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Efficient Route Selection in Ad Hoc On-Demand Distance Vector Routing

***Abstract*— The protocol diversities of mobile ad hoc have already got hold of the field to a peak of a matured and developed area. Still, the restraint of delay and bandwidth of mobile ad hoc network have kept a little room to draft a routing protocol for the pursuit of providing quality of service. In the paper, we proposed protocol namely Efficient Route Selection in Ad Hoc On-Demand Distance Vector Routing. We select the best path among multiple paths from source to destination using covariance and delay. We accomplish our implementation in NS3and it shows the more reliable path and less end to end delay than other counterpart protocols.**

***Keywords*—covariance, quality of service, link stability, link breakage**

I. Introduction

Wireless networking depends on two primary models, one has fix infrastructure based model where nodes are mobile but connected through fixed backbone nodes with a wireless medium. However, the other one is Mobile Ad-hoc Network (MANET), which implies a network formed with some wireless sensor nodes where the node freely and dynamically self-organize, randomly and temporary "ad-hoc" network topologies so that people and devices can communicate within the area without any pre-existing communication infrastructure. Consequently, none-to-node connectivity could change frequently because of nodes mobility [1]. Like as another network system, the research of mobile ad hoc networks is being continued on a layer basis. In this paper, we consider the network layer to design a routing protocol that finds out the Stable Path based on Delay, Hop counts, link Stability and Energy and handle link breakage with the help of a metric, which is calculated based on distance, node vulnerability and usability. In MANET, as the chance of links to be broken frequently due to nodes' mobility, the transmission of data between two communicating devices is very challenging [2].However, MANET has no fixed infrastructure or base station to carry out their operation, each device in a MANET is had the freedom to move independently and randomly in any direction, which allows them to change its link to other devices instantly [3]. Although many papershave already worked with the parameters used in our paper, we use them in a tactical way to ensure better performance of the protocol and the repairing system of link breakage is an efficient technique in the terms of energy and node involvement to backup data. Our contributions include devising two new metrics to select the most balanced path among multiple paths and to find out the best backup node.

In section 2, we represent the most related paper of our protocol and in section 3 we describe the details of our proposed protocol. In section 4, performance analysis is elucidated and finally, the conclusion and future works are stated.

II. Literature Review

Ad hoc on-demand distance vector routing (AODV) where the route is established only there is a demand for a new route. AODV is able to unicast, broadcast and multicast routing and response quickly if any change occurred in the network topology. Moreover, it is capable of updating only the hosts that may be affected by the changes in the network [4].Each mobile host is operating as an individual router and a route is obtained by on-demand basis. This algorithm has the guarantee to produce loop free path in any condition. To identify the most recent path, it uses destination sequence numbers.

A route breakage in AODV is determined using periodic beacons or through by link-level acknowledgments and finally, both source and destination nodes are notified. When a source node knows about the route breakage, it re-establishes the path from the source to that destination if it requires more communication. If an intermediate node finds route error, it will notify the sender by using unsolicited route reply setting the hop count infinitive. With the fuzzy AODV, to build a reliable path and minimize the probability of route failure while the data packet is transmitted, residual energy node and mobility are taken into account that limits the route selection decision making and makes the path less stable [5]. Interestingly, nodes are not intended to keep track of location's information of other nodes to reduce energy consumption. Advanced Optimized Link State Routing (AOLSR) protocol shortest path is selected from multiple paths and link failure is handled by searching other neighbor nodes. But security issue is not covered with the idea. [6]. With proposed AQA-AODV approach which tries to recover link failure for multimedia applications over MANET, bandwidth efficiency high lightened video streaming quality but end-to-end delay worsen performance [7]. The work presented in [8] proposes Stability and Energy Aware Reverse Ad hoc On Demand Distance Vector(SEAR-AODV) routing protocol that optimizes existing Reverse-AODV routing protocol in terms of reliability factor which includes energy and route stability aware metric The main advantage of AODV is destination sequence number is used to find latest available route and disadvantages of AODV are heavy control overhead and beacon messages.

In [9], the author considers the weight to the correspondent energy level at each node as a backup node. Ad hoc on-demand distance vector-backup routing (AODV-BR) [10] is a modified protocol from the basic AODV. The basic route discovery procedure of both AODV and AODV BR are same. In AODV-BR, every node in the network operates in promiscuous mode. In promiscuous mode, each node other than on route overhears communication and understands the next hop to the destination by which it was early received route-reply (RREP) packet. This information is then entered into its alternate route table. All of the nodes besides the route update their alternate route table after overhearing RREP packet. In this way, a mesh structure is formed consisting of nodes on the route and neighbors of each node on the route. There is one primary route and all other routes are an alternate route. If the primary route is failed, then any other alternate routes can be used.

