The Effectiveness of Dynamic Probabilistic Flooding in On-Demand Routing Protocols for MANETs was Assessed Through a Performance Analysis

Abdalla M. Hanashi
Computer Department, Faculty of Engineering, Sabratha University, Sabratha, Libya

Saleh Algoul
Faculty of Information Technology, University of Tripoli, Tripoli, Libya

Abstract:

In mobile ad hoc networks (MANET), broadcasting is widely used in route discovery and many other network services. The efficiency of broadcasting protocol can affect the performance of the entire network. As such, the simple flooding algorithm aggravates a high number of unnecessary packet rebroadcasts, causing contention and packet collisions. Proper use of probabilistic method can reduce the number of rebroadcasting, therefore reduce the chance of contention and collision among neighboring nodes. A good probabilistic broadcast protocol can achieve high save rebroadcast and low collision. In this paper, we propose a dynamic probabilistic approach when nodes move according to way point mobility and compare it with simple flooding AODV and fixed probabilistic scheme. Our approach dynamically set the rebroadcasting probability according to the number of neighbors nodes distributed in the ad hoc network. Simulation results show our approach performs better than both simple flooding and fixed probabilistic flooding.

Keywords: AODV, MANETs, probabilistic broadcasting, reachability.

Introduction

Mobile ad hoc networks (MANETs) represent autonomous mobile wireless networks without a predetermined infrastructure for communication. Network-wide propagation is extensively employed in MANETs (Cartigny & Simplot, 2003) for tasks such as route discovery and address resolution in the network layer. For instance, on-demand routing protocols like ad-hoc on-demand distance vector (AODV) (Perkins & Royer, 1999) and dynamic source routing (DSR) (Johnson & Maltz, 1996) utilize broadcast details in route request packets to formulate routing tables at each mobile node (Zhang & Agrawal, 2005). However, the dynamic nature of MANETs mandates routing protocols to regularly update routing tables, resulting in numerous broadcast packets being generated across nodes. Given that not every node within a MANET can directly reach nodes beyond its communication range, broadcast packets might necessitate multiple rebroadcasts through intermediary nodes to ensure comprehensive reach. Hence, an inefficient broadcast approach could lead to a proliferation of redundant rebroadcast packets (Pleisch, et al., 2006).
Diverse approaches have been proposed for broadcasting in MANETs. The most straightforward method is flooding, where in each mobile host rebroadcasts received packets for the first time; subsequently received packets are discarded. Despite its simplicity, flooding exacts substantial network resources by introducing a plethora of duplicate messages. This, in turn, triggers redundancy, contention, and collisions in mobile wireless networks, commonly termed as the "broadcast storm problem" (Tseng et al., 2002).

This paper introduces a dynamic probabilistic broadcasting approach. The rebroadcast probability of a host is dynamically adjusted based on neighbor node count. Specifically, in densely populated areas, where the host is surrounded by numerous neighbor nodes, the rebroadcast probability remains low; conversely, in sparsely populated regions, characterized by fewer neighbor nodes, the rebroadcast probability increases. Simulation outcomes demonstrate a significant reduction in broadcast redundancy through this proposed approach.

The subsequent sections are organized as follows: Section 2 furnishes background and related research on dissemination within MANETs. Section 3 outlines the novel dynamic probabilistic approach, accentuating its distinguishing attributes compared to analogous techniques. Section 4 presents the experimental parameters, performance outcomes, and analyses aimed at evaluating the efficacy and constraints of the proposed method. The paper concludes in Section 5, encapsulating findings and delineating future directions.

Related Works

This section scrutinizes pertinent research endeavors aimed at curtailing the proliferation of broadcast packets engendered by the flooding algorithm. Within MANETs, the excessive redundancy of broadcast packets stemming from flooding has been denoted as the "Broadcast Storm Problem" (Tseng et al., 2002). Five distinct flooding schemes (Williams & Camp, 2002) have been posited in MANETs, encompassing probabilistic, counter-based, distance-based, location-based (Tseng et al., 2002), and cluster-based (Tseng et al., 2002; Williams & Camp, 2002) paradigms. In the probabilistic scheme, a host, upon receiving an inaugural broadcast message, rebroadcasts the message with a consistent probability denoted as P. Counter-based methodology suppresses rebroadcasting if the message has been encountered more than a stipulated count, C. The distance-based approach mandates a node to rebroadcast only when the distance between sender and recipient surpasses a defined threshold, D. Meanwhile, the location-based scheme dictates message rebroadcast contingent upon the expansion of coverage resultant from the new transmission, surpassing a specified boundary, A. The cluster-based strategy employs a cluster selection algorithm for cluster creation, with rebroadcasting subsequently executed by head clusters and gateways. Notably, the location-based scheme is acclaimed for its effectiveness (Tseng et al., 2002), albeit necessitating a positioning system for supplementary area coverage attainment.

