An Efficient Probability Based Broadcast Scheme for AODV Mobile ad-hoc Network Protocol

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Abstract:-Many routing protocols uses broadcasting technique to distribute control information, that send the control information from an origin node to all other nodes and leads to flooding. It initiates high number of unnecessary packet rebroadcasts, causing contention and packet collision. The basis of this paper is to use Probabilistic scheme which can be used to reduce the number of broadcast without compromising the reach-ability. This scheme also defines phase transition phenomenon observed in percolation theory and random graphs to improve the performance of AODV based on varying the probability and speed of nodes, on basis of these parameters like control packet overhead, average end-to-end delay and number of retransmitting nodes. Simulation environment i.e. NS-2 network simulator is used for implementing the proposed work.

Keywords- Broadcasting, Flooding, Overhead, AODV, Simulation and NS –2

I. Introduction

"An adhoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any centralized administration or standard support services regularly available on the wide area network to which the host may normally be connected"[1,4]. Since the nodes are highly mobile, the network topology changes frequently and the nodes are dynamically connected in a arbitrary manner. Further, the limitation imposed on the transmission range of the nodes have lead to the development of routing policy where packets are allowed to traverse through multiple nodes thus making each node act as terminal as well as router. Since the nodes in adhoc networks are free to move over a certain area which results into frequent change in the network topology, design of suitable routing protocol is essential to adapt the dynamic behavior of the network. Routing protocols can be classified as three types: reactive, proactive, and hybrid routing protocols [1]. A mobile ad hoc network is a collection of self configuring and adaption of wireless link between communicating devices (mobile devices) to form an arbitrary topology without the use of existing infrastructure. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. MANET nodes are equipped with wireless transmitters and receivers using antennas, which may be Omni directional (broadcast), highly directional (point-to-point), possibly steerable, or some combination thereof. Routing protocols occupied to determine the routes subsequent to a set of rules that enables two or more devices to communicate with each others. All these protocols uses a simplistic form of broadcasting called Flooding [3], in which each node retransmits each received unique packet exactly one time. The main problems with Flooding are that flooding can be very costly and can lead to serious redundancy, bandwidth contention and collision: a situation known as broadcast storm [2].

II. Ad-Hoc on Demand Vector Routing Protocol

Ad hoc On-Demand Distance Vector (AODV) routing is a routing protocol for mobile ad hoc networks and other wireless ad-hoc networks. It is jointly developed in Nokia Research Centre of University of California, Santa Barbara and University of Cincinnati by C. Perkins and S. Das. It is an on-demand and distance-vector routing protocol, meaning that a route is established by AODV from a destination only on demand. AODV is capable of both unicast and multicast routing. It keeps these routes as long as they are desirable by the sources. Additionally, AODV creates trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. The sequence numbers are used by AODV to ensure the freshness of routes.

It is loop-free, self-starting, and scales to large numbers of mobile nodes. AODV defines three types of control messages for route maintenance: RREQ- A route request message is transmitted by a node requiring a route to a node. As an optimization AODV uses an expanding ring technique when flooding these messages. Every RREQ carries a time to live (TTL) value that states for how many hops this message should be forwarded. This value is set to a predefined value at the first transmission and increased at retransmissions. Retransmissions occur if no replies are received. Data packets waiting to be transmitted (i.e. the packets that initiated the RREQ). Every node maintains two separate counters: a node sequence number and a broadcast_ id. The RREQ contains the following fields.

Table1: RREQ Packet Format

Source address	**Broadcast ID**	**Source Sequence No.**	**Destination Address**	**Destination Sequence No.**	**Hop Count**

The pair <source address, broadcast ID> uniquely identifies a RREQ. Broadcast_id is incremented whenever the source issues anew RREQ.RREP- A route reply message is unicast back to the originator of a RREQ if the receiver is either the node using the requested address, or it has a valid route to the requested address. The reason one can unicast the message back, is that every route forwarding a RREQ caches a route back to the originator. RERR- Nodes monitor the link status of next hops in active routes. When a link breakage in an active route is detected, a
RERR message is used to notify other nodes of the loss of the link. In order to enable this reporting mechanism, each node keepsa ―precursor list", containing the IP address for each its neighbors that are likely to use it as a next hop towards each destination.

