DVM based Scalable and Adaptive Multipath Routing in MANET For Emergency Rescue Application

Maneesha V Ramesh[1], Prabaharan. P[2], Shameem Ansar. A Rekha. P,
Amrita Centre for Wireless Networks and Applications, [2]Amrita Centre for Cyber Security
Amrita Vishwa Vidyapeetham , Amritapuri,India
[1]maneesha@am.amrita.edu , [2]Praba@amrita.edu ,shameemansar@gmail.com,rekhap@am.amrita.edu

ABSTRACT: Mobile ad hoc networks [MANET] are typically characterized by high mobility and frequent link failures that result in low throughput and high end-to-end delay. Present approaches to multipath routing make use of pre-computed routes determined during route discovery. All the paths are maintained by means of periodic update packets unicast along each path. In existing method best path is determined and maintained only with signal strength of disjoint paths. Signal strength between nodes is only the mobility prediction factor, which does not address the durability and stability of paths. Residual energy of nodes determines stability of path contains those nodes. Also does not consider the consistency of node through the previous behaves. This paper provides a design and a simulation frame work for measuring a Decision Value metric for mobility prediction of each alternate paths in MANET. Here a Periodic update packets measure Decision Value metric [DVM] and route maintenance is possible by means of the Signal strength between nodes, Residual energy and Consistency of each hop along the alternate paths, helps protocol to select the best scalable paths.

I. INTRODUCTION

Ad hoc networks are characterized by dynamic topology, high node mobility, low channel bandwidth and limited battery power. In these scenarios, it is essential to perform routing with maximal throughput and, at the same time, with minimal control overhead. Several on -demand routing protocols have been proposed for ad hoc networks. In such protocols, nodes build and maintain routes as they are needed. Also, frequent route breaks cause the intermediate nodes to drop packets because no alternate path to the destination is available. This reduces the overall throughput and the packet delivery ratio. Moreover, in high mobility scenarios, the average end-to-end delay can be significantly high due to frequent route discoveries.

Multipath on-demand protocols try to improve these problems by computing and caching multiple paths obtained during a single route discovery process. The link failures in the primary path, through which data transmission is actually taking place, cause the source to switch to an alternate path instead of initiating another route discovery. A new route discovery occurs only when all pre-computed paths break. This approach can result in reduced delay since packets do not need to be buffered at the source when an alternate path is available.

Current protocol provides multipath route discovery and path maintenance mechanism on the basis of a calculated cumulative metric value only on signal strength between two nodes in a path. This metric only address strength of link of the current path, does not address the durability of the path; which fully depends on the residual energy of node .Also does not consider the consistency of node through the previous behavior. Since it does not consider node's behavior and energy, it cannot be applied in heterogeneous MANETS having high mobility nature [13].

This paper provides a solution for this problem with variation in the method of Decision Value metric [DVM] which represent the overall strength of a path , and thus provide a scalable and adaptive multi path routing in MANETs.

The rest of this paper is organized as follows. Section II discusses the related work in the area of multipath routing. In section III, we present an algorithm for finding number of alternate paths with least complexity. We then present the details of our protocol and describe its operation in section IV. Section V explains how it is adaptive to different QoS. Finally, section VI provides our conclusions and future works.

II.RELATED WORKS

Similar to the work proposed here, the Ad hoc On-Demand Multipath Distance Vector Routing protocol [1] and AODV-Backup Routing (AODV-BR) [4] are both based on the AODV protocol. Multiple link-disjoint paths are computed from the source to destination through a modified route discovery process in the case of [1].The main drawback of this protocol is that the alternate paths that are computed during route discovery are not maintained during the case of data transfer. Thus the paths could become stale and outdated by the time they are actually utilized. The multipath approach in this protocol is therefore not adaptive to the changes in the network topology. The effectiveness of this protocol decreases as the mobility

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increases. While the route discovery mechanisms of solutions are based on multipath AODV, where we modify both the manner in which alternate paths are selected and how those paths are maintained.

The authors recommend a method to calculate alternate paths with refernce [4] such that when a link failure occurs, the intermediate node searches for an alternate path to avoid the broken link. The basic theory made in this protocol is that all the nodes are in promiscuous mode and that they can listen in every transmission within their range. This protocol, however, has a number of limitations. First, it assumes that several nodes are within transmission range of each other. Also, constant mobility of the nodes is not taken into account. Moreover, the utilization of promiscuous mode greatly increases the power consumption of each node.

