Performance of Probabilistic Broadcasting of Dynamic Source Routing Protocol

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Abstract **- Blind flooding have been proposed to perform route discovery operations in Mobile Ad-hoc Networks as an early method, but it suffers from a serious problem relied to the broadcast storm problem. Several probabilistic approaches have been proposed to overcome this problem, such as fixed probabilistic, adjusted probabilistic and smart probabilistic schemes. This paper investigates the use of probability with Dynamic Source Routing Protocol (DSR) algorithm to overcome the broadcast storm problem. The paper invistigates issues regarding the implementation and integration of probability in DSR algorithm and how it can be improved. Simulation results show that the new scheme provides good results in performance levels by taking in consideration the status of the network density (sparse versus dense networks).**

Keywords-Source Routing; Probabilistic Flooding; Fixed Probability; Broadcasting

I. INTRODUCTION

In computer networks, the key functionality is to transmit and receive data. Controlling this functionality requires routing the data from the source to the destination. In mobile ad hoc networks, this is a critical and sensitive issue that has to be investigated due to the limitation on such networks, as mobile ad hoc network is designed to be robust. The nodes in such networks are continuously moving and changing there positions, and therefore, the topology of the network are changing frequently, the process of finding the route from source to destination is a challenging task.

One of the first route discovery mechanisms used is blind flooding [1][2]. In blind flooding, when a node receives a Route Request (RREQ) message for the first time, it retransmits it to all its neighbors. This approach is costly and can cause what is called broadcast storm problem [3].

Several schemes have been proposed to overcome this problem using probabilistic approaches. For example, using fixed probability, in which the node rebroadcast the RREQ with a predetermined probability p. Other approaches used adjusted or smart probability where the rebroadcasting of the RREQ is performed according to a probability calculated based on some local information of the node’s neighbors [4].

In this paper, we investigate the use of probability with DSR algorithm in order to reduce the effects of broadcast storm problem and reduce the contention aiming at improving the performance of the network. The basic idea is to gather useful information about the current status of the network and then make the routing decision based on the collected data.

Finally, for further improvements, we propose a technique to use a global knowledge about the network based on some estimations about the network to enhance the accuracy of the routing decisions.

II. RELATED WORK

One of the earliest techniques used to find a route from a certain source node to a destination node is flooding. Flooding is the basic technique used and implemented in DSR [1] and AODV [2] routing protocols. Flooding is performed by broadcasting a RREQ packet from the source node to all of its neighbors. If one of the neighbors is the destination, it replies by sending a Route Reply (RREP) packet, otherwise, it rebroadcast the request to all it neighbors. If a node (not the destination) receives a RREQ, it will check if the packet has seen before, if so, it will discard the packet, else it will rebroadcast it until the destination node is reached where RREP packet is sent. The concept of flooding is attractive due to its simplicity, effectiveness and ease of implementation.

However, this technique can lead to a serious problem called broadcast storm problem [3]. This problem occurs because the flooding is likely to happen frequently in ad hoc networks. Due to the number of rebroadcast operations, this will result in many redundancies in RREQ packets and cause a contention in the network.

Several approaches were proposed to reduce the redundancy and control rebroadcasting process. One of the earliest techniques is using probabilistic broadcasting in which the intermediate nodes rebroadcast the RREQ according to a certain probability [6].

Bani yassein and Bani Khalaf in [4] used the concept of four probabilities (P's) in their smart probabilistic approach to calculate the rebroadcasting probability based on local information of the neighbors. They choose the value of p's such that $p1>p2>p3>p4$ without specifying initial value for p.

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A.Overview of Dynamic Source Routing Protocol (DSR)

The DSR protocol consists of two phases; route discovery phase which is a mechanism for finding a route from source to destination, and route maintenance phase which is the process of discovering the failure or keeping the link active [1].

