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PERFORMANCE ANALYSIS OF GENETIC ALGORITHM BASED UNICAST AND MULTICAST ROUTING OPTIMIZATION MODEL FOR MOBILE ADHOC NETWORKS

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ABSTRACT

Wireless Mobile devices are designed to work in co-operative manner in Mobile Ad Hoc Networks (MANETs). These devices are connected via wireless link to communicate with each other. In MANET, transmission failure occurs due to several reasons, such as node mobility, channel collision and abnormal channel conditions. Even though several routing schemes are available to handle these problems, robust and novel solution is needed to provide better communication among large scale wireless devices. The solution must have capability to handle poor channel condition and connectivity failures in both unicast and multicast transmission. Genetic Optimization Based Routing (GOBR) protocol is developed to outperform during bad channel conditions and high mobility situations and to handle communication failure. GOBR provides unique, methodology to establish unicast and multicast communication based connectivity and resource availability of wireless devices. Simulation results attain better performance for GOBR compare to Adhoc On-Demand Distance Vector Routing Protocol (AODV) and Multicast operation of Ad-hoc On-demand Distance Vector routing protocol (MAODV) in both unicast and multicast transmission.
Keywords: *MANET, GA, RDP, RDR and Tree and Load Balancing.*

1. INTRODUCTION

In recent years, there has been a lot of study of Mobile Adhoc Networks (MANETs). A MANET is a self-configuring network of mobile devices connected by a wireless link without fixed infrastructure. Due to shorter radio transmission range, multiple hops are essentially needed for communication. Further, node mobility causes the topology of the networks to be dynamically changed, frequently re-initiating the route discovery procedure.

The major contribution of the proposed GOBR algorithm provides end-to-end bandwidth calculation and assignment, and time slot management which utilize the global resource information along the route to determine the unicast routing. The proposed paper outperforms the existing one, in the sense of new cross-layer framework of data transmission of an optimized unicast and multicast routing method using Genetic Algorithm (GA) that may be real time (e.g., voice conversations) or elastic (e.g., http).This work can be significantly demonstrated by the simulation result in an efficient manner.

Genetic Algorithm (GA) is a multi-purpose search and optimization algorithm. The results of the genetic operations are the next generation that gives the solution. The process continues until a solution is found or a termination condition exists. The idea behind genetic algorithm is to have the chromosomes in the population to slowly converge to an optimal solution.

GA is used to select the channel aware multi-traffic effective path and it also achieves the acceptable load balancing. GAs is among the most popular control tool in MANETs particularly focusing on the topology control and to optimize the routes in MANETS. A systematic performance evaluation of this protocol is done by performing certain simulations under network simulator (NS-2). Finally the performance of this protocol has been compared with MAODV and AODV.

The remainder of this paper is organized as follows. Section 2, related work describes about achievement of efficient routing in unicast and

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multicast traffic. GOBR network design assumptions, GOBR protocol overviews are given in the sections 3 and 4 respectively. Section 5 and 6 describe unicast and multicast data transmission. In section 7 illustrates about GA to give the best path for the identified paths for both data transmission. The simulation result is described in section 8, followed by conclusion in section 9.

2. RELATED WORK

Due to lack of space limitations a small representative sample of prior cross-layering approach is required to attempt routing and channel access in an efficient manner in mobile ad hoc networks. A comprehensive survey on routing protocols that provide some sort of support for QoS in wireless sensor networks is proposed by Melodia et.al. [1] and MANETs by Chen et.al [2]. Like MAODV [3], this protocol conforms either proactive or reactive routing methods. It maintains any neither routing table nor exchange routing information periodically. In MAODV, source node performs paths reconstruction process and creates multiple disjoint routes to reach the destination node. The difference between AODV [4] and MAODV is that instead of sending RREP in single path, it sends RREP message in multiple disjoint paths. During the RREQ and RREP process intermediate nodes creates and updates the entry to reach the destination and source nodes.

