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A Fuzzy Set Approach in MANET with FSR (Fisheye State Routing) Protocol

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Abstract— Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes that dynamically forms a network. Packet Reach ability and Broadcasting in Mobile Ad Hoc Networks (MANETs) is a fundamental data dissemination mechanism with a number of important applications, e.g., route discovery, address resolution. Broadcasting in MANETs has traditionally based on flooding, which simply swamps the network with large number of rebroadcast messages in order to reach all network nodes. Although probabilistic flooding has been one of the earliest suggested schemes to broadcasting, there has not been so far any attempt to analyze its performance behavior in a MANET environment. In an effort to fill this gap, this paper investigates using extensive NS-2 simulations the effects of a number of important system parameters in a typical MANET, including node speed, pause time, and node density on the performance of probabilistic flooding. The results reveal that most of these parameters have a critical impact on the reach ability and the number of saved rebroadcast messages achieved by probabilistic flooding. To overcome these problems an optimal path management approach called path vector calculation based on fuzzy and rough set theory were addressed. The ultimate intend of this study is to select the qualified path based on packet reach ability of the node, number of internodes and traffic load in the network. Simple rules were generated using fuzzy set techniques for calculating path vector and to remove irrelevant attributes (resources) for evaluating the best routing to reduce flooding. The set of rules were evaluated with proactive protocols namely FSR in the NS-2 simulation environment based on metrics such as Saved rebroadcast, Packet Reachablity, Node speed, Density and Pause-time.

Index Terms— Broadcasting **,** Density**,** Flooding probability **,** FSR (Fisheye State Routing) Protocol , Fuzzy Set Theory**,** mobility, Node Speed ,NS2, Packet Reach ability, Pause time ,Saved Broadcasting.

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1 Introduction

A mobile ad hoc network is a group of mobile nodes which communicate with one another without any fixed networking infrastructure. Wireless networking technology is evolving as an inexpensive alternative for building federated and community networks (relative to the traditional wired networking approach). In particular, they do not need a base station controlling medium access.This type of network allows for spontaneous communication without previous planning between mobile devices. Some devices may even have forwarding capabilities to extend coverage.

2 Fisheye State Routing Protocol

The Fisheye State Routing (FSR) protocol uses the fisheye technique to reduce the routing overhead. It is proposed by Kleinrock and Stevens, the eye of a fish captures with high detail the pixels near the focal point. The detail decreases as the distance from the focal point increases. In routing, the fisheye approach translates to maintaining accurate distance and path quality information about the immediate neighborhood of a node, with progressively less detail as the distance increases. The FSR concept originates from Global State Routing (GSR). GSR can be viewed as a special case of FSR, in which there is only one fisheye scope level. As a result, the entire topology table is exchanged among neighbors. Clearly, this consumes a considerable amount of bandwidth when network size becomes large. The link state packets are exchanged periodically instead of event driven. Through updating link state information with different frequencies depending on the scope distance, FSR scales well to large network size and keeps overhead low without compromising route computation accuracy when the destination is near. By retaining a routing entry for each destination, FSR avoids the extra work of “finding” the destination and thus maintains low single packet transmission latency. As mobility increases, routes to remote destinations become less accurate.

However, when a packet approaches its destination, it finds increasingly accurate routing instructions as it enters sectors with a higher refresh rate. FSR is suitable for large and highly mobile network environments as it triggers no control messages on link failures. Broken links won’t be included in the next link state message exchange. This means that a change on a link far away does not necessarily cause a change in the routing table. FSR introduces the notion of multilevel fisheye scope to reduce routing update overhead through reducing the routing packet sizes and update frequency.

Figure 1 illustrates how the fisheye technique is applied to a MANET. When the size of a network increases, sending update messages may potentially consume the bandwidth. FSR uses the fisheye technique to reduce the size of the update message without affecting routing. In the figure, three fisheye scopes are defined with respect to the focal point, node 11.

