Performance Analysis of Ad-hoc On Demand Multipath Distance Vector Routing Protocol with Accessibility and Link Breakage Prediction

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ABSTRACT
Mobile Ad-Hoc is a self-organizing network without centralized control, where each node acts as router to attain coverage over multiple hops. Routing plays a very important role. Some of the well-established routing protocols are AODV and AOMDV. Mobility results in disturbed routes thereby generating route errors and new route discoveries. Existing protocol like AOMDV computes multiple loop-free and link-disjoint paths but nodes are unaware of relative movement and location. In this work we present a scheme to integrate Accessibility prediction and Link breakage prediction with AOMDV. Our scheme AOMDV-APLP makes AOMDV aware of access of neighbor nodes in the network. Nodes acquire the accessibility information of other nodes through routine routing operations and maintain it in their routing table. Based on this information route discovery is restricted to only "accessible" and "start" nodes. Multiple paths are generated by accessibility prediction and from these paths route with the strongest signal strength is selected depending on Link life value predicted by Link Breakage prediction technique.

Simulations were done on Ns-2.34 on Fedora 9 Linux environment. Experiments show that our protocol results in reduction of MAC overhead, routing overhead and average end-to-end delay it also improves the Packet delivery ratio to a large extent as compared to standard AOMDV. A comparison is done with AODV-APLP and results show that AOMDV-APLP performs better.

General Terms
Algorithm, Performance.

Keywords
Accessibility Prediction, Link Breakage Prediction, Accessible, Inaccessible.

1. INTRODUCTION
Ad hoc networks are characterized by dynamic topology, high node mobility, low channel bandwidth and limited battery power. The dynamic nature of topology in mobile adhoc networks (MANET) is the major cause of MAC (media access control) overhead and Routing overhead, thus reducing the performance enormously. As nodes are changing their position consistently, routes are rapidly being disturbed, thereby generating route errors and new route discoveries. In these scenarios, it is essential to perform routing with maximal throughput and, at the same time, with minimal control overhead [2] [6]. The packets moving over wireless links also suffer from radio interference of neighboring nodes. The topological change due to mobility and limited battery power of nodes have to be managed without causing long link break periods.

Adhoc On-demand Distance Vector AODV [1] uses on-demand approach for finding routes. Adhoc on demand Multipath Distance Vector AOMDV [6] is an extension to the AODV [1]. Studies have proved that AOMDV always offers a superior overall routing performance than AODV in a variety of mobility and traffic conditions. The AOMDV protocol computes multiple loop-free and link-disjoint paths. The routine routing information in AOMDV can be used to avoid huge overhead by making nodes aware of their relative movement and location. Packet delivery ratio can also be increased by selecting path with the strongest signal strength. Accessibility prediction is implemented in AODV [9] which has reduced control overhead, the frequent route breaks cause intermediate nodes to drop packets because no alternate path to destination is available. AOMDV is a protocol, which generates multiple paths on single route discovery but however does not use the routine routing information. We propose scheme AOMDV-APLP that integrates Accessibility prediction and Link Breakage prediction, which enable us to predict relative state of the node using routine routing information. This prediction is very useful in future for reducing control overhead. AOMDV with accessibility prediction routing protocol make use of pre-computed routes determined during route discovery. These solutions, however, suffer during high mobility because the alternate paths are not actively maintained [10]. Hence, precisely when needed, the routes are often broken. To overcome this problem, Link breakage prediction algorithm [4] [5] [8] is implemented at MAC layer, calculates link life value, which is used by protocol layer to select route with strongest signal strength from multiple paths generated with accessibility prediction.

The rest of the paper is organized as follows. In section 2, we present working of AODV and AOMDV routing protocol. Section 3 describes our proposed scheme AOMDV-APLP. In section 4 we present the Implementation and result analysis. Finally Section 5 we give our conclusion followed by section 6 that contains the References.

