Performance Analysis of GJIBR and AODV Routing Protocols in Vehicular Ad Hoc Networks

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***Abstract*—Vehicular ad hoc networks (VANETs) can provide ascendable results for dynamic route planning and condition-aware advertisement using short-range wireless interaction. This paper shows routing mechanisms dealing with performance characteristics in their plan, such as big solidity and constrained strength. It can provide good production for a large spectrum of applications. The objective of this paper is to focus on the performance comparison of the dynamic routing protocols Geographical Junction Information Based Routing (GJIBR) and Ad Hoc On-Demand Distance Vector (AODV) in terms of (i) Throughput (ii) Delay time (iii) Packet delivery Ratio and (iv) Control Overhead using NS-2 simulator.**

Keywords - VANET, DSDV, DSR, AODV and GJIBR

I. INTRODUCTION

VANET (Vehicular Ad Hoc Network) is an emerging technology to achieve intelligent inter vehicle communications, it is the specialized derivation of pure multi hop ad hoc networking and are already going through industrial prototyping; the dreamed idea of general purpose vehicular ad hoc network is still away from reality [1]. VANETS are spontaneously formed between moving vehicles equipped with wireless interfaces that could have similar or different radio interface technologies, employing short range to medium range communication system [2]. The geographic routing protocols are more efficient and scalable when there is a dynamic change in the network topology and when the mobility is high [3]. On-demand reactive routing protocols namely AODV and Dynamic Source Routing (DSR) which works on gateway discovery algorithms and a geographical routing protocol namely Greedy Perimeter Stateless Routing (GPSR) which works on an algorithm constantly geographical based updates network topology information available to all nodes in VANETs for different scenarios [4]. Features of AODV routing protocol are loop free routing and notification to be sent to affected nodes or link breakage [5]. In geography based routing, the metaheuristic method provides the optimal route to use to transmit packets in with the least geometric distance from the source to the destination [6]. AODV protocol is a reactive routing protocol is basically a modification of Destination Sequenced Distance Vector (DSDV) protocol in which routes are defined only when it required [7]. The route discovery mechanism in AODV includes routing tables, one route per destination, sequence number to maintain route [8]. The Multicast Ad-hoc On-demand Distance Vector (MAODV) routing protocol builds directly upon their previous work on AODV by adding support for multicast operation to the protocol [9]. AODV is probably more suitable for cognitive wireless networks compared to Dynamic Source Routing (DSR). One of the reasons is because DSR route discovery may lead to unpredictable packet length, which is not suitable for intermittent connectivity environment of cognitive radio networks [10].

Classification of Ad hoc Routing protocols:

A. Ad hoc routing mechanism with or without network topology information

Proactive routing protocols: Every node maintains the network topology information with the help of routing tables by periodically exchanging routing information. The topology information is generally flooded in the entire network. Whenever a node requests a path to the destination, protocol runs a path-finding algorithm based on the topology information maintained.

Reactive routing protocols: Reactive category of protocols does not maintain the network topology information. Route discovery is done only when required, by means of connection establishment process.

Hybrid routing protocols: Combine the best features of proactive and reactive categories. Nodes within a particular geographical area are said to be within the routing zone of the given node. To find the path within this zone, a proactive approach is used and for routing beyond the zone a reactive approach is used.

B. Based on the use of temporal information for routing

Routing protocols using past temporal information: Protocols use information about the status of the links at the past or the link status at the time of discovery.

Protocols with use of future temporal information: The future status of the link is used to make necessary routing decisions. Apart from the lifetime of wireless links, the future status information is about the lifetime of the node, prediction of location and link availability.

C. Based on the routing topology

Flat topology routing protocols: Make use of a flat addressing scheme by assuming the presence of a globally unique addressing mechanism for nodes in an ad hoc wireless network.

Hierarchical topology routing protocols: Make use of an associated addressing scheme with logical hierarchy in the network. The hierarchy is based on geographical information and hop distance.

D. Based on the utilization of specific resources

Power-aware routing: Aims at minimizing the battery power consumption and routing decisions are made by minimizing the power consumption either logically or globally in the network.

Geographical information assisted routing: Improves the routing performance based on the geographical information available and also reduces control overhead.