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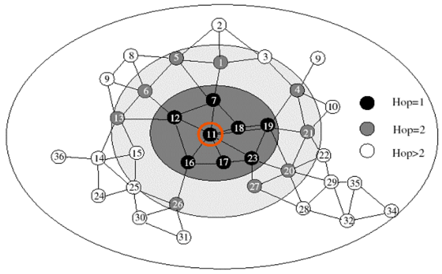


Fig. 1 : Fisheye Scope

Each scope is defined by the set of nodes that can be reached by a certain number of hops. The figure illustrates three scopes of size 1, 2, and greater than 2 hops. Selection of scope levels and radius are dependent upon individual network requirements. Routing overhead is reduced by modifying how often entries are propagated from the central node. Because of this frequency modification, overhead can be reduced. However, while neighboring nodes are receiving timely updates, large latencies are created from more distant nodes. Compensating for this latency increase is the fact that as the packets get closer to the central node, the routes are increasingly more accurate.

3. MATERIALS AND METHODS

The motivation for an analytical solution of path selection is based on various reasearch efforts. A number of routing protocols such as AODV, DSR, DSDV, FSR and WRP have been proposed for Ad Hoc networks.FSR protocol based on source routing where all the routing information is maintained (continually updated) at mobile nodes. However, it uses source routing instead of relying on the routing table at each intermediate device. When the size of a network increases, sending update messages may potentially consume the bandwidth. FSR uses the fisheye technique to reduce the size of the update message without affecting routing.The selection is based on consideration of four resources such as saved rebroadcast, reachability, density, pause time.

3.1 Fuzzy set Theory

Fuzzy set theory: Fuzzy set theory was first proposed by Zadeh (1965). The main objective of this theory is to develop a methodology for the formulation and solution of problems that are too complex or ill-defined to be suitable for analysis by conventional Boolean techniques. A fuzzy set can be defined as a set of ordered pair A = {x, μA (x)/x∈U}. The function μA(x) is called the membership function for A, mapping each element of the universe U to a membership degree in the range [0, 1]. An element x∈U is said to be in a fuzzy set if and only if μA(x) > 0 and to be a full member if and only if μA(x) = 1. Membership functions can either be chosen by the user arbitrarily, based on the user experience or they can be designed by using optimization procedures. The triangular membership function is defined as:

$$\mu A(x) = \text{triangular}(x, a, b, c)$$

$$A = \begin{cases} 0, x \le a \\ (x-a)/(b-a), x \in (a,b) \\ (c-x)/(c-b), x \in (b,c) \\ 0, x \ge c \end{cases}$$

3.2 Information system

An information system can be viewed as atable of data, consisting of objects (rows in the table) and attributes (columns). As information system may be extended by the inclusion of decision attributes. Such a system is termed as decision system. Suppose we are given two finite and non empty sets U and A, where U is the universe and A, a set of attributes. With attribute a∈A, we associate a set (value set) called the domain of a. Any subset B of A determines a binary relation IND (B) on U which will be called an indiscernibility relation Eq. 1:

IND (B) = {(x, y) ∈U/□∀a∈B, a(x) = a(y)} (1)

where, IND (B) is an equivalence relation and is called B-indiscernibility relation.

3.3 Lower and upper approximation

Let us consider B⊆A and X⊆U. We can approximate X by using only the information contained in B by constructing lower approximation (2) and upper approximation (3) of x in the following way Eq. 2 and 3:

B* (x) = {x∈U: B(x) ⊆ x} (2)

and:

B* (x) = {x∈U: B(x) ∩X≠ φ} (3)

Equivalence classes contained within X belongs to the lower approximation whereas equivalence classes within X and along its border form the upper approximation. Let P and Q be set of attributes including equivalence relation over U, then the positive region is defined as Eq. 4:

POSp(Q) = ∪ P*X (4)

x∈U□/Q

where, POSP(Q) compromises all objects of U that can be classified to classes U□Q using the information contained within attributes P.

4. SIMULATION ENVORNMENT

Table 1.Summary of the Parameters used in the Simulation experiments.

Simulation Parameters	Value
Transmitter range	250 m
Bandwidth	2 Mbit
Simulation Time	100 seconds
Pause Time	0, 5, 10 seconds

Topology Size Number of Nodes Maximum Speed	600 X 600 m2 25,50,75,100 0, 5, 10, 15, 20 m/sec

Since revealed in Table 1, we initially made some hypothesis on the parameters of the system architecture in the simulations. The simulation transmitter range of a network in an 600X600m2 area with 100 mobile nodes. In these simulations used the same communication pattern for all mobility simulations. We assumed that the mobility of the mobile nodes was random. Each simulation was run for 100 sec. The network having the bandwidth of 2Mbit and the Pause time is 0, 5, 10, 15 sec. The traffic pattern consisted of Constant Bit Rate(CBR) traffic type. The speed of each mobile node was assumed varied from 0,5,10,15,20 m/sec. The Transmitter range for each node was assumed to be 250m. The communication traffic and scenarious simulations are randomly generated by NS2 itself.