2. RELATED WORK

Routing protocol in Mobile Adhoc networks can be classified into two main categories. The Proactive or Table driven routing protocols attempt to maintain consistent up-to-date routing information to every other node in the network. The routing information is kept in a number of different tables and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view. DSDV [3] Dynamic Destination-Sequenced Distance-Vector Routing is a table driven protocol developed on Distributed Bellman Ford algorithm where a correct route to any node in the network is always maintained and updated. In DSDV, each node maintains a routing table that contains the shortest path to every other node in the network. The tables are exchanged between neighbors at regular intervals to keep up to date view of the network topology. The tables are also forwarded if the nodes find a significant change in topology. The exchange of table imposes a large overhead so to reduce this potential traffic routing updates are classified into two categories. The first is known as "full dump" where all the routing information is sent which should be done infrequently when there is complete topology change. In the case of occasional movements smaller "incremental" updates are sent carrying only information about changes since the last full dump.

The second category is of On-demand routing protocols that are designed to reduce the overheads in Table driven protocols by maintaining information for active route only. When a node requires a route to a destination it initiates a route discovery process within the network. Once a route is established it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until route it is no longer desired. On-Demand routing protocols can be classified into two categories: source and hop-by-hop routing. In source routed on-demand protocols each data packet carry the complete path from source to destination. Therefore each intermediate node forwards the packet according to the information in the header of each packet. The major drawback of source routing protocol is that it in large network it does not perform well as the number of intermediate node grows the amount of overhead carried in each header of each data packet will grow as well. In hop by hop routing each data packet only carries the destination address and the next hop address. Therefore each intermediate node in the path to the destination uses its routing table to forward each data packet towards the destination. The advantage of this strategy is that routes are adaptable to the dynamic changing environment of MANETs, since each node can update its routing table when they receive fresh topology information and hence the forward the packets over fresh and better routes. The disadvantage of this strategy is that each intermediate node must store and maintain routing information for each active route and each node must be aware of surrounding neighbors through the use of beaconing messages. There are many routing protocols that have been proposed and developed.

2.1 AODV

Ad Hoc On Demand Distance Vector [AODV] [2] is an improvement on DSDV. AODV uses an on-demand approach for finding routes. A route is established only when it is required by a source node for transmitting data packets and it maintains these routes as long as they are needed by the sources. AODV uses hop-by-hop routing by maintaining routing table entries at intermediate nodes. A node updates its route information only if the destination sequence number of the current received packet is greater than the destination sequence number stored at the node. It indicates freshness of the route and prevents multiple broadcast of the same packet. AODV makes use of the broadcast identifier number that ensures loop freedom since intermediate nodes only forward the first copy of the same packet and discards the duplicate copies. The route discovery process is initiated when a source needs route to a destination and it does not have a route in its routing table it floods the network with RREQ packet specifying the destination for which the route is requested. If it has a route the node generates a RREP and sent back to the source along the reverse path and if it does not have then the request is forwarded to other nodes. Once the source node receives the RREP it can begin using the route to send data packets. The source node rebroadcasts the RREQ if it does not receive a RREP before the timer expires, it attempts discovery up to maximum number of attempts or else aborts the session. If one of the intermediate nodes move then the moved nodes neighbor realizes the link failure and sends a link failure notification to its upstream neighbors and so on till it reaches the source upon which the source can reinitiate route discovery if needed. The HELLO messages are sent at regular intervals by the intermediate nodes to find the correct information of the neighboring node.

2.2 AOMDV

Adhoc on demand Multipath Distance Vector (AOMDV) [6] is an extension to the AODV. The main difference lies in the number of routes found in each route discovery. In this protocol RREQ propagation from the source towards the destination establishes multiple reverse paths both at intermediate nodes as well as the destination. The AOMDV [6] protocol computes multiple loop-free and link-disjoint paths. There are three phases of the AOMDV protocol. The first phase is the Route Request, second is the Route Reply and the third phase is the Route Maintenance phase. These RREQ, RREP and RERR are three messages generated to discover and maintain routes by AOMDV in mobile adhoc networks. RREQs are route request packets initiated by a node in the networks. RREQs are route request packets initiated by a node (originator) when it is in need of a route to some other node (destination).These packets are broadcast packets and every intermediate node re-broadcasts them in case it has no valid route to the destination. RREPs are route reply packets initiated by a node in response to a RREQ for itself or for a node to which it has a valid route. RREPs are uni-cast packets. RERRs are route error packets generated by a node when it receives a data packet for an unknown or invalid destination. These packets can be uni-cast or multi-cast.

