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Reaodv: Reliability Enhanced AODV Routing Protocol for MANET

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Abstract:Mobile ad-hoc network (MANET) is always remains the centre of attention for research and development of wireless network. Its dynamic nature imposes several challenges to the MANET, frequent link breakage occurs due to its dynamic nature. Hence there must be some technique which maintains the link stability in spite of mobility. A challenging problem is how to select a more reliable path from source node to destination in moderate to high level of mobility. This paper presents an reliability enhanced AODV (RE-AODV) routing protocol in which we provides stable path selection considering stable links on the basis of different factors like power of node, signal strength of node and distance between the nodes and link expiration time and also presents a modified route discovery process. We discussed and analyzed this protocol with help of example which shows improvement over existing AODV protocol.

Keywords: Path Selection Factor, Reliability Pair Factor, Link Expiration Time

I. INTRODUCTION

An ad-hoc network, as the name suggests, is a network formed by nodes connected arbitrarily for some temporary time. Since a MANET has no infrastructure and it is multi hop in nature, each node acts as a router. The nodes are moving arbitrarily, and the topology of the network is dynamic. However, the advantages are numerous. Firstly, deployment is easy and speedy. Secondly, because there is no dependence on infrastructure, the network is robust and low-cost. Finally, MANETs form the basis of all pervasive and ubiquitous computing. Few examples which use the concept of Ad- hoc networking include students working with laptop for participation in an interactive lecture, soldiers communicating information for situational awareness on the battlefield and emergency disaster relief personnel coordinating efforts after a earthquake. MANETs can be a viable solution for communications and information access.

Routing poses several problems in MANET since mobility causes radio links to break frequently [1]. When any link or path breaks, this path needs to be either repaired by finding another link if any or replaced with a newly found path. This rerouting operation cost the radio resource and battery power while rerouting delay may affect quality of service (QoS) for applications and degrade the network performance. Link stability [2] is a qualitative measurement of the capacity of link for how much time of span this link can survive in the environment condition. Node mobility, limited battery and scarce Bandwidth resource makes the routing protocols designed for traditional networks impractical for use directly in MANETs.

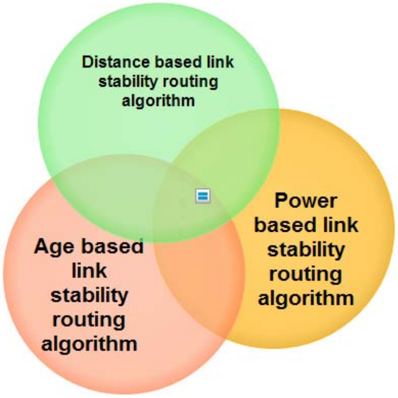
It is necessary to find a new metric for selection of stability of link. This paper proposes a new metric for the Route Discovery process which is known as path selection factor which is composed of two parts one is reliability pair factor and another one is link expiration time. RE-AODV is destination oriented routing strategy in which destination decides that which path has highest value of stability considering reliability pair factor [2] metric comprises of three main factors as energy of node, signal strength of node and distance between nodes. Another sub metric which is link expiration time [3] depends on the value of velocity of node of the link and the direction of movement of node. The path selection is done on destination side. Destination node accept all the Route Requests during Δt time and compare all the value of the metric known as path selection factor and finally, send a route reply packet to the source node by path which has highest value of path selection factor. For the verification of our work we present here an example.

The remaining part of our paper is organized as follows: In section II related work done in field of link stability in MANET has discuss the and in section III problem statement has discuss and in section IV the proposed approach for the selection of stable path is describe and analysis of example discussed in section V finally in section VI we will conclude the paper and give the future scope of this paper.

