

Analyzing Performance of Zone Routing Protocol by Varying Node Density and Transmission Range

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Abstract— Mobile Ad hoc Network (MANET) is a collection of mobile nodes that are arbitrarily located so that the interconnections between nodes are dynamically changing. In MANET mobile nodes forms a temporary network without the use of any existing network infrastructure or centralized administration. Each node participating in the network acts both as host and a router and must therefore is willing to forward packets for other nodes. For this purpose, a routing protocol is needed. A routing protocol is used to find routes between mobile nodes to facilitate communication within the network. The Zone Routing Protocol (ZRP) is a hybrid routing protocol for MANET which combines the advantages of the proactive and reactive approaches by maintaining an up-to-date topological map of a zone centered on each node. I am going to do simulation based study in order to analyze performance of ZRP protocol and I am Using Network Simulator (NS-2) tool to analysis performance of ZRP and doing sensitivity analysis by varying node density and transmission range on different parameter like throughput, average end to end delay, and Normalized Routing load.

Keywords— Routing Protocols, ZRP, Proactive Routing, Reactive Routing, Hybrid Routing

I. INTRODUCTION

The wireless network can be classified into two types: Infrastructure or Infrastructure less. In Infrastructure wireless networks, the mobile node can move while communicating, the base stations are fixed and as the node goes out of the range of a base station, it gets into the range of another base station. In Infrastructure less or Ad Hoc wireless network, the mobile node can move while communicating, there are no fixed base stations and all the nodes in the network act as routers. The mobile nodes in the Ad Hoc network dynamically establish routing among themselves to form their own network ‘on the fly’.

Ad-hoc networks are also capable of handling topology changes and malfunctions in nodes. It is fixed through network reconfiguration. The routing protocol has two main functions, selection of routes for various source-destination pairs and the delivery of messages to their correct destination. The second function is conceptually straightforward using a variety of protocols and data structures (routing tables). This report is focused on selecting and finding routes.

This paper contains all the detail about ZRP protocol and the result generate from the experiment with conclusion and also mentions the parameter use for generating the result.

II. OVERVIEW OF PROTOCOL

Proactive routing uses excess bandwidth to maintain routing information, while reactive routing involves long route request delays. Reactive routing also inefficiently floods the entire network for route determination [2]. The Zone Routing Protocol (ZRP) aims to address the problems by combining the best properties of both approaches. ZRP can be classed as a hybrid reactive/proactive routing protocol. [12] In an ad-hoc network, it can be assumed that the largest part of the traffic is directed to nearby nodes. Therefore, ZRP reduces the proactive scope to a zone centered on each node. In a limited zone, the maintenance of routing information is easier. Further, the amount of routing information that is never used is minimized. Still, nodes farther away can be reached with reactive routing. Since all nodes proactively store local routing information, route requests can be more efficiently performed without querying all the network nodes. [12].

Despite the use of zones, ZRP has a flat view over the network. In this way, the organizational overhead related to hierarchical protocols can be avoided. Hierarchical routing protocols depend on the strategic assignment of gateways or landmarks, so that every node can access all levels, especially the top level. Nodes belonging to different subnets must send their communication to a subnet that is common to both nodes. This may congest parts of the network. ZRP can be categorized as a flat protocol because the zones overlap. Hence, optimal routes can be detected and network congestion can be reduced. Further, the behavior of ZRP is adaptive. The behavior depends on the current configuration of the network and the behavior of the users.

A. IntraZone Routing Protocol (IARP)

“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 zone radius”. In ZRP, a node proactively maintains the route to the destination within its zone radius. Zone is defined in

terms of hops and not as a physical distance. All nodes proactively store local routing information and route requests can be more efficiently performed through a special type of multicasting process, known as bordercasting. Bordercasting utilizes the topology information provided by IARP to direct query request to the border of the zone [6]. The Bordercast packet delivery service is provided by the Bordercast Resolution Protocol (BRP). The nodes of a zone are divided into interior nodes and peripheral nodes. Peripheral nodes are those nodes whose minimum distance to the node in question is exactly equal to the zone radius (ρ). The nodes whose minimum distance is less than zone radius (ρ) are known as interior nodes.