Nodes maintain routing tables containing information about other nodes in the network and active routes through them. In addition to the information acquired from RREQ, RREP and RERR packets, some parameters like Lifetime field ACTIVE_ROUTE_TIMEOUT, DELETE_PERIOD also have important role in routing [8].

2.3 Motivation for AOMDV-APLP

It is observed that in AOMDV [6] during the usual routing operations, a node can collect significant information enabling it to predict the accessibility and the relative mobility of the other nodes in the network. Nodes acquire the accessibility information of other nodes through routine routing operation and keep it in there routing tables. Nodes can predict the accessibility of the other nodes in topology and can enhance its routing operations. One possible use of this accessibility information restricts the route discovery for inaccessible nodes. This prediction can be supportive in future routing operations, thereby improving the performance. Another source of information is from periodic update packets unicast along each path. These update packets measure the signal strength of each hop along the alternate paths. This signal strength can be used to select a path with the strongest signal strength for data transmission.

3. PROPOSED ALGORITHM

We propose scheme AOMDV-APLP, which integrates Accessibility Prediction and Link Breakage Prediction. Accessibility prediction enables us to predict relative state of the node using routine routing information. This prediction is very useful in future for reducing control overhead. AOMDV with accessibility prediction routing protocol make use of pre-computed routes determined during route discovery. These solutions, however, suffer during high mobility because the alternate paths are not actively maintained Hence, precisely when needed, the routes are often broken. To overcome this problem, second method, Link breakage prediction algorithm is also implemented. Proposed modification is done at two different layers a) Accessibility Prediction based on routing information is done at protocol layer. b) Signal strength prediction using Link Breakage Prediction is done at MAC layer.

AOMDV protocol needs interface to MAC layer to access state of link before initiating proactivity.

In AOMDV repeated RREQs are not discarded. All duplicate RREQs arriving at the node are examined but not propagated further as each duplicate defines an alternate route. Thus AOMDV allows for multiple routes to same destination sequence no. With multiple redundant paths available, the protocol switches routes to a different path when an earlier path fails. Thus a new route discovery is avoided. Route discovery is initiated only when all paths to a specific destination fail. Routing table entry has one common expiration timeout regardless of no of paths to the destination. If none of the paths are used until the timeout expires, then all the paths are invalidated and the advertised hop count is reinitialized. While doing all this, routing information such as RREQs, RREP and REER packets collected can be used to predict the accessibility of nodes. This prediction is used to reduce routing overhead, MAC overhead and to enhance packet delivery ratio and connection success ratio.

3.1 Accessibility Prediction Algorithm

Following algorithm is used for accessibility prediction [9]

a) If a node A receives a routing packet from another node B, node B is in A's neighborhood and is accessible to A.

b) If a node A receives a routing packet originated by a node B, node B is accessible to node A and there exists a valid route from node A to node B.

c) If a node A receives a RERR from a node B, all the unreachable nodes mentioned in this RERR are no more accessible to node A through node D.

Routing entries will never be deleted a new field "Accessible" is added to each routing table entry depicts the predicted accessibility information

Possible values

Start = No information

Accessible = A valid route to node exists or would be possible

Inaccessible = A valid route to node would not be possible

There is no route discovery for "Inaccessible" nodes, which reduces overhead. The value of the accessibility field is just a prediction. It is likely that this information gets stale. To assume an "Inaccessible" node "Accessible" is not an issue as in such a situation usual AOMDV procedures will be followed. However, the converse could have serious consequences. For example, nodes can conserve plenty of resources by not performing route discoveries for "Inaccessible" nodes, provided the prediction is correct. However, if this prediction is incorrect, this resource conservation will cost them in the form of connectivity loss and consequently throughput loss. Thus, in such a situation there is a trade-off between overhead reduction and connectivity.

