# Power Management In Zone Routing Protocol (ZRP)

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**Abstract:** An ad hoc network is a dynamically re-configurable wireless network with no fixed infrastructure or central administrator [1]. However, such a mobile wireless network environment is difficult to be managed. Furthermore, as it aims to be applied mainly for mobile devices, for example, laptops, PDAs and perhaps mobile phones, the power consumption problem will be the main issue that needs to be addressed. Because nowadays, most of the mobile devices are equipped with low power batteries, it could be impossible for a mobile device to sustain for a long time if it send and receive data more often like in the wired network. This paper describes a way to solve the power management issues in mobile nodes by modifying and using Zone Routing Protocol (ZRP), which is one of the routing protocols considered by IETF for standardization.

## 1 Introduction

DARPA funded a Packet Radio Network Program during the 70's, which used broadcast radios for relaying data over multi hop mobile network [3]. Its purpose was to provide, for sharing bandwidth and for operation under dynamic conditions. At that time the radios were heavy and required much energy and had low processing capability. But after two generations of ad hoc network that is Survivable Radio Network and Global Mobile Communication (Glomo), rapid development in technologies and Internet infrastructure has taken place. Since then further research is going on in advancement of Ad Hoc networks [3].

In ad hoc networks, routing protocols are basically divided into re-active and pro-active routing protocol [1]. The re-active routing protocol becomes active only when a node is willing to forward a request and the pro-active routing protocol learn the network topology before a request comes in for forwarding. Some of the re-active routing protocols are DSR, AODV, TORA and ABR and some of the pro-active routing protocols are DSDV, WRP, GSR and Fisheye [5].

There are many open issues in ad hoc networks like providing scalability, energy efficient routing, QOS for the mobile nodes, Security and some MAC layer issues like Hidden Node and Exposed Node problem [4]. In that the energy efficient routing in ad hoc networks have been considered because routing packets through mobile nodes without losing much of the nodes power is one of the major open issues that needs to be tackled [5].

In this paper, ZRP has been modified to provide better power management and it has been analysed by using Glomosim simulator. ZRP was primarily designed to support a very large network in the range of 1000 nodes, but that was not the case in AODV or DSR [2], which would support only in the range of 100 nodes. But the main issue in ZRP was the lack of power management and due to that only reason, ZRP protocol was considered for modification.

## 2. Zone Routing Protocol (ZRP)

ZRP is a hybrid routing protocol suitable for a wide variety of mobile ad-hoc networks, especially with large network span and diverse mobility patterns [1]. Each node proactively maintains routes within a local region, which are the zones created by ZRP with hops as the base. Knowledge of the zone topology is leveraged by the ZRP to improve the efficiency of reactive route query/reply mechanisms [2]. The proactive maintenance of routing zones also helps improve the quality of discovered routes, by making them more robust to changes in network topology. Zones in ZRP are configured by proper selection of only one parameter, the zone radius, which will be in hops [1] [2].

The ZRP framework is designed to provide a balance between the contrasting proactive and reactive routing approaches. The proactive routing approach is implemented in ZRP as *IntrAzone Routing Protocol* (IARP) and the reactive routing approach is implemented in ZRP as *IntErzone Routing Protocol* (IERP) [2]. Since ZRP consists of several components, which only together provide the full routing benefit to ZRP. Each component works independently of the other and they may use different technologies in order to maximize efficiency in their particular area. For example, a reactive protocol such as AODV might be used as the IARP, while the IERP is most commonly a pro-active protocol such as OLSR.

Since ZRP assumes that local neighbour discovery is implemented on the link-layer and is provided by the *Neighbour Discovery Protocol*, the first protocol to be part of ZRP is the *Intrazone Routing Protocol*, or IARP [1]. This protocol is used by a node to communicate with the interior nodes of its zone and as such is limited by the zones radius. As the global reactive routing component of the ZRP, the *Interzone Routing Protocol*, or IERP, takes advantage of the known local topology of a node's zone and, using a reactive approach enables communication with nodes in other zones

Even though the hybrid nature of the ZRP seems to indicate that it is a hierarchical protocol, it is important to point out that the ZRP is in fact a *flat* protocol. In hierarchical network architecture, two different protocols are maintained for communication among (a) each individual cluster's nodes and (b) the different clusters [2]. The main difference here is that in the ZRP there is a one-to-one correspondence between nodes and routing zones, causing overlapping zones maintained by each individual node.