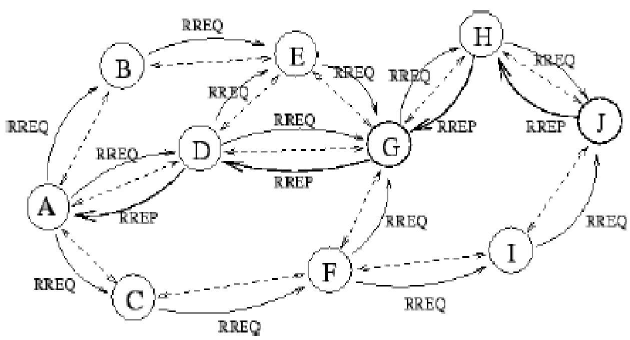

Fig 1: A possible path for a route replies if A wishes to find a route

AODV builds routes using a route request/route reply query cycle. When a source node desires a route to a destination for which it does not already have a route, it broadcasts a route request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables. In addition to the source node's IP address, current sequence number, and broadcast ID, the RREQ also contains the most recent sequence number for the destination of which the source node is aware. A node getting the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. If this is the case, it unicast a RREP back to the source. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ's source IP address and broadcast ID. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it [6].

III. Probabilistic Scheme

This is similar to flooding except the nodes broadcast the packets with predetermined probability. This scheme is identical to flooding when probability of broadcast is 100%.As the blind flooding provokes a high number of unnecessary packet rebroadcasts, causing contention, packet collisions and ultimately wasting precious limited bandwidth. Probabilistic scheme can be used to reduce the number of broadcast without compromising the reach-ability. Probabilistic scheme can be defined by many methods [3]. The basis of this paper is to use phase transition phenomenon observed in percolation theory and random graphs to define probabilistic flooding .Where a phase transition is a phenomenon where a system undergoes a sudden change of state. Small changes in a given parameter of the system induce a great shift in the system's global behavior. Two models are considered as a basis for this method. The first model (square grid model) is quite simplistic but is not useful for extracting best-case results for a specific MANET topology. Through the second and more realistic model (fixed radius model) any MANET topology may be represented.

1. *Probabilistic Broadcasting Based on Coverage Area and Neighbor Confirmation in Mobile Ad Hoc Networks*:

The rebroadcast probability is set based on the coverage area of the node. If mobile nodes reside nearer to the sender node then there will be less additional coverage area and hence rebroadcast probability is set lower, and higher for larger additional coverage area.

- Each node is allowed to choose according to the distance from sender. Where, the distance between sender and receiver estimates the coverage area.
- In previous research work a fixed rebroadcast probability (p= 0.65) is set where p=1 means flooding.
- Shadowing effect is used to determine coverage to set the appropriate probability.

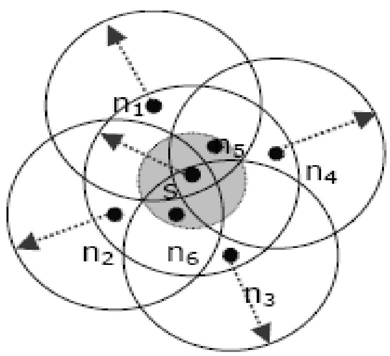

Fig 2: Shadowing effect of inner nodes

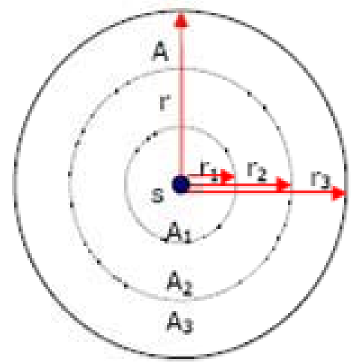

Fig 3: The coverage area of the sender is divided where coverage ratio μ:

A1, A2 and A3 are coverage area. General Concept of Probabilistic Approach:

1: Upon reception of message m at node n

2: If (message m received for the first time)

