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Evaluation of ZRP using various applications in Adhoc Mobile Wireless Network Using Qualnet Simulator

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Abstract—Without any pre-existing fixed network infrastructure with rapid configuration of wireless connections on-the-fly, network topology in MANETs keep on changing rapidly. Thus achieving data transmissions between wireless nodes in MANETs with improved QoS parameters become a challenging issue. To achieve this one has to concentrate on the routing protocol they choose. Routing is the main part of wireless adhoc network conventionally there are two approaches first one is Proactive and another one is Reactive. Both these approaches have some substantial disadvantage and to overcome hybrid routing protocols designed. ZRP (Zone Routing Protocol) is one of the hybrid routing protocols, it takes advantage of proactive approach by providing reliability within the scalable zone, and for beyond the scalable zone it looks for the reactive approach.In our project we proposed an algorithm to provide improved quality of service via hybrid routing protocol Zone Routing Protocol (ZRP) and compared its performance using different applications like File Transfer Protocol (FTP) and Constant Bit Rate (CBR).We have used well known network simulator QualNet to compare QoS parameters viz., throughput, number of bytes received, number of packets received, average end-to-end delay and the time at which first packet is been received for the different applications in Zone Routing Protocol.

Keywords—ZRP, CBR, FTP, QoS parameters etc.

INTRODUCTION

Wireless networks have continued to play prominent roles in day to day communication. It is widely used in military applications, industrial applications and even in personal area networks. It has been very popular in different applications in view of its different valuable attributes which includes simplicity of installation, reliability, cost, bandwidth, total required power, security and performance of the network. But similar to wired networks, it also make use of fixed infrastructures such as cordless telephone, cellular networks, Wi-Fi, microwave communication, Wi-MAX, satellite communication and RADAR etc.

Nowadays, next generation wireless ad-hoc networks are widely used because of user base of independent mobile users, need for efficient and dynamic communication in emergency/rescue operations, disaster relief efforts, and military networks and also for different applications. The network covers a large geographical area without fixed topology which may change dynamically and unpredictably. These networks improve the scalability of the network compared to the infrastructure-based wireless networks because of its decentralized nature. In any critical scenarios such as natural disasters, military conflicts etc., ad-hoc network provides better performance due to the minimum configuration and quick operations.

Ad-hoc networks can be classified into three categories depending on their applications: Mobile Ad-hoc Networks (MANETs), Wireless Mesh Networks (WMNs) and Wireless Sensor Networks (WSN). Routing in MANETs is one of the primary functions that, each node must achieve network functions at any point of time. Routing enables connections between nodes those are not within each other's vicinity. We have presented a comparison of Zone Routing Protocol using FTP and CBR to have a better understanding of the performance of the protocol..

ZONE ROUTING PROTOCOL

Zone Routing Protocol or ZRP was the first hybrid routing protocol with both a proactive and a reactive routing component. ZRP was first introduced by Haas in 1997 whereby whole network area is divided into several small zones to perform its operation. Zone size or radius does not depend on distance or radius; it depends on the number of hops. It is applicable in a wide variety of mobile Ad-hoc network with diverse mobility across a large span. It uses separate strategy to find out a new route between nodes, which are lying within or outside the zone.

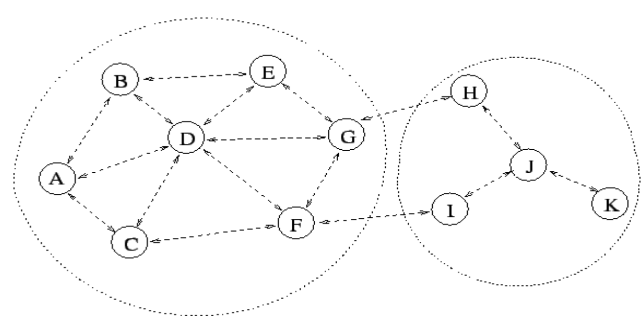

Fig.2. Zone Routing Protocol Structure

ZRP is proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by routing discover in reactive routing protocols. ZRP defines a zone around each node consisting of its neighbourhood (e. g. k=3).

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In ZRP, the distance and a node, all nodes within -hop distance from node belongs to the routing zone of node.ments. When you submit your initial full paper version, prepare it in two-column format, including figures and tables.

A. .Architecture

ZRP refers to the locally proactive routing component as the IntrA-zone Routing Protocol (IARP). The globally reactive routing component is named IntEr-zone Routing Protocol (IERP). IERP and IARP are not specific routing protocols. Instead, IARP is a family of limited-depth, proactive link-state routing protocols. IARP maintains routing information for nodes that are within the routing zone of the node. Correspondingly, IERP is a family of reactive routing protocols that offer enhanced route discovery and route maintenance services based on local connectivity monitored by IARP. The fact that the topology of the local zone of each node is known can be used to reduce traffic when global route discovery is needed. Instead of broadcasting packets, ZRP uses a concept called bordercasting. Border casting utilizes the topology information provided by IARP to direct query request to the border of the zone. The bordercast packet delivery service is provided by the Bordercast Resolution Protocol (BRP). BRP uses a map of an extended routing zone to construct bordercast trees for the query packets. Alternatively, it uses source routing based on the normal routing zone. By employing query control mechanisms, route requests can be directed away from areas of the network that already have been covered.