II. RELATED WORK

A number of researches have been conducted on the link stability in MANET but still lot of work has to done in future for MANET and link stability for MANET is still an open problem for research work. In this section, we briefly present routing protocols in MANETs. Mainly link stability based algorithms are classified in to three categories:-

In the distance-based strategies, the estimated distance between two connected nodes is used for the prediction of the remaining lifetime of the link between them. In, GPS measurements are used to derive the distances between terminals and the node speeds In age based approach the connectivity time between two nodes is measured and it is further utilized to found the remaining lifetime between nodes.



In power based routing algorithm the remaining battery power is used to calculate the link stability.

In [4] a composite metric has been developed which utilizes two sub parameters like mobility factor and energy factor to calculate the link stability. She define metric as Link Stability Degree (LSD) is defined as

LSD = Mobility factor / Energy factor

It defines the degree of the stability of the link. Higher the value of LSD, higher is the stability of the link and greater is the duration of its existence. But the problem with this metrics is that in numerator part it considers the mobility factor and in denominator it uses the energy but stability is proportional to energy not mobility so this cannot be used as measuring link stability.

Mr. H.B.Li proposes a Link Life time based Segment-by-Segment Routing protocol (LL-SSR) [5] in mobile ad-hoc networks, where each node maintains a routing table for its k-hop region. A region is unstable if most of its nodes change their presence in the region during the time interval. In contrast, if most of the nodes in the region remain the same during the time interval, it is considered as a stable region.

To choose more stable route in Ad Hoc network, Limin Meng [6] integrated the link stability arithmetic and the principle of the least hop number in route discovery, and proposed link stability Dynamic Source Routing protocol. This protocol chooses route with high link stability, and decreases the number of route interrupted, which results in lower packet loss rate and improves the performance of the network.

The link stability arithmetic is based on radio communication model [7] which opens out the relationship among the send power, the receive power and communication distance. With proper radio communication model, we can calculate the distance between nodes. In this paper, we use Two-Ray model as,

$$P_r = \frac{P_i \cdot G_i \cdot G_r \cdot (h_i \cdot h_r)^2}{D^4}$$

Long-lived Route Prediction (LRP) [8] scheme is proposed to help discover long-lived routes. The LRP scheme predicts route based on the history of link lifetime. The benefit of the LRP scheme is that it is not using the GPS or the received signal strength has not affect by the presence of shadow effect. Each node maintains a record of link lifetime, which is the history of link lifetime observed by the node. Each node monitors the lifetime of links to its neighbors. The age and lifetime of a link can be determined by counting the number of hello packets received.

Celimuge Wu proposes a MANET routing protocol considering link stability and bandwidth efficiency. This uses distributed Q-Learning and preemptively switching to better route before current route fails. It use dynamic Q-Table that the size of Q-Table [9] of a node is determined by the number of destination nodes and neighbor nodes. QLAODV can efficiently reduce the number of route errors and route discoveries. QLAODV also increases the packet delivery ratio while considering bandwidth usage between nodes.

Little material focuses on the link expiration time prediction and its implementation with the DSR protocol. This approach discussed in [10] compares three prediction algorithms based on either the Global Positioning System (GPS), or the signal strength (SS), or both. this integrate of the link expiration time (LET) prediction in order to decrease the data packets' loss due to links' failures.

Weiying Zhu addresses the issue of reducing path breakage during data transmission. Ticket-based probing with stability estimation (TBP-SE) [11] is an enhancement for the multi-path distributed QoS routing scheme. TBP-SE enhances the stability of selected paths in terms of average relative path stability, path breakage speed, and amount of data transfer taken before path breaking.

III. PROBLEM STATEMENT

As the dynamic characteristics of MANETs impose many challenges to network protocol designs on all layers of the protocol stack. Considering [2] author gives a metric known as "Reliable pair factor" for the selection of stable path. In this approach author takes local decision for selection of reliable neighbor it calculate the reliability pair factor in the unicast manner and select the path in unicast pattern this scheme does not provide method for global selection of stable links and also the problem which I analyze is that in this approach does not calculate the reliability pair factor of possible links and if the case that it ignore the link of high reliability factor then this technique result in the lower link stability degree. So we can enhance this with broadcast version of route discovery process of the protocol that should be combined with the AODV protocol to the remaining strategy.