II. RELATED WORK

1. Ad Hoc On-Demand Distance Vector (AODV):

AODV is a simple source initiated reactive protocol in which route is established only on demand. It combines the properties of Dynamic Source Routing (DSR) and Destination Sequenced Distance Vector (DSDV) routing protocols. It utilizes sequence numbers from DSDV and performs route discovery using DSR. The AODV establishes route only on-demand. In AODV algorithm the source node sends a route request packet to its neighbors and then forwards it till the destination node path is found. The sequence number of packet is checked at every intermediate node to produce a loop free path. If a node finds that number in its routing table, then node discard the route request packet otherwise store record in its table. It has the ability of unicast & multicast routing and also maintains routing tables. It doesn't need to maintain routes to nodes that are not communicating. AODV use only symmetric links between the nodes since the route reply packet follow the reverse path. If one of the intermediate nodes realizes path is broken than it updates its neighbor and this process is repeated till it reaches the source node. After that, again source node transmits the route request packet to neighbor nodes for finding new path. The AODV performs route discovery only on-demand route between source and destination. Route is established only when it is required by a source node. It identifies the most recent path with the destination sequence numbers. Source node and intermediate nodes maintains next hop information corresponding to each flow for data packet transmission. It uses Destination sequence number (DestSeqNum) to determine an up-to-date path to the destination. A Route Request includes the information about the source and destination identifier, the source and destination sequence number, the broadcast identifier and the time to live field. DestSeqNum contains the route accepted by the source. When an intermediate node receives a Route Request, it forwards it or generates Route Reply if it has a valid route to the destination. The validity of the intermediate node is determined by comparing the sequence numbers. If a Route Request is received multiple times, then duplicate copies are discarded. AODV does not repair a broken path locally. The end nodes are notified due to the broken link. Source node re-establishes the route to the destination if required. Disadvantages are: The intermediate nodes can lead to inconsistent routes if the source sequence number is very old. Due to the use of more number of intermediate nodes results in heavy control overhead and consumes more bandwidth.

Algorithm Description of AODV:

Step1: Source node broadcasts Route Request (RREQ) to the nearest neighbor nodes towards destination.

Step2: On receiving RREQ, each neighbor node rebroadcast RREQ to its neighbor node in all possible paths and reverse path is setup.

Step3: If reverse path from destination node to source node completed

Go to step4.

ELSE

Go to step 2.

Step4: Destination node sends Route Reply (RREP) to the Source node in the shortest reverse path found and discards all other paths.

Step5: Source node forwards data packet in the discovered route.

