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Broadcasting in AODV Routing Protocol of MANETs: A Novel Approach

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Abstract: MANET (mobile ad hoc network) is a wireless mobile network which forms a temporary network without the aid of an established infrastructure. If a source node is unable to send a message directly to its destination node due to limited transmission range, the source node uses intermediate nodes to forward the message towards the destination node because each node in MANET acts as a router. Broadcasting is important in MANET for routing information discovery, for instance, protocols such as dynamic source routing (DSR), ad hoc on demand distance vector (AODV), and location aided routing use broadcasting to establish routes. Broadcasting in MANET poses more challenges than in wired networks due to node mobility and scarce system resources. Due to the mobility, there is no single optimal scheme for all scenarios.

In this paper a new approach is proposed to overcome these limitations in an attempt to enhance and promote the quality of the probabilistic scheme. Our proposed approach is augmented with a well-know ad hoc routing protocols including AODV. We have conducted intensive simulation experiments on GloMoSim, under different operating conditions. The simulation results show that our proposed approach outperforms its counterparts including the well known blind flooding, fixed probabilistic and traditional dynamic probabilistic approaches.

Keywords: GloMoSim Collision rate, end-to-end-delay, broadcasting.

1. Introduction

Ad-hoc networking [11] is a concept in computer communications, which means that users wanting to communicate with each other form a temporary network, without any form of centralized administration. Each node participating in the network acts both as host and a router and must therefore be willing to forward packets for other nodes. For this purpose, a routing protocol is needed. An ad-hoc network has certain characteristics, which imposes new demands on the routing protocol. The most important characteristic is the dynamic topology[8], which is a consequence of node mobility. Nodes can change position quite frequently, which means that we need a routing protocol that quickly adapts to topology changes. The nodes in an ad-hoc network can consist of laptops and personal digital assistants and are often very limited in resources such as CPU capacity, storage capacity, battery power and bandwidth. This means that the routing protocol should try to minimize control traffic, such as periodic update messages. Instead the routing protocol should be reactive, thus only calculate routes upon receiving a specific request. The Internet Engineering Task Force currently has a working group named Mobile Ad-hoc Networks that is working on routing specifications for ad-hoc networks.

Broadcasting is a fundamental and effective data dissemination mechanism for route discovery, address resolution and many other network services in ad hoc networks. Many MANETs routing protocols[11],[12] need to flood a route request to seek out a multi hop route to the destination. Most ad hoc routing protocols use the IEEE 802.11 MAC protocol, which could cause serious contention when many adjacent nodes decide to broadcast simultaneously, such as in flooding. Contention, collision and redundant broadcasts are referred to as broadcast storm problem[9]. Many approaches i.e Probabilistic based Scheme, distance based Scheme, Counter based Scheme, Area based Scheme, Location based Scheme, a cluster based Scheme and neighbor knowledge-based etc are proposed for broadcasting in MANETs[2]. The simplest one is flooding, which also generates the highest number of redundant rebroadcasts. The probabilistic approaches reduce the number of rebroadcasts at the expense of reachability. Counter-based approaches have better throughput and reachability, but suffering from relatively longer delay. The neighbor-knowledge based algorithms require the exchange of neighborhood information among hosts. The distance-based scheme succeeds to reach a large part of the network but do not economize the number of broadcast messages.

Nodes in MANETs move randomly and also they can arbitrary connect to the network or disconnect from it. So, the operation of establishing routes between any pair of nodes within an ad hoc network can be difficult, because the randomly movement of nodes and they can also arbitrary join and leave the network. This means that an optimal route at a certain time may does not work again. Classification of routing protocols in MANETs can be done in three methods depending on routing strategy; proactive, reactive and hybrid.

The paper is divided in 7 sections. Section 2 deals with the related research in the field, section 3 explains the working of the AODV protocol, section 4, a novel technique is proposed in section 4 along with a proposed algorithm which is implemented in GloMoSim 2.03. Section 5 describes the Implementation methodology and result analysis based on some of performance metrics. Conclusion of the research paper is summarized in section 6 followed by important references in section 7.

2. Review of Literature

Flooding is one of the earliest protocols for multicasting and broadcasting in ad hoc networks [1], [2]. In flooding, every node in the network transmits the message to its neighbours after receiving it. Flooding can lead to severe contention, collision and redundant transmissions: a situation referred to as broadcast storm [3].

