Modeling and Analysis of an Intelligent AODV Routing Protocol based on Route Request Retransmission Strategy in MANETs

Deepak Dembla
Associate. Prof., Deptt. of CSE
AIET, Jaipur, India

Dr. Yogesh Chaba
Associate Prof., Deptt. of CSE,
GJU S&T, Hisar, Haryana, India

ABSTRACT
A mobile ad hoc network (MANET) is comprised of mobile hosts that communicate with each other using wireless links and based on the peer-to-peer paradigm. A MANET is a self-configuring network that can have an arbitrary topology along the time. Each mobile host works as a router and it is free to move randomly and connect to other hosts arbitrarily. Thus, the network topology can change quickly and unpredictably since there may exist a large number of independent ad hoc connections. The default mechanism of route discovery in MANETs is flooding. Many routing protocols (such as AODV and DSR) and applications are operated based on flooding and data dissemination to all nodes in network. Therefore, a robust and efficient flooding algorithm is necessary in an ad hoc network environment. In this paper, an intelligent AODV protocol is proposed and analyzed that follows a efficient method of route discovery based on network density and probability, and adjusts itself dynamically based on the network density of MANET. The proposed algorithm is analyzed on GloMoSim simulator in various scenarios of mobility, network density, traffic load etc. The simulation results show that I-AODV (intelligent-AODV) method significantly reduces the no. of rebroadcasts and hence reduces the contention and collision rate among the neighbor nodes. The results show great improvements over simple flooding approach in AODV, in terms of performance measures such as routing overheads, collisions rate, end to end delay, no. of broadcast requests etc. hence solves the problem of broadcast storm in MANETs.

Keywords- AODV, flooding, MANETs, GloMoSim, mobility, route discovery.

1. INTRODUCTION
A MANET [6],[7],is a self-configuring network that can have an arbitrary topology along the time. Each mobile host works as a router and it is free to move randomly and connect to other hosts arbitrarily. MANET consists of a set of wireless nodes, which are spread over a geographical area. These nodes are able to perform processing as well as capable of communicating with each other by means of a wireless ad hoc network. With coordination among these wireless nodes, the network together will achieve a larger task both in urban environments and in inhospitable terrain. Routing protocols can be primarily categorized as proactive (table-driven) and reactive (on-demand) protocols [16]. Proactive routing protocols maintain routes between all pairs of nodes at all times. Reactive routing protocols, on the other hand, do not maintain routes. When a route is needed, they will initiate route discovery process to find a route (or possibly multiple routes). Only after the route is found, the node can start the communication.

Another way is to organize them as flat and hierarchical routing protocols [7]. Flat routing protocols regard the whole network as uniform where each node in the network has same functions and responsibilities. Each node has uniform responsibility for constructing routes. Hierarchical routing protocols organize the network as a tree of clusters, where the roles and functions of nodes are different at various levels of the hierarchy. Routes are constructed according to the node's position in the virtual hierarchy.In a MANET a route between two hosts may consist of hops through one or more nodes. An important problem in a MANET is finding and maintaining routes since host mobility can cause topology changes. Several routing algorithms for MANETs have been proposed in the literature such as ad hoc on-demand distance vector routing (AODV)[2],[10], dynamic source routing protocol (DSR)[1] optimized link state routing protocol (OLSR)[6],[19]. Broadcasting is a basic communication technique of for route discovery in MANETs and its basic mechanism is known as pure or blind flooding which results in serious contention, collisions and redundancy in the network, called as broadcast storm problem[3]. To remove these problems several algorithms are proposed to reduce the number of retransmissions and to improve the network performance. The simplest and most trivial broadcasting algorithm is pure flooding. Every node that receives the broadcast message retransmits it to all its neighbors [6],[12]. The problem of pure flooding is that it produces many redundant messages, which may consume scarce radio and energy resources, and cause collision that is called broadcast storm problem [9]. Therefore, the basic principle of designing an efficient and resource conservative broadcast algorithm is trying to reduce the redundant messages, which means to inhibit some nodes from rebroadcasting and the message can still be disseminated to all nodes in the network.

In this research paper, a new intelligent approach is implemented in which each intermediate node forwards the RREQ packet to its neighbor with some probability, based on the density of neighborhood nodes. In this approach, neighborhood densities are divided in two categories; dense and sparse. If the node is in the sparse region, it retransmits the RREQ packet with high probability so that it can reach to maximum no. of nodes , otherwise it forwards the packet with a low probability, if node is in the dense network region. The new model of I-AODV is implemented in GloMoSim simulator [14] to perform a no. of simulations and performance of new I-AODV protocol is compared and analyzed against the AODV based on pure flooding algorithm [2].

The rest of the paper is structured as follows: Review of literature is discussed in section II. The concept of route discovery is explained in section III. Section IV discusses proposed intelligent algorithm i.e. I-AODV, its design, analytical modeling, algorithm and depicts the code for new I-AODV algorithm. Experimental setup is discussed in section V. Section VI discusses important performance metrics. Results analysis and performance evaluation is presented in section VII followed by conclusions and future work in section VIII. Important references are mentioned in the end.