5 RULES EXTRACTION

Table.2 Dataset for No of Nodes Vs Saved Re Broadcast

Nodes	SRB1	SRB2	SRB3
25	1	1	1
50	0.5652	0.4389	0.4546
75	0.4347	0.3217	0.1857
100	0	0	0

Table.3 Dataset for Speed Vs Reachablity

Nodes	Reach1	Reach2	Reach3
40	0	0	0
30	0.14286	0.26538	0.25
20	0.57143	0.06326	0.625
10	1	1	1

Table.4 Dataset for Node Density Vs Reachablity

Nodes	Density1	Density2	Density3
50	1	1	1
100	0.7685	0.85923	0.52035
150	0.54500	0.71767	0.37955
200	0.24884	0.00622	0.16612
250	0	0	0

Table.5 Pause time Vs Reachability

Nodes	Pause1	Pause2	Pause3
50	1	1	1
100	0.632	0.63934	0.745
150	0.325	0.39665	0.379
200	0.419	0.71550	0.166
250	0	0	0

5.1 Fuzzifying The Dataset

From Dataset, consider Saved Rebroadcast, Reachability, Pause time, Density as three condition attributes and total vector cost as a decision attribute to represent minimum cost for the selection of best path. A very common parametric function is the triangular membership function which can be derived through automatic adjustments. Each attribute have three fuzzy regions (low, medium and high) described as follows:

Saved Rebroadcast
Low (0, 0.1, 0.2, 0.3, 0.4)
Medium (0.5, 0.6, 0.7)
High (0.8, 0.9, 1.0)

Reachability
Low (0, 0.1, 0.2, 0.4)
Medium (0.4, 0.5, 0.6)
High (0.6, 0.7, 0.8, 0.9, 1.0)

Density
Low (0, 0.1, 0.2, 0.3, 0.4)
Medium (0.5, 0.6)
High (0.7, 0.8, 0.9, 1.0)

PauseTime
Low (0, 0.1, 0.2, 0.3, 0.4)
Medium (0.5, 0.6, 0.7)
High (0.8, 0.9, 1.0)

Thus three Fuzzy membership values are produced for each path according to the predefined membership functions. The fuzzified result is shown in concern Tables.

Table.6 Nodes Vs Saved rebroadcast

Nodes	SRB1	SRB2	SRB3	T. V. C
E1	H	H	H	G
E2	M	L	L	P
E3	L	L	L	P
E4	L	L	L	P

From the Table 6, it is depicted that E1 has the Good Total Vector Cost. So the rule generated as, When number of nodes is decreased the saved rebroadcast will be increased.

Table.7 Speed Vs Reachablity

Nodes	Reach1	Reach2	Reach3	T.V.C
E1	L	L	L	P
E2	L	L	L	P
E3	M	H	H	G
E4	H	H	H	G

From the Table 7, it is depicted that E3 and E4 has the Good Total Vector Cost. So the rule generated as, When number of nodes is decreased the reachability will be increased.

Table.8 Node Density Vs Reachability

Nodes	I	II	III	T. V. C
E1	H	H	H	G
E2	M	H	M	G
E3	M	H	L	G
E4	L	L	L	P
E5	L	L	L	P

From the Table 8, it is depicted that E3 and E4 has the Good Total Vector Cost. So the rule generated as, When number of nodes is decreased the density will be increased.

Table.9 Pause time Vs Reachability

Nodes	Pasue1	Pause2	Pause3	T.V.C
E1	H	H	H	G
E2	M	M	M	G
E3	L	L	L	P
E4	L	M	L	P
E5	L	L	L	P

From the Table 9 , it is depicted that E3 and E4 has the Good Total Vector Cost. So the rule generated as, When number of nodes is decreased the pause time will be increased.

