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Enhancing Route Maintenance in RS-AODV

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ABSTRACT
Mobile Ad hoc Networks (MANETs) are temporary formed, infrastructure-less networks. The performance metrics degrades due to the unstable channel conditions, network connectivity, and mobility and resource limitations. To improve different performance metrics, various cross-layering techniques are used where different layers from protocol stack communications with each other via exchange of information. Ad hoc on demand Routing Protocol (AODV) is a well reactive ad hoc routing protocol. We proposed RS-AODV (Route Stability based AODV), a modified version of AODV routing protocol, based on route discovery by utilizing Physical Layer information instead of the minimum hop count approach of the default distance vector algorithm. Our research will also elaborate how the proposed model uses the received Signal Strength (RSSI) to find its route. We will focus on parameters like traffic throughput, response, time, packet loss, delay, link stability, optimal usage of battery resource to increase overall lifetime of a network. And also use novel approach “make before break” that starts finding alternate route when it seems link failure due to mobility of node. Simulation results show that RS-AODV has performance better that AODV routing protocol in terms of the metrics: End-to-End delay, Packet Delivery Ratio, Network Routing Load and number of route repairs.
***Keywords* -** AODV, Link Failure, MANET, NS2, Route Stability, RSSI.

I. Introduction

A mobile ad-hoc network (MANET) [1] is composed of mobile nodes that form distributed systems without any fixed infrastructure or centralized administration. In these systems, nodes can be freely and dynamically self organized into arbitrary and temporary, “ad-hoc” network topologies, nodes communicate with each other directly or via intermediate nodes. Packets are transferred to neighboring nodes along with the path from the source node to the destination node is done by intermediate nodes. In MANET each node works as a router and autonomously performs mobile functionality. The link connectivity changes continuously due to mobility, to reflect this routing information also needs to get changed continuously. The performance of MANETs is related to efficiency of routing protocols and efficiency depends on several factors like convergence time after topology changes, bandwidth overhead to enable proper routing, power consumption. Efficient routing protocols are needed for the network as the link failure is high due to the dynamic network topology and the packet drops as it travels through multiple hops. Routing protocols for static network are not suitable for MANET. Most of these protocols use min-hop as the route selection metric. It is found that shortest path route has short lifetime, especially in highly dense ad hoc networks even with low mobility; due to edge effect they do not address the issue of reducing the path breakage during data transmission. In most of the on-demand routing algorithms it will take some time to detect the link failure after which, route recovery procedures are initiated. These procedures consumes substantial amount of resources like bandwidth, power, processing capacity at nodes and also introduce extra delay. The efficiency of networks is greatly reduced due to re-route discoveries.

Link stability is a measure of how stable the link is. Stability based routing protocols tends to select paths that will last longer. Signal strength, pilot signals, relative speed between nodes are the parameters used for the computation of link stability. RS-AODV is an extension of AODV that integrates route stability into route discovery. It ensures the selected path to be valid for sufficiently longer period and also extends the lifetime of the network. In this work, we propose a novel "make-before-break" mechanism, to enhance the route maintenance in RS-AODV. This mechanism find an alternate route for data transfer, when there seems any possibility for link break due to mobility through cross layer approach. Performance results show that RS-AODV with route maintenance outperforms AODV in high load and highly dynamic environment.

This paper is organized as follows. Section II represents the related work on various stability based routing and route maintenance approaches. In section III, we describe the proposed RS-AODV with "make before break" mechanism in detail. Section IV depicts performance evaluation and comparison results with similar protocols. Section V concludes the proposed work and future work.

II. Related Work

We expose relevant research work related to stability based routing and route maintenance approaches.

SQ-AODV [2] - authors proposed Stability-based QoS-capable Ad-hoc On-demand Distance Vector protocol, is an enhancement AODV protocol in which residual node energy is used for route selection and maintenance. It also proposed a novel make- before-break mechanism that finds an alternate route when energy of node goes below threshold. It provides stable routes by accounting for the residual life-time calculated using the current Average-Energy-Drain-Rate (AEDR)) at intermediate nodes and the duration of the session at the route selection stage. This minimizes packet loss and session disruptions. SQ-AODV proactively re-routes sessions, without losing any packets, this provides near-zero packet loss and superior QoS performance.