2. RELATED STUDY

The basic approach of broadcasting is to let every node retransmit the message to all its one-hop neighbors when receiving the first copy of the message, which is called flooding in the literature [5],[12],[21]. Despite its simplicity, flooding is very inefficient and can result in high redundancy, contention, and collision. One approach to reducing the redundancy is to let a node only forward the message to a subset of one-hop neighbors who together can cover the 2-hop neighbors. In other words, when a node retransmits a message to its neighbors, it explicitly asks a subset of its neighbors to relay the message. The MPR multipoint relaying method, discussed in detail by Viennot, et al.[8], and dominant pruning method, proposed by Lim et al.[22], are both based on a heuristic that selects a minimal-sized subset of neighbors of a given node S that will "cover" all two hop neighbors of S. A node is called "covered" if it received (directly or via retransmissions by other nodes) the message originating at S. Relay points of S are one-hop neighbors of S that cover all two-hop neighbors of S. That is, after all relay points of S retransmit the message; all two-hop neighbors of S will receive it. The goal is to minimize the number of relay points of S.

The lightweight and efficient network-wide broadcast protocol by Sucec and Marsic [23] relies on two-hop neighbor knowledge obtained from "Hello" packets. Each node decides to rebroadcast based on knowledge of which of its other one- and two-hop neighbors are expected to rebroadcast. Neighbors with a high degree of knowledge have higher priority to rebroadcast. Since a node relies on its higher-priority neighbors to rebroadcast, it can proactively compute if all of its lower-priority neighbors will receive those rebroadcasts; if not, the node rebroadcasts. J.-P. Sheu et al. [3] et al. proposed several approaches flooding : the decision of rebroadcast is based upon a threshold value for the number of duplicate packets received by the broadcasting node in selective flooding scheme. If the number of duplicate packets is less than the threshold value, then the node will rebroadcast. Otherwise, it will not rebroadcast. An expected additional coverage function may be defined, which shows that the more times a host has heard the same broadcast packet, the less additional coverage the host contributes if it rebroadcasts the packet. In distance and location-based scheme, the heuristic may involve distance in a relative sense – physical distance between nodes or the transmission power required. Each node is equipped with a GPS device or is able to determine signal strength of a neighboring node. Given the distance or location of broadcasting nodes, it is possible to calculate the expected additional coverage , a node may contribute by rebroadcast.

Lou et al. [20] proposed protocols based on neighbor information which are based on global state information. It has been recognized that scalability in wireless networks cannot be achieved by relying on solutions where each node requires global knowledge about the network. In quasi global broadcasting, a broadcast protocol is based on partial global state information. In quasi local broadcasting, a distributed broadcast protocol is based on mainly local state information and occasionally partial global state information. In local broadcasting, a distributed broadcast protocol is based on solely local state information. All protocols that select forward nodes locally (based on 1-hop or 2-hop neighbor set) belong to this category. To achieve scalability, the concept of localized algorithms was proposed, as distributed algorithms where simple local node behavior, based on local knowledge, achieves a desired global objective. E.-Y. Shih et al. [18] show that probability of rebroadcasting the packet to reach additional area is inversely proportional to the no. of times a packet is received t a node. This result is the basis of their counter based approach. Upon reception of a previously unseen packet, the node initiates a counter with a value of one and sets a RAD (which is randomly chosen between 0 and Tmax seconds). During the RAD, the counter is incremented by one for each redundant packet received. The disadvantage of all counter and probabilistic schemes is that delivery is not guaranteed to all nodes even if ideal MAC is provided. In other words, they are not reliable.

J. Boleng et al. [4] classified the flooding protocols into simple (blind) flooding, probability-based, area-based, and neighbor-knowledge methods. In this paper, area based methods are reclassified within other groups, whereas neighbor-knowledge methods are divided into clustering-based, selecting forwarding neighbors, and internal-node-based methods.

D.Simplot et al.[17] described a distance-based method without using position information. The distance between two neighboring nodes is measured by a formula that depends on the number of common neighbors. The broadcast message is piggybacked with a list of one-hop neighbors. Neighbor elimination is also used to enhance the performance. The method is suitable for highly mobile environments.

3. PROPOSED ALGORITHM - INTELLIGENT AODV

3.1 Route Discovery Approach In AODV

Like most reactive routing protocols, route finding in AODV [2],[5],[6],[7] protocol is based on a route discovery cycle involving a broadcast network search and a unicast reply containing discovered paths. In AODV, nodes maintain a route table in which next-hop routing information for destination nodes is stored. Each routing table entry has an associated lifetime value. If a route is not utilized within the lifetime period, the route is expired. Otherwise, each time the route is used, the lifetime period is updated so that the route is not prematurely deleted. When a source node has data packets to send to some destination, it first checks its route table to determine whether it already has a route to the destination. If such a route exists, it can use that route for data packet transmissions. Otherwise, it must initiate a route discovery procedure to find a route. To start route discovery, the source node creates a route request (RREQ) packet. It places in this packet the destination node's IP address, the last known sequence number for that destination, and the source's IP address and current sequence number.

