A Survey on Zone Routing Protocol

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ABSTRACT
In this paper, the Zone Routing Protocol (ZRP) is surveyed for the nature of its parametric performance. ZRP is hybrid routing protocol works on various routing phenomenon such as Intra-Zone Routing Protocol (IARP) which routes within its routing zone, Inter-Zone Routing Protocol (IERP) which routes outside the routing zone, Bordercast Resolution Protocol (BRP), Query Control Mechanisms includes Query Detection (QD1/QD2), Early Termination (ET), Random Query Processing Delay (RQPD). Multicast Zone Routing Protocol, Two-Zone Routing Protocol along with security of Zone Routing protocol in considered. The analyzed performance of the variety of parameters such as PDR (Packet Delivery Ratio), Average Jitter, Average Throughput, Average End-to-End Delay, Route Acquisition Latency, Control Traffic, Overhead of Zone Routing Protocol in different simulating environment under the normal and with blackhole attack circumstances is compared.

Keywords
Hybrid Routing, Proactive Routing, Reactive Routing, Routing zone, Black hole Attack, Performance parameters.

1. INTRODUCTION
ZRP is among most popular hybrid routing protocols. Zone Routing Protocol is a prominent protocol combining both proactive and reactive nature of routing. It is the ad hoc protocol in which proactive procedure is being followed within a scope of local neighborhood or routing zone only. ZRP composed of Intra-Zone Routing Protocol (IARP), Inter-Zone Routing Protocol (IERP), Bordercast Resolution Protocol (BRP) along with various Query Control mechanisms. IARP has limited scope which is defined by zone radius. Within this routing zone radius, IARP very well maintains the topology information of its local zone. IERP acts as a global routing component for ZRP. Whenever a node needs to send information outside the routing zone or the route needed by a node is not available in local neighborhood, IERP is used to send the data. As the traditional nature of reactive routing protocols, route discovery and route maintenance is also performed by IERP. For the reduction of routing overhead Bordercast Resolution Protocol is used. By using the information provided by IARP, it directs the route requests outward. The outward request sent is multicast in nature sent to certain set of peripheral nodes (surrounded). If in case there is no reply after BRP, these set of nodes again perform bordercasting to their peripheral nodes.Two main approaches may be followed for bordercasting, root directed bordercast and distributed bordercast. The query control mechanism in ZRP includes: Query Detection (QD1/QD2), Early Termination (ET), and Random Query Processing Delay (RQPD). In bordercast tree all nodes can detect the QD1 and can avoid the redundancy of queries in node's routing zone. Overhearing in transmission range by any node is possible, extending the QD2. During relaying of query, it can prune covered nodes or already relayed nodes resulting ET. With RQPD a relaying node can have another chance to prune downstream nodes.

2. ZRP ARCHITECTURE
ZRP acts as a framework for other protocols. The local and global neighborhood in ZRP are separated in such a way so as to gain advantages of each routing technique. Local neighborhood, named as 'Zone', have number of nodes which may be overlapped within different zones (may have different sizes). Size of the zone in ZRP is defined as the count of number of hops it takes to reach to its peripheral nodes called 'Zone Radius' [1]. This hybrid behavior suggest and decide to follow the technique among both. This initiates route-determination procedure on demand but at limit search cost [2]. The proactive nature of this protocol minimizes the waste count associated to this technique. The Zone Routing Protocol consists of several components, which only together provide the full routing benefit to ZRP [3].

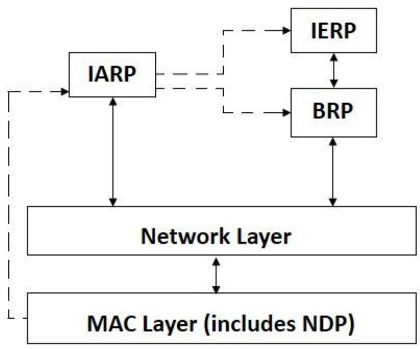

Fig 1: ZRP Architecture

Each component works independently of the other and they may use different technologies in order to maximize efficiency in their particular area. Components of ZRP are IARP, IERP and BRP. The relationship between components is illustrated in Figure 1. IARP is responsible for proactive maintenance while IERP for the reactive one. Bordercasting leverages IARP's up-to-date view of local topology to efficiently guide route queries away from the query source [4].

