# Eccentricity in Zone Routing Protocol for MANET

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***Abstract*— A Mobile Ad-Hoc Network (MANET) is a decentralized network of autonomous mobile nodes, able to communicate with each other over wireless links. Due to the mobility of the nodes, the topology of the network changes spontaneously, therefore use of conventional routing tables maintained at fixed points (routers) is not suggested. Such a network may operate in a standalone fashion. There are various routing protocols available for MANETs. The most popular ones are DSR, DSDV and ZRP .The zone routing protocol (ZRP) is a hybrid routing protocol that proactively maintains routes within a local region of the network. ZRP can be configured for a particular network through adjustment of a single parameter, the routing zone radius. In this paper, we address the issue of configuring the ZRP to provide the best performance for a particular network at any time with the concept of eccentricity. The results illustrate the important characteristics of different protocols based on their performance and thus suggest some improvements in the respective protocol. The tools used for the simulation are NS2 which is the main simulator, NAM (Network Animator) and Tracegraph which is used for preparing the graphs from the trace files.**

***Keywords*— MANET, DSR, DSDV, ZRP, Eccentricity, NS2.**

## I. INTRODUCTION

The key feature of MANET is the absence of infrastructure. It is dynamically formed by an autonomous system of mobile nodes connected via wireless links. These mobile nodes communicate with each other through bandwidth-constrained, variable capacity, error-prone, and insecure wireless channels. Wireless links have significantly lower capacity and hence, congestion is more challenging. The batteries carried by node have limited power which in turn limits services and applications that can be supported by each node. These constraints require the traffic to be evenly distributed among the mobile hosts, else heavily-loaded nodes cause congestion and large delays or even deplete energy quickly. Unfortunately, most current MANET routing protocols lack load-balancing. Here we present in this paper the load-balancing mechanisms that send the traffic further from the centre of the network in order to reduce the load at central nodes. A major problem is to provide an appropriate localization-free definition of the centre of the network, using the topology information available at every node. The topology information can be exhaustive (proactive protocols) or partial (reactive protocols), we consider each case separately.

## II. PROTOCOLS

The IETF MANET Working Group has introduced many protocols for MANET. These protocols are categorized into two groups: pro-active and reactive protocols.

*Pro-active* protocols use approaches similar to the one used in wired routing protocols. They continuously evaluate the new routes, and maintain the latest information of the network, which allows efficient transfer of packets. Pro-active also known as table-driven protocols, maintain the constantly changing network graph due to new, moving or failing nodes, and hence require continuous updates, which use large amounts of bandwidth and this mark a disadvantage in the wireless world, where bandwidth is a limitation. The family of Distance-Vector protocols, including Destination-Sequenced Distance-Vector Routing come under the category of pro-active protocols.

*Reactiv*e protocols determine the proper route only when a packet needs to be forwarded. Here, the node floods the network with a route-request and builds the route on demand from the responses it receives. This approach does not require constant broadcasts and discovery, but on the contrast causes delays since the routes are not already available. Also, the flooding of the network may lead to additional control traffic, again putting load on the on the limited bandwidth.

These reactive (or on-demand) protocols include Classical flooding algorithm as well as Ad-hoc On-Distance Vector Routing (AODV) and the Dynamic Source Routing

### *A. DSR- Dynamic Source Routing Protocol*

DSR was originally proposed by Johnson, Maltz, and Broch. The use of source routing, allows packet routing to be loop free. The efficiency is increased by allowing nodes that are either forwarding route discovery requests or overhearing packets through promiscuous listening mode to cache the routing information for future use. It reduces the bandwidth use especially in situations where the mobility is low. It is a simple and efficient routing protocol for use in ad-hoc networks. It has two important phases, route discovery and route maintenance. The main algorithm works in the following manner. A node that desires communication with another node first searches its route cache to see if it already has a route to the destination. If it does not, it then initiates a route discovery mechanism. This is done by sending a Route Request message. When the node gets this route request message, it searches its own cache to see if it has a route to the destination. If it does not, it then appends its id to the packet and forwards the packet to the next node; this continues until either a node with a route to the destination is encountered.

