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An Efficient and Optimal Adaptive Routing Technique for MANET with Fading Avoidance

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***Abstract:** Ad-hoc networking is a concept in computer communications, which means that users wanting to communicate with each other form a temporary network, without any form of centralized administration. Each node participating in the network has multi-identity acting both as a host and as a router. Mobile Adhoc Networks (MANET) are characterized by high mobility leading to dynamic topology and frequent link failures that result in low throughput and high end-to-end delay, where routing is impaired by fluctuations in the path and signal strength. Thus the channel is found to have fading disrupting the communication between adjacent nodes. In this paper an adaptive routing technique is proposed, which allows multiple paths to remain valid and the path of transmission can be altered during packet transmission. An alternate path is chosen only when the current path becomes unserviceable. The physical environment which is found to have fading is overcome by predicting the channel state information, average fading duration, average non fading duration and signal strength. The simulations are done using NS2. The simulation is done for various performance matrixes like packet delivery ratio, average end-to-end delay, routing overhead and network throughput. The results indicate that the proposed adaptive fading avoidance technique has improved network performance in comparison with Adhoc On-demand Multipath Distance Vector (AOMDV).*

***Keywords:** Adaptive routing, channel state information, fading avoidance, MANET, signal prediction.*

I. INTRODUCTION

In ad-hoc networks, communications are done over wireless media between stations directly in a peer to peer fashion without the help of wired base station or access points. Mobile Ad-hoc networks are characterized by dynamic topology, high node mobility, low channel bandwidth and limited battery power. As the nodes dynamically join and leave the ad hoc network, the topology in MANETs vary frequently with time and requires a good routing strategy. With the popularity of ad-hoc networks, many routing protocols have been designed for route discovery, route maintenance and route update. They are mostly designed for best effort transmission without any guarantee of quality of transmissions. Several routing protocols in the literature exploit on-demand routing and multihop paths to route packets [7], [10], [12]. On-demand routing protocols establishes a path from the source to destination only when required to route packets. A route may easily suffer from channel variations due to fading, shadowing, interference, path loss, attenuation of signal, user mobility and node failures [4], [6]. Therefore successful packet transmission depends on the reliability of the wireless channel. This paper employs an adaptive routing technique based on AOMDV called as Adaptive Fading Avoidance AOMDV (AFA-AOMDV) for MANET, where multiple paths to the destination remain valid and the path can be altered during packet transmission. All the paths are maintained by unicast periodic update packets. We opt for an alternate path only when the current active path cannot be used for further packet transmission due to the rapid changes in the environment and channel. The key aspect of this enhancement is that we predict the channel state information, average fading duration, average non fading duration and signal strength to predict the failures ahead and perform path handoff pre-emptively. Routing is allowed on an alternate path only if it is found to be reliable and has the required signal power. No path is discarded on a failure, as it would recover from fading after a specific duration and the path can be reused. This enhances the efficiency of AFA-AOMDV by avoiding unnecessary route discoveries and improves the network performance.

II. REVIEW OF RELATED WORK

Routing through unreliable paths can cause large packet loss. Hence we consider adaptive routing, such that at any point of time we can have successful routing by adapting to a reliable path. We review the predecessor protocols Ad-hoc On-demand Distance Vector (AODV) [3] and Ad-hoc On-demand Multipath Distance Vector (AOMDV) [2] in this section along with the impact fading has on routing.

A. Overview of AODV

Ad-hoc On-Demand Distance Vector (AODV) computes a loop free single path on demand. A mobile node discovers and maintains a route to another node only when it needs to communicate. One observation of AODV is that, though the source actually discovers multiple paths during the route discovery process, it chooses only the best route and discards the rest. 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. When route failures occur, the process of route discovery has to begin from scratch consuming more network resources and overhead.