## 3. ZRP Limitations

Even though ZRP is designed by using the proactive and reactive routing approaches there are some major issues that need to be considered and they are outlined below

- **Power Management** – The packets are forwarded with full power without considering the node's position inside the zone. Since according to Inverse Square Law, the power received by the receiving node is inversely proportional to square of the distance between the nodes (i.e)

$$\gamma = Pt / 4\pi(r*r) \qquad (1)$$

The node could waste power if the distance between the sender and the receiver node is less.

- **Bandwidth Utilization** – If the distance between the sender and border nodes increases then the zone area will also increase, which means the radio coverage of the sender node will not be able to reach the border nodes in the zone. Due to that reason, the sender node will increase the number of broadcasts to find the border nodes in the zone, which will obviously increase the bandwidth utilization.

## 4. ZRP Modification

### 4.1 Routing Zones in ZRP

A node's routing zone is defined as a collection of nodes whose minimum distance in hops from the node in question is no greater than a parameter referred to as the zone radius. Note that each node maintains it own routing zone. An important consequence is that the routing zones of neighbouring nodes overlap [2]. An example of a routing zone for node A of radius 2 is shown below

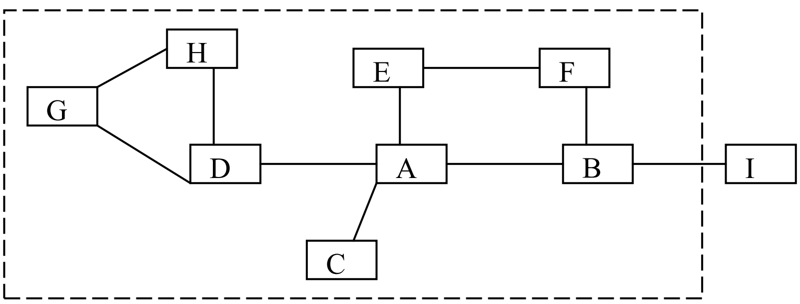


Figure 1 Routing Zone for node A, Radius = 2 Hops [1]

Note that in the example nodes B through H are within the routing zone of A. Node I is outside node A's routing zone. Also note that node G can be reached by two paths from A, one with length 2 and other with length 3. Since the minimum is less or equal to 2, G is within A's routing zone. Border nodes are nodes whose minimum distance to the node in question is equal exactly to the zone radius. Thus, in the above figure, nodes D, F, and G are A's border nodes. The intermediate nodes are nodes whose minimum distance to the node in question is less than the zone radius. Thus, in the above figure node B, C, D and E are A's intermediate nodes [1].

## 4.2 Power Factor in ZRP

From the above explanation, it can be understood that ZRP protocol creates zones with respect to hop count to cover a network of large span. But the main problem is, whenever the node forwards a packet to the intermediate or border node in the zone it uses the maximum power to reach the destination, for example, Cisco Aironet 350 Series maximum power level is 100mW [5]. By following this approach the node will lose its full power in a very short period of time. To avoid this problem, the ZRP protocol is modified to create zones with respect to two power levels, for example 30mW and 50mW. The reason for creating a zone with two power level is that, if a node is elected as a border node or as a intermediate node and if the node is moving at a particular speed of 2 m/sec. Then the corresponding nodes should be in that respective state (intermediate or border node) for a particular period of time to avoid the rapid fluctuation from border node to intermediate node or vice-versa. So by doing this, the node can avoid generating unnecessary routing updates or change its state more frequently.