In order to detect new neighbour nodes and link failures, the ZRP relies on a Neighbour Discovery Protocol (NDP) provided by the Media Access Control (MAC) layer. NDP transmits “HELLO” beacons at regular intervals. Upon receiving a beacon, the neighbour table is updated. Neighbours, for which no beacon has been received within a specified time, are removed from the table. If the MAC layer does not include a NDP, the functionality must be provided by IARP. The relationship between the components is illustrated in Figure 3. Route updates are triggered by NDP, which notifies IARP when the neighbour table is updated.

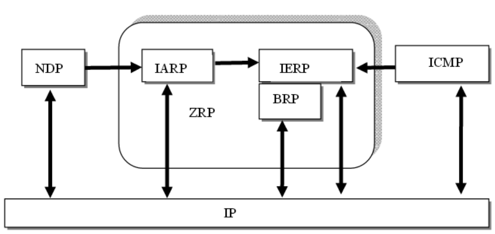

Fig.3 ZRP ARCHITECTURE

IERP uses the routing table of IARP to respond to route queries. IERP forwards queries with BRP. BRP uses the routing table of IARP to guide route queries away from the query source.

B. Routing

A node that has a packet to send first checks whether the destination is within its local zone using information provided by IARP. In that case, the packet can be routed proactively. Reactive routing is used if the destination is outside the zone. The reactive routing process is divided into two phases: the route request phase and the route reply phase. In the route request, the source sends a route request packet to its peripheral nodes using BRP. If the receiver of a route request packet knows the destination, it responds by sending a route reply back to the source. Otherwise, it continues the process by bordercasting the packet. In this way, the route request spreads throughout the network. If a node receives several copies of the same route request, these are considered as redundant and are discarded, the reply is sent by any node that can provide a route to the destination.

To be able to send the reply back to the source node, routing information must be accumulated when the request is sent through the network. The information is recorded either in the route request packet, or as next-hop addresses in the nodes along the path.

In the first case, the nodes forwarding a route request packet append their address and relevant node/link metrics to the packet. When the packet reaches the destination, the sequence of addresses is reversed and copied to the route reply packet. The sequence is used to forward the reply back to the source. In the second case, the forwarding nodes records routing information as next-hop addresses, which are used when the reply is sent to the source. This approach can save transmission resources, as the request and reply packets are smaller.

The source can receive the complete source route to the destination. Alternatively, the nodes along the path to the destination record the next-hop address in their routing table.

In the bordercasting process, the bordercasting node sends a route request packet to each of its peripheral nodes. This type of one-to-many transmission can be implemented as multicast to reduce resource usage. One approach is to let the source compute the multicast tree and attach routing instructions to the packet. This is called Root-Directed Bordercasting (RDB). Another approach is to reconstruct the tree at each node, whereas the routing instructions can be omitted. This requires that every interior node knows the topology seen by the bordercasting node. Thus, the nodes must maintain an extended routing zone with radius 2 ρ-1 hops. Note that in this case the peripheral nodes where the request is sent are still at the distance ρ. This approach is named Distributed Bordercasting(DB).

The zone radius is an important property for the performance of ZRP. If a zone radius of one hop is used, routing is purely reactive and bordercasting degenerates into flood searching. If the radius approaches infinity, routing is reactive. The selection of radius is a tradeoff between the routing efficiency of proactive routing and the increasing traffic for maintaining the view of the zone.

C. Route maintenance

Route maintenance is especially important in ad-hoc networks, where links are broken and established as nodes move relatively to each other with limited radio coverage. In

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purely reactive routing protocols, routes containing broken links fail and a new route discovery or route repair must be performed. Until the new route is available, packets are dropped or delayed.

In ZRP, the knowledge of the local topology can be used for route maintenance. Link failures and sub-optimal route segments within one zone can be bypassed. Incoming packets can be directed around the broken link through an active multi-hop path. Similarly, the topology can be used to shorten routes, for example, when two nodes have moved within each other's radio coverage. For source-routed packets, a relaying node can determine the closest route to the destination that is also a neighbour. Sometimes, a multi-hop segment can be replaced by a single hop. If next-hop forwarding is used, the nodes can make locally optimal decisions by selecting a shorter path.

