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Preemptive AOMDV Routing for Mobile Ad-Hoc Networks

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Abstract

An Ad hoc network will often change rapidly in topology, this courses for routes in the network to often disappear and new to arise. The Ad-hoc On-Demand Distance Vector Routing Protocol(AODV), is based on the principle of discover routes as needed. The Ad Hoc On Demand Distance Vector (AODV) routing protocol performs better than the table-driven protocol. Link failure caused by node mobility is a common feature of multi-hop, wireless ad hoc networks. With a reactive routing protocol such as AODV (Ad hoc On-demand Distance Vector), this leads to increased delay and routing overheads while route repair procedures are carried out. In this paper we will extend the definition of AODV with the ability to discover multiple routes to a host and switch between them, if an active route is becoming weak and there is a risk that it will disappear. We will refer to it as "pre-emptive AOMDV". We will show that the performance of pre-emptive AOMDV do handle changes in topology better than AODV it self. To show the effect of extending AODV, the suggested protocol is implemented in a simulator. Performance enhancements will be presented from different scenarios, to compare pre-emptive AOMDV with the ordinary AODV.

1 Introduction

Currently, great demands for self-organizing, fast deployable wireless Mobile Ad Hoc NETworks (MANETs) come along with the advances in wireless portable technologies. Unlike the conventional cellular wireless mobile networks that rely on extensive infrastructure to support mobility, a MANET does not need expensive base stations or wired infrastructure. This feature is important in battlefields or disaster rescue sites where fixed base stations are undesirable or unavailable. For commercial applications such as convention centers, electronic classrooms, and conferences, a rapid deployment of all-on-air networks provides users with more flexible and cheaper ways to share information.

The absence of a fixed infrastructure, however, requires every mobile user to cooperate together for message transmission. Since radio transmission range is limited for each host, a source host must depend on several intermediate hosts to send its message to a host far away. Finding a path from the source to the destination, or routing, is fundamental for providing other advanced services. Routing, however, is very challenging in MANETs due to frequent network topology changes and power and bandwidth constraints.[1][2]

The Routing Protocols in MANET fall into two categories:

1. Reactive
2. Pro-active

Re-active routing protocol does not take initiative for finding routes. It establishes routes "on demand" by flooding a query.

Some pros and cons of reactive routing protocols are:

- It does not use bandwidth except when needed.
- Much network overhead is present in the flooding process when querying for routes.
- There is initial delay in the traffic.

On the other hand pro-active routing protocols set up routes based on continuous control traffic. All routes are maintained all the time.[1][2]

Some pros and cons of these protocols are:

- Constant overhead is created by control traffic.
- Routes are always available.

The idea of this paper is to demonstrate how pre-emptive routing and multi path routing can be added to the AODV protocol and how it will improve performance in a network with a low overhead.

2 AODV

The AODV protocol, is designed for mobile nodes in ad-hoc networking, where there often are changes in topology. The AODV protocol is based on on-demand route discovery. Because of that every node have different and limited local knowledge of the network. The fact that a node seeks information about the network, only when needed, is causing low overhead since nodes does not have to maintaining unnecessary route information.

To handle router information AODV uses 3 different kinds of messages Route request (RREQ), Route Reply (RREP) and Route Error RERR. AODV is using ring expansion when discovering new routes to limit flooding of the network and there by reducing overhead. The protocol is ideal for discovering neighbour nodes. If a node needs a route to a node in the other end of the network1 the protocol will course a reasonable flooding of the network.

Expansion ring search is a better strategy than doing a full scale search for the node. Likely some other node in the network has a valid route to the destination, and will send a RREP to source, and there by reducing overhead. By every RREQ a node sends, a sequence number is increased, this is used by the protocol to guarantee loop-freedom in paths found.

3 Preemptive Routing

The idea behind pre-emptive routing is to look for a new route to a host that the node already could have a active route to, before the basic AODV protocol initiates a route discovery. There could be a lot of reasons to do this, we will use it to minimize end-to- end delay in a transfer between two nodes, before the link that they are using disappears. A link can disappear for multiple reasons, but we will look into the case where mobility of nodes is the reason. To be able to see that a node is moving and a route is about to break, we relay on the fact that communication is based on electronic signals. Because of that it is possible to measure the quality of the signal and based on that guess if the link is about to break. Based on this we will discuss how to handle route breaks, with in the AODV routing protocol. Figure 1 is showing how it could look, in a network when a node (X) is moving away from another node and enters its pre-emptive zone.

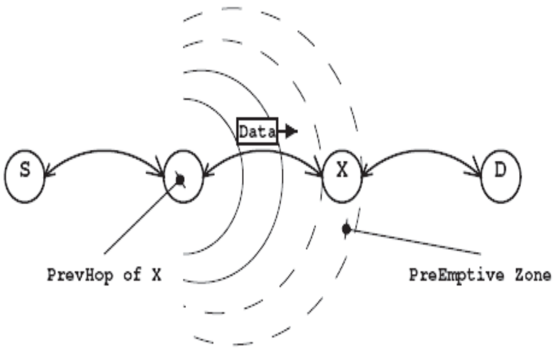

Figure 1: Preemptive Zone

4 Multi Path Route Discovery

The multi path route discovery will not be explained in depth in this rapport, we will just give a overview of the idea and refer to [3] for deeper discussion.

The basic idea behind multi path route discovery is finding multiple node-/link disjoint paths to a destination node. This can be done with a low overhead, because flooding RREQ's through the network is being done already by AODV. Due to AODV already flooding the network, it is easy to see that a change in behavior when a node receives a RREQ can result in multiple routes to the same destination. The destination node must be allowed to send more RREP's, one for each path.

Figure 3 shows two node disjoint paths from a source to a destination. In article [3] its proved how link-/node disjoint paths are discovered, and how it is implemented. We will in the rest of the rapport assume the availability of multi path routing.

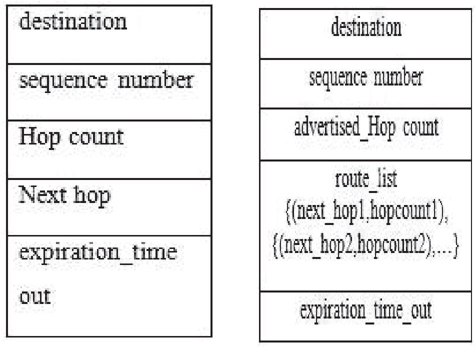

Figure 2: Structure of Routing table entries for AODV & AOMDV

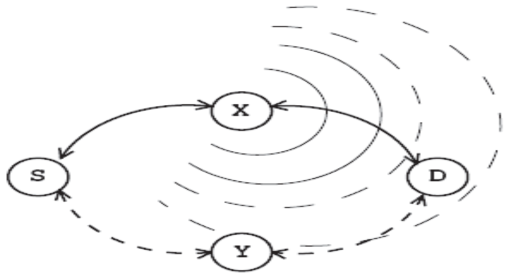

Figure 3: Two Paths

This section will describe how to extend the AOMDV routing protocol [3], to handle pre-emptive routing as presented and describe how the different approaches can cooperate to create a more efficient algorithm. Using multipath route discovery with preemptive routing, will hopefully cause a smaller end-to-end delay and a larger throughput to a host. The RERR message in AODV, needs to be changed to contain information about the error type. This can be done by altering the definition of the reserved field. Some bits in the reserved field could indicate what kind of error, that the sending node wants to report. We are using the last bit to represent the type of error, table 1 shows how the different errors are represented. To differ between the two RERR messages, it is enough to use 1 bit, since we are only interested in whether the error is send to indicate a dead link or a weakened link.

Table 1: Representation of RERR Messages.

Link broke	0
Link possibly going to break	1

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |N|          Reserved           |   DestCount   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Unreachable Destination IP Address (1)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Unreachable Destination Sequence Number (1)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-|
|  Additional Unreachable Destination IP Addresses (if needed)  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Additional Unreachable Destination Sequence Numbers (if needed)|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: AODV RERR Message Format

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |N|          Reserved           |P|  DestCount  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Unreachable Destination IP Address (1)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Unreachable Destination Sequence Number (1)          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-|
|                       Source IP address                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               0                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: AOMDV RERR Message Format

The error messages will be used in the following way:

link broke: When a link is broke the last bit of the reserved is set to 0. This will indicate that the sending node have to find another route to the destination and that the current route does not exist any more.

Link possibly going to break: When the routing node, believes that the link will break within a short period of time. This means that the sending node, should find another way to the destination, as soon as possible.

To avoid flooding when sending a RERR we choose to send it to the original source. The "Additional Unreachable Destination IP Addresses" from the AODV RERR message is altered with the source IP address. Each intermediate node will forward the RERR to source.

5 Algorithm for AOMDV with Preemptive Routing

Algorithm 1

```
Data : IP packet
if ReceivingNode.isInPreemptiveZone then
    send RERR to source of IP packet
end
```

Algorithm 2

```
if Receive(RERR) then
    if Destination == this.NodeIP then
        if existRouteInMultipath then
            Change default route to destination;
        else
            Initiate a new route discovery to destination, while
            continuing using the weak link.
        end
    else
        send via next_hop to destination
    end
end
```

Algorithm 1 is showing when a node must send a RERR message, to notify a sending node of a route being weak, this is based on the assumption that a lower network layer is able to indicate when a IP packet is received from a node in a pre-emptive zone.

Algorithm 2 shows how a node must behave when it receives a RERR. The first case is handling the RERR if the receiving node is the destination of the RERR. This could course two kinds of actions, either the node could choose another route found using multi path or it could initiate a new route discovery. The second case is if the receiving node is not the destination, then it needs to forward the RERR to the destination using its own default_route, to the destination.

By using the algorithms 1 and 2 we ensure that a RERR message is sent when a active node is entering a pre-emptive zone, as described in the previous sections and if a node receives a RERR, it either initiate a new route discovery or uses a route found using multi path, in the previous route discovery.

When using the algorithm in a real network, it is the strength of the signal with which a packet is received that indicates the link condition. It is important to notice that the reception of a packet that determines if a node is in pre-emptive zone. This have the consequence that a node entering pre-emptive zone can look in the packet to see where to send the RERR message. This assures that when a source receives a RERR then the default_route to destination is weak.

Pre-emptive AOMDV always find three paths to destination, and only paths with traffic will enter pre-emptive zones and shortly after move out of range. This creates the best results in our protocol.

6 Simulation Results

The results shows that using pre-emptive AOMDV instead of AODV in our limited scenarios is an improvement.

	AODV		Pre-emptive AOMDV	
	AODV messages	packets received	AODV messages	packets received
10 Packets/sec,512bytes	153	75	81	79
4 Packets/sec, 512bytes	152	30	79	32

The table show that traffic is increased by approximately 6% and AODV-messages are reduced by around 47%.

Here we present a comparative analysis of the performance metrics of both the on-demand routing protocols AODV and AOMDV with TCP New Reno as the traffic source for different node speeds 5,10,15,20 & 25m/s.

Throughput

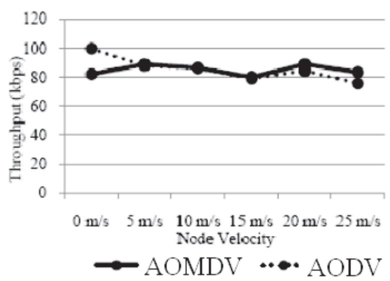

Figure 6: Throughput Vs Node Velocity

From above figure it is clear that at 0m/s, AODV gives better throughput than AOMDV. As the node mobility increases to 18m/s both AODV and AOMDV has almost same throughput but as the speed increases beyond 18m/s AOMDV outperforms AODV (as the throughput of AODV decreases with node velocity).

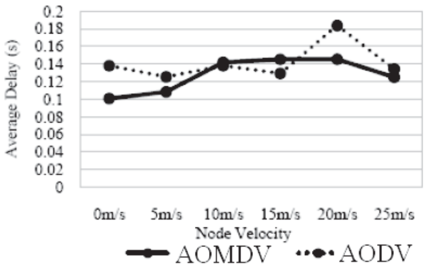

Figure 7: Average delay Vs Node Velocity

From figure7 it is clear that AODV gives more delay than AOMDV routing protocol and it increases with the node velocity. Average delay is less for AOMDV routing protocol and is almost constant for various node velocity. Thus AOMDV gives better delay performance than AODV.

7 Conclusion

By reducing the number of AODV-messages, the overhead on the network is also reduced, which gives more network bandwidth to ordinary traffic. Since we are getting 6% more traffic through from source to destination, we conclude that nodes spend less time to find alternative routes to destination. This means that the end-to-end delay also is reduced.

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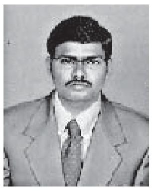
Biographies



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