An example of a routing zone for node S of radius $\rho = 2$ hops is shown in figure 1 In the given example nodes A, B, C, D, E and F are interior nodes and G, H, I and J are peripheral nodes where K node not in the zone radius and it is outside the zone of node S. Each node is assumed to maintain the routing information to all nodes within its routing zone and those only. So, even a network can be quite large, the updates are locally propagated. The node learns the topology of its routing zone through a localized proactive scheme which is known as IntrAzone Routing Protocol (IARP). IARP is a family of limited-depth proactive link state routing protocol.

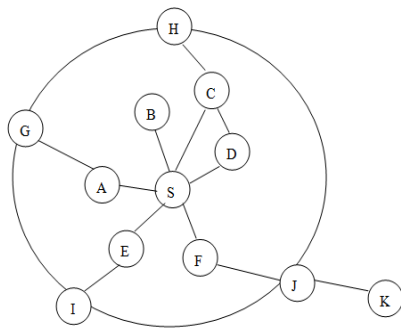


Fig 1: Example of Routing Zone with $\rho=2$ [1]

B. IntErzone Routing Protocol (IERP)

In ZRP, the globally reactive routing is named as IntErzone Routing Protocol (IERP). Using IERP, ZRP reactively discover routes to destination beyond a node's routing zone [7]. Knowledge of local routing zone topology can be exploited to efficiently relay a query through the network. This is achieved through a packet delivery service, called bordercasting, which directs message from one node out to its peripheral nodes. One approach is for a node to compute its bordercast (multicast) tree and append the corresponding packet forwarding instructions to the bordercast packet. Alternatively, each node may reconstruct the bordercast tree of its interior routing zone by proactively maintaining the topology of an extended zone. If IARP maintains an extended zone of radius $2\rho-1$, bordercast messages can be relayed without the need for explicit directions from the bordercast source.

C. Bordercast Resolution Protocol

The BRP is responsible for forwarding IERP route queries to the peripheral nodes of the bordercasting node.

To save network resources, a multicast tree is used. Although the receivers of a bordercast packet are the peripheral nodes, the BRP deliver the query to the IERP at every hop. The protocol keeps track over the nodes that have been covered by the query. When a node receives a query packet, it marks the interior nodes of the previous bordercaster as covered by reconstructing its bordercast tree. If the receiving node is a peripheral node of the previous bordercaster, then this node becomes a new bordercaster and its interior nodes are marked as covered. Before the query is delivered to higher layers, the state is stored in a cache, so that the query can be properly forwarded when it returns from the higher layer [10].

When BRP receives a new query to bordercast, it marks the node as the bordercaster and marks the interior nodes as covered, and the query is delivered to the peripheral nodes. On the other hand, when a previously received query returns from higher layers, the protocol determines which branches to be pruned based on the map of covered nodes. The query is delivered to the remaining peripheral nodes, and these nodes are marked as covered. By maintaining a map of covered nodes, BRP can terminate the delivery if it receives the query from another direction [10] [12].

The BRP packet contains the query source and destination addresses, the query ID and previous bordercaster address. The route request is transported as an encapsulated packet. BRP utilizes the routing table and link state table of IARP. In addition, it uses a cache of detected queries, containing the query source, the query ID, the BRP cache ID and the previous bordercaster. The query coverage map contains a graph for every combination of query source and query ID. Route selection process given in fig 2.

