Position Based Routing for Wireless Mobile Ad Hoc Networks

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***Abstract*— In mobile ad hoc network there are several routing algorithms, which utilize topology information to make routing decisions at each node. aim of this paper is to utilize position information to provide more reliable as well as efficient routing for certain applications. Thus extensions to existing position based routing algorithm have been described to work more efficiently even in cases where they are not working at present. In this paper an algorithm is proposed, which removes some of the drawbacks of the existing GPSR (Greedy perimeter stateless routing) position based routing algorithm. In proposed algorithm different algorithm has been used to planarize the graph so that it will not disconnect the route in case of location inaccuracy in perimeter mode whereas in GPSR in certain cases of location inaccuracy it will disconnect the graph and hence the packets will not be routed thereby decreasing packet delivery ratio.**

Keywords- ***Adhoc Networks, Ad hoc on demand DVR, DSDV, Zone Routing Protocol.***

I. Introduction

Mobile ad-hoc networks (MANETs) are infrastructure-free networks of mobile nodes that communicate with each other in wireless mode [1]. There are several routing schemes that have been proposed and several of these have been already extensively simulated or implemented as well [2]. The primary applications of such networks have been in disaster relief operations, military use, conferencing and environment sensing. There are several ad hoc routing algorithms at present that utilize topology information to make routing decisions at each node in the network [3]. The aim of this work is to utilize position information to provide more reliable as well as efficient routing for certain applications. Thus extensions to existing position based routing algorithm have been described to work more efficiently even in cases where they are not working in presently implemented algorithms for implemented applications. In this work an algorithm is proposed, which removes some of the drawbacks of the existing GPSR (Greedy perimeter stateless routing) position based routing algorithm [5]. In proposed algorithm different algorithms have been used to planarize the graph so that it will not disconnect the route in case of location inaccuracy in perimeter mode. However, in GPSR, in certain cases of location inaccuracy it will disconnect the graph and hence the packets will not be routed, which causes decreased packet delivery ratio [4]. The validity of the proposed algorithm is verified and it works in those cases where existing RNG algorithm for planarization fails. This algorithm is integrated with GPSR and is simulated for quantitative evaluation. Analysis of the results shows that the proposed algorithm works where in GPSR fails to route packets.

A. Classification of Routing Protocols

Most of the routing protocols are classified as topology based and position based protocols. Topology based is classified further as reactive or on- demand while others are proactive. In general, a proactive protocol finds routes in advance while a reactive protocol finds routes to the destination only when it absolutely must. For example, Ad hoc On demand Distance Vector routing (AODV) is an on-demand protocol since no protocol information is transmitted before an application decides to send data and no data is sent until a route is formed, whereas Destination Sequenced Distance Vector protocol (DSDV) is a more proactive protocol in which routes are discovered and stored even before they are needed. Proactive protocols generally generate much more traffic than on-demand protocols. A third general category is a hybrid algorithm that effectively combines multiple characteristics in a unique and meaningful way. For example, the Zone Routing Protocol (ZRP) is a hybrid protocol that combines local proactive routing with a globally reactive routing strategy.

B. Position Based Routing Basics

One way of characterizing MANET routing protocols is whether they utilize position information or not. AODV for instance does not use position information whereas protocols like GPSR, GRID and LAR do use position information. GPSR, GRID and LAR and can be considered position based or geographic routing protocols since the position of each node is used as the basis for most routing decisions[7]. It is assumed that individual nodes are aware of their own positions in absolute or relative terms as well as their velocity and the direction in which they are moving. This category is very relevant to this work since the protocols proposed lie in this category though presently there are already over thirty such position based protocols.

II. POSITION BASED ROUTING

Since mobile ad-hoc networks change their topology frequently and without prior notice, routing in such networks is a challenging task. Position-based routing algorithms eliminate some of the limitations of topology-based routing by using additional information. They require information about the physical position of the participating nodes in the network their availability. Commonly, each node determines its own position through the use of GPS or some other type of positioning service. Position based routing is mainly focused on two issues: one; A location service is used by the sender of a packet to determine the position of the destination and to include it in the packet's destination address and two; A forwarding strategy used to forward the packets. A location service can be any one of the four:

a) Some for some
b) Some for all
c) All for all
d) All for some.