In [3] node measure the signal strength of the link and send Route Request to other node, after that intermediate node accept that packet compare the signal strength value of the link with Route Request packet, if it is less than packet value then its modified the packet value with minimum value and forwarded to other node until it reach to the destination, with the help of this approach weak link of the route is calculated ,after receiving Route Request by the destination node ,its send the Route Reply with minimum of the route to source then source node first select earliest established path to forward packets, then changes to the strongest signal strength path for long transmissions.

In this paper [4] every node maintains the RSSI table , RSSI table contain the signal strength value of node's neighbour, with the help of this RSSI table node predict that his neighbour node is moving away from us, after predicting the link failure it performs following steps:

i) Dropping: If the quality of link is severely damaged or the link is already broken, then this method drops the packet.

ii) Relaying: In this technique, a node can become a relay node when both sender and receiver are in its neighbour table and forward the data between source and destination, if the link is fail between source and destination.

iii) Selective forwarding: In this technique, the intermediate node drops the packet if it comes from bad links.

LAER [5] – in this paper authors proposed A link stability and energy aware routing (LAER) protocol, which consider joint metric of link stability and energy drain rate into route discovery, and on the local topology knowledge, which results in reduced control overhead and balanced traffic load. It increases the link stability of the transmission. To account the energy consumption and link stability of mobile nodes, a bi-objective integer programming (BIP) mode was formulated.

In [6] proposed model predict the lifetime of a routing path, based on mobility and prediction technique. It considers a probability model derived through the subdivision into cells of the area where mobile nodes move and on the observations of node movements in these cells. Each connection between a mobile node in a cell and the other mobile nodes among its neighbour cells is considered as the state of the wireless link. In this way, the wireless link dynamic is determined between a mobile node and its neighbours, permitting the calculation of the link lifetime. After this, through the assumption of independent link failure, the route breakage probability is derived. More details can be found in.

Link life based routing protocol (LBR) [7] is stability-based routing protocol. It converts signal strength into distance using a free space propagation model assumption. LBR estimates link lifetime based on estimated distance and speed of nodes. When the source node initiates a route request, each intermediate node attaches its estimated link lifetime to the route request message. When the destination receives it, it starts calculating the path lifetime for that path. So, the destination can select a path that is expected to have the longest lifetime. In order to react to path breakage, proactive and reactive maintenance is proposed in LBR. In reactive maintenance, the source node needs to reinitiate a route request to the destination, which results in increased delay and control overhead. In proactive maintenance, a backup path is found prior to path breakage. However, the estimated path lifetime is not valid when a path is broken. Therefore, the backup path may be unstable. The purpose of stable routing should be not only reducing routing overhead but also increasing packet delivery ratio.

We propose EBL (A Routing Protocol for Extend network life time through the Residual Battery and Link Stability in MANET) [8]. The EBL considers distance among neighbour nodes, Residual Battery Capacity and Link Stability. EBL considers distance among neighbour nodes, Residual Battery Capacity and Link Stability. EBL is able to increase the Lifetime of Network through minimizing the whole energy consumption and distribute the traffic load. A route is selected in consideration of Residual Battery Capacity, Link Stability and distance vector to prevent unbalanced energy consumption of nodes.

In [9] Li et al. have proposed the link prediction in the AODV routing protocol by establishing a signal intensity threshold which is Pr-THRESHOLD. If the received signal intensity is lower than the threshold, the upstream node will calculate the distance between it and the sending node through the intensity of the received packet signal, and estimate the relative velocity between it and the sending node through the time difference of the neighbouring received data and the intensity of the packet signal. Then, according to the relative position and the relative velocity with the sending node, a node can estimate when to send a RRER to the sending node to warning it about a link failure. When the source node received this RRER message, it will start its restored process searching its routing table and find another route to the destination.