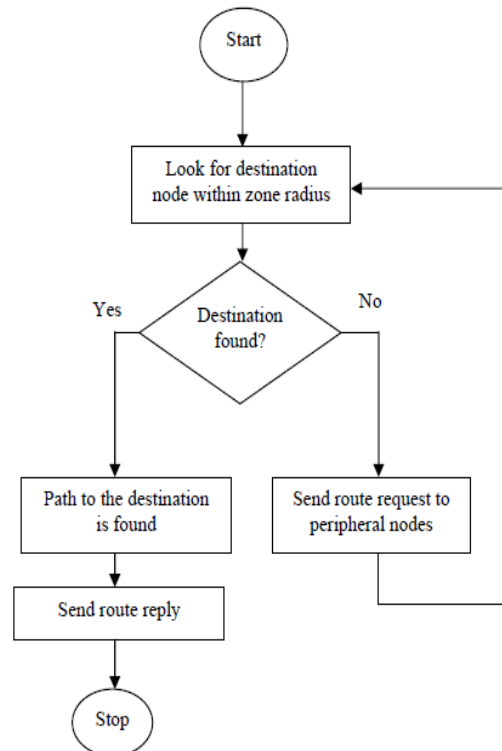


Fig 2: ZRP algorithm Route discovery process [12]

III. SIMULATION METHODOLOGY

Simulation based study using Network Simulator NS-2 [11] has been used to analyze the performance of Zone Routing Protocol under varying node density and varying zone radius. It is assumed that the size of network, pause time, maximum speed of nodes and transmission rate are constant while the density of nodes in the network and the zone radius of each node vary considerably. Tables 1 and Table 2 summarize the parameters used in the communication and movement models for simulation.

A. Communication Model

The simulator assumes constant bit rate (CBR) traffic with a transmission rate of 4, 8, 12, 15, 20 packets per second. The number of nodes varies from 25 to 150 and Transmission Range 250 and 500.

TABLE 1 PARAMETERS OF COMMUNICATION MODEL

Parameter	Value
Traffic type	CBR
Number of Nodes	25,50,75,100,150
Transmission Range	250,500
Transmission Rate	4,8,12,15,20 packets/second

B. Movement Model

In line with the realistic mobility pattern of the mobile nodes, the simulation assumes a Random Waypoint Model, where a node is allowed to move in any direction arbitrarily [12]. The nodes select any random destination in the 800 X 800 space and moves to that destination at a speed distributed uniformly between 1 and nodes maximum speed varies from 20 to 90 m/s. Upon reaching the destination, the node pauses for 20 to 120 for different scenario under constant node of 50, selects another destination, and proceeds there as discussed above. This behavior repeats throughout the duration of the simulation (500 seconds). Meanwhile, number of nodes has been varied to compare the performance of the protocols for low as well as high density environment. Table 2 lists the movement parameters of the simulations.

TABLE 2 PARAMETERS OF MOVEMENT MODEL

Parameter	Value
Simulator	NS-2
Simulation Time	500 Seconds
Area-of-Network	800 x 800 m
No of Nodes	25,50,75,100,150
Pause Time	20,40,60,90,120 second
Maximum Speed of Nodes	20,40,60,90 m/s
Mobility Model	Random Waypoint

C. Performance Metrics

Three performance metrics have been measured for the protocols:

1) *Throughput*: Throughput is the number of packet that is passing through the channel in a particular unit of time [8]. This performance metric shows the total number of packets that have been successfully delivered from source node to destination node. Factors that affect throughput include frequent topology changes, unreliable communication, limited bandwidth and limited energy. Update message.