A forwarding strategy can be like;

a) Greedy forwarding
b) Restricted directional flooding and
c) Hierarchical routing.

The routing decision at each node is then based on the destination's position contained in the packet and the position of the forwarding node's neighbors. Position-based routing does not require the establishment or maintenance of routes. The nodes neither have to store routing tables nor do they need to transmit messages to keep routing tables up-to date.

A. Problems with the existing Algorithm

There are many problems with the existing GPSR protocol. There are certain problems like edge problem in which if an edge is repeated twice the GPSR protocol drops the packet. There are cases where the route exists but GPSR fails to deliver the packet. Then there are problems of location inaccuracy in which the graph is disconnected because the location information is not accurate. In this paper problem of location inaccuracy has been taken into account. In the absence of location errors, position based routing (GPSR) has been shown to work correctly and efficiently. In this work details of the effects of location errors on the correctness and performance of GPSR are provided. The evaluations of all geographic routing protocols till date have assumed the availability of accurate location information. In practice however, location measurement is often noisy and incurs some error. For example many state-of- the- art techniques usually incur around 10 % or more in localization error. There are scenarios in which an inaccurate node location causes one of the following errors: Disconnection due to incorrect edge removal by planarization, Permanent loop due to planarization failure in not removing edge, Cross links causing face routing failure and Destination inaccuracy causing failure in reaching the destination. In fig.1 Node S is the closest node, among its neighbors, to node D, hence it cannot use greedy forwarding. In the accurate topology, S uses face routing to forward the packet to f1 and the packet goes around the perimeter till it reaches D. In fig.2, the estimated topology, node E has an inaccurate location such S's planarization algorithm sees E as a witness and removes the edge(s, f) from the planar graph. Removal of (s, f) causes the planar graph to be disconnected and accordingly face routing fails to deliver the packet. Due to this the graph is disconnected in case of the existing algorithm. In the next section the algorithm is proposed which removes this drawback of the existing algorithm.

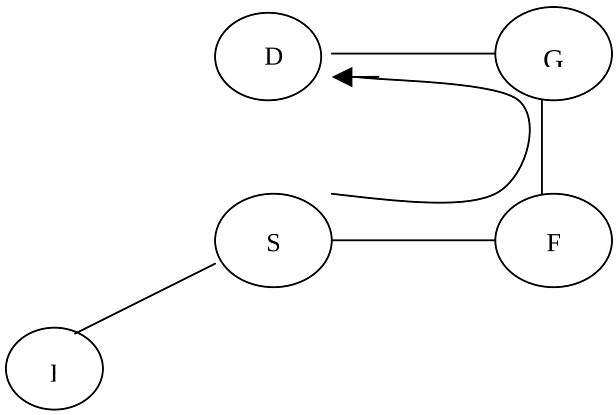

Figure 1 Accurate Graph.

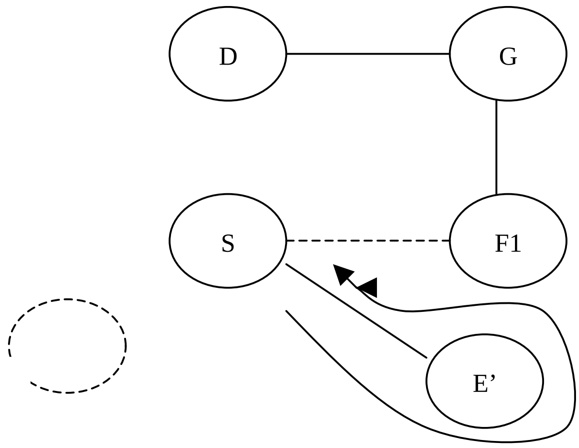

Figure 2 Estimated Graph.