The RREQ also contains a hop count, initialized to zero, and a RREQ ID. The RREQ ID is a per-node, monotonically increasing counter that is incremented each time the node initiates a new RREQ. In this way, the source IP address, together with the RREQ ID, uniquely identifies a RREQ and can be used to detect duplicates. After creating this message, the source broadcasts the RREQ to its neighbors. When a neighboring node receives a RREQ, it first creates a reverse route to the source node. The node from which it received the RREQ is the next hop to the source node, and the hop count in the RREQ is incremented by one to get the hop distance from the source. The node then checks whether it has an unexpired route to the destination. If it does not have a valid route to the destination, it simply rebroadcasts the RREQ, with the incremented hop count value, to its neighbors. In this manner, the RREQ floods the network in search of a route to the destination. When a node receives a RREQ, it checks whether it has an unexpired route to the destination. If it does have such a route, then one other condition must hold for the node to generate a reply message indicating the route. The node's route table entry for the destination must have a corresponding sequence number that is at least as great as the indicated destination sequence number in the route request. When this condition holds, the node's route table entry for the destination is at least as recent as the source node's last known route to the destination. This condition ensures that the most recent route is selected, and also guarantees loop freedom. Once this condition is met, the node can create a route reply (RREP) message. The RREP contains the source node's IP address, the destination node's IP address, and the destination's sequence number as given by the node's route table entry for the destination.

If at a particular node, hop count approaches to zero before route request reaches to destination, an error is detected and this node sends back a RERR packet to source following the same route, but in the reverse order. On receiving the RERR , source initiates a new RREQ with different sequence number.

3.2 Protocol Design

In pure flooding or simple flooding approach, a source node broadcasts it s packet to all neighbors. Each of those neighbors in turn rebroadcast the packet first time it receives the packet. Redundant packets are simply dropped. This behavior continues until all reachable network nodes have received. However, blind flooding produces high overhead in the network, resulting in the broadcast storm problem. In I-AODV, a innovative algorithm is proposed for reducing broadcast overhead in flooding based message delivery. This algorithm prevents blindly flooding requests packets in the whole network and involves a number of nodes in the request process o ensure route discovery rate and the transmission range is determined without considering the node distribution of the network hence may flooding zone may contain excess nodes and increases overheads which is not acceptable.

I-AODV automatically selects the forwarding range based on network density at each intermediate node. Each node will forward a message based on its neighbor density and the previous node's neighbor density and the present. That is, each node will decide to forward or drop the received message based on the neighbor densities. If a cluster of nodes loosely connected with few intermediate nodes, then there will be a chance of failure of forwarding the message at that point. The proposed algorithm tries to avoid that situation by giving high priority at that point. Similarly, if a node is having high density of neighbors, then there will be lot of chance for packet collision at that point. The proposed algorithm tries to avoid that situation by giving low priority at that point. Network density demonstrates the node distribution of the local area. This algorithm is mix of probability and knowledge based approaches. It dynamically adjusts the RREQ probability of rebroadcasting at each node, as per the value of no. of neighbors and this value is large in sparse region as compared to dense regions. The decision to rebroadcast RREQ packets is made instantly after receiving a packet without any delay.

3.3 Assumptions Of Model

The new approach is based on a few assumptions;

- All the nodes in the network participate fully in routing protocol and each node is ready to forward the packet to other nodes in the network.
- Some of the packets can be lost or corrupted in the transmission medium because of any reason and any node receiving any corrupted packet, is able to detect and discard the packet.
- All mobile nodes are homogeneous in nature.

3.4 Analytical Modeling

In this section, mathematical model of I-AODV algorithm is presented. Let A be the area of the adhoc network, N be the total no. of mobile nodes in he network, r be the Transmission range. Let μ be the fraction of the total network area covered by the mobile node. Then

$$\mu = \frac{\pi}{A} r^2 \quad \text{-------} \quad (i)$$

The average number of neighbors of a node is

$$avg = (N-1)(k)\frac{\pi}{A} r^2 \quad \text{---------} \quad (ii)$$

The Density of a network is

$$= (N / A)*r2 \quad \text{-----------} \quad (iii)$$

Where, N is the total no. of nodes in the network, A is the area of the region, r is the transmission range of the wireless node, k is the connectivity parameter. To validate the equation no. ii, extensive simulations are conducted to determine the average no. of 1-hop neighbors of various network densities and is found that at k=.7 simulations result and analytical results match together. As per our new approach of route discovery, the probability of RREQ forwarding is determined by the local density information and neighbors covered in transmission range.