The MRL records updates in an update message need to be retransmitted and which neighbors should acknowledge their transmission.

$$\text{Throughput} = \frac{\text{Received_packet_size}}{\text{Time_to_send}} \quad [8]$$

2) *Average End-to-End Delay*: A specific packet is transmitting from source to destination node and calculates the difference between send times and received times. This metric describes the packet delivery time. Delays due to route discovery, queuing, propagation and transfer time are included metric

$$\text{Avg_e2e_Delay} = \frac{\sum_i^n (\text{CBRSentTime} - \text{CBRRecvTime})}{\sum_i^n (\text{CBRRecvTime})} \quad [8]$$

3) *Normalized Routing Load*: Normalized Routing Load is the ratio of total number of routing packet received and total number of data packets received [8].

$$\text{NRLoad} = \frac{\text{Number_of_Routing_pkts_received}}{\text{Number_of_Data_pkts_received}} \quad [8]$$

IV. IMPLEMENTATION METHODOLOGY

A. Network Scenario and Traffic Generating

As the problem may exist in above, we then will need nodes placement and network traffic can be generated automatically and thus could meet the demand of scalable performance test for a specific network configuration. There are some third part tools that could help us to do so [15].

1) Network Scenario Generation:

For nodes positions and their movement, we can generate a file with the statements which set nodes' positions and nodes movement using CMU generator. It is under \$NS2_HOME/indep-utils/cmu-scen-gen/setdest. But, before we use it, we need first run "make" to create executable "setdest" program. In fact, this is a third party which is CMU's version auxiliary scenario creation tool. It used system dependent /dev/random and made calls to library functions initState () for generating random numbers. The usage of this executable command is:

```
./setdest [-n num_of_nodes] [-p pausetime] [-s maxspeed][[-t simtime] [-x maxx] [-y maxy] > [scenario_output_file]
```

For example, if the command we use is like:

```
./setdest -n 25 -p 20.0 -s 20.0 -t 500 -x 800 -y 800 > scen25
```

This means, the topology boundary is 800m X 800m, the scenario has 25 nodes with nodes' max moving speed of 20.0m/s and the pause between movements is 20s. Also, Simulation will stop in 500s, and finally, output the generate tcl statements into file whose name is scen25.

2) Network Traffic Generating:

For network traffic generating, what are generated are also statements on such as sources, connections, and so on. This work could be done as a TCL file, which is in \$NS2_HOME/indep-utils/cmu-scen-gen/cbrgen.tcl. Since this can be easily read and modified, if you want, you can just simply modify it so that the scenario be generated will be more suitable to what your need.

For this network traffic generating tool, random traffic connections of TCP and CBR can be setup between nodes. It can be used to create CBR and TCP traffics connections between wireless nodes. In order to create a traffic-connection file, we need to define the type of traffic connection (CBR or TCP), the number of nodes and maximum number of connections to be setup between them, a random seed and incase of CBR connections, a rate whose inverse value is used to compute the interval time between the CBR packets. So the command line is:
`ns cbrgen.tcl [-type cbr/tcp] [-nn nodes] [-seed seed][[-mc connections] [-rate rate]`

Here, “-type cbr/tcp” means define the type of traffic connection, “-nn nodes” means the number of nodes could be used, “-mc connections” means maximum number of connections to be setup between those nodes,“-seed seed” means a random seed, if it not equal to 0,the traffic pattern will reappear if all the other parameters are the same. “-rate rate” means a rate whose inverse value is used to compute the interval time, which easily to say is packets sending rate. For an example:
`ns cbrgen.tcl -type cbr -nn 25 -seed 1.0 -mc 12 -rate 8.0> cbr25`

Means create a CBR connection pattern between 25 nodes, having maximum of 20 connections, with a seed value of 1.0 and a rate of 8.0 packets/second.

V. SIMULATION RESULT ANALYSIS

A. Impact of Node Pause Time

Figure 3, 4 and 5 shows the result obtained from Analysis of Zone Routing Protocol considering that Pause time of nodes are varying from 20 to 120 in an area of 800m X 800m , the zone radius for each node is 2(constant) and no of nodes are 50. This is in order to understand the response of ZRP when node pause time in the network is varying. Here the routing operation under the given scenario (as indicated in Table – 1 and 2).