Step6: Stop

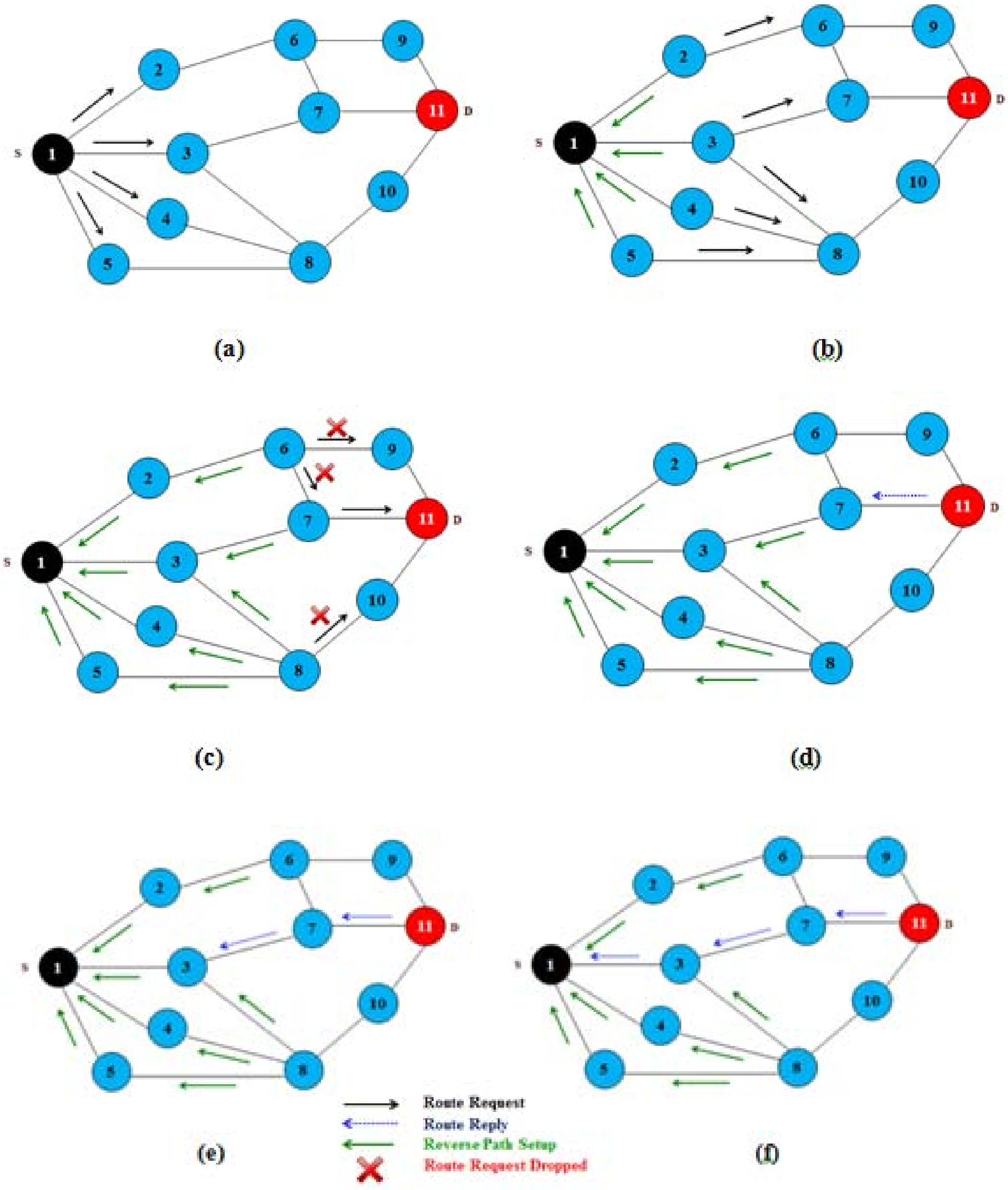


Fig.1.Route Discovery of AODV

2. Geographical Junction Information Based Routing (GJIBR):

GJIBR finds the minimum possible path length between a source and the destination involving minimum number of nodes to transmit data using geographical information at the junction. It broadcasts RREQ to only one nearest neighbor node within the transmission region based on the location information instead of broadcasting in the entire transmission region. There are some special designed nodes called as junction nodes. Every node broadcasts its GPS location on movement and it is stored in junction nodes. Junction nodes keep the location update only for limited expiry (1 sec) time after which it deletes it. The core of routing in GJIBR relies on the location cache at the junction nodes. A node which wants to send data to another node B, broadcast the RREQ, junction node will check if the location can be found in cache and if found will reply with RREP with the location of node B, so that A can construct data packet to B and send to that location. If the location is not found in the location cache, junction node re-broadcast the RREQ. The target node which receives the RREQ broadcasts the RREP and the nearest junction verifies and sends the RREP in the shortest path towards the junction which originated and the RREP is send to the A. Any node in the hop towards source node will check if the source node is in the cache, if it is found it will send the RREP to the source node directly from that hop and will not send RREP to the source junction which originated. Once the RREP comes, the source node A sends the data packet to destination node B in the path. The data packet goes through the junction and junction node verifies if the destination B is in current cache, if it is in its cache it will redirect the data packet to new destination bypassing the further hops in the data packet route information.

Mathematical Analysis of GJIBR

In this section, GJIBR mathematical analysis is presented.

To analyze the delay and network communication overhead mathematically, Let A be the source and B be the destination and A wants to send message to B. The geographical distance between A and B is say dAB and dAB>R, R is the Transmission Range. So A and B cannot communicate directly with each other and need the assistance of intermediate junction to forward. Let H be the number of intermediate hops or junction between A and B. If the propagation delay in each hop is td then the delay D is given as

$$D = H * td$$

But due to queuing of messages in each junction and processing capacity of junction the delay is always greater than the ideal delay D. Let Q be the maximum messages that can be queued at the junction and each junction has uniform processing capacity of n messages. Then the delay Pd is given as

$$Pd = \sum_{k=0}^{H} Q * n$$

The network communication overhead (NC) is the number of messages to be communicated for successful transmission of message from source A to destination B. In GJIBR, a constant message size Md is fixed. The messages are propagated from junction to junction of H hops till the messages reaches destination.