3: Broadcast message with probability p

4: else

Do not broadcast message

5: end if

VI. MOVEMENT MODEL

The Random Waypoint Mobility Model is very widely used in simulation studies as a movement model. Performance measures in mobile ad hoc networks are affected by the movement model used. One of the most important parameters in mobile ad hoc simulations is the nodal speed. The users want to adjust the average speed to be stabilized around a certain value and not to change over time. They also want to be able to compare the Performance of the mobile ad hoc routing protocols under different nodal speeds. For the Random Waypoint Mobility Model a common expectation is that the average is about half of the maximum, because the speeds in a Random Waypoint Model are chosen uniformly between 0 m/s and Vmax.

1. RANDOMIZED ALGORITHM:

To implement a randomized algorithm we require a source of randomness. The usual source of randomness is a random number generator. Therefore, before presenting randomized algorithms, we first consider the problem of computing random numbers.

1.1 GENERATING RANDOM NUMBERS:

The most common algorithms for generating pseudorandom numbers are based on the linear congruential random number generator invented by Lehmer. Given a positive integer m called the modulus and an initial seed value X_0 ($0 \le X_0 <$ m), Lehmer's algorithm computes a sequence of integers between 0 and m-1. The elements of the sequence are given by

$$X_{i+1} = (aX_0+c) \bmod m \ \ldots\ldots\ldots\ldots\ldots (1)$$

Where a and c are carefully chosen integers such that $2 \le a < m$ and $0 \le c < m$. For example, the parameters a=13, c=1, m=16 and X_0=0 produce the sequence 0,1,14,7,12,13,10,3,8,9,6,15,4,5,2,11,0…..In practice the increment c is often set to zero. In this case, Equation 1 becomes

$$X_{i+1} = a X_i \bmod m \ \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This is called a multiplicative linear congruential random number generator. (For $c \neq 0$, it is called a mixed linear congruential generator). In order to prevent the sequence generated by Equation 2 from collapsing to zero, the modulus m must be prime and X_0 cannot be zero. For example, the parameters a=6, m=13 and $X_0 = 1$ produce the sequence 1,6,10,8,9,2,12,7,3,5,4,11,1…..

As the final step of the process, the elements of the sequence are normalized by division by the modulus:

$$U_i = X_i/m$$

V. SIMULATION ENVIRONMENT

We give the emphasis for the improving the efficiency of Ad Hoc routing protocol AODV with varying the probability and node mobility. The simulations have been performed using network simulator NS-2 version 2.34 running on Fedora 7 is an open source discrete event simulation tool, which means it simulates events such as sending, receiving, forwarding and dropping packets[5].

1. Simulation Model:

We consider a network of nodes placing within a 400m X 400m area. The performance of AODV is evaluated by keeping the number of mobile nodes constant and varying the probability and node mobility. Table 2 shows the simulation parameters used in this evaluation.

Table 2: Simulation Parameters

Simulator	**NS 2.35**
Protocol	**AODV**
Simulation Duration	**100 seconds**
Simulation Area	**400m x 400m**
Number of nodes	**100**
Movement Model	**Random Waypoint Mobility Model**
MAC Layer Protocol	**IEEE 802.11**
Pause Time	**2 seconds**
Node Mobility	**2 m/s to 10 m/s**
Traffic Type	**CBR(UDP)**
Data Payload	**256 bytes/sec**
Maximum Probability	**0.1 to 1**

2. *Performance Metrics:*

While analyzed the AODV protocol, we focused on three performance metrics which are Control Packet Overhead, Average End-to-End Delay and Number of Retransmitting Nodes. Control Packet Overhead (CPO): It is the number of packets generated by routing protocol during simulation. The generation of overhead will decrease the protocol performance.

Average end to end delay of data packets (AD): The average time from the beginning of a packet transmission at a source node until packet delivery to a destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, re-transmission delays at the MAC, and propagation and transfer times of data packets. Calculate the send(S) time (t) and receive (R) time (T) and average it.

Number of Retransmitting Nodes: It is the number of nodes that retransmit the message to other nodes in the network area.