DSR caches multiple routes received during the route discovery process, on the basis of hop count of each route.. This approach is not effective under high mobility conditions where the alternate paths become stale very often, as shown in [3].

A different remarkable effort in this area is accessible in [6]. The authors recommend an on-demand routing Scheme, called Split Multipath Routing (SMR), that establishes and utilizes multiple routes of maximally disjoint paths.The SMR protocol is a deviation of the DSR protocol and makes use of source routing to cache pre-computed alternate routes.

While not a multipath protocol, the Signal Stability based Adaptive (SSA) routing protocol [12] performs on-demand route discovery by selecting longer-lived routes based on signal strength. The signal strength criteria allow the protocol to differentiate between strong and weak channels. SSA is a distributed protocol that uses the signal strength information on a per link basis, whereas, solution uses the signal strength information accumulated over an entire path.

Finally Dynamically Adaptive Multipath Routing based on AODV [13] use only signal strength information for route discovery and route maintenance on Node-Disjoint MP-AOMDV and Link-Disjoint MP-AOMDV. But could not to ensure that the alternate paths stored at each source node remain up-to date on the basis of residual energy and consistency with the changes in the network topology.

All the above mentioned methods except last one explain with on demand multipath routing but have least consideration for route maintenance. Scenario with large density of nodes having high mobility in nature causes frequent link failure. Lacking of maintenance mechanism will lead most awful network performance in the form of large number of dropped packets and high end to end delay.

In precious application like Emergency disaster relief where nodes may deployed in an ad-hoc manner with great mobility in nature and thus occurs frequent in time updation in routing table. This mobile in nature will also cause frequent link failures and thereby re-initiating route discovery, which decrease overall performance of network in terms of throughput. For getting valuable expected result, not only the signal strength also need to consider Residual energy and consistency parameters for each node ,which play a role for transmitting data in the deployed adhoc network. Also every Mobile Ad hoc Network are formed under the design challenges like Limited wireless transmission range, Broadcast nature of the wireless medium , Packet losses due to Mobility and transmission errors ,Mobility-induced route changes, Battery constraints and Potentially frequent network partitions

III . ROUTE SELECTION

The environment of Mobile ad hoc network can be different to the highest degree in terms of the of the network density, number of nodes, and bandwidth constraints. There are two variations of Route selection in Mobility prediction multipath AODV; which are, Node Disjoint Routes and Link Disjoint routes. The node-disjoint version produces fewer alternate routes than link disjoint and it discovers completely independent paths. Here each path will fail independently and the number of paths determines the existence of network. But in the link disjoint individual node movement can cause the failure of multiple paths.

Algorithm for finding Node Disjoint paths

It is impossible to find large number of node disjoint path for a given graph in polynomial time. But two distinct path at a time can possible with the algorithm given below.

1. Assume there exists more than one path from S(source) to D(destination).
2. Initially paths, P=Q=NULL
3. P=RUN_DFS_ALGORITHM(G,S,D)
4. Q=RUN_DFS_ALGORITHM(G-P,S,D)
5. If Q !=NULL, Exit()
6. Else
7. Get the list of vertices {u} in P on which second DFS meets and backtracks
8. w = Find the nearest u to D
9. v = FIND_PREDESESSOR(w)
10. Path, R=LOOK_PATH(S,v,D)
11. If R=NULL,
12. If v = S, then Only one path P is there
13. Else
14. w = v
15. GoTo Step 9
16. Else Two paths are: S-v-D and S-w-D

The time and space analysis of DFS differs according to its application area. In theoretical computer science, DFS is typically used to traverse an entire graph, and takes time O(|V| + |E|), linear in the size of the graph. It also uses space O(|V|) in the worst case to store the stack of vertices on the current search path as well as the set of already-visited vertices. Here DFS perfectly runs two times and hence time and space complexity remains as O(|V| + |E|). Figure 3 gives two node disjoint path for given graph in figure 1.

IV. SCALABLE AND ADAPTIVE MULTIPATH ROUTING

In the proposed protocol, predictions are made regarding the overall stability of routing paths based on the relative signal strength of the links, residual energy of node and consistency of node along those paths. Based on these predictions, the various paths are prioritized so that the most stable path is chosen for routing before any other path. Measure the stability of a route based on the calculated cumulative DVM of the individual links in that route and not on the hop count.