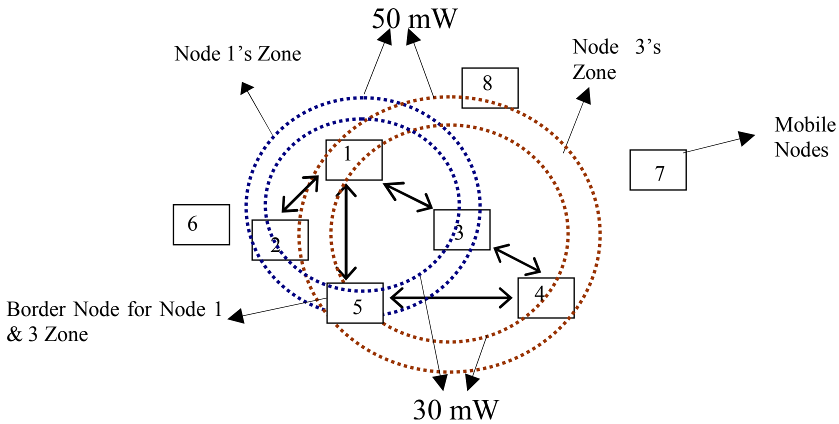


Figure 2 Routing Zones of Node 1 & 3, Threshold powers are 30 & 50mW

From the above diagram it can be seen that every node creates their own routing zones and initially when the node switches ON, it creates the zone with 30mW and 50mW, since that is the threshold power level set initially by the protocol. But if a node is unable to find a border node since the node's threshold power level is high (30 & 50mW), then the corresponding node will start reducing its threshold power level until its able to find the border node. The reason for creating a dynamically changing zone is that, if a node has no border nodes elected but full of intermediate nodes elected then the intermediate nodes inside the zone wont be able to talk with its neighboring zone nodes. Because according to this protocol one zone can communicate to another zone through the border nodes only [1]. If we consider the above diagram, if node 1 wants to talk with node 4 then node 1 should pass through one of its border nodes to reach the neighboring zone, they are nodes 2, 5 or 3.

To calculate the power consumption, consider node 1 wants to forward a packet to destination node 8. The source node sends a broadcast with 50mW to all its border nodes (i.e) nodes 2, 5 and 3. Then the corresponding nodes check their own routing table and in that node 3 can reach node 8 since it is the border node of node 3's zone. After seeing that, node 3 sends a unicast packet to destination node 8 with 50mW. Therefore, the source node found the destination node by shedding only 50mW in the modified ZRP protocol. But in the actual ZRP protocol the node would have spend 100mW to reach the destination since all the nodes form zone with respect to hop count and it always forwards the packet with full power level (100 mW) [1]. So as the number of broadcasts increase, the power usage will also increase according to the formula

$$P=C*N, \text{ Where } C=\text{Transmit power and } N=\text{Number of Broadcasts.} \qquad (2)$$

## 5. Simulation Results Analysis

The ZRP was modified to test only the power management of the node and it was simulated in Glomosim simulator under windows 98 operating system, Toshiba Laptop with battery capacity of 3600mAh and D-link Wireless adapter supporting 802.11 b standard. The simulation parameters are shown in the table below.

| | |
|---|---|
| **Channel Bandwidth** | 2 Mbps |
| **Power Levels Used** | 20, 30, 50and 100 mW |
| **Transmission Range** | Obstruction: 300 to 600 ft<br>Without Obstruction: around 32 ft |
| **Packet Size and Rate** | 150 Bytes, 5 packets/sec |

Table 1 Simulation parameters

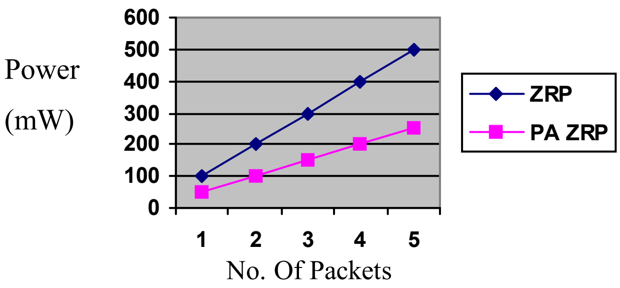


Figure 3 IERP Power Consumption

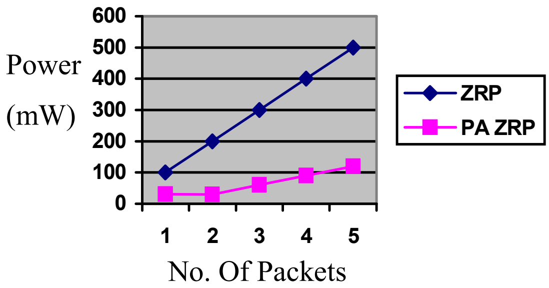


Figure 4 IARP Power Consumption

The protocol was tested to see the performance with respect to power consumption. From the above simulation results we can see that ZRP protocol wastes more power compared to the Power Aware (PA) ZRP protocol, which is the modified version of ZRP. Since ZRP protocol forwards packet with 100mW constantly, the node wastes more power as the number of packets increases. But in the case of PA ZRP, the power consumption was less; because packets were send with 30 or 50 mW power level. Since the simulation is in initial stages, the protocol was tested only for power consumption and with less number of packets.

## 6. Conclusion.

In this paper a new method was proposed to reduce the power consumption using ZRP protocol and since the design and simulation is in initial stages, the protocol was tested with less number of packets and only for packet level power consumption. The future scope of this protocol is to successfully simulate it for a very large network and implement it with a voice application to study the performance and efficiency of the PA ZRP protocol.

## References.

[1] http://www.cs.hut.fi/~mart/mail/manet/1999/0106.html (Referred 14th June 2003)

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[4] Aggelou G, Tafazolli R. RDMAR: A bandwidth efficient routing protocol for mobile ad hoc networks, ACM International Workshop on Wireless Mobile Multimedia; August 1999.

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