But messages can be transmitted between hops based on a probabilistic since the messages can be lost because of queue exceeded, interference loss etc. Let the probability of message transmission be Pm with value from 0 to 1. The maximum number of retransmission between hops is bound by Mx. Number of retransmission is directly proportional to Pm. For one hop the network communication overhead Nch is given as

$$Nch = \sum_{k=0}^{Mx} Pm * Md$$

For H hops it is given as

$$HNch = \sum_{k=0}^{H} \sum_{k=0}^{Mx} Pm * Md$$

GJIBR always tries to minimize the H value from source A to destination B, ideally H is given as

$$H = dAB / R$$

GJIBR always tries to find a path around the periphery of the shortest path even if Q size in the shortest hops crosses the threshold in case of network congestion. The delay and the network communication overhead are bound by ability of choosing the shortest hop junctions in GJIBR.

GJIBR for multi casting

GJIBR – single casting, a class of VANET routing protocols for city-based environments that take advantage of the roads topologies to improve the performance of routing in VANETs. GJIBR protocols use real-time vehicular traffic information to create road-based paths between end-points. Geographical forwarding is used to find forwarding nodes along the road segments that form these paths. The methodology is described and simulation concepts are added additionally to show performances. Vehicles create groups and do group communication and the proposed protocol for group communication must reduce the network overhead as much as possible. Network overhead is caused due to flooding of packets and duplicate transmissions and the motivation for GJIBR for multi casting is to enable group communication and at the same time reducing the flooding of packets and reducing duplicate transmission. Once the multi cast is created or new vehicle joins multicast group, GROUP INFO message is broadcasted to nearest junction and the junction will keep a mapping from GROUP ID to the vehicles present. Junction will also exchange the GROUP INFO message so that mapping is kept at all junction nodes. The mappings have a life time of say one day, so it is deleted after the life time. It is up to the vehicles to refresh the group info by sending GROUP INFO message periodically based on life time to the junction node. When a vehicle in group wants to send data message to group it will construct a DATA message with group id information and broadcast it to the nearest junction. Junction will get the group member vehicles from the group info table in its cache and checks if vehicle is present in its influence zone and if found, it will broadcast the DATA message, it will also send the DATA message to nearest junction.

Algorithm Description of GJIBR:

Step1: Source node is ready to broadcast RREQ based on location information.

Step2: checks for N

Where N is the number of nodes in the network for ‘i’ lies between 0 to N.

Selects Ni such that it lies within S, Where S is the set of all nodes within the junction.

If Ni lies in S

Go to step3

ELSE

Go to step9

Step3: Broadcasts RREQ to the nearest node of the junction.

Step4: Increases the transmission range by 400m.

Step5: If path completed from source node to destination node

Go to step6

ELSE

Go to step2

Step6: If receiving node is the destination of RREQ

Go to step7

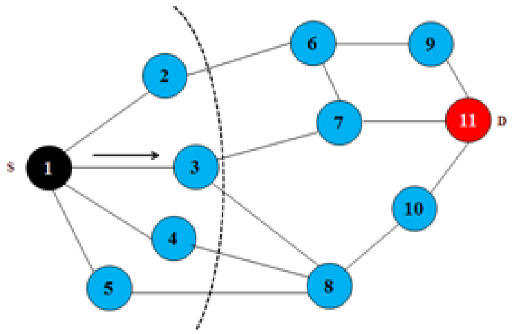
ELSE

Go to step2

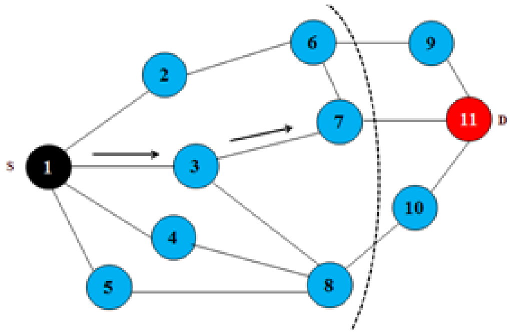
Step7: Destination node sends RREP to the Source node in the shortest path found.

Step8: Source node forwards the data packet in the discovered route.