When a node creates a packet to be sent to a destination, a route path is appended to the head of packet to determine which path the packet should move through. The node can find this path by searching the route cache for previously learned paths. If the path could not be found in route cache, then this node sends a route discovery packet to find a path to the destination. When a node receives a route discovery packet, it returns a route replay packet to the sender, if it is the target, containing a copy of accumulated route through the network. When the sender receives this message, it put it in its cache to be used in later requests. If the node is not the target node, it appends its address to the route path accumulated in the message and forwards it by a local broadcast packet. If the node finds it own address listed in the message or the message contains a request id that has seen before, it discards this message. The destination node when receiving a route discovery packet, it looks in its route cache to fine a route to the source, if the path found in cache, the destination send pack route replay message through this path, otherwise, the destination starts its own route discovery process.; However, this operation may cause infinite loop, therefore the destination may include the path in the route replay message. Also the destination could reverse the source route if the network has a bidirectional link. The destination saves route replay message in send buffer which contains the messages that cannot be transmitted and try to retransmit the messages later on. Also it can be time stamped so it can be discarded later

B.Adjusted Probabilistic broadcasting

The adjusted probabilistic broadcasting [4] depends on calculating the average number of neighbors in the network. Node's *a* neighbors are defined as the nodes that can be directly reached by node *a*. The average number of neighbors can be calculated as the following:

$$avg = \frac{\sum_{i=1}^{n} N_i}{n} \qquad (1)$$

where N_i is the number of neighbors of node *I* and *n* is the number of neighbors in the network. In [4], the nodes estimate the average using the following equation:

$$avg = (N-1)0.8\frac{\pi^2}{A} \qquad (2)$$

where *N* is the number of nodes in the network and *A* is the area of the ad hoc network.

Once a node receives a RREQ, it checks if this is not the first time the node receives this RREQ, the node will discard the RREQ, else, it will find the number of its neighbors. If the number of its neighbor is less than *avg*, then the node is probably in a sparse area and therefore high broadcast probability is assigned to the RREQ. On the other hand, if the number of neighbors is greater than *avg*, then the node is probably in dense area and a low probability is assigned to the RREQ.

C. Smart Probabilistic Broadcasting

Smart probabilistic broadcasting algorithm [1] defines four values of probabilities *p1, p2, p3, p4* where *p1>p2>p3>p4*. The algorithm calculates the *avg* as above and calculate the average number of neighbors for the nodes whose number of neighbors is less than *avg* (*avg1*) and the average number of neighbors for the nodes whose number of neighbors is greater then *avg* (*avg2*) using the following equations:

$$avg1 = \frac{\sum_{i=1}^{n} N_i}{k} \qquad (3)$$

where *Ni* <avg, *k* is the number of node satisfying the condition, and *n* is the number of nodes in the network.

$$avg2 = \frac{\sum_{i=1}^{n} N_i}{k} \qquad (4)$$

where *Ni* ≥ avg, *k* is the number of node satisfying the condition, and *n* is the number of nodes in the network.

Once receiving a RREQ for the first time the node get the values of *avg*, *avg1* and *avg2* then it calculates number of its neighbors *c*. Now, if *c<avg1*, then this node is in low sparse area which means high probability is assigned to RREQ *p=p1*. If *avg1<c< avg*, then the node is in medium sparse area and a medium high probability is assigned to RREQ *p = p2*. If *avg < c < avg2*, then the node is in medium dense area and medium low probability is assigned to RREQ *p=p3*. Finally, if *c>avg2*, then the node is in high dense area and low probability is assigned to RREQ *p=p4*.

III. MOTIVATION

DSR is one of the earliest routing algorithms that have been introduced. It uses flooding technique for route discovery operation. However, as mentioned above, although blind flooding is simple, effective and easy to implement, it can lead to a serious problems like broadcast storm problem.

Many approaches have been proposed to improve the route discovery process. One of the most important approaches is probabilistic broadcasting using fixed probability approaches[4], dynamic probabilistic

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approaches, adjusted probabilistic or two-p scheme and smart probabilistic of four-p approaches [3][4].

The aim of using probability is to reduce the redundancy and overlapping in radio signals and hence reduce the contention and collision in the network.

Those techniques mentioned above have been implemented and tested using AODV routing scheme and shows a significant improvement and increase in network performance with the AODV protocol.

As stated in [1], typically, AODV performance is close to the DSR performance. However, in high mobility environments, DSR outperforms AODV because AODV spends significant amount of time to expand the search range. Search in route discovery phase in both AODV and DSR have the same overhead but with a noticeable advantage to DSR as DSR performs less route discovery operations on control overhead over transmission bytes. However, with respect to delivery bytes, AODV outperforms DSR due the increased reliability in AODV.