### *B. DSDV - The Destination Sequenced Distance Vector Protocol*

DSDV is one of the most well-known table-driven routing algorithms for MANETs. It is a distance vector protocol. In distance vector protocols, every node $n$ maintains for each destination x a set of distances $\{d_{nj}(x)\}$ for each node j that is a neighbour of $n$. Node $n$ treats neighbour $k$ as a next hop for a packet destined to x if $d_{nk}(x)$ equals $\min_j\{d_{nj}(x)\}$. The succession of next hops chosen in this manner leads to x along the shortest path. In order to keep the distance estimates up to date, each node monitors the cost of its outgoing links and periodically broadcasts to its entire neighbour’s its current estimate of the shortest distance to every other node in the network. The distance vector which is periodically broadcasted contains one entry for each node in the network which includes the distance from the advertising node to the destination. The distance vector algorithm described above is a classical Distributed Bellman-Ford (DBF) algorithm. In DSDV, each node maintains a routing table which is constantly and periodically updated (not on-demand) and advertised to each of the node’s current neighbours. Each entry in the routing table has the last known destination sequence number. Each node periodically transmits updates, and it does so immediately when significant new information is available. The data broadcasted by each node will contain its new sequence number and the following information for each new route: the destinations address the number of hops to reach the destination and the sequence number of the information received regarding that destination, as originally stamped by the destination. In multi-path approaches, many paths are established between a source–destination pair of nodes, and traffic between these nodes is split on the different paths. Load-balancing consists in this case in determining the amount of traffic on each path minimizing a certain cost function.

### *C. ZRP - Zone Routing Protocol*

The ZRP is an example of a hybrid reactive/proactive routing protocol. It limits the scope of the proactive procedure only to the node’s local neighbourhood. The local routing information is referred to quite often in the operation of the ZRP. On the other hand, the global search throughout the network, is performed by efficiently querying selected nodes in the network, as contrary to querying all the nodes in the network.

The protocol finds multiple loop-free routes to the destination, increasing reliability and performance. Routing is flat rather than hierarchical, reducing organizational overhead, allowing optimal routes to be discovered which reduces the threat of network congestion. The protocol is adaptive based on the current configuration of the network and the demand of the users.

## III. THE MODEL

The idea is motivated by the result of Pham and Perreau's work that I briefly describe here. Pham and Perreau had proposed a routing model to determine the load distribution in an ad-hoc network which uses single-path routing. They assumed a network of N nodes uniformly distributed over a disk D of radius R with the density $\delta$. N is related to the surface density $\delta$ by the following equation:

$$N = \pi R^2 \delta \text{ ........................................................................(A)}$$

Let A be a node within the distance r from the centre of the disk D and X($\alpha$) a point of the disk border so that the angle [AO, AX($\alpha$)] would be of aperture da. Let S$\alpha$(d$\alpha$) portion of the disk D. Fig.1 portrays the network model. The aim is to determine the number of traffic routes going through A and whose sources are nodes from S$\alpha$(d$\alpha$). In order to answer this question, we need to determine the number of possible destinations B of traffic generated by a source from S$\alpha$(d$\alpha$) and forwarded by A. Since the studied routing protocols use shortest-path algorithms, Pham and Perreau approach optimal routes to straight lines. Therefore, the number of optimal routes through A would be the number of straight lines joining a point of S$\alpha$(d$\alpha$) to a node of S$\alpha$+π(d$\alpha$). This number was approached to the value:

$$N_A = \frac{\pi(R^2 - r^2)^2 \delta^2 \beta}{4} d\alpha \text{ ...............................(B)}$$

Here $\beta$ is a positive small real used to adapt the theoretical model to reality. We know that links are bidirectional, the total number of optimal routes passing through A and generated by any node from the whole disk D is

$$N_T = 2 \times \int_0^{\pi} \frac{\pi(R^2 - r^2)^2 \delta^2 \beta}{4} d\alpha \text{ ........................................(C)}$$

$$N_T = \pi \frac{(R^2 - r^2)^2 \delta^2 \beta}{2} \text{ ..............................  (D)}$$

and the forwarded traffic by node A would be

$$\lambda_A = N_T \times \lambda = \pi \frac{(R^2 - r^2)^2 \delta^2 \beta}{2} \lambda \text{ .....................(E)}$$

Here, λ represents the average load in a route.