A technique reliant on a uniformity parameter has been introduced (Cartigny & Simplot, 2003), where each node in a given region receives a broadcast and determines rebroadcast probability based on a constant efficacy parameter and local density, although this approach is intrinsically locally uniform. Zhang and Dharma (2005) have delineated a dynamic probabilistic mechanism amalgamating probabilistic and counter-based techniques. The packet counter’s value doesn’t invariably correspond to the exact neighboring count of the current host, as some neighbors may curtail rebroadcasts as per their local rebroadcast probability. Additionally, rebroadcast decisions incur random delays, augmenting latency.

Bani Yassein et al. have advanced a fixed pair of probabilistic broadcast schemes where the forwarding probability p adapts via local topology data garnered from proactive exchange of "HELLO" packets among neighbors (Yassein

**Dynamic Probabilistic Broadcast Algorithms**

In prior exploration, conventional flooding was observed to suffer from the predicament of redundant message receipt, where identical messages reached each node multiple times. This inefficiency squandered valuable resources and could trigger intense contention within the transmission medium. Fixed probabilistic flooding sought to address this by imposing a constant rebroadcast probability 'p' for all nodes, thereby striving to curb redundant transmissions. In this schema, upon the initial reception of a broadcast message, a node would rebroadcast it with a pre-established probability 'p'. Consequentially, each node held an equivalent likelihood of rebroadcasting the message, irrespective of its neighbor count.

In environments characterized by dense networks, wherein numerous nodes share comparable transmission ranges, these probabilities regulated rebroadcast instances, potentially conserving network resources without compromising delivery rates. It is noteworthy that in sparse networks, with less communal coverage, certain nodes might fail to receive all broadcast packets unless the probability parameter is set high. Our algorithm dynamically computes the rebroadcast probability 'P', wherein an elevated 'P' corresponds to a heightened redundancy in rebroadcasting, while a diminished 'P' signifies reduced reachability.

The calculation of 'P' is as follows:

When the neighbor count (Snbr) of a node is 1, 'P' is set to its maximum value (P_max = 1).

When the neighbor count (Snbr) of a node is greater than or equal to 12, 'P' is set to its minimum value (P_min = 0.4).

An abridged depiction of the dynamic probabilistic flooding algorithm is presented below. Upon the initial reception of a broadcast packet (pkt) at host node 'i', the node rebroadcasts the message based on a computed probability derived from the neighboring nodes of 'i'. Thus, if node 'i' possesses a higher probability 'p', rebroadcasting is more likely. Conversely, if 'i' maintains a lower probability 'p', rebroadcasting is less probable.

**Algorithm: Dynamic probabilistic broadcasting algorithms**

This algorithm relays the packet (pkt) for ith node with probability P.

**Input Parameters:**

- pkt(i): Packet to relay by ith node.
- P(i): Rebroadcast probability of packet (pkt) of ith node.
- RN(i): Random No. over [0,1] for ith node to compare with the rebroadcast probability P.
- S_nbr (i): Size/No of neighbour nodes of ith node.

**Output Parameters:**

- Discpkt(i): Packet (pkt) will be discarded for node(i), if it is in the packet list of ith node.
- Rbdpkt(i): Packet (pkt) will be rebroadcasted by ith node, if probability P is high.
- Drpkt(i): Packet (pkt) will be dropped by ith node, if probability P is low.

**DPFlood(msg): Dynamic Probabilistic Flooding**

1: Upon reception of packet (pkt) at node (i)
2: if packet (pkt) received for the 1st time then
3: Go to Procedure (1)
4: Relay the packet (pkt) when (P > RN(i))
5: else
6:            Drop pkt
7: endif

Procedure (1)
This procedure calculates the Rebroadcast Probability P of
ith node

Input Parameters:
S_{nbr}(i): Size/No of neighbour nodes of ith node.

Output Parameters:
P(i): Rebroadcast probability of packet (pkt) of ith node.

Probability (S_{nbr}(i)): Rebroadcast Probability for
ith node
1: Set P = 1
2: Go to Procedure (2)
3: \[ P := \prod_{i=0}^{S_{nbr(i)}} P \times P_{\text{max}} \]
4: if P < P_{\text{min}} then
5: \[ P = P_{\text{min}} \]
6: endif
7: return (P)

Procedure (2)
This procedure calculates the size/No of neighbour nodes of
ith node

Input Parameters:
\text{nbrTable}(i): Neighbor table for ith node.

Output Parameters:
S_{nbr}(i): Size/No of neighbour nodes of ith node.

NBRsize(nbrTable): Size of the neighbour nodes
1: if \text{nbrTable}->size = 0 then
2:    return (0)
3: else
4:    return (nbrTable->size)
5: endif

The proposed algorithm dynamically adjusts the rebroadcast probability p at each mobile host
according to the number of neighbor nodes. The value of p is different in different areas. In a
sparser area, the rebroadcast probability is large whilst in the denser area, the probability is low.
Compared with the probabilistic approach where p is fixed and comparing with the existing
approaches (Yassein et al., 2006; Pleisch, et al., 2006), the proposed algorithm achieves higher
saved rebroadcast and lower collision.