B. Overview of AOMDV

In order to route with low overheads even under highly dynamic conditions, Adhoc On-Demand Multipath Distance Vector was introduced. AOMDV computes multiple loop free and link disjoint paths providing fault tolerance and efficient recovery from route failures. Each node maintains a list of its next hop neighbors that are sorted based on the hop count. When failures occurs during routing an alternate path is chosen, if there is no alternate path a route error message is given. The routing metric considered is the number of hops, thus paths with a small number of long hops are chosen. When paths with long hops are chosen, there is high probability for the occurrence of fading. Moreover the stability of the path is completely ignored as the alternate paths are not maintained. Thus the paths are stale and cannot be used on a failure. Therefore AOMDV is not adaptive to the dynamic changes in network topology.

C. Impact of fading

In urban areas, where MANET applications are mostly used a simple propagation model may not represent the real wireless channel effects such as reflection, diffraction, scattering and shadowing phenomena. Typically, multipath propagation and hence fading are vital factors to be considered for routing in urban areas. Since fading will affect whether a node can communicate with the adjacent nodes, this can have a significant effect on network performance. Signal fading arises from the constructive and destructive addition of the multipath components. Multipath results in both slow and fast fading. Fast fading is said to occur if the channel impulse response changes rapidly within the symbol duration. Slow fading occurs when the coherence time of the channel is large relative to the delay constraints of the channel. Various distribution functions have been used for modelling fading in the wireless communication channel. Rayleigh fading is used as a fast fading model and Lognormal shadowing as a slow fading model. Literature [1] states that slow fading degrades the performance of AODV very severely than fast fading. Therefore fading avoidance seems to be a severe threat for routing in ad-hoc networks.

III. DESIGN AND ADAPTIVE FADING AVOIDANCE (AFA) TECHNIQUES

The design of the adaptive fading avoidance technique for AOMDV is a combination of the on-demand strategy and adaptive mechanism. As the pre-computed routes could be useless due to the mobility of the nodes to avoid the drawbacks of the proactive approach we go for an on-demand approach. As the channel conditions vary based on time, we use adaptive mechanism to alter the path during packet transmission. In this section the routing algorithm designed for AFA-AOMDV is described.

D. Route Discovery

The route discovery algorithm discovers the route from the source node to the destination node reactively. The route discovery is triggered by the mobile nodes under any of the following conditions, and an update is required in the routing table.

i. When a node initiates or receives the route request message (RREQ), it first queries the routing table. If the corresponding route is null or out dated, the route discovery method is invoked.

ii. When an intermediate node issues a route error message (RERR) to the node which initiated the data transmission and no alternate paths are available. The initiating node starts the route discovery method.

A description of the route discovery algorithm is given below:

i. When a node M initiates or receives a RREQ message, it will first compare the source address, broadcast identifier and last hop information present in the RREQ with the information cached. If they are matched, it means the RREQ has been received already and therefore discards it. Otherwise, go to step 2.

ii. Node M checks whether the destination node belongs to the routing table entries. If so go to Step 3, otherwise go to Step 8.

iii. Node M checks whether the destination node is M itself. If so go to Step 7, otherwise go to Step 4.

iv. Node M checks whether the destination sequence number is greater than the one in the RREQ and has a lower hop count. If so go to Step 7, otherwise go to Step 5.

v. Node M checks whether the destination sequence number is lesser than the one in the RREQ. If so, the route is out dated and marked as stale and proceed to Step 8. Otherwise go to Step 6.

vi. Node M checks whether the destination sequence number and hop count is equal to the one in the RREQ and has a greater non fading duration. If so the routing table is updated and a Route Reply (RREP) message is sent to the query initiating node.

vii. Node M will return a RREP to the query initiating node.

viii. Node M increments the hop count by one and broadcasts the RREQ to its neighbors.

Thus path selection for AFA-AOMDV is based on the average non fading duration, destination sequence number and hop count.