2.1 Intra-Zone Routing Protocol (IARP)
This protocol communicates with interior nodes of the zone. Zone radius limits the zone size. In IARP, the change in topology results in change in local neighborhood. IARP signifies the use of indoor routing zone. It always desires to

update the routing information [5]. IARP helps in removal of node redundancy along with tacking to link-failures. Figure 2. Shows the routing zone concept with radius 2 hops. Here S is considered as a source node having zone radius of 2 hops. So in this case, the node A, B are considered as interior nodes having hop count less than zone radius. The nodes C, D and G are considered to be peripheral nodes having hop count less than or equal to the zone radius. While Nodes E, F have the hop count greater than the zone radius, i.e. Outwards the specified zone.

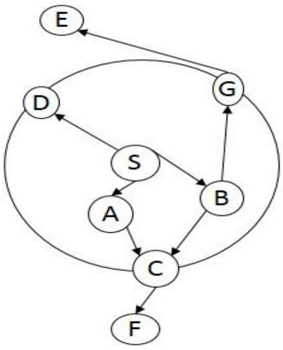

Fig 2: A routing zone of radius 2 Hops

However, it should be kept in mind that zone is not a description of physical distance [4]. Media Access Control (MAC) protocol and Neighbor Discovery Protocol (NDP) can be use to provide identification of neighbors. Operation of IARP is done by broadcasting "hello" beacons. The reception of these beacons indicates the connection establishment.

2.1.1 When to send

Source node send new routing information if:

- there is change in topology or there is a link failure,
- there is change in routing zone of node,
- if the node has not send the packet in its previous time slot.

2.2 Inter-Zone Routing Protocol (IERP)

It is the global reactive routing component of ZRP. IERP is responsible for acquiring route to destination that are located beyond the routing zone. With the help of knowledge gained about local topology, IERP perform the on-demand routing mechanism [6]. In presence of route, it issues route queries. Bordercasting helps to minimize the delay caused by route discovery. Redundancy of nodes (already covered) is avoided. An example is illustrated in Figure 3.

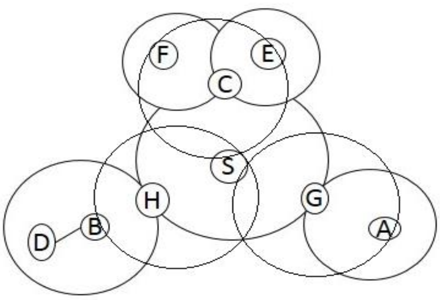

Fig 3: IERP operation

S prepares to send data to destination D. S checks if D exists in its local neighborhood. If so, route is already known by S. Otherwise, a query is sent to its peripheral nodes by S i.e. (C, G, H). These peripheral nodes further checks for D in their routing zone. Like in here, when H send query to B, B recognized D as the node in its routing zone and respond back to query. The path then established is S-H-B-D [4].

2.3 Bordercast Resolution Protocol (BRP)

Whenever route is requested with the global reactive technique, BRP is used to nonstop it and maximizes its effectiveness. IARP routing information is used by BRP. This information is constructed by IARP from its map provided by local proactive technique. It maintains the redundancy removal phenomenon by pruning the nodes it has already covered (received the query) i.e. When a node receives a query packet for a node that does not lie within its local routing zone, a bordercast tree is constructed so that it packet can be forwarded its neighbors. Upon reception of the packet, bordercast tree is reconstructed by these nodes so they can determine whether or not it belongs to the tree of the sending node. If it does not belongs to the bordercast tree of the sending node, it continues to process the request and determines if the destination lies within it's routing zone and takes the appropriate action, so that the nodes within the zone are marked covered [1]. The two approaches of BRP are

2.3.1 Root Directed Bodercast

In this source nodes and peripheral nodes construct their multicast trees to which the forwarding instructions to routing query packet are appended, resulting additional route overhead which increase with increase in zone radius.

2.3.2 Distributed Bordercast

In this, an extended routing zone is established and maintained by each node which increases the local routing information exchanges, resulting in reduction of route discovery requirement.

2.4 Query Control Mechanism

As per ZRP strategy, querying performing is more efficient than directly flooding the route requests but due to heavy overlapping, multiple forwarded route requests can result into more control traffic than flooding. This happens because whenever a query is bordercasted, it efficiently covers the node's complete routing zone and excess route query traffic is the result of redundant query messages. Thus a collection of query control mechanism is introduced by ZRP.