The probabilistic techniques have not yet investigated using DSR algorithms. A significant improvement is expected to be achieved when implementing probabilistic techniques (fixed, adjusted and smart probabilistic) with DSR.

We propose to use a probabilistic technique in DSR routing scheme based on local knowledge about the neighbors collected by the nodes. The proposed framework will not generate an extra overhead to the network as it will uses the “hello” message mechanism to gather this data. The “hello” message mechanism is explained later in this paper.

IV. IMPLEMENTATION

To implement adjusted and smart probability the node must have some knowledge about the state of the network (its neighbors and their neighbors). Thus, a technique must be defined that enable the node to collect this information in repeated manner. Hence in this work, we define **hello message** to be used with DSR algorithm since the original DSR algorithm was designed to be fully dynamic and did not use hello message. Hello message was defined in our approach to be sent periodically by nodes every some fixed period of time, each hello message contain a broadcast destination address and the originated node source address along with the number of neighbors of the sending node so any node that receives this message will indicate that the sending node is a neighbor and has *n* neighbors and store this information in a local data structure so it can be used when needed, also the hello massage must include a Time To Live (TTL) value equal to 1 to prevent propagating this massage to other nodes other than its neighbors. however not receiving a hello massage for some time this will indicates that a node is no longer a neighbor and has to be discarded from the local data structure, this can be done by adding a time stamp that indicates the time of receiving the hello message and add it to the local data structure along with the sending node and its neighbors, a periodic check is performed based on expiration time property so any neighbor that did not send a hello message for some period of time is no longer a neighbor and has to be eliminated from the local data structure. After collecting information sent by all its neighbors any node in the network can use this information to calculate the probability of resending a route request.

A.Simulation Environment

For the purpose of testing our approach we use NS2 simulator version 2.33 running under Fedora Linux operating system.

B.Simulation Parameters

We use NS2 simulator to test our approach, the simulation area was 250×250 m, 500×500 m, 750×750 m and 1000×1000m the node bandwidth is 2Mbps using IEEE802.11 MAC layer protocol. Regarding the number of nodes the approach was simulated with 25, 50, 75 and 100 mobile node. Nodes speed was chosen to be 4, 8, 12 and 16 m/s [5]. And the last parameter is the number of connections used the simulation is performed at 5, 10, 15 and 20 connections.

In order to test our approach several scenarios must be generated to represent different simulation parameters, each point at the simulation was tested using 10 deferent scenarios to ensure an acceptable degree of confidence, also different algorithms was tested using the same scenarios at the same point in the simulation, and using different scenarios at different points in the simulation to represent different simulation parameters.

C. Evaluation Criteria

The following metrics where used as an evaluation criteria’s:

1- Average end-to-end delay: it include all end to end delay in data packet sending from source to destination which include delay caused by route discovery, MAC layer delay and application layer delay.
2- Routing overhead: it is the number of route request packets generated through the simulation process to find a path for sending a data packet.
3- Normalized routing load: it is the ratio of routing packet transmitted to the data packet delivered through the simulation.

D. Average End to end Delay

Figure 1 shows the average end-to-end delay for Blind Flooding DSR, Fixed Probability DSR, 2P DSR and 4P DSR against the simulation area. The results were obtained for simulation area between 250×250 and 1000×1000 with 50 node, speed of 16m/s and number of connections 10. It can be seen that the for areas below 750x750 the delay is under 0.2 whereas the delay is increased rapidly afterwards at 1000x1000 to around 1.6.

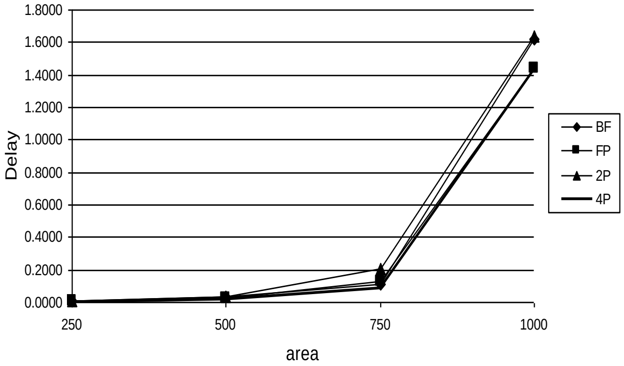

Figure 1. End-to-end delay against area when n=50, speed 16m/s and connections=10.