VI. EXPERIMENTAL RESULTS

The performance of AODV based on the varying the probability and speed of nodes is done on parameters like control packet overhead, average end-to-end delay and number of retransmitting nodes. “Fig.4”, helps us to see the flow of packets i.e. route discovery between 100 nodes by AM which is a built-in program in NS-2-allinone package.

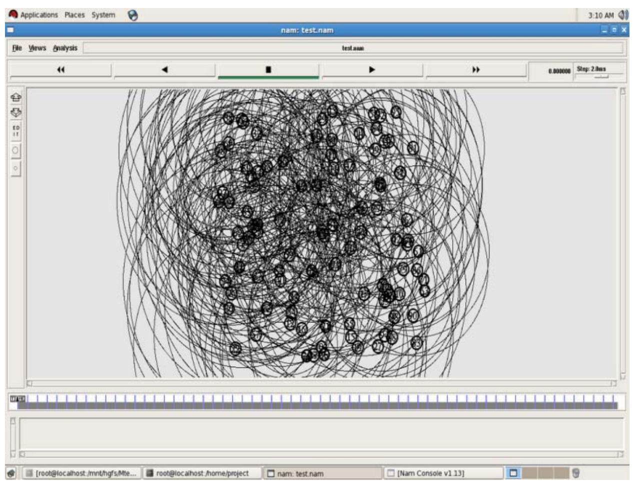

Fig 4: Screenshot of AODV with 100 nodes: Route Discovery

The ns-2 packet level simulator (v.2.31) is used to conduct extensive experiments to evaluate the performance of probabilistic flooding. The network considered for the performance analysis of the rebroadcast probability vs. control packet overhead, average end to end delay, and number of retransmitting nodes with fixed number of nodes 100 placed randomly on 400 * 400 m^2,having bandwidth of 2Mbps. The random waypoint model is used to simulate the mobility patterns with retransmission probabilities ranging from 0.1 to 1.0 with 0.1 percent increment per trial. In short, the random waypoint model considers nodes that follow a motion-pause recurring mobility state. Each node at the beginning of the simulation remains stationary for pause time seconds, then chooses a random destination and starts moving towards it with speed selected from a uniform distribution (0, max_speed]. After the node reaches that destination, it again stands still for a pause time interval and picks up a new destination and speed. This cycle repeats until the simulation terminates. The maximum speeds of 2, 4, 6, 8, 10 meter/second and pause times of 2 seconds are considered for the purposes of this study.

1. *Control Packet Overhead vs Probability*

Table 3: The value of Control Packet Overhead for probability 0.7 with different node mobility.