2.4.1 QD1/QD2

With the help of BRP, the relaying nodes in the tree becomes able to detect the query which is redundant (QD1). BRP use bordercast tree hop by hop for this process. It is possible for queries to be detected within the transmission range of relaying node, extending query detection capability (QD2).

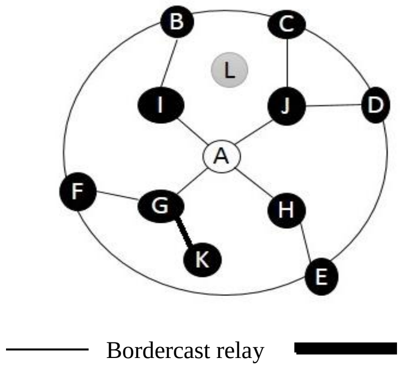

Fig 4: Query Detection (QD1/QD2)

In example, as when node A bordercast to its peripheral nodes (B-F), The intermediate nodes (relaying) (G, H, I, J) are able to detect query by QD1. Using QD2, node K able to detect node G's transmission even if node K does not belong to node A's bordercast tree. Even with the high level query detection, QD2 does not guarantee of the whole routing zone being informed. Like in here, node L does not overhear and is thus unaware that L's routing is covered by query or not. The relationship between components is illustrated in Figure 1. IARP is responsible for proactive maintenance while IERP for the reactive one. Bordercasting leverages IARP's up-to-date view of local topology to efficiently guide route queries away from the query source [4].

2.4.2 Early Termination (ET)

In general, it may not be possible to understand that whether query has perfectly outward to the uncovered zones but the information obtained from QD1 and QD2 can very well support Early Termination.

2.4.3 Random Query Processing Delay (RQPD)

During bordercast, node's routing zone is covered instantly but even the query take some infinite amount of time to make a way along the bordercast tree, it can be detected by QD mechanism. Within this time, it is possible that any neighboring node may re-bordercast the message simultaneously. This problem can be addressed by bordercasting RQPD. During scheduling of random delay by waiting node, it can benefit to detect the previous bordercast tree for already covered areas. This is how RQPD can significally improve performance up to a point [4].

In Multicast Zone Routing Protocol, a multica--st tree membership information is maintained proactively. Multicast ZRP makes on-demand route requests by Multicast Inter zone routing protocol with an efficient query mechanism [7].

For MANETs, there exist an extension of ZRP named as Two-Zone Routing Protocol (TZRP). In this two zones may having different topologies and route updation mechanisms are used to attain the decoupling of protocol's ability to adapt to traffic characteristics which are gained from the ability to adapt the mobility. TZRP provides a framework to balance tradeoff between pure proactive and reactive routing techniques more effectively than ZRP [7].

The security of any protocol is a big issue. Security of ZRP aims to tackle the problem of excess bandwidth and long route requests delay etc. There may be certain mechanisms for security such as identity based key management. In this, identifier with the strong cryptographic binding is chosen. Another can be mechanism which may provide a secure neighbor discovery. To secure the routing packets can be a way out. A mechanism for certain alarm messages in presence of any malicious node (s) can also be adapted [8].

3. ANALYSIS OF ZRP

ZRP has been analyzed on number of platforms with different kind of methods. As per simulation in [9], the proactive protocol shows the slightly constant number of flooded packets with increase in the transmission radius while ZRP as compare to this protocol, shows a drastic increase in the number of flooded packets. As concluded in [2], the amount of intrazone control traffic required to maintain the zone radius increases along with the size of routing zone. ZRP configuration can provide good reduction (25%) in control traffic compared to traditional flood search. The reactive nature of ZRP is observed more suitable for networks which exhibits smaller network spans, larger transmission radii. For highly volatile networks, it is conclude that ZRP provide 20% less delay then reactive routing only. In real-time scenarios, ZRP (mobile nodes) may attain good performance as done on real-time network and traffic configuration as per experimentation performed in [10][11].

The simulations performed in [12], shows that the proactive part is able to communicate a large amount of routing information at very low overhead as shown in Figure 5.and high value of MAXHOPS results in small route acquisition latencies, but there exist higher routing overhead and higher information storing cost. If the networks that are largely idle, the proactive part may cause unnecessary overhead.