At simulation area of 250×250, the results from the four algorithms seems to be identical but as the simulation area increase the 4P and FP show better performance than BF and 2P.

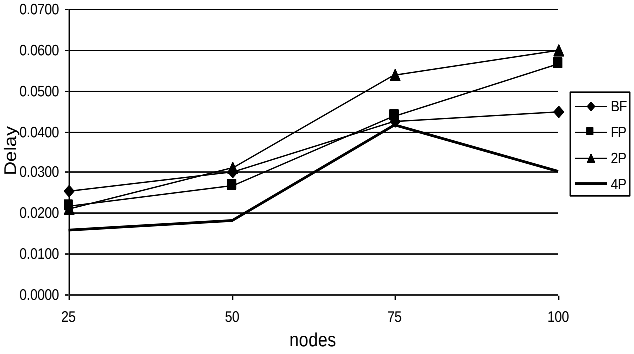

Figure 2. End-to-end delay against number of nodes when area= 500×500, speed 16m/s and connections=10.

Figure 2 shows the end-to-end delay against the number of nodes for the four algorithms at simulation area 500×500m, a speed of 16m/s and number of connections equal 10.

As can be seen that the 4P algorithm gives better performance than the other algorithms because of its flexibility in determining different probabilities, while the BF still shows a better improvement than 2P and FP.

Figure 3 shows the end-to-end delay against the speed of nodes for the four algorithms at simulation area 500×500m, a number of nodes of 50 and number of connections equal 10.

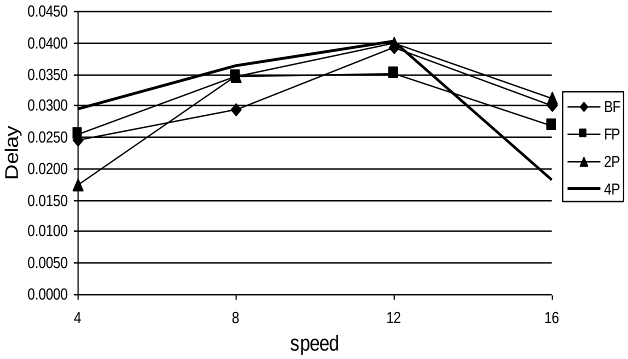

Figure 3. End-to-end delay against the speed of nodes when area=500×500, n=50 and connections=10.

As the speed of nods increases, the 4P algorithm shows a significant improvement over the other algorithms; moreover, FP algorithm performance is better than BF and 2P.

V. "HELLO" PACKETS

"Hello" packets are periodically generated by a given node in order to know the number of its neighbors. These packets are extra control packets sent by nodes to successfully accomplish broadcast operations. Each node sends a short packet that informs its neighbors of its presence. So, a node can know its neighbors by simply listening to the medium. Since nodes obtain neighborhood information through "Hello" packets, the information in the "Hello" packet varies depending on it usage. Thus it is necessary to quantitatively assess the impact of the size of the "Hello" packets on the overhead involved and thus be able to comment on any possible performance tradeoffs. To this end, we have used a "Hello" packet with a size of 12 bytes for exchanging neighborhood information.

VI. CONCLUSION AND FUTURE WORK

The paper presented a performance evaluation of using probabilistic approach in DSR routing algorithms. It is noticeable that the performance of probability approach is better than Blind Flooding especially at high number of connections and high simulation area. Also it is noticeable that at low network area (e.g., 250×250 and 500×500), all the four algorithms show relatively close performance. But at higher network area (e.g., 750×750 and 1000×1000) probabilistic approaches shows a significant improvement over the Blind flooding approach.

The simulation experiments show that our proposed scheme significantly outperforms the 2P-based and flooding schemes in terms of reducing overhead at low speed of nodes (1 m/s). In addition, the 4P algorithm substantially outperforms the other algorithms in terms of reducing average end-to-end delay for low speed nodes. Regarding packet delivery ratio, the experimental results show that our scheme outperforms the other schemes.

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