Node Mobility	**Control Packet Overhead**
4m/s	**1578**
8m/s	**891**

1.1 Node Mobility 4m/s

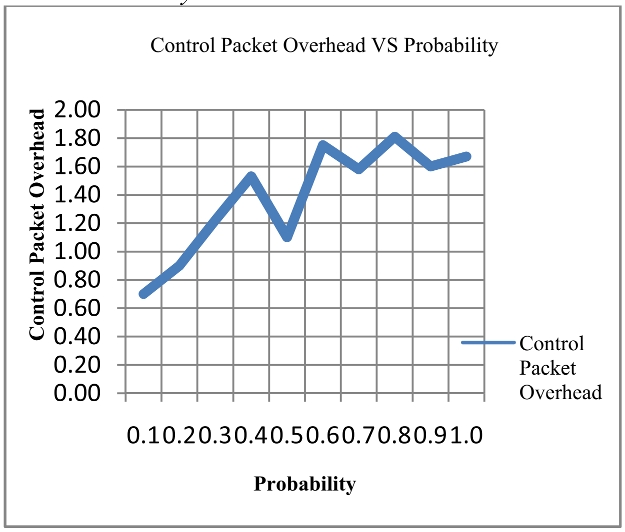

Fig 5: Control Packet Overhead vs Probability with Node Mobility 4 m/s

1.2 Node Mobility 8m/s

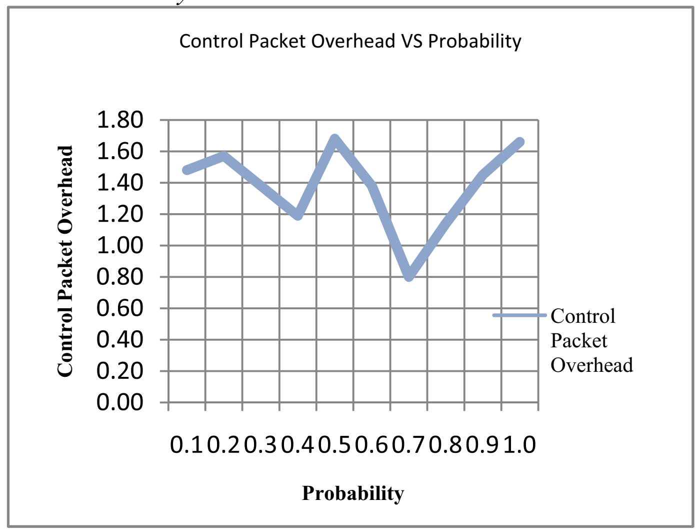

Fig 6: Control Packet Overhead vs Probability with Node Mobility 8 m/s

These figures highlights the relative performance of AODV i.e. it delivers a less overhead at probability 0.7. The redundant packets in network are 891 at node mobility 8m/s.it is the least value among all. It is the best result when 70% of nodes are broadcasting with maximum speed and only 891 redundant packets are there in network. The reason for having high probability is to achieve the reach-ability. Reach-ability means that the source packet should reach to the destination. The reach-ability will be good when the probability is high.

2. *Average end to end delay vs Probability*

As node mobility increases, the average delay increases because when node mobility increased more RREQ packets fail to reach their destination. In such circumstances more RREQ packets are generated and retransmitted, which lead to higher chance of collision.

2.1Node Mobility 4m/s

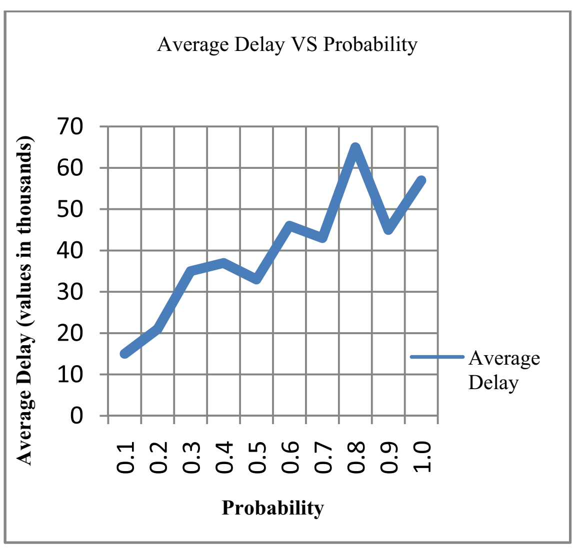

Fig 7: Average Delay vs Probability with Node Mobility 4m/s

2.2Node Mobility 8m/s

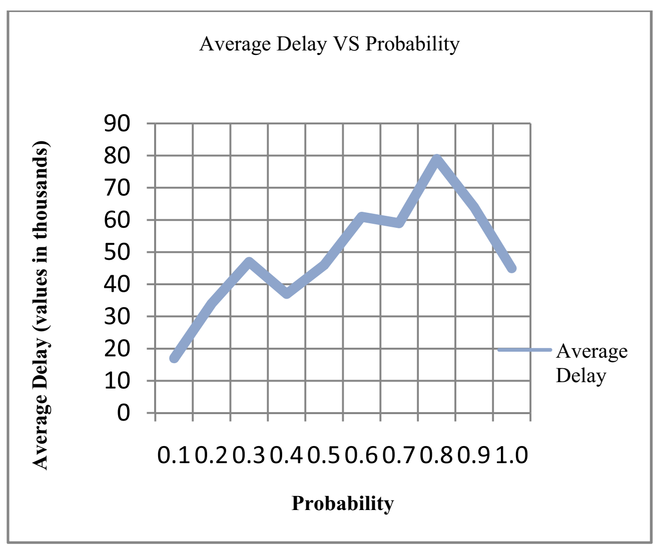

Fig 8: Average Delay vs Probability with Node Mobility 8 m/s

Table 4: The value of average delay for probability 0.1 with different node mobility.