In a series of papers [4], [5], it was proposed that a connected dominating set (CDS) can be used as a virtual backbone for routing in ad hoc networks.

Williams and Camp [3] have classified the broadcast protocols into flooding, probability-based, counter based, distance-based, location-based and neighbor knowledge schemes. Similarly, neighbour knowledge schemes can be divided into selecting forwarding neighbours and clustering-based. In counter-based scheme inhibits the rebroadcast if the packet has already been received for more than a given number of times.

In the probabilistic scheme [13] when receiving a broadcast packet for the first time, a node rebroadcasts the packet with a probability p; when p=1, this scheme reduces to blind flooding. In the distance-based scheme a node rebroadcasts the packet only if the distance between the sender and the receiver is larger than a given threshold. In the location-based scheme, a node rebroadcasts a packet only when the additional coverage due to the new emission is larger than a certain bound. In the selecting forwarding neighbours a broadcasting node selects some of its1 -hop neighbours as rebroadcast nodes. Finally, the cluster structure[7] is a simple backbone infrastructure whereby the network is partitioned into a group of clusters. Each cluster has one cluster head that dominates all other members in the cluster. A node is called a gateway if it lies within the transmission range of two or more cluster heads. Gateway nodes are generally used for routing between clusters. The rebroadcast is performed by cluster heads and gateways.

In this paper, we report results from Glomosim. 2.0 as the simulation platform. Glomosim 2.03 is a popular network simulator which has originally been designed for wireless networks and has been support simulations in MANET[10] settings in order to characterize neighborhood's information, such as the average number of neighbours of a given node by means of 'Hello' packet exchanges.

3. Working of AODV

AODV [1],[11]is one of the most important reactive routing protocols and it is widely used in MANETs. This type of protocols establishes routes between nodes only on-demand (when they are required to send data packet). There is no need to update all routes in the network; instead it focuses only on routes that are currently used or being set up. Any mobile host can broadcast a RREQ packet when it needs to send information to another mobile host in the network and does not have a valid path to it. Intermediate nodes rebroadcast the received RREQ for the first time to all hosts in the network. This process only stops if the required destination is found and the successful path established. The total cost of using broadcasting technique to find a path between pairs of nodes is equal to the number of nodes in the network, but the source and destination are excluded. This is because the source does not rebroadcast its packet and the destination sends back a Route Replay packet when it is reached. Maintaining local network connectivity can be done either by broadcasting local HELLO packets or through network layer mechanisms. A node sends HELLO packet every second for 1-hope to insure that weather it has a valid route to its neighbours or to create one if necessary. If the node already has a valid route, then the Lifetime variable should be increased for a current route to be at least equal to HELLO INTERVAL* ALLOWED HELLO LOSS. HELLO INTERVAL is used as a threshold time waiting to set the maximum number of seconds of waiting for the node before sending another hello message to its neighbors. ALLOWED HELLO LOSS is used to determine neighbours node connectivity. If the node does not receive a HELLO packet with the maximum number of periods of HELLO INTERVAL the node will assume it has lost its neighbours connectivity.

4. Proposed Technique

Here, we propose novel approach of dynamically adjusted flooding to yield higher performance in term of reachability and save rebroadcast. In addition, it is simple enough for easy implementation without the use of neighbor's information or maintaining a counter for duplicate packets .In our research study we contribute to minimize the Broadcast storm problem and propose a new approach which is A novel probabilistic approaches based on distance based selective flooding. In Distance based probabilistic broadcasting approach We use the distance of a node to estimate forwarding probability and adjust the rebroadcast probability. If a mobile node is located in the area closer to sender, its rebroadcast probability will be set lower. On the other hand, if a mobile node is located in the area far from sender, its rebroadcast probability will be set higher, because rebroadcast through this node can cover much extra area. The distance between sender and receiver can be estimated by signal strength or global positional system. The proposed schemes keep up the reachability of blind flooding while maintaining the simplicity of probability based schemes. Simulation results show that our approaches can improve the average performance of broadcasting in various network scenarios. A brief outline of the Novel Approach algorithm is as follows;

Begin
{
Step1: Upon reception of a broadcast RREQ at a Node X for
the first time.
Step2: Get the Number of neighbours for 1-hope **NHello_Packet** //
local neighbourhood information.
Step3: Get the Number of neighbours within node's transmission range **Transmission_Range** // global neighbourhood
information.