In link stability and lifetime, prediction(LSLP) routing protocol [11] describes the best path to route from source to destination based on QoS aware routing. To find the best path LSLP routing protocol defines Cost Effective lifetime prediction routing(CLPR) which has given entire emphasis on the end-to-end energy consumption and based on the minimum path cost that considers the total energy required to transmit on that path. It is obvious to achieve QoS path along with extended network lifetime and reduce packet loss calculating three parameters for a path such as a path stability, lifetime prediction and the ratio of QoS support and requirements. The work presented in [12] introduces any cast routing in MANET with dynamic source routing is used to select k-servers based on less congestion, hops number, route expiry time and better stability have contributed to the improvement in packet delivery ratio, although high throughput is a drawback.

AODV-ABL [13] is an adaptive backup routing protocol which provides local repair. By overhearing reply messages (RREP) and data packets, backup routes are created in this protocol. Each node is associated with a main and an alternative routing table. Data is sent according to the routes in the main routing table and alternative routes are stored in the backup routing table.

Based on AODV, a protocol proposed named M-AODV [14] which is actually a overhearing backup protocol. In this protocol, nodes overhear the neighbors and compare the information of main and alternative tables constantly. The proposed protocol was proved to be safe and some attacks were tested on it.

According to the literature review, there is scope to improve AODV routing protocol in MANET to make the link more stable. Thus, there is a scope to develop a robust and effective stability of QoS based routing protocol in MANET. We have designed an QoS aware routing protocol by considering the stable link, delay and energy efficiency.

III. The Proposed Route Selection Protocol

A. *The Protocol*

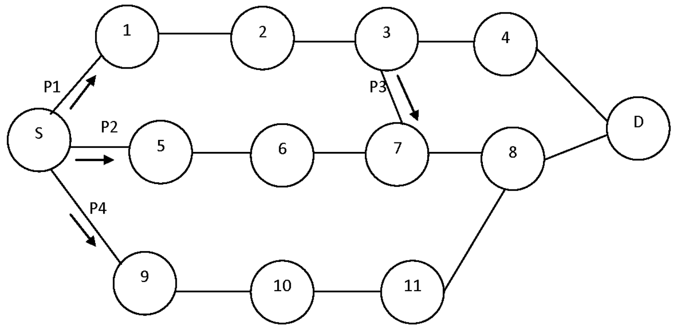

Fig. 1: Multiple paths from source to destination

By using AODV, It is normally possible to discover multiple paths from the source node to destination node as shown in figure 1. In the above figure, there are four paths from source S to destination D. In most of the research, only one path has been chosen among some paths based on the quality of the path and the quality of the path is determined by different metrics such as link stability, node energy etc. When measuring path quality, the minimum link stability of a path is considered the ultimate path stability and the minimum energy of the node is considered the ultimate energy or lifetime of the path. However, this approach has disadvantages, because the only minimum stability of a link and minimum energy of a node along the path do not state the whole scenario of the path. Link stability and energy of the other nodes might be close to maximum threshold and a path might appear a potentially better path with respect to other nodes' energy and link stability despite having a comparatively a node with lower energy or least link stability. Therefore, in order to judge a path, we need to consider link stability and energy of every node over a path. We use covariance formula to evaluate the overall condition of a path. With a view to selecting the best path, we find out the covariance of every path in terms of link stability and node lifetime separately. We assume that $l1, l2, l3, .., ln$ ln are link stability of a path respectively and the maximum threshold link stability of those link are $L1, L2, L3, \dots, Ln$. Here, we consider the different threshold link stability as different nodes have a different velocity of moving. The covariance of the path with respect to link stability can be written as the following the way.

$$Pcov(l, L) = \sum_{i=1}^{n} \frac{(l_i - \bar{l})(L_i - \bar{L})}{n}$$

Where li stands for link stability of a link and Li stands for the maximum threshold for that link. The less covariance, the more stable the path is on average. Because, less covariance indicates that the link stability difference (maximum threshold stability- current link stability) of the individual node along the path is minimum. Hence, it is a more stable path overall. In the same way, we can calculate the covariance of the path in terms of nodes 'energy.

$$Pcov(e,E) = \sum_{i=1}^{n} \frac{(e_i - \overline{e})(Ei - \overline{E})}{n}$$

Where, Ei indicates the maximum threshold energy of an individual node along a path and ei is the current residual energy.

In this case, the less the value of covariance, the better the path is. Finally, we can combine the both covariance and average delay to make a path selection metric.

$$p_k = \frac{1}{\alpha}\left(cov(l,L) + cov(e,E)\right) + \frac{1}{(1-\alpha)} d_k$$

Where, $0<\alpha<1$, the value of α depends on which factors we emphasize whether reliability of the path or time required to reach data to the destination. The high value of α ensure the high reliable path rather than considering the delay of the path.d_k represents delay of a path.