D. Working Principle

Consider the network in Figure 4. The node S has a packet to send to node X. The zone radius is ρ=2.The node uses the routing table provided by IARP to check

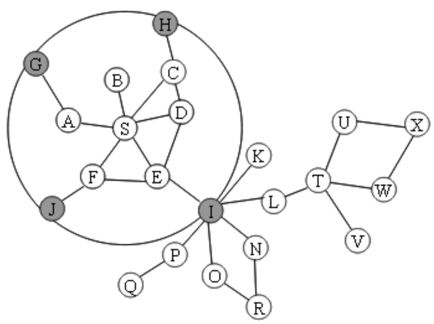

Fig.4 Routing zone of node S

whether the destination is within its zone. Since it is not found, a route request is issued using IERP. The request is bordercast to the peripheral nodes (gray in the picture). Each of these searches their routing table for the destination Node I does not find the destination in its routing table. Consequently, it broadcasts the request to its peripheral nodes, shown in gray in Figure 5. Due to query control mechanisms, the request is not passed back to nodes D, F and S.

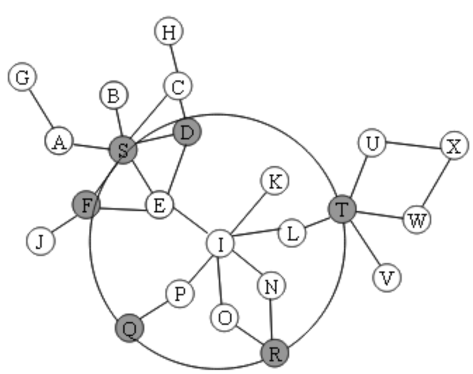

Fig.5 Routing zone of node I

Finally, the route request is received by node T, which can find the destination in its routing zone, shown in Figure 6. Node T appends the path from itself to node X to the path in the route request. A route reply, containing the reversed path is generated and sent back to the source node. If multiple paths to the destination were available, the source would receive several replies.

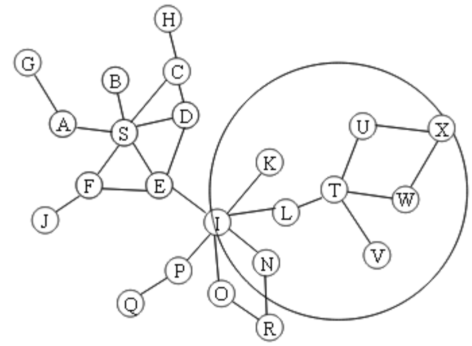

Fig.6 Routing zone of node T

E. Query-Control Mechanisms

Bordercasting can be more efficient than flooding, since route request packets are only sent to the peripheral nodes, and thus only on the corresponding links. Further efficiency can be gained by utilizing multicast techniques. In that case, only one packet is sent on a link although several peripheral nodes can reside behind this link.

However, since the routing zones of neighbouring nodes overlap, each node may forward route requests several times, which results in more traffic than in flooding.When a node bordercasts a query, the complete routing zone is effectively covered. Any further query messages entering the zone are redundant and result in wasted transmission capacity. The excess traffic is a result from queries returning to covered zones instead of covered nodes as in traditional flooding.

To solve this problem, ZRP needs query-control mechanisms, which can direct queries away from covered zones and terminate query packets before they are delivered to peripheral nodes in regions of the network already covered by the query. ZRP uses three types of query-control mechanisms: query detection, early termination and random query-processing delay. Query detection caches the queries relayed by the nodes. With early termination, this information is used to prune bordercasting to nodes already covered by the query.

F. Query detection

When a bordercast is issued, only the bordercasting node is aware that the routing zone is covered by the query. When the peripheral nodes continue the query process by bordercasting to their peripheral nodes, the query may be relayed through the same nodes again. To illustrate with an example, the node S in Figure 7 bordercasts a query to its peripheral nodes F–J. As the node J continues by bordercasting to the nodes C, S and E, the query is again relayed by nodes D and E. The query issued by node J to nodes C, S and E is redundant, since these nodes have been covered by the previous query.

To be able to prevent queries from reappearing in covered regions, the nodes must detect local query relaying activity. BRP provides two query detection methods: QD1 and QD2.

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Firstly, the nodes that relay the query are able to detect the query (QD1). Secondly, in single-channel networks, it is possible to listen to the traffic by other nodes within the radio coverage (QD2). Hence, it is possible to detect queries relayed by other nodes in the zone. QD2 can be implemented by using IP broadcasts to send route queries. Alternative, unicast can be used if the MAC and IP layers operate in promiscuous mode.

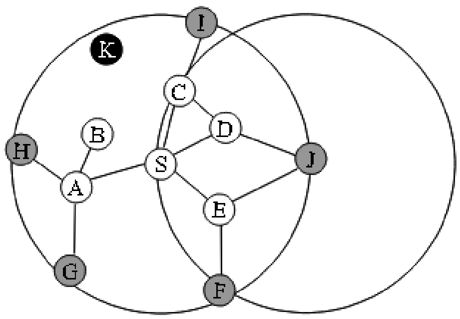


Fig.7 Query detection Example

In the above example, all nodes except node B relay the query of S. They are thus able to use QD1. Node B does not belong to the bordercast tree, but it is able to overhear the relayed query using QD2. However, node K does not overhear the message, and is therefore unaware that the zone of node S is covered.