Since the signal strength of a route is not sufficient to determine the quality and stability of the path, here propose the use of the cumulative Mobility Prediction Value [DVM] metric over signal strength. A path with high signal strength metric, could lead to a significant number of dropped packets due the presence of low Residual Energy and Inconsistent Nodes exist in that path. In contrast, since cumulative DVM metric is based on the signal strength of each individual link, residual energy of node and consistency of node along the path, it provides information about overall quality, reliability and scalability of the path.

This protocol attempts to solve the mentioned problems by periodically re-validating (Periodic update(Pu) packets are used) each of the alternate paths, while introducing a minimum of control overhead.. The path maintenance process of protocol also provides information on the quality of the paths on the basis of durability and stability of nodes belongs in that path. Based on this information the source can choose the best available path for data transmission. The source does not wait for its current path to break in order to switch to a different path. Instead, it constantly monitors each of its alternate paths and always selects the best among them for transmitting data. This selection is based on a Mobility prediction value [DVM] proposed to represent the overall quality of a path.

IV. a Design Parameter on node:

(i)Signal strength[S]

In order to determine whether a node is still within range, a node keeps a record of the received signal strengths of neighboring nodes. Since Received signal strength measurements are taken at the physical layer there is no more computation is needed in node .When a node receives a packet from a neighbor, it measures the received signal strength.

$$Sr = S_t G_t G_r (\lambda/4\P d)^n; \; 2 \leq n \leq 4 \; [7] \quad \ldots\ldots\ldots\ldots(1)$$

Where, 'S_r' is Received Power in Watts , 'S_t' is Transmitted Power in Watts , 'G_t' is Transmit Antenna Gain, 'G_r' is Receive Antenna Gain, 'λ' is Wavelength and 'd' is Tx/Rx separation. For an ideal case value of n is always 2.

(ii) Residual Energy of Node[E]

As batteries provide limited working capacity to the mobile nodes Residual Energy is one of the most important design criteria for Mobile ad hoc networks. Power breakdown of a mobile node not only affect the node itself but also its capability to forward packets on behalf of others and hence affects the overall network life span. Here, Residual Energy of a node is the energy remaining at the time of path finding process. Since every node maintain an output queue for packet transmission, length of output queue need to mention in the calculation of current residual energy.

Current Residual Energy (E)= Available Energy – (Output Queue Length * Energy required to send one packet).

…………….(2)

Let Battery status is a variable indicate the residual energy of nodes in the MANET
If (Battery Status < 20%)
Then Set $E = 1$
If (20% ≤Battery Status <50%)
Then Set $E = 2$
If (50% ≤Battery Status <80%)
Then Set $E = 3$
If (Battery Status ≥80%)
Then Set $E = 4$.
If (Battery Status == 1) Node is not allowed to participate in the route discovery.

(iii) Consistency factor[H]

In MANETs each node selects its 1-hop neighbors based on exchanging periodical "Hello" messages among neighbors. Each node uses a small transmission range to cover their neighbors. Low transmission range conserves energy and bandwidth consumption, while maintaining the network connectivity. When a node is moving to a hard to reach area the consistency parameter will be monotonically decreasing and the parameter will increase consistently while moving to a denser region. Let stability be the variable which determines consistency factor in terms of the frequency of hello messages received by each nodes. This can be determined as

$$\text{Stability}_{New}[H] = \text{Stability}_{Old} \times (1\text{-}C) + \text{Stability}_{Current} \times C \quad \ldots\ldots\ldots\ldots(3)$$

where , C carrying value between 0 and 1

IV. b. ***Maintenance of Alternate Paths***

To ensure that the alternate paths stored at each source node remain up-to date with the changes in the network topology, a separate mechanism is needed. The source node periodically sends a special update message, called Periodic update(Pu), to the destination along each of its alternate paths. It has three fields containing measure of Signal Strength, Residual Energy and Consistency. Before the propagation of Pu source always initialized these value with infinite. As the periodic update(Pu) packets propagate through the alternate paths, every node along that path updates the packet with minimum value of corresponding parameter. After receiving, destination returns the packet along the same path and repeat the updation procedure in intermediate node. Source compute Decision value metric (DVM) as

$$\mathbf{DVM} = \sum_{i=1 \text{ to } 3} \mathbf{Min}(\mathbf{x_i}) \quad \text{………………..(4)}$$

and

$$\sum(\mathbf{x}) = \mathbf{S} + \mathbf{E} + \mathbf{H} \quad \text{………………..(5)}$$

$\mathbf{S} = (\mathbf{S_{AB}} - \mathbf{S}_{min}) / \mathbf{S}_{min}$; Signal Strength of link, say AB
$\mathbf{E_{i=}}$ Residual Energy of Node i
$\mathbf{H_{i}}$**=** Consistency factor of node i