III. PROPOSED ALGORITHM

Based on the understanding developed through analysis of the above problems some fixes for the above problems have been proposed and the rationale for choosing those fixes. Not all the problems are equally likely to occur. Based on their cause, the probability of their occurrences is taken into account and the solution is provided for the one which is most likely to occur. Density is a factor that affects when problems happen. At high density, greedy forwarding is used most of the time and with reasonable inaccuracy range this is unlikely to change. Since the errors happen due to face routing, dense networks look robust to these errors. Hence the emphasis is on the probability of these problems in sparse networks. Intuitively, in a sparse network, disconnection seems to be the most serious problem that can happen. More specifically, the problem of edge removal will happen when any node enters the planarization intersection between two nodes causing their edge to be removed. This is a reasonably possible error in sparse networks even with low accuracy. Based on the analysis, the disconnection problem caused by edge removal seems to have the highest probability and solving this seems likely to give the most gains in performance. So here the solution for this problem is discussed and evaluated thereafter. In the existing GPSR protocol RNG algorithm has been used for planarization. As already discussed before due to the availability of inaccurate information this planarization algorithm may result in disconnected graph due to which the packets will be dropped and will not be routed thereby degrading the performance of the protocol. Here an algorithm is proposed which removes this drawback of the existing algorithm. From the existing planarization algorithm (RNG), an edge is removed from the planar graph when a witness is seen by a node. Disconnection happens when this witness is connected to the node removing the edge but not to the other node of the edge. This fix requires modification to the planarization algorithm as follows. Before removing an edge ***(u.v),*** a node, ***u,*** sends a message to its neighbor, ***v,*** to inquire whether ***v*** sees the witness ***w***. Node ***u*** must not remove the edge until and unless it gets a reply from ***v,*** indicating that v indeed sees ***w***. This message exchange is local between neighbors and it is required only during planarization and so will not consume much overhead. This guarantees that the planar graph is always connected if the topology is connected.

The proposed algorithm is given below:

In this: N = Neighbors of u.

N1= Neighbors of v.

If P. Mode = Greedy then Forward packet using greedy forwarding.

Else set P. Mode = Perimeter and planarize the graph as below:

For all v ε N do

For all w ε N do

If (w !=N1) then

Continue

else if d(u, v) > max[d(u, w), d(v, w)] then

eliminate edge (u,v)

break

end if

end for

end for

If P. Mode = Greedy then start Forwarding packet using greedy forwarding

This algorithm overcomes the drawback of existing RNG algorithm. This algorithm has to be run in distributive manner. In the GPSR algorithm the forwarding will start as greedy forwarding and when it fails the graph is to be planarized first using the above method. In this method the neighbors of both u and v are considered. In this algorithm a set of all the neighbors of v is taken and now when u sees any witness w in between u and v it will first check that whether w is a neighbor of v or not. If w is not a neighbor of v then no need to delete the edge between u and v and it can continue as normally but if w is a neighbor of v then the condition is to be checked as specified in the given algorithm. If the condition is true, w is in shaded line between u and v then the edge is deleted. Then after planarizing the graph it gets switch over to perimeter routing and the packets are forwarded in the perimeter mode till a point is reached where it can switch back to greedy forwarding, at this point packets will be forwarded in the greedy way. The proposed algorithm works better than the existing algorithm as is clear form the analysis and the results. It has been shown that in scenarios where RNG will disconnect the graph, the proposed. Algorithm will not disconnect the graph thereby improving the routing protocol performance. Thus with this algorithm the location inaccuracy problem is no more i.e even if we have some inaccuracies in finding the location of a node then it won't result in disconnection of the graph. The algorithm is implemented using C++ on windows XP platform with VC++ IDE. It is compared with existing RNG and it is shown that it will work better. Thus it is clear from the output shown above that for a given graph the output of RNG deletes the edge which should not be deleted whereas MODIFIED RNG does not deletes that edge in case of inaccuracy of information. Thus it is clear from the output that the modified algorithm works better than RNG. Since in case of location inaccuracy due to RNG the graph is disconnected and the packets are not delivered thereby decreasing the packet delivery ratio.