5.2 Information gain

The decision attribute (Total vector cost) has two values, Good and Poor. Each value may be classified into its partition. From Table6, it is clear that XG = {1} and XP = {2, 3, 4}. It means path 1 belong to partition XG and path 2, 3 and 4 belong to partition XP. From Table7, it is clear that XG = {3, 4} and XP = {1, 2}. It means path 3 and 4 belong to partition XG and path 1 and 2 belong to partition XP. From Table8, it is clear that XG = {1, 2, 3} and XP = {4, 5}. It means path 1, 2 and 3 belong to partition XG and path 4 and 5 belong to partition XP. From Table 9, it is clear that XG = {1,2} and XP = { 3, 4, 5}. It means path 1and 2 belong to partition XG and path 3,4 and 5 belong to partition XP.For each partition, dentifying the C-lower approximation of XY and XN, we have CXG = {0} and CXP = {0}.

6 SIMULATION RESULTS

Pause Time

Pause time refers to the rest time of the node. A node begins by staying in one location for a certain period of time.

Node Speed

Node speed refers to the average speed with which nodes move in the simulation area.

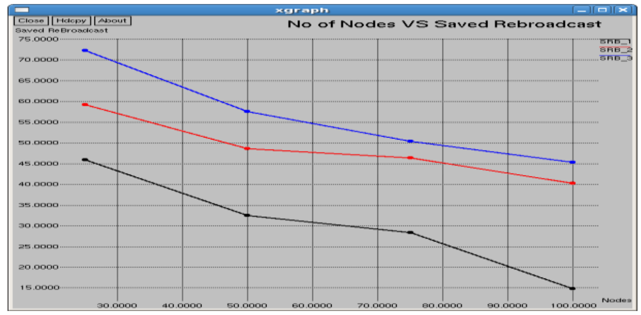


Fig. 2 Impact of Saved rebroadcast of three broadcast schemes against network density with 100 nodes.

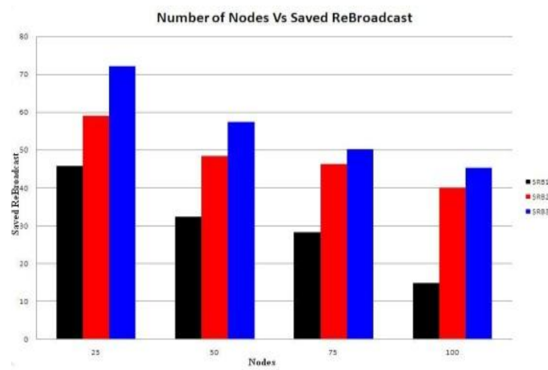


Fig. 3: Different levels of SRB with respect to Number of Nodes

Fig.2 and Fig.3, The saved rebroadcast achieved by for continuous mobility (0 and 20 s pause time). For each pause time, the maximum speed of the nodes has been varied from 1, 5, 10 to 20 m/s. For each probability value, as the node pause time increases the amount of saved rebroadcasts increases.

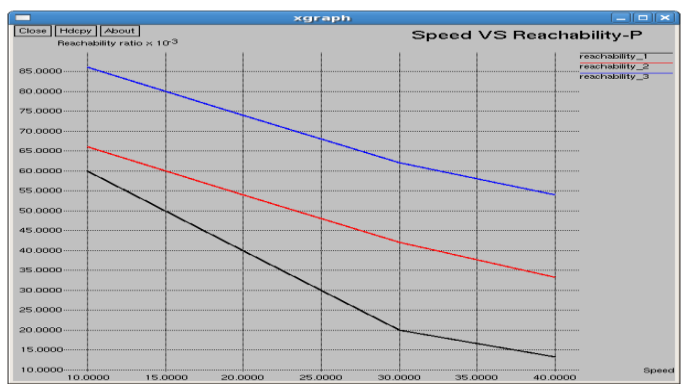


Fig. 4: Impact of P-Reachability with different node Speed 0, 40 m/s

Fig. 5: Different levels of Reachability Ratio with respect to Nodes and Speed

Fig.4 and Fig.5, Reach ability get decreased if node speed is increased. For high pause time, reach ability results high, and if pause time is low then reach ability results low reach ability. The results for saved rebroadcasts achieved by continuous (i.e., 0 s pause time) and non-continuous mobility. For each pause time, the maximum node speed has been varied from 1, 5, 10, to 20 m/s.