Multiple Access Collision Avoidance with Piggyback Reservation (MACA/PR) was one of the first approach proposed by C.R.Lin [5] attempting to integrate channel access, routing and traffic management. PRIME by Garcia-Luna-Aceves et.al [6]] is mesh routing algorithm that uses enclave model to establish routes and channel access scheduling is proposed by [7]. DARE by Emma Carlson et.al. [8] is a channel access protocol for MANETs that provides end-to-end reservations. Soft-TDMAC by Petar Djukic et.al [9] is a synchronized layer-2 routing protocol that maximize throughput and reduces retransmissions. Cai et al [10] proposed an algorithm for end-to-end bandwidth allocation that focuses on maximizing the number of flows with bandwidth restrictions that a MANET can accommodate. Setton et al. [11] proposed a cross-layer framework that incorporates adaptations across all layers of the protocol stack.

Network stability metric based evaluation is proposed by Yuanyuan et al. [14]. A normalized method is used for network stability mechanism based on neighbor mobility, which is used in multicast tree merging. NBS_MAODV uses GPS positional device to identify the location of each nodes and it reduces the link fracture links. Dynamic time slot assignment for QoS multicast routing is proposed by Neng-Chung Wang et. al [15]. The slot assignment process for multicast tree is modeled by availability of bandwidth during data transmission. In case of heavy traffic the unallocated time slots are efficiently designed for upstream and downstream nodes. Bandwidth resource availability based on multicast tree routing is established by Nehan Moh et. al [16]. The flood request is initiated by source node and it is forwarded by all nodes in the network to establish the multicast tree. The flood reply message is used to create the multicast tree. It provides a reduced bandwidth by dropping duplicate message before forwarding. The congestion control is achieved by time delay reduction. High level QoS requirement based multicast routing is proposed by Salim et. al [17]. MF_Scout is propagated by multicast group head which is flooded throughout the network. Group joint message is initiated by the multicast members to the multicast source node as MB_Scout message. By verifying the sequence number of this message the duplicate forward is reduced. Congestion avoidance mechanism based multicast communication is established by G.S.Sreedhar et. al.[18] in MALMR. The MAC layer congestion avoidance mechanism is modeled in MALMR which uses point-to-point communication among neighbors. The CSMA avoiding ACK technique is used to deduce the congestion and instead by broadcasting procedure for multicasting, it uses the unicast communication model by including request to send and clear to send (RTS-CTS) mechanism. MALMR uses mesh based multicasting transmission to control the congestion and to improve the multicast routing process.

The proposed framework is mostly based on centralized algorithms and a link-state approach is needed, which is not well suited for the highly dynamic MANETs or very large ad hoc networks. This paper the best path is achieved by scheduling certain characteristics like energy requirements, BW reservations, BW calculation and link failure

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of the nodes in the MANET. The scheduling operation is done prior to data transmission. The tool used is GA along with GOBR protocol to achieve the best solution by route optimization.

3. GENETIC ALGORITHM BASED ROUTING (GOBR) NETWORK MODEL

In this paper a GOBR network model has been proposed which has a number of nodes that are deployed and moving in any direction. The network model can be described with following assumptions.

In GOBR network the wireless devices are configured with single interface to communicate with other devices. Medium Access Control model are designed to work in co-operative channel access manner. The network is modeled as *G= (V, E),* where *V*- Vertices and *E* - Edges with communication radius R. All nodes in the network have at least one communication link to establish connection with all other nodes. (i.e., all nodes are connected). The network members are equipped with homogenous energy model with fixed initial energy. Node energy decreases during data and message transmission including circuit energy loss either in onehop or multihop manner. Nodes of the network are aware of its geographic location, i.e., latitude and longitude.

4. GOBR PROTOCOL OVERVIEW

GOBR protocol is designed to work in co-operative manner in unicast communication. The protocol assumes that the wireless devices are sharing a single wireless channel organized into time frames in both fixed and various number of time slots. The protocol performs following functions to handle communication such as channel reservation, route reservation, connection maintenance, route failure handling and traffic management.

In each frame, distributed election method is used to access time slots and reserves the overall time slot for all nodes based on its requirement. A virtual communication link is established to provide support among all nodes for both real and non real time elastic traffic model. The connected node model is established to route data packets from source to destination by creating virtual mesh link.