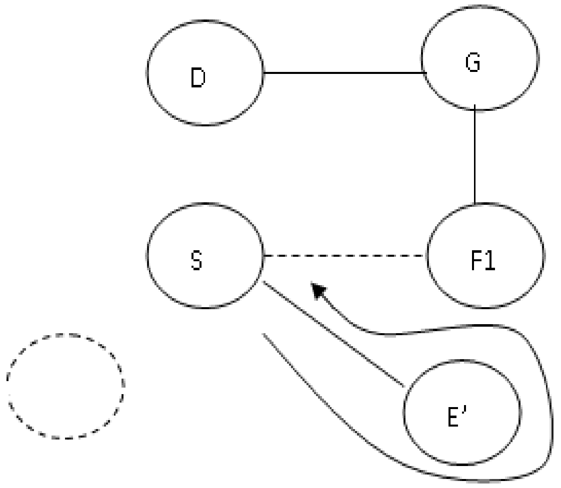

Figure 3. Estimated Inaccurate Graph

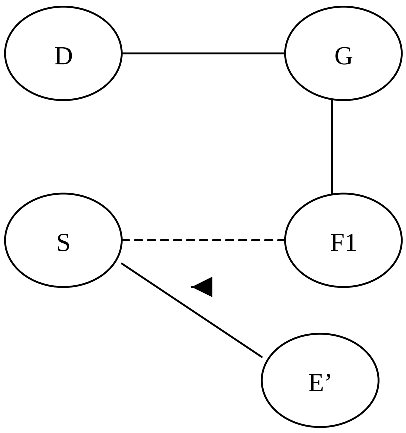

Figure 4 RNG planarized graph

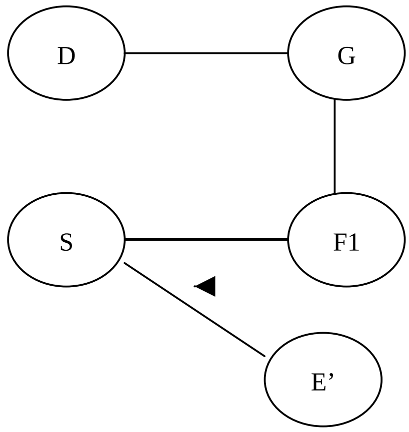

Figure5 Modified RNG planarized graph.

IV. MODEL AND ASSUMPTION

Before analyzing, the impact of location errors on position based routing protocols, the model of the wireless network is discussed here. The network consists of a set of wireless nodes, where each node knows its position using some localization technique. All nodes have the same radio range and they broadcast beacons to their neighbors, so that each node knows about its neighbors and their locations. In an ideal environment: firstly; the nodes detect and announce their accurate locations. Secondly; radio range of all nodes are exact and symmetric. Thirdly; there are no obstacles and so nodes within radio range can always communicate. Thus changes in the topology are slow comparable to the announcements such that all nodes have consistent view of the network. In this work the focus is on the effect of inaccurate localization errors on position based routing. Thus, a static and stable network has been assumed without obstacles and with nodes having accurate and symmetric radio ranges. It has been assumed that nodes have consistent location information about other nodes, which means that a node estimates its location and announces it, and all nodes observe the same estimated location for that node.

V. METHODOLOGY AND METRICS

Here the focus is in evaluating the effects of location inaccuracy on position based routing without any interference from other layers such as MAC collisions or physical layer effects. Thus the routing behavior in an ideal wireless environment is considered in simulations for GPSR. In the simulations a static and stable network of 100 nodes having the same radio range of 80 meters is considered. In the simulations the density of the network is varied by changing the space size, where the density is presented as the number of nodes per radio range. Each simulation run, nodes are placed at random locations in the topology and results are computed as the average of 20 runs. In this only those topologies are considered where network is connected. The maximum localization error is presented as a fraction of the radio range. The estimated node location is picked uniformly from a random location around the node accurate position limited by the maximum localization error. The main metric that is used in the simulation is the success rate of packet delivery since this represents the correctness of the protocol in the face of inaccuracy.

VI. RESULTS

In this section results are presented for uniformly distributed random topologies with localization errors 1-10% of the radio range. The density is changed from 5 nodes per range to 20 nodes per range and the success rate is observed. Although, sensor networks deployment are expected to be of high density, the operational node density could be much less. Figure shows the success rate of GPSR.

Even with relatively low location inaccuracy, the success rate is affected. At high densities the success rate is above 99 %, but all failures are persistent and non-recoverable, as mentioned earlier. At lower densities , the success rate decreases significantly. From the figures it is clear that errors happen mainly at low densities, which gives another indication that these errors are due to edge removal from the planar graph.

Figure shows the success rate of GPSR without fix at various densities at different location inaccuracies. Figure 18 shows the success rate of Modified GPSR with Modified RNG in place of RNG. The results in table 2 below shows that even for realistic and relatively small location errors, the effects of location errors are noticeable. Furthermore, the validation of the proposed algorithm shows very promising results. The modified GPSR achieve near-perfect performance even in the presence of significant localization errors. The results are shown in graphs too.