The equation that defines the relation between the local density, forwarding probability and neighbor covered set can be formulated. Let n be the no. of neighbors of nodes of x, Nc be the no. nodes of x that are covered by the broadcast. The forwarding probability Px can be defined as follows:

$$Px = \begin{cases} \frac{N-Nc}{avg}; & N<=avg \\ \frac{N-Nc}{N}; & N>avg \end{cases} \quad \text{----(iv)}$$

Based upon the value of node density (retrieved from the equations i,ii and iii , for variables like node density, no. of nodes, average no. of neighbors etc,) probability of forwarding the RREQ packets is assigned to each node. The whole process of RREQ packet rebroadcast based on node density and probability is explained in following algorithm:

3.5 Algorithm For Proposed I-AODV Protocol

Step1 Processing procedure when route request is received.
On hearing a broadcast RREQ packet at node x.
Step 2 Get the number of neighbors nbr of node x .
Step 3 Get average number of neighbors AVG
Step 4 If packet RREQ received for the first time then
If nbr <=AVG then
Node x has a low degree: sparse region
Set high rebroadcast probability proba= P1 ;
(set it maximum to ensure high reachability,
due to small no. of nbr nodes- it may incur more
no. of retransmissions)
Else
nbr >= AVG
Node X has a high degree: dense region
Set low rebroadcast probability proba= P2 ;
End_if
End_if
Step 5 Generate a random number RN over [0, 1].
If RN <= proba then
Rebroadcast the received RREQ.
Else
Drop it
End algorithm

3.6 Implementation Code for Proposed intelligent I- AODV

The following code is implemented in the original code of AODV protocol for the desired results and is implemented and tested in GloMoSim on various scenarios to analyze the performance of the new I-AODV protocol on different parameters values. The no. of neighbors at each node are calculated ill all the nodes are covered in the neighbor table list. The value of variable nbr++ is incremented. If this values of no. of neighbors is less then the average value of node density based on transmission range of the ad hoc network, then this node is in the low density or sparse network region and high probability value is assigned for retransmission that data packet reaches to the destination without much chances of collision and contention, otherwise node is assigned low probability value for retransmission. Depending upon the value of the random number, RREQ packet will be relayed or free, as explained in the code below.

```
void RoutingAodvHandleRequest(GlomoNode *node, Message *msg, int ttl)
{
AODV_NT_Node *current;
int nbr;
double rn, proba;
AODV_NT* nbrTable=&aodv->nbrTable;
for(current=nbrTable->head;current!=NULL;current=current->next)
nbr++;

/*In route request relay function */
RoutingAodvRelayRREQ(node, msg, ttl);
If (nbr<=AVG)
proba=P1;
else
proba=P2;
rn=Random();
if (rn<=proba)
RoutingAodvRelayRREQ(node, msg, ttl);
Else
GLOMO_MsgFree(node, msg);
```

4. EXPERIMENTAL SET-UP

The performance is analyzed against parameters such as mobility, network traffic load and no. of nodes. The simulations are studied under GloMoSim simulator. The objective is to reduce the no. of RREQ packets. i.e. reducing the no. of forwarding nodes, which would reduce the signal collision in the network. Both the protocols are simulated in same settings of parameters and scenarios to compare the results. Simulations are run on 4 seeds and the averaging of the values is used for final analysis and comparison. The mobility model used is Random Waypoint Mobility model in a terrain range of 1000 x 1000 meters [15]. According to this model, each node in the beginning of the simulation remains stationary for a pause time second, then chooses a random destination and starts moving towards it with a random speed [0, max.-speed] and after reaching at destination, node stops for a pause time interval and chooses a new destination and speed. This process repeats until the simulation ends. To analyze the performance of AODV and I-AODV protocols, scenarios are set as per the parameters shown in table 1.

Table 1. Simulation Parameters

SIMULATION ENVIRONMENT PARAMETERS	
SIMULATION-TIME	45M
TERRAIN-DIMENSIONS	(1000, 1000)
NUMBER-OF-NODES	25,50,100,150
NODE-PLACEMENT	RANDOM
MOBILITY	RANDOM WAYPOINT
MOBILITY-WP-PAUSE	30S
MOBILITY-WP-MIN-SPEED	0
MOBILITY-WP-MAX-SPEED	10,20,30,50(m/sec)
PROPAGATION-LIMIT	-111.0
PROPAGATION-PATHLOSS	TWO-RAY
NOISE-FIGURE	10.0
RADIO-FREQUENCY	2.4e9
RADIO-BANDWIDTH:	2000000 bps RADIO-
RX-SNR-THRESHOLD 10.0	
RADIO-TX-POWER:	15.0 dBm
RADIO-ANTENNA-GAIN	0.0
RADIO-RX-SENSITIVITY	-91.0
RADIO-RX-THRESHOLD	-81.0
MAC-PROTOCOL	802.11

5. PERFORMANCE METRICS

AODV and I-AODV are included in simulator for evaluating and comparing the performance of the protocols in various network densities, node distribution, mobility scenarios etc. It is assumed in all the simulations that links between all the nodes are bidirectional and transmission range is a circle area. The performance of broadcast protocols can be measured by a variety of metrics.

- *Routing overhead:* It is the total number of route request packets transmitted during the simulation time. If there is multi hop transmission, each transmission over 1-hop is counted as 1-transmission.
- *Control Overheads:* the total no. of control messages transmitted during the simulation, it affects the bandwidth and hence efficiency of the network.
- *End to end delay:* It is the average time difference between the time a data packet is sent by the source node and the time it is received by the destination node. This is average end to end delay of all successfully transmitted data packets from source to destination. Formula for average end to end delay is:

$$Average\ EtEDelay = \frac{\sum_1^n \left(CBR_{sent_{time}} - CBR\ receive_{time}\right)}{\sum_1^n CBR_{receive_{time}}}$$

where n is number of received packets.