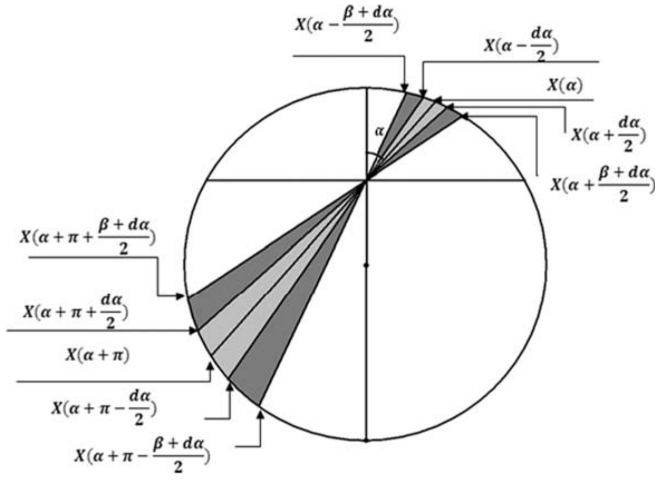

Figure 1: Pham and Perreau's analytical model.

The analytical model presented above, was implemented on Matlab. It randomly generated a 100-node graph with a uniform density of probability in a 100 Â 100 unit surface, each node having a transmission range of 20 units. Then, using Dijkstra's algorithm, we computed shortest-paths between each possible pair of nodes in the network. Fig. 2 illustrates the resulting graph. From this, it appears that central nodes are much implicated in shortest-paths then peripheral nodes, which is in accordance with Pham and Perreau's conclusions.

From this result, we believe that Pham and Perreau's conclusions are correct. Thus, we propose in the following section our mechanisms to achieve load-balancing in shortest-path routing protocols, based on their results. Since shortest-path routing is to be considered for load unbalance, it is a mandatory to provide a new routing metric (instead of a simple hop count) that takes into consideration the degree of nodes centrality when deciding on a route. In other terms, instead of choosing shortest routes, we must choose routes that are relatively short but are formed by nodes that are the far from the centre of the network.

We put forward a definition of the centrality ε(k) of a node k, that we will specify afterward. We propose the following routing metric as a basis of decision on the best route to a destination:

$$\text{Minimize } \tfrac{1}{n}\sum_{k=1}^{n}\varepsilon(k) \quad \text{………………..(F)}$$

where, n represents the number of nodes in a route. In other words, such a metric, favours the routes where nodes are the far from to the centre of the network.

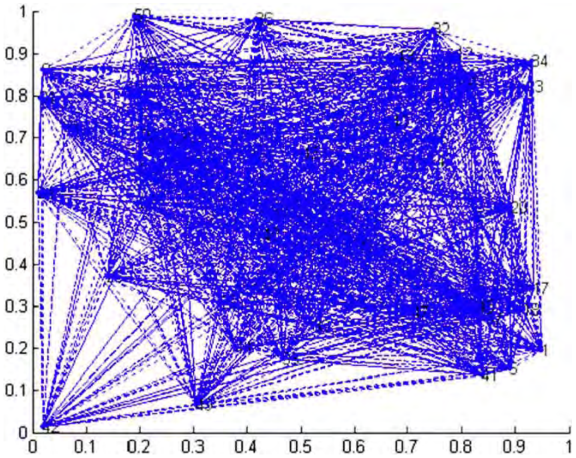

Figure 2: Possible shortest-paths in a 100-node connected graph.

For example, minimizing the number of hops in a route would maximize the sum of nodes centralities (since shortest routes pass through central nodes), and vice versa. Also the number of hops is always equal to or above 1, as a node is at least 1-hop away from another.

The routing metric presented will be used to achieve the load-balancing. In the following, we define the measure ε (*k*) that reflects the centrality of a node k.

According to this study, the number of routes passing through a node A at distance r from the centre of the disk using a shortest-path routing algorithm is as

$$N = \frac{\pi(R^2 - r^2)^2\,\delta^2\beta}{2} \quad \text{……………………………...…..(G)}$$

Given that, for a route to be established through node A, A needs to have a corresponding entry in its routing table, we infer that the size of the routing table of node A is also as smaller as r increases (i.e. as the node A gets further from the centre). So we opt for the size of a node's routing table as a characterization of its centrality and we suggest the following metric:

$$\text{Minimize } \tfrac{1}{n}\sum_{k=1}^{n} size(rtable(k)) \quad \text{..............................................(H)}$$

Where size(rtable(k)) represents the number of entries in the routing table of a node k among the n nodes participating in the studied route.

