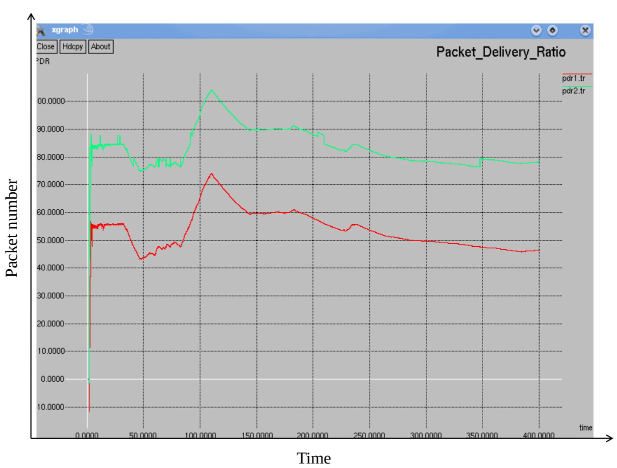

Fig. 2: Packet_Delivery Ratio of EORP Vs PORPDSB

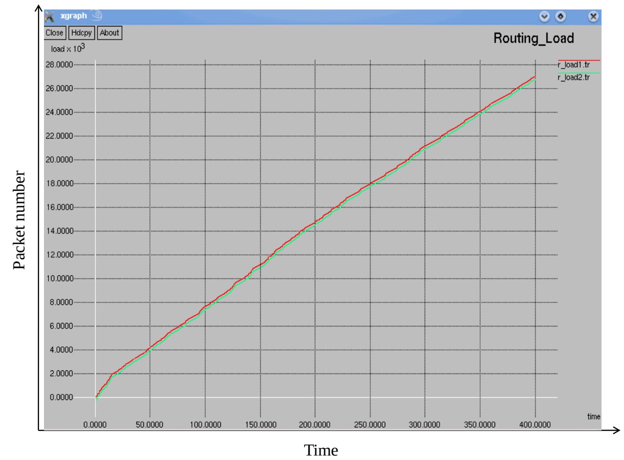

Fig. 3: Routing Load of EORP Vs PORPDSB

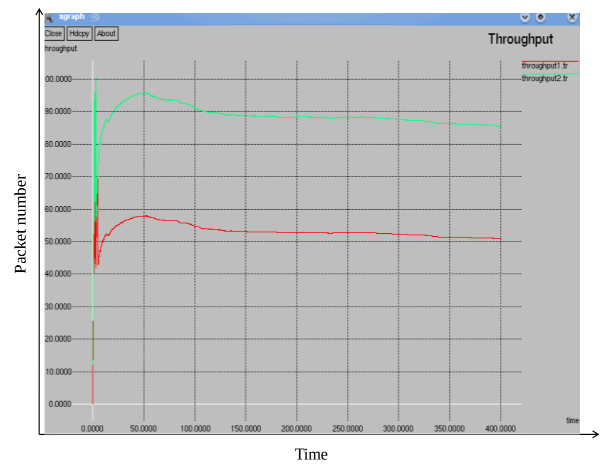

Fig. 4: Throughput rate of EORP Vs PORPDSB

IX. CONCLUSIONS

Proposed methodology use historical and probabilistic traffic information of time and space of each node to compute route from source to destination and reduce the probability of collision, rebroadcast at the expense of reach ability and enhanced scheme has higher throughput, lower latency and better reach ability. By using a Dumpster- Shafer belief method proposed methodology limited the flooding of broadcast requests. The simulation results show that the proposed method is better than the traditional methods. The graphs show the packet delivery ratio, routing load and throughput in both methods.

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