A query detection table is used to cache the detected queries. For each entry, the cache contains the address of the source node and the query ID. The address–ID pair is sufficient to uniquely identify all queries in the network. The cache may also contain other information depending on the query detection scheme. Especially the address of the node that most recently bordercasted a query is important.

G. Early termination

With Early Termination (ET), a node can prevent a route request from entering already covered regions. Early termination combines information obtained through query detection with the knowledge of the local topology to prune branches leading to peripheral nodes inside covered regions. These regions consist of the interior nodes of nodes that already have bordercast the query. A node can also prune a peripheral node if it has already relayed a query to that node.

Early termination requires topology information extending outside the routing zone of the node. The information is required to reconstruct the bordercast tree of other nodes within the routing zone. The extended routing zone has a radius of $2r-1$. Alternatively, in the case of root-directed bordercast (RDB), the topology of the standard routing zone and information about cached bordercast trees can be used.

In the previous example, node E can use the information in its query detection table to prune the query that the node J sends to its peripheral node F. Node E has an extended routing zone with radius $2r-1=3$, shown as a dashed circle in Figure 8.

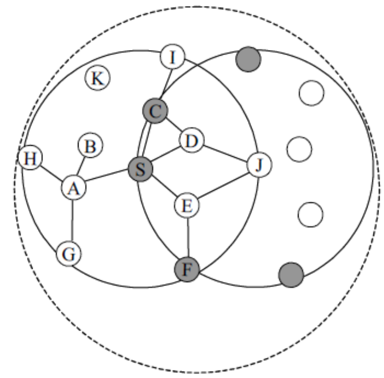


Fig.8 The Extended Routing of zone E

H. Random query-processing delay

When a node issues a node request, it takes some time for the query to be relayed along the bordercast tree and to be detected through the query detection mechanisms. During this time, another node may propagate the same request. This can be a problem when several nearby nodes receive and re-broadcast a request at roughly the same time.

To reduce the probability of receiving the same request from several nodes, a Random Query-Processing Delay (RQPD) can be employed. Each bordercasting node waits a random time before the construction of the bordercast tree and the early termination. During this time, the waiting node can detect queries from other bordercasting nodes and prune the bordercast tree. To avoid additional route discovery delay, the delay can be combined with the pre-transmission jitter used by many route discovery protocols.

Assume that in Figure 8 the nodes C and S both receive a query. Node C schedules a bordercast to its peripheral node E, and node S to its peripheral node F. Without RQPD, both nodes would issue the broadcast simultaneously, and thereafter detect the message of the neighbor node. With RQPD, the node C may detect the query sent by node S during the delay, and prune the branch leading to E.

I. Caching

This project further proposes caching as a technique for reducing control traffic. The nodes cache active routes, and by using this cache, the frequency of route discovery procedures can be reduced. Changes in network topology, such as broken links, are compensated by local path repair procedures. A new path then substitutes the path between the ends of the broken link and a path update message is sent to the endpoints of the path. Since the repair reduces the efficiency of the routes, the endpoints may initiate a new route discovery procedure after a number of repairs.

J. IntrAzone Routing Protocol(IARP)

IARP is a limited scope proactive routing protocol. The scope of IARP is defined by the routing zone radius: the distance in hops that IARP route updates are relayed. The routing zone for a node X is defined as the set of nodes whose minimum distance in hops over which X is no greater than a parameter referred to as the zone radius. An important subset of the routing zone nodes is the collection of nodes whose minimum distance to the central node is exactly equal to the zone radius, and these are called peripheral nodes.

Every node will broadcast its local routing information within its own routing zone. This causes each node to maintain a local routing table, which contains the routes to the nodes in its routing zone. By using IARP, a node can get a route without any delay if the destination is within its routing zone.

K. IntErzone Routing Protocol(IERP)

IERP is the global reactive routing component of ZRP. When a node needs a route which is not yet available, IERP will help to find it. IERP initiates a route discovery process; instead of flooding the request, it uses 'Bordercast' along with a query control mechanism, which will be described in the following subsections.

L. Bordercast Resolution Protocol

Bordercasting makes use of the information that IARP provides and directs the route request outward, via multicast, to a set of surrounding peripheral nodes. Then the peripheral nodes perform bordercasting again if they cannot reply to this query. Finally, the query spreads throughout the network. There are two approaches to performing the bordercasting: one is called root directed bordercast; the other is called distributed bordercast.