GOBR uses priority queuing based reservation model for each and every incoming and outgoing traffic that implement channel access schedules. The queuing model has the capability to distinguish the real time and non real time traffic. It creates a new field in common header to identify and set the priority of each packet.

4.1. Routing Model for Unicast and Multicast Data Transmission

The routing model for both unicast and multicast transmission uses two different optimized solutions to transmit and forward the data packets, which is briefly described in following sections.

4.1.1. Channel Reservation

Distributed election method is modeled to reserve the channel to transmit data over wireless medium. The time frame format is of channel reservation as shown in fig 1.

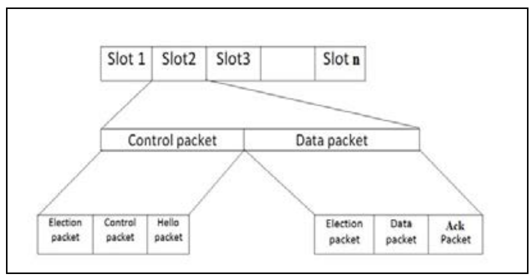

Figure 1: Time Frame format

For each time slot nodes have data or control packet to transmit, send election message over medium, which is dissimilar to RTs message in IEEE 802.11. The similarity during broadcasting is channel reservation and dissimilarity is election packet, where RTs is unicast. The priority assignment model added in MAC frame gives the priority to the nodes while sending the reservation packet. All nodes have equal priority to transmit hello and other control messages.

4.1.2. Connection Management

Connection management starts functioning by establishing connection with neighbor nodes and maintain second hop connecting list. Each slot node sends hello message that includes node id, latitude, and longitude, current energy level, moving speed and direction with its one hop neighbor list that is updated during last time slot. The message is broadcasted over the

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wireless medium and based on its communication radius (R), it is received by neighbor nodes within its coverage area. Nodes receiving hello message of its neighbor create a new entry or update the existing neighbor entry. Nodes receiving the hello message update its routing table for both one hop and two hop neighbors. The criteria are that the nodes that included in one hop list are ignored in two hop list.

4.1.3. Connection Maintenance

All nodes create its neighbor list with specified expire time which is updated by the time of last hello message reception. If the expire time is less than the current clock time of the node, then it is removed from the neighbor list. Whenever node is removed from the neighbor list then it also removed from the forwarding route list. This will lead to dynamic updation of route which is used to handle routing packet. Hence, the connection maintenance is effectively modeled in GOBR.

4.1.4. Route Reservation

Route reservation process is initiated after establishing complete path from source to destination and it is maintained during the route failure handling. For this purpose each node maintains a table, namely unicast routing forward table. Route reservation process takes place based on priority of data. For each forward entry, expire time is used to remove the unused connection. The reservation is ordered based on traffic priority. Because of this property, the protocol perfectly achieves the load balancing during data transmission in unicast and multicast.

Route reservation process takes place based on priority of data. For each forward entry, expire time is used to remove the unused connection. The reservation is ordered based on traffic priority. The protocol is designed to handle the situation of avoiding or minimizing the use of same link for more than one traffic. Because of this property, the protocol perfectly achieves the load balancing during data transmission in both unicast and multicast.

4.1.5. Route Failure Handling (Link Failure Prediction)

By using link layer detection process i.e., by transmitting RTS - CTS and data message transmission the current link failure detection process is achieved. Once link failure occurs, node initiate route recovery process by sending reroute establishment message in unicast transmission and recovery is done by alternate sub trace establishment process in multicast transmission. Link failure prediction is performed by validating node position and its direction of movement to outside of its transmission range. If the link failure process is predetermined then it immediately initiates the route recovery process to avoid packet loss during data transmission.

4.1.6. Traffic Management

Traffic management process is done by classifying the incoming and outgoing data packet. The traffic manager prioritizes the real time data traffic over elastic traffic. For each packets priority is estimated and noted in the packets itself. Traffic manager also monitors the incoming traffic level for load balancing.

5. GOBR UNICAST ROUTING MODEL

GOBR unicast routing strategy is commenced from source node by initiating route discovery process (RDP) from source node and sending route discovery message to destination through network-wide broadcasting manner.