Where S_{AB} is the power of the signal from node A as received by node B and S_{min} is the minimum threshold power with which the signal must be received for it to be considered as a valid transmission. Thus, the DVM is a minimum value representation of the signal strength of links, Node's residual energy and consistency along the path. The source initializes field value of Periodic update packet to infinite and as the packet traverses through the path, each node updates with its minimum value in the periodic update(Pu). The destination unicasts the periodic update(Pu) packet back to the source along the same path and also perform updation. In this process, all nodes obtain the information about the paths to both the source and destination. Hence when the periodic update(Pu) reaches the source from distinct routes, the value of the DVM in the periodic update(Pu) is a minimum value representation of node parameters of all links and nodes along that path. The path selection on the basis of DVM is given by:

$$\mathrm{DVM}_{path} = \mathbf{Max_n} \sum_{i=1 \text{ to } 3} \mathbf{Min}(\mathbf{x_i}) \quad \text{………………..(6)}$$

where n is the number of node disjoint paths

This gives a measure of the relative stability of the path because links and nodes with higher signal strength, higher residual energy and consistent are less likely to break. As the value of the DVM increases, so does the scalability of the path.

Figure 3 through figure 6 gives an example for selection of primary route and maintenance of routes by periodic update message when there occur a change in network topology .

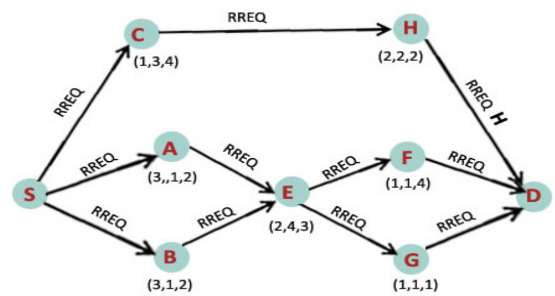

Fig. 1. Tracing Node-Disjoint paths: Node A and B send RREQ to E respectively. E receives and forward only the RREQ from A and rejects the one from B. Destination D receives RREQs from nodes F,G and H. It sends RREPs only to F and H and discards the RREQ from G since it has come from the same neighbor (node A) of the source as has the RREQ from node F. The numbers on each link indicate the signal strength of that link.

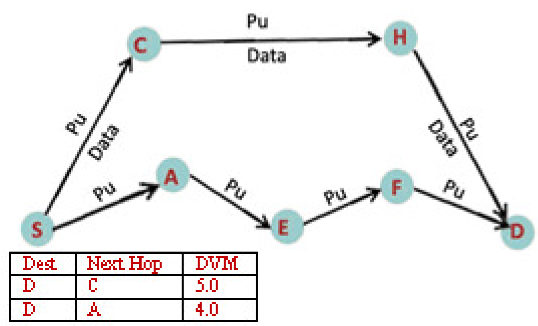

Fig. 2. Source S has received RREPs via two node-disjoint paths: S-A-E-F-D and S-C-H-D. Since path S-C-H-D has a higher Decision Value , it is selected as the primary path. The other path becomes the alternate path. The source sends periodic update(Pu) message periodically along both paths.

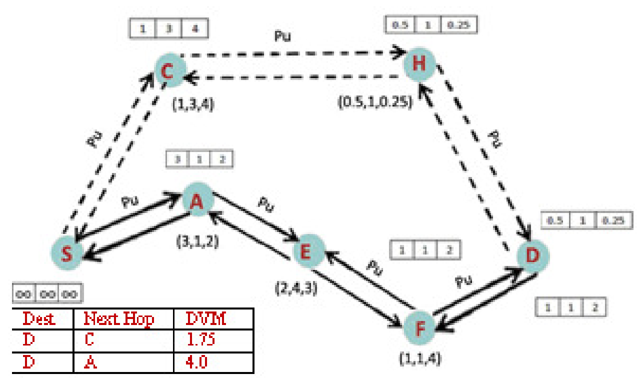

Fig. 3. Suppose node H moves away from nodes C and D. The DVM parameters shows degradation from previous stage. Thus DVM of S-C-H-D become very weak.