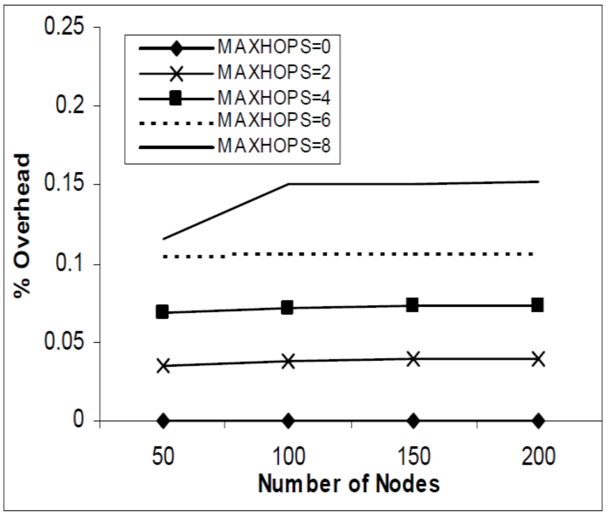

Fig 5: Proactive routing overhead when time is 200sec

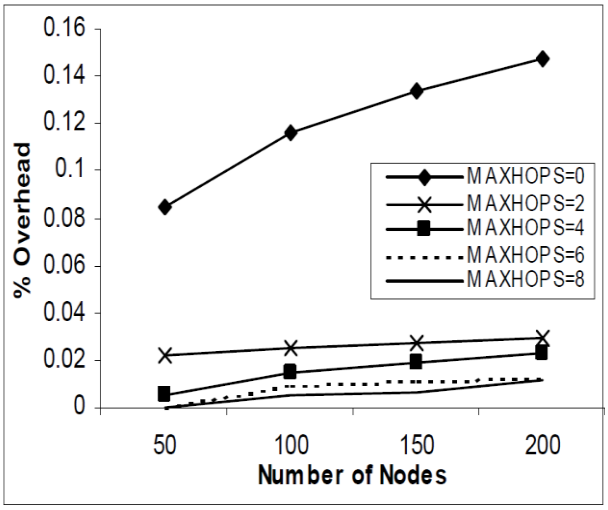

Fig 6: Reactive routing overhead when time is 200sec

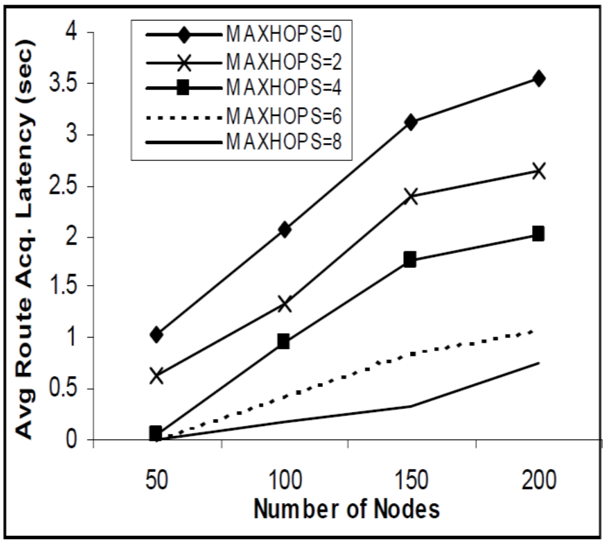

Fig 7: Route Acquisition latency when time is 200sec

Fig 5 and Fig 6 shows the proactive and reactive routing overhead in the network size of 150 with 200sec of simulation time span. The MAXHOPS of 8 showed highest value in proactive and lowest value in reactive nature one.

In Fig 7, the MAXHOPS of 8 showed lowest value for Route Acquisition Latency as the needed routes were already present for the connection establishment.

In simulations performed in [4], with query control mechanism, it is observed that traffic (number of packets) increases with increase in zone radius during proactive technique while in reactive technique, there is a fall in number of traffic (number of packets) with increase in zone radius.

It is observed that, ZRP's response time is comparable to that of flood searching, but with less routing control traffic. The improvements in route response time are even greater when we consider that a node can immediately provide routes for all of its routing zone nodes.