IV. PROPOSED APPROACH

In this section we discussed working of Modified link stability based Routing RE-AODV routing protocol of Mobile Ad-hoc Network) protocol which use the metric known as path selection factor. The base protocol which we are using is AODV (Ad-hoc On Demand Distance Vector).We have modified route discovery process. In existing route request packet format we added five fields known as energy, signal strength, location of node in RREQ header format. In route discovery process of RE-AODV we take the decision of route selection at the destination node. As source node broadcast route request through all possible paths, when route request reaches to destination it wait Δt time for more route request packet after that destination send route reply to one path in which node have maximum numerical value of path selection factor. After route discovery process source node send packet to destination node with the selected path.

In this approach four different factor has been used to calculate the value of stability (Path selection factor), we are also giving here a discussion about the model which are used in this approach.

a. Energy model
b. Signal strength model
c. Mobility model
d. Link Expiration time

A. Energy Model:

A limited battery backup is provided in MANET and when the data transmission occur each node's energy decreases hence it is very important to discuss the energy model when we are talking about the link stability.

At the end of certain time interval, it is calculated as the remaining power of a node that may not be same as initial power when node transmit a number of packets during an interval causes little amount of drain in node's battery power. The diagram below shows that as time are increases the power level of node decreases. As we know that power drop as data transmission takes places as shown in fig.2 suppose after each packet transmission decrement in power take place as shown in equation (1)

$W_{irem} = W_{itotal}$ - N*$W_{transfer}$ ……….(1)

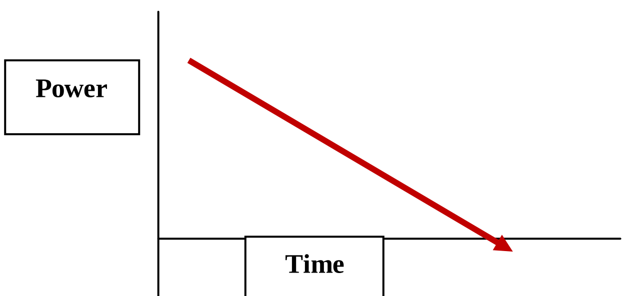


Fig. 2: Power vs time

Where

W_{irem} be the remaining battery power of node i after time t sec

$W_{i\ total}$ is the total energy of node i at initial stage

N is the number of transferred packets

$W_{transfer}$ is the amount of energy needed to transfer a packet

In our energy model we are also take the concept of threshold power (W_t). The threshold power is the minimum power of a node which require for participation in further route discovery process. We take value W_t as threshold value of power of node. If the node power level goes below this then node does not participate in the Route Discovery process Then node discard the RREQ packet and if node power level goes above this value, node take part in the route discovery process. We considered value of W_t as 120 mili Watt in our proposed approach.

B. Signal Strength Model:

Once the distance between two neighborhoods exceed a certain extent, the transmission signal will not be received correctly by receiver. Thus, it will result in link failure. If a node receives a strong signal from a neighbor then the link between them is considered as stable, otherwise the link is considered as unstable.

When two mobile nodes are moving closer or in opposite direction, the latest signal power strength will be greater than the previous one or the latest signal power strength will be smaller than the previous one

$S_{final} = S_1 \pm S_2$ …………….(2)

Where S_1 and S_2 are the signal strength of the nodes. If they get closer this equation will take plus signa and if they are moving in opposite direction this equation will take minus sign.

C. Mobility Model:

Let initial positions of nodes i and j have coordinate values (X_1, Y_1) and (X_2, Y_2), respectively. Suppose nodes i and j are moving with variable velocities V_1 V_2 in a particular direction decided by angles θ_1 and θ_2 with x-axis. We are finding the new co-ordinate of i,j. After movement node i, new co-ordinate is (X_1', Y_1').

