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# Comparison of routing protocols in mobile ad-hoc wireless networks

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**Abstract**
Routing protocols for Mobile Ad-Hoc Wireless Networks are faced with challenges such as sequential topology variation, low transmission power and asymmetric connections. It has been proved that both proactive and reactive protocols are non-functional with these conditions. Zone Routing Protocol (ZRP) blends the proactive and reactive protocols benefits and the zone topology plan for each node is kept in it timely. In this work, the zone routing protocol is implemented and compared with proactive and reactive protocols which the experiment results are presented.

Keywords: Mobile ad-hoc wireless networks, Proactive protocol, Reactive protocol, Zone routing protocol;

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## 1. Introduction

Mobile Ad-Hoc Wireless Networks (MANETs) are networks which network nodes have wireless connections and also these nodes have a mobile attribute; meaning that their geo-location may change over time and this variability affects the quality of connections between nodes. Routing protocol schemes for these networks are totally different with wireless networks due to the mobile infrastructure and this difference is very effective on managing this mobility (Haas, 2002). There are two typical protocols generally in these networks: Proactive protocols and Reactive protocols

(Beijar, 2002). In proactive protocols which are based on tables, each node maintains the complete and up to date information of paths to all other node in the network. In Reactive protocols which are based on demands, each node runs a path discovery procedure only when attending to connect to another node (Beijar, 2002). Dynamic Source Routing (DSR) and Ad-hoc On-demand Distance Vector (AODV) are proactive protocols and Destination-Sequenced Distance Vector (DSDV) is reactive protocol. In DSR protocol (Johnson & Maltz, 1996), in order to send a packet for another host, transmitter produces a path by including inter-path node addresses in the packet header. When a host receives a packet, if the host is not the destination node, it will simply send the packet to the next node identified in the packet header. In DSDV protocol (Perkins & Bhagwat, 1994), packets are exchanged between nodes using routing tables stored in nodes inside the network. In order to maintain adjustment between routing tables, each node transmits its revised values to all network node periodically and every time a new event occurs for it. As such as the DSR protocol, the AODV protocol (Perkins & Royer, 1999) uses the path discovery method through broadcast. Instead of routing at source, AODV attends to dynamically produce new routing table members in inter-link node. Zone Routing Protocol (ZRP) is in fact a general architecture which it implementation details are not described (Beijar, 2002). The zone routing protocol is implemented and compared with proactive and reactive protocols in this paper.

## 2. Combined Approach

Each one of these proactive and reactive protocols has strengths which makes them useful in some conditions. But these protocols have weaknesses to which produces problems in using them in some conditions. A perfect idea could be using them in a way which maintains both ways strengths. If we combine these two methods under conditions, we can reach a method that has both ways strengths and also recovers their weaknesses (Haas, 2002; Nikaein, Bonnet, & Nikaein, 2001; Ramasubramanian, Haas, & Sirer, 2003). Such a method is called Combined Approach. In the Combined Approach, each node only holds routing information of nodes which are in its zone. This method uses the Proactive protocol in its zone and the Reactive protocol outside of its zone. The size and dynamic of the zone vary over different protocols (Nikaein et al., 2001; Nikaein, Labiod, & Bonnet, 2000; Ramasubramanian et al., 2003; Beijar, 2002). Thus, in combined protocol, the path to the destination which exists inside the zone is made without any delays, but as for destinations outside the zone a path discovery and path maintenance progress is required.

## 3. Zone Routing Protocol

The Zone Routing protocol is based on zones. The routing zone is defined separately for each node and neighbor nodes have shared zones (Beijar, 2002). Each zone has a radius with the length of R which is expressed based on the number of nodes. The nodes of one zone are divided in two peripheral nodes and interior node. Peripheral nodes are those which their shortest distance to the central node is exactly the zone radius R. Nodes which have a shorter minimum distance to the central node than the radius are interior nodes. This protocol uses a proactive routing, called Inter-Zone routing inside the zones and for routing outside the zone, it uses Intra-Zone routing (Haas, 2002). This protocol uses Bordercasting. Bordercasting uses the inter-zone routing information and connects directly to the zones margin nodes.