The root directed bordercast needs the source node and the peripheral nodes to construct their multicast trees and append forwarding instructions to the routing query packet. This result in additional routing overhead and increases when the zone radius increases, thus obscuring the benefits of ZRP. The distributed bordercast needs each node to maintain an extended routing zone, which increases the number of local routing information exchanges. However, it also reduces the requirement for route discovery.

III. SIMULATION AND RESULTS

Simulation for various scenarios had been performed in QUALNET 4.5 Version. It is performed in 2 Dimensional scenario taking terrain of 800*800.Though ZRP can be done by placing the nodes in the scenario itself, because of transmission limitation of nodes, delays, simulation time are longer which may take half day sometimes even a day for entire nodes to complete the process. In-order to overcome this issue, nodes are taken under 1 hierarchy. Assigning source and destination is made to analyse the delay in packet transmission and reception, end to end delay between hierarchies.

For example: Taking 200 nodes into consideration, and placing it in individual hierarchy. The scenario is shown below:

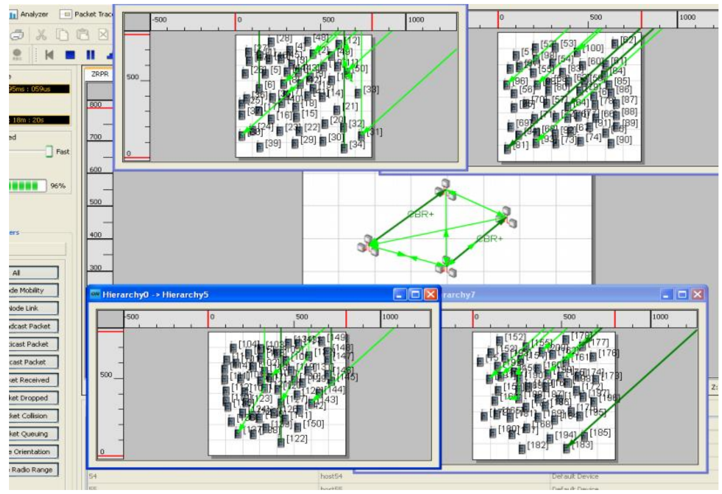
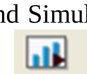


Fig.9.Simulation for 200 nodes(CBR)

Algorithm(CBR):

1. Open Qualnet Simulator → Fix the terrain → Fix the hierarchy and allocate nodes .
2. Then, Configure the Routing Protocol as ZRP → Connect the Source and Destination → Give the application as CBR
3. Then, Save and Simulate the scenario and Analyse the results using  .

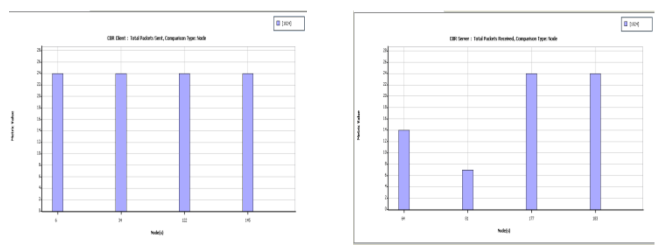


Fig 10.Total packets Transmitted and Received

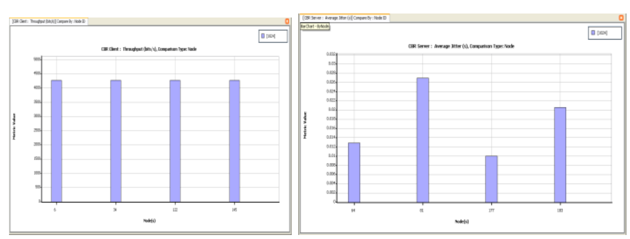


Fig.11.Throughput in the client and server

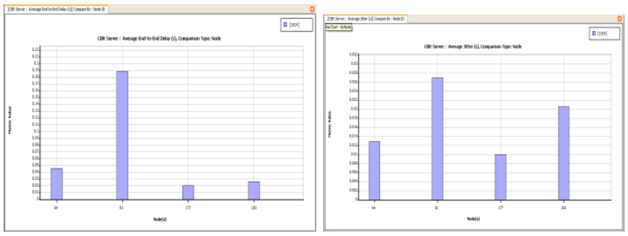


Fig.12.Average Jitter and End to End Delay

The same process is carried out by connecting the source and destination with FTP application. The simulation part is shown below.