Table 1 shows routing table of AOMDV-APLP in which a new field Accessibility is added.

Table 1. Routing Table of AOMDV-APLP

Destination
Sequence number
Advertised_hopcount
Expiration _timeout
Route list {(nexthop1, hopcount1), (nexthop2, hopcount2)…
Accessibility

3.2 Link Breakage Prediction

AOMDV with accessibility prediction routing protocol make use of pre-computed routes determined during route discovery. These solutions, however, suffer during high mobility because the alternate paths are not actively maintained. Hence, precisely when needed, the routes are often broken. To overcome this problem, we go for link breakage prediction. Prediction can be done only for multiple paths that are formed during the route discovery process. All the paths are maintained by means of periodic update packets unicast along each path. These update packets are MAC frames which gives the transmitted and received power from which distance can be measured ,this distance can be used to predict whether the node is moving inward or outward relative to the previous distance value that is it give the signal strength . At any point of time, only the path with the strongest signal strength is used for data transmission. Following is the method to calculate link lifetime.

P_r = k $\frac{P_t}{d^4}$ where k = $G_t.G_r.(h_t.h_r)^2$ where k = is a constant

A link breakage algorithm is used to predict the value of tbreak using'd'. Now tbreak can be calculated by the following algorithm

Always assume nodes moving radially outward. Initially

$$V = V_{prev} = V_{\max}\, m/s \,, d_{prev} = 0.0m$$

$$v = \left| \frac{d - d_{prev}}{t - t_{prev}} \right|$$

$$V = (w)^* v + (1-w)^* V_{prev} \text{ k}$$

w based on ratio of time since last sample (! t = t – t prev) and average sample interval T

Time dependency of w ensures quick adaptation to change

$$t_{break} = \left[\frac{d_{\max} - d}{V} \right]$$

$$V_{prev} = V ; d_{prev} = d$$

Thus Accessibility and Link Breakage Prediction (APLP) techniques are incorporated in AOMDV protocol.

4. IMPLIMENTATION

4.1 Simulation Environment

The proposed protocol AOMDV-APLP is implemented in NS2 version 2.34 on Fedora 9.0 platform, by making modification in the existing AOMDV protocol patch.

4.2 Performance Parameters

Performance of AOMDV-APLP protocol is measured based on following parameters.

MAC overhead – the total number of all kinds of MAC packets generated during the simulation time. The retransmission of data frames is also included in it.

MAC packets=Routing packets + Data packets

Routing overhead – it includes all kinds of AOMDV packets generated as well as forwarded during simulation.

Routing Overhead =Total No of Routing packets

Packet Delivery Ratio – The ratio of total number of data packets successfully received by all the destinations to the total number of data packets generated by all the sources.

Packet Delivery Ratio = (No. Of Packets received /No. Of Packets sent) * 100.

Average Delay – The average end–to-end delay is defined packets traveling from the source to the destination node. The packets generally sometimes get delayed due to transmission, processing, collision and queuing.

Total Delay = ∑rRecievedTime [packet_id] - ∑rSentTime [packet_id]

Average Delay = Total Delay / No. of Received Packet

4.3 Result Analysis

4.3.1 Simulation –set 1

We simulated network of 100 and 500 mobile nodes. The performance analysis was done on four parameters MAC overhead, Routing overhead, Packet Delivery Ratio and Average delay. The comparison of the designed protocol is performed with respect to standard AOMDV.

The application pattern consists of mobile nodes running on TCP within 1500m x 300m areas. The start time for simulation is 0.3 sec and the pause interval for output were set at 60,120,300,600,900 seconds.

The Figure 1 below shows the graph of Pause time Versus MAC overhead for 100 and 500 number of nodes for AOMDV-APLP and AOMDV. The MAC overhead is significantly reduced in AOMDV-APLP as compared to standard AOMDV.