Before initiating the data transmission process, it validates the route in proactive manner. The proactive process checks the availability of route in single hop neighbor and multihop neighbor list. If the route is proactively available then the data transmission process is initiated immediately by sending the packets through available links. If the proactive process fails to identify the available route to destination then it initiates RDP process.

Source node sends route discovery message to establish path to destination. It broadcast this packet in wireless medium to reach its entire neighbor with maximum power. This broadcast includes the broadcast id in the packet to uniquely identify the packet. It also includes the source id, destination id, sender location and hop count of packet.

Once the node accepts the packet then the required field is updated and the destination address in both first hop and second hop list is validated. Once destination receives the route discovery message it generates route discovery reply message to source node by forming the

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reverse route of discovery packet and sending unicast reply packet to source node.

Intermediate node receives the reply message and update link availability list to second hop node in the form of novel of the route discovery process. The network model, discovery and reply process is depicted in fig 2, fig 3 and fig 4. Once all the paths are generated in the source node the genetic operation is performed for optimizing and identifying the better available path to reach the destination.

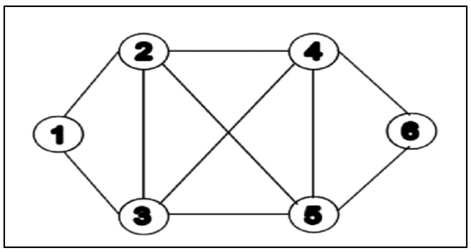

Figure 2: MANET Establishment

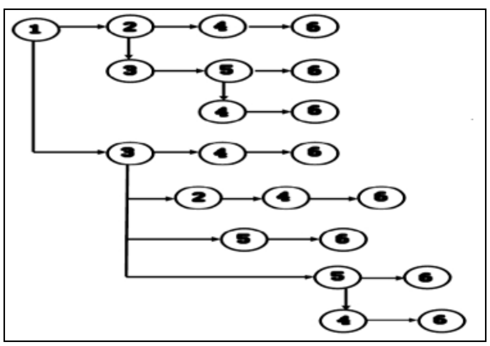

Figure 3: RDP- Message transmission path

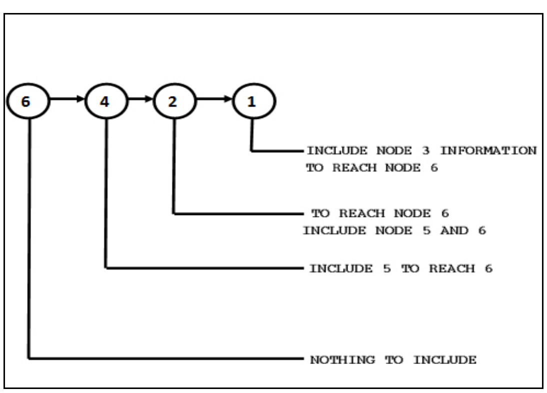

Figure 4: RDR –Message reply path

Once source receives reply message it updates the required field and generates all path information available to reach destination.

6. GOBR MULTICAST ROUTING MODEL

Multicast communication, a critical communication, compared to unicast transmission, has a set of process to establish multicast routes and to maintain multicast link failures. Multicast communication begins from member joining process and tree establishment.

The first node which tries to join the multicast group looks for multicast table entry. If the entry is not available for particular multicast address, then it sends GROUP ANNOUNCE -MENT message with GRP ADDRESS by network-wide flooding.

All nodes in the network are classified into four types namely, HEAD, MEMBER, MULTICAST SRC and TREE EDGE. Whenever a node receives GRP ANNOUNCEMENT message it creates entry in parent list to reach source HEAD node. It also updates the broadcast id of the packet with hop count, previous hop address, forwarding address in the packet and broadcast over wireless medium.

ALGORITHM FOR GROUP ESTABLISHMENT

1. Start
2. Initiate GRP Head Join
3. Head Send Join MSG
4. NBR RECV MSG Create or Update Entry with PREV hop as Upstream Node
5. Rebroadcast until reach all nodes in network
6. Member Send GRP MSG To Head THR Upstream Node
7. Upstream Node RECV and Make Prev Hop Node As Downstream Node
8. Unicast to GRP Head Node
9. GRP Head Add Entry in Member table
10. Stop.