### *3.1. Zone Creation*

Developing zones is in this order which at first the zone of each node is empty. Each node sends its own zone information to its neighbor. So at the beginning each node becomes aware of its neighbor and sends them to other neighbors. This progress continues until the zone table of each node completes and/or by occurring any change the table's updates. Eventually each node identifies its interior and peripheral nodes (Haas, 2002; Beijar, 2002).

### *3.2. Routing inside a zone*

While sending a packet, if the packets destination is inside the zone, the source node knows the path of reaching the destination and/or next node by easily looking up the inter-zone table. Through the path, each node that receives the packet directs it to the next node using its inter-zone table so the packet reaches its destination.

### *3.3. Routing outside a zone*

For routing outside a zone, performing the path discovery and path maintenance procedure is required (Beijar, 2002).

#### *3.3.1. Path discovery procedure*

This procedure includes two phases: Route Request Phase and Route Reply Phase (Haas, 2002), (Beijar, 2002). In the route request phase, the source node sends a route request packet to peripheral zone node using the inter-zone table. If the packet receiver knows the destination address, send a reply packet to the transmitter. Otherwise continues the packets Bordercasting operations. The reply packet is transmitted by the first node which is able to have a path to the destination. As for the reply packet, in order to come back to its source, the path information should be stored somewhere when sending the request. There are two ways for this matter. First, path information could be gathered in the transmitted packet. Second, each inter-link node stores this information.

#### *3.3.2. Path maintenance procedure*

This protocol is very important in dynamic networks, because in these networks, the nodes move and due to this displacement, connections are established or deleted. At the start of data transition and after path discovery, a timer starts clicking and when the considered time has finished, a new path must be replaced.

## 4. Experiment Results

Routing protocol performances could be assessed in terms of parameters such as Packet Delivery Ratio, Routing Load, End-to-End Delay and Delay Jitter. In this part, the zone routing protocol will be compared in terms of the above parameters with DSR, AODV and DSDV protocols. In order to perform the experiment, we have produced 25 scenarios with different stop time values and random connection numbers. The average stop time, is the stop time after each node movement which the node moves for a while and then produces a random number by using a specific distribution and will stay still for that time and will start moving again. The number of connection parameter, indicates the amount of connections between applications and the bigger the parameter, the higher the network traffic. In order to compare the methods, we have considered the average of the calculated values for all of the connections.

### *4.1. Packet Receive Rate*

If the Packet Receive Rate increases, it means that fewer packets are discarded in the network and this issue is important in two manners. First that if the packet discarding rate is high, too much time has to be spend for retransmitting the packets and this delay may result in losing the application deadline. Second that with increasing the Packet Receive Rate, the network sources are used in a more optimized manner. This parameter is calculated by Formula 1:

$$Packet\ Receive\ Rate = \frac{No.of\ Received\ Packets}{No.of\ Sent\ Packets} \qquad (1)$$

Various methods in terms of Packet Receive Rate are compared in Figure 1. As you can see in the figure, the reactive algorithms have less interference in transmitting data packets due to the low volume of the routing packets and perform better than proactive algorithms. The ZRP protocol has improved this weakness in proactive protocols and has indicated a better performance than DSDV because of having a reactive property.

### *4.2. Routing Load*

Routing packets are used for managing routing and maintaining the path. So the less the packets, the more network sources are used efficiently and the less power usage at the nodes. Also, the routing load will affect the Packet Receive Rate and optimizing them indirectly will result in increasing packet rate benefits. This parameter is calculated using the Formula 2:

$$Routing\ Load = \frac{No.of\ Routing\ Packets}{No.of\ Received\ Packets} \qquad (2)$$

In Figure 2, various methods are compared in terms of routing load. As you can see in the figure, reactive algorithms use routing packets if necessary due to their based on request feature and thus have less routing load than the proactive protocol. This weakness has in proactive protocols has been improved in ZRP protocol due to its reaction property and has less routing load than DSDV.