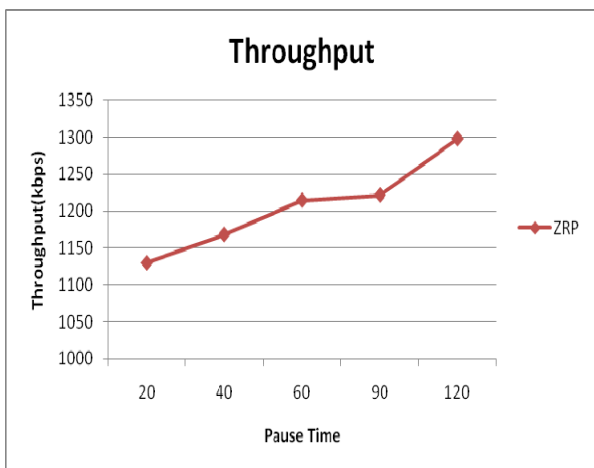


Fig 3 Analysis of Throughput for Pause Time

Figure 3 illustrates impact of varying pause time on Throughput. I can observe that Throughput increase with increase in Pause Time just because of less packet drop as node get enough time to successfully send the packet.

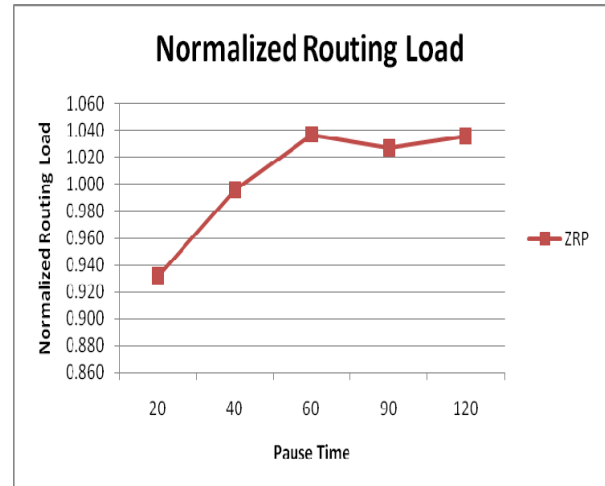


Fig 4 Analysis of Normalized Routing Load for Pause Time

Figure 4 illustrates impact of varying pause time on Normalized Routing Load. I can observe that Normalized Routing Load increase with increase in Pause Time just because of more no of control packet generate which result in increase in normalized routing load.

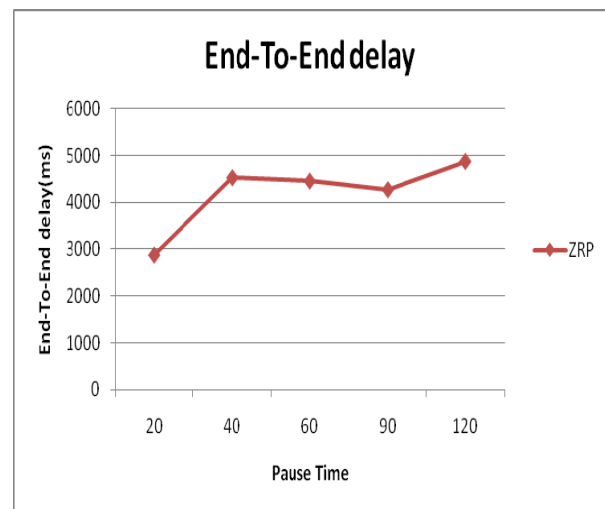


Fig 5: Analysis of End-To-End delay for Pasue Time

Figure 5 illustrates impact of varying pause time on End to End delay. I can observe that End to End delay increase with increase in Pause Time just because of time require in processing will increase between two node with increase in node pause time.

B. Impact of Node Sending Rate

Figure 6, 7 and 8 shows the result obtained from Analysis of Zone Routing Protocol considering that Packet Sending rate of nodes are varying from 4 to 20 in an area of 800m X 800m and no of node are 50. This is in order to understand the response of ZRP when node sending rate in the network is varying. Here the routing operation under the given scenario (as indicated in Table – 1 and 2).