### *A. Modifying the routing algorithm so that it supports the new routing metric*

We change the way in which RREQ and RREP messages are forwarded. We consider that in reactive routing protocols, routing tables update occurs when such messages are received. For example, when a node (X) receives a RREQ message (expressing the desire of the source node (S) to establish route to destination through node (X)), the routing table is updated using the predecessors list that figures in this packet, before evaluating the possibility of favourably considering the source's request ,but this list of predecessors happen to be shorter than the route node (X) has in its routing table to the source, node (X) deletes the old route from its table and replaces it by this sequence of predecessors.

In the following, instead of comparing the route to (S) announced by node (S)'s RREQ message with the route to (S) that already exists in node (X)'s routing table on a count basis, (X) compares these two routes using the proposed metric (Eq. (G)). However, in practice Eq. (G) cannot be implemented as it is, because it requires that every node knows the average size of the routing tables of all nodes involved in the path, which leads to frequent signalling updates between nodes. In the proposal, we provide an enhanced average eccentricity computation formula that takes into account the signalling constraints. Using this formula, it suffices for a nth node ($V_n$) in a path to know the number n of previous nodes and the arithmetic average of their eccentricities $(\varepsilon_k)_{1\leq k\leq n-1}$ , to obtain the new average P($n$ + 1) as follows:

$$P(n+1)=\tfrac{1}{n+1}\sum_{k=1}^{n+1}\varepsilon_k \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{.(I)}$$

$$P(n+1)=\tfrac{1}{n+1}\sum_{k=1}^{n}\varepsilon_k+\tfrac{1}{n+1}\varepsilon_{n+1} \ldots\ldots\ldots\ldots\ldots\ldots \text{(J)}$$

$$P(n+1)=\tfrac{n}{n+1}\times\tfrac{1}{n}\sum_{k=1}^{n}\varepsilon_k+\tfrac{1}{n+1}\varepsilon_{n+1} \ldots\ldots\ldots\ldots \text{(K)}$$

$$P(n+1)=\tfrac{n}{n+1}\times P(n)+\tfrac{1}{n+1}\varepsilon_{n+1} \ldots\ldots\ldots\ldots \text{(L)}$$

Computation of best routes according to the proposed routing metric is subsequently provided in Algorithm.

Proposed algorithm to compute less-loaded routes in ZRP

1. Source node S sends a RREQ message including the size of its routing table as its eccentricity:
   $$P(1)=\varepsilon_1=size(rtable(S))$$
2. On receipt of this message, neighbour node V, not knowing a route to the solicited destination, acquires P($n$) = P(1) and $n$ = 1 from the received RREQ message and diffuses a modified replica with the novel average eccentricity:
   $$P(2)=0.5\times P(1)+0.5\times size(rtable(V_1))$$
3. Iteratively, an nth intermediate node $V_n$, not knowing a route to the solicited destination, acquires P(n) and n from the received RREQ message and diffuses a modified replica with the novel average eccentricity:
   $$P(n+1)=\tfrac{n}{n+1}P(n)+\tfrac{1}{n+1}size(rtable(V_n))$$
4. Eventually, when the solicited destination node D receives the different RREQ messages from the possible paths to S, it simply chooses the route having the smallest average eccentricity, by sending a RREP message to the source via this selected path.

## IV. SIMULATION SETUP

The MANET network simulations are implemented using NS-2 simulator. The Simulation runs are made with the number of nodes varying from 5 to 25. The MAC layer protocol IEEE 802.11 is used in all simulations. The performance evaluation, as well as the design and development of routing protocols for MANETs, requires additional parameters which is addressed in RFC developed by Internet Engineering Task Force (IETF).

## V. ANALYSIS

We have selected the Packet Delivery Fraction (PDF) and Throughput during the simulation in order to evaluate the performance of the different protocols.

*Packet Delivery Fraction*: This is the number of packets sent from the source to the number of received at the destination.

*Throughput*: This is the average rate of successful message delivery over a communication channel.

## VI. RESULTS

The following figures shows that the Packet Delivery Fraction (Fig. 3) and Throughput (Fig. 4) of the three protocols: DSDV, DSR and ZRP. We observe that ZRP applied with *eccentricity* algorithm shows slightly better performance than DSR and DSDV respectively.