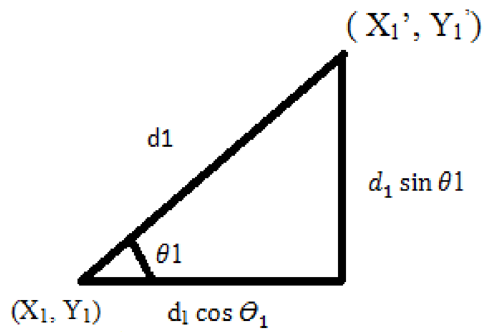


Figure.3: co-ordinate calculation

$$X_1' = X_1 + d_1 \cos \Theta_1$$
$$Y_1' = Y1 + d_1 \sin \theta 1$$

D. Route Discovery Process:

For the calculation of Reliable pair factor and Link Expiration Time we need the energy and signal strength and distance moved by node .So we append this information in RREQ header and broadcast it.

a. Modified RREQ packet header: This approach adds five fields in existing route request header as following:

a) Power of node
b) Location of node (X,Y co-ordinate)
c) Signal strength of node
d) Numerical value of Reliable pair factor calculated at each node in the route
e) Numerical value of Link Expiration Time of each link

The complete header is shown below:-

<table>
<tr><td colspan="5">Route Request ID</td></tr>
<tr><td colspan="5">Source IP</td></tr>
<tr><td colspan="5">Destination IP</td></tr>
<tr><td colspan="5">Source Sequence Number</td></tr>
<tr><td colspan="5">Destination Sequence Number</td></tr>
<tr><td>TYPE</td><td>HOP COUNT</td><td>Xnode</td><td>Ynode</td><td>Power node</td></tr>
<tr><td>LET</td><td colspan="3">SIGNAL STRENGTH OF NODE X</td><td>Frp</td></tr>
</table>

E. Working of Proposed Approach:

- ***a. At Source Node:*** Source node append their geometric location and signal strength and power of node to the header of the route request and broadcast the RREQ to all their neighbors
- ***b. At Intermediate Node:*** After receiving the route request packet neighbors' extract the information and check that Power of node is above threshold. If power is below threshold then node discard the RREQ packet and does not take part in Route Discovery process and if the power is above the threshold value then computes the value of Path selection factor with the help of the formula-

$P_{sf} = F_{RP*}$ LET.. ……………………………………(1)

Where reliability pair factor is computed as

$F_{RP} = \frac{\min(P_i, P_j) + D_s}{d_{(ij,t)}}$ …………………………..……(2)

Where P_i , P_j represents the power of node i and j

D_s represents the differential signal strength of link (i,j).

$D_{(ij,t)}$ represent the distance between node i and j at time t.

And also calculate the value of link expiration time of each link with the help of formula given in

LET=

$\{-(ab+cd)+\sqrt[2]{(a^2+c^2)r^2-(ad-bc)^2}\}/\ \{a^2+c^2\}$

…………………………..(3)

Where $a = V_i \cos\theta_i - V_j \cos\theta_j$

$b = X_i - X_j$

$c = V_i \sin\theta_i - V_j \sin\theta_j$

$d = Y_i - Y_j$

Where V_i, V_j are velocity of node i and j θ_i , θ_j are angle of node i and j from Xaxis in anticlockwise d direction.

Note also that the equation cannot be applied when $V_i = V_j$ and $\theta_i = \theta_j$ and when LET is ∞.

Intermediate node put the computed value of reliability pair factor and link expiration time along with the header of RREQ packet. Each node rebroadcast RREQ packet to their neighbor .They receive RREQ header and calculate the value of F_{RP}, LET and compute the average value and replace these value by previous value in header and further broadcast it.

- ***c. At Destination Node:*** After receiving the route request the destination node will wait for Δt time where Δt is defined as the extra time of .02ms of TTL for receiving the more requests where default value of TTL is 1ms. After Δt time destination node check for all the value of reliability pair factor, successive average of link expiration time and calculate the path selection factor as:-

$$\mathbf{P_{sf} = F_{RP} * LET}$$

Coming from different RREQ destination calculate the value of path selection factor and make a route reply to the source node with that path which have maximum value of path selection factor.