The path with minimum Pk will be the target path to convey data to destination among the all of the possible existing paths. Our target is to discover a balanced path in terms of link stability, energy and delay so that the path becomes sustainable for more times. The algorithm for finding out of one of the best balanced paths is written below.

Algorithm balanced-path **is**

Input: Some paths discovered by basic AODV algorithm

Output: balanced path in terms of link stability, energy and delay

for each path k $= 1$ to n **do**

for each edge (i,j) from S t**o D do**

Calculate li, lj, di, dj and ei, ej

for each path $k = 1$ to n **do**

$Pcov(L,l) = \sum_{i=1}^{n} \frac{(l_i - \overline{l})(L_i - \overline{L})}{n}$

$Pcov(e,E) = \sum_{i=1}^{n} \frac{(e_i - \overline{e})(E - \overline{E})}{n}$

$$P_k = \frac{1}{\alpha}\left(Pcov(L,l) + Pcov(e,E)\right) + \frac{1}{(1-\alpha)} d_k$$

if min>P_k **then**

$min = P_k$

$balancedPath \leftarrow k$

return *balanced Path*

Indeed, nowadays, the energy of the nodes in MANET is no more a problem; link stability, security, and delay are a great concern in mobile ad hoc network in many areas. We can confirm a node as reliable in terms of link stability and delay based on its usability(μ) history that indicate how many times it has been used to transfer data. Sometimes the more regular nodes provide better security. In our proposed routing, while it creates primary paths using AODV, then a node chooses a neighbor with higher usability $balancedPath$

B. Link Repairing Process

Although the overall performance of the routing approach outperforms its counterparts, it has a drawback. The link broken happens more times in comparison to another routing approach. Because, our metric find out the most balanced routing path and it does not ensure that every node possesses a good amount of energy and higher link stability. A balanced path has one or two node with lowest threshold value of energy and link stability. Therefore, few link breakages can happen one the way to the balanced path. To handle link broken, we apply local repairing process. Not all of the nodes along a path ask other neighboring nodes to act as backup node. The nodes in between a link that might be broken soon will send a request message to their neighbor nodes so that they get ready to convey data when any of the nodes of the link is down. Only one node that is the closest to both nodes of the link and higher usability value will save data overhearing from the link and will join in the link when a node of the link is dead. We also introduce another metrics called vulnerability, which indicates how much the node is susceptible to malicious attack and environmental factors. The backup node is determined by the following formula:

$$b = \frac{1}{1 + e^{-(\frac{u}{g} - v)}}$$

Here, u and v stand for usability and vulnerabilities of a node respectively. Where g is measured as follows

$$g = \frac{d_1 + d_2}{2}$$

where, $d1$ is the distance from data sending node to the backup node and $d2$ is the distance from the backup node to the forwarding node. The node with least average distance from sending node and forwarding is the most preferable as backup node.

Finally, the node having the highest backup value b will be nominated to act as a backup node if the sending or the forwarding node is unable to convey data further and hence repair the link breakage of the routing path in AODV. The local link fixing algorithm is stated below.

Algorithm link-repair **is**
Input: the balanced path
Output: backup nodes
for each node i of the path do
    if check(li, ei)= true
        broadcast backup REQ
for each backup node j

$$bj = \frac{1}{1 + e^{-(\frac{u}{g} - v)}}$$

If max > b_j then
    $max = b_j$
    $backup \leftarrow j$
return *backup*

check (li, ei)
    if $(li \leq LTH \,||\, ei \leq ETH)$
    return *true*$true$
else
    return *false*

Here, LTH and ETH represent the lower threshold of link stability and energy respectively for the data to be transferred.

If link stability or energy of a node of the balanced path is less than or equal to a threshold value that is determined by considering the energy and link stability that are required for the data which the node is to transfer.

IV. Performance Analysis

We have evaluated the performance of the proposed ERS-AODV protocol using simulation and compared it with that of the AODV-D[12] and the QoS-AODV Routing protocols. In this chapter, we describe the simulation setup, performance metrics, experimental results with the comparison of existing routing protocols in mobile ad hoc networks.

A. *Simulation Environments*

For our simulation, we used 50 nodes, which randomly distributed over the simulation area, confined in a 1000m*1000m.Every node has a 250 m transmission range with fixed transmission power. To generate node movement, "random waypoint" is used. Between nodes within the transmission range, random connections were established. Each packet is 512 bytes in size. The flows of packets occur 10 times. The simulation time is 900s.