E. Route Maintenance

Route Maintenance is required due to the highly dynamic and mobile nature of the nodes. The nodes tend to have different geographic positions thus rendering the active route as useless. Moreover the quality of the channel is found to vary with time due to fading. The route maintenance algorithm is described below:

i. If fading duration or signal strength is below the threshold, generate Handoff Request (HREQ) and go to Step 2, otherwise continue routing packets.

ii. On receiving HREQ, the node compares the source sequence number with the information cached in the local handoff table. If the corresponding source entry is found go to Step 3, otherwise go to Step 4.

iii. If the entry has expired or the HREQ has a higher sequence number go to Step 4, otherwise drop the HREQ as it is a duplicate.

iv. Create a new entry in the local handoff table and check for alternate paths. If alternate path is found to be reliable go to Step 5, otherwise forward the HREQ.

v. Mark the link as dormant according to the fading duration recorded in the HREQ and handoff to an alternate reliable path adaptively. Drop the HREQ.

The source does not wait for the current active path to fail, it constantly monitors the alternate paths and adaptively swaps to a better and reliable path when a fade is predicted and route handoff is performed. Fading duration is recorded and the path is marked as dormant. The faded path can be reused after the fade improving the performance of the AFA-AOMDV.

F. Route Update

As a MANET routing technique, AFA-AOMDV must handle the problem with the mobility of nodes. As a node's position changes over time, the network has dynamic topology and a node may join or leave the network at any instant of time.

1. Node Join:

A new node joins the network, by finding its neighbour with the help of the HELLO messages that are periodically broadcasted. The node issues a Route Join (RJOIN) message to join the network. To save the route maintenance cost, when a node joins the network, the routing table will not be initialized. On contrary, the node will construct the routing table only on demand, when it has to communicate.

2. Node Departure:

A node may be out of reach due to the normal or abnormal departure of the corresponding nodes or the destination. Once this happens the route update algorithm is triggered reactively. The departure of nodes is classified into two types:

1. Normal departure: nodes leave the system deliberately and issue a Route Quit (RQUIT) message.
2. Abnormal departure: nodes leave the system without any signs. When a neighbor node finds that the corresponding node or destination is out of reach, it issues a Route Error (RERR) message.

The route update algorithm is described below:

i. When a node receives RQUIT or RERR message, it deletes all the routes corresponding to that node and searches for alternate paths. If the alternate path is found to be reliable go to Step 2, otherwise go to Step 3.

ii. Update the new route to the targeted nodes and continue routing through the alternate path.

iii. If all the alternate paths have failed, trigger the route discovery algorithm.

IV. Simulation Results

The simulations are done using NS2 for 50 nodes that are randomly distributed with 2 Mb/s channel bandwidth. The movement of the nodes is random. Traffic sources are generated at Constant Bit Rate (CBR).

A. Packet Delivery Ratio

Packet Delivery Ratio is the ratio of the data packets that are delivered to the destination to that generated by the source. It is an important criterion that estimates the routing technique's performance on how well it adapts to the change in network topology and how efficient the alternate paths are used adaptively. From figure 1 which depicts the comparison of packet delivery ratio between AFA-AOMDV and AOMDV with average path life time, we understand that AFA-AOMDV has good packet delivery ratio by using adaptive mechanism to predict fading along a path and perform pre-emptive path handoff.

Fig. 1 Comparison of Packet Delivery Ratio between AFA-AOMDV and AOMDV

B. Average End to End Delay

Average end-to-end delay includes all possible delays caused by buffering during path handoff, queuing delay at the interface, retransmission delays, propagation and transfer times. The average end-to-end delay of AFA-AOMDV is low when compared with AOMDV because; the alternate paths are actively maintained and the delay can be reduced by routing along an alternate path when a failure is predicted. Moreover re-route discovery is required only when all the alternate paths fail. Figure 2 shows the comparison of average end-to-end delay between AFA-AOMDV and AOMDV.