F. Route Maintenance Process:

In the routing of mobile ad hoc networks (MANET), frequent link breaks occur in the path due to random motion of nodes and link failures can also take place which arises the need of route maintenance. In this protocol destination node have more than one value RREQ and each RREQ corresponds to the value of Path selection factor and link expiration time.

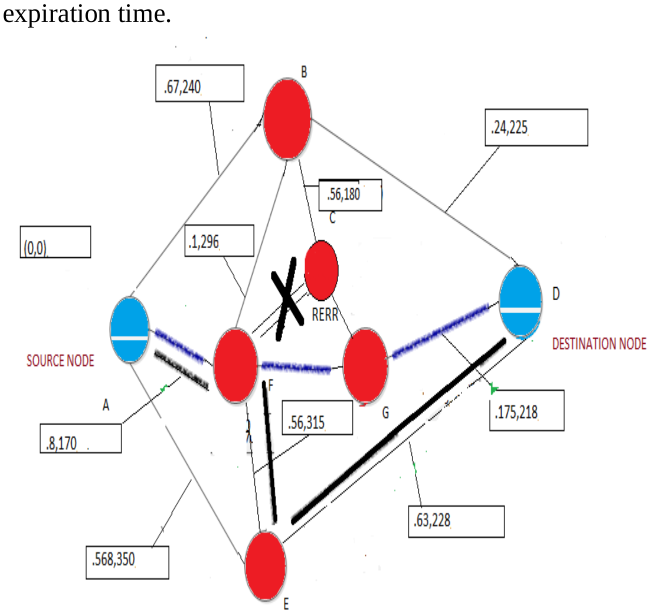


Figure.5: Route Maintenance

Each value corresponding to a path i.e. destination node have more than one path so if link failure occur while communication taking place then destination can swap previous path to the new path which have link expiration time less than previous one .With this approach it does not have overhead of re Route Discovery. Suppose communication is taking place in fig5. Suppose the node which goes down is C .C cannot transfer the Data packet further transferred so C send a RRER message to its predecessor which is F.

At this point of time F check its cache to find the stored value of Link expiration time to the different corresponding path and check that which path have better value of reliability pair factor and link expiration time to previous path .If the predecessor of C is able to find that path then it send data with that path. But if it is not able to find the path then it propagate the REER message to their neighbor nodes .The same procedure has done on neighbor nodes until there is a new path along which we send the data. In this type route maintenance the packet drop is reduced because as we find route breakage then we start to find alternative path to send the data and as soon as we find new path we started sending the packet with new one.