After establishing the path from GRP HEAD to all nodes in the network, the nodes belonging to same group address send GRP JOIN message to GRP HEAD through the established path. GRP JOIN message is unicast to its parent

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node until it reaches the GRP HEAD. Whenever a node receives join message it creates an entry in child list and unicast the packet to its parent node. Now all nodes maintain parent list and child list. The HEAD node also maintains GRP Member list.

6.1. Multicast Data Transmission

In multicast data transmission model is shown in fig 5. It has 3 classes are described in the following sections.

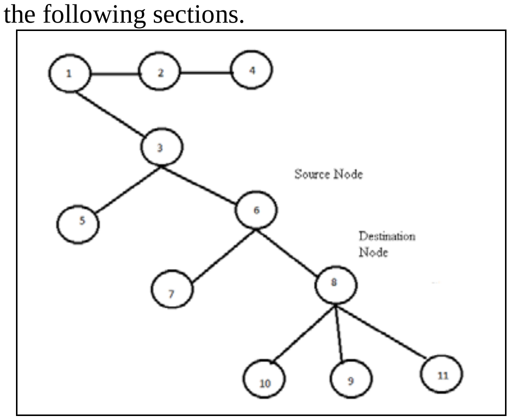

Figure 5: Multicast Data Transmission Model

6.1.1. GRP Head as Source Node

The source node and destination node is chosen. GRP head includes the multicast group address in the data packet and multicast the packet to its entire child listed nodes. Once a packet is received from the GRP Head all nodes belonging to a group, accepts a copy of data packet and unicast to its members in the child listed nodes. If the current node does not belong to a group then it just forward the packet to its child.

6.1.2. Intermediate Node as Source Node

When the source node considered as intermediate node of the tree node and it has both parent and child nodes. The intermediate node now forward the packet to all nodes listed in both parent and child list. The receiver node classifies the received packet as either from parent node or from child node. If the packet is received from parent then it multicast the packet to its child node only.

ALGORITHM (DATA TRANSMISSION)

1. START
2. Source node start send data, if source node is leaf node,
3. Then it unicast data packet to upstream (parent) node.
4. Else if node is GRP head multicast packet to all downstream node
5. Else if node is intermediate node then
6. Multicast packet to downstream nodes and unicast packet to upstream node
7. Node RECV PKT and call classify algorithm
8. If PKT RECV from upstream node then multicast packet to all downstream node
9. Else if PKT from downstream then unicast it upstream node and multicast it to all downstream except PREV hop node
10. STOP
11. Classify
12. START
13. If PREV hop node is downstream then return FROM_DOWN
14. Else if PREV hop node is upstream then return FROM_UP
15. STOP

If the packet is received from child listed node, the node multicast the packets to its parent node and to its child listed node except the visited child.

6.1.3. Least Node as Source Node

In the network model, the leaf node is considered as source node, it has only parent node and not any child in the child list. The leaf node forwards the multicast copy of packet to its entire parent node. The receiver node checks the packet reception from parent node or child node. If packet belongs to parent node it directly multicast the packets to each and every nodes in child. Otherwise it multicast packet to child nodes except the previously visited child and forwards to all nodes in the parent node.

7. GA BASED OPTIMIZATION ROUTE SELECTION

GA optimization performed to get the best path and best alternate path during link failure in the MANETs. A routing path contains of sequence of nodes in network. The GA is applied to paths that have been obtained from the route discovery

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phase. A routing path is encoded by a string of positive integers that indicating the IDs of the nodes in the network. The GA optimization process is discussed in the sections with its operators.

The paths obtained from route discovery phase are considered as initial chromosomes. Identified paths are encoded as 0 and 1 using path encoding scheme to form the initial chromosome. During chromosome formation, node ID bit is marked as 1 and remaining bits are marked as 0. The objective value of the chromosome is calculated using fitness function. It uses the node parameter in terms of bits which are 1 in the chromosome and the values are applied to summation to get the fitness function value of the chromosome. The top most chromosomes are selected based on the objective value. The selected chromosomes are used for as parent chromosomes for the next iteration.