Node Mobility	**Average Delay**
4m/s	**14.74**
8m/s	**17.76**

3. Retransmitting Nodes Vs Control Packet Overhead

As redundant packets increases, the overhead increases with randomly varies probability. The reason of increasing the overhead is increased number of retransmitting nodes in the network.

3.1Node Mobility 8m/s

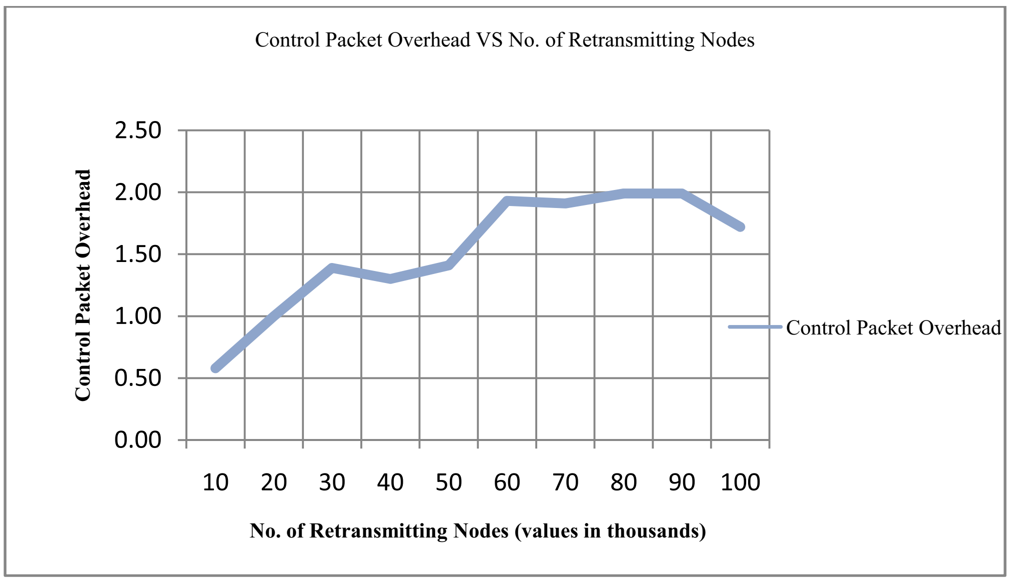

Fig 9: Number of Retransmitting Nodes Vs Control Packet Overhead with Node Mobility 8 m/s

VII. CONCLUSION AND FUTURE WORK

In the presented work, the goal is to improve the efficiency of AODV routing protocol by reducing the flooding in the MANET. Flooding is the by default method of broadcasting. As such, the plain flooding algorithm provokes a high number of unnecessary packet rebroadcasts, causing contention, packet collisions and ultimately wasting precious limited bandwidth. This flooding overhead is reduced by using probabilistic scheme. In this scheme, when receiving a broadcast message for the first time, a node rebroadcasts the message with a pre-determined probability p; every node has the same probability to rebroadcast the message (symmetric environment).The performance of AODV has been measured with respect to metrices viz. control packet overhead, average end to end delay and retransmitting nodes under varying node mobility environment. The results indicate that in high node density the performance of the protocol increases significantly, whenever the network density increases in number of nodes greater than 80 nodes. The reason of performance up gradation is due to the fact when probability increases with increase in the number of nodes the control packet over head, average end to end delay and retransmitting nodes varies with node mobility increases or decreases due to probability approach. In current work, only three performance metrics have been considered to analyze the performance of AODV. Inclusion of other performance metrics will provide in-depth efficiency analization which may provide an insight on the realistic behavior of the protocol under more challenging environment. The current work has been limited with constant pause time and fixed simulation area(400 x 400m) with CBR traffic. By considering metrics i.e. Routing load. Will provide in-depth performance analysis of AODV.

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