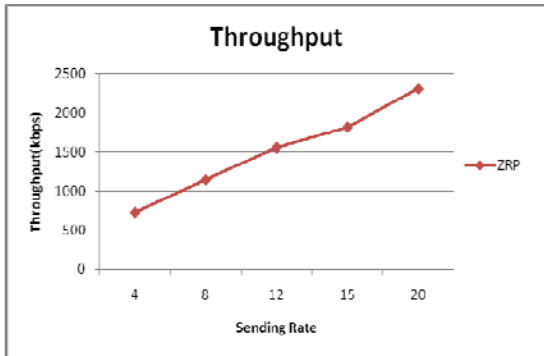


Fig 6 Analysis of Throughput for Sending Rate

Figure 6 illustrates impact of varying packet rate on Throughput. I can observe that Throughput increase with increase in sending rate just because of large no of packet will generate which leads in increase in throughput.

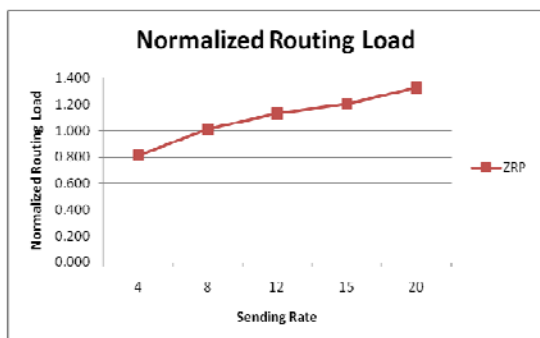


Fig 7 Analysis of Normalized Routing Load for Sending Rate

Figure 7 illustrates impact of varying packet rate on Normalized Routing Load. I can observe that Normalized Routing Load increase with increase in Pause Time just because of more no of control packet generate with increase in sending rate.

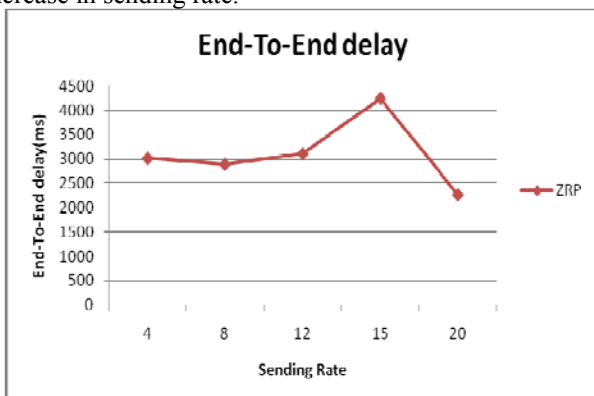


Fig 8 Analysis of End-To-End delay for Sending Rate

Figure 8 illustrates impact of varying packet rate on End to End delay. I can observe that End to End delay will increase with increase in sending rate upto some rate but then it will start decreasing after some rate.

C. Impact of Node Mobility

Figure 9, 10 and 11 shows the result obtained from Analysis of Zone Routing Protocol considering that speed of node are varying from 20 to 90 in an area of 800m X 800m and no of nodes are 50. This is in order to understand the response of ZRP when node speed in the network is

varying. Here the routing operation under the given scenario (as indicated in Table – 1 and 2).