- *Throughput:* It is the total no. of data packets received at the destination in one second.
- *Average no. of Collisions:* It is the total no. of packets dropped resulting from the collisions at the MAC layer.
- *Normalized Routing Load* (NRL): NRL is number of routing packets transmitted per data packet delivered at the destination. Formula for NRL is:

$$\text{NRL} = \frac{\sum_1^k Routing\_packets}{\sum_1^n CBR\_received}$$

where n is number of received packets, and k is number of routing packets.

- *No. of Broadcasts:* No. of broadcast packets sent across the network also affects the performance of the protocol in terms of bandwidth consumption and other overheads.

6. RESULT ANALYSIS AND PERFORMANCE EVALUATION

Both the algorithms are highly dependant on the density of the network. In sparse networks, these are expected to perform similar to flooding, as each node may have to reach isolated neighbors and as the density increases, proportionally fewer nodes should rebroadcast. A few of the above mentioned metrics are evaluated for simulation set up of AODV and I-AODV protocols.

6.1 Routing Overhead

The routing overhead increases when the network density increases as shown in the figure 1. It is clear from the graph that the routing overhead reduces in I-AODV as compared to AODV, at low and medium dense networks. The overheads in I-AODV reduces to around 48% as compared to conventional AODV protocol. It increases proportionally with the increase in the no. of nodes as well as speed of the nodes also. There is a direct relationship between the no. of nodes in the network and the no. of RREQ packets. The routing overhead increase with the increase of traffic load also. Comprehensive analysis of the graph depicts that overhead in AODV increases more with the increase in no. of nodes, speed and source nodes as compared to I-AODV protocol. When the density increases, no. of RREQs also increases and in turn no. of duplicate packets also increases which leads to more contention and collisions rate also. Similarly the no. of broadcasts packets increases with the increase in the speed, no. of nodes, and no. of source nodes. There is a relatively very less no. of broadcasts requests in I-AODV protocol as compared to conventional AODV protocol, because there is now selective rebroadcasting based on node density at each node. It shows that I-AODV is more scalable than AODV in terms of higher node density in a fixed area.

