A Study on Advancements on the Zone Routing Protocol of Hybrid Ad Hoc Networks

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Abstract— The Ad hoc networks are decentralized type of wireless network. The ad hoc networks incorporate several protocols that are used to mainly serve the process of communication from one node to another. The routing protocols are categorized as Reactive and Proactive Routing Protocols. To overcome the disadvantages of these both, the Hybrid Routing Protocol has been proposed. Zone Routing Protocol is one such Hybrid Ad Hoc Network. This paper mainly focuses on the enhancements made on the Zone Routing Protocol and evaluated against few parameters. Each enhancement is carefully studied and analyzed for their characteristics and compared to the Zone Routing Protocol.

Keywords— *MANETS, DSR, AODV, OLSR, DSDV, ZRP, ZHLS, CEDAR, IERP, IARP, Bordercasting.*

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I. INTRODUCTION

A Mobile Ad hoc Network (MANET) is a network that instantaneously and dynamically be created with the collection of wireless mobile nodes that works without the support of any fixed network infrastructure [1]. In ad hoc networks, each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. A routing protocol specifies how the communicating devices correspond with each other. The routing protocol enables the communicating devices to decide on a route between them to exchange information.

The routing protocols in mobile ad hoc networks have been divided into two broad categories- Reactive and Proactive. In Reactive or on-demand routing protocols, the routes are created only when they are looked-for. Dynamic Source Routing Protocol (DSR) and the Ad-hoc On-demand Distance Vector Routing Protocol (AODV) are to be named as few Reactive Routing Protocols. The Proactive or Table-driven routing protocols are the ones whose nodes keep updating their routing tables by periodical communication. This can be seen in Optimized Link State Routing Protocol and Destination Sequenced Distance Vector Protocol (DSDV). A combination of the methods of both reactive and proactive routing protocols can be categorized as Hybrid Ad Hoc Routing Protocol. Zone Routing Protocol (ZRP) [2], Zone-based Hierarchical Link State Routing (ZHLS) and Core Extraction Distributed Ad Hoc Routing Protocol (CEDAR) are few Hybrid Routing Protocols.

In this paper, the various developments made on the ZRP are studied and result analysis of each of the enhancements is stated.

1.1 Zone Routing Protocol

The comparison of proactive and reactive routing protocol shows that there is a need for a protocol that combines the advantages of Proactive and Reactive Routing Protocol. The Zone Routing Protocol is one such routing protocol of Hybrid Ad Hoc Networks [3]. The ZRP localizes the nodes into sub-networks (zones). Within each zone, proactive routing is adapted to speed up communication among neighbors. In other words, node routing zone is defined as a collection of nodes whose minimum distance hop from the node is no greater than a parameter referred to as the zone radius. Each node maintains its own zone, within which the routing takes place, but the routing zones of neighborhood nodes overlap. If a node wants to communicate with in its zone it can communicate proactively and the Intrazone Routing Protocol is made use of and Interzone Routing Protocol for routing afar from the routing zone.

ZRP uses the concept of border casting. If a node cannot find its destination with in a zone it forwards the packets to its border nodes of its routing zone and then that border node is responsible for probing the destination to its own zone proactively. This bordercasting process continues until the source finds its destination.

1.1.1 Analysis

ZRP performs better than any single proactive or reactive protocol [2]. ZRP is superiorly appropriate for the large networks. The performance of protocol has been adjusted accordingly. However, several useless control packets are used ensuing in the increase of network load and decrease of performance of the network. In the reactive protocol, the IERP request packets are sent to the entire border nodes. The IERP packets are obligatory for searching a route. However, these

packets may cause a network congestion resulting in the decrease of network performance.

II. ENHANCEMENTS OVER ZRP

Enhancements are utmost necessary for a scheme to make an improvement over the predecessor. The enhancements aim to gain over the previous advancement and aim to demonstrate an significant improvement over the previous advancement.

Considering the case of ZRP, the initially proposed ZRP does not have significant improvement in the performance wise, valuated against various parameters. However, several advancements/enhancements on the ZRP, shows that the initially proposed ZRP can be overloaded with schemes to make it better in terms of performance evaluated against several parameters. The following are the enhancements/modifications that are worked upon the Zone Routing Protocol.