Step3: Set the value of rebroadcasting probability according to local and global density:
P = **NHello_Packet /Transmission_Range** .
Step4: Generate a random uniform number R over the interval between [0,1]**{**
If (R > P)
Rebroadcast the received RREQ packet
Else
Free(RREQ)
}
}
End

The rebroadcast probability should be set differently for one node to another in order to alleviate the number of rebroadcasting RREQ control packets and increase the efficiency of the network. Upon the selection of the value of forwarding P, the algorithm generates a random number between the interval [0, 1], compares it with the value of P, and decides to rebroadcast or drop the RREQ packet

5. Implementation and Simulation Results

a) Experimental Setup

The simulation was carried out using Glomosim. 2.03.[14] The parameters used in the following simulation experiments are listed in Table 1. The MAC layer scheme follows the IEEE 802.11 MAC specification. We have used the broadcast mode with RTS/CTS/ACK mechanisms for all packet transmissions.

b) Performance Metrics

In this study we evaluated the broadcast schemes using the following performance metrics:

•**Routing overhead:** The total number of RREQ packets generated and transmitted during the total simulation time.

•**Collisions rate:** The total number of RREQ packets dropped by the MAC layer as a result of collisions between RREQ packets during route discovery operation, per simulation time unit.

•End-to-end delay: The average delay that a data packet takes to reach from source to destination. This includes all possible delays caused for example buffering during route discovery delay and queuing at the interface.

c) Result Analysis

To evaluate the performance of the new a p p r o a c h , G l o M o S i m i s u s e d a n d t h e the effects of an offered load on the performance of the broadcast schemes have been investigated by changing the number flow for each simulation experiment. We have varied the nodes density from low to high, and the traffic load as well from low to high to insure that our approach is applicable over different traffic loads. We present the performance results of our scheme N-AODV against those for Fixed Probability (FP -AODV), Blind Flooding (BF-AODV) and SPB-AODV). Each collected data point in the simulation output represents an average of 30 different randomly generated mobility models with 95% confidence intervals. The average of 30 randomly network topologies give more precise and accurate results than, for example, 10 or 20 topologies. The network density has been varied from low to high density by changing the number of nodes placed in a 1000m x 1000m area of each simulation scenario. Each node moves according to a random way point mobility model with a speed chosen between 1 and 4m/sec to mimic the human speed in this scenario. For each simulation experiment, the number of random source and destination connections are selected to be 10 (i.e. traffic flows), each generates 4 data packets/second.

Fig.1 shows that the number of packets collisions incurred by the four protocols increase as the number of nodes grows. The scalability and applicability characteristic of N-AODV becomes obvious when the number of nodes increases. This is due to the reduction of the possibility of having more than two nodes transmitting at the same slot time by using N-AODV. As a result a number of large duplicated and dropped packets are reduced.

Fig.2 shows the routing overhead incurred by N- AODV, SBP-AODV, FB-AODV and BF-AODV for different network densities. The figure shows that for a given network density, the generated routing overhead incurred in each of the four routing protocols increases proportional to the number of nodes. In fact, we can conclude that there is a direct relationship between the number of nodes in the network, and the number of RREQ packets. However, the N-AODV outperforms all the other protocols. For example, the routing overhead in N- AODV is reduced by approximately 52% for the 100 nodes network compared with BF-AODV. Now, we investigate the impact of traffic load with the injection rates of 5, 10, 20, 30 and 40 packets per second. The network topology is 1000m x1000m, and 100 nodes are deployed over it. Each node in the network moves according to random way point mobility model with speeds chosen between 1m/s and 4m/s respectively. The results in Fig.3 show that the number of collisions incurred by the routing protocols increase as the offered load increases. This is because; as the offered load increases the number of RREQ generated and disseminated packets increases too. The figure also reveals that for a given injection rate point, N-AODV outperforms SPB-AODV FB- AODV and BF-AODV. For instance, the collision rate of N-AODV is approximately 49% lower than that of BF-AODV.

The main parameters used in the simulations are summarized in Table 1.

Table1: Simulation parameters used.