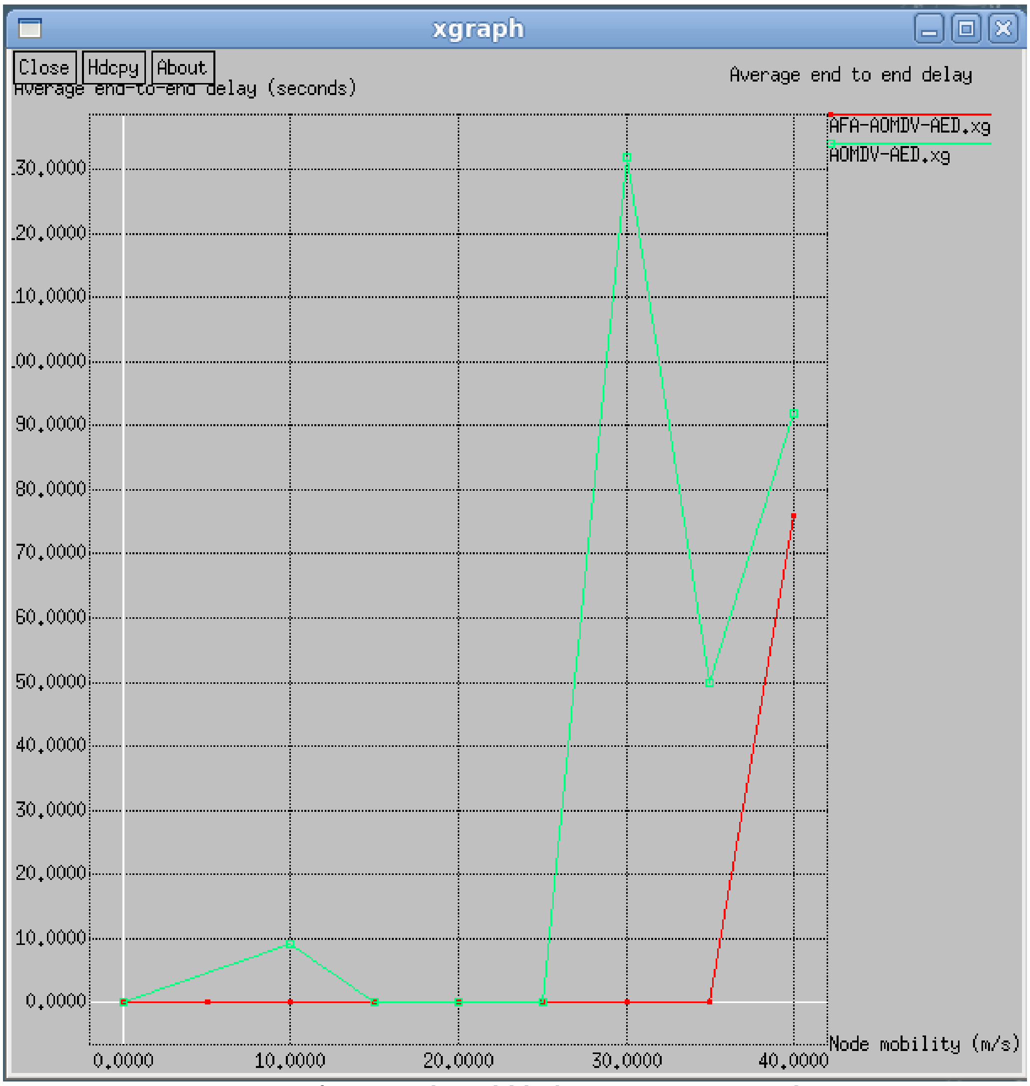

Fig. 2 Comparison of Average end-to-end delay between AFA-AOMDV and AOMDV

C. Routing Overhead

Routing Overhead is the ratio of the number of routing control packets to the delivered data packets. The channel state information used in route maintenance improves the network performance and does not add additional overhead to the network. Therefore AFA-AOMDV has low routing control overhead than AOMDV. Figure 3 shows the comparison of routing overhead between AFA-AOMDV and AOMDV.

Fig. 3 Comparison of Routing Overhead between AFA-AOMDV and AOMDV

D. Network Throughput

Network throughput is an important criterion used to evaluate performance. Figure 4 which shows the comparison of network performance between AFA-AOMDV and AOMDV, the throughput decreases with node mobility as the characteristics of the physical environment change rapidly. AFA-AOMDV has a higher throughput than AOMDV by predicting the fading duration and using adaptive technique for path handoff.