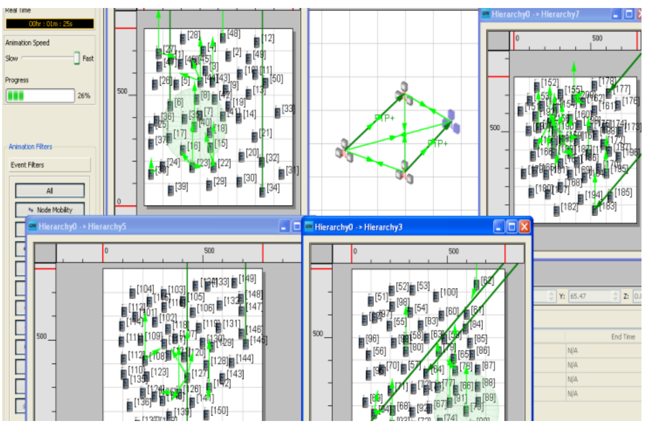
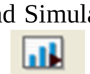


Fig.13.Simulation for 200 nodes (FTP)

Algorithm(FTP):

1. Open Qualnet Simulator → Fix the terrain → Fix the hierarchy and allocate nodes
2. Then,
   Configure the Routing Protocol as ZRP → Connect the Source and Destination → Give the application as FTP
3. Then, Save and Simulate the scenario and Analyse the results using .

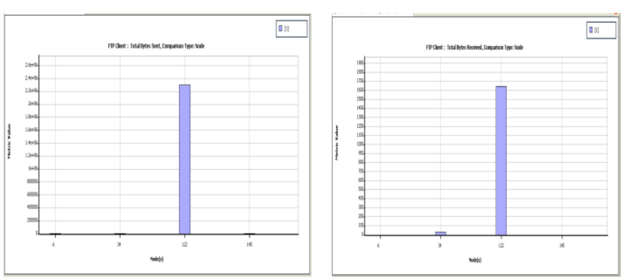


Fig.14.Total bytes Transmitted and Received

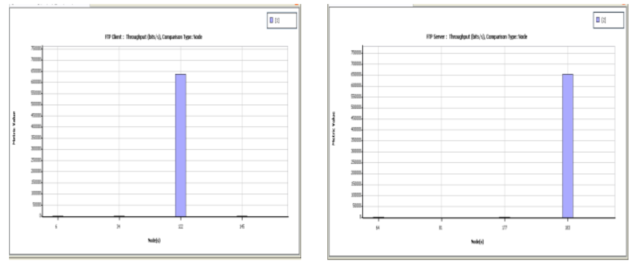


Fig.15.Throughput by client and server

Variation in Number of Nodes:

To witness the various delay, end to end delay, simulation has been made by increasing and decreasing the number of nodes in a hierarchy. From 200 nodes, the number of nodes is decreased to 20 nodes in each hierarchy; total of 100 nodes in the entire scenario is shown below

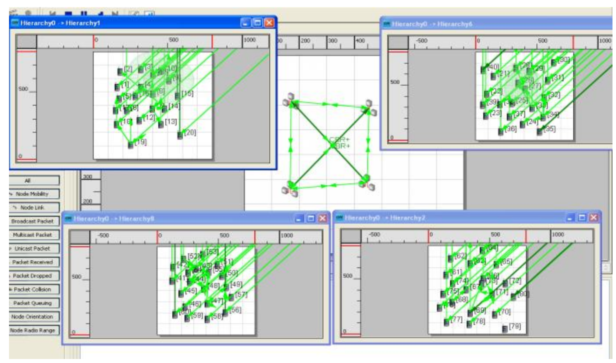


Fig.16.Simulation for 20 nodes(CBR)

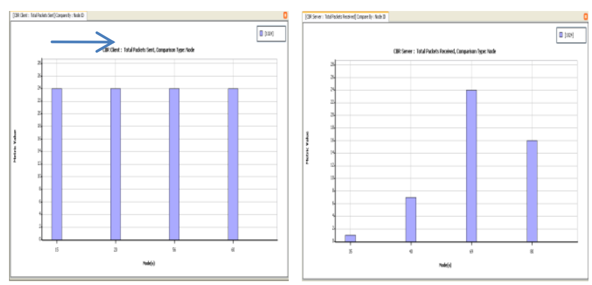


Fig.17.Total packets Transmitted and Received

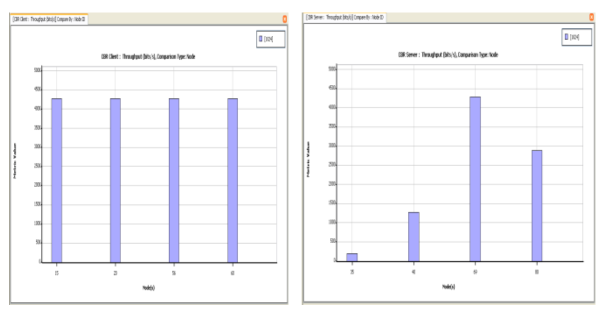


Fig.18.Throughput by the client and server

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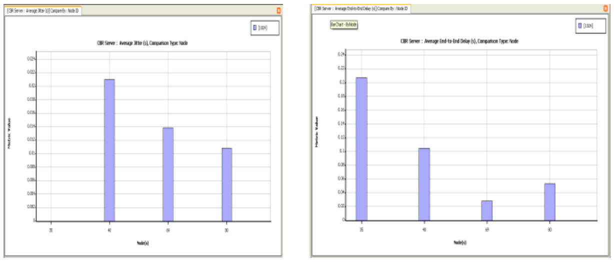

Fig.19.Average Jitter and End to End to delay

The same process is carried by connecting the source and destination with FTP application. The simulation part is shown below.