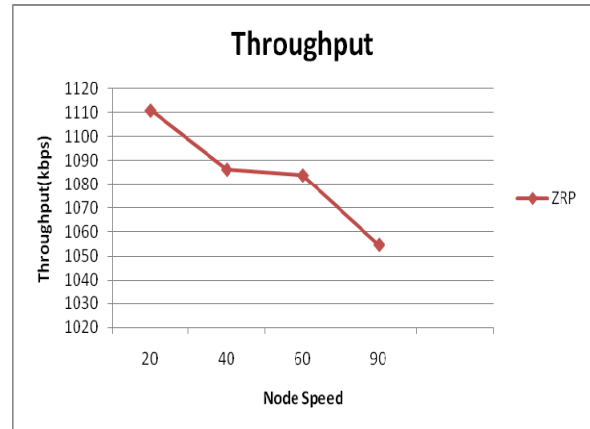


Fig 9 Analysis of Throughput for Node Mobility

Figure 9 illustrates impact of varying node speed on Throughput. I can observe that Throughput decrease with increase in node speed just because of large no of packet packet get lost and successful communication is difficult to establish between nodes.

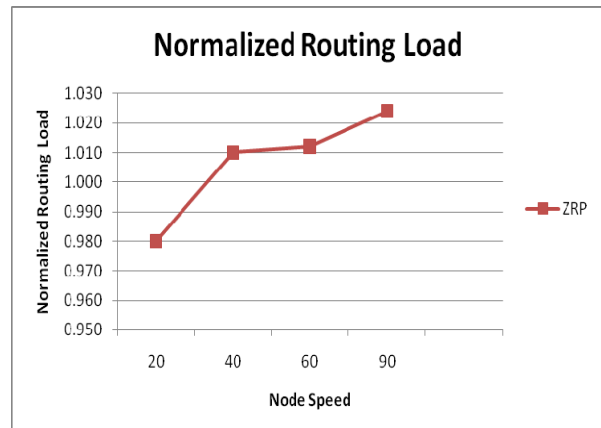


Fig 10 Analysis of Normalized Routing Load for Node Mobility

Figure 10 illustrates impact of varying node speed on Normalized Routing Load. I can observe that Normalized Routing Load increase with increase in node speed just because of more no of control packet generate for establishing right path or searching for correct node for successful transmission of packet.

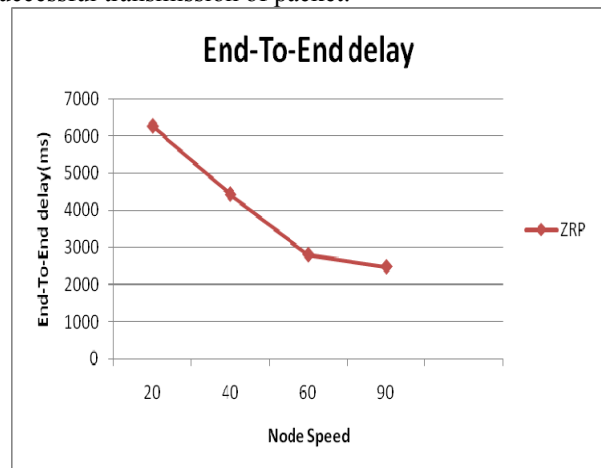


Figure 11 Analysis of End-To-End delay for Node mobility

Figure 11 illustrates impact of varying node speed on End to End delay. I can observe that End to End delay will decrease with increase in node speed as there are less time require for communication as speed of node is more or less buffering of packet is require for communication.

D. Impact of Node Density and Transmission Range

Figure 12, 13 and 14 shows the result obtained from Analysis of Zone Routing Protocol considering that the density of nodes are varying from 25 to 150 in an area of 800m X 800m, the zone radius for each node is 2(constant) and Transmission Range 250 and 500. This is in order to understand the response of ZRP when the number of nodes in the network is varying. Here the routing operation under the given scenario (as indicated in Table – 1 and 2).