In [10] Qin & Kunz have dealt with the problem of link failure prediction by proposing an equation to calculate the exact time that a link breakage can occur. They named their method the link breakage prediction algorithm. In their idea, each node maintains a table that contains the previous hop node address, the value of the received packet signal power, and the time which this data packet has been received. After receiving three data packets, a node will calculate the link breakage time and compare it with a fixed threshold. If the node predicted that the link with its previous neighbour will have a link breakage soon, it will send a warning message to the source node of the active route to warn it about the link breakage probability. If the source still needs the route it will perform a route discovery process to establish a new route to the destination. Their idea has been implemented using DSR routing protocol.

In [11] Choi et al. has dealt with the problem of link breakage prediction in vehicular ad hoc network. They proposed an algorithm to predict a link breakage possibility using the value of the RSSI (Received Signal Strength Indicator). Each vehicle in the network periodically scans the received signals from its neighbours and uses the collected value to calculate the distance, the velocity, and the acceleration of its next hop which it receives data packets from. By calculating these three values, the node can predict if a link breakage will occur, and can determine if the effected link can be maintained or a new link is needed to be constructed. If the effected vehicle found that a link breakage in the link with its next hop will occur, it will use one of its neighbours which has the highest value of RSSI with (that means the one which is the nearest to it) to build a new link with before the previous link with its other neighbour becomes broken.

In [12] authors have proposed a stable, weight-based, on-demand routing protocol. The "weight" carried in the protocol messages used to select stable routes is based on three components: Route Expiration Time (RET), which is the predicted time of link breakage between two nodes due to mobility, Error Count (EC), which captures the number of link failures due to mobility, and Hop Count (HC). The authors have assumed that all nodes are synchronized via a Global Positioning System (GPS), so that two adjacent nodes may predict the RET. While the proposed scheme may combat against link breaks due to mobility, link breaks due to the draining node energy is a factor that also must be accounted for when computing weights for stable routing.

In [13] the authors have proposed a stable route selection scheme based on Link Expiration Time Threshold (LETth). The Link Expiration Time (LET) is computed based on a prediction of neighbour mobility. LET computation needs to know the position of the neighbours, and hence requires periodic topology updates.

[14] Paper proposed a novel scheme to enhance the route maintenance process in Route Stability and Energy Aware Routing (RSEA-AODV) protocol that keep track of stability and energy metrics during route discovery, through cross layer approach. In this work, we propose a novel "make-before-break" mechanism, to enhance the route maintenance in RSEAAODV. This mechanism finds an alternate route for data transfer, when there seems any possibility for link break due to mobility, energy drain and congestion, through cross layer approach. At some fixed interval it continuously check the status of established route, if any node is in critical battery state or receiving weaker signal or interface queue length increases beyond the threshold then it starts finding alternate route before it actually breaks. This mechanism increases packet delivery ratio and reduces the number of packet drops and delay incurred.

In this paper [15] authors proposed a method which measures signal strength between nodes and compare with RSSI threshold values. If RSSI is greater than threshold value then it is accepted for further processing otherwise it is discarded. It increases the lifetime of the network by selecting a strong route to the destination can. Stable route in MANETs is a route that is established for an acceptable period for transmission.

III. Proposed Work

In the MANET, one of the major constraints is unpredictable link failure. Major challenge of routing protocol is to reduce the link failure due to the mobility of node in the network. To achieve this, stable route is required which is more flexible in mobile networks. Stable route in MANETs is a route that is established for an acceptable period for transmission. So we propose a new model for routing protocol that created routes have more stability, to implement it we used received signal strength indicator (RSSI) metric to find stable route from source to destination. The following cases are used to forward the data over the network.

3.1 Route Discovery

When a node needs to send packets to some destination, it searches for route in its route cache. If route to the destination is not available, the source will broadcast route request RREQ to its neighbors. On receiving a RREQ packet, intermediate nodes measure the strength at which it received the packet. If the signal strength (RSSI) is above the threshold value, it stores RSSI value into cache, and if RSSI is less than threshold value then it drops the route request.