2.1 A CACHING SCHEME FOR ROUTING IN MOBILE AD HOC NETWORKS AND ITS APPLICATION TO ZRP

ZRP is based on the concept of a zone. Every node 'n' is the center of a zone with radius 'r' hops, denoted Z_r (n). Nodes at a distance lesser than or equal to 'r' from the node 'n' belong to Z_r (n). A proactive routing protocol is used among the nodes of Z_r (n). A reactive routing protocol is used by the node 'n' to reach a node outside its zone. Basically, the radius 'r' is assumed to a value much lesser than the network diameter to get a fast convergence of the proactive component of ZRP. Therefore, the probability that a sender chooses a destination out of its zone is high, thus, caching is useful to reduce path discovery procedure of the reactive part of ZRP. Whenever a route to a destination outside of the zone is to be discovered then that route is to be cached for further handling [4].

A simplest form of caching is based on timeouts linked with cache entries. When an entry is cached, a timer starts. When the timeout elapses, the entry is removed from the cache. Each time the entry is used, the timer is started. Therefore, the effectiveness of such a system depends on the timeout value connected with a cached route. If the timeout is well-tuned, the protocol performance amplifies; otherwise, a severe degradation arises as entries are detached either in advance or lately from the cache.

2.1.1 Analysis

- *Overhead*: The number of overhead packets generated for each data packet decreases with extreme case of one discovery per destination as Pause Time increases.
- *Average Delay in Transmission*: The onwards time from when a source has a packet to send until the packet is delivered to the destination, beginning from the source, shows the average transmission delay for the mobility. At low mobility, delay decreases with the load since the number of route requests decreases. At higher mobility, the transmission delay first reduces for the same reason, but it start to increase when the load reaches a given value due to an increasing number of path discoveries.

2.2 A SELECTIVE BORDER CASTING ZONE ROUTING PROTOCOL FOR AD-HOC NETWORKS

A Selective Border-casting Zone Routing Protocol (SBZRP) was introduced to decrease the network load by restricting the amount of control packets when the protocol searches for a new route. The performance evaluation through simulations shows that the SBZRP has a superior behavior and better performance than ZRP. The proposed SBZRP uses for intra-zone routing the IARP the same as ZRP, but uses a new IERP for inter-zone routing [5]. The proposed scheme is evaluated at two scenarios- when the nodes were not moving and when the nodes were moving. A Border-cast Hop Number (BHN) is introduced to keep track of the Border-cast Hops in the network. The nodes in the Zone boundary receive the packet and increase the BHN by 1. Then, that node checks to see if the route to the destination is available. Otherwise, if the route is not found at the border-cast node, the Border-cast procedure is continued. In SBZRP, when a new search is carried out for the same node, the number of IERP packet sending directions is limited.

The number of the border-cast nodes and IERP packets can be decreased resulting in the increase of the throughput and the decrease of packet mean delay.

2.2.1 Analysis

The performance of the proposed protocol was evaluated considering the two scenarios: Scenario-1: with nodes moving and Scenario-2: without nodes moving.

In Scenario I, when the network load is high, the number of arrived packets to destination without loss of SBZRP is higher than ZRP, resulting in better throughput of SBZRP. Also, the mean delay of the newly proposed SBZRP is lower than ZRP. For Scenario II, when the node moving degree is high, the SBZRP has high link usability than ZRP.

- *Throughput:* Throughput or network throughput is the rate of successful data delivery over a channel. When the network load is high, the SBZRP has better behavior than ZRP. When the network load is low, the throughput is decreased for both protocols.

2.3 E-ZRP

In order to affix service discovery capabilities to ZRP, an additional field is added in NDP (Neighbor Discovery Protocol), through which every node periodically broadcasts a "Hello" message to represent its presence, "Hello" messages for storing service IDs. The concept of Unique Universal Identifiers (UUIDs) [6], is used in place of service

descriptions, keeping packet lengths small for the routing messages and minimizing the effects on the network (the larger the messages, the larger the delays and the possibility of transmission errors). ZRP was extended in order to include service information in every routing entry of the IARP routing messages and the tables. IARP listens to information collected from NDP messages, updates its table and then periodically broadcasts its table to its neighbors [6].