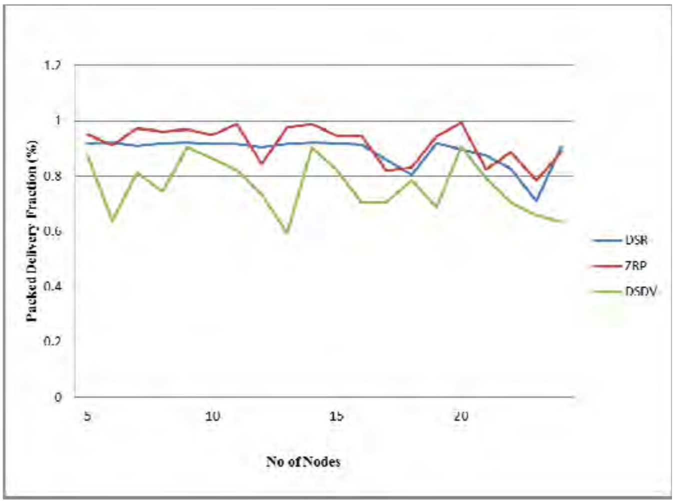

Figure 3: Packet Delivery Fraction v/s No. of Nodes

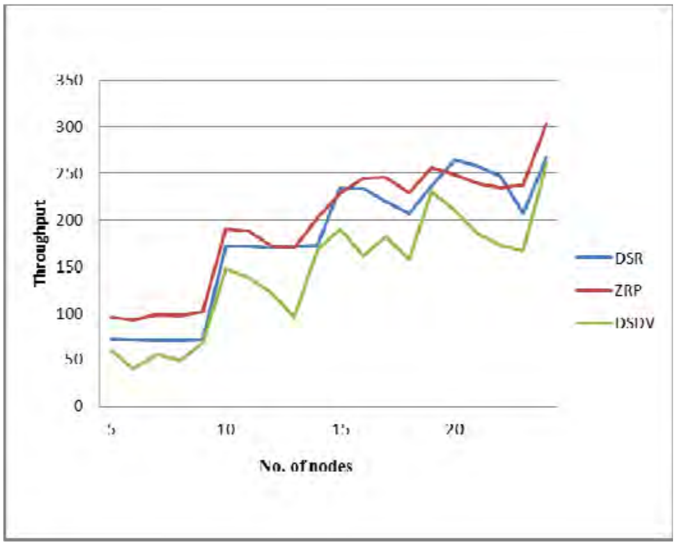

Figure 4: Throughput v/s No. of Nodes

## VII. CONCLUSIONS

Simulation results illustrates the empirical performance, and that ZRP has significantly improvised then these routing protocols in terms of throughput and packet delivery fraction.

## ACKNOWLEDGMENT

I thankfully acknowledge all the support obtained from Amity University, Noida

## REFERENCES

[1] S. Yin, X. Lin, MALB: MANET adaptive load balancing, in: IEEE Vehicular Technology Conference (VTC2004-Fall), vol. 4, September 2004, pp. 2843–2847.

[2] L. Zhang, Z. Zhao, Y. Shu, L. Wang, O.W., W. Yang, Load balancing of multipath source routing in ad hoc networks, in: Proceeding of the IEEE International Conference on Communications (ICC 2002), May 2002.

[3] K. Wu, J. Harms, Performance study of a multipath routing method for wireless mobile ad hoc networks, in: Proceeding of the Ninth International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunications Systems (MASCOTS'01), August 2001.

[4] Y.J. Lee, G.F. Riley, A workload-based adaptive load-balancing technique for mobile ad hoc networks, in: IEEE Wireless Communications and Networking Conference (WCNC'2005), vol. 1, 2005, pp. 2002–2007.

[5] M. Perlman, Z. Haas, P. Scholander, S. Tabrizi, Alternate path routing for load balancing in mobile ad hoc networks, in: IEEE Military Communications Conference (MILCOM 2000), October 2000.

[6] P.Pham, S. Perreau, Multi-path routing protocol with load balancing policy in mobile ad hoc networks, in: IFIP Int'l Conference on Mobile and Wireless Communications Networks (MWCN 2002), September 2002.

[7] Y. Ganjali, A.Keshavarzian, Load balancing in ad hoc networks: single-path routing vs. multi-path routing, in: Twenty-third Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM 2004), March 2004.

[8] S. Basagni, M. Conti, S. Giordano, I. Stojmenovi, Mobile Ad Hoc Networking , IEEE Press and John Wiley & Sons, Inc., 2004.

[9] P.Pham, S. Perreau, Performance analysis of reactive shortest path and multi-path routing mechanisms with load balance, IEEE Conference on Computer Communications (INFOCOM 2003), March 2003.

[10] NS-2,http://www.isi.edu/nsnam/ns