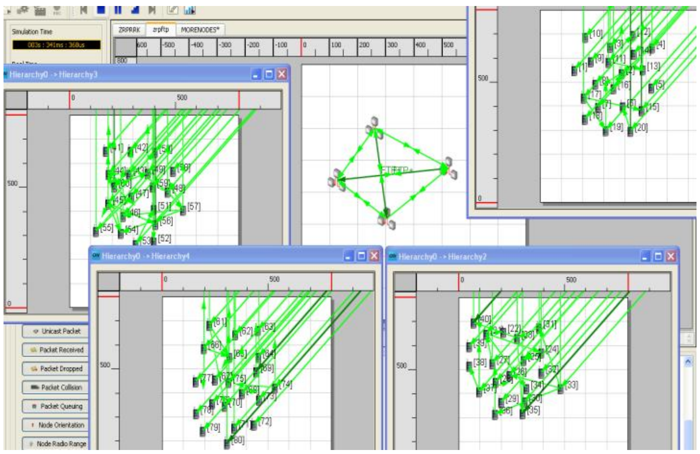

Fig.20.Simulation of 20 nodes(FTP)

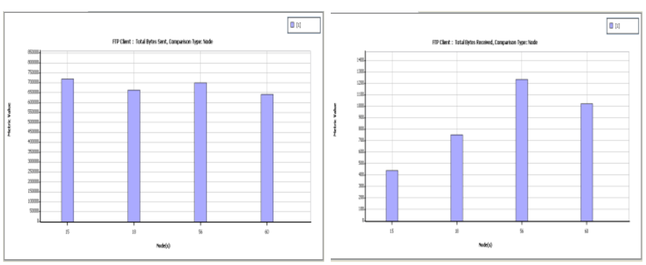

Fig.21.Total bytes Transmitted and Received

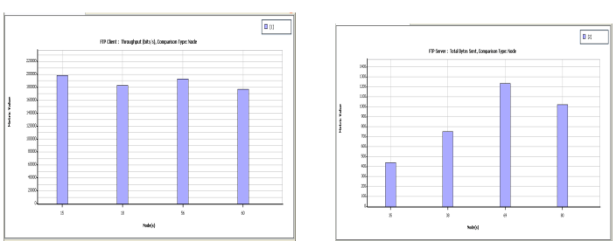

Fig.22.Throughput by client and server

From 200 nodes, the number of nodes are increased to 250 nodes by increasing the number of hierarchies, the scenario is shown below.

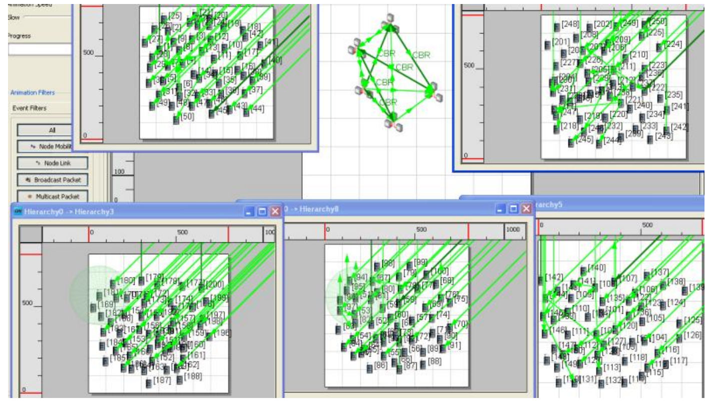

Fig.23.Simulation for 5 Hierarchies(CBR)