Algorithm 1: Implemented in Intermediate Node

```
If (Node listen a RREQ) {
If (same as forwarded in near past) {
Discard;
}
Else //This is a new RREQ {
Calculate RSSI
    If (RSSI < RSSI_Thr1) then
        Drop packet P
        Return
End If
Else
Entry for Reverse Route // (Route from node to originator of this RREQ message) {
    // update the sequence no. ,
        // Set the valid flag for route,
    // Change the life time for route to
    originator.
Update the routing table entries for originator IP address;
Increase the hop count by one in RREQ packet;
}
IF (TTL > 1) {
Decrease the TTL field by one;
    If [(Node is Destination for this RREQ) OR (Node has route to destination)] {
    Send RREP;
Discard RREQ;
    }
    Else {
Broadcast RREQ;
}
}
}
}
```

3.2 Route Maintenance

After establishing route between source and destination, each intermediate node continuously monitors the established link status. On receiving data packets, each intermediate node calculates RSSI value from received packet at MAC layer and passes it to the network layer. At network layer routing protocol compare RSSI with RSSI Threshold (RSSI_Thr2) value, if it is below Threshold then it queued the received packet and send route error message to the source and also intimate source to find alternate route in order to continue communication.

Algorithm 3: Route Maintenance by Make-Before-Break Mechanism

```
Input: A Data Packet P from neighbor node
    Calculate RSSI
    If (RSSI < RSSI_Thr2)
        Queue packet into cache
        Send RERR
        Send Route Request to Source
    Return
    End if
```

IV. Simulation And Performance evaluation

In this section, the performance of AODV and RS-AODV are evaluated using NS2.

4.1 Calculation of RSSI value

The RSSI value is calculated with the help of two ray ground model

$$P_r(d) = \frac{P_t * G_{t*} G_r * \; h_t^2 * h_r^2}{d^4 L} \tag{1}$$

P_r: Power received at distance d
P_t: Transmitted signal power
G_t: Transmitter gain (1.0 for all antennas)
G_r: Receiver gain (1.0 for all antennas)
h_t: Transmitter antenna height (1.5 m for all antennas)
h_r: Receiver antenna height (1.5 m for all antennas)
d: Distance from the transmitter
L: Path loss (1.0 for all antennas)

4.2 Performance Metrics

Packet Delivery Ratio: Packet Delivery Ratio (PDR) is the ratio between the number of packets transmitted by a traffic source and the number of packets received by a traffic sink.

Normalized Control Overhead: It is the ratio of control packets sent and the number of packets delivered at the destinations.

End-End Delay: It is a measure of the average time a data packet has taken to reach its destination.

No. of Route Repairs: total number of local route repairs.

4.3 Simulation Parameters

We have simulated it in NS 2.35. We used simulation parameters, which are listed in the table.

Table: Simulation Parameters

Parameter Name	**Value**
Topology	800×800, 1000×1000, 2450×2450 and 3500×3500 (m)

No. of Nodes	50, 100, 250 and 500
Mobility Model	Two Ray ground
Simulation Time	50 Seconds
Pause Time	5
No. of Connections	20
Buffer length	60
MAC Protocol	IEEE 802.11
Packet Size	512 Bytes
Traffic Type	Cbr
Mobility Speed	5 m/s
Traffic Rate	4 Packets/Second

4.4 Simulation Results

We simulated RS-AODV along with AODV using NS2. In this section, we present the simulation results and compare RS-AODV with AODV.

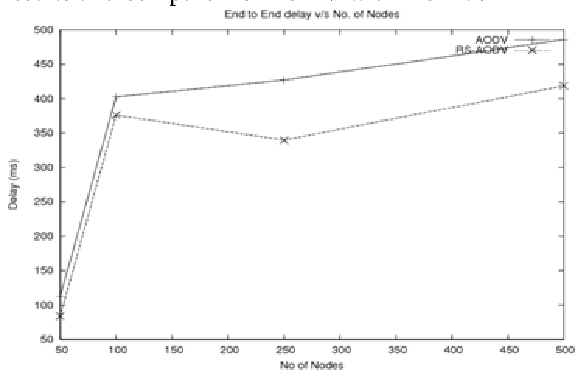

Fig. 1 End-To-End Delay versus Number of Nodes

Fig. 1 shows graph of end to end delivery ratio vs. number of nodes. It shows that as the number of node increases end to end delay also increases. In AODV end to end delay increases rapidly as compared with RS-AODV. Reason behind the reduction in end to end delay is because of the selective processing of signals. Weaker signals are discarded at the routing layer after comparing the RSSI with Signal threshold. This makes only selected signals entering into further processing phase thus reducing the end to end delay.