Step9: Stop



(a)



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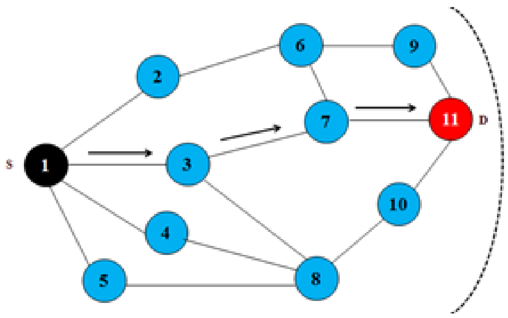

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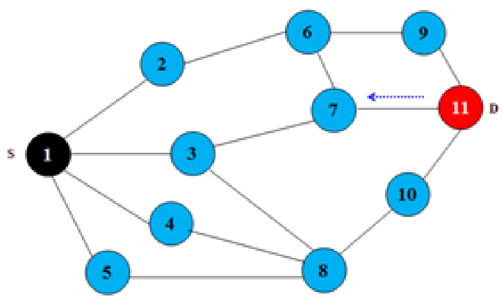

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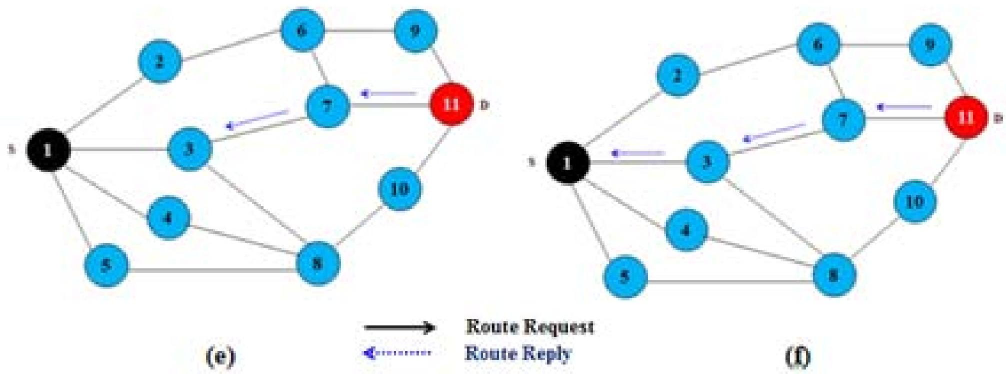

Fig.2.Route Discovery of GJIBR

III. SIMULATION RESULTS

The performance of the metrics Throughput, Delay Time, Packet Delivery Ratio, Control Overhead for the protocols AODV and GJIBR is evaluated using network simulator NS–2. The experiments were conducted in networks of different node densities: 350 nodes scenario is used as a representative of relatively dense networks, 250 nodes scenario for medium density networks and 150 nodes for sparse networks. The simulation scenario is a 1500m x 1500m area extracted from the TIGER/Line database of the US Census Bureau. SUMO, an open-source microscopic, space-continuous and time discrete vehicular traffic generator package is used to generate the movements of the vehicle nodes. SUMO uses a collision-free car-following model to determine the speeds and node locations. The input to the SUMO is the map given from Tiger/Line database along with specifications about the speeds limits and number of lanes of each road segment on the map. Traffic lights operated junctions as well as priority junctions are also specified. Less than one-fifth of the junctions are regulated using traffic lights. The first 2000 seconds of SUMO output are not considered in order to obtain more accurate node movements. This configuration is used with different number of vehicle nodes and the output from SUMO is converted into input files for the random location of nodes in the NS-2 simulator. The IEEE 802.11 with Distributed Coordination Function (DCF) standard is used at the MAC layer. The Shadowing propagation model characterizes physical propagation at the physical layer. The transmission range is set as 400m with 80% probability of success for communication. Some studies results in the real-time measurements of moving vehicles over the transmission region between 450m and 550m. However standard specific range can be up to 1000m for safety applications. The Shadowing propagation model makes use of the values for path loss exponent β as 3.25 and deviation σ as 4.0. Simulation of buildings in a city environment is done using the following obstacle model. The area of each street can either be a building wall or an empty area. Thus for each street border, a random signal attenuation value is selected between 0dB and 16dB. For a given pair of transmitter-receiver nodes, the attenuation of the signal at the receiver is computed as follows: first the attenuation from each wall in the direct line of sight between the nodes are summed; then the sum value is added to the attenuation determined through the shadowing propagation model. The signal attenuation values obtained were comparable to values reported from field experiments at 5.3GHz.