Parameter	Value
Topology	1000m*1000m
No of Nodes	50
Mobility Model	Random Way Point
CBR Sending	8m/s
rates(Packets/Sec)	
Pause Time	0
Transmission range	250 meters
Propagation model, Antenna type	Two ray ground reflection, omni directional
Simulation Time	900s
Packet Size	512 bytes
Data traffic	CBR
MAC Layer	IEEE 802.11 DCF
No of Flows	10

B. *Results and Analysis*

The results of the simulation of our protocols analysis with three performance metrics as packet delivery ratio (PDR),Average End-To-End Delay and Route life time and show the better performance comparing with existing protocols in mobile ad hoc networks.

1) Packet Delivery Ratio: The proposed protocol ERS-AODV is compared with other three protocols: M-AODV [14], AODV [5] and AODV-ABL [13]. The average control overhead is improved than the previous protocols; is shown in figure 2. It shows an average improvement rate of above 1 percent more than M-AODV.

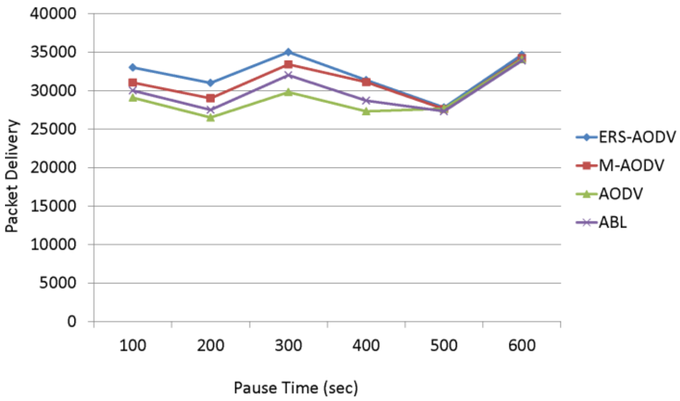

Fig. 2. Comparison of packet delivery ratio

2) Overhead : In Figure 3, the number of received packets versus the pause time has improved compared with the other three existing protocols- M-AODV, AODV and AODV-ABL. Packet delivery ratio is higher than previous protocols in literature. The average improvement rate for ERS-AODV is about 2.5% more than M-AODV.

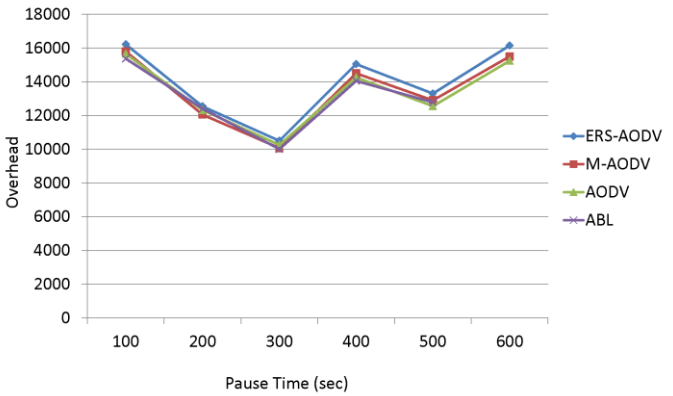

Fig. 3. Comparison of overhead

3) Delay: The amount of delay versus pause time in the proposed protocol has been improved compared with M-AODV, AODV and AODV-ABL. M-AODV diagram is relatively linear but the proposed QoSLRP-AODV yields the minimum delay versus pause time. This is represented in figure 4. The average improvement rate for ERS-AODV is approximately 2% compared to M-AODV.

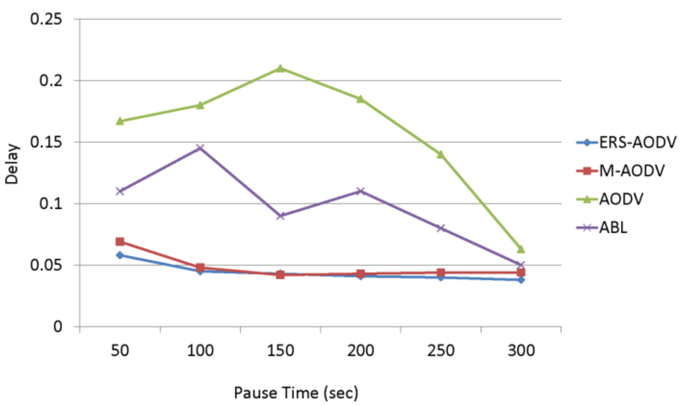

Fig. 4. Comparison of delay

V. Conclusion

Three parameters pertaining to Quality of Services are considered for building a metric for the proposed protocol. Link stability, delay, and energy of a node are some parameters that ensure to establish an energy aware routing protocol. If there are multiple paths from the source node to the destination, the protocol chooses a balanced path in terms of link stability, delay per node and energy of the path. We devise a new metric that selects a stable path with lower communication cost that provides along lifetime of network and reduced packet loss along the QoS support. We also propose a new metric for choosing the most promising backup node in order to repair local link.

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