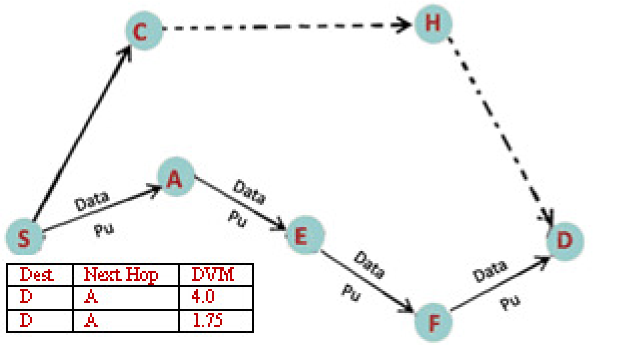

Fig. 4. Source S detects this change through the low DVM Since the other path now has a higher DVM, source switches its primary path to S-A-E-F-D.

The RREQ and RREP packets are customized to carry this DVM value during the route discovery process. The source is thus able to learn the stability of the multiple paths during the route discovery itself. Once the source receives the RREPs, it sorts its next hop information in decreasing order and chooses the path with the greatest DVM as its primary path. The source node thus maintains a priority list of next hop information. Based on this information, it uses the most stable path for data transmission.

As a result of the above mechanism, data packets always travel along the most stable and scalable path. Whenever the DVM of the current primary path becomes lower than one of its alternate paths, the primary path is switched. At all times, the best available path is the primary path. In this way, the source switches routes to a better alternative when it sees the primary path growing weaker. Since the route is switched before the primary path is broken, fewer data packets are dropped and the end-to-end delay is also minimized. To prevent path oscillations, a hysteresis mechanism is adopted. Here, the source node switches from its current primary path to an alternate path only if the difference in the corresponding path stabilities is greater than some predefined threshold. Computation of the most stable paths, based on the DVM, involves only a marginal increase in computation at the source nodes.

IV.c Scalable Route selection

1. Define RREQ, RREP, RREP packet structure to carry Decision value parameters.
2. Obtain Node disjoint paths
3. Define Periodic Update(Pu) Message packet; a triple of Signal Strength(S) ,Energy(E) and Consistency(H); [S,E,H]
4. Loop 1:Initialize field values of Pu message of DVM at Source = [Infinite, Infinite, Infinite]
5. **Intermediate Nodes**
   If Node's [S,E,H] value < received [S,E,H]
   Update [S,E,H] of Pu with minimum value .
   Forward to next hop
6. **Destination Node**
   Unicast received Pu message to Source
7. **Source Node**
   DVM = $\sum$**Min(xi)**
   i=1 to 3
   DVM_{path}= $\mathbf{Max_n}$ $\sum$**Min(xi)**
   i=1 to 3
8. Sort the next hop information in decreasing order of $DVM_{path\,:}$ Loop 1
9. Maintain a priority list of DVM information.
10. Select path with highest DVM as primary path
11. If (DVM of current path< DVM of alternate paths)
12. Switched to next best alternate path.

V. ADAPTIVE TO DIFFERENT QoS

Since this protocol performs with a combined metric value it can make adaptive to different quality of services by using tunable weight parameter .Applications as sensor ad hoc network where energy is a major constrain, energy efficiency can be achieved by giving importance to the coefficient of Ei. Similarly the applications where reliability of links are of major concern like that of a battle field , signal strength and consistency are tuned accordingly. So this routing protocol can effectively use in the place of the other related protocol. In these circumstances the equation (5) can be represented as

$$\mathbf{DVM= a.S+ b.\ E_i + c.H_i} \quad ....(7)$$

Where **a,b,c** are Tunable weight parameter

VI. SIMULATION RESULT

Main objective of this simulation is, compare the performance of the proposed protocol with that of basic AODV ,and the study of performance with different the number of nodes in the network Varying the number of nodes can be accomplished in two basic ways. One is by varying field size, keeping node density constant. Another is by keeping the field size constant and increasing the density We work out total message activity as the total number of AODV messages sent and received at each node..

The simulation of the protocol has been performed using the JiST/SWANS [14]. We compared message activity of nodes in MANET with Scalable Multipath AODV[SM-AODV] and AODV, in a constant-density field.