Table 1- Comparison of modified one with GPSR

Location In-accuracy	Density	Success Rate	
		GPSR	Modified GPSR
10 %	5	0.85	0.95
	6	0.87	0.97
	8	0.90	0.98
	10	0.92	0.99
	12	0.95	0.992
	14	0.97	0.994
	16	0.98	0.996
	18	0.99	0.997
	20	0.99	0.998
20 %	5	0.75	0.94
	6	0.80	0.96
	8	0.87	0.97
	10	0.92	0.98
	12	0.94	0.99
	14	0.96	0.991
	16	0.97	0.993
	18	0.98	0.995
	20	0.99	0.997
30 %	5	0.70	0.92
	6	0.75	0.93
	8	0.85	0.94
	10	0.89	0.96
	12	0.92	0.97
	14	0.95	0.98
	16	0.96	0.985
	18	0.97	0.99
	20	0.99	0.995
40 %	5	0.55	0.90
	6	0.65	0.92
	8	0.80	0.93
	10	0.90	0.94
	12	0.92	0.96
	14	0.94	0.97
	16	0.95	0.98
	18	0.98	0.985
	20	0.99	0.994
50 %	5	0.50	0.90
	6	0.55	0.91
	8	0.75	0.92
	10	0.85	0.93
	12	0.90	0.95
	14	0.95	0.96
	16	0.97	0.975
	18	0.98	0.98
	20	0.99	0.993

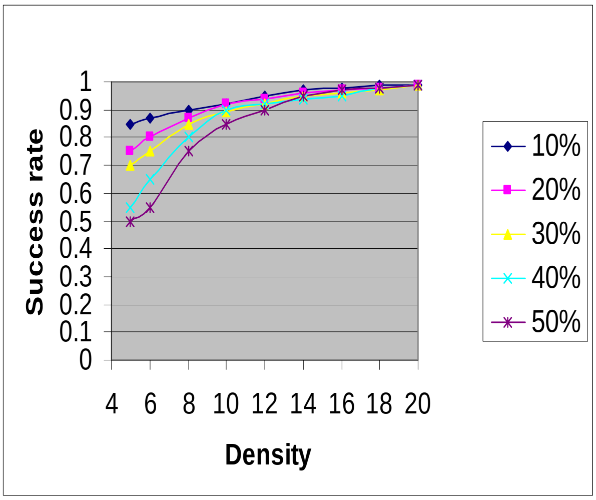

Figure 6 GPSR performance without Fix

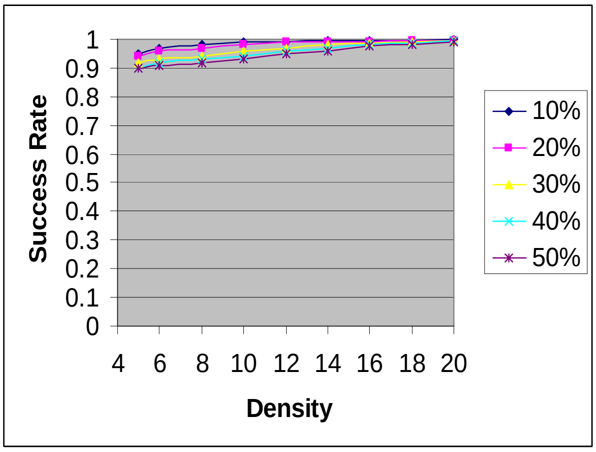

Figure 7 Modified GPSR performance

VII. CONCLUSION

In this work a new algorithm has been proposed to fight with the problem of location accuracy in the existing GPSR algorithm. GPSR is causing failures in such location inaccuracy scenarios. The problem was mainly due to the flaw in the planarization algorithm used in the existing GPSR algorithm. Hence here that algorithm has been modified. Since in case of location inaccuracy due to RNG the graph is disconnected and the packets are not delivered thereby decreasing the packet delivery ratio. Whereas in case of modified RNG it guarantees that the planar graph is always connected if the topology is connected. The proposed algorithm is working in scenarios where RNG gives error. Moreover it is clear from the quantitative comparison with the GPSR that it works better than the existing algorithm.

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