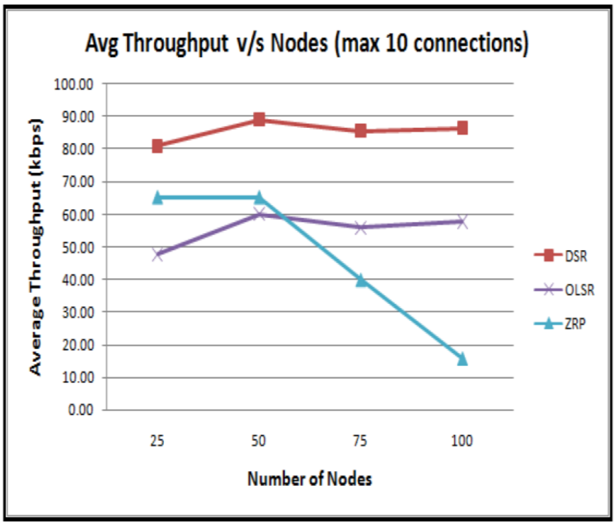

Fig 8: Average Throughput with 10 Connections

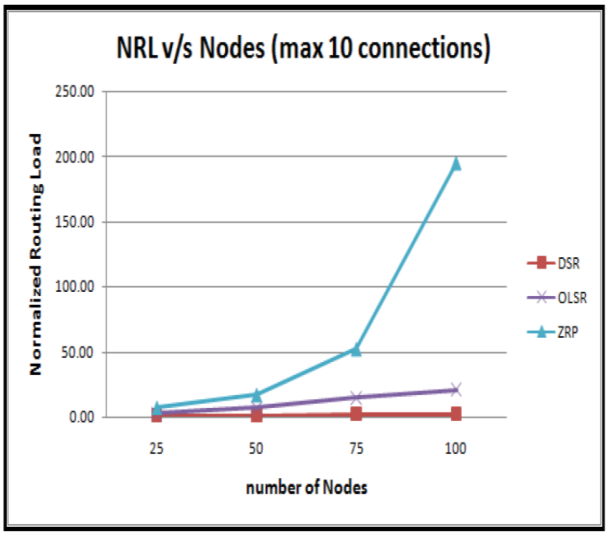

Fig 9: Normalized Routing Load with 10 Connections

As observed in simulations performed in [13], average throughput of ZRP, initially showed moderate performance with respect to DSR (reactive) and OLSR (proactive). As the network size increases, the great fall in the performance of ZRP is observed. While the Normalized Routing Load of ZRP is overall high in comparison to DSR and OLSR, resulting lack of performance.

While increase in traffic also increase the optimal zone radius value. In case of jitter evaluation of ZRP [14], it shows bad performance as the number of nodes and packets increases. As observed in [5] simulation, ZRP is not considered so good in the presence of black hole attack. In Black Hole attack any fake or malicious node sends information of having a shortest route to the destination resulting data discard or data misuse. I can be a attack by any single node or by group of nodes. Further Performance of ZRP protocol can be enhanced as per done in [15], where various parameters are taken into consideration and observed that radius value low (2 here) is considered to be optimal for small and medium loads while medium value (3 here) is optimal for important and high density loads.

4. COMPARISON OF PARAMETERS

In this survey, we have compared the following parameters of ZRP with the zone radius as shown in Table 1.

Table 1. Comparison of parameters with the zone radius

Zone Radius / Parameters	Low	High
Control Traffic (Proactive)	Low	High
Control Traffic (Reactive)	High	Low
Overhead	Low	High
Mobility	Increase	Decrease

Route Acquisition Delay		Low
Packet Delivery Ratio	Moderate	Moderate
Packet Delivery Ratio (with blackhole attack)	Moderate	Deteriorates
Av. Jitter	Low	High
Av. Jitter (with blackhole attack)	High	High
Av. End-to-End Delay	Moderate	High
Av. End-to-End Delay (with blackhole attack)	High	High
Av. Throughput	Moderate	Moderate
Av. Throughput (with blackhole attack)	Low	Low

5. CONCLUSION

In this survey of Zone Routing Protocol, it is concluded that in comparison with only proactive protocols and only reactive protocols, this hybrid routing protocol is more efficient but if restricted to small area networks only. For the larger network routing, ZRP is unable to show such a good performance with various parameters such as control traffic, Packet delivery ratio, End to End delay, Jitter, Throughput, Overhead etc. as it shows in small routing networks. These parameters are examined and compared on the basis of concluded simulation results. The efficiency of these parameters also depends on the proactive or reactive nature of the routing. The whole nature of ZRP depends on its zone radius. With increase and decrease in routing zone radius, the performance of ZRP increases or falls considerably. The lower value of zone radius has proved better for ZRP processing than the greater one.

For future perspective, the analysis of ZRP can be performed with various platforms. Further, the performance of ZRP can be observed for large network sizes such as, with respect to mobile criteria. Performance of ZRP can be enhanced with new improvements in its routing mechanisms.

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