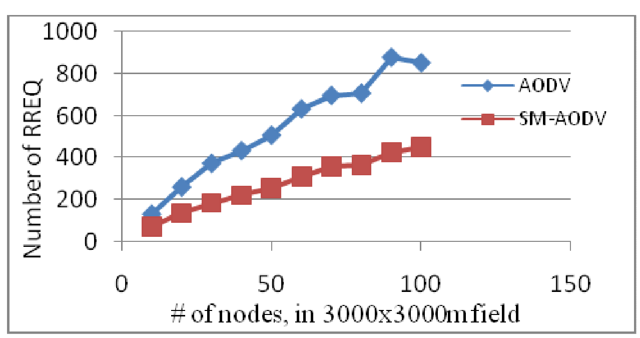

Figure 5.Comparison of RREQ

Figure 5 illustrates that RREQ messages frame, the majority of the messages passed throughout the AODV network. Moreover, the proportion of RREQ messages increases as the number of nodes increases. This is similar in the case of RREP messages as shown in figure 6.

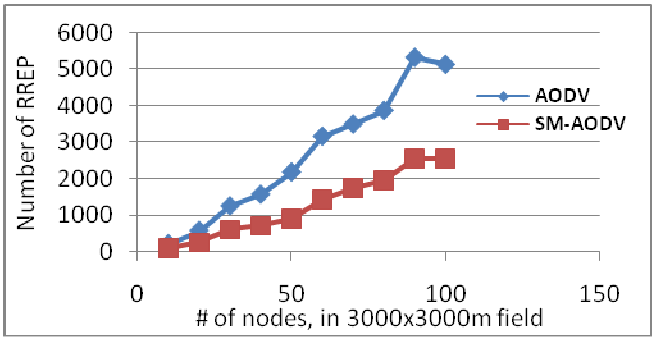

Figure 6.Comparison of RREP

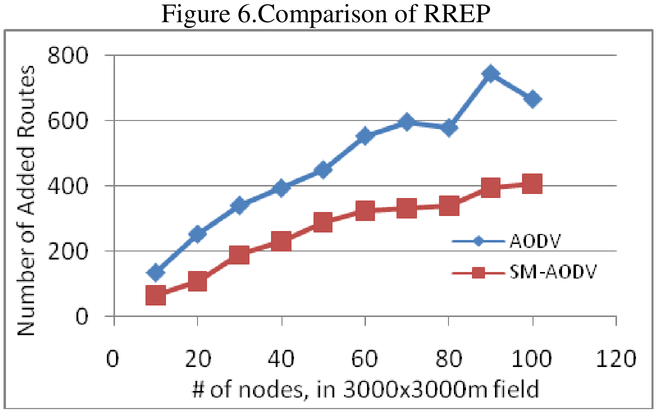

Figure 7.Comparison of Added Routes

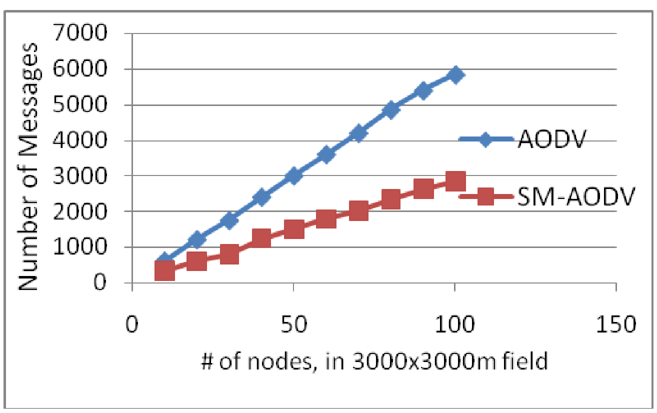

Figure 8.Comparison of total Messages to Deliver

VI. CONCLUSION AND FUTURE WORKS

Here a new approach for multipath routing in mobile ad hoc networks is discussed; the path maintenance process of protocol provides information on the quality, durability and stability of the paths. The source does not wait for its current path to break in order to switch to a different path. Instead, it constantly monitors each of its alternate paths and always selects the best among them for transmitting data. The primary characteristic of this approach is that it dynamically adapts to varying network topology by monitoring the quality of each path to the destination and always using the best path. It is able to eliminate stale routes and thereby reduce the number of data packets dropped due to the use of these invalid paths. Though control overhead is introduced through the periodic periodic update(Pu) packets, results prove that the overall overhead is still lower than other approaches. It makes use of a periodic maintenance mechanism considering signal strength information, Residual Energy and consistency parameter for determining 'quality' of path.

Various applications of this model includes; military to take advantage of commonplace network technology to maintain an information network between the soldiers, vehicles, and military information head quarters, and Emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed.

The performance can be enhanced by using known graph representation algorithm, can also implement Security in routing for dealing with Selfish and Malicious Nodes, use Power Aware MAC algorithm thereby can avoid the computational overhead calculating Signal strength.

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