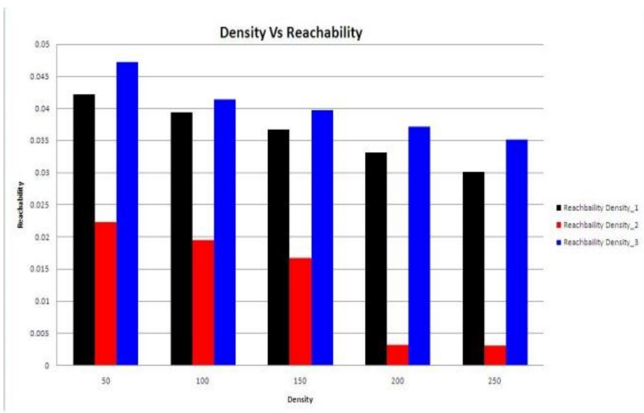
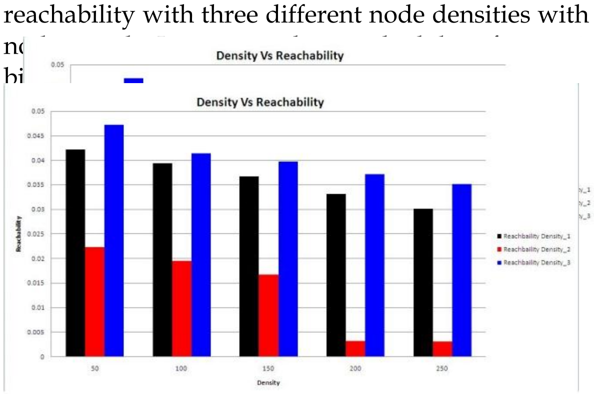


Fig. 6: Different levels of Density on Reach ability Ratio

Fig.6 ,depict the degree of reachability achieved when the rebroadcast probability is increased. The figures show how reachability with three different node densities with different nc ... uous mo- bi ... the figure ... vork den- ... e Time on ... ith Reach



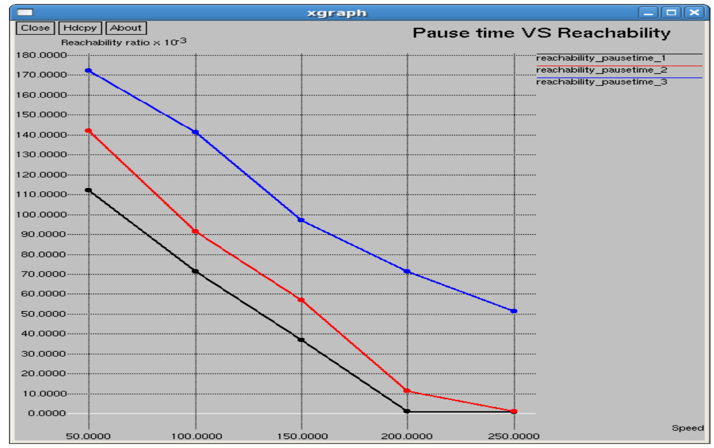


Fig.7 Impact of Pause Time on Reach ability with different Node Speed

7 CONCLUSION AND FUTURE WORK

The results have shown that in MANET, decision rules with fuzzy and rough set technique has provided qualified path based best routing to reduce flooding using FSR protocol. This paper has analyzed the effects of node speed and pause - time on the performance of the probabilistic approach to flooding (or broadcasting) in MANETs. Results from extensive ns-2 simulations have revealed that mobility and pause times have a substantial effect on the reach ability and saved rebroadcast metrics. The results have shown that for different rebroadcast probabilities, as the node speed increases, reach ability and saved rebroadcast decreases. Moreover, as the pause-time increases saved rebroadcast increases. So, during Simulation at certain period of time some node does not rebroadcast as messages are saved. In Future work, similar performance trends can be observed when the other important system parameters, notably with node density and traffic load, which may have a great impact on the degree of reach ability and the number of saved rebroadcasts achieved by the probabilistic broadcasting scheme. The network life time and performance of proactive protocols – FSR in MANET has improved with fuzzy and rough set based decision rules.

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