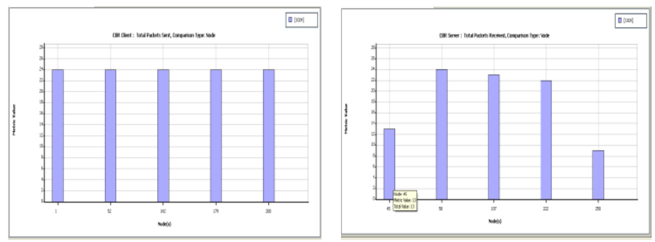

Fig.24.Total packets Transmitted and Received

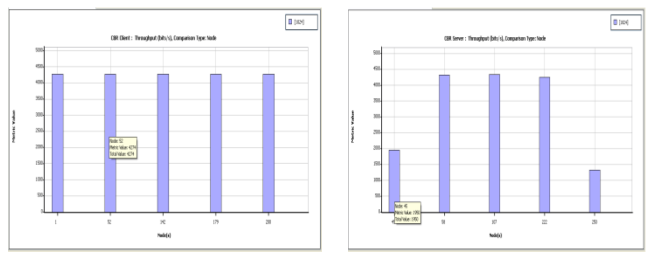

Fig.25.Throughput by client and server

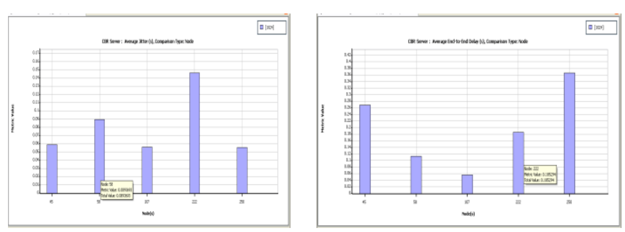

Fig.26.Average Jitter and End to End Delay

The same process is carried by connecting the source and destination with FTP application. The simulation part is shown below.

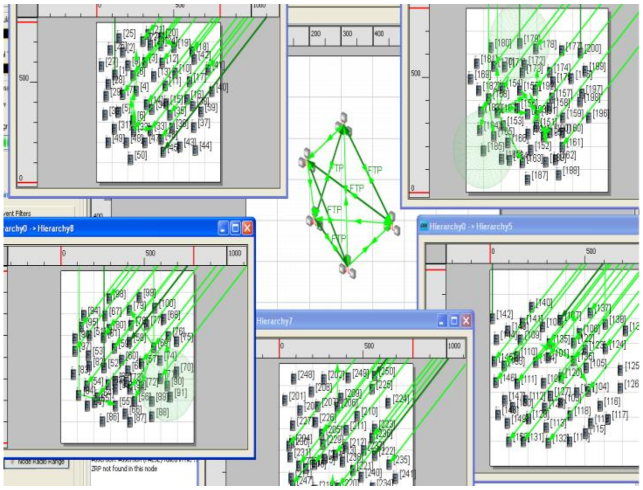
Fig.27.Simulation for 5 Hierarchies(FTP)

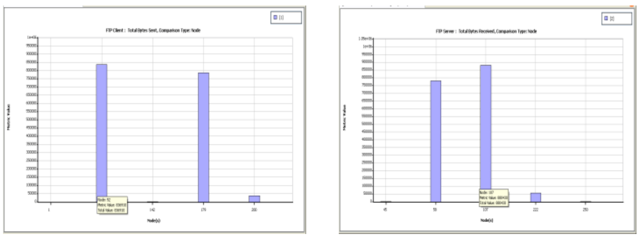
Fig.28.Total bytes Transmitted and Received

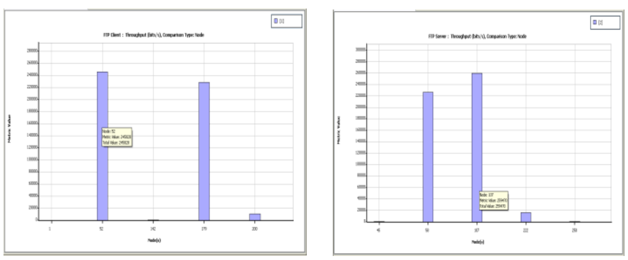
Fig.29.Throughput in client and server

Note: TBS-Total Bytes Sent; TBR-Total Bytes Received; TPS-Total Packet Sent;TPR-Total Packet Received; AJ-Average Jitter; AEED-Average End to End Delay.

CONCLUSION

Without any pre-existing fixed network infrastructure with rapid configuration of wireless connections on-the-fly, network topology in MANETs keep on changing rapidly. Thus achieving data transmissions between wireless nodes in MANETs with improved QoS parameters become a challenging issue. To achieve this one has to concentrate on the routing protocol they choose.

In this work we proposed to provide improved quality of service via hybrid routing protocol Zone Routing Protocol (ZRP) with various application involving in it. Comparing each scenario will help the ISP and Network designers to analyse and implement a protocol in real time locations. Analysing ZRP will help in acquiring route acquisition delay and quick route reconfiguration during link failure. These parameters viz., route acquisition delay and quick route reconfiguration have their impact on increase in end to end delay, this automatically decreases the number of packets received thus the throughput.

We used well known network simulator QualNet version 4.5 to compare QoS parameters viz., throughput, number of bytes received, number of packets received, average end-to-end delay by taking CBR and FTP. Thus by the implementation of our proposed algorithm the average end-to-end delay will be minimized, which results in better throughput. So the number of bytes and total packets received at the destination will be increased.

The above process helps to compare not only the delays carried out by increasing and decreasing the number of nodes, but also transmission taking place with various application. In future, we will implement this completed algorithm in real time application and compare the performance with HTTP and TelNet.

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