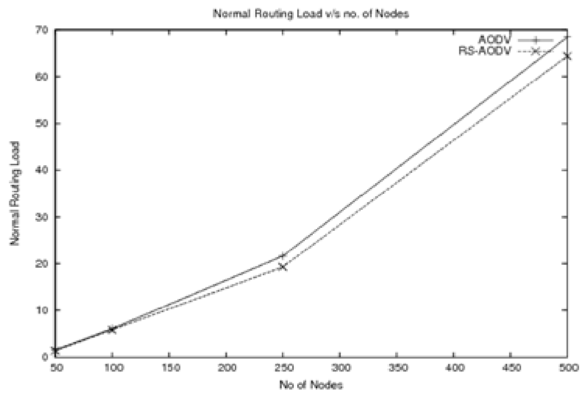

Fig. 2 Normalized routing Load versus Number of Nodes

Fig. 2 shows graph of normalized routing load vs. number of nodes. In that as the number of nodes increases routing overhead also increases, RS-AODV avoid unreliable mobile nodes from the route, it requires less rerouting and leads to less control overhead. So in large network RS-AODV perform better than AODV.

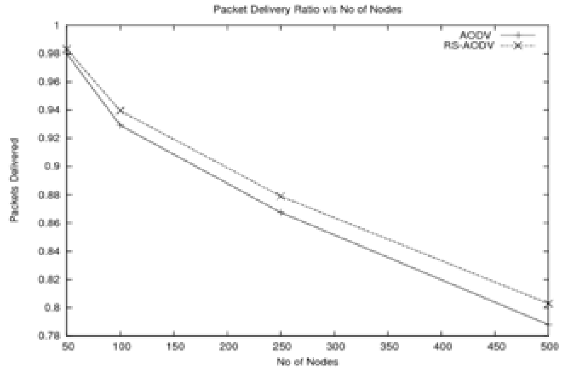

Fig. 3 Packet Delivery Ratio versus Number of Nodes

Fig. 3 shows graph of packet delivery ratio vs. number of nodes. RS-AODV selects the most reliable path so number of packet drop is also low as compare to AODV. Make before break avoids link failure due to node mobility, so the packet delivery ratio is also better than AODV in denser network.

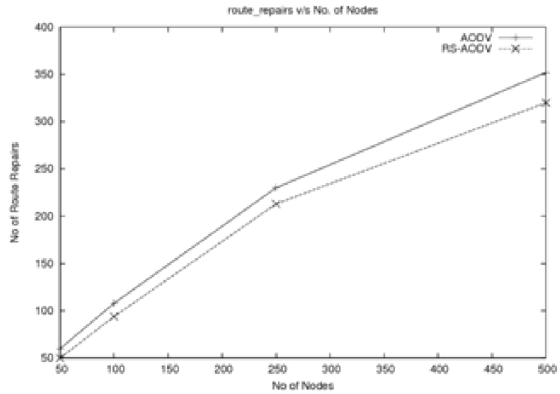

Fig. 4 No. of Route Repairs versus Number of Nodes

Fig. 4 shows graph of route repairs vs. number of nodes. As number of nodes increases number of route repairs also increases. RS-AODV attempts less route repairs compare to AODV because of make before break mechanism, which finds alternate route before route breaks.

V. Conclusion and Future Work

This paper presented new routing protocol RS-AODV which is extension of existing AODV routing protocol. RS-AODV incorporates route stability using received signal strength indication parameter in the route discovery. Make-before-Break mechanism enhances route maintenance approach and reduces link failure. Simulation results showed that the proposed scheme significantly increased the packet delivery ratio, reduced the control overhead, end to end delay and number of route repairs incurred due to unpredictable link breaks, by early alert compare to traditional AODV. It shows considerably better performance in highly dynamic networks. In case of low or nil mobility, the proposed model resulted in slightly high delay compared with AODV. Improve protocol by considering more parameters that might affects link failure like energy of node, parameter queue length and signal-to-noise ratio are left as part of our future work.

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