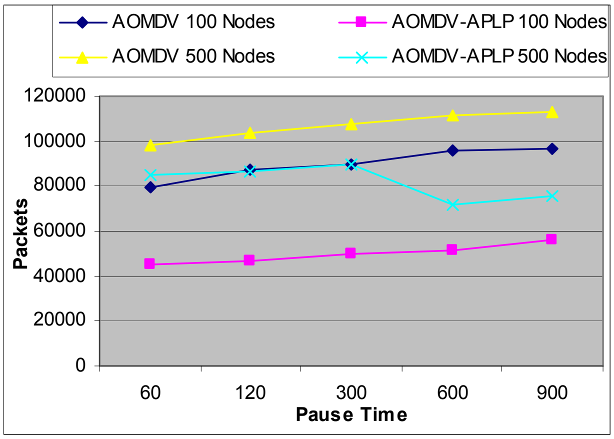

Figure 1.Pause Time vs. MAC Overhead

The Figure 2 below shows the graph of Pause Time versus Routing overhead for 100 and 500 nodes. There is significant reduction in Routing overhead in proposed protocol AOMDV-APLP as compared to standard AOMDV which is a result of limiting RREQs and effective utilization of resources.

The Figure 3 below shows a graph of Pause time vs. Packet delivery Ratio for 100 and 500 nodes. As the Pause time and nodes varies Packet Delivery Ratio also changes. The Packet Delivery Ratio increases in AOMDV-APLP as compared to standard AOMDV.

The Figure 4 below displays the graph of Pause Time vs. Average Delay for 100 and 500 number of nodes. It is observed that as the Average delay varies as no of nodes and time for AOMDV and AOMDV-APLP varies. It is observed that average delay increases heavily in standard AOMDV as compared to AOMDV-APLP.