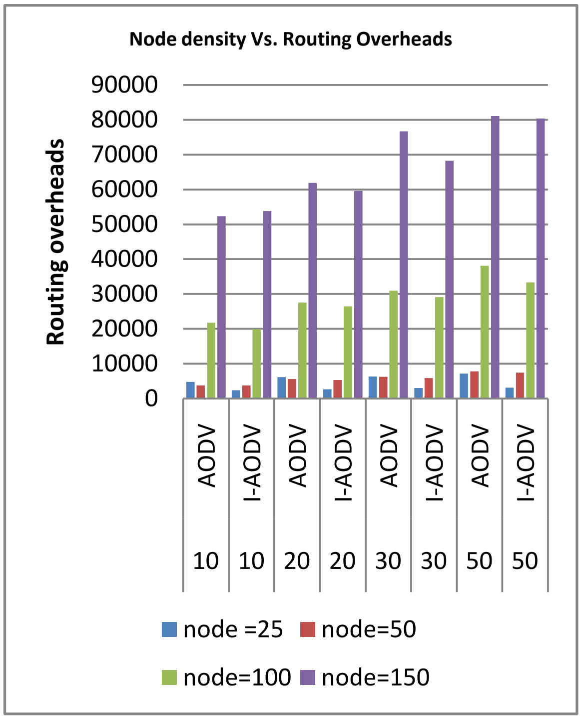

Fig 1. Node density and Mobility Vs Routing overhead

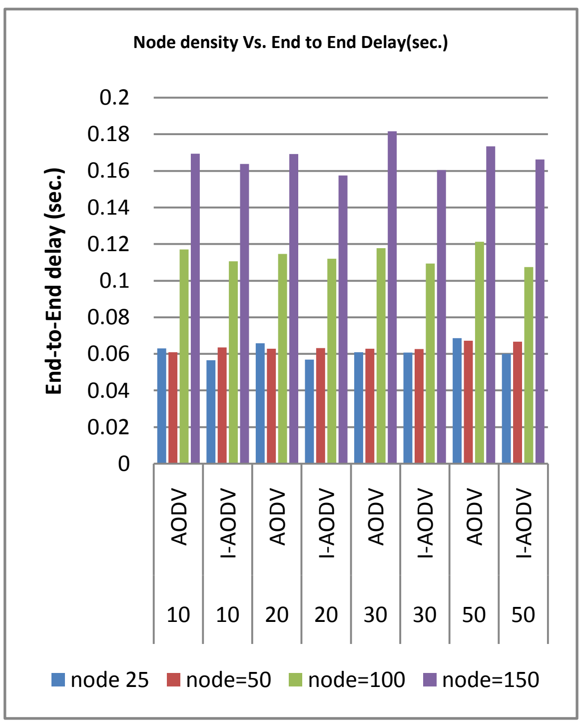

Fig.2. Node density and Mobility Vs. End to End Delay

6.2 End to End Delay

It is the average time difference between the time a data packet is sent by the source node and the time it is received by the destination node. The fig. 3 clearly shows that there is 15% to 20% less end to end delay in I-AODV protocol as compared to AODV protocol and this delay increases with the increase in speed because route paths between nodes change more frequently and more requests need to be performed. When a node receives the packet, it immediately decides whether to forward to the neighbor or discard the packet immediately, based on the local node density. When network density increases, more RREQ packets fail o reach the destinations due to high probability of packet collisions and channel contention caused by excessive redundant retransmissions of route requests packets. I-AODV reduces the latency in dense networks up to 25% as shown in the figure 2, as compared to traditional AODV.

6.3 Collision Rate

Figure. 3 shows that the no. of packets collisions increases as the no. of nodes increase. The graph shows that there is around 25% to 30% less collisions in I-AODV protocol as compared to AODV. The no. of collisions increase with the increase in no. of nodes and speed also. In I-AODV large duplicate packets are reduced as the possibility of having more than 2 nodes transmitting at the same slot is reduced when the no. of nodes increases. When the no. of source nodes increases, generated no. of RREQ packets also increases. Hence, many RREQ packets collide with each other and due to contention among the nodes in shred transmission channel in the network.

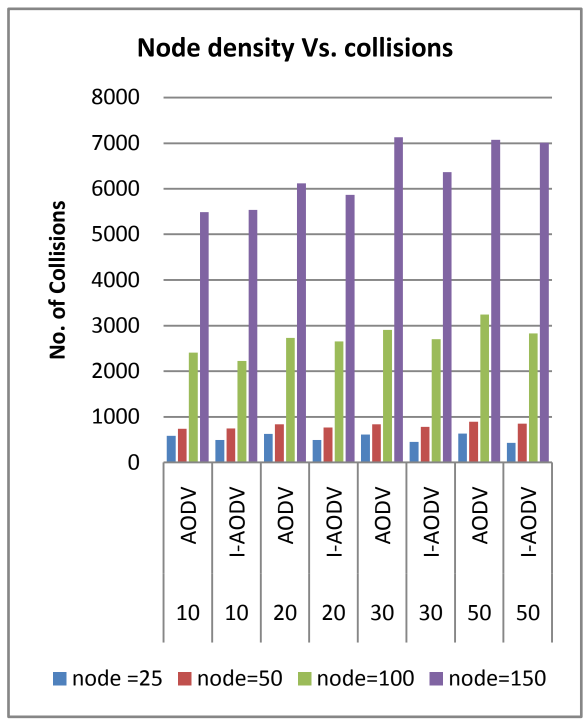

Fig. 3 Node density and mobility (m/sec) Vs. Collision

6.4 Control Overheads

It is defined as the total no. of control packets transmitted during the simulation. Control packets also consumes bandwidth of the network and should be minimum for better performance. The figure 4 clearly depicts that no. of control packets are around 50% less in I-AODV as compared to AODV protocol. Control packets increases with the increase in no. of nodes and traffic load also because when the load increases, need for route discovery process increases. It is minimum at low speeds and less dense network. I-AODV protocol broadcasts update information, only when a mobile node sends a request for it, which causes less control packets overheads.