V. NUMERICAL EXAMPLE

Example: Here we are explaining our proposed approach with help of an example

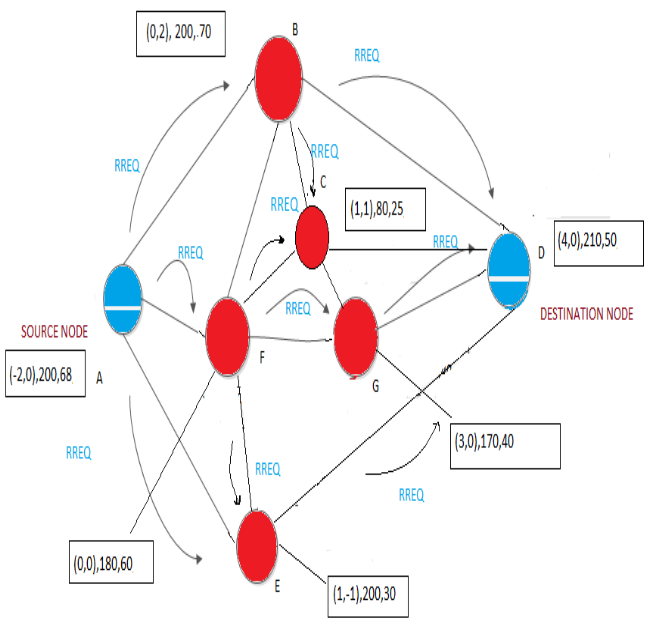


Figure.6: Working of proposed approach

The above diagram shows the network of seven nodes. Initial parameters are given in the square block of respective nodes as shown in fig. 4.6 and also summarized in the table below. We also consider the mobility of different nodes. Node's velocity are also assumed and put on the same table. We consider the scenario after time t=1 mili second.

Table.1: Initial parameter

Node	Co-Ordinate	Energy (mW)	Signal Strength (nW)	Angle	Velocity (m/s)
A	(-2,0)	200	70	180	2
B	(0, 2)	160	50	90	1
C	(1,1)	80	25	45	1.5
D	(4,0)	210	50	0	2
E	(1,-1)	200	30	225	1
F	(0,0)	180	60	0	.5
G	(3,0)	170	40	0	1.6

Node A broadcast the RREQ packet to the neighbors'. Node B,F,E are receiving the packet. Now at node B, E, F they check the header of node A for the checking of threshold value of power and find that it takes part in the Route Discovery process and then perform the computation for reliability pair factor for the value of F_{RP} we need the distance between node A and B.

For the calculation of Distance (A,B) we need the new co-ordinate of A,B during motion. New co-ordinate are calculated as-

Suppose Node A Co-Ordinate =(X_1, Y_1),

Node A angle with X-axis=Θ_1,

Node A velocity=V_1

$$d_1=V_1*T_1$$

New co-ordinate (X_1', Y_1') calculated as

$$X_1' = X_1 + d_1 \cos \Theta_1$$

$$Y_1' = Y1 + d_1 \sin \theta 1$$

In the same way we find the new co-ordinate of each node which is summarized in table below

Table.2: Nodes new co-ordinate

Name of Node	New Co-ordinate
A	(-2.002,0)
B	(0,2.0001)
C	(1.001,1.001)
D	(4.0002,0)
E	(1.001,-1.001)
F	(.0005,0)
G	(3.0016,0)

After calculating new co-ordinate we calculate the distance between them which is summarized as below in table

Table.3: Calculated Distance

Link name	Distance
AB	.000223
BC	1.414
AF	2.002
AE	3.165
ED	3.1663
GD	.968
FG	3.015
CF	1.415
EF	1.416

After computing the distance we compute the reliability pair factor as per equation no (2)

$$F_{Rp}(A,B)= \frac{\min(150,200)*10^{-8}+20*10^{-9}}{2.23*10^{-8}} =.67$$

Similarly We compute other value of F_{RP} for each link and put in table 4.4 below

Table.4: Reliability Pair Factor Value

Link	Value of reliability pair factor
(A,B)	.67
(A,E)	.568
(A,F)	.8
(B,C)	.56
(F,C)	.12
(F,G)	.56
(F,E)	.134
(C,D)	.243
(G,D)	.175
(E,D)	.632

And now compute the value of link expiration time of each link calculated with the following the equation:

LET =

$$\{-(ab+cd)+\sqrt[2]{(a^2+c^2)r^2-(ad-bc)^2}\}/\{a^2+c^2\}$$

Where a=$V_i\cos\theta_i - V_j\cos\theta_j$,

b=$X_i - X_j$

c=$V_i\sin\theta_i - V_j\sin\theta_j$

d=$Y_i - Y_j$

Table.5: Link Expiration Time calculation

LINK	A	B	c	d	LET(m Sec)
(A,B)	-1	-2	-1	2	240
(A,F)	-.5	-2	2	0	169.7
(A,E)	.7	3	.7	1	350
(B,C)	1.06	1	-.006	2	180
(F,C)	.5	1	1.07	1	296
(F,E)	.965	1	.36	1	339
(F,G)	-1.1	1	0	0	315
(G,D)	1.6	1	0	0	218
(E,D)	1.29	3	.7	1	228

When it perform the calculation it append the value of reliability pair factor and link expiration time into the header and again broadcast in the network. The same procedure is working at node F and E and again broadcasting take place further when this packet reach to the node C,G they again perform computation for reliability pair factor and link expiration time and append their values in RREQ header and broadcast it in the network and until it reaches to the destination node.