2.3.1 Analysis

- *Service discoverabilities:* Average number of discovered services per node proactively is almost the same in both the protocols.

2.4 AN ENHANCED ZONE-BASED ROUTING PROTOCOL FOR MOBILE AD-HOC NETWORKS BASED ON ROUTE RELIABILITY

The Zone distribution does not meet an efficient method which can help ZRP reduce the overlapping areas between the zones and such overlapping area shall cost more power to maintain the network [7].

In order to eliminate such limitations, a new scheme is proposed which will just take fewer nodes for routing and forwarding of packets and an algorithm to meet the corresponding idea. Two situations are considered. One by considering the routing within the same zone and the other by considering different zones.

In Enhanced Zone-based Routing Protocol [7], each node computes the dependability of the route. In the case of reliable route, the source node shall send the data packet directly to the destination node without route searching. While, in the case of unreliable route, the source node searches for a new route again. Also, a Reliable Degree parameter (RD) is calculated. If the RD of the route is high, a data packet is sent directly without route searching. When the RD is in the middle, a route searching is performed for some limited directions. When RD is low, the route searching is carried out in all directions.

2.4.1Analysis

- *Arrival rate of the packet:* The loss in packets in EZRP is lower than in ZRP.

- *Delay:* Delay in EZRP is lower than ZRP.

2.5 EVOLUTIONARY ZONE ROUTING PROTOCOL

Evolutionary Zone Routing Protocol [8] proposes a generic routing protocol that finds out multiple shortest paths. A normal Route Discovery Protocols shall find out only one shortest path to the destination, but the Evolutionary Zone Routing Protocol shall find out multiple based on an algorithm.

In the algorithm implemented, the practices of Exhaustive algorithm and Greedy algorithm are considered. In the Exhaustive algorithm, permutations are computed and converted into paths. Also, the cost of each of the paths is calculated. A final path, i.e, the shortest path among the available is selected by comparing the cost themselves.

In Greedy algorithm, a node is selected and the path to all the available nodes along with the cost is selected. A cross-over point is chosen at the middle of the path of the nodes. Next, the cost is computed on the now available two entities.

2.5.1Analysis

- *Packet Delivery Ratio:* The packet delivery ratio is better compared to the existing ZRP.

- *End-to-End Delay:* The end-to-end delay is nearly reduced to half of the existing from the ZRP when 10 nodes are considered. However, the EZRP still has less end-to-end delay with increasing number of nodes in the network.

2.6 GENETIC ZONE ROUTING PROTOCOL (GZRP)

The Genetic Zone Routing Protocol [9], is an enhancement made on ZRP that is used to find out a limited number of multiple alternate route to the destinations. The GZRP shall also consider fault tolerance during link breaks and provides load balancing mechanism as well.

In the Genetic algorithm approach, the algorithm is applied to the border nodes to find out the alternative routes available. Therefore, the border node shall apply algorithm by making use of route database available at the nodes to find other routes when there is an path break.

In order to compensate for the packet loss, the GZRP provides alternative routes to a border node. This shall act as a robust for the network and also decreases the control overhead due to rediscovery of the routes.

2.6.1 Analysis

- Significant reduction in control overhead in the network by use of GZRP upto 12%.

- *Packet Delivery Ratio:* The delivery of the packet to the destination is high especially during higher mobility conditions.

III. CONCLUSION

This paper focuses on the various advancements made on the Zone Routing Protocol of Hybrid Ad Hoc networks. Various such enhancements include Caching, Selective Border-casting, Extended Zone Routing Protocol, Enhanced Zone Routing Protocol, Evolutionary Zone Routing Protocol and Genetic Zone Routing Protocol. Considering the enhancements compared in this paper, the Evolutionary and Genetic Zone Routing protocol shall elevate over the issue of

control overhead that shall ultimately reduce the bandwidth and power constraints of the network.

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