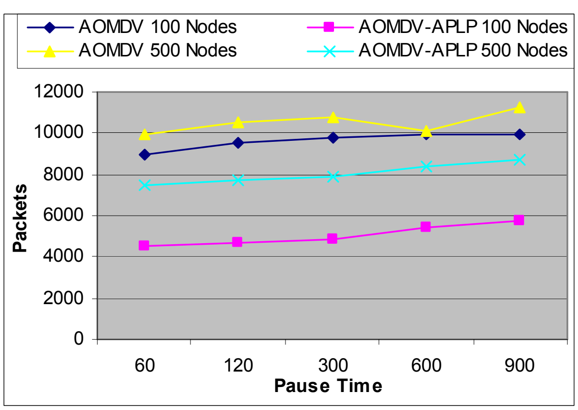

Figure 2.Pause Time vs. Routing Overhead

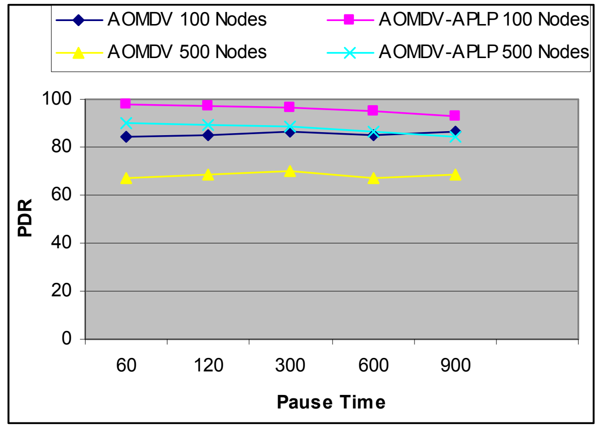

Figure 3.Pause Time vs. Packet Delivery Ratio

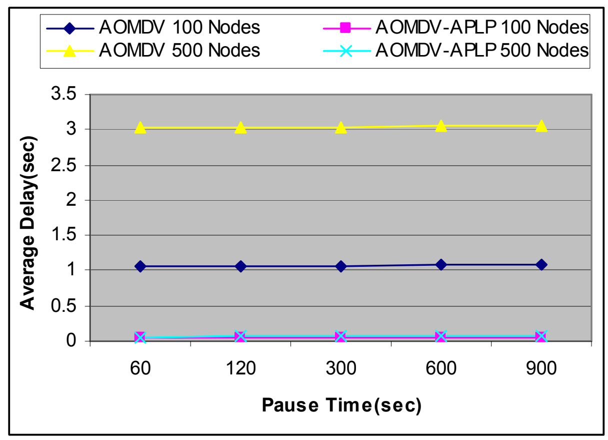

Figure 4.Pause Time vs. Average Delay

4.3.2 Simulation-set 2

Here again we simulated network of 100 and 500 mobile nodes. A comparison was done between AODV-APLP and AOMDV-APLP for the parameters PDR and Average delay

The application pattern consists of mobile nodes running on TCP within 1500m x 300m areas. The start time for simulation is 0.3 sec and the pause intervals for outputs were set at 60,120,300,600,900 seconds.

The Figure 5 below displays the graph of Pause Time vs. Average Delay for 100 and 500 number of nodes. It is observed that as the Average delay varies as no of nodes and time for AOMDV-APLP and AODV-APLP varies. It is observed that average delay increases in AODV-APLP as compared to AOMDV-APLP.

The Figure 6 below shows a graph of Pause time vs. Packet delivery Ratio for 100 and 500 nodes. As the Pause time and nodes varies Packet Delivery Ratio also changes. The Packet Delivery Ratio increases in AOMDV-APLP as compared to AODV-APLP.

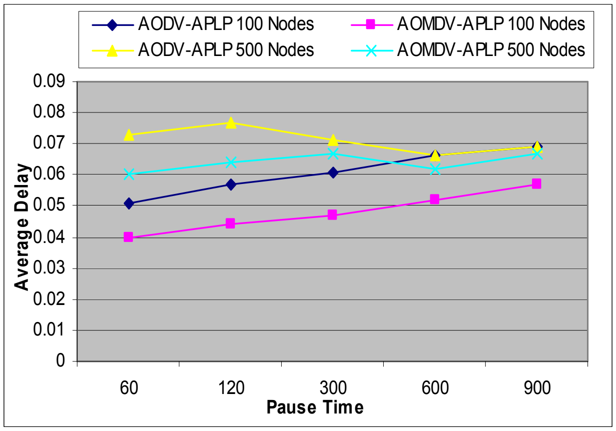

Figure 5.Pause Time vs. Average Delay

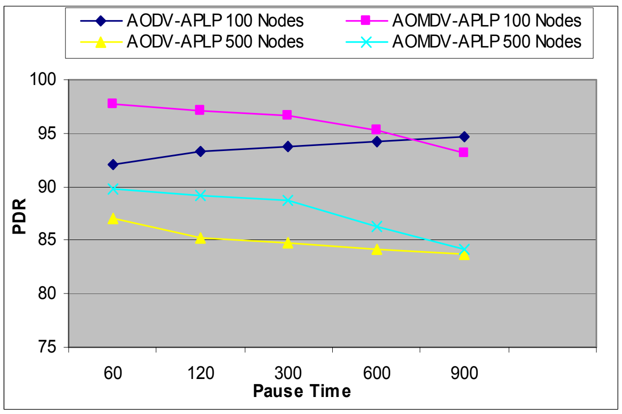

Figure 6.Pause Time vs. Packet Delivery Ratio

5. CONCLUSION

On-demand routing protocols like AODV and AOMDV have addressed the problems of rout discovery in MANETs, but suffer from huge Routing and MAC overhead on node failure. This is primarily because RREQs are sent to all the nodes. We propose a scheme, which integrates Accessibility prediction and Link Breakage prediction in both these protocols

Protocols simulation were done and results show that, our proposed protocol AOMDV-APLP reduces packet delay by 70%, and increases packet delivery ratio considerably as compared to standard AOMDV and AODV-APLP protocol. Our protocol also gives stable connectivity as route with the strongest signal strength is selected with the help of Link lifetime.

6. REFERENCES

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