In the generation phase new populations are generated using crossover and mutation. In crossover two chromosomes are selected and crossover is applied. The bits between chromosomes are exchanged in random manner with respect to crossover rate. In mutation individual chromosomes are given as input. A random bit exchange is adopted to interchange the bit from 1 to 0 and 0 to 1 with specified mutation rate. After formation of new chromosomes, it is applied to chromosome fitness evaluation, selection and new population generation until the specified iterations are met. After specified iterations the final best chromosome is selected as optimal solution based on high fitness value. After selection of final chromosome, decoding is applied to get the solution. This selected final path is used for data transmission.

The GA is used to select routing path and identified paths are formed as initial chromosomes. The fitness function selects the top most chromosomes based on the fitness value. The selected chromosomes are involved in crossover and mutation process. As a result new chromosomes are generated and selection, fitness evaluation and crossover mutation process are performed. The iteration process is repeated till a final best chromosome is selected based on high fitness value to routing scheme. The selected best path is used to transmit path. The fitness function is described as,

Fitness function =

$$\left[\frac{1}{(node\ mobility+1)}+\frac{1}{(used\ bandwidth+1)}+\frac{1}{(data\ rate+1)}+\frac{energy}{(Initial\ energy)}\right]$$

8. PERFORMANCE EVALUATION

The Network protocol performance is evaluated in terms of packet delivery ratio, end-to-end delay, throughput and bandwidth utilization ratio for unicast and multicast traffic. The considered mobility model is random way point for simulation. The proposed work is simulated by considering 50-150 nodes with a packet size of 1024 bytes at a transmission range 250m. The simulation environment is illustrated in Table. 1.

Table.1: Scenario for Implementation of GOBR, AODV and MAODV

SIMULATION ENVIRONMENT PARAMETERS	
Number of nodes	50, 75,100,125 and 150
Maximum Speed	4m/sec
MAC Type	MAC 802.11 DCF
Network Type	1000 X 1000 m^2
Transmission Range	100, 250 meter
Traffic Type	CBR & FTP
Mobility Model	Random way point
Simulation Time	100, 200 Sec

8.1. Performance with Unicast Traffic and Multicast Traffic

The performance of unicast protocol is evaluated for GOBR protocol by considering only unicast and multicast flow and by increasing the number of nodes from 50 to 150. Source and destination nodes are selected in random and r each CBR source generates a total of 1024 bytes of packet at the rate of 10 packets/sec. In this model all nodes move according to the random way mobility model with parameters as described in Table.1.

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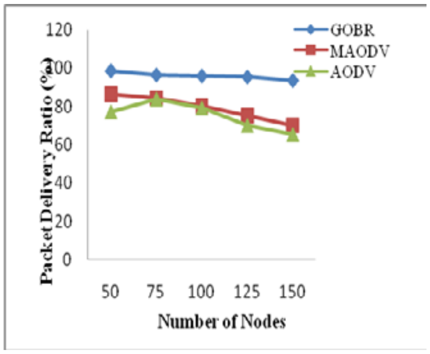