Now we are heaving all the computed value of LET and F_{RP}. Now referring again to fig.6 we find the following path

Table.6: Path Selection Factor Value

PATH NAME	F_{RP} VALUE	LET VALUE	Psf
A-B-C-D	1.3	215	279.5
A-F-C-D	1.16	230	266.80
A-F-G-D	1.475	253	373.175
A-F-E-D	1.56	240	374.40
A-E-D	1.1	190	209.0

By looking at above table we find that the maximum value of path selection factor is for A-F-E-D and it comes out as 374.40. Hence we select the path A-F-E-D as most stable and most long lasting in the network.

At Destination After receiving the route request the destination node will wait for Δt time where Δt is defined as the extra time of .02ms of TTL for receiving the more requests where default value of TTL is 1ms. After Δt time destination node check for all the value of reliability pair factor, successive average of link expiration time and calculate the path selection factor

Psf = F_{RP}* LET

Coming from different path and arrange value in the decreasing order and forward RREP packet to the path heaving maximum value of compare value of reliability pair factor. Dark blue line shows the path heaving max value average link expiration time and dark black shows path heaving max reliability pair factor.

Algorithm for Route Discovery:-

Step 1: Source node append own residual power, signal strength and co-ordinate to RREQ Packet and broadcast RREQ packet to neighbors

Step 2: Neighbors receive RREQ packet and check for node power

If (Power of node < 120 mWatt)

{

Discard RREQ packet

}

Step 2.1: Else if (Neighbor = Destination

{

Destination node waits for Δ t time, in Δt time node have more than one RREQ,

each RREQ has value of F_{RP} , and LET value and calculate Psf for each path as

$P_{sf} = F_{RP} * LET$

Finally calculate which path has maximum value of P_{sf} as

$P_{sfm} = \max\left(\sum_{i=1}^{n} P_{sf}\right)$

and send RREP packet to the source by the same path

}

Step 2.2:

Else {

Neighbor's nodes extract RREQ header and calculate reliability pair factor of header as

$$F_{RP} = \frac{\min(P_{S,}P_{n}) + D_S}{d_{(S,N)}}$$

and now replace header F_{RP} value to this new calculated F_{RP} value and append this value to RREQ header and neighbor's node compute own link expiration time (LET) of each link LET=

$$\{(ab+cd)+\sqrt[2]{(a^2+c^2)r^2-(ad-bc)^2}\}/\{a^2+c^2\}$$

a=$V_i\cos\theta_i - V_j\cos\theta_j$,

c=$Vi\sin\theta_i - V_j\sin\theta_j$

b=$X_i - X_j$, d=$Y_i - Y_j$

and extract LET from header and compute average value of both LET value and replace to header value of LET to this average value of LET and replace this LET value to RREQ packet's LET value and broadcast to their neighbors.

}

VI. CONCLUSION AND FUTURE WORK

Link stability issues are significant for the route selection process in mobile ad hoc networks (MANETs). Nodes are free to move arbitrarily; thus, the network topology--which is typically multi hop--may change randomly and rapidly at unpredictable times, RE-AODV routing protocol enhances the link stability as it selects path which satisfied the reliability criteria in route discovery procedure. The main characteristics of our proposed mechanism are that it takes into account the Psf (path selection factor) to select path which has maximum value of Psf. We have explained our proposed solution with help of example which showed improvement in path selection as well as to route maintenance. We will present our simulation results in my upcoming research work.

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