Performance Analyses
Within this segment, we undertake an extensive assessment of the proposed dynamic probabilistic
broadcasting algorithm's performance. A comparison is drawn between the proposed algorithm and both
the simple flooding algorithm and the fixed probabilistic algorithm. Key metrics of evaluation
comprise the average count of rebroadcasts for routing requests, saved rebroadcasts, and the
average occurrence of collisions.

Simulation Setup
Extensive experimentation for scrutinizing the behavior of the dynamic probabilistic flooding
algorithm is carried out using the GloMoSim network simulator (version 2.03) (Zeng, Bagrodia
& Gerla, 1998). Evaluation is conducted within the context of a higher-level application, namely, the
AODV routing protocol (Perkins & Royer, 1999; Sasson & Cavin, 2003; Sasson, Cavin & Schiper, 2002),
which is integrated into the GloMoSim framework. Two variants of AODV are deployed: one employing
a fixed probabilistic approach denoted as FPAODV (AODV + fixed probability), and the other employing dynamic
calculation of rebroadcast probability termed P-AODV (AODV + dynamic probability).

The simulation is enacted in a 1000m × 1000m area, employing an 80-mobile host random waypoint model. Network parameters encompass a bandwidth of 2 Mbps and IEEE 802.11 medium access control (MAC) layer protocol (Zhang & Agrawal, 2005). Additional simulation parameters are enumerated in Table 1.

Within the simulation setup, each node's initial movement incorporates a randomized start time, direction, and distance. Upon traversing the predetermined distance along the predefined direction, the node enters a random pause phase before commencing the next movement round. The broadcast approaches' performance is scrutinized within these contextual scenarios.

**Saved Rebroadcast (SRB)**

In our algorithm, rebroadcast probability is dynamically determined, with higher values in sparser regions and lower values in denser regions. The metric of Saved Rebroadcast (SRB) is defined as the ratio of rebroadcasted route request (RREQ) packets to the total received RREQ packets, excluding those terminated due to time-to-live (TTL) expiration.

As depicted in Fig.1, our enhanced algorithm distinctly diminishes the saved rebroadcast (SRB), particularly evident in a network with 80 nodes, varying mobility speeds, and 10 source-destination pairs' connections.

**Fig.2 illustrates the correlation between relay count and varying mobility, featuring 80 nodes and 10 source–destination pairs. Introduction of mobility induces heightened generation of route requests, with certain requests encountering failures in reaching their intended destinations. These failures necessitate subsequent rounds of route request packet transmission. Notably, as depicted in Figure 2, our proposed approach outperforms FP-AODV and blind flooding methodologies, exhibiting fewer relay instances.**

**Table1. Simulation Parameters**

<table>
<thead>
<tr>
<th>Simulation Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulator</td>
<td>GloMoSim v2.03</td>
</tr>
<tr>
<td>Network Range</td>
<td>1000m × 1000m</td>
</tr>
<tr>
<td>Transmission Range</td>
<td>250m</td>
</tr>
<tr>
<td>Mobile Nodes</td>
<td>80 and 100</td>
</tr>
<tr>
<td>Traffic Generator</td>
<td>Telnet</td>
</tr>
<tr>
<td>Band Width</td>
<td>2Mbps</td>
</tr>
<tr>
<td>Packet size</td>
<td>512Bytes</td>
</tr>
<tr>
<td>Packet Rate</td>
<td>10 pps</td>
</tr>
<tr>
<td>Simulation time</td>
<td>900s</td>
</tr>
</tbody>
</table>

**Collisions**

We measure the number of collisions for these schemes at the physical layer. Since data packets and control packets share the same physical channel, the collision probability is high when there are a large number of control packets. Fig. 3 shows our algorithms incur fewer collisions than that of simple AODV and FP-AODV.
Conclusion

In this paper, we present a novel dynamic probabilistic broadcasting strategy tailored for mobile ad hoc networks, incorporating nodes that adhere to the waypoint mobility model (Camp, Boleng & Davies, 2002). Our proposition dynamically configures the rebroadcast probability for each host node based on the available neighbor information. Through meticulous simulations, we substantiate the efficacy of our approach in achieving heightened saved rebroadcasts, surpassing those attained by the static probabilistic method, as well as the dynamic (Zhang & Agrawal, 2005) and adapted probabilistic (Yassein et al., 2006) strategies. Moreover, our approach exhibits reduced collision occurrences and generates fewer route requests than all previously explored techniques.

In terms of future endeavors, we envision an exploration of the algorithm across diverse mobility models within mobile ad hoc networks, leveraging neighbor information. Additionally, we intend to assess the performance of dynamic probabilistic flooding within the context of Dynamic Source Routing (DSR), encompassing varying mobility models that emulate more authentic scenarios.

References