Figure 6: Packet Delivery ratio Vs Number of Nodes

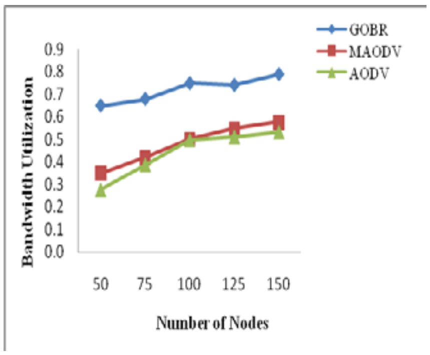

Figure 7: Bandwidth Vs Number of Nodes

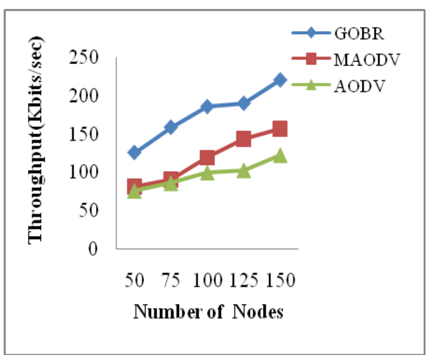

Figure 8: Throughput Vs Number of Nodes

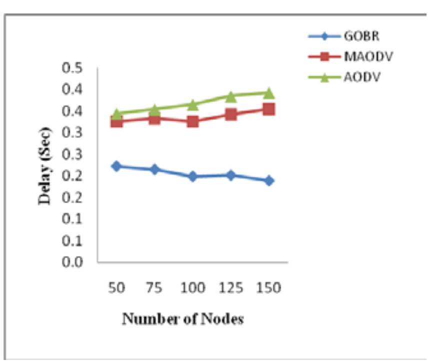

Figure 9: Delay Vs Number of Nodes

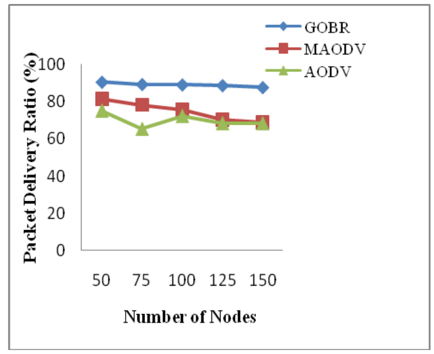

Figure 10: PDR Vs number of Nodes

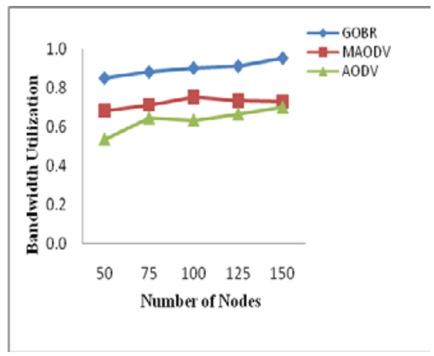

Figure 11: Bandwidth utilization Vs No. of Nodes

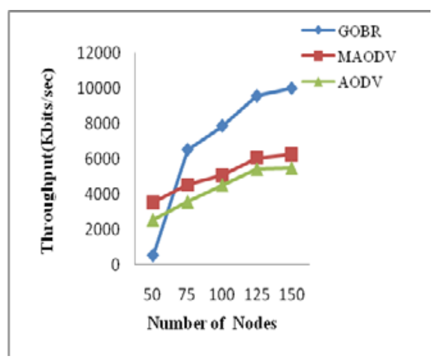

Figure 12: Throughput Vs No. of Nodes

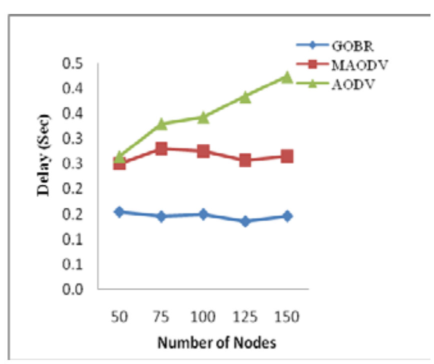

Figure 13: Delay Vs No. of Nodes

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Figures. 6, 7, 8 and 9 compare the results against number of nodes for GOBR, AODV and MAODV in unicast routing and Figures 10, 11, 12 and 13 for multicast routing. From the graph it is noted that the GOBR for both unicast and multicast traffic produces better results when compared to AODV and MAODV protocol.

9. CONCLUSION AND FUTURE WORK

The proposed GOBR, a cross layer protocol for wireless MANET which generalizes the channel access management and routing process by including management of traffic, connection maintaintence and distributed scheduling for concurrent transmission. The integrated components sharply works together to provide better outcome for end-to-end delay and bandwidth utilization for both unicast and multicast transmissions in multihop wireless network. The GOBR provided an optimal solution to handle routing problem and connectivity problem based on GA.The performance shows that the GOBR is highly stable and robust for data transmission and also improved the relaying of packets in all mobility situations, compared to MAODV and AODV for both unicast and multicast cases. Furthermore, the scheme can be improved by applying optimization model for channel access and transmission scheduling. This may improve the protocol robustness and can achieve better performance.

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