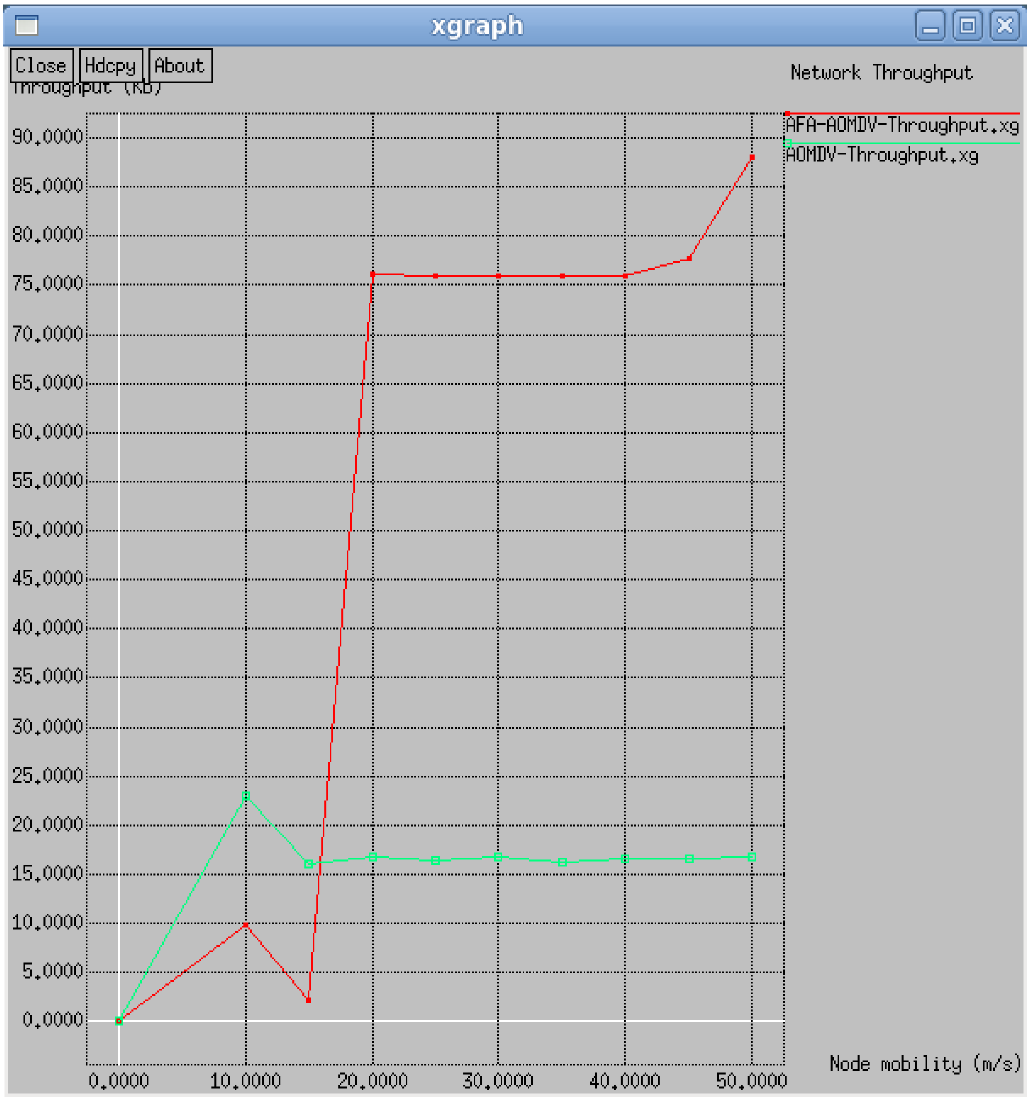

Fig. 4 Comparison of Network throughput between AFA-AOMDV and AOMDV

V. CONCLUSION

The adaptive fading avoidance technique AFA-AOMDV proposed in this paper dynamically adapts to the change in topology by maintaining the alternate paths. The channel state information, fading and signal strength prediction allow successful routing in ad-hoc networks. It never discards a path on failure but reuses the paths, thus avoiding unnecessary route discoveries. Thus the combination of on-demand approach with adaptive mechanism is found to improve the network performance.

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