Table I. Simulation Setup

Parameter	Value
Simulation area	1500m x 1500m
Number of vehicles	150-250-350
Number of CBR sources	1-20
Transmission range	400 m
Simulation time	300 s
Vehicle velocity	25-55 miles per hour
CBR rate	0.5 – 5 packet per second
MAC protocol	IEEE 802.11 DCF
Data packet size	512 bytes

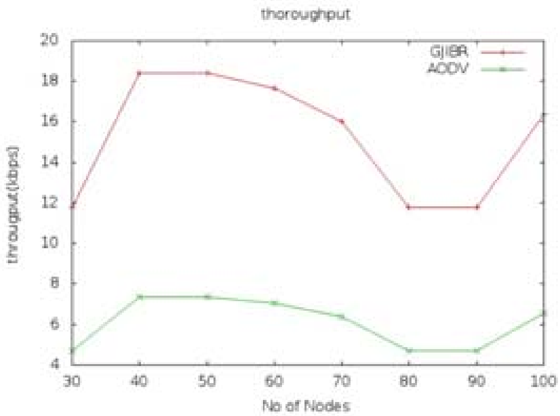

Fig.3.Throughput

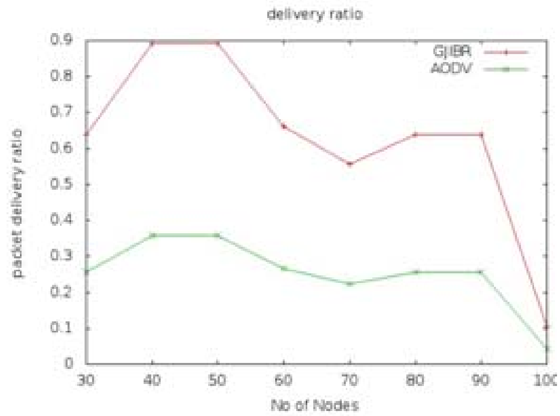

Fig.5.Packet Delivery Ratio

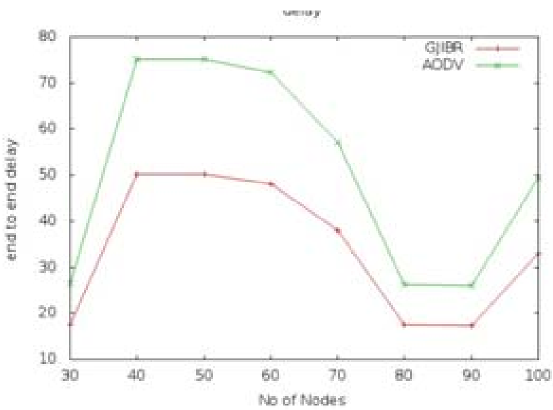

Fig.4.Delay Time

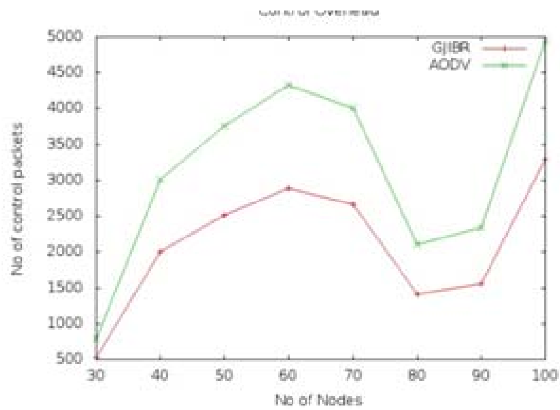

Fig.6.Control Overhead

IV. CONCLUSION

The simulation of AODV and GJIBR is run for 600 seconds. In the simulation results shown, it is proved that GJIBR transmits larger number of data packets than AODV with increase in the number of nodes. Hence throughput and packet delivery ratio are high in GJIBR than AODV. GJIBR protocols use real-time vehicular traffic information to create road-based paths between end-points. Geographical technique in GJIBR minimizes the number of nodes involved in the transmission along the road segments. Thus, GJIBR reduces the total number of packets generated by the nodes in the network due to requisition for route (RREQ), reply to indicate ready for transmission (RREP) and the error (RERR) generated during the transmission of information. Therefore, AODV shows less performance in terms of delay time and control overhead than GJIBR.

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