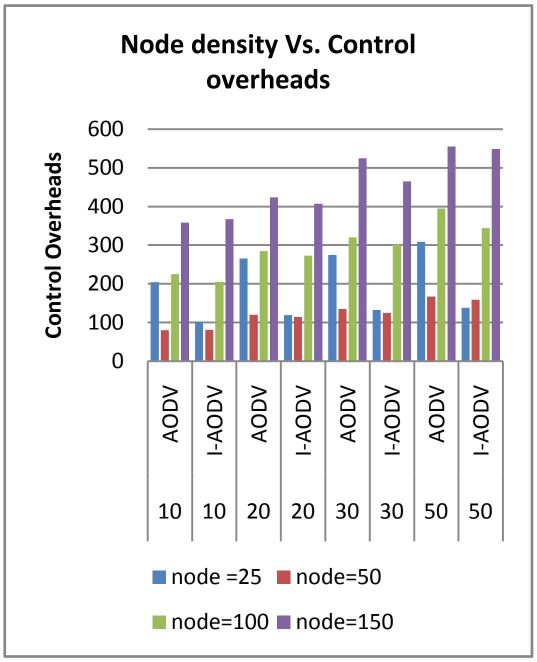

Fig. 4 Node density and mobility (m/sec) Vs. Hop Counts

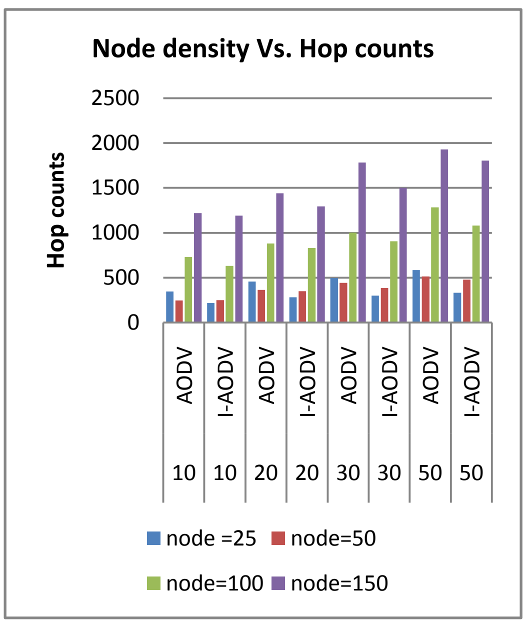

Fig. 5. Node density and Mobility (m/sec) Vs. Hop counts

6.5 Hop Counts

It is a measure for the number of relay stations that a data packet or a routing message is expected to pass through while traveling between arbitrary source and destination nodes. Therefore understanding the hopcount is important for estimation of the relay traffic, routing overhead and delay in ad-hoc networks. It is obvious from the fig. 5 that hop counts in I-AODV is around 45% less than in AODV protocols and it increases proportionally with the increase in speed and traffic load in the network.

6.6 Broadcast Packets Sent

The total no. of broadcast packets sent over the network also adds on to the overhead and affects the performance of the network. It is also a good measure of the performance of the protocol. The total no. of broadcast packets sent in I-AODV protocol is around 45% to 50% less than that in AODV as shown in the fig. 6. It increases exponentially with increase in the traffic load.

It is found from the analysis, that all the performance measures discussed above have been improved to a great extent in I-AODV protocol as compared to results of conventional AODV protocol based on pure flooding method. The results of this new protocols are also compared and found improved over by the previous work done on AODV by C.E. Perkins and E.M.Royer in [10], Rahman, W. Olesinski and P. Gburzynski in [12], W. Peng, X.C. Lu in [9] , LIU, W.and QU Z. The no. of rebroadcasts is minimum in I-AODV protocol which increases its efficiency in congested networks. The results confirm that I-AODV, which is based on intelligent route discovery method, performs better than conventional AODV which is based on simple flooding approach.

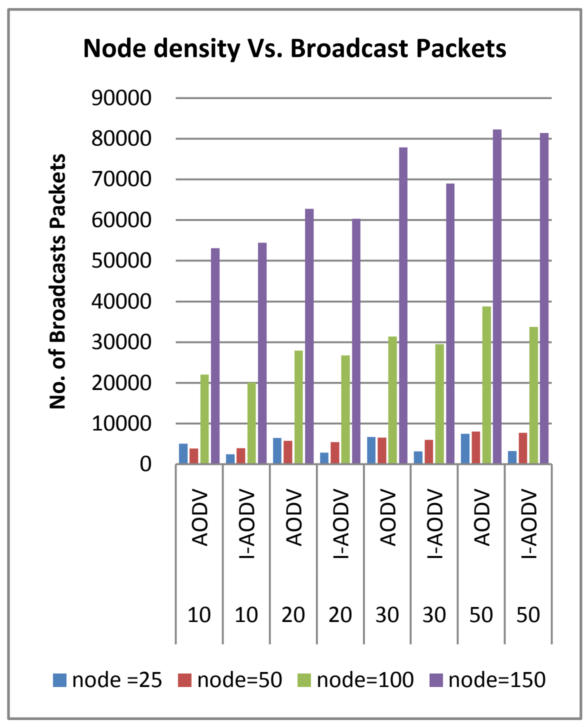

Fig.. 6 Node density and mobility (m/sec) Vs .Broadcast Packets

7. CONCLUSION AND SCOPE

The main conclusion of this research work is that proposed model offers better cost effective performance than conventional AODV protocol which uses simple flooding for route discovery process. In blind flooding technique (used in AODV), each node in the network, retransmits the RREQ packet exactly once, resulting in the maximum no. of retransmissions. In our new approach of selective flooding based on neighbor node density and probability of rebroadcasting, RREQ retransmissions are reduced a lot, hence improving the performance of the algorithm. The main objective of any flooding optimization algorithm is achieve higher reachability with less or minimum no. of RREQ and broadcast packets retransmissions. The proposed model is flexible and can be configured for pure flooding, fixed probability and auto adjusted node density algorithms. The selection of maximum probability value, minimum probability value, average no. of neighbor nodes and node density needs careful calculation and selection for best results.. The results confirm that I-AODV , which is based on intelligent route discovery method , performs better than conventional AODV. The performance is evaluated in terms of end-to-end delay, routing overheads, control overheads and I-AODV is found better than AODV.

In future work it is recommended to investigate effect of transmission range on the performance of the I-AODV protocol and in different mobility models etc. Route discovery approach used in I-AODV may be implemented on other on demand reactive routing protocols of MANETs such as DSR. to investigate their performance in similar scenarios. The protocol can be tested in wireless sensor network environment. It is concluded from the results that the I-AODV protocol is superior to conventional AODV and performance metrics are improved with significant reduction in the number of rebroadcasting messages.