Parameter	Value
Transmitter range	250 m
Bandwidth	2 Mbit
Interface queue length	50 messages
Simulation time	900 Sec
Pause time	0 Sec
Packet size	512 bytes
Topology size	1000 x 1000 m ^{2}
Nodes speed	4 m/sec
Number of node	25, 50, 75, 100 nodes
Traffic load	5, 10, 20, 30
Data traffic	CBR Random Way-Point
Mobility model	30 trials
Number of trials	31

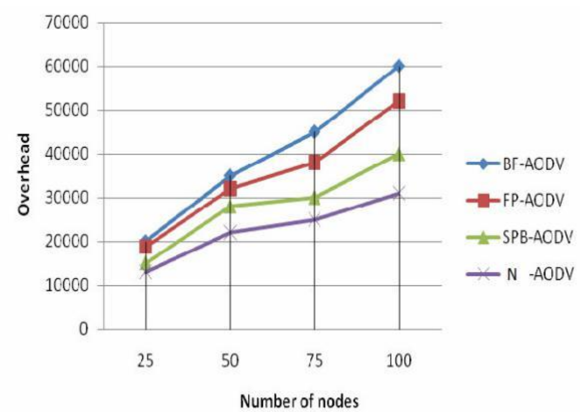

Fig.1: Network density Vs. Control Overhead

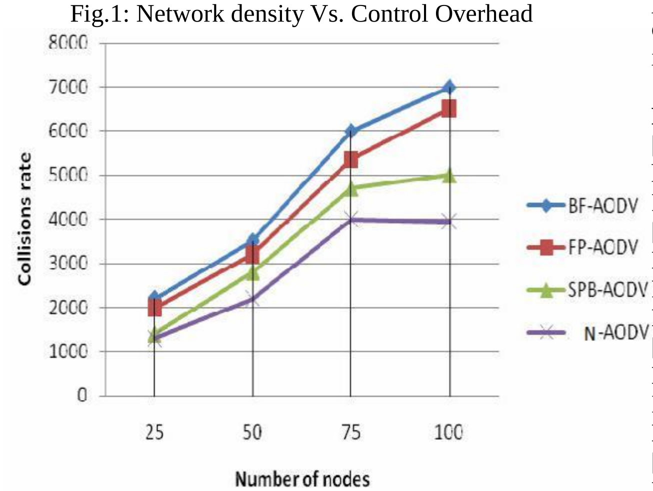

Fig.2: Network density Vs. Collision Rate

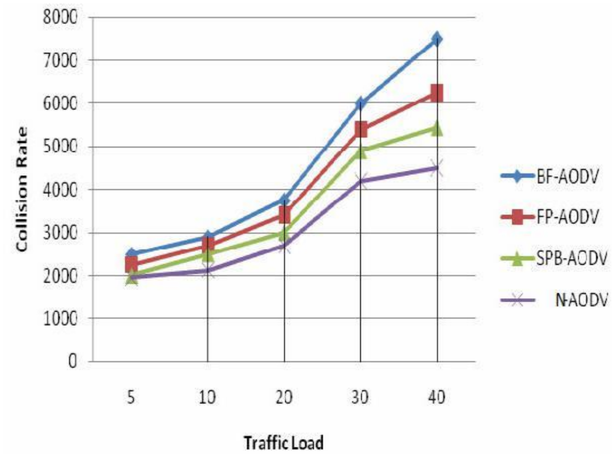

Fig.3: Traffic load Vs. collision rate.

6. Conclusions

The broadcast nature of wireless transmissions, that all the neighbours of a host will receive the packet when the host transmits a packet. Extremely limits the scalability of the network. When the size of the network increases and the network becomes dense, even a simple broadcast operation may trigger a huge transmission collision and contention that may lead to the collapse of the whole network. This is referred to as the broadcast storm problem. To reduce this problem, we proposed cluster structure for broadcasting in MANETs. In this paper, we proposed a novel solution for the broadcast storm problem in MANETs. Our proposed approach is based on the well known probabilistic scheme. We have conducted simulations experiments and evaluated our proposed scheme under different operating conditions including different network densities and offered loads. We showed that our approach can significantly improve the broadcast operation in MANETs due to our new efficient mechanism of packet request rebroadcasting. Moreover, it is also confirmed that our approach outperforms existing protocols by reducing network overhead and packets collision. As a future work, we can deploy our approach in more scenarios and large scale networks.

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