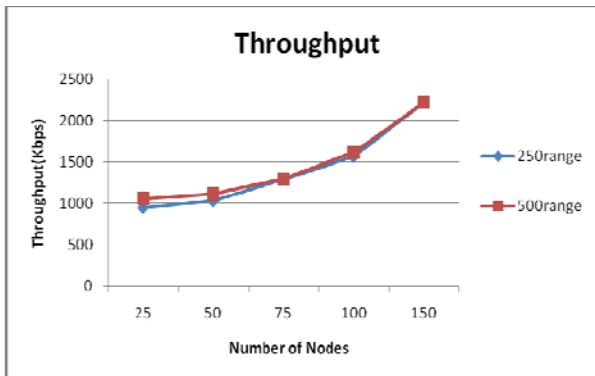


Fig 12: Analysis of Throughput

Figure 12 illustrates that there is a increase in throughput with an increase in node density but the performance is better while taking transmission range 500 rather than 250. It is depend on the connection specify to the node. Here i have take connection $= (0.50\%) * (\text{node})$. The possible reason behind this is that if the number of connection will increase it is possible to successfully transsmitt packet to the destination. Other reason is that increase in number of node it is possible to find the destination using intermidiate node which leads to increase in performance by successfully transmitting packet.

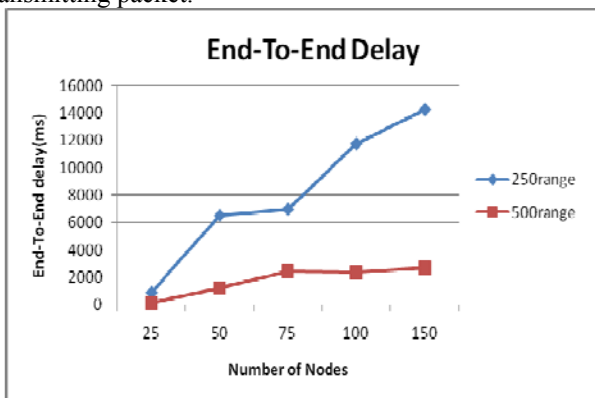


Fig 13 Analysis of End-To-End delay

Based on the simulation result illustrates in figure 13, it is evident that the average end-to-end delay increase with the increase of node density but the end-to-end delay increase is less while taking transmission range 500 rather than 250. Here various factor like buffering of packet, delay in sending packet etc. will affect on performance of ZRP for End-to-End delay.

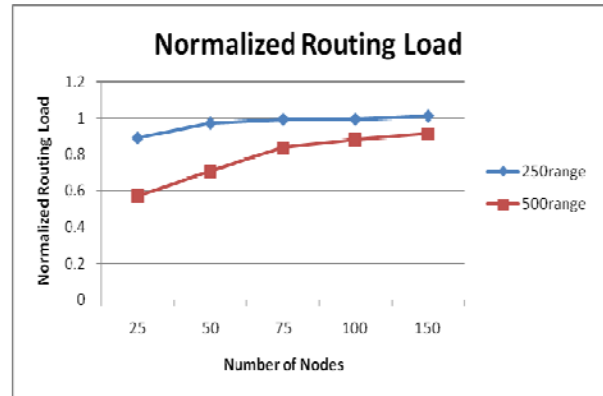


Fig 14 Analysis of Normalized Routing Load

Result shown in figure 14 illustrates that there is a rise in normalized routing load whenever there is an increase in node density but the rise in normalized routing load is less while taking transmission range 500 rather than 250. The possible reason behind the rise of normalized routing load is due to the fact that more number of control packets will be generated whenever there is a slight topological change of the network. This effect is more prominent in denser network than a sparsely dense network, thus tending to increase the normalized routing load. The effect of increased normalized routing load can be interpreted as loss of packets in the network.

VI. CONCLUSION AND FUTURE WORK

The performance of Zone Routing Protocol is evaluated in respect to parameter like Throughput, Normalized Routing Load and End-to-End delay. The result shows that performance of ZRP will increase in case of throughput and decrease in case of normalized routing load and end-to-end delay while varying node density and transmission range but after varying transmission range I got better result than default transmission range. But Transmission range affect the performance of ZRP when we consider large area otherwise there is minor variation in performance. In future I will analyze performance of ZRP by varying node radius.

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