8. REFERENCES

[1] Johnson D, Hu Y, Maltz D. The Dynamic Source Routing Protocol (DSR). In: IETF mobile ad hoc networking Working Group INTERNET RAFT, RFC 4728, February 2007,http://www.ietf.org/rfc/rfc4728.txt

[2] Perkins C, Belding-Royer E, Das S. Ad hoc on-demand distance vector (AODV) routing. In: IETF mobile ad hoc networking Working Group INTERNET DRAFT, RFC 3561, July 2003, http://www.ietf.org/rfc/rfc3561.txt. Experimental RFC.

[3] S.-Y. Ni, Y.-C. Tseng, Y.-S. Chen, J.-P. Sheu, The broadcast storm problem in a mobile ad hoc network, Wireless Networks, vol. 8, no. 2, pp.153-167, 2002.

[4] T. Camp, J. Boleng, B. Williams, L. Wilcox, and W. Navidi. Performance evaluation of two location based routing protocols. In Proceedings of INFOCOM 2002.

[5] C.E. Perkins and E.M. Royer, "Ad-hoc on-demand distance vector routing," in Proceedings of the Second Annual IEEE Workshop on Mobile Computing Systems and Apllications, Feb. 1999, pp. 90–100.

[6] C-K. Toh, Ad Hoc Mobile Wireless Networks: Protocols and Systems, Prentice Hall PTR, 2002.

[7] C.E. Perlins, Ed., Ad Hoc Networking, Addison Wesley, 2001.

[8] Qayyum, L. Viennot, and A. Laouiti. Multipoint relaying for flooding broadcast messages in mobile wireless networks. In Proceedings of the 35th Annual Hawaii International Conference on System Sciences (HICSS'02), Big Island, Hawaii, Jan 2002.

[9] W. Peng, X.C. Lu, on the reduction of broadcast redundancy in mobile ad hoc networks, in: Proc. Workshop on Mobile and Ad Hoc Networking and Computing (MobiHOC'2000), Boston, Massachusetts, USA, pp. 129–130, 2000.

[10] C.E. Perkins and E.M.Royer," Ad hoc On Demand Distance Vector Routing" Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, pages 90-100, New Orleans, LA, February 1999.

[11] Y. B. Ko and N. H. Vaidya. Location-Aided Routing (LAR) in Mobile Ad Hoc Networks. Journal of Wireless Networks, Vol. 6, Issue 2, pp. 307-321, 2004.

[12] Rahman, W. Olesinski and P. Gburzynski. Controlled Flooding in Wireless Ad Hoc Networks. Proceedings of IEEE International Workshop on Wireless Ad Hoc Networks (IWWAN'04), University of Oulu, Finland, 2004.

[13] Barrett, S. Eidenbenz, L. Kroc, M. Marathe, and J. Smith. Parametric Probabilistic Routing in Sensor Networks. Journal of Mobile Networks and Applications, Vol. 10, Issue 4, pp. 529-544, 2005.

[14] Jorge Nuevo, "A Comprehensible GloMoSim Tutorial", University of Quebec, September 2003

[15] Guolong Lin, Guevara Noubir and Rajmohan Rajaraman, "Mobility Models for Ad hoc Network Simulation", INFOCOM 2004.

[16] LIU, W.and QU Z., "Scheme for on-demand route protocol in Ad-hoc networks". Science Direct, Elsevier, pp 41-45, 2008.

[17] J. Cartigny, D. Simplot. "Border node retransmission based probabilistic broadcast protocols in ad-hoc networks, Telecommunication Systems, vol. 22, no 1–4, pp. 204, 2003.

[18] Y.-C. Tseng, S.-Y. Ni, and E.-Y. Shih, "Adaptive Approaches to Relieving Broadcast Storms in a Wireless Multihop Mobile Ad Hoc Network," IEEE Trans. Computers, vol. 52, no. 5, pp. 545-557, May2003.

[19] Stojmenovic, Ed. "Broadcasting in Wireless Networks," in Handbook of Wireless Networks and Mobile Computing, Wiley, pp. 509–528, 2002.

[20] J.Wu and W. Lou,"Forward-node-set-based broadcast in clustered mobile ad hoc networks, "Wireless Communications and Mobile Computing, vol. 3, pp. 155–173, 2003.

[21] P. Boustead, J. Lipman and J. Judge, "Efficient and Scalable Information Dissemination in Mobile Ad Hoc Networks," in Proceedings of the First International Conf. on Ad-hoc Networks and Wireless ADHOC-NOW, Toronto, September 2002, pp. 119–134.

[22] H. Lim and C. Kim, "Flooding in Wireless Ad Hoc Networks," In Proceedings of ACM MSWiM Workshop at MobiCom, Aug. 2000; Computer Communication Journal, 24, 3–4, 353–363, 2001.A.

[23] J. Sucec and I. Marsic, "An Efficient Distributed Network-wide Broadcast Algorithm for Mobile Ad Hoc Networks," CAIP Technical Report 248, Rutgers University, September 2000.