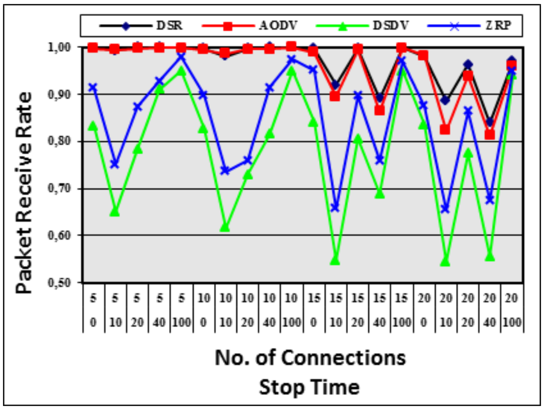

Figure 1. Packet Receive Rate Comparison

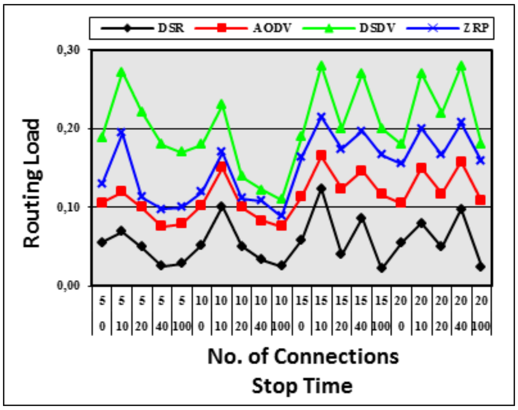

Figure 2. Routing Load Comparison

### *4.3. End-to-End delay*

This parameter is very important to real-time applications which use the routing layer service. In Figure 3, different methods are compared by looking at their end-to-end delays. As you can see in the figure, reactive protocols spend more time over finding a path rather than proactive protocols due to not updating paths. Due to having a proactive feature, the ZRP protocol has covered this weakness in reactive protocols and reduced this amount of delay.

### *4.4. Delay Jitter*

This parameter specifies the difference between the maximum and minimum of end-to-end delay and is very important in terms of time. This parameter is calculated using Formula 3:

$$Delay\ Jitter = Max\ Delay - Min\ Delay \qquad (3)$$

Different methods are compared in terms of delay modulation in Figure 4. As you can see, has to perform new operations for different data packets due to its out of date paths, which this increases the end-to-end delay. In ZRP protocol, because of having a proactive property, this weakness has been improved and the modulation amount has decreased.

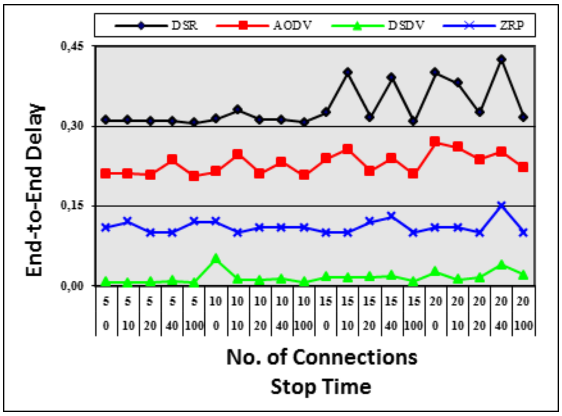

Figure 3. End-to-End Delay Comparison

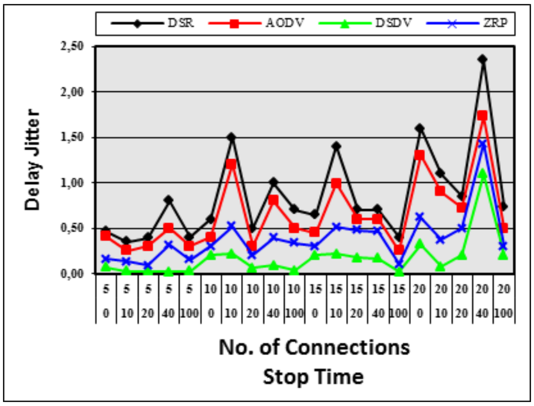

Figure 4. Delay Jitter Comparison

## 5. Conclusion

The Zone Routing Protocol blends two different protocols. This protocol updates the routing table inside the proactive component zone. As for paths outside the zone, uses the reactive component. Also, the performance can be maximized by determining the proper size of the zone radius. The zone routing protocol has reduced the traffic load and increased the Packet Receive Rate in comparison with proactive protocols. Also in comparison with reactive protocols, it has reduced the end-to-end delay and delay modulation. In general, we can conclude from the assessments made in this paper that the zone routing protocol (